PROPOSED BY: PUBLIC WORKS
INTRODUCTION DATE: 2/25/25

RESOLUTION NO. ________

AMENDING THE 2006 BIRCH BAY COMPREHENSIVE STORMWATER PLAN TO INCLUDE FOUR SUBWATERSHED MASTER PLANS

(Council acting as the Whatcom County Flood Control Zone District Board of Supervisors)

WHEREAS, the Whatcom County Council adopted the Birch Bay Community Plan as a Subarea Plan of the Whatcom County Comprehensive Plan on September 28, 2004; and

WHEREAS, the Whatcom County Council adopted the Birch Bay Comprehensive Stormwater Plan on November 8, 2006 (Res 2006-070); and

WHEREAS, on March 13, 2007, the Whatcom County Flood Control Zone District Board of Supervisors adopted Ordinance 2007-019, which created the Birch Bay Watershed and Aquatic Resources Management (BBWARM) District pursuant to RCW 86.16; and

WHEREAS, capital improvement projects would solve many of the drainage problems in the Birch Bay area and could also be used to improve water quality and aquatic habitat; and

WHEREAS, historically, decisions on drainage-related infrastructure projects have been made one at a time without the benefit of master planning to address several other problems or plans in the area; and

WHEREAS, the Birch Bay Comprehensive Stormwater Plan, the Birch Bay Characterization and Watershed Planning Pilot Study (2007), and the BBWARM citizen advisory committee all recommended the implementation of watershed master planning to develop a systematic approach to solving stormwater management problems in the Birch Bay watershed by improving drainage and reducing flooding; and

WHEREAS, four subwatershed master plans (SWMPs) were developed for the BBWARM District between 2013 and 2023 entitled: Central North Subwatershed Master Plan; Central South Subwatershed Master Plan; Birch Point, Terrell Creek Urban Area and Point Whitehorn Subwatershed Master Plan; and Birch Point Subwatershed Drainage Study; and

WHEREAS, developing the plans consisted of collecting data on existing drainage infrastructure, analyzing system capacity, identifying and addressing deficiencies, and creating a guide for implementing capital projects to address drainage deficiencies in a prioritized and scheduled manner; and

WHEREAS, preparation of the SWMPs was based on substantial public involvement activities, including public outreach and workshops, presentations, and engagement with the BBWARM District citizen advisory committee and partners; and

WHEREAS, pursuant to WAC 197-11-660, Whatcom County may adopt plans as SEPA policies for substantive authority and determining appropriate mitigation measures for development impacts; and

WHEREAS, a SEPA Determination of Non-Significance (DNS) was issued on December 11, 2024.

NOW, THEREFORE, BE IT RESOLVED the Whatcom County Flood Control Zone District Board of Supervisors hereby:

1. Amends the Birch Bay Comprehensive Stormwater Plan to include four SWMPs as outlined in Exhibit A of this resolution.
2. Adopts the plan as an agency SEPA policy under the State Environmental Policy Act.

APPROVED this_____day of__________, 20__ .

	WHATCOM COUNTY COUNCIL
ATTEST:	WHATCOM COUNTY, WASHINGTON
______________________________	______________________________
Cathy Halka, Clerk of the Council	Kaylee Galloway, Council Chair
	WHATCOM COUNTY EXECUTIVE
APPROVED AS TO FORM:	WHATCOM COUNTY, WASHINGTON
Chris Quinn approved via email (2/4/25)	______________________________
Chief Civil Deputy Prosecuting Attorney	Satpal Sidhu, County Executive
	( ) Approved ( ) Denied
	Date Signed: ____________________

Exhibit A

BIRCH BAY

COMPREHENSIVE STORMWATER PLAN

PREPARED FOR

Whatcom County Washington

PREPARED BY

CH2MHILL

July 2006

Birch Bay Comprehensive Stormwater Plan

Prepared for
Whatcom County

Prepared by
CH2MHILL

July 2006

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On _____________, Whatcom County Council, acting as the Whatcom County Flood Control Zone District Board of Supervisors, approved a resolution (Res 2025-___) amending the 2006 Birch Bay Comprehensive Stormwater Plan to include the four subwatershed master plans (SWMPs) that were completed between 2013-2023, and adopted the plan as an agency SEPA policy under the State Environmental Policy Act.

The SWMPs address drainage and surface water flooding problems in the geographical areas identified in each plan through development of capital projects. These projects consist primarily of new or improved storm drain systems. Collectively, the plans identify and prioritize 58 capital projects to solve drainage-related problems. The SWMPs also identify small works projects, special studies, and maintenance needs within the urbanized areas of the Birch Bay watershed.

The SWMPs provide Whatcom County staff, the Birch Bay Watershed & Aquatic Resources Management District (BBWARM) Advisory Committee, and other community groups and agencies with guidance and details on the condition of stormwater infrastructure and drainage issues throughout the Birch Bay watershed, as well as project cost estimates and prioritization of needs. The recommended projects contained within the four SWMPs are intended to protect water quality, enhance aquatic habitat, and reduce stormwater impacts such as flooding and erosion in Birch Bay.

The purpose of adopting the plans and studies into the Birch Bay Comprehensive Stormwater Plan is to make them a more widely-known and available resource to county staff, government agencies, developers, and the community, as well as enhance awareness of their existence and legitimacy. Of specific importance is the identification of undersized systems where flooding is known or shown to occur based on extensive hydraulic and hydrologic modeling undertaken as a component of each SWMP. This information should help ensure that project proposers and reviewers are aware of potential impacts to downstream drainage systems.

Addendum 1: Central North Subwatershed Master Plan (2013)

Addendum 2: Central South Subwatershed Master Plan (2015)

Addendum 3: Birch Point, Terrell Creek Urban Area and Point Whitehorn Subwatershed Master Plan (2016)

Addendum 4: Birch Point Subwatershed Drainage Study (2023)

These four documents are also available on the BBWARM website at:
www.bbwarm.whatcomcounty.org/about/reference-documents

Acronyms and Abbreviations

AKART	all known, available, and reasonable technology
BMPs	best management practices
CAC	Citizens Advisory Committee
CAO	Critical Areas Ordinance
CCTV	closed-circuit television
CFR	Code of Federal Regulations
CIP	Capital Improvement Program
CRIS	County Road Inventory System
DO	dissolved oxygen
DOH	Washington State Department of Health
Ecology	Washington Department of Ecology
EIS	environmental impact statement
ERUs	equivalent residential units
ESA	Endangered Species Act
FC	fecal coliform colonies
FCZD	flood control zone district
ft^2	square feet
FTE	full time equivalent
G.O.	General obligation
GPS	Global Positioning System
HB	House Bill
LID	low-impact development
LIDs	local improvement districts
LWD	large woody debris
M&O	Maintenance and Operations
MEP	maximum extent practicable
mg/L	milligrams per liter

ml	milliliters
MRC	Whatcom County Marine Resource Committee
MRSC	Municipal Research & Services Center
NPDES	National Pollutant Discharge Elimination System
NSEA	Nooksack Salmon Enhancement Association
NWIFC	Northwest Indian Fisheries Commission
O&M	operation and maintenance
PIE	Public Involvement and Education
PWTF	Public Works Trust Fund
RCW	Revised Code of Washington
REET	Real estate excise tax
ROW	right-of way
SDC	system development charge
SFRs	single-family residences
SMP	Shoreline Management Program
SRF	State Revolving Fund
SWMP	Stormwater Management Program [or Plan]
SWPPP	Stormwater Pollution Prevention Plan
TSS	total suspended solids
UGA	urban growth area
ULIDs	utility local improvement districts
USC	United States Code
WAC	Washington Administrative Code
WCC	Whatcom County Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WRIA	Water Resource Inventory Area

Glossary

Best management practices (BMPs) - Structural or nonstructural methods to prevent or reduce the movement of sediment, nutrients, pesticides, or other pollutants from the land to surface or groundwater.

Capital improvement program (CIP) – An infrastructure planning tool for a municipality, county, or other government entity. The CIP often contains a listing of the infrastructure projects planned for a defined period of time into the future.

Fecal coliform bacteria – Microorganisms that live in large numbers in the intestines of warm-blooded animals that aid in the digestion of food. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of humans or other animals.

Impervious surface – Ground or rooftop surface that is paved or otherwise impermeable to water.

Large woody debris (LWD) – Felled or fallen vegetation (often trees) that accumulate near and within a stream or river that aid in the habitat diversity of a waterbody.

Low-impact development (LID) – The term for a series of measures whose overall goal is to reduce the negative effects of urbanization and development, including increased impervious surface, that lead to a hydrologic regime altered from the natural state.

National Pollutant Discharge Elimination System (NPDES) - A national permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States. In most cases, the permit program is administered by the State.

Non-point source pollution – The pollution that is picked up by stormwater runoff as it makes it way through the watershed to the receiving water body.

Riparian – Relating to the bank of a natural watercourse such as a river or tidewater.

Special service district – A limited-purpose local government entity, separate from a city, town, or county government, that performs a single function. Special service districts are generally created through the County legislative authority to meet a specific need of the local community, such as a new or higher level of service.

Funding Mechanisms

Additional funding will be needed to address the stormwater issues raised by Birch Bay citizens. New funds will allow the County to protect public health and safety, meet public expectations, and address regulatory requirements while preparing a long-term strategy for operating surface water management programs.

Stormwater Funding Mechanisms

- Establishing a sub flood control zone district with authority to levy fees and charges.
- Introducing stormwater service rates and charges, and associated policies that include incentives and development financing.
- Complete a public involvement program prior to implementation of the surface water fee.
- Exploring the availability of Whatcom County funding, as well as federal, state, and other grant funding sources, and pursuing suitable options.

Several alternatives are available for funding stormwater management programs. To secure adequate funding, Birch Bay decisionmakers should incorporate a combination of mechanisms that consider both immediate and long-term needs. Any funding plan should also be guided by broad goals, such as customer acceptability, defensibility, revenue sufficiency and stability, equity, administrative ease, and consistency/compatibility with local policies, practices, and long-term strategies. It should include public education and involvement to help ensure ultimate support and success. Additional analysis and public debate are needed before adoption of any funding mechanism.

For More Information

To learn more about Birch Bay and Whatcom County comprehensive planning programs, contact:

Roland Middleton, Special Projects Manager
Whatcom County Planning & Development Services
322 N. Commercial, Suite 120
Bellingham, Washington 98225

E-mail address: RMiddlet@co.whatcom.wa.us
Telephone number: (360) 676-6907

Or visit the Whatcom County web site at http://www.co.whatcom.wa.us/pds/BirchBayStormwaterManagementPlan.htm to view the plan online.

Birch Bay, looking southwest toward Point Whitehorn and the San Juan Islands beyond.

Executive Summary

Introduction

Birch Bay, Washington, is located about 20 miles north of Bellingham in Whatcom County. This vibrant community and recreational destination includes a shallow, crescent-shaped bay containing cobble and sand beaches and expansive tide flats. The beach in Birch Bay is a very popular recreation area with many activities including swimming, fishing, boating, admiring flora and fauna, strolling the tide flats, and shellfish harvesting. The bay has extensive shellfish beds and recreational shellfish harvesting. The 194-acre Birch Bay State Park provides public access to these resources. Whatcom County Parks manages other public access points to the water. Terrell Creek is the predominant freshwater system in the Birch Bay watershed, draining approximately 17 square miles.

Birch Bay is currently experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat as a result of increasing growth and development in the region.

Goal of the Birch Bay Comprehensive Stormwater Plan

The primary goal of this plan is to enable Birch Bay residents to reach agreement on a stormwater management plan that sustains the lifestyle and restores the aquatic resources of Birch Bay under the pressure of increasing growth and development.

This comprehensive stormwater plan addresses these issues and provides guidance on addressing or preventing future problems that may arise as growth continues.

In 2002, the Birch Bay Community Plan Steering Committee completed a community plan for the Birch Bay Urban Growth Area (UGA) and surrounding area. The Birch Bay Community Plan was adopted as a Sub Area Plan of the Whatcom County Comprehensive Plan in 2004. The plan includes the community's vision for accommodating future growth in the area, including the recommendation to develop a stormwater plan. This comprehensive stormwater plan has been developed in response to the Birch Bay Sub Area Plan action item.

Regulations Affecting Surface Water Management

Chapter 2 of this plan discusses stormwater regulatory requirements and compliance issues in Birch Bay. Relevant regulations include the Endangered Species Act (ESA), the Clean Water Act National Pollutant Discharge Elimination System (NPDES), and several Whatcom County ordinances, plans, and standards, such as the Whatcom County Comprehensive Plan, the update to Whatcom County's Shoreline Management Program (currently underway), the Birch Bay Sub Area Plan, the Whatcom County Zoning Ordinance, and the Whatcom County Development Standards. The County plans, programs, and ordinances influence and provide guidance for the development of a stormwater management program in Birch Bay.

As part of the preparation of this plan, a gap analysis was conducted to identify areas in Whatcom County regulations, ordinances, programs, and plans where improvements are needed to meet the regulatory requirements of the NPDES stormwater permit and other State requirements. The detailed recommendations produced by the gap analysis are presented in Chapter 2.

Surface Water Issues in Birch Bay

Several types of surface water problems have occurred recently in the Birch Bay area. The most publicized problem is the decline in the water quality of Birch Bay itself.

In July 2003, Birch Bay was added to the Washington State Department of Health's list of "threatened" shellfish harvesting areas. This status indicates a downward trend in water quality and was given as part of the Department of Health's Early Warning System. The Early Warning System is intended to identify areas that may be on the verge of failing public health standards or that show deteriorating water quality based on high fecal coliform levels. Although now removed, the threatened status for the shellfish resources of Birch Bay is a "wake-up call" for residents, planners, and policymakers in addition to commercial and recreational shellfish harvesters. This surface water problem highlights the need for regional stormwater planning efforts.

Cottonwood Beach outfall, January 2006.

Rogers Slough, looking toward its outlet to Birch Bay, January 2006.

Public Involvement

This Birch Bay Comprehensive Stormwater Plan has benefited from significant public involvement. The Citizens Advisory Committee (CAC) has worked through identification of problems, potential solutions, and possible funding sources for the elements described in this plan. A public workshop was well attended and was vital to the development of an all-inclusive plan.

Besides declining water quality in Birch Bay, several other types of surface water problems occur in the area. Localized drainage issues, including flooding and erosion/sedimentation, have developed or worsened in several neighborhoods. Aquatic habitat in wetlands, freshwater creeks, and the saltwater bay has been lost. Surface water quality of local freshwater bodies has also declined. These issues are generally the result of historical and recent development in the area. The problems have been made worse by the greater impervious surface and non-point source pollution that accompanies increasing development.

Solutions to Surface Water Problems

The potential solutions to the identified water quantity, water quality, habitat, and policy issues can be divided into two categories: programmatic (non-structural) and capital (structural). Several of the surface water problems identified in Birch Bay can be addressed with construction projects suitable for the Whatcom County Stormwater Capital Improvement Program (CIP), and others can be solved with stormwater management programmatic actions.

Programmatic alternatives have the benefit of often being strategic rather than reactionary. Instead of fixing a single problem with a structural solution, programmatic alternatives often address several existing problems and are effective at preventing future problems. Potential programmatic solutions as part of a county-wide or Birch Bay stormwater management program are discussed in Chapter 4. Whatcom County has previously implemented most or all of these recommendations at one time or another in various locations in the county. Therefore, most of these actions could be implemented as an extension of existing activities or programs.

Programmatic Solutions

- Complaint response
- Inspections and illicit connections
- Spill response
- Maintenance and operations (M&O)
- Education
- Monitoring
- Regulatory and policy changes
- Record-keeping and annual reporting
- Identifying a watershed keeper
- Administration
- Implementation of mandatory low-impact development (LID) measures

Capital Improvement Projects

1. Birch Bay Drive roadway improvements
2. Drainage improvements, Cottonwood Neighborhood
3. Drainage improvements, Shintaffer Road at Richmond park
4. Lower Terrell Creek improvements for water quality benefits
5. Drainage improvements, Birch Point, various locations
6. Terrell Creek culvert at Grandview Road
7. Drainage improvements, Rogers Slough at Birch Bay Drive

Capital improvement projects would solve many of the drainage problems in the Birch Bay area, and could also be used to improve water quality and aquatic habitat. Several of these projects have been recommended for the Whatcom County CIP. Historically, decisions on drainage-related infrastructure projects have been made one at a time without the benefit of master planning to address several other problems or plans in the area. With the implementation of this stormwater plan, decisions can be made and projects can be planned, implemented, and prioritized based on the rating of that problem compared to others that have already been identified. Recommended capital projects are discussed in detail in Chapter 4.

1 Introduction and Background

Birch Bay is a beachfront community about 20 miles north of Bellingham, Washington. The shallow bay and tide flats provide recreational opportunities for residents and visitors alike. The extensive shellfish beds and shoreline are primary attractions. The Birch Bay watershed is experiencing increasing growth, and planning efforts need to keep pace with the development. The purpose of this Birch Bay Comprehensive Stormwater Plan is to provide guidance on current stormwater issues while providing a mechanism to deal with future problems as they arise.

1.1 Goals and Objectives of this Birch Bay Comprehensive Stormwater Plan

This section describes the goals and measurable objectives for this Birch Bay Comprehensive Stormwater Plan.

1.1.1 Goals

The goal of this plan is to enable Birch Bay residents to reach agreement on a stormwater management plan that sustains the lifestyle and restores the aquatic resources of Birch Bay under the pressure of increasing growth and development.

1.1.2 Objectives and Performance Measures

Table 1-1 lists the objectives of this plan and the corresponding performance measures. Several individual measures can be used to quantify or qualify performance for any one individual objective. There are other measures of performance that may not be listed here.

One set of objectives are that stormwater discharges should not cause or contribute to a violation of Washington State's Surface Water Quality Standards (Chapter 173-201A WAC), groundwater quality standards (Chapter 173-200 WAC), sediment management standards (Chapter 173-204 WAC), or human-health-based criteria in the National Toxics Rule (40 CFR Part 131.36).

1.2 Previous Planning Efforts in Birch Bay

Because Birch Bay is an unincorporated area, comprehensive planning is the responsibility of Whatcom County. Past comprehensive planning efforts included the *Birch Bay Comprehensive Plan* (Whatcom County, 1977), the *Blaine-Birch Bay Sub-Area Plan* (Whatcom County, 1987), the *Birch Bay Community Plan* (Sub Area Plan) (Kask Consulting, 2002), and the *Whatcom County Comprehensive Plan* (Whatcom County, 2005).

In 2004, the Birch Bay Community Plan Steering Committee completed a community plan for the Birch Bay Urban Growth Area (UGA) and surrounding area. This Birch Bay Community Plan (Sub Area Plan) was adopted as a Sub Area of the Whatcom County Comprehensive Plan in 2004. The plan includes the community's vision on accommodating future growth in the area.

TABLE 1-1. OBJECTIVES AND PERFORMANCE MEASURES

Objective	Corresponding Measure of Performance
Drainage, Flooding, and Erosion:	
Identify drainage, flooding, and erosion issues throughout the planning area and prioritize these issues	Consensus on prioritized list of current drainage, flooding, and erosion issues
Take action to resolve priority drainage, flooding, and erosion issues to the extent possible with available funds or acceptable future funding levels	Reduction in magnitude and frequency of drainage issues, flooding, and erosion. Funding obtained to implement high-priority projects.
Identify public versus private issues	Identification of what makes a public issue vs. what makes a private issue
Water Quality:	
Identify sources of coliform bacteria and other stormwater pollutants	Results of field identification efforts and data from source tracing, monitoring, etc. indicate source(s) of bacteria
Identify opportunities to eliminate or reduce sources of bacteria that lead to shellfish restrictions/closures Eliminate or reduce other stormwater pollutants such as nutrients	Programs are implemented to address these issues; monitoring data used to measure performance after implementation of programs Meet Washington State's Surface Water Quality Standards (Chapter 173-201A WAC), Ground Water Quality Standards (Chapter 173-200 WAC), Sediment Management Standards (Chapter 173-204 WAC), and human-health-based criteria in the National Toxics Rule (40 CFR Part 131.36)
Identify sources of fine sediment and soil reaching beaches; identify opportunities to mimic historical levels	Mitigation of unnatural sediment transport processes
Aquatic Habitat:	
Identify key shellfish, stream, and wetland habitats	Inventory of aquatic habitat resources is completed
Outline opportunities to sustain and improve shellfish habitat, salmon habitat, and wetland habitat	Develop action items and programmatic and structural alternatives
Maintain and protect natural areas including riparian zones, wetlands, and beachfront by discouraging development in these areas	Measure/map remaining natural areas, including wetlands and undeveloped beachfront area Documented changes in regulations, ordinances, and policies that discourage development in critical areas
Community Planning:	
Minimize additional impervious surface by reducing width of streets, encouraging smaller building footprints, etc.	All new projects implement LID concepts to the maximum extent possible
Funding:	
Identify, explain, and evaluate alternative funding mechanisms	Knowledge of all stakeholders on alternative funding mechanisms
Ensure recommended funding alternative is adequate, fair and equitable	General agreement among residents and Whatcom County on recommended funding alternative
Outline action steps and responsibilities for implementation of recommended funding alternative	Implementation of an adequate funding alternative

TABLE 1-1. OBJECTIVES AND PERFORMANCE MEASURES

Objective	Corresponding Measure of Performance
Management of Stormwater System:	
Identify level of service and service delivery options; evaluate and outline preferred alternative	Agreement on preferred alternative for Stormwater Management Program (SWMP)
Establish a mechanism for ongoing citizen review and comment on system performance and priorities	Implementation of forum for citizen review and comment
Outline action steps and responsibilities for implementing the recommendations of this plan	Consensus on procedures and responsibilities for plan implementation

The purpose of the *Whatcom County Comprehensive Plan* (2005) was to establish a framework of goals, policies, and action items for growth planning in both the UGAs and rural areas of Whatcom County. The most recent updates were made to the *Whatcom County Comprehensive Plan* in January 2005.

Development of the *Whatcom County Comprehensive Water Resources Plan* commenced in October 1998. This plan, dated 1999 and updated in 2000 and 2001, outlines Whatcom County's vision and goals in regard to water resources issues. Major goals and objectives outlined in the plan pertain to water supply, fish/shellfish, surface water management, groundwater management, and coordinated planning and management.

1.3 Public Involvement in Birch Bay Comprehensive Stormwater Plan Development

The public has been a vital part of the development of this Birch Bay Comprehensive Stormwater Plan. Several public involvement activities were held, including public workshops and presentations to and discussions with the Citizens Advisory Committee (CAC).

The first public workshop (Workshop #1) was conducted on October 1, 2005. The goal of this workshop was to gain an understanding of interests, goals, context, and issues with surface water, and to receive citizen input on surface water problems in the watershed. Residents were divided into groups by neighborhood and were given the task of identifying locations and severity of surface water problems.

Local area residents provided information on surface water problems both at Workshop #1 and via email and other correspondence during the weeks and months following.

Monthly CAC meetings provided opportunities for public involvement in plan development. Committee input was requested on assembled data and on potential alternative solutions.

A second public workshop (Workshop #2) will be held to receive public input on a draft version of this plan. The emphasis of the final workshop will be to present the findings and recommendations for review and comment.

Public hearings will be held by the County council as part of the Council consideration process for the Birch Bay Comprehensive Stormwater Plan.

2 Regulatory Requirements and Planning Documents

Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay have completed a Comprehensive Land Use Plan that called for low-impact development (LID) and a stormwater plan to protect their lifestyle, activities, and aquatic resources while accommodating the anticipated growth. This Comprehensive Stormwater Plan has been prepared to achieve those goals.

This section identifies compliance requirements for Birch Bay under the National Pollutant Discharge Elimination System (NPDES) and the Endangered Species Act (ESA) in the context of currently implemented Whatcom County programs, policies, and regulations in and around Birch Bay.

With respect to NPDES requirements, Whatcom County is a required permittee under the Washington State Department of Ecology (Ecology) NPDES Phase II permit, along with Cowlitz, Kitsap, Thurston, and Skagit counties. Birch Bay is not required to be covered in the County’s permit because Birch Bay is not defined as an urban area by the U.S. Census Bureau. However, Whatcom County’s future population growth estimates for Birch Bay indicate that the area may meet or exceed this urban area criterion in the next 5 to 10 years. Therefore, it is prudent for Whatcom County to adopt the same stormwater management program in Birch Bay UGA as is required by the County’s NPDES Phase II permit.

The City of Ferndale, located just south of the Birch Bay area, is a Phase II city. Currently, the City of Blaine and the area within the Birch Bay UGA are not individual permittees under Phase II. However, because the City of Blaine’s UGA and the UGA of Birch Bay share a boundary, it is possible that Blaine and Birch Bay together may be covered under NPDES Phase II in the future.

This section discusses how Whatcom County’s stormwater management program addresses the NPDES Phase II requirements, specifically for the Birch Bay area. It presents an NPDES regulatory gap analysis report describing deficiencies in the County’s approach according to NPDES requirements. Potential additions to the Whatcom County Stormwater Management Program are recommended.

With respect to ESA requirements, Terrell Creek is the largest and most productive stream in the Birch Bay Watershed. Terrell Creek supports coho and chum salmon but not Chinook. Steelhead and cutthroat trout also may use the creek. Other streams in the watershed are much smaller and support few or no salmon. Therefore, the ESA is not a significant regulatory driver in Birch Bay, and analysis of ESA requirements is not included here.

This section describes the regulatory requirements of the current NPDES permit, presents a gap analysis with respect to the NPDES requirements, identifies State of Washington requirements, and makes recommendations for revising County regulations, ordinances, programs, or plans to address the requirements identified in the gap analysis.

Note that the scope of this analysis was limited largely to the use of existing review materials. This analysis has been substantially expanded beyond those materials, but the analysis is still somewhat limited.

2.1 Relevant Whatcom County Ordinances, Plans, Programs, and Standards

In 2005, a number of activities were completed in Whatcom County such as the adoption of the Critical Areas Ordinance (CAO) and Water Resource Inventory Area (WRIA) 1 Watershed Management and Salmon Recovery plans. These and other Whatcom County ordinances, plans, programs, and standards have different levels of influence on stormwater management in Whatcom County and Birch Bay. Following is a list of ordinances, plans, and programs whose policies collectively affect stormwater management in Birch Bay:

- Whatcom County Comprehensive Plan (2005)
- Whatcom County Development Standards (2002)
  - Design standards for roads and drainage
- Birch Bay Sub Area Plan (2002)
- Update to Parks and Recreation Open Space Plan (2006)
- Subdivision Ordinance, WCC Title 21
- Zoning Ordinance, WCC Title 20
  - Stormwater Special District (WCC 20.80.636)
  - Water Resource Special Management Area (WCC 20.80.735)
- Washington State Department of Ecology’s NPDES Phase II Stormwater Regulations
- Whatcom County Critical Areas Ordinance, Whatcom County Code (WCC) Chapter 16.16 (2005)
- Update to County’s Shoreline Management Program, WCC Title 23 (underway)
- WRIA 1 Watershed Management Project Plan
- WRIA 1 Salmon Recovery Plan
- Comprehensive Flood Hazard Management Plan
- River & Flood Repair and Maintenance Program
- Lake Whatcom Management Program
- Drayton Harbor Shellfish Closure Response Strategy
- Portage Bay Shellfish Closure Response Strategy
- Marine Resources Committee Annual Project List
- 6-Year Road Program

The plans influence and provide guidance to development of a stormwater management program in Birch Bay. The ordinances and development standards control development and provide potential protection of the existing Birch Bay environment (natural, social and economic) with new development.

The Shoreline Master Program and the CAO regulate development of aquatic areas such as lakes, wetlands, streams, and marine waters. They require buffers for new development from aquatic resources. The Zoning Ordinance (WCC Title 20) also includes requirements for setbacks that protect aquatic resources. The CAO does not require use of LID techniques, but does allow some buffer reduction if LID is used where appropriate.

The Birch Bay watershed has been designated as a stormwater special district by the County Zoning Ordinance, WCC 20.80.635. The Zoning Ordinance requires use of stormwater BMPs in stormwater special districts. However, the stormwater special district requirements under WCC 20.80.636 do not specifically require the use of LID techniques. The special district provisions do require implementation of permanent stormwater BMPs, which could result in management measures that qualify as LID techniques. Because of this, new development in the watershed has not been required to maximize LID techniques. Development and adoption of an LID ordinance should be considered. Whatcom County may wish to use Ecology's NPDES Phase II permit Minimum Requirement #5 as a means for evaluating LID techniques and performance. In addition, care should be taken to apply LID techniques appropriate for the project location. For instance, infiltration along coastal bluffs may not be appropriate.

Birch Bay was designated as a Water Resource Special Management Area in February 2005. Existing provisions of the Water Resource Special Management Area requirements that have not been applied within the Birch Bay watershed to date include, "tree canopy area retention". Retention of existing trees on both public and private property is a key citizen concern.

Chapter 2 of the Whatcom County Development Standards (Whatcom County, 2002) covers stormwater management throughout Whatcom County. Section 221 of Chapter 2 covers the Stormwater Special District Standards that apply to Birch Bay. As this section is written, an applicant has the option of using either the same requirements that were in the 1996 Whatcom County Development Standards or the most recent version of Ecology's *Stormwater Management Manual for Western Washington* (2005). The 1996 Development Standards refer to the 1992 Ecology manual, rather than the updated 2005 Ecology manual. Generally, applicants opt for the lesser 1996 Development Standards when developing a comprehensive stormwater management plan for a new development or re-development covered by the standards. Whatcom County should adopt the 2005 Ecology manual.

The Ecology manual requires detention and treatment of stormwater for most developments. The manual recommends the use of a continuous simulation model such as Hydrological Simulation Program—Fortran (HSPF) or Ecology's own version of HSPF, WWHM2. The 1992 version of the manual allows the use of the Santa Barbara Urban Hydrograph (SBUH) model with a correction factor. The Ecology model is available and easy to use. The 2005 version of the Ecology model no longer allows the use of the SBUH. Whatcom County still allows use of the SBUH model.

Stormwater design and design review require detailed technical knowledge and thorough analysis. There are many assumptions that must be checked. For example, a developer must estimate the size of future houses and amount of impervious surface on lots. This affects the size of the stormwater detention and treatment facilities. Over the years, the size of new homes has increased greatly, yet many developers still use old estimates with lower impervious areas. This means that stormwater facilities may be too small to provide the expected benefits.

The Road Standards chapter (Chapter 5) of the Whatcom County Development Standards (May 2004) includes provisions for road widths within Stormwater Special Districts. Section 505.U of these standards states that "developers shall work with design professionals to reduce stormwater runoff by presenting low-impact alternatives to the standard road design" and that "the County Engineer shall review low-impact alternatives to the standard road design…as warranted to reduce stormwater runoff in the [stormwater] special district areas." Drawings contained within the development standards show recommendations for road widths depending on average daily traffic volumes. Whatcom County should increase the implementation of reduced-width roadway designs by increasing implementation and enforcement of this requirement.

2.2 NPDES Phase II Regulatory Requirements and Gap Analysis

2.2.1 NPDES Phase II Requirements

The NPDES Phase II Draft Permit dated 2/16/06 was used for the regulatory gap analysis. The six minimum requirements under Section S5 in the previous Phase II permit were consolidated into five minimum requirements in the new permit. The new permit has the same requirement categories, but two of the requirements were combined into one. In the new draft permit, the fourth requirement, "Controlling Runoff from New Development, Redevelopment and Construction Sites," includes the performance measures covered in two different requirements in the old permit. The following five requirements are included in Section S5 of the new NPDES Phase II Draft Permit issued by Ecology on 2/16/06 (Ecology, 2006):

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination (includes requirement for inventory)
4. Controlling Runoff From New Development, Redevelopment, and Construction Sites
5. Pollution Prevention and Operations and Maintenance for Municipal Operations

Each of these five NPDES Phase II requirements are described by a set of minimum performance measures outlined in the permit. Each of the performance measures are addressed individually in this gap analysis for the Birch Bay area. Table 2-1 at the end of this chapter contains additional detail on these requirements.

Other requirements of the permit include the following:

- Develop and implement a Stormwater Management Program (SWMP)
- Report any monitoring studies
- Assess effectiveness of BMPs and any changes needed
- Prepare a plan for future comprehensive long-term monitoring program
- Submit a detailed annual report on the status of SWMP implementation

Each of these is described in more detail in Table 2-1.

The Clean Water Act requires stormwater treatment by permittees to the maximum extent practicable (MEP). Washington State law requires all known, available and reasonable treatment (AKART). Ecology has determined that MEP is equivalent to AKART and that compliance with the Ecology *Stormwater Management Manual* is AKART.

2.2.2 NPDES Phase II Gap Analysis

Table 2-1 contains an outline of the NPDES Phase II requirements and corresponding performance measures along with the county regulations, ordinances, programs, or plans and any Birch Bay programs or plans that address each performance measure. Table 2-1 also contains a listing of potential improvements to Whatcom County programs, plans, or policies that would address the identified gap.

2.3 State of Washington Requirements and Gap Analysis

There are several other State of Washington requirements other than NPDES Phase II that address surface water management and/or stormwater. These include the Growth Management Act, Shorelines Management Act, State Environmental Policy Act, the *Puget Sound Water Quality Management Plan* (Puget Sound Water Quality Action Team, 2000), and many others. For example, the Growth Management Act requires:

- "(1) A land use element… Where applicable, the land use element shall review drainage, flooding, and stormwater run-off in the area and nearby jurisdictions and provide guidance for corrective actions to mitigate or cleanse those discharges that pollute water of the state…"
- "(5) Rural element… (c) Measures governing rural development. The rural element shall include measures that apply to rural development and protect the rural character of the area… (iv) Protecting critical areas…and surface water and ground water resources…). Section .030(15) states " 'Rural character' refers to the patterns of land use… (g) That are consistent with the protection of natural surface water flows and ground water and surface water recharge and discharge areas."

Compliance with the Phase II NPDES requirements will achieve compliance with most of the other state regulations relevant to stormwater, as the NPDES Phase II requirements generally cover topics mentioned in these other State of Washington documents with at least one exception. The above language from the Growth Management Act would require retention of forest cover and limitations on impervious surfaces to provide "protection of natural surface water flows". This is addressed in the requirements for forest retention in the County regulations designating Birch Bay as a Water Resource Special Management Area. A thorough gap analysis has not been conducted on all of the other State of Washington requirements as part of the Birch Bay Comprehensive Stormwater Plan.

A new bill related to septic systems, House Bill (HB) 1458, has been passed by the Washington State Legislature. HB 1458 requires local health authorities to identify and correct failing septic systems by 2012. The provisions adopted under HB 1458 apply within "marine recovery areas" to be defined by the local health officer in the 12 counties bordering Puget Sound. Marine recovery areas are to be proposed "…where existing on-site sewage disposal systems are a significant factor contributing to concerns associated with: a) Shellfish growing areas that have been threatened or downgraded by the department under chapter 69.30 RCW; b) Marine waters that are listed by the Department of Ecology under section 303(d) of the federal clean water act (33 USC Sec. 1251 et seq.) for low-dissolved oxygen or fecal coliform; or c) Marine waters where nitrogen has been identified as a contaminant of concern by the local health officer…" The requirements of HB 1458 constitute a regulatory gap that will need to be addressed.

2.4 Recommendations Based on Gap Analysis

Gaps were identified between regulatory requirements of the NPDES Phase II permit and other State of Washington requirements, and Whatcom County regulations, ordinances, programs, and plans. The following recommendations are made to meet requirements identified by the gap analyses:

- Adopt and require compliance with the 2005 version of the Ecology *Stormwater Management Manual*.
- Develop a program to inspect and require correction of inadequate septic systems per the requirements of HB 1458.
- Conduct a survey of the average amount of impervious surface on new construction projects in the last 1 to 3 years. Require that new development applications use the results as an estimate for calculating stormwater hydrographs and sizing facilities, or limit impervious surface on individual lots through building permits to the amount of impervious surface identified in the original permit application for subdivision. Encourage smaller lot sizes and shared open space.
- Require the maximum potential infiltration on development sites. Require amended soils to increase infiltration and detention of stormwater. Require pervious pavement with suitable base materials for infiltration for walkways, patios, driveways, and residential streets.
- Enforce Chapter 5 Section 505 U of the Whatcom County Development Standards to reduce pavement widths on residential streets. Whatcom County should increase the implementation of reduced-width roadway designs by increasing implementation and enforcement of this requirement.
- Implement the same stormwater management program in the Birch Bay UGA as is required by Whatcom County's NPDES Phase II stormwater permit to address the gaps outlined in Table 2-1. Table 2-1 contains a listing of sections in this plan with recommendations to address the various requirements of the NPDES Phase II permit.

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
1. Public Education and Outreach [Education programs aimed at residents, businesses, industrials, elected officials, policy makers, planning staff and other employees of the Permittee to reduce or eliminate behaviors and practices that cause or contribute to adverse stormwater impacts.]	a.) Implement or participate in an education and outreach program targeting a minimum of two [of these eight] audiences: i. Awareness by the general public of the need of improving water quality, reducing impervious surfaces, and protecting the existing and designated uses of waters of the state and the potential impacts caused by stormwater discharges. ii. Awareness of natural yard care techniques among homeowners, the general public, landscape professionals, and property managers. iii. Awareness by homeowners, general public, landscape professionals and property managers of the need to protect water quality by reducing purchase of and properly storing, using and disposing of pesticides, fertilizers, and other chemicals. iv. Awareness by homeowners, general public, landscape professionals and property managers of the need to protect water quality by reducing purchase of and properly storing, using and disposing of automotive chemicals, hazardous cleaning supplies, and other hazardous materials. v. Use of technical standards to develop stormwater site plans and erosion control plans by engineers, construction contractors, developers, development review staff, and land use planners, Use of BMPs to mitigate quality and quantity of runoff from development sites. vi. Understanding of the use of low-impact development (LID) among engineers, contractors, developers, architects, landscape architects, realtors and potential home buyers. vii. Awareness by small businesses and the general public about impacts of illicit discharges. viii. Involvement by the general public in environmental stewardship activities to increase awareness of the importance of water quality and mitigate, reduce, or eliminate adverse impacts of stormwater runoff.	ii. Lake-Friendly Gardening Kit. (Whatcom Co. Water Resources, Washington State University Whatcom County Cooperative Extension, Lake Whatcom Management Program) Geared towards homeowners living in the Lake Whatcom watershed. http://lakewhatcom.wsu.edu/gardenkit/INDEX.HTML iii. WCC Chapter 16.32, establishing regulations for fertilizer application on residential lawns and public properties within the Lake Whatcom Watershed. v. *Whatcom County Development Standards,* dated August 1996, *Chapter 2: Stormwater Management* (revised Sept. 11, 2002); Part 2, Temporary Erosion and Sediment Control; Part 3, Permanent Stormwater Management (Section 219, Technical Requirements). viii. The public is involved in stewardship activities such volunteer activities for Nooksack Salmon Enhancement Association (NSEA) or the Chums of Terrell Creek. The Whatcom County Water Resources Public Involvement and Education (PIE) program implements programs in watershed planning, management of Lake Whatcom, and recovery of endangered and threatened fish species. The PIE program led the development of a newsletter (*Watershed News*) about the WRIA 1 Watershed Management Project, a countywide watershed planning effort. Whatcom County Health Department http://www3.doh.wa.gov/here/materials/CRA_Detail.aspx?ID=358 WSU Cooperative Extension http://whatcomshellfish.wsu.edu/Drayton/	Additional education on natural yard care techniques, especially for homeowners, landscapers, and property managers. Reducing purchase of and properly storing, using, and disposing of automotive chemicals, hazardous cleaning supplies, and other hazardous materials; education and spill prevention efforts. Increasing involvement in environmental stewardship activities – reach out to children, students, adults, and visitors. See Chapter 5	5.2.2.5 Education

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
	b.) Implement or participate in an effort to measure understanding and adoption of the targeted behaviors among the targeted audiences. The resulting measurements shall be used to direct education and outreach resources most effectively as well as to evaluate changes in adoption of the targeted behaviors.		Develop on-going program action.	5.2.2.5 Education
	c.) Track and maintain records of public education and outreach activities.		Develop on-going program action.	5.2.2.8 Record-Keeping and Annual Reporting
2. Public Involvement and Participation [On-going opportunities for public involvement through advisory councils, watershed committees, etc.]	a.) Create opportunities for the public to participate in the decision-making process involving the development, implementation, and update of the Permittee's entire Stormwater Management Plan (SWMP). Each Permittee must develop and implement a process for consideration of public comments on their SWMP.	The Citizens Advisory Committee of Birch Bay. The Birch Bay Comprehensive Stormwater Plan adoption process will include public notification, public workshops and hearings.	Implement public participation plan.	5.2.2.5 Education
	b.) Each Permittee must make their SWMP, the annual report required under S9.A, and all other submittals required by this Permit, available to the public.	Reports and plans are posted on the county website. Follow links from county homepage: http://www.co.whatcom.wa.us.	Create opportunities for on-going public involvement.	5.2.2.9 Watershed Keeper
3. Illicit Discharge Detection and Elimination [On-going program to detect, remove, and prevent illicit connections, discharges, and improper disposal, including spills, into the MS4. Full implementation of an illicit discharge and elimination program]	a.) A storm sewer system map shall be developed no later than 4 years from the effective date of this permit. These maps should be periodically updated.	Whatcom County is currently inventorying all drainage structures, such as culverts, catch basins, and manholes using Global Positioning System (GPS). Inventory of the Lake Whatcom Watershed, as the highest priority, will occur first. There are 28 basins to inventory. The next highest priority is the Lake Samish basin. (http://www.co.whatcom.wa.us/publicworks/maintenance/surface.jsp)	Complete for Birch Bay.	5.2.2.2 Inspections and Illicit Connections
	b.) Develop and implement an ordinance or other regulatory mechanism to effectively prohibit non-stormwater, illegal discharges, and/or dumping into the Permittee's municipal separate storm sewer system to the maximum extent allowable under State and Federal law.		Develop and implement.	5.2.2.7 Regulations
	c.) Develop and implement an ongoing program to detect and address non-stormwater discharges, spills, illicit connections and illegal dumping into the Permittee's municipal separate storm sewer system.	Public Works, Solid waste division, performs public education (brochures, classroom presentations, household newsletters [84,000 homes]), performs litter pickup for illegal dump cleanups, and organizes Adopt-a-Road programs; garbage pickup and disposal is contracted for the Birch Bay area; yard waste disposal is available for City of Bellingham residents (over 5,300 tons collected in 2004).	Develop and implement.	5.2.2.2 Inspections and Illicit Connections

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
	d.) Permittees shall inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.	Partially implemented in other Whatcom County watersheds.	Develop and disseminate.	5.2.2.5 Education
	e.) Adopt and implement procedures for program evaluation and assessment, including the tracking number and type of spills or illicit discharges identified; inspections made; and any feedback received from public education efforts.		Develop and implement.	5.2.2.8 Record-Keeping and Annual Reporting
	f.) Provide appropriate training for municipal field staff on the identification and reporting of illicit discharges into MS4s.		Develop and implement.	5.2.2.5 Education
4. Controlling Runoff from New Development, Redevelopment and Construction Sites [Develop, implement, and enforce a program to reduce pollutants in stormwater runoff to MS4 from new development, redevelopment, and construction site activities. This applies to all sites 1 acre or less, including those projects less than 1 acre part of a larger projects and including roads.]	a.) The program shall include an ordinance or other enforceable mechanism that addresses the runoff from new development, redevelopment, and construction site projects.	*Whatcom County Development Standards, Chapter 2: Stormwater Management*, dated August 1996, revised September 2002. WCC 20.80.635 designates the Birch Bay Watershed as a Stormwater Special District. WCC 20.80.636 requires the use of permanent on-site stormwater quantity and quality facilities on all lots less than 5 acres where new development or redevelopment increases impervious surfaces by 500 ft^2 or more. *Whatcom County Development Standards, Chapter 2 Section 221: Stormwater Special District Standards,* dated May 2002. WCC 20.80.735 designates the Birch Bay watershed as a Water Resource Special Management Area. This requires enhanced erosion and sedimentation control.	Update to adopt 2005 Ecology manual.	5.2.2.7 Regulations
	b.) The program shall include a permitting process with plan review, inspection and enforcement capability to meet the standards listed for both private and public projects, using qualified personnel. At a minimum, this program shall be applied to all sites that disturb a land area 1 acre or greater, including projects less than one acre that are part of a larger common plan of the development or sale.	Whatcom County “Watersheds” Planners and Inspectors conduct the review of private and public permits, conduct Erosion and Sedimentation Control BMP inspections, conduct field education, and coordinate on enforcement actions, etc. within the regulatory Birch Bay watershed. Inspection of water quality violations is provided by Ecology. County inspectors work closely with Ecology inspectors. County inspectors inspect BMPs at the start of a project and periodic inspections occur until the project is complete. Correction notices are often issued and penalty assessments are issued as well.	Enhance the County inspection program with adequate staffing to reduce noncompliance with BMP requirements and water quality violations.	5.2.2.7 Regulations

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
	c.) The program shall include provisions to ensure adequate long-term operation and maintenance (O&M) of post-construction stormwater facilities and BMPs that are permitted and constructed pursuant to (b) above.	*Whatcom County Development Standards,* dated September 2002; *Chapter 2: Stormwater Management*; *Section 220: Maintenance of Stormwater Facilities* Site owners are required to inspect annually and maintain as appropriate. The County has no routine inspection program for maintenance. Residential facilities are unlikely to be maintained without formal County inspection program. A penalty for failing to maintain would require a complaint and demonstration that lack of maintenance of such a facility by the responsible party is in violation of a permit condition. In such cases, enforcement action may be pursued by the applicable County department/division (i.e., Public Works – Engineering). Penalties do not appear to be common occurrences.	Expand the County inspection program to ensure maintenance. Increase inspections and expand enforcement efforts.	5.2.2.4 Maintenance and Operations
	d.) The program shall include a procedure for keeping records of inspections and enforcement actions by staff, including inspection reports, warning letters, notices of violations, and other enforcement records. Records of maintenance inspections and maintenance activities shall be maintained. Permittees shall keep records of all projects disturbing more than 1 acre, and all projects of any size that are part of a common plan of development or sale that is greater than one acre that are approved after the effective date of this permit.	The County currently uses a permit tracking system to document inspections, enforcement actions, etc. associated with a permit action.	Enhance tracking and reporting function to ensure maintenance is conducted adequately.	5.2.2.8 Record-Keeping and Annual Reporting
	e.) The program shall make available copies of the “Notice of Intent for Construction Activity” and/or copies of the “Notice of Intent for Industrial Activity” to representatives of proposed new development and redevelopment. Permittees will continue to enforce local ordinances controlling runoff form sites that are also covered by stormwater permits issued by Ecology.	In place.	None.	Not included in this plan. This is implemented by the Planning and Development Services Department
	f.) The Permittee shall ensure that all staff responsible for implementing the program to Control Stormwater Runoff from New Development, Redevelopment, and Construction Sites, including permitting, plan review, construction site inspections, and enforcement, are trained to conduct these activities. Follow-up training shall be provided as needed to address changes in procedures, techniques, or staffing. Permittees shall document and maintain records of the training provided and the staff trained.		Develop and fund program.	5.2.2.5 Education

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
5. Pollution Prevention and Operation and Maintenance for Municipal Operations	a.) Adoption of maintenance standards that are as protective, or more protective, of facility function as those specified in Chapter 4 of Volume V of the 2005 *Stormwater Management Manual for Western Washington.*		Develop and fund program.	5.2.2.7 Regulations
[Develop and implement an O&M program that includes training and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations.]	b.) Annual Inspection of all municipally owned or operated permanent stormwater treatment and flow control facilities and taking appropriate maintenance actions in accordance with the adopted maintenance standards.	Updating the Maintenance and Operations (M&O) Surface Drainage Program occurs regularly for changes made by the National Marine Fisheries Service, Ecology, and Washington Department of Fish and Wildlife (WDFW) on water quality and ESA issues. Other activities include checking drainage structures (ditches, culverts, catch basins, and manholes) to make sure that they are in good working condition. There are approximately 3,000 culverts in Whatcom County inventoried into the County Road Inventory System (CRIS), with many requiring cleaning, reset, or replacement (replacement usually requires an upgrade in order to meet the standards of the WDFW fish passage program. Catch basins can also require replacement because of failure or being undersized (restricting flow), and many need annual maintenance for debris removal and cleaning.	Expand program to include annual maintenance.	5.2.2.4 Maintenance and Operations
	c.) Spot checks of potentially damaged permanent treatment and flow control facilities (other than catch basins) after major storm events.	Not currently done.	Fund and train appropriate staff to make inspections.	5.2.2.4 Maintenance and Operations
	d.) Inspection of catch basins and inlets owned or operated by the Permittee at least once before the end of the permit term. Clean catch basins if the inspection indicates cleaning is needed to comply with maintenance standards established in the 2005 *Stormwater Management Manual for Western Washington*. Decant water shall be disposed of in accordance with Appendix 5 *Street Waste Disposal*.	Activities include checking drainage structures (ditches, culverts, catch basins, and manholes) to make sure that they are in good working condition. There are approximately 3,000 culverts in Whatcom County inventoried into the CRIS, with many requiring cleaning, reset, or replacement (replacement usually requires an upgrade in order to meet the standards of the WDFW fish passage program. Catch basins can also require replacement because of failure or being undersized (restricting flow), and many need annual maintenance for debris removal and cleaning.	Fund and train staff to inspect all facilities.	5.2.2.4 Maintenance and Operations
	e.) Compliance with the inspection requirements in a, b, c, and d above shall be determined by the presence of an established inspection program designed to inspect all sites and achieving inspection of 95 percent of all sites.			-
	f.) Establishment and implementation of practices to reduce stormwater impacts associated with runoff from streets, parking lots, roads or highways owned or maintained by the Permittee, and road maintenance activities conducted by the Permittee.	No program in Birch Bay.	Develop and fund program.	5.2.2.4 Maintenance and Operations

TABLE 2-1. NPDES PHASE II REQUIREMENTS AND CORRESPONDING WHATCOM COUNTY REGULATIONS, PLANS, AND PROGRAMS

NPDES Phase II Requirements[a]	Minimum Performance Measures Associated with NPDES Phase II Requirements[a]	Applicable County Regulation or Program	Potential Improvement to Whatcom County Programs, Plans, or Policies	Sections in this Plan with Recommendations to Address This Requirement
	g.) Establishment and implementation of policies and procedures to reduce pollutants in discharges from all lands owned or maintained by the Permittee and subject to this Permit, including but not limited to: parks, open space, road right-of-way, maintenance yards, and at stormwater treatment and flow control facilities.	No program in place for existing facilities.	Develop and fund program.	5.2.2.4 Maintenance and Operations
	h.) Develop and implement an on-going training program for appropriate employees of the Permittee whose construction, operations or maintenance job functions may impact stormwater quality.		Develop and fund program.	5.2.2.5 Education
	i.) Development and implementation of a Stormwater Pollution Prevention Plan (SWPPP) for all heavy equipment maintenance or storage yards, and material storage facilities owned or operated by the Permittee in areas subject to this permit that are not required to have coverage under the Industrial Stormwater General Permit.	No facilities in Birch Bay.	None.	None in watershed.
	j.) Records of inspections and maintenance or repair activities conducted by the Permittee shall be maintained in accordance with S9.		Develop and fund program.	5.2.2.8 Record-Keeping and Annual Reporting

[a]The Ecology NPDES Phase II permit is currently in draft form dated 2/15/06. This draft version was used for this analysis.

3 Birch Bay Watershed Characteristics and Conditions Assessment

3.1 Watershed Characteristics

This report is one element of an overall comprehensive stormwater plan for the watersheds of Birch Bay. Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay completed a comprehensive land use plan that called for low-impact development and a stormwater plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth. This plan will recommend measures to do that.

This report includes a basic description of the watershed, aquatic resources and land use of the Birch Bay area.

3.1.1 Watershed Description

Birch Bay, Washington, is located about 20 miles north of Bellingham, Washington, in Whatcom County. This vibrant community and recreational destination includes a shallow crescent-shaped bay approximately 2.5 miles wide containing cobble and sand beaches and expansive tide flats. The Birch Bay watershed (the area that drains into the bay) is approximately 17,255 acres (27 square miles) (Figure 3-1).

Dominant natural features of the Birch Bay area are the 12 miles of Puget Sound shoreline and the 194-acre Birch Bay State Park. The beach in Birch Bay is a very popular recreation area with extensive shellfish beds and recreational shellfish harvesting. Birch Bay State Park has 8,255 feet of saltwater shoreline in Birch Bay and 14,923 feet of freshwater and saltwater marsh shoreline on Terrell Creek. Terrell Creek flows from its source in Lake Terrell to its outlet in Birch Bay 8.7 miles away. Other creek drainages exist in the watershed, though Terrell Creek is by far the largest.

Daily average temperatures in Birch Bay vary from 62°F in July and August to 30°F in December and January. The area receives on average less than 6 inches of precipitation per month during December and January and just over 1 inch of precipitation in July and August. The area receives approximately 35 inches of precipitation annually.

Four or more cycles of glacial advance and retreat over the last 2.5 million years have shaped the topography and geology of western Whatcom County. The most recent glacial event ended approximately 12,000 years ago. Each time the glaciers advanced, the underlying sediments were compacted. The glacial ice was approximately 6,000 feet thick in the area. The weight of the ice compacted the underlying material and created a hard-packed material called glacial till. This glacial till has low permeability – approximately one inch per month. Drainage is poor and wetlands are common in flat areas consisting of glacial till. The southern portion of the Birch Bay area consists of glacial till. The northern portion of the Birch Bay area consists of marine sediments that were deposited when the area was under water.

The current topography of the Birch Bay area is a result of a diverse geologic history. The northern and southern extents of the watershed at Birch Point and Point Whitehorn, respectively, are the highest points in the watershed. The highest point in the Point Whitehorn area is approximately 150 feet above mean tide level and the highest point in the Birch Point area is approximately 250 feet above mean tide level. Steep bluffs exist along the shoreline of Birch Point and Point Whitehorn that are susceptible to erosion from wave action and stormwater runoff. The central inland portions of the watershed are relatively flat.

As with the rest of the Puget Sound, Birch Bay experiences diurnal tidal changes with two local high and two local low tides per 24-hour day. The mean diurnal tide range is 9.15 feet between mean higher high tide and mean lower low tide. This significant difference between high tide and low tide yields large areas of tidal flats that stretch up to a mile out into the bay depending on tidal changes.

3.1.2 Watershed Drainage Basins

Several different drainages discharge to Birch Bay through open channels, culverts, pipes, and tide gates. Figure 3-1 shows the locations and sizes of the 12 drainage sub-basins delineated as part of this plan. Table 3-1 lists the names of these 12 sub-basins and their contributing areas.

TABLE 3-1. BIRCH BAY WATERSHED DRAINAGE SUB-BASINS

Subbasin	Area (acres)
Birch Point, north	951
Birch Point, south	1,167
Rogers Slough	473
Shintaffer	890
Cottonwood	95
Hillsdale	463
Central Reaches	237
Central Uplands	716
Terrell Creek, lower	1,677
Terrell Creek, upper	8,362
Fingalson (drains to Terrell Creek)	1,037
Point Whitehorn	809
TOTAL	**17,255**

Major Outfall or Outlet

Tide Gate

Stream

Drainage Subbasin

Watershed

N

0 0.5 1 Miles

FIGURE 3-1

Birch Bay Watershed

File Path: \\simba\proj\WhatcomWaCountyOf\335334\GIS\MapDocuments\Watershed.mxd, Date: March 1, 2006 8:50:50 AM

The predominant freshwater drainage in the Birch Bay area is the 8.7-mile-long Terrell Creek system that begins at Lake Terrell in the southeastern portion of the Birch Bay watershed. This drainage covers approximately 17 square miles (11,077 acres). The outlet of Terrell Creek is an open channel located along the Birch Bay shoreline north of Alderson Road. The Fingalson sub-basin contributes 1,037 acres to the total acreage of Terrell Creek, and the Lower Terrell Creek sub-basin contributes 1,677 acres (Table 3-1). The remaining 8,362 acres is within the Terrell Creek sub-basin.

3.1.2.1 Birch Point North

The Birch Point North sub-basin consists of the area within the Birch Bay watershed that drains to the north of the point. The upper reaches of this sub-basin are on Trillium Corporation property. Development is centered mainly along Birch Point Road that runs along the coastline. The edge of the sub-basin along the shoreline is mostly made up of bluffs.

3.1.2.2 Birch Point South

The Birch Point South sub-basin includes the area of Birch Point that drains south and east of the point. Most of the northern reaches of this sub-basin are on Trillium property. Development is mainly within Birch Bay Village in the lower reaches of the sub-basin. Much of this sub-basin drains to Birch Bay through the Birch Bay Village Marina. The remaining portion of the sub-basin drains through various small ditches and channels out to Birch Bay to the west of Birch Bay Village. The shoreline of this sub-basin is mainly beach with some bluff along the western shoreline.

3.1.2.3 Rogers Slough

Rogers Slough is located to the west of Cottonwood Beach on the eastern edge of Birch Bay Village. A tide gate controls the outlet of this sub-basin that drains some of Birch Bay Village and a portion of undeveloped area to the north of Birch Point Road. Development has been concentrated within Birch Bay Village, although new development is planned for the area north of Birch Point Road. The northern extent of this sub-basin has not been well-defined because of the difficulties associated with drainage pattern delineation.

3.1.2.4 Shintaffer

The Shintaffer sub-basin was named for the main street that runs north-south through the center. Portions of the golf course at Semiahmoo are within this sub-basin as well as other areas north of Lincoln Road and east of Shintaffer Road. The northern extent of this sub-basin has not been well-defined. A large portion of the runoff from this sub-basin is conveyed in ditches along Shintaffer Road and through culverts and pipes through the Richmond Park Subdivision and then through an open channel finally discharging to Birch Bay through a piped outfall. The densest development in this sub-basin is located along Birch Bay and in the subdivisions along Shintaffer Road.

3.1.2.5 Cottonwood

The upper portion of the Cottonwood sub-basin consists of the open area to the west of Harbor View Road north of Anderson Road and south of Lincoln Road. The lower part of this sub-basin along Birch Bay is of a higher density zoning than the upper potion of the watershed. Drainage from the upper area is conveyed through a ditch and culvert across Anderson Road into a wooded area. According to local residents, this used to be a seasonal creek that now flows year-round.

The outlets of this system are two outfalls near Cedar Road along Birch Bay. These two outfalls are hydraulically connected with one acting as the relief for the other. There is another drainage that starts in the wetlands north of Harborview. The runoff from this area flows in pipes and discharges to the outlet at the intersection of Beach Way and Birch Bay Drive.

3.1.2.6 Hillsdale

The Hillsdale sub-basin includes the area within the Birch Bay watershed to the east of Harbor View Road. The eastern edge of the sub-basin is east of Blaine Road. Development is concentrated in the area along Birch Bay.

3.1.2.7 Central Reaches

This sub-basin consists of the area on either side of Birch Bay–Lynden Road stretching to the east nearly to Blaine Road past the fire station. The Central Reaches sub-basin includes area that is residential and area that is commercial and very little area that is not developed. The outlets for drainage from this sub-basin are two outfall pipes along Birch Bay shown on Figure 3-1.

3.1.2.8 Central Uplands

The Central Uplands sub-basin is low-lying and flat with an extensive ditched drainage network. A large portion of this sub-basin is covered with residential and commercial development along with the golf course and the Sunset Farm Equestrian Center. Development is centered along Birch Bay.

3.1.2.9 Terrell Creek, Lower

The Lower Terrell Creek sub-basin encompasses the area draining to the stretch of Terrell Creek along Birch Bay from Birch Bay State Park to the outlet. More than half of this area discharges through a series of outfall pipes along the length of the creek. The remainder is conveyed to Birch Bay through the open channel flowing west along Lora Lane and discharges at the mouth of Terrell Creek through a tide gate. This unnamed creek along Lora Lane could potentially provide enhanced habitat for fish if the tide gate were removed.

The upper portions of this drainage sub-basin are much less developed than the lower portions along Birch Bay. The area east of Blaine Road is currently less developed than the remainder of the sub-basin.

3.1.2.10 Terrell Creek, Upper

The Upper Terrell Creek sub-basin extends further east than any other sub-basin in the Birch Bay Watershed, nearly 8 miles. The predominant feature of the sub-basin is Lake Terrell, located in the southeastern portion of the sub-basin. The dam at the outlet of Lake Terrell controls the flow in Terrell Creek. The upper reaches of the sub-basin are mainly rural residential. A portion of the Cherry Point Refinery facility operated by BP Corporation lies within the Upper Terrell Creek sub-basin. Portions of the Cherry Point Refinery, including on-site ponds, discharge through a permitted deep water outfall into the salt water and not to Terrell Creek. For the most part, development has been concentrated within the lower reaches of the creek. Birch Bay State Park is located along Birch Bay where Terrell Creek turns and flows along the shoreline behind the beach berm.

3.1.2.11 Fingalson

The Fingalson sub-basin is a part of the Terrell Creek drainage. Fingalson Creek intercepts Terrell Creek near Kickerville Road between Pleasant Valley Road and Grandview Road. This sub-basin is less developed than the other sub-basins with most of the area in rural residential land use.

3.1.2.12 Point Whitehorn

The Point Whitehorn sub-basin consists of the area draining to the bay stretching from the western edge of Birch Bay State Park around the point to well within the Cherry Point Major/Port Industrial UGA. Much of the southern portion of the sub-basin is within the Cherry Point Major/Port Industrial UGA, the western boundary of which is Koehn Road. The northern part of the sub-basin contains residential development along Whitehorn Way and Grandview Road. The central part of the sub-basin is on Trillium property.

3.2 Conditions Assessment

A conditions assessment of natural resources, the built environment, and existing regulatory environment in the Birch Bay is presented in this section. The existing condition of natural resources in the Birch Bay area is a product of the natural processes, historical and current land use, patterns of development, and regulatory environment in the area. The existing condition of the built environment is also a product of the natural processes, historical and current land use, regulatory environment, and the history of investment in and maintenance of infrastructure such as roads, sewers, water systems, pipes, ditches, and ponds. These factors together have affected the current conditions within the Birch Bay area.

3.2.1 Natural Resources

The Birch Bay area has large numbers of fish, shellfish, marine birds, raptors, and other wildlife. Fish, shellfish, birds, and other wildlife use the wetlands, shorelines, creeks, and terrestrial areas as well as Birch Bay itself for refuge and rearing purposes. The near-shore marine waters provide rearing habitat for many species of fish, including the Pacific herring. The Terrell Creek watershed provides habitat for fish and wildlife including salmon and trout. Several species of waterfowl and raptors find habitat opportunities in Birch Bay. The northern bald eagle and the great blue heron are present.

The following sections describe the existing condition of the shorelines, shore lands, and near-shore marine waters of Birch Bay. The freshwater ecosystems of Terrell Creek and Lake Terrell are also covered here, as are wetlands watershed-wide.

3.2.1.1 Marine Waters

Birch Bay and associated salt marshes, beaches, and mud flats provide habitats that play a vital role in the health of the local environment. These habitats are spawning, rearing, and feeding grounds for a wide variety of marine and terrestrial life. Juvenile and adult fish, birds, and shellfish inhabit the waters of Birch Bay. Birch Bay is a shallow bay estuary with exposed tide flats stretching up to a mile under extreme low tides. This shoreline also provides recreational opportunities for local residents and visitors; it is one of the largest and most productive clamming areas in the state of Washington. Birch Bay supports large numbers of shellfish in its warm, nutrient-rich tide flats. Native clams are a key ecological resource in Whatcom County.

The harvest of shellfish safe for public consumption is directly linked to surface water quality in the terrestrial areas discharging to the marine waters supporting these shellfish populations. An important indicator of water quality for shellfish harvesting is bacterial contamination. The source of bacteria of concern to people (fecal bacteria) can be animal waste or human sewage. In general, potential sources of fecal bacterial include municipal sewage treatment plants, on-site sewage systems such as septic systems, broken sewage conveyance pipes, waste discharge from boat tanks, farm animals, pets, and wildlife.

In July 2003, Birch Bay was added to the Washington State Department of Health's (DOH) list of "threatened" shellfish harvesting areas. This status as "threatened" indicates a downward trend in water quality. Birch Bay was given this "threatened" status along with 19 other shellfish areas in the state. This status was given as part of the DOH's Early Warning System. The Early Warning System is intended to identify areas that are potentially on the verge of failing public health standards or that have currently deteriorating water quality based on fecal coliform levels.

The DOH classifies shellfish-growing areas on the basis of surveys that include assessments of water quality and pollution sources. The presence of fecal coliform bacteria is used as the primary indicator of water quality. In classifying each shellfish-growing area, DOH analyzes the 30 most recent samples taken from each sampling station located in and around the shellfish harvest area. The samples at each station must meet a two-part standard for water quality. The geometric mean of the samples cannot exceed 14 fecal coliform colonies per 100 milliliters of water (fc/100 ml), and no more than 10 percent of the samples can exceed 43 fc/100 ml (that is, the 90^{th} percentile of all samples should be less than 43 fc/100 ml). Table 3-2 lists these standards for both freshwater and marine waters. Samples must be taken six times a year. In most cases, several individual sampling stations exist over the harvesting area.

TABLE 3-2. FECAL COLIFORM WATER QUALITY STANDARDS FOR SHELLFISH

Class of Water	Part 1	Part 2
Freshwater – Class A	Fecal coliform are not to exceed a geometric mean of 100 organisms per 100 ml	Not more than 10% of the samples are to exceed 200 organisms per 100 ml
Marine Water – class AA and Class A	Fecal coliform are not to exceed a geometric mean of 14 organisms per 100 ml	Not more than 10% of the samples are to exceed 43 organisms per 100 ml

Washington State DOH uses the four following classifications when determining the status of commercial shellfish growing areas in the state: Approved, Conditionally Approved, Restricted, and Prohibited. An Approved status means that the standards have been met for shellfish harvest. A Conditionally Approved status means that there are specific predictable events such as wet-weather events that can cause an area to exceed water quality standards. The area is approved for harvest unless an event occurs. A Restricted status is given to an area that does not meet the standards but where pollution sources are limited and generally predictable. A Prohibited status means that an area is unable to meet the standards and has pollution sources that are unpredictable and abundant.

In 1995, all commercial shellfish beds in Drayton Harbor (to the north of Birch Bay) and Portage Bay (south of Birch Bay near Bellingham) were specified as Prohibited to harvest due to issues with non-point source pollution. Since 1995, resources have been dedicated to improving water quality in Drayton Harbor with the goal of reopening the shellfish beds to commercial harvest. In May of 2004, 575 acres of Drayton Harbor were upgraded to Conditionally Approved.

The Whatcom County Water Resources Plan (1999, updated in 2001) quotes the Washington State DOH as having identified six significant or potentially significant pollution sources contributing to the degraded water quality in Drayton Harbor that led to the closure of shellfish beds there. These are:

1) Failing on-site septic systems on or near the harbor shoreline and creeks,

2) City of Blaine sewage treatment facilities and bypasses,

3) Stormwater runoff,

4) Blaine and Semiahmoo marinas,

5) Agricultural practices in California and Dakota watersheds, and

6) Fish processing wastewater.

The January 1995 reclassification of the shellfish beds in Drayton Harbor attributed the pollution to these six sources (Meriwether, 1995). The types of potentially significant sources identified in Drayton Harbor may also be sources of pollution in the Birch Bay watershed, including failing septic systems, leaking wastewater collection pipes, stormwater runoff, marinas, and agricultural practices. Note that the wastewater treatment plant outfall for Birch Bay is outside the bay and discharges in deep water (deeper than Birch Bay) in an area with strong currents. The strong currents result in rapid dispersal and dilution. Thus, the outfall is unlikely to be a significant source of bacteria in the bay but can not be discounted completely.

In the 2004 Annual Inventory of Commercial and Recreational Shellfish Areas of Washington State (DOH, 2005), pollution status was tallied and compared between nearly 100 commercial growing areas in Puget Sound for the year ending in December 2004. To determine pollution status, 90th percentiles were calculated for all sampling dates in 2004. The 90th percentiles were sorted into three categories: Good (0-30 coliform/100 ml), fair (31-43 coliform/100 ml), and bad (above 43 coliform/100 ml). Status was determined as percent of 90th percentiles falling into each category (good, fair, or bad). Birch Bay had one site with a 90th percentile that was rated “fair” and one site with a 90th percentile that was rated “bad” out of the 10 stations monitored. The remaining eight sites were rated, “good”. This 2004 Annual Inventory (DOH, 2005) was the first to show any sites within Birch Bay as having less than a “good” status. These 2004 annual results are in contrast to the Annual Inventories of 2001, 2002, and 2003 (DOH, 2002; DOH, 2003; and DOH, 2004), that show all sites within Birch Bay as rated, “good”.

The Washington State DOH has historically encouraged shellfish harvesters to stay a minimum of 50 feet from the stormwater outfall pipe located near the south end of the beach within Birch Bay County Park approximately 1/3 of a mile north of the Terrell Creek outlet. DOH conducted an outfall inventory in 1994 that lead to this warning. A second outfall inventory is planned for December 2006. Other “hot spots” for bacteria contamination are near the mouth of Birch Bay Village Marina and near the outlet of Terrell Creek.

The Whatcom County Marine Resource Committee (MRC) has conducted clam inventories along Birch Bay since 2004. In the summer of 2004, the MRC coordinated clam surveys in Birch Bay with the help of local volunteers. In 2005, surveys focused on Point Whitehorn and Birch Point. These surveys provided information about the types, numbers, and sizes of clams found in these areas. Until now, there has been limited species-specific population data available. The information gathered through these surveys will be used to formulate a plan to protect shellfish areas in the future. In addition, these data will be used to help identify potential clam enhancement and restoration sites.

The MRC will be conducting water quality sampling at several sites in Birch Bay over a one-year period starting in 2006. Sites will be sampled monthly for flow and fecal coliform bacteria with the help of local volunteers.

Nutrient dynamics in Birch Bay are dominated by oceanic nutrient inputs from the Georgia Straits. Circulation patterns within Birch Bay and terrestrial and fluvial inputs from several small streams and Terrell Creek also affect nutrient cycling. Areas of intensive nutrient cycling and/or retention include freshwater and estuarine wetlands along the lower reaches of Terrell Creek, as well as the extensive intertidal sand and mud flats in Birch Bay (Whatcom County, 2006). Loss of estuarine and freshwater tidal wetlands along the northern shore of Birch Bay and to the west of Birch Bay State Park has reduced the capacity and opportunity for nutrient retention and cycling in wetlands.

Marine waters are generally well mixed in the marine reaches due to the exposure of the shoreline, even within the relatively low-energy and semi-enclosed waters of Birch Bay. The areas of weakest circulation occur in the southeastern corner of Birch Bay near the state park; this area is more susceptible to elevated nutrient levels than other locations within the watershed (Whatcom County, 2006).

3.2.1.2 Marine Shoreline

The shoreline stretching from the south at Point Whitehorn to Birch Point at the north is a "Shoreline of Statewide Significance", the only marine shoreline in Whatcom County with this designation (Kask Consulting, 2002). This designation applies to the area from the extreme low tide line to the ordinary high water mark. Tidelands, adjacent uplands, and associated wetlands are included. All salt waters in Whatcom County lying seaward from the line of extreme low tide are also "Shorelines of Statewide Significance" per RCW 90.58.030.

A series of bulkheads, rip-rap revetments, and groins have been constructed along the shoreline to maintain beach widths and to protect development and infrastructure along the shoreline. Because of this, the sediment budget and sediment transport processes that contribute to Birch Bay's beaches have been highly disturbed (Phillip Williams & Associates, 2002).

The principal sediment sources are the eroding headlands of Birch Point and Point Whitehorn (Phillip Williams & Associates, 2002). These "feeder" bluffs are a source of sand, gravel, and cobbles for the Birch Bay beaches. The shoreline sediment sources and paths of transport have been disrupted by development in Birch Bay.

3.2.1.3 Wetlands

Wetlands are an invaluable part of the water cycle as they contribute to aquifer recharge, provide groundwater storage, provide floodwater detention, and act as large-scale biofilters for pollutant removal. The loss of wetlands in developed and developing areas may increase pathogen loading, where numerous onsite septic systems occur. Wetlands also provide key fish and wildlife habitat.

A large portion of land in the southern part of the Birch Bay watershed supports wetlands that provide large amounts of surface water storage. These areas could be important for attenuating storm flows in areas with limited infiltration/recharge potential. Loss of wetlands in the Birch Bay area has been due to many factors, such as development and re-configuration of the natural drainage network. This re-configuration was performed for flood control purposes and to drain areas for other land uses such as development.

The Birch Bay Community Plan (Kask Consulting, 2002), also known as the Birch Bay Sub Area Plan, included an inventory of wetlands for all areas within the Birch Bay planning area. This was strictly a planning-level survey intended to provide a general delineation of existing wetlands in the Birch Bay area. Existing wetlands were classified using the Cowardin Scientific Classification System. With this system, each wetland category is based on connection to other water bodies, type and density of vegetation present, and other factors. According to the wetlands inventory, approximately 1,250 acres of the approximately 8,700 acres (14 percent) included in the planning area for the Birch Bay Sub Area Plan are covered by wetlands.

3.2.1.4 Terrell Creek

The Terrell Creek drainage area is a significant part of the Birch Bay ecosystem. The Terrell Creek watershed provides habitat for large numbers of fish, birds, and other wildlife. Terrell Creek supports a variety of native fish species such as cutthroat trout and coho salmon. Numbers have declined in the past 50 years, mostly due to habitat degradation. Chum and coho were once found in great numbers within Terrell Creek. The Terrell Creek marsh is one of the few remaining saltwater/freshwater estuaries in northern Puget Sound. The north end of Birch Bay State Park is a natural game sanctuary providing refuge for smaller birds, migratory waterfowl, northern bald eagles, and great blue herons.

Terrell Creek begins at the outlet of Lake Terrell in the southeastern corner of the Birch Bay watershed. The stream meanders in a northwesterly direction for 2 miles and is joined by Fingalson Creek from the east. Fingalson Creek is fed by a natural spring in the upper reaches of that sub-watershed. The main stem of Terrell Creek flows west for 3 miles before entering Birch Bay State Park. The creek flows through the state park then makes an abrupt turn to the north and flows along the beach. The last 2 miles of Terrell Creek follow the shoreline from Birch Bay State Park north to the outlet north of Alderson Road.

Floodplains are an important hydrologic mechanism in Terrell Creek, which has a wide floodplain and associated riparian wetlands. Past development and current development has altered the floodplain dramatically by confining certain reaches of Terrell Creek and by altering the natural hydrologic regime.

The lower reach of Terrell Creek between Birch Bay State Park and the outlet of the creek into Birch Bay is confined to its current location. Historically, Terrell Creek meandered back and forth through the watershed and found its own path to Birch Bay. As development increased and infrastructure was constructed, this path became permanently fixed in its current position as a result of human intervention. Historical dredging was reportedly conducted in this lower reach.

Much of the Terrell Creek riparian zone has been converted to non-forest cover. Most of the remaining cover is scrub-shrub and deciduous and mixed forest stands. No significant conifer stands remain on the stream. The lack of conifer stands prevents recruitment of large woody debris (LWD) into Terrell Creek. The Nooksack Salmon Enhancement Association has begun an evaluation of current conditions in and around Terrell Creek. NSEA uses a smolt trap to count young salmon leaving the creek during the spring months. This smolt trap has been placed about one mile upstream from the mouth of Terrell Creek within Birch Bay State Park at the same location from March to June each year since 2000. When this smolt trap is in use, it is checked twice per day. Since the smolt trap was first installed, many species of fish were discovered. Many coho and some steelhead smolts were discovered in the trap, including several wild (non-hatchery) coho. Many non-salmonids were also found, including yellow perch, pumpkinseed, starry flounders, and sculpins, some of which are stocked for sport fishing in Lake Terrell.

According to the *Catalog of Washington Streams and Salmon Utilization*, Volume 1 (WDFW, 1975), Terrell Creek provided fair to good populations of coho plus some chum salmon. This catalog describes how all but the lower 1.5 miles of creek present good pool-riffle stream character with small-gravel bottom and considerable sand in many areas with a few gravel-rubble stretches. The catalog also describes how cover ranges from sparse to moderate with low brush or overhanging grass along cleared land sections. Lastly, the catalog describes how smaller tributaries with intermittent flow present similar features.

Data available from StreamNet (2006) and gathered by the WDFW indicate distribution and activity of coho salmon in all reaches of Terrell Creek. In addition to coho, StreamNet recognizes the presence of winter steelhead in Terrell Creek. This dataset was last updated in June of 2005.

Chinook are known to use the estuarine portion of Terrell Creek, and the creek is presumed to be used for juvenile foraging and possibly rearing during migration to sea (Whatcom County, 2006 referencing NWIFC 2004; Whatcom County, 2005). Sea-run and resident cutthroat trout are known to use Terrell Creek, and winter steelhead are presumed to use Terrell Creek (NWIFC 2004, Whatcom County, 2005).

NSEA has completed fish habitat assessments, including water quality and flow measurements, to determine fish habitat conditions. These efforts yielded a list of concerns. First, the riparian areas both upstream and downstream from the Jackson Road Bridge were in need of significant physical restoration efforts. Secondly, several barriers to fish passage needed attention. These include culverts at Grandview and Blaine roads. Third, these efforts highlighted the need for a plan to manage flow rates in Terrell Creek during the dry periods of the year using flow regulation at the outlet of Lake Terrell.

Low summer flows reduce available juvenile rearing habitat during summer months. In addition, when flows are low, connections to wetlands and beaver ponds are nonexistent. These low flow conditions may also be accompanied by poor water quality and elevated temperatures. Outlet flows from Lake Terrell could be adjusted to prevent summer flows from reaching critical levels.

A number of projects have begun with the goal of improving riparian and in-stream habitat. Invasive reed canary grass has been removed and native vegetation has been planted along the banks of the creek. Large woody debris has been placed at various locations along a 2,500-foot stretch of the creek. This large woody debris provides diversity in flow quantity and velocity necessary for good salmon habitat. Salmon find refuge in slow-moving areas behind large woody debris and take advantage of the fast-moving flow between the obstructions.

Projects have also begun to restore fish passage at various locations along the length of Terrell Creek. Culverts are a common type of fish barrier. Existing culverts can be replaced with new structures that allow for fish passage under varying flow conditions. The first culvert creating a barrier for fish under certain flow conditions is the culvert at Blaine Road (SR 548). The Washington State Department of Transportation plans to replace this culvert. Another culvert, located at Grandview Road, is situated high enough above the creek bed that all fish passage is impossible. Either this culvert would have to be replaced or the channel downstream from the culvert would have to be built up in elevation to allow for fish passage through the existing culvert. Lastly, the dam at the outlet of Lake Terrell prohibits fish passage into the lake. Several smaller streams discharge to Lake Terrell that may provide good spawning habitat if they were accessible to fish.

BP Corporation has performed wetland enhancement work on their property along Terrell Creek at Cherry Point Refinery.

Local citizen groups and volunteers have been an integral part of the monitoring, enhancement, and restoration projects in the Terrell Creek watershed. The Terrell Creek Stream Stewards conduct work parties to remove invasive vegetation and plant trees and shrubs, monitor stretches of Terrell Creek for fish use, and educate other members of the community on the importance of environmental responsibility. A subgroup of the Terrell Creek Stream Stewards, the Chums of Terrell Creek, have been involved in such projects as restoration work on the stretch of Terrell Creek on WDFW property downstream on Jackson Road.

Both the Washington Department of Ecology and NSEA have performed water quality sampling at different sites in Terrell Creek and along Birch Bay beaches. Ecology sampled monthly for fecal coliform and other pollutants in Terrell Creek at the Jackson Road bridge monthly from the fall of 2001 through the fall of 2002. In addition to fecal coliform, samples were analyzed for temperature, dissolved oxygen, turbidity, conductivity, ammonia, nitrogen as NO_2 and NO_3, nitrogen as NH_3, and total and dissolved phosphorus. Data for fecal coliform ranged from 3 coliform /100 ml to 470 coliform/100 ml. Of these samples, only two exceeded the Freshwater Class A Part 1 criteria of 100 coliform /100 ml. These two samples exceeding criteria were taken on 7/23/02 and 9/16/02. The temperature ranged from 2°C on 3/18/02 to 15°C on 7/22/02 at this Jackson Road site. All of the temperature data were below the aquatic life temperature criterion of 16°C for salmon and trout spawning, core rearing, and migration (Ecology, 2003). Dissolved oxygen ranged from 12.9 milligrams per liter (mg/L) on 3/18/02 to 1.2 mg/L on 6/18/02, with seven of the twelve samples taken at or below the freshwater water quality criteria of 9.5 mg/L. The dissolved oxygen samples that were below criteria represent all samples taken during the months of May through November.

NSEA has conducted water quality sampling in the creek and on Birch Bay beaches since May 2004. NSEA has conducted weekly sampling at five sites within the creek since May 2004 and added two additional creek sites to this protocol in late August of 2005. NSEA has measured the samples from the creek sites for temperature, pH, dissolved oxygen, and conductivity. In addition, NSEA has taken monthly fecal coliform samples at two sites along the beach in Birch Bay from November 2004 through the spring of 2005 and at the five creek sites from November 2004 to the present.

Weekly temperature data from May 2004 through November 2004 are shown in Figure 3-2 for the seven sites in Terrell Creek. The water quality criterion for temperature of 16.5°C is also shown. Most of the data taken between the months of June and October exceeded the criterion. A similar pattern is evident for dissolved oxygen as well, with most samples reading below the criterion of 9.5 mg/L for the months of June through November (Figure 3-3).

Fecal coliform data taken from November 2004 through September of 2005 ranged from non-detect (<2 coliform/100 ml) to 600 coliform/100 ml. One of the 10 samples taken at Site 1 (Lake Terrell outfall) was above the criterion of 100 coliform/100 ml (350 coliform/100 ml in January of 2005). All samples taken from all sites on that date were above the criterion and ranged from

FIGURE 3-2. TEMPERATURE DATA FROM SITES ALONG TERRELL CREEK FROM MAY 2004 THROUGH NOVEMBER 2005

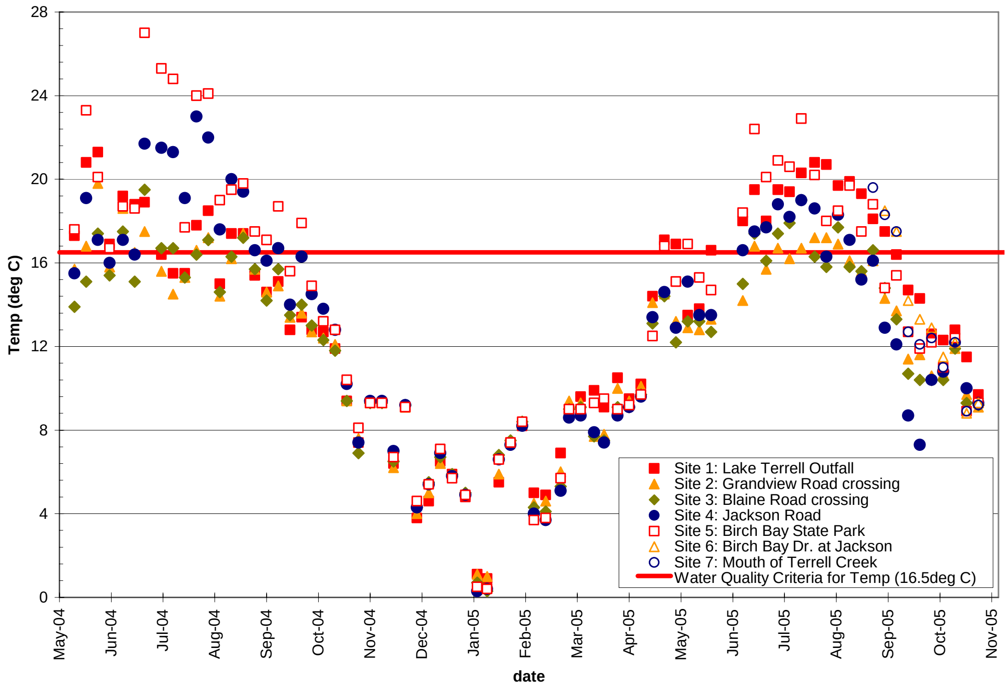
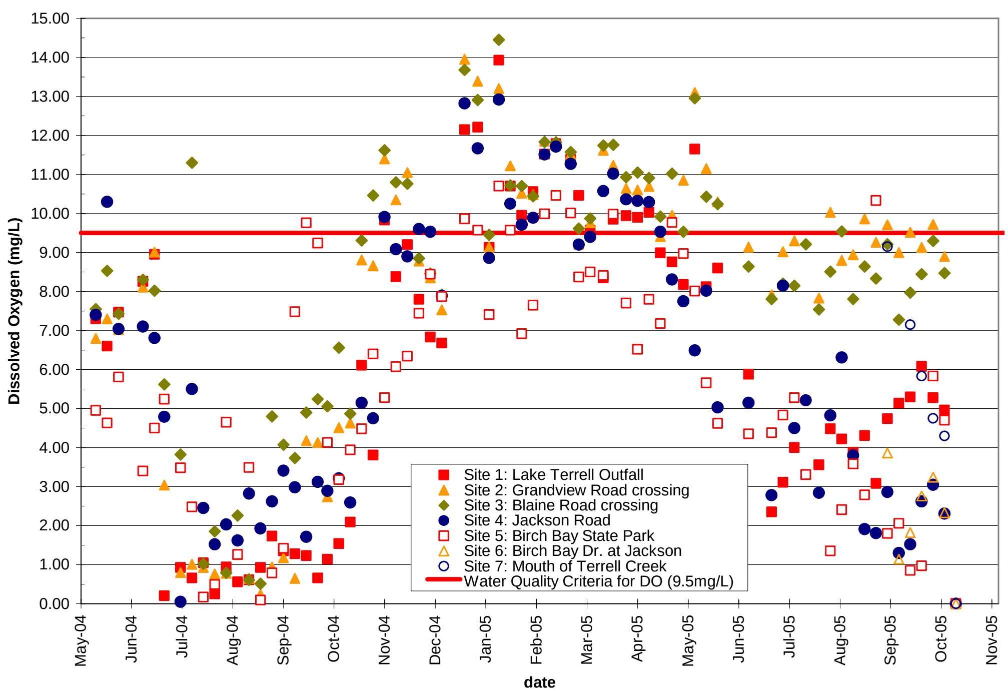


FIGURE 3-3. DISSOLVED OXYGEN DATA FROM SITES ALONG TERRELL CREEK FROM MAY 2004 THROUGH NOVEMBER 2005



Note: Data in Figures 3-2 and 3-3 received from Nooksack Salmon Enhancement Association via personal communication on 11/4/05.

340 to 600 coliform/100 ml. For the entire sampling period, four out of the ten samples taken at each of the Sites 2, 5, and 6 were above the criterion, six of the ten samples taken at Site 3 were above the criterion, and two of the ten samples taken at Site 4 were above the criterion. Overall, 21 of 60 samples taken for fecal coliform during this period were above the criterion of 100 coliform/100 ml.

In addition to water quality monitoring, NSEA has performed flow monitoring on Terrell Creek. Interns for NSEA from Western Washington University have set up flow rating curves at sites along Terrell Creek in preparation for flow monitoring activities. These locations are the dam at Lake Terrell, Grandview Road, Blaine Road, and Birch Bay. When water quality measurements are taken, staff gage readings are also recorded and corresponding flow rate information is calculated using the rating curves developed individually for each site.

NSEA and local community groups have made efforts to re-introduce chum to the waters of Terrell Creek because chum tend to be more tolerant of lower flows than coho. Chum eggs were fertilized and developed in a remote site incubator, then placed in Terrell Creek in January of 2005. Some chum have shown up in the smolt trap placed a mile upstream from the mouth of Terrell Creek within Birch Bay State Park. Juvenile chum leave streams and enter saltwater quicker than coho do. Coho tend to reside in freshwater streams for at least a year before entering the salt water. It is anticipated that chum, once they enter the saltwater, would return from the saltwater within a 3- to 5-year period to spawn. Results of this introduction of chum into the waters of Terrell Creek will not be evident until this 3- to 5-year period begins in January of 2008.

3.2.1.5 Lake Terrell

Four dairy farms purchased in the 1940s by the Department of Game became the 1,500-acre Lake Terrell unit and surrounding area. The farms were acquired for the purpose of producing and harvesting wild game. The area is now managed by the Department of Fish and Wildlife for waterfowl habitat restoration and preservation and to provide recreational opportunities.

Lake Terrell is located along the Pacific Flyway, which is the route of migrating waterfowl to/from British Columbia and areas farther north. Lake Terrell is a food source and resting place for migrating waterfowl. In addition, Lake Terrell supports a year-round population of birds and ducks. The lake itself provides habitat for bass and spiny-ray fish as well as rainbow and cutthroat trout. The surrounding habitat types include wetlands, grasslands, and upland mixed forest (Washington Department of Fish and Wildlife, 1998).

3.2.2 Built Environment

3.2.2.1 Population

The population of the Birch Bay community was recorded as approximately 4,900 people in the year 2000 census reflecting an 87 percent growth rate from the 1990 census. According to the same census, slightly more than 50 percent of the 5,100 housing units in Birch Bay were for seasonal or part-time use. By 2022, Birch Bay is expected to grow to over 9,600 people with over 4,100 full-time housing units and approximately the same number of seasonal or part-time housing units (Whatcom County, 2005).

These population numbers are for the Birch Bay Census Designated Place. The boundaries of this area are similar to those of the planning area for the Birch Bay Sub Area Plan. However, the northern portion of the Birch Point area and the Drayton Harbor area were excluded from the

Birch Bay Community planning area because those areas are within the UGA of the City of Blaine.

3.2.2.2 Neighborhoods

The planning area included in the Birch Bay Community Plan was split into ten different neighborhoods: Birch Point, Birch Bay Village, Cottonwood, Hillsdale, Central Reaches, Central Uplands, Terrell Creek, State Park Reach, West Cherry Point, and Point Whitehorn. An eleventh neighborhood, Lake Terrell, was added to this Stormwater Comprehensive Plan to incorporate the upper Terrell Creek watershed outside of the planning area boundary of the Birch Bay Community Plan. Figure 3-4 shows these neighborhoods. A breakdown of the acreage within each neighborhood is included in Table 3-3.

TABLE 3-3. BIRCH BAY COMMUNITY PLAN NEIGHBORHOODS

Neighborhood	**Area (acres)**
Birch Point	721
Birch Bay Village	444
Central Reaches	397
Central Uplands	2,275
Cottonwood	622
Hillsdale	812
Point Whitehorn	546
State Park Reach	688
Terrell Creek	1,300
West Cherry Point	894
Lake Terrell	8,000
TOTAL	**16,699**

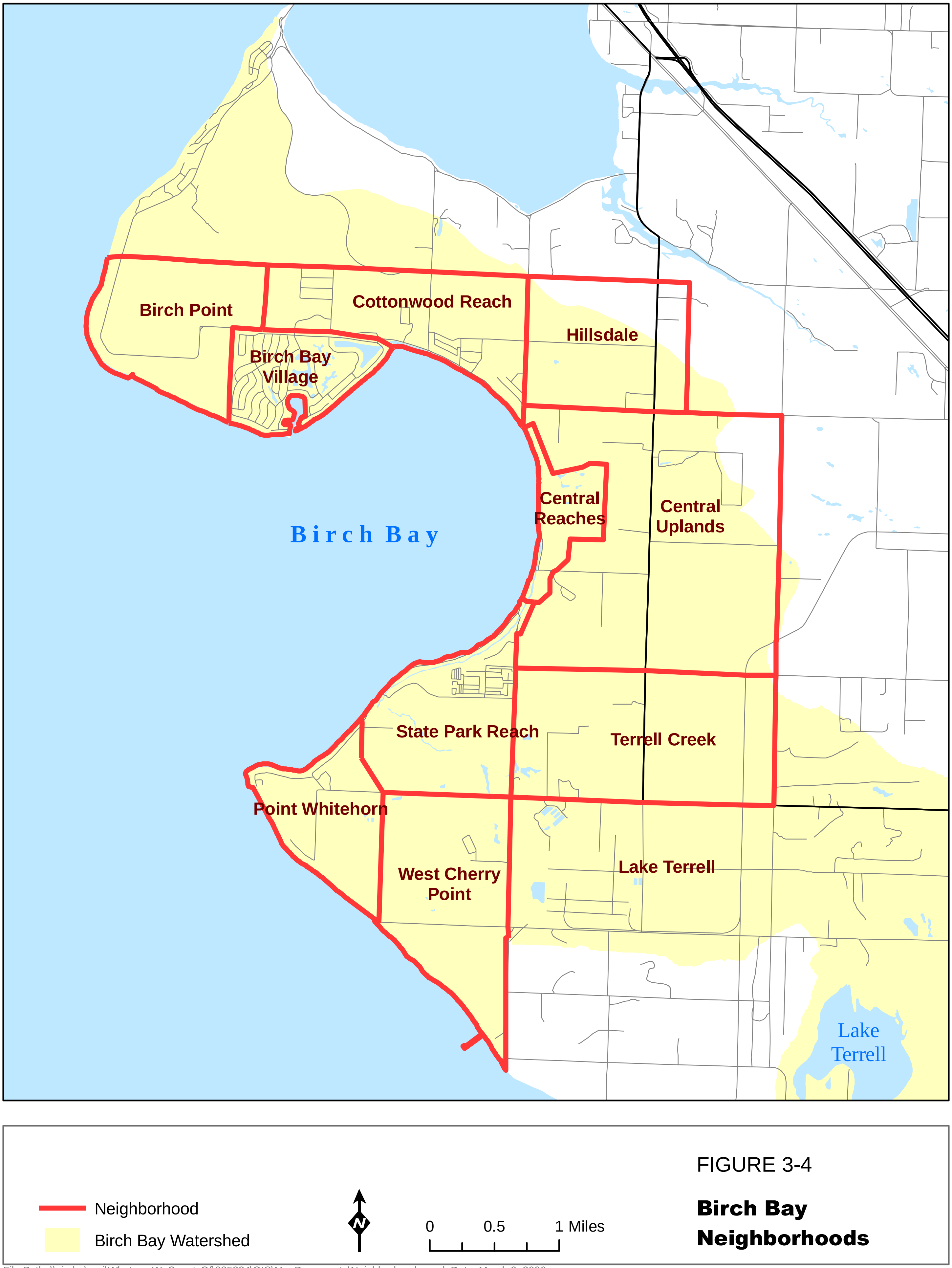


FIGURE 3-4

Birch Bay Neighborhoods

File Path: \\simba\proj\WhatcomWaCountyOf\335334\GIS\MapDocuments\Neighborhoods.mxd, Date: March 9, 2006

3.2.2.3 Land Use

Based on percentage, the Birch Bay area is one of the fastest growing areas in the state. Rapid home building is occurring, with condominiums and single-family residences built along the shoreline and throughout the area. The northern and central portions of Birch Bay have already been developed with residential homes and some commercial structures.

Birch Bay comprehensive planning is the responsibility of Whatcom County because Birch Bay is an unincorporated community. The Whatcom County Comprehensive Plan (2005) designates four UGAs in the general vicinity of Birch Bay: the Birch Bay UGA, the Cherry Point Major/Port Industrial UGA, City of Blaine UGA, and the City of Ferndale UGA. The only UGA designated for the unincorporated community of Birch Bay is the Birch Bay UGA. The northern border of the Birch Bay UGA is adjacent to the City of Blaine UGA (Figure 3-5). The Blaine UGA encompasses all of the area north of Lincoln Road except for a tract of land on either side of a stream north of Lincoln Road. The western and northern boundaries of the Cherry Point UGA are defined as Koehn Road to the west and Grandview Road and Terrell Creek to the north.

Certain neighborhoods were not included within the adopted Birch Bay UGA to protect steep slopes and public resources. Birch Point and portions of Point Whitehorn were removed to protect wetlands and potential landslide areas.

Most of the tidelands in Birch Bay are privately owned except areas at Birch Bay State Park and the areas owned by Whatcom County. This is in contrast to Drayton Harbor, where the City of Blaine owns much of the tidelands. Historically, Birch Bay tidelands have been accessible to the public.

Two major land owners in the Birch Bay area are Trillium Corporation and BP Corporation. Trillium owns a great deal of land inland of Birch Point and inland of Point Whitehorn. The BP Cherry Point Facility is located in the southeastern part of the Birch Bay watershed.

The Cherry Point UGA contains approximately 7,000 acres of industrial land and is currently the site of three major industrial facilities, including two oil refineries and an aluminum smelter. These facilities cover about 4,100 acres of the total area within the Cherry Point UGA.

The Cherry Point shoreline is part of the area that provides spawning habitat for Pacific herring. In September 2003, the Washington State Department of Natural Resources (WDNR) accepted the recommendation that Cherry Point be further evaluated for Aquatic Reserve status. A supplemental environmental impact statement (EIS) is currently being prepared for the proposed reserve. The proposed reserve extends from the southern boundary of Birch Bay State Park to the northern border of the Lummi Indian Nation Reservation, including the Cherry Point shoreline. The site excludes the current leases (BP, Intalco, ConocoPhillips shipping piers) and one proposed lease (Gateway Pacific Terminal site).

Existing development has been located primarily along the shoreline on Birch Bay Drive and along the major roads and highways between the shoreline and Interstate 5. Most future development along the shoreline will be re-development of existing structures.

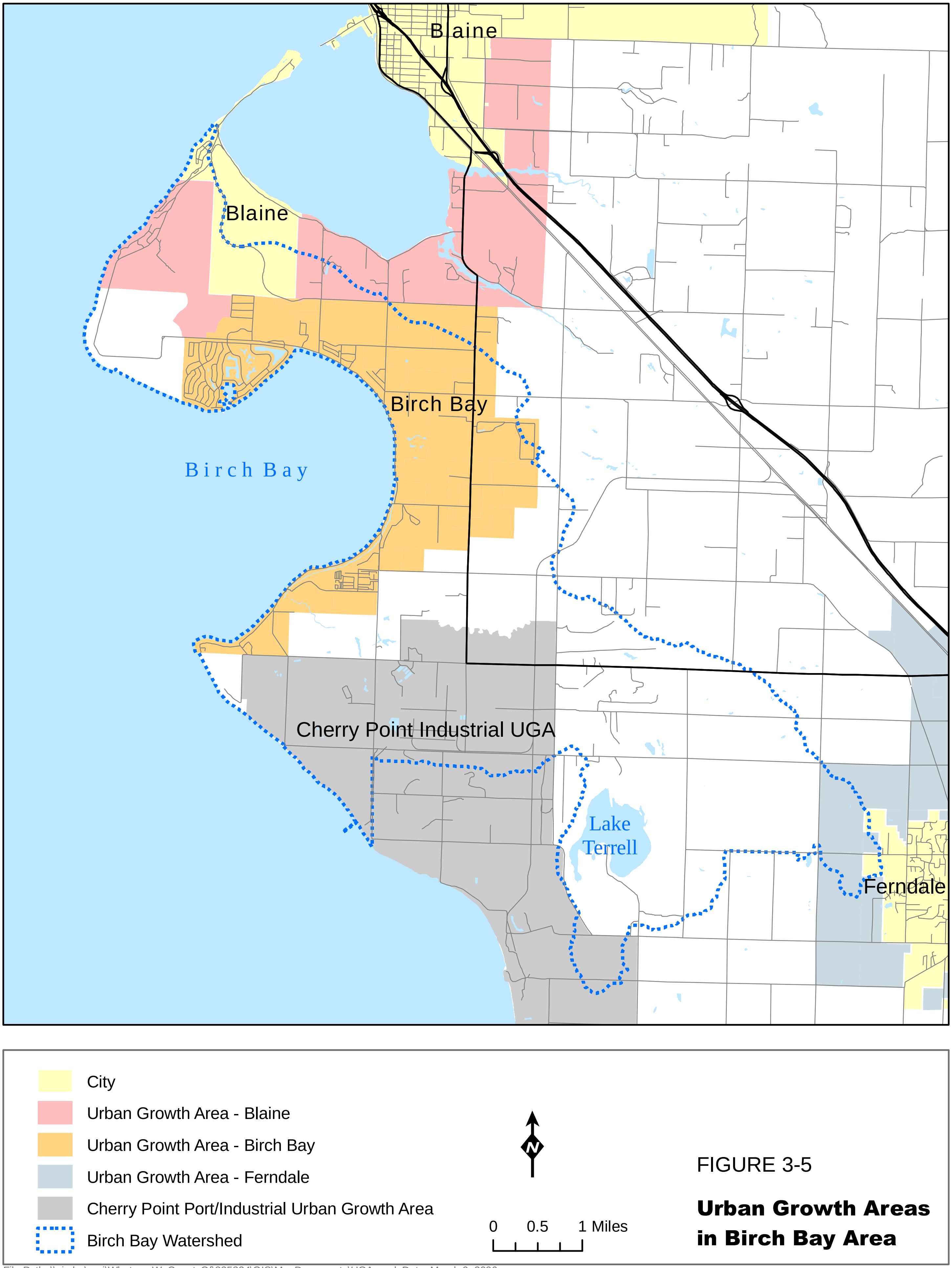


FIGURE 3-5

Urban Growth Areas in Birch Bay Area

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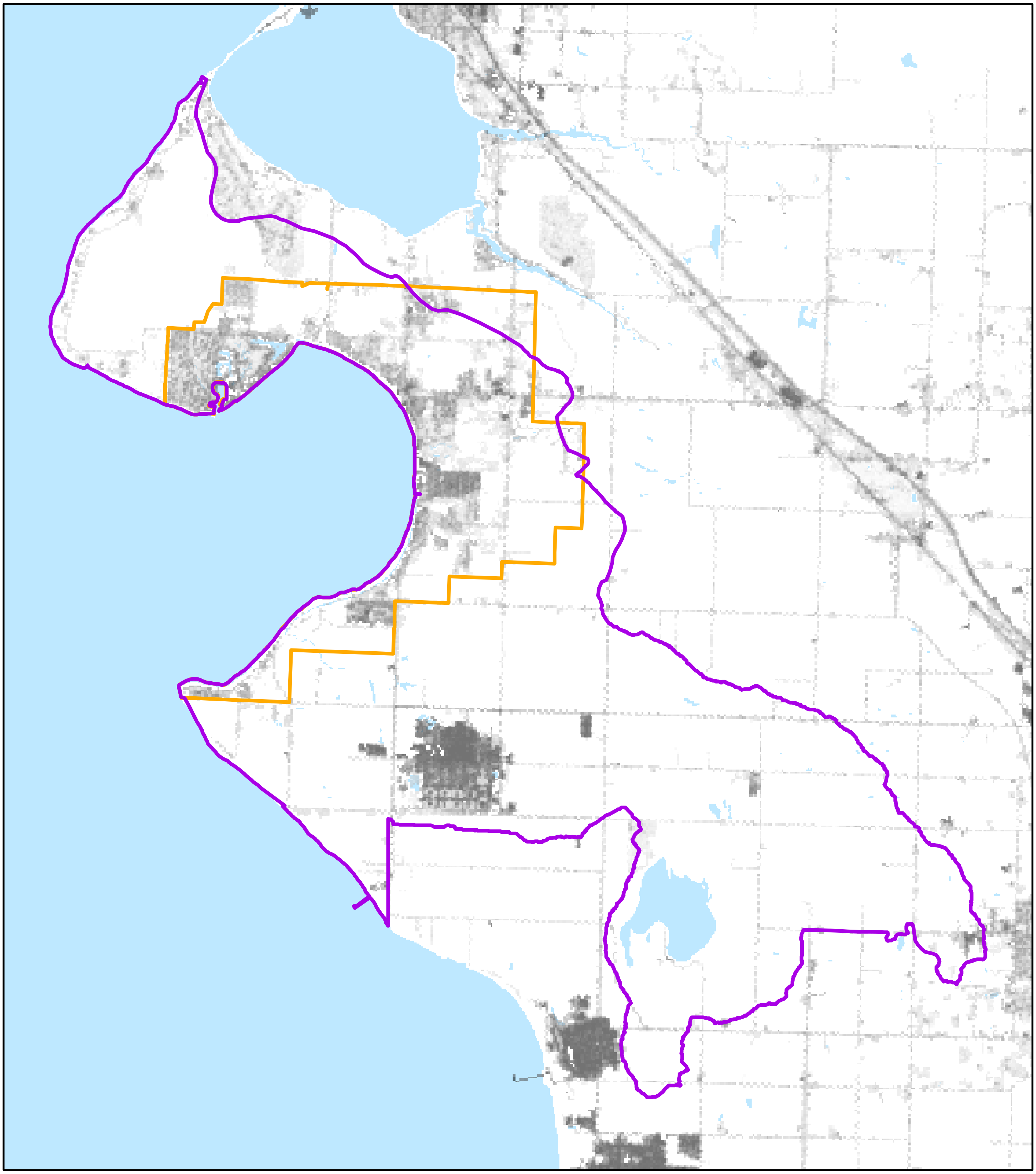
According to the Birch Bay Community Plan (Kask Consulting, 2002), nine different Whatcom County zoning designations are present in the Birch Bay area. These include the following:

- UR-4 (Urban Residential, maximum of four dwelling units/acre)
- URM-6 (Urban Residential, maximum of six dwelling units/acre)
- NC (Neighborhood Commercial, small concentrated land areas intended for retail sales of convenience goods and services within neighborhoods)
- GC (General Commercial, allows development of most commercial establishments, also allows single-family and multi-family development)
- RC (Resort Commercial, accommodates single-family and multi-family dwelling units, mobile home and RV parks, hotels, motels, and time-share condominiums; also some retail development)
- R-5A (Rural Residential, minimum lot size of 5 acres per dwelling unit with minimal commercial activities)
- R-10A (Rural Residential, minimum lot size of 10 acres per dwelling unit with minimal commercial activities)
- LII (Low Impact Industrial, services and associated distribution, manufacture, and assembly of finished products)
- HII (Heavy Impact Industrial, production, distribution, and changing the form of raw materials)

The areas containing the BP Cherry Point property are mainly HII and LII. The areas along Birch Point, Birch Bay Village, and north are mainly UR-4. The areas to the east and inland are mainly R-10A and R-5A. The sections of Birch Bay directly along the shoreline are mainly RC with some URM-6 mixed in.

Of the 8,343 acres within the Birch Bay Community Plan Planning Area, 3,447 acres (41 percent) are urban residential (UR-4 and URM-6), 438 (5 percent) are commercial (NC, RC, and GC), 2,747 acres (33 percent) are rural residential (R-5A and R-10A), and 1,711 acres (21 percent) are zoned industrial (LII or HII).

Figure 3-6 shows impervious surface coverage for the Birch Bay Area. The inventory of impervious surface was done by 30-meter grids with each cell shaded according to the total percent imperviousness. Impervious surface is concentrated along the beach and within the industrial areas. The locations of the greatest amount of impervious surface correspond with the locations of greatest zoning density. Generally, impervious surface increases with development density. Tools like LID measures can be used to mitigate the negative impacts of this relationship.



Legend
Watershed
Urban Growth Area - Birch Bay
Built Impervious Surfaces Draft (NOAA C-CAP 2004)
% Impervious
100
0

N
0 0.5 1 2 Miles

FIGURE 3-6

Impervious Surface in Birch Bay

File Path: \\simba\proj\WhatcomWaCountyOf\335334\GIS\MapDocuments\Impervious.mxd, Date: March 9, 2006

3.2.2.4 Drainage Network

The Birch Bay built drainage network consists of ditches, culverts, catch basins, detention ponds, and tide gates. Major outlets and outfalls and locations of tide gates are shown on Figure 3-1. Implementation of this drainage infrastructure has significantly altered the natural hydrology of the area.

Three main tide gates have been identified in Birch Bay. These are located in Rogers Slough east of Birch Bay Village, at the outlet of the creek along Lora Lane near the mouth of Terrell Creek, and at the intersection of Morrison and Wooldridge near where Jackson Road meets Birch Bay Drive (Figure 3-1).

The existing drainage network in the Birch Bay area is a product of the development history of the area. Many of the drainage ditches were developed years ago to dry out wetlands to allow a limited amount of development such as beach-front cottages or agriculture. The removal of forest and the increase in impervious surfaces with development beyond this initial minimal level have increased both the volume and the peak rate of runoff in the watershed. The capacity of existing drainage ditches and other drainage infrastructure may not be adequate to convey these higher flows. Removal of flood storage areas and constriction of natural drainages by filling and construction of culverts and tide gates have reduced the ability of some areas to drain and has caused water to back up. As a result, localized flooding has increased in certain areas.

Construction of roadways and roadside ditches has altered the surface and subsurface flow. Subsurface flow in the upper portion of soil is intercepted by roadside ditches and is conveyed more quickly and in more concentrated amounts than if the roadway and roadside ditches had not been there. This is most evident in areas such as Birch Point and Point Whitehorn, where surface flow is conveyed in cross-culverts and roadside ditches and then flows towards Birch Bay in concentrated flow streams that may promote erosion and stability problems.

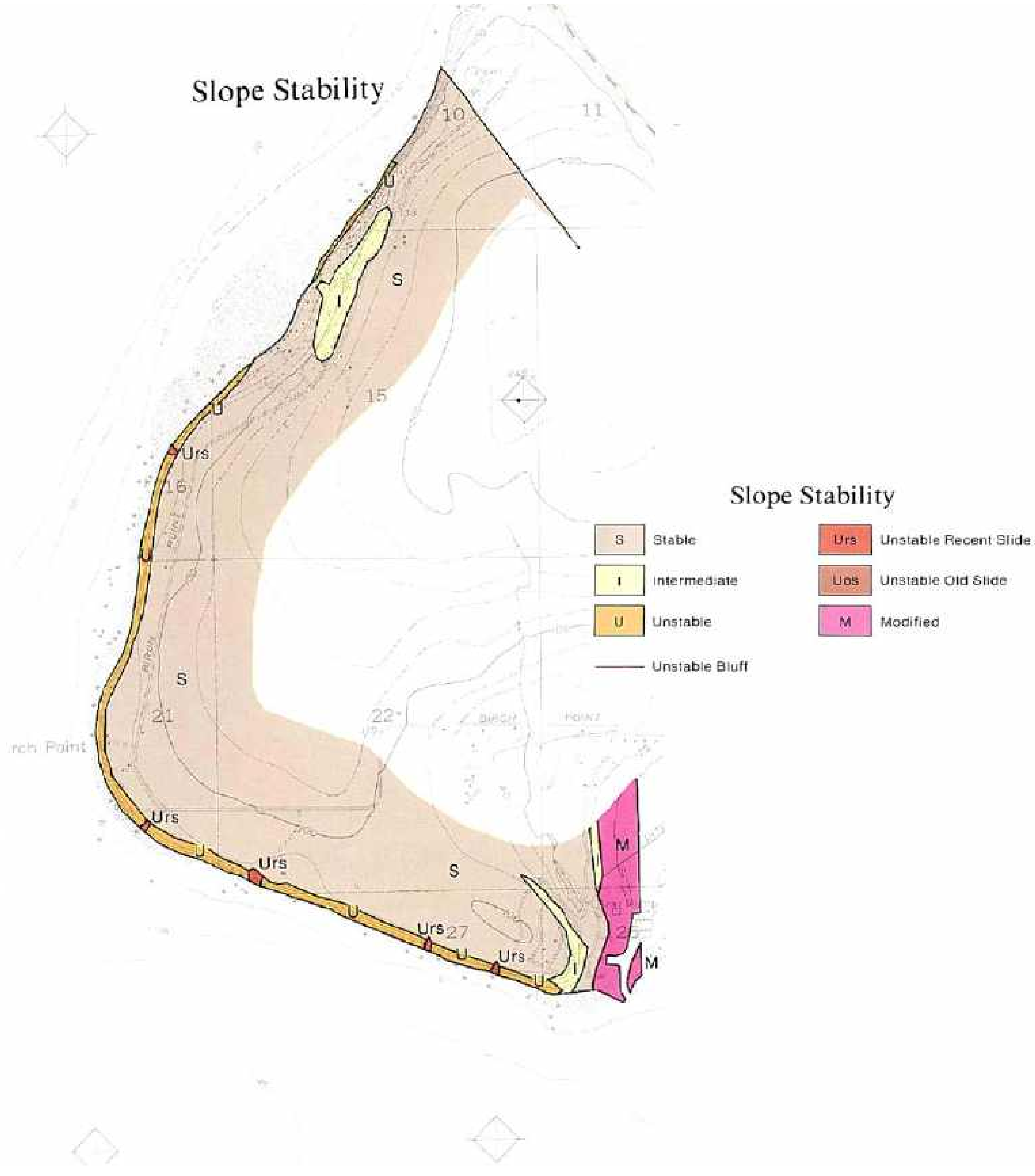
The expectations of the drainage network have also changed with changing population and land use in Birch Bay. Historically, periodic flooding and other drainage issues may have occurred during the winter seasons when seasonal visitors were not in residence. Areas that experienced localized flooding issues in the winter months were dry by the time seasonal residents returned after the winter months. As property values have increased and the area has housed more year-round residents, a greater number of citizens and a greater amount of property have been affected by drainage-related issues. Incoming residents may be accustomed to drainage services provided in cities and therefore may have lower tolerances for drainage-related issues. While the existing drainage network may have been adequate for a seasonally-based beach-front community, the evolving demands for drainage service and response cannot be met with this system.

3.2.2.5 Slope Stability and Landslide Hazards

Slope stability is a problem all across the bluffs of Birch Point and Point Whitehorn. Natural processes may have been accelerated by increased runoff velocities and volume due to removal of vegetation, the installation of septic tank drainfields, and the construction of impervious surfaces and channelized ditches. Increases in subsurface flows can affect slope stability and can increase landslide hazards.

Land use activities in contributing areas have impacts on subsurface flows. Removal of vegetation may have increased the subsurface flows in the area. An increase in subsurface flow has been reported by certain Point Whitehorn and Birch Point residents living along the edge of the steep slopes who state that they have witnessed increased seepage and groundwater flow underneath their homes and out the sides of the slopes. Increases and changes in subsurface flow can affect the rate of slope movement and increase the risk of landslide action.

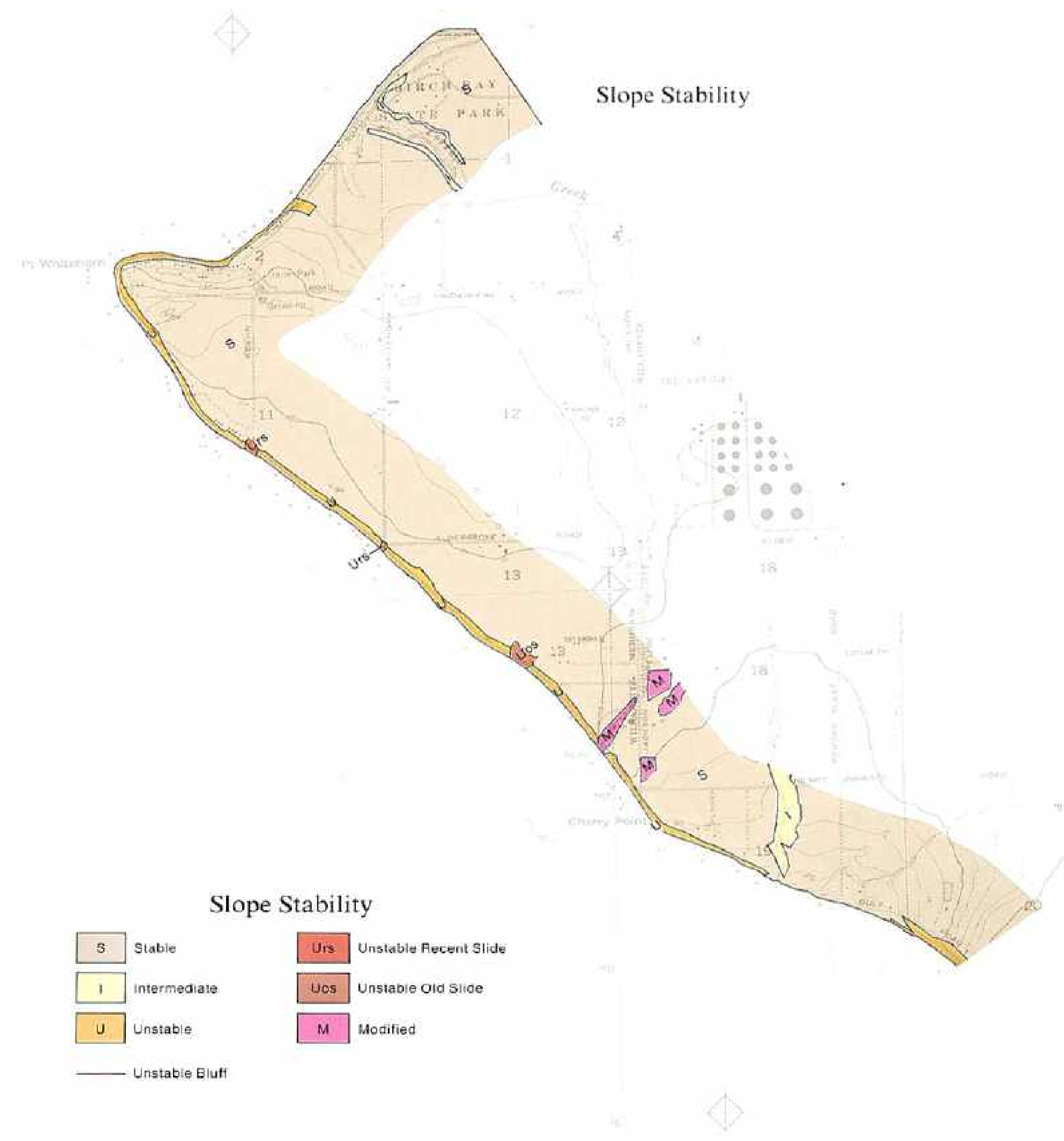
The Coastal Zone Atlas for Whatcom County (Ecology, 1979) shows the entire shoreline areas of Birch Point and Point Whitehorn as unstable. The maps show five recent slide areas along Birch Point and two recent slide areas along Point Whitehorn as of 1978. These maps show that slides are not new on either Birch Point or Point Whitehorn. Figure 3-7 shows the slope stability assessment for Birch Point and Figure 3-8 shows the stability assessment for Point Whitehorn from the 1978 Coastal Zone Atlas.



Source: Washington Department of Ecology. 1978. *1978 Coastal Zone Atlas of Washington. Volume 1: Whatcom County*.

FIGURE 3-7

Slope Stability Assessment for Birch Point from the 1978 Coastal Zone Atlas of Washington



Source: Washington Department of Ecology. 1978. *1978 Coastal Zone Atlas of Washington. Volume 1: Whatcom County*.

FIGURE 3-8

Slope Stability Assessment for Point Whitehorn from the 1978 Coastal Zone Atlas of Washington

4 Surface Water Issues and Problems Identified in Birch Bay

4.1 Introduction

Birch Bay is a rapidly growing community that is experiencing increasing stormwater drainage problems, declining water quality, and loss of aquatic habitat. Water quantity problems include erosion, flooding, slope instability, and sedimentation. Water quality concerns involve mainly fecal coliform bacteria and other pollutants from point and non-point sources. Aquatic habitat degradation is caused mainly by physical alterations through development. This chapter describes the drainage problems, water quality problems, and problems with aquatic habitat identified in Birch Bay.

4.2 Sources of Data

Surface water issues and problems were identified by collecting information from a variety of sources, including the following:

- Information from the Washington Department of Ecology, Whatcom County, the Birch Bay Steering Committee, the Washington State Department of Health, and the Nooksack Salmon Enhancement Association.
- Studies and reports from previous work conducted in and around the Birch Bay area, including:
  - *Point Whitehorn to Birch Bay State Park Shoreline Reach Analysis*, Whatcom County, Washington, Final Report (Coastal Geologic Services, 2003).
  - *Birch Bay Shoreline Improvement Plan and Conceptual Design*, Draft Report (Philip Williams and Associates, 2002).
  - *Birch Bay Community Plan (Sub Area Plan)*, Birch Bay Community Plan Steering Committee (Kask Consulting, 2002).
- Citizens Workshop #1: a workshop conducted with local area residents to identify problem areas or issues of concern. (A memorandum summarizing this workshop is included in Appendix A.)
- Correspondence from local area residents reporting continuous issues/problems or wet-weather-specific problems.
- Field visits conducted by Whatcom County, CH2M HILL, and local area residents.

Lists of problems identified in the Citizens' Workshop #1, during field work efforts, by residents and others via correspondence in the weeks and months following Workshop #1, and those problems identified in previous studies and historical information were combined into a master list presented in Table 4-1. Details of identified problems are included in technical memorandums attached to this plan (Appendix A and Appendix B).

4.3 Description of Problem Types

The following general types of stormwater management issues were identified:

- Water quantity
- Water quality
- Aquatic habitat

Erosion and flooding are examples of water quantity issues. Bluff erosion and slope stability issues are often created by increased volume and velocity of runoff and therefore are included as water quantity issues.

Water quality issues may include point source pollution, such as stormwater runoff containing a large concentration of suspended sediment discharging from a construction site, or non-point source pollution such as fecal contamination from domestic animals, birds, and/or wildlife.

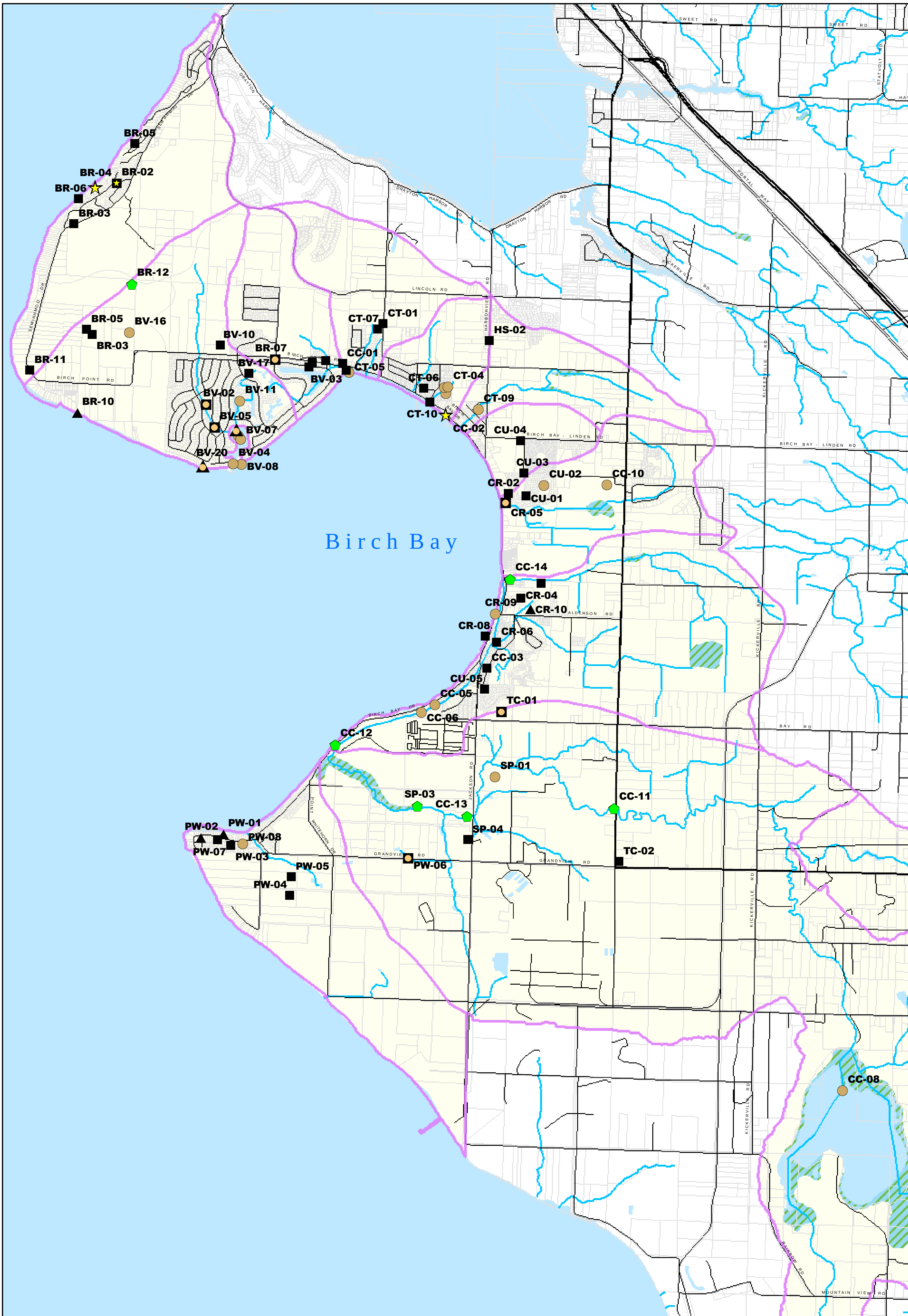
Aquatic habitat in local streams, wetlands, and near-shore areas is often physically altered by new development. These physical alterations may include decreased access to habitat due to road culverts or channelized sections of creek, each of which is problematic. Habitat can also be physically altered by changes in stream flow as a result of land clearing and an increase in impervious surfaces due to buildings and paving.

In addition to the water quantity, water quality, and aquatic habitat problem types, several problems identified by citizens refer to policy and planning issues or generally relate to new development.

4.4 Identified Surface Water Issues and Problems

A total of 27 different water quantity problems were identified by citizens, by field investigations, by conversations with other stakeholders, or by historical studies. Sixteen water quality problems and six aquatic habitat problems were also identified. These 49 problems are all described in detail in Appendices B and C. Figure 4-1 shows the locations of the water quantity, water quality, and habitat problems identified in the Birch Bay area. Several problems pertaining to policy and planning issues were omitted from Figure 4-1 as they did not pertain to a specific location.

These original 49 identified problems were grouped by type (water quantity, water quality, and habitat). Several of these were consolidated based on similar locations, causes, symptoms, and potential solutions, and the list was reduced to 41 individual problems. Of the 41 problems, 19 are strictly water quantity problems (primarily drainage and erosion), 13 are water quality problems, and 5 are habitat-related. Three additional problems are both water quantity and water quality related, and one problem is water quality and habitat related. Table 4-1 contains a listing of these 41 problems.



Potential Problem Location

- Drainage and Flooding
- Water Quality
- Habitat
- Site Erosion
- Bluff Erosion and Stability
- Drainage and Flooding/Water Quality
- Drainage and Flooding/Site Erosion
- Bluff Erosion and Stability/Water Quality
- Project Area
- Drainage Subbasins

N

0 0.25 0.5 Miles

FIGURE 4-1
Locations of Identified Problems within the Birch Bay Area

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TABLE 4-1. IDENTIFIED PROBLEMS AND ISSUES RATED AND RANKED

						Types of Potential Solutions				
							Non-Structural (programmatic solution)			
Rank	**Score[a]**	**Name[b]**	**Other Related Problems**	**Description**	**Type of Problem**	**Structural (potential capital solution)**	**Education, Public Involvement**	**Inspection & Enforcement (for drainage & water quality)**	**M&O[c]**	**Regulatory and Policy**
1	37.7	CC-02	CC-02	Roadway erosion issues on Birch Bay Drive, several locations	drainage or erosion/stability	●				
2	36.0	BR-10	BR-10	Slope Stability/erosion in Birch Point area	drainage or erosion/stability		●	●		●
3	35.8	CC-04	CC-04	Potential for septic systems to be failing in Birch Bay area	water quality		●	●		●
4	35.1	CT-01	CT-07	Flooding issues along Shintaffer, north side of Richmond Park Subdivision	drainage or erosion/stability	●			●	
4	35.1	CT-06	CT-10; CU-01	Flooding issues behind two outfalls at Cedar Rd. and Cottonwood Beach	drainage or erosion/stability	●			●	
6	34.8	CC-12	CC-05	Confined reach of Terrell Creek in lower part along beach - low dissolved oxygen (DO) and high temp	water quality, habitat	●				
7	34.5	CC-05	CC-06	Water quality issues, Terrell Creek - algae, low DO, high temp, etc.	water quality		●	●		●
8	33.8	BV-04	BV-04	Fecal coliform issues, Birch Bay - as sampled by DOH; shellfish beds threatened	water quality		●	●		●
9	33.5	CC-13	CC-13	Degraded physical habitat in Terrell Creek	habitat		●			●
10	32.7	CR-06	CR-06	Tide gate and culvert blockage - N. Morrison	drainage or erosion/stability				●	●
11	32.5	SP-01	SP-01	Presence of large numbers of ducks and birds, Birch Bay State Park	water quality		●			●
11	32.5	CC-08	CC-08	Presence of large numbers of ducks and birds, Lake Terrell	water quality		●			●
11	32.5	SP-03	SP-03	Low summer flows in Terrell Creek	habitat					●
14	31.7	PW-03	BV-16; PW-04; PW-05; PW-07	Tree loss throughout Birch Bay watershed (sediment transport, drainage issues)	drainage or erosion/stability, water quality		●	●		●
15	31.4	PW-06	BR-04; CT-02; CT-03; CT-04; CT-09; CU-02	Drainage conveyance issues, yard debris and trash accumulate and block inlets/outlets	drainage or erosion/stability		●	●	●	●

TABLE 4-1. IDENTIFIED PROBLEMS AND ISSUES RATED AND RANKED

						Types of Potential Solutions				
							Non-Structural (programmatic solution)			
Rank	Score[a]	Name[b]	Other Related Problems	Description	Type of Problem	Structural (potential capital solution)	Education, Public Involvement	Inspection & Enforcement (for drainage & water quality)	M&O[c]	Regulatory and Policy
16	31.0	BR-02	BR-03; BR-04; BR-05; BR-06; BR-11	Drainage/flooding in Birch Point area (Cary Ln, Semiahmoo Dr, Normar Pl, Semiahmoo Rds.)	drainage or erosion/stability	●	●	●	●	●
17	30.8	BV-02	BV-05; BV-10; BV-11; BR-07	Water quality of ponds, stream, marina at Birch Bay Village	water quality		●	●		●
17	30.8	CC-11	CC-11	Fish passage blockages at Blaine and Grandview Road culverts	habitat	●				
19	29.8	CT-05	CT-05	Presence of large numbers of Canada geese throughout watershed	water quality		●			
20	29.3	BV-01	BV-02	Drainage/flooding Issues behind Rogers Slough (eastern portion of Birch Bay Village plus roadside ditches, excess runoff)	drainage or erosion/stability	●			●	●
21	29.0	CC-01	CC-01	Tree and material accumulation at Rogers Slough and Cottonwood Beach	drainage or erosion/stability				●	
22	28.8	CR-05	CR-05	Water quality at outfalls, much algae present at outfall near beach	water quality		●	●		●
23	27.8	CU-05	TC-01	Retention pond overflow at Bay Crest (quality and quantity)	drainage or erosion/stability, water quality			●	●	●
24	27.1	PW-01	PW-02; PW-03	Drainage, slope stability/erosion, and subsidence issues in Point Whitehorn Area	drainage or erosion/stability		●	●		●
25	26.8	CR-09	CR-09	Presence of dogs, problematic if waste isn't removed, near Terrell Creek and other places	water quality		●			●
25	26.8	CC-10	CC-10	Use of County Equestrian Center, potential water quality issue if rules aren't followed re: waste	water quality		●	●		●
27	25.8	BR-12	BR-12	Protect existing wetlands	habitat					●
28	23.7	TC-02	TC-02	Drainage issues at intersection of Blaine and Grandview Rds.	drainage or erosion/stability	●			●	
29	23.1	CC-14	CC-14	Tide gates block potential fish habitat (Lora Lane tide gate to Terrell Creek)	habitat	●			●	●
30	22.0	CR-03	CR-04	Drainage issues at Pine Drive, etc. behind tide gate at Lora Lane	drainage or erosion/stability					●

TABLE 4-1. IDENTIFIED PROBLEMS AND ISSUES RATED AND RANKED

						Types of Potential Solutions				
							Non-Structural (programmatic solution)			
Rank	**Score[a]**	**Name[b]**	**Other Related Problems**	**Description**	**Type of Problem**	**Structural (potential capital solution)**	**Education, Public Involvement**	**Inspection & Enforcement (for drainage & water quality)**	**M&O[c]**	**Regulatory and Policy**
30	22.0	CU-03	CU-04	Retention pond overflow at Sealinks	drainage or erosion/stability	●		●		●
32	21.2	BV-20	BV-12	Erosion issues at Birch Bay Village beach and bluff	drainage or erosion/stability, water quality		●			●
33	21.1	CC-09	CC-09	Presence of animals on properties near drainages to Terrell Creek and Birch Bay	water quality		●			●
34	20.8	SP-04	SP-04	Outfall blocked at Terrell Creek near Jackson Road	drainage or erosion/stability				●	
35	18.7	CR-02	CR-05	Drainage issues near Mariners Cove	drainage or erosion/stability	●			●	
35	18.7	CC-03	CC-03	Drainage issues in yards along Wooldridge	drainage or erosion/stability				●	
35	18.7	CR-08	CR-08	Flooding at Alderson Rd. at extreme high tide and winds	drainage or erosion/stability	●				
38	18.3	HS-02	HS-02	Ditch overwhelmed at Harborview Rd.	drainage or erosion/stability				●	
39	17.7	PW-08	PW-08	Potential use of herbicides/pesticides and other chemicals	water quality		●	●		●
40	16.3	CC-07	CC-07	Mud tracked out of worksite	water quality		●	●		●
41	11.7	CR-10	CR-10	Slope stability on hillside east along Alderson Road	drainage or erosion/stability		●	●		●

[a] See section 4.5 for an explanation of this score.
[b] Problem name is original name given during problem identification process; Letters such as CT refer to the neighborhood in which the problem was identified. The number following the letters is the unique identifier for problems identified within that neighborhood and does not signify rating or ranking.
[c] M&O = maintenance and operations

4.4.1 Water Quantity Problems

Water quantity challenges in the Birch Bay watershed can be categorized in three groups:

- **Low-lying areas along the beach:** There are extensive low and flat areas behind the natural dune of the beach. Even without development, these areas were likely inundated during extreme high tides and high wind conditions. Many of the areas that now have homes and roads were once large, natural wetlands. Development has increased runoff and in some cases may have blocked natural flow paths.
- **New development:** The watershed is experiencing rapid development, particularly near the beach. New development is increasing the peak flow rate and volume of runoff even with on-site detention, resulting in increased downstream flooding and erosion. Existing standards and review procedures may need to be improved to reduce the impacts of new development.
- **Bluff erosion:** There are examples of slides all along the bluffs at both the south and north ends of Birch Bay. Beach erosion and slides along bluffs are natural events, but their occurrence may be accelerated by stormwater that is routed over the bluffs or if additional water is infiltrated into the ground near the bluffs from either stormwater or septic tank drain fields.

Many of the problems identified by citizens may be problems caused by individual property owners affecting themselves or other individual property owners. Such problems are often not the responsibility of the government but the responsibility of the individual property owners to resolve. For example, a property owner that routes rooftop runoff over the edge of the bluff would be responsible for removing the cause and repairing any damage to their own property.

Localized flooding problems are a primary water quantity concern of Birch Bay residents. Bluff erosion and hillside stability are also important and relevant concerns.

4.4.2 Water Quality Problems

Water quality challenges in the Birch Bay watershed can be categorized in two groups:

- **Activities of residents:** The majority of water quality problems reported by the citizens are due to activities of residents. This underscores the need for extensive and focused education of the local residents.
- **New construction:** Several water quality problems are related to new construction. This indicates that regulations should be stronger or more strictly enforced.

Additional descriptions of water quality issues are available in Appendix B. For example, coliform bacteria monitoring in Birch Bay has resulted in the listing in 2003 of the bay by the Washington DOH as “Threatened” for closure to recreational shellfish harvesting.

Residents of Birch Bay are concerned with the composition of stormwater runoff entering Birch Bay.

4.4.3 Aquatic Habitat Problems

The streams, wetlands, and near-shore marine waters in the Birch Bay area provide aquatic habitat for birds, fish, and shellfish. Residents of Birch Bay are concerned about the preservation of existing aquatic habitat and the restoration of habitat previously lost.

Key aquatic habitat issues in Birch Bay include fish passage and loss of wetlands. Additional habitat issues are described in Appendix B. For example, stream monitoring data show that the low summer flows near the mouth of Terrell Creek may stress or kill juvenile salmon and trout.

4.4.4 Policy / Planning Issues

Several issues were identified by citizens and others that do not relate to a site-specific water quantity, water quality, or aquatic habitat issue, but have more to do with how relevant policies and plans are created and carried out. These include:

- Citizens expressed concern about stormwater quantity and quality issues surrounding new development projects and how these new projects will influence existing conditions.
- Citizens stressed the importance of working with the City of Blaine on regional stormwater planning and possible stormwater detention projects.
- Citizens questioned the current water quality complaint system. Issues were the lines of communication and the process of enforcement.
- Citizens are concerned about the increase in impervious surface created by new development.
- Citizens expressed interest in LID for new development and re-development.
- Citizens are concerned about the rate of tree loss on public and private property.

4.5 Prioritization of Issues and Problems

Each individual water quantity, water quality, and habitat issue on the comprehensive list was rated against several criteria. These criteria reflect the goals and action items outlined in both the *Whatcom County Comprehensive Plan* (Whatcom County, 2005) and the *Birch Bay Sub-Area Plan* (Kask Consulting, 2002). The goals of the *Birch Bay Sub-Area Plan* include the following:

- Goal SW1: To protect water resources and natural drainage systems by controlling the quality and quantity of stormwater runoff.
- Goal SW2: To implement stormwater management policies and strategies which recognize the value of wetland areas in solving stormwater problems
- Goal SW3: To implement ongoing monitoring of stormwater so that fresh and salt water quality problems can be identified early on.

The goals of the *Whatcom County Comprehensive Plan* include the following:

- Goal 11E: Protect and enhance water quality and promote sustainable and efficient use of water resources.
- Goal 11F: Protect and enhance Whatcom County's surface water and groundwater quality and quantity for current and future generations.
- Goal 11G: Protect water resources and natural drainage systems by controlling the quality and quantity of stormwater runoff.

The specific criteria used to rate each surface water issue are related to impacts on people or the environment, or are related to the frequency of occurrence. The criteria used are shown in Table 4-2.

TABLE 4-2. PROBLEM RATING CRITERIA

Category (relative weight)	Criteria (relative weight)
People (total of 50%)	Health and safety (20%)
	Property (personal property (10%), public property (10%), magnitude of problem (10%)) (total of 30%)
Environment (total of 40%)	Shellfish resources (10%) Water quality (10%) Habitat (10%) Water quantity (hillside stability, erosion) (10%)
Frequency (total of 10%)	Frequency of occurrence (10%)

Health and safety is a primary concern in Birch Bay. Therefore, it has the highest individual weight of all the individual criteria at 20 percent. Cumulatively, “property” accounts for more at 30 percent, but personal property, public property, and problem magnitude each are only 10 percent individually.

A total score was assigned to each problem based on the relative weight of each criterion. Once this process was completed, the surface water problems were ranked according to that total score.

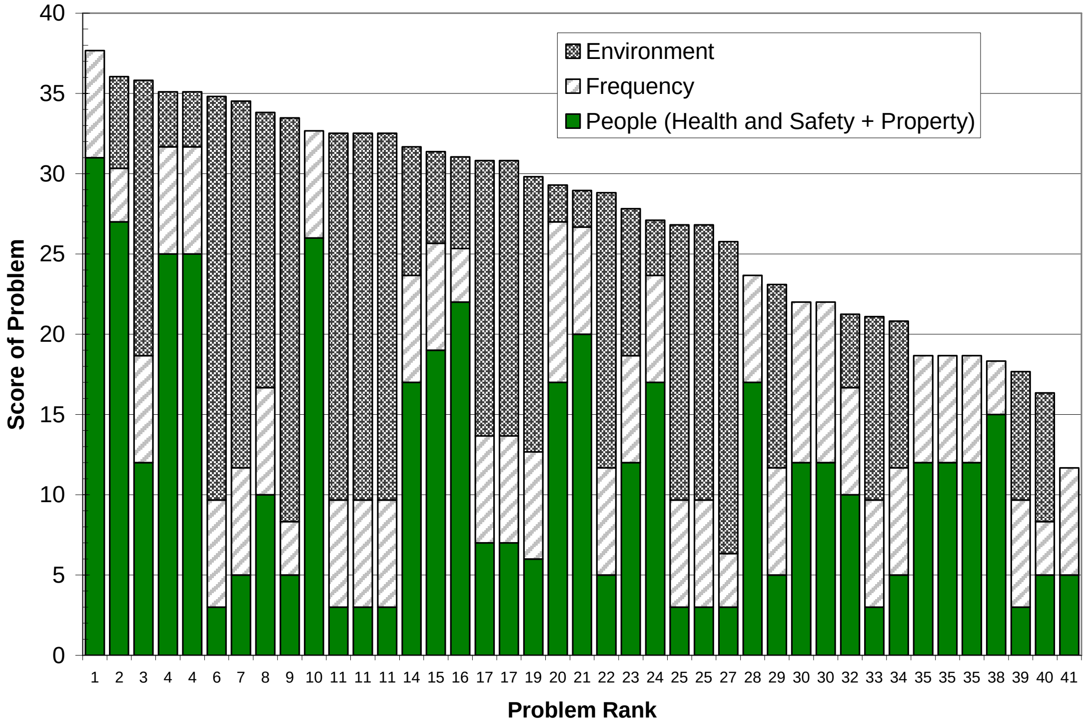
Table 4-1 shows the ranking of the 41 surface water problems according to the criteria used. A brief description of the problem is given as well as the type of problem (water quantity, water quality, or habitat). There is a good distribution of problem types throughout the list.

Figure 4-2 shows the portion of the score for each problem that is attributed to people, the environment, or frequency of occurrence. This allows for a comparison between problems that are priorities because of the potential effect(s) on people versus problems that are priorities for their effect(s) on the environment. The frequency of occurrence indicates how often a problem occurs and how that metric influenced the rating and ranking of the problem.

The prioritized list of surface water issues and problems was used to formulate the list of structural (capital project) and programmatic alternatives recommended in this Birch Bay Comprehensive Stormwater Plan.

Future problems and issues that may arise after the formulation of this plan can be rated according to this same set of criteria. This will allow for an ongoing prioritization of issues and problems.

FIGURE 4-2. RANKED SCORES, SUMMARY BY CONTRIBUTING FACTOR



5 Alternatives

5.1 Introduction

The citizens of Birch Bay completed the Birch Bay Sub-Area Plan which included a comprehensive land use plan that called for low-impact development and a stormwater plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth in the community. This Comprehensive Stormwater Plan recommends measures to do that.

Water quantity, water quality, and habitat issues identified within Birch Bay were outlined and prioritized in Chapter 4. The identified problems were prioritized using criteria reflecting the goals and action items outlined in both the Whatcom County Comprehensive Plan and the Birch Bay Sub-Area Plan. Some prioritized problems have structural (capital project) solutions, while others have programmatic solutions, and several problems have both programmatic and structural solutions. Stormwater management programmatic actions should be addressed in a Stormwater Management Program. Capital project solutions should become part of the Whatcom County Capital Improvement Program.

5.2 Stormwater Management Program

Potential solutions to Birch Bay's stormwater problems were divided into actions that would not involve construction or acquisition, collectively referred to as programmatic approaches, and actions that would require capital projects and would be listed in the Capital Improvement Program (CIP). The programmatic alternatives have the benefit of often being strategic rather than reactionary. Instead of fixing a single problem with a structural solution, programmatic alternatives often address a series of existing problems and are effective at preventing future problems. The combination of programmatic actions and capital improvements comprise the Stormwater Management Program (SWMP). Currently, there is no formalized SWMP within Whatcom County. However, many current Whatcom County programs do address stormwater issues and therefore have been acting as an informal SWMP.

5.2.1 Summary of Issues that Require a Programmatic Approach

5.2.1.1 Regulatory Requirements and Guidance

Ecology's draft Phase II NPDES municipal stormwater permit lists programmatic solutions for permittees. Although Birch Bay is not subject to an NPDES permit at this time, it will likely be covered in the future. The list of solutions included in the Phase II permit is a good reference. Solutions listed in the permit include:

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination (includes requirement for inventory of the drainage system)
4. Controlling Runoff From New Development, Redevelopment, and Construction Sites

5. Pollution Prevention and Operations and Maintenance for Municipal Operations

Each of these five NPDES Phase II requirements is implemented by a set of minimum performance measures outlined in the permit. These performance measures are described in Chapter 2.

Other requirements of the NPDES Phase II permit include:

- Develop and implement a stormwater management program
- Report any monitoring studies
- Assess effectiveness of best management practices (BMPs) and any changes needed
- Prepare a plan for future comprehensive long-term monitoring program, and
- Submit a detailed annual report of the status of SWMP implementation to Ecology

5.2.1.2 Water Quality

The primary water quality concern in Birch Bay is coliform bacteria in the bay. The Washington State Department of Health monitors bacteria in the bay and has previously listed Birch Bay as threatened for restricted shellfish harvesting. There are several potential sources of bacteria in Birch Bay. These include:

- The conveyance and treatment system belonging to the Birch Bay Water and Sewer District
- Dogs and cats
- Livestock
- Commercial sources
- Recreational vehicles and trailers
- Marina
- Wildlife
- Waterfowl (ducks and geese)
- Onsite septic systems
- People

Each of these is discussed below.

The conveyance and treatment system belonging to the Birch Bay Water and Sewer District. The district has an existing permit for operation of the treatment plant and collection system. The treatment plant outfall discharges to deep water outside of Birch Bay and is an unlikely source of bacteria in the bay. However, drift cells on a flood tide do come around Point Whitehorn so this deep-water outfall should not be eliminated as a potential source of bacteria within Birch Bay. Because all collection systems have a potential for leaks and infiltration, the district should have an ongoing program to detect and correct leaks and infiltration.

Dogs and cats. Dogs, cats, and other outdoor pets are a likely source of fecal bacteria, particularly near or on the beaches and streams. RNA source tracing in other locations regularly identifies cats and dogs as sources of bacteria. A program of education regarding picking up waste from dogs and cats is recommended. Signs and free bags and waste receptacles along the beach should be provided.

Livestock. There are no large commercial livestock operations within the watershed. There are a few hobby farms with livestock. The County should coordinate with the Conservation District to work with these owners to develop appropriate manure management practices.

Industrial sources. No potential industrial sources of bacteria have been identified within the watershed.

Recreational vehicles and trailers, commercial trailer parks. There are large numbers of recreational vehicles and trailers in the watershed, particularly during the summer months. An inventory of holding tank dump sites and their use should be conducted. Routine, unannounced inspections of trailer parks should be conducted to detect trailers that are not connected to sanitary sewers. An educational program should be implemented for the commercial and public parks. Counters should be installed on pump-out stations to determine frequency of use.

Marina. High coliform counts have been detected at the mouth of the marina. The County should work with the marina operators to develop an inspection program to assure that the discharge valves for holding tanks in the boats are closed. A review of the marina’s pump-out station should be conducted to assure ease of use and proper function. If feasible, a counter should be added to the pump-out station to determine the level of use. An education program for boat owners should be developed and implemented. Volunteers among the boat owners should be identified to promote proper management among other boat owners. Water quality sampling could be conducted on the lakes and streams discharging to the marina as well as in the mouth of the marina itself to determine the source(s) of bacteria.

Wildlife. Large concentrations of birds occur in several locations in the watershed. In general, these are naturally occurring and are not a concern as a bacterial source. In a few places, birds concentrate because of particular human actions and should be discouraged. Geese are particularly attracted to large areas of open grass. These include the State Park and Birch Bay Village. The best deterrent is to replace the grass areas with native shrubs, particularly along bodies of water. Waterfowl prefer to have open sight lines, so a border of shrubs along the grass would also discourage them. Active programs of trained goose-control dogs may be employed to discourage geese from congregating. This approach has been successful in parks in other areas of the state. A program of signage to explain the issue and prohibit feeding of ducks and geese should be deployed.

Birch Bay Village has implemented a program to trap and remove adult geese and collect eggs from goose nests. Residents indicate that the program has been effective in reducing the numbers of geese in the village.

Onsite septic systems. The County should implement a program to test on-site septic systems and require corrections as appropriate. This approach has been successful in Portage Bay.

Results of fecal coliform sampling by Washington DOH at locations within Birch Bay led to a “threatened” status for shellfish beds in the area. A “threatened” status is given to an area that shows declining water quality. No source tracing has been preformed to determine if fecal coliform detected in Birch Bay samples is of human or animal origin. However, a study performed for Drayton Harbor to the north of Birch Bay points to several potential sources of fecal coliform in that watershed, including failing septic systems (Meriwether, 1995).

A new bill has been passed by the Legislature related to septic systems. HB 1458 requires local health authorities to identify and correct failing septic systems by 2012.

Existing data can be used to create an accurate inventory of users connected to the sewers of the Birch Bay Water and Sewer District. Water users who are not connected to the sewer are served by onsite septic. Suspect areas can be investigated using such techniques as dye tracing, appearance of wet soils, lush vegetation surrounding systems, odor, or visible discharges. The County should enact requirements for owners to inspect systems and make corrections as needed.

People. Large numbers of people visit Birch Bay, particularly in the beach area. Public restrooms should be readily available and well maintained.

5.2.1.3 Water Quantity, Drainage, and Erosion

There are several areas in the Birch Bay watershed that have drainage problems. Most of these are large puddles that form occasionally and sometimes cover all or a portion of a roadway.

5.2.1.3.1 Bluff Erosion

Coastal bluff erosion is a natural process but may have been accelerated by human activity. The Coastal Zone Atlas for Whatcom County (Ecology, 1979) shows the entire shoreline areas of Birch Point and Point Whitehorn as unstable and shows five recent slide areas along Birch Point and two recent slide areas along Point Whitehorn as of 1978. Slides and bluff erosion are not new to the Birch Bay area.

The departments of Ecology and Natural Resources both have information available on proper management practices near coastal bluffs to reduce risks of slides. The Department of Ecology has published several guides for Puget Sound coastal and bluff property owners. These include:

- *Slope Stabilization and Erosion Control Using Vegetation, a Manual of Practice for Coastal Property Owners* (Ecology, 1993a)
- *Vegetation Management: A Guide for Puget Sound Bluff Property Owners* (Ecology, 1993b)
- *Surface Water and Groundwater on Coastal Bluffs: A Guide for Puget Sound Property Owners* (Ecology, 1995)

These manuals describe techniques used for minimizing the negative affects that surface water and groundwater mismanagement can have on the natural processes of landslides and erosion. *Surface Water and Groundwater on Coastal Bluffs* (Ecology, 1995) provides coastal property owners with general information concerning the management of water on coastal slopes. The publication describes the relationship between coastal geology, water, and slope stability. Techniques for evaluating site drainage and potential drainage control are presented within the publication. The other two resources, *Slope Stabilization and Erosion Control Using Vegetation* (Ecology, 1993a) and *Vegetation Management* (Ecology, 1993b) provide coastal property owners with basic information concerning the nature and use of slope planting techniques to manage soil erosion and shallow land movements. These three documents and others can help land owners minimize the risk of slide hazards.

The County should:

- Develop and implement a program of education for property owners in areas of coastal bluffs.
- Work with the Trillium Corporation to identify problems and solutions related to discharges from the Trillium property and conveyance to the beach as a condition of development approval.

5.2.1.3.2 Drainage

Development alters the natural hydrologic regime of an area. The initial clearing of vegetation yields the most significant alteration in hydrologic patterns. Once this initial clearing occurs, impervious surface coverage and hydrologic channelization that come with development exacerbate the problem. LID measures can mitigate these negative effects of development. Appendix D of this plan contains a review of the feasibility and potential effectiveness of LID measures within the Birch Bay watershed. For this review, the Low Impact Feasibility Evaluator (LIFE™) model was used to evaluate the effectiveness of LID measures in one development currently planned for Birch Bay.

LIFE™ model results indicate large reductions in peak flow rates generated by the 2-year, 10-year, and 100-year 24-hour events. The peak flow rates are reduced by 69 percent or more between the "Traditional Development" and "Development with LID" scenarios for each of three storm events run through the LIFE™ model. This study was performed based on one planned development of approximately 34 acres. It is likely that LID measures implemented to the scale and density as modeled with the LIFE™ model in this study would have comparable results elsewhere in the watershed. Detailed results of the LID review are contained in Appendix D.

Current Whatcom County regulations and requirements could be updated to reflect requirements for LID in new and redevelopment situations. For instance, a certain depth (such as 12 inches) of amended soils could be required on all pervious surfaces in new developments. Requirements could be set up to promote LID.

For the implementation of LID measures to truly be feasible in the Birch Bay area, the demand for "green" homes and LID must be known to developers and regulators alike. Developers would be more likely to incorporate LID measures into future developments if they are marketable and therefore more cost-effective.

5.2.1.4 Aquatic Habitat

There are ongoing programs to protect and restore aquatic habitat along Terrell Creek and the beach. These programs, which are largely volunteer, should be supported by the County and other agencies. In addition to the physical improvements made by the volunteers, the programs provide education to the volunteers and their circle of contacts.

5.2.2 Recommendations for Programmatic Solutions

5.2.2.1 Complaint Response

The public should be provided with a single number to call with complaints regarding drainage, erosion, or water quality issues. The County should place signs along the beach and key tributary locations providing the contact information to report water issues. Public works staff should be trained to collect appropriate information, track calls by type and location, and notify appropriate personnel to determine response. Staff should respond to all complaints within 24 hours even if just to acknowledge receipt of the complaint. A follow-up system should be in place to address and resolve complaints or explain why complaints are not addressed. Complaint records should be periodically reviewed to identify “hot spots,” and proactive solutions should be developed for them.

5.2.2.2 Inspections and Illicit Connections

An inventory of the drainage system in the Birch Bay watershed should be completed. All outfalls should be identified. An inspection program to detect and eliminate illicit connections to the stormwater system should be developed and implemented.

A semi-annual inspection of the tide gates and other drainage structures along the beach should be established.

A program should be established to inspect private drainage facilities such as stormwater ponds annually. This program will require a significant element of education with property owners. Many do not understand their systems or their importance and the need for maintenance.

The County should conduct inspections of existing and new development for adherence to existing Whatcom County regulations, including those for tight-line drainage along slopes.

The County should inspect pump-out facilities and coordinate with marina owners to develop a system of inspecting all boats in the marina. Boats should be inspected to assure that Y valves are closed and waste is not discharged to the water.

The County should conduct periodic inspections of RVs and trailers to ensure that there are no discharge pipes from holding tanks discharging sewage to ditches or streams.

The Birch Bay Water and Sewer District should sustain an annual inspection program to detect and eliminate infiltration and leakages in their pipe system. This may include dye tests.

The Whatcom County Health Department recommends that homeowners have their septic tank and drainfield inspected yearly and septic tank pumped once every 3 to 5 years. The Public Works Department should coordinate with the Health Department to develop a program of on-site sewage system inspections at least once every 5 years. Some warning signs of a failure are:

- Odors, surfacing sewage, soggy spots with lush green grass growth in the drainfield or septic tank area.
- Plumbing or septic tank backups
- Slow-draining fixtures
- Gurgling sounds in the plumbing system

Information regarding improper discharges to the stormwater system should be provided to community groups. If citizens notice suspicious pipes discharging to a ditch or stream they should contact public works. Similarly if citizens notice odors, sheens, colors, or turbidity, they should contact the Public Works Department. (Note that this will require discussion and training for Public Works staff.)

5.2.2.3 Spill Response

Supplies of absorbents and booms should be available on all maintenance trucks belonging to the Public Works Department and the Birch Bay Water and Sewer District as well as on all fire trucks. Crews should be trained in noticing and responding to spills.

5.2.2.4 Maintenance and Operations

At present, most public maintenance activity is limited to roads within the watershed. Road maintenance is conducted as necessary and appropriate to maintain road functions. It is funded by the road fund and taxes. Occasionally, additional maintenance related to the drainage system is conducted upon request or in emergency situations.

The drainage system primarily consists of roadside ditches and culverts throughout the watershed. There are also several tide gates and many surface water detention facilities. The roadside ditches and culverts are maintained by the County as needed to protect the roadway and to provide a safe transportation facility. The ditch and culvert system should continue to be maintained by the road program. Work orders generated by the inspections should be implemented. The drainage system should be evaluated to identify opportunities to enhance treatment, infiltration, and detention. The opportunities should be evaluated and prioritized. High priority retrofit projects should be funded and implemented.

There is currently no entity responsible for maintaining the tide gates. When requested, the County has occasionally cleaned or repaired the tide gates and other drainage facilities outside the road right-of-way. Responsibility and a funding source for tide gate maintenance and repair should be clarified.

Detention pond maintenance is the responsibility of the private property owner. Experience in multiple jurisdictions has shown that private detention ponds are rarely maintained by private parties without a public inspection program and a legal requirement to do so. The County should establish a program of annual inspection of private drainage detention and treatment facilities and a mechanism to require maintenance. Alternatively, the County should assume the responsibility for maintenance of residential facilities.

Maintenance and operations are also discussed in a separate technical memorandum attached as Appendix C to this plan.

5.2.2.5 Education

Most of the stormwater issues in the Birch Bay Watershed are caused by the everyday actions of the people that live in or visit the watershed. Changing behavior patterns would be far more effective than capital programs. The first step in changing behavior patterns is to increase the understanding of the need for the change and the specific actions that individuals can take. This requires an education program for commercial property owners, maintenance crews, homeowners’ associations, livestock owners, pet owners, boat owners, RV owners, and visitors.

Because of the high levels of short-term summer visitors, it is important to develop educational actions that are onsite at the beach. These would be interpretive panels and displays related to people and pet waste management practices, care of habitat, and other topics.

A list of recommended educational topics and actions includes:

- Manure and erosion management for livestock owners conducted by Whatcom Conservation District. Funding would be needed for one-on-one visits and technical assistance. This would apply to any non-commercial “hobby farms” that are in the area.
- Support for local environmentally focused volunteer organizations including the Watershed Masters/Beach Watchers program and the Marine Resources Committee. Funding would be needed for developing education materials, lab tests for volunteer monitoring activities, a small grants program, and staff time.
- Support for community activities such as volunteer clean-up and native plant days and waterfront celebrations or festivals. Funding would be needed for staff time and display materials.
- Regular articles and advertisements in the local Birch Bay newspaper. Funding would be needed for staff time.
- Display materials for festivals and other special events.
- Information on stormwater management on the County website, http://www.co.whatcom.wa.us/.
- Septic system maintenance information.
- Lawn and garden care, nutrient and pesticide management – adapt the Lake Whatcom “watershed kit” for Birch Bay and make it available in the community.
- Work with local schools to provide teaching materials and opportunities for water quality related actions.
- Provide technical assistance to citizen organizations, developers, and commercial property owners.
- Provide training to maintenance and permit review staff.
- Work with the State Park, Birch Bay Village, and other land owners to develop plans and implement alternatives to large grass areas to discourage waterfowl.
- Provide training information to coastal bluff property owners regarding proper management of drainage, on-site sewage systems, and vegetation..
- Create display boards and fliers for campgrounds and trailer parks.
- Provide signs and brochures for boat owners in marina. Coordinate volunteer education and inspection program. Coordinate with Marina staff.
- Provide information to homeowner associations regarding proper maintenance of drainage systems.

Whatcom County has previously implemented most or all of these recommendations at one time or another in various locations in the county. Therefore, these actions could be implemented as an extension of the responsibilities of staff. Existing materials could be used or modified for Birch Bay as needed rather than developed from new. Refer to Table 5-1 for a list of specific needs for educational actions and their costs.

TABLE 5-1. PROPOSED BIRCH BAY WATERSHED EDUCATION PROGRAM

Issue or Potential Pollutant Source	Audience	Message	Media	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)[a]
Wastewater conveyance system	Birch Bay W&S District	Inspect pipes for leaks	Personal contact with staff	none	Minimal time of existing County staff, $30,000 one-time inspection costs to W&S District from existing revenues	30,000	x
Dogs and cats	Pet owners	Confine pets, pick up waste	General community education media, provide signs and free "mutt mitts" along beach.	one-time grant, expired	Small grants program	15,000	x
Livestock	Owners	Keep manure out of stream, protect soil	Manure and erosion management conducted by Cooperative Extension	"Tips Handbook for Small Farms"	One-on-one contacts by Whatcom Conservation District	15,000	5,000
Commercial sources	Owners and operators	Awareness, source control	Brochures, inspections, individual contact if problems noticed	none	Watershed keeper, 0.5 FTE		50,000
Recreational vehicles and trailers	Owners and operators	Use dump station	Display boards and fliers for campgrounds and trailer parks	none	Materials and installation	25,000	x
Marina	Owners and staff	Awareness, close Y valves, use pump station	Signs, inspections, coordination with marina staff and volunteers	none	Watershed keeper	10,000	x
Wildlife	General public	Focus on human-induced issues	General community education media	none	Watershed keeper	-	-
Waterfowl (ducks and geese)	Property owners and beach visitors	Modify, grass areas, don't feed	Work with the State Park, Birch Bay Village, and other land owners to develop plans and implement alternatives to large grass areas to discourage waterfowl	none	Watershed keeper	x	x

TABLE 5-1. PROPOSED BIRCH BAY WATERSHED EDUCATION PROGRAM

Issue or Potential Pollutant Source	Audience	Message	Media	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)[a]
Onsite septic systems	Property owners	Clean, maintain, test and repair systems	Septic system maintenance	Health Department has brochures	Watershed keeper	-	x
People	Beach visitors	Use public restrooms	Signs along beach	none	Materials and installation	20,000	-
Improperly maintained detention facilities	Homeowners associations	Maintain detention ponds and conveyances	Brochures, inspections, individual contact if problems noticed	none	Watershed keeper	-	x
New development	Developers, developer engineers, County plan reviewers, inspectors and maintenance staff	Technical issues and solutions, critical factors affecting performance	Provide technical assistance to citizen organizations, developers, and staff. Formal training programs for staff and private engineers.	none	Develop training materials, staff time for technical assistance, provide training. Initial cost to develop materials and provide one round of training: $50,000. Annual cost to provide training: watershed keeper and staff.	50,000	x
Road maintenance	Road maintenance staff and managers	Awareness of issues, how to identify problems, BMPs for maintenance	Provide training to maintenance and permit review staff	none	Watershed keeper	x	x
General	Residents and visitors	Awareness of issues and specific measures that individuals can do	Support local environmentally focused volunteer organizations including the Watershed Masters / Beach Watchers program	none	Watershed keeper, small grants program: $20,000	x	20,000
			Support community activities such as volunteer clean-up and native	none	Watershed keeper,	x	x

TABLE 5-1. PROPOSED BIRCH BAY WATERSHED EDUCATION PROGRAM

Issue or Potential Pollutant Source	Audience	Message	Media	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)[a]
			plant days and waterfront celebrations or festivals		small grants program		
			Regular articles and advertisements in the local Birch Bay newspaper	none	Watershed keeper	x	x
			Display materials for festivals and other special events	none	Watershed keeper	x	x
			Maintain internet information	none	Watershed keeper	x	x
			Septic system maintenance	none	Watershed keeper	x	x
			Lawn and garden care, nutrient and pesticide management – adapt the Lake Whatcom “watershed kit” for Birch Bay and make available. Refine "stormwater checklist for your lot"	none	Watershed keeper	x	x
			Work with local schools to provide teaching materials and opportunities for water quality related actions	none	Watershed keeper, small grants program	x	x
			Provide technical assistance to citizen organizations, developers, and commercial property owners	none	Watershed keeper	x	x
Coastal Bluff Erosion	Coastal bluff property owners	Sustain native vegetation, connect to sewer, convey stormwater safely to beach	Provide training information to coastal bluff property owners regarding proper management of drainage, on-site sewage systems and vegetation	none, Island County has appropriate printed materials for property	Watershed keeper, $3,000 for printing materials	3,000	x

TABLE 5-1. PROPOSED BIRCH BAY WATERSHED EDUCATION PROGRAM

Issue or Potential Pollutant Source	Audience	Message	Media	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)[a]
				owners			
TOTAL						**168,000**	**75,000**

[a] x = provided by 0.3 FTE of watershed keeper staff position

Note that costs for small grant program are listed only once.

5.2.2.6 Monitoring

In accordance with the NPDES permit conditions, a coordinated monitoring program should be developed. Since the primary water quality issue in the watershed is coliform bacteria, monitoring should be focused on that. The Department of Health monitors bacteria in the shellfish harvesting areas of the bay. There is no systematic monitoring program for the individual sources of bacteria. There have been reports that algae growth has increased in the bay. This may indicate that nutrients have increased.

Monitoring programs should include three elements:

- Compliance monitoring: were the program actions implemented (inspections, education)?
- Effectiveness: did the actions achieve objectives (reduce or eliminate bacterial sources)?
- Validation: did the objectives achieve goal (unrestricted shellfish harvesting)?

The first and most important question to resolve is how the monitoring information would be used to adapt management actions. The monitoring program should be long-term to identify trends. A work group should be formed in the County to answer this question and plan a monitoring program accordingly. The monitoring program should be adjusted periodically to increase its value but care should be taken to sustain a program in a consistent format so that data can be compared and trends identified.

The County has monitoring programs established in other watersheds and already has knowledgeable staff. Professionals from Whatcom County or a third-party consultant may be required to conduct some of the sampling of stormwater discharges to Birch Bay. Using professionals to collect samples or to coordinate sampling events could provide more consistent and reliable water sampling results. However, the program should include an element for volunteer training and coordination that would minimize monitoring hours spent by Whatcom County staff.

A stormwater monitoring program that includes both sampling and visual monitoring can be used for multiple purposes to better protect water quality. Much of the key monitoring may be visual indicators such as oil sheens, surveys of bird and pet concentrations, and discolored stormwater or stormwater with high turbidity. Volunteers can perform visual monitoring as well as most water quality sampling activities.

County staff should coordinate with the DOH to develop a program to monitor septic systems.

The County currently coordinates an annual clam survey. A vegetation survey should be added at the same time to identify potential increases in algae over time. If increases in algae are identified, water quality samples should be taken to test for nutrients. If high concentrations of nutrients are found, additional investigations should be made to find the source. Likely sources of excessive nutrients include golf courses, onsite sewer systems, and large livestock or bird populations.

The Nooksack Salmon Enhancement Association has begun an evaluation of current conditions in and around Terrell Creek. NSEA uses a smolt trap to count young salmon leaving the creek during the spring months. This smolt trap has been placed about one mile upstream from the mouth of Terrell Creek within Birch Bay State Park from March to June each year since 2000. When this smolt trap is in use, it is checked twice per day. Since the smolt trap was first installed, many species of fish were discovered. NSEA has completed fish habitat assessments, including water quality and flow measurements, to determine fish habitat conditions.

Future habitat assessments should include the stretch of open channel along Lora Lane behind the tide gate to determine if this stretch would provide beneficial fish habitat. The fish habitat potential would have to be weighed against the benefits of the existing tide gate.

Following adoption of the stormwater plan, the County should require an annual review of implementation of the recommended actions (compliance monitoring). This could be incorporated with the annual budget review process. At the same time staff should present a list of specific potential bacterial sources identified and whether or not they were reduced or eliminated (effectiveness monitoring). The annual review should include a summary of DOH annual monitoring of coliform in Birch Bay and an analysis of implications for the effectiveness of the programs.

Refer to Table 5-2 for a list of specific needs for monitoring actions and their costs.

TABLE 5-2. PROPOSED BIRCH BAY STORMWATER MONITORING PROGRAM

Common Pollutants of Concern and Other Issues	Typical Sources	Indicator or parameter	Monitoring Approach				Existing County Resource	Additional County Resources Needed	One-time Cost of Additional Need	Annual Cost of Additional Need
			Targeting and Phasing	Frequency	Staff	Volunteers				
Human pathogens such as cholera, salmonella,	Septic systems, boats, trailers and motor homes, leaking sewers, people outdoors	Coliform bacteria or optical brighteners	Coliform counts at stormwater outfalls first, then upstream of problem areas to source. Pilot-test RNA source tracing and optical brighteners, then expand to additional locations as appropriate.	Monthly, random days	Organize and train volunteers to collect samples, manage laboratory testing and data management	Available to help collect samples	Knowledgeable staff but limited availability	Watershed keeper, 0.2 FTE. Consultant and laboratory assistance to conduct pilot tests.	$100,000	$20,000
Total Suspended Solids (TSS)	Construction, stream channel erosion, landslides, roadside ditches, soil erosion from yards and fields, brake and tire wear, dust, pavement wear, road sanding	TSS	Regular visual inspections to identify locations with frequent problems	Monthly, random days	Organize and train volunteers to conduct visual inspections	Available to provide visual monitoring	Knowledgeable staff but limited availability	Watershed keeper	0	x

TABLE 5-2. PROPOSED BIRCH BAY STORMWATER MONITORING PROGRAM

Common Pollutants of Concern and Other Issues	Typical Sources	Indicator or parameter	Monitoring Approach				Existing County Resource	Additional County Resources Needed	One-time Cost of Additional Need	Annual Cost of Additional Need
			Targeting and Phasing	Frequency	Staff	Volunteers				
Turbidity	Construction, stream channel erosion, landslides, roadside ditches, soil erosion from yards and fields, brake and tire wear, dust, pavement wear, road sanding,	Turbidity	Regular visual inspections to identify locations with frequent problems	Monthly, random days	Organize and train volunteers to conduct visual inspections	Available to provide visual monitoring	Knowledgeable staff but limited availability	Watershed keeper	0	x
Nutrients	Detergents and fertilizers, failing septic systems or leaking wastewater systems	Total and dissolved phosphorus, nitrogen. Visual indicators include excessive algae growth and vegetation transects on beach.	Regular visual inspections to identify locations with frequent problems, transects on beach	Annual	Organize and train volunteers to conduct visual inspections	Available to provide visual monitoring	Knowledgeable staff but limited availability	Watershed keeper	0	x
Hydrocarbons	Vehicle exhaust, leaks and drips	Visual indicators include oil sheen on surface	Regular visual inspections to identify locations	Monthly, random days	Organize and train volunteers to conduct visual	Available to provide visual monitoring	Knowledgeable staff but limited availability	Watershed keeper	0	x

TABLE 5-2. PROPOSED BIRCH BAY STORMWATER MONITORING PROGRAM

Common Pollutants of Concern and Other Issues	Typical Sources	Indicator or parameter	Monitoring Approach				Existing County Resource	Additional County Resources Needed	One-time Cost of Additional Need	Annual Cost of Additional Need
			Targeting and Phasing	Frequency	Staff	Volunteers				
		water	with frequent problems		inspections					
Heavy metals	Brake and tire wear, pipe leaks	Total and dissolved zinc and copper	No monitoring proposed						0	x
Healthy clam populations	Multiple factors include pollutants, disease, over-harvesting, exotic species competition, silt, temperature, natural predators	Species diversity and abundance	Volunteer transects combined with vegetation surveys	Annual	Organize and train volunteers to conduct visual inspections	Available to provide visual monitoring	Knowledgeable staff but limited availability	Watershed keeper	$500	x
Data management								0.1 FTE	0	$10,000
Overall coordination								watershed keeper	0	x
Total Cost									$100,500	$30,000

x = cost of watershed keeper shown only once

5.2.2.7 Regulations

The County should:

- Adopt and enforce the 2005 version of the Ecology Stormwater Management Manual for Western Washington (Ecology, 2005) and update County Development Standards for stormwater management in response.
- Adopt a LID ordinance that includes requirements for infiltration and reduced impervious surface. Small lots and shared open space should be encouraged. Remove any regulatory barriers to this, including allocating appropriate resources to ensure enforcement. Apply LID regulations in a way that makes sense given variations in site conditions (for instance, along steep slopes and on coastal bluffs).
- Prohibit discharge of pollutants to the stormwater system.
- Adopt requirements for annual inspections and corrections for septic systems.
- Create a Shellfish Protection District that comprises the Birch Bay watershed to increase awareness of the resource.

County maintenance staff indicated that permit review staff do not normally check with Public Works maintenance crews to determine if there are drainage issues near proposed developments. Existing drainage problems can be made worse by additional development, or they could often be resolved by the new development if the design engineers are aware of the issue. New development should not be allowed to make existing drainage problems worse. It would be helpful to identify a mechanism to check with road maintenance staff about existing drainage problems when reviewing permit applications.

Additional recommendations for additions and modifications to regulations are discussed in Chapter 2.

5.2.2.8 Record-Keeping and Annual Reporting

The draft NPDES permit requires keeping records of all activities. These include:

- SWMP development and implementation
- Annual report of SWMP effectiveness
- Number of inspections
- Enforcement actions
- Education activities

5.2.2.9 Watershed Keeper

Many of the needs for Birch Bay could be addressed by having a staff person dedicated to the water quality, quantity, and habitat issues of the watershed. Many jurisdictions have identified these staff as watershed keepers. This is the person that residents know to call and that coordinates all of the activities of the watershed. Approximately one half-time (0.5 full-time-equivalent [FTE]) person is needed to provide the education and coordination of related activities in the watershed. Approximately 20 percent of a full-time person (0.2 FTE) is needed to conduct or coordinate monitoring activity in the watershed.

5.2.2.10 Administration

The SWMP program recommendations will require additional administration costs and personnel. One staff person should act as a “watershed keeper” or similar designation. As an initial effort to establish the education program, approximately 50 percent of a FTE person should be adequate. A permanent and dedicated funding source should be found.

5.2.3 Summary of Programmatic Recommendations

The programmatic action recommendations are summarized in Table 5-3.

TABLE 5-3. NEEDS ADDRESSED BY PROGRAMMATIC RECOMMENDATIONS

Program Element	Needs Addressed		
	Water Quality	**Drainage and Erosion**	**Aquatic Habitat**
Complaint Response	💧	💧	💧
Drainage Inspections and Illicit Connections	💧	💧	
Spill Response	💧		
Maintenance and Operations	💧	💧	
Education	💧	💧	💧
Monitoring	💧	💧	💧
Regulatory Changes	💧	💧	💧
Record Keeping	💧	💧	💧
Watershed Keeper	💧	💧	💧
Administration			

5.3 Projects Recommended for Capital Improvement Program

Projects recommended for the Whatcom County CIP are structural, not programmatic, in nature. Twelve different stormwater problems were identified as having potential structural solutions. The six ranked at the top are recommended here. Additional details of each project are included in the technical memorandum and fact sheets included in Appendix E.

One top-ranked problem, erosion of the Birch Bay Drive road surface, will be addressed in a future Whatcom County project (CC-02) that is already in the planning stages. Therefore, it was eliminated from this CIP prioritization analysis.

5.3.1 Descriptions of Priority Capital Projects

5.3.1.1 Drainage Improvements, Cottonwood Neighborhood (CT-06)

Stormwater runoff for a large portion of the Cottonwood Neighborhood is conveyed through an open channel through the County Park and into a closed-pipe system consisting of a pipe leading to a structure that diverts the flow into two different outfalls along Cottonwood Beach. Flooding occurs in the yards along Birch Bay Drive close to the system outlets. Development is expected to continue in the upstream portions of the drainage basin. This system must be capable of handling any additional flows due to these new developments. The failing system is on private property and was constructed by private property owners.

Solutions involving full trenching and pipe re-route/replacement would be the most cost-intensive potential alternatives. Installation of cast-in-place lining in the northernmost outlet pipe and replacement of outfall structures on both the outlet pipes appear to be the most cost-effective structural options.

Additional analysis of the system and the flows is needed followed by design and construction of improvements. Additional analysis may include a hydrologic and hydraulic model of the system. Further hydrologic study would allow designers to quantify the contributing area and corresponding design flows through the system. The hydraulics of the system should be analyzed to determine current head losses and other flow characteristics when the system is running at capacity. Site investigation techniques such as closed-circuit television (CCTV) pipe inspections, dye-testing, surveys, etc., should be used to further characterize the system before a preferred solution is implemented.

5.3.1.2 Drainage Improvements, Shintaffer at Richmond Park (CT-01)

The drainage ditch flowing south along the west side of Shintaffer Road conveys runoff from a large area west of Shintaffer. The ditch along the west side of Shintaffer flows through two 90-degree bends from the drainage ditch along Shintaffer towards the Richmond Park Subdivision. Runoff is then conveyed in ditches and culverts through the subdivision before discharging to a creek system through a ravine flowing to the south towards Birch Bay. The creek enters a culvert under Birch Bay Drive, and then enters Birch Bay within Rogers Slough.

Yards in the Richmond Park Subdivision are submerged during heavy rains as the system backs up. Residents near the creek below the Richmond Park subdivision have experienced erosion and slope degradation in back yards along the ravine.

Preliminary development plans for the open area to the north and west of the Richmond Park Subdivision indicate that runoff from most of that area will be re-routed away from the current outlet through the subdivision. A new conveyance will be constructed to Birch Bay for those flows. Approximately 1.5 acres of the currently contributing area will then drain through the subdivision. This will remove most of the peak flows that currently cause problems in the Richmond Park subdivision.

Due to these preliminary development plans, the preferred solution is to promote this re-routing of flows and to maximize the current conveyance capacity of the system. The existing drainage ditches along the east side of Shintaffer Road should be re-graded to provide positive drainage and maintained. The drainage system through the Richmond Park Subdivision should also be inspected and maintained as needed.

Additional analysis of the system and the flows may be needed to assess the long-term affects this hydrologic regime may have on the erosion and slope degradation occurring in the backyards along the ravine downstream of the Richmond Park Subdivision. The preferred solution should incorporate the potential impacts that future development will have on the hydrologic regime of this system.

5.3.1.3 Lower Terrell Creek Improvements for Water Quality Benefits (CC-12)

It is natural for a coastal stream to move in the direction of long-shore drift. Then, during large storm events the creek would cut through to a new, more direct outlet to salt water and the process starts over. As development in Birch Bay proceeded, sections of Terrell Creek were confined and the creek no longer was allowed to find a natural course. Terrell Creek has low dissolved oxygen levels and high temperatures due to upstream activities within the watershed plus the confined nature of its path that limits circulation.

One alternative under this project would involve a feasibility analysis plus the design and construction of a more direct outlet for Terrell Creek. However, this alternative may be more harmful than it is helpful, as the current configuration of Terrell Creek includes an extensive estuarine area that provides habitat for several species of fish, birds, and waterfowl. Though conditions in Terrell Creek under the current alignment aren’t ideal, realigning the mouth of the creek has the potential to negatively affect the current habitat conditions in the creek.

Because of this constraint, the preferred solution for this project is to improve water quality conditions within Terrell Creek through programmatic solutions such as source control efforts rather than structural means. These programmatic solutions are described earlier in this chapter. An intensive program of tree planting is included to provide shade.

Programmatic solutions would provide more benefit for less cost (both financial and environmental) than would the structural solution. A concept-level cost estimate for the structural alternative of re-aligning Terrell Creek is close to $2 million, including construction costs (plus 50 percent contingency) and soft costs (permitting, legal costs of 30 percent of construction costs, and engineering study/design costs of an additional 30 percent). The high costs for permitting and engineering study/design reflect the specific issues of a construction project along a shoreline and within a salmon-bearing stream such as Terrell Creek.

5.3.1.4 Drainage Improvements, Birch Point, Various Locations (BR-02)

The natural hydrology in the Birch Point area has been altered due to past development. Construction of roadways, roadside ditches, and homes has altered the surface and subsurface flow. Loss of vegetation has increased volumes of runoff and peak flows. Surface flow is conveyed in cross-culverts and roadside ditches, and then flows towards Birch Bay in concentrated flow streams that may contribute to erosion and stability problems at the bluff.

Several localized surface drainage issues have been identified in the Birch Point Area. This project would involve addressing these issues by increasing the capacity of these drainages in a manner consistent with BMPs for active landslide areas. The most immediate need is for proper conveyance of drainage from upstream contributing areas. This project would involve the design and construction of tight-line (closed-pipe) drainage at the edge of the slope then down the slope. This setup would be repeated up to three additional times depending on location and magnitude of runoff flows from upstream areas.

The preferred solution is the structural alternative of constructing tight-line drainage from the edge of the bluff (including steep slopes) and down to the beach. This solution could be applied at any or all of the specific identified surface runoff outlets from upstream property.

Several of the problem spots may be addressed with structural projects such as drainage re-routes and capacity increases. However, these capital project solutions should be performed concurrently with programmatic solutions such as public education on proper drainage techniques, stricter requirements on addition of impervious surface and tree removal, increased inspection and enforcement of land clearing and drainage requirements, and the implementation of projects such as LID that have the potential for limiting runoff from upstream areas. Infiltration should not be encouraged within 300 feet of the bluffs due to the potential to increase slides. These programmatic solutions are addressed earlier in this chapter. These programmatic solutions will address sub-surface flow and erosion/stability issues around Birch Point that are not specifically addressed with this structural surface runoff improvement project.

If slides along the bluff continue, residents should consider formation of a local improvement district to finance installation of sewers. Homeowners should inspect their own property and route their drainage away from the bluff, or build their own conveyance to the beach.

5.3.1.5 Terrell Creek Culvert at Grandview Road (CC-11)

The Grandview Road crossing of Terrell Creek is currently a fish passage barrier under low-flow conditions. The culvert is situated high enough above the creek bed that any fish passage is impossible under low flows.

The preferred solution is the replacement of the existing culvert with a box culvert to allow for year-round fish passage under all flow regimes.

5.3.1.6 Drainage Improvements, Rogers Slough at Birch Bay Drive (BV-01)

Drainage ditches discharging to Rogers Slough back up behind the tide gate under high tide and/or wet weather conditions. When these ditches overflow, backyard flooding occurs in the homes within Birch Bay Village that have back yards along Birch Point Road. Ditches also back up along the north side of Birch Point Road.

Much of this area may be at or just above high tide level. During wet periods, runoff will back up behind the existing tide gate until the tide recedes and this runoff can discharge through the gate. Note that the flooded areas are low and historically are likely to have been wet even before homes and roads were built in the area.

More frequent removal of dead trees from Rogers Slough may help alleviate the drainage problems. A biological review of this activity should be conducted to determine potential impacts. An analysis of coastal processes should also be completed to determine if it would provide long-term benefit.

A detailed study of the area and the problem should be conducted as part of the preferred solution. A survey would yield detailed elevations of homes, yards, roadways, drainage ditches, pipes, and the tide gate in relation to tidal elevations within Rogers Slough. Further hydrologic study would allow designers to quantify the contributing area and corresponding design flows through the system. In addition, the formulation of a hydrologic model would enable planners to determine adequate detention requirements for future developments. This may include increased detention requirements for any additional developments planned for the contributing area that would exceed the current detention capabilities of the existing system.

Drainage ditches, culverts, and pipes may be upgraded to maximize conveyance capacity. The tide gate may be replaced, depending on the results of the initial study. As an initial estimate, this preferred structural solution (if required, depending on results of detailed study) would cost $425,000, including construction costs plus 50 percent contingency and soft costs (permitting, engineering/design, etc.) of 30 percent.

Any capital project should be coordinated with updated operations and maintenance procedures and plans associated with tide gates and tide gate operation. In addition, any updates to planning requirements and requirements on LID and other source control should be made with this problem and project in mind.

5.3.2 Summary of Action Recommendations

- Pursue capital projects to address water quantity, water quality, and habitat issues
- Implement programmatic solutions along with capital projects to optimize success

5.4 Estimated Costs of Programmatic and Structural Alternatives

Tables 5-4, 5-5, and 5-6 summarize the costs of the programmatic and structural alternatives.

TABLE 5-4. BIRCH BAY PROPOSED PROGRAM COSTS

Program Element	Actions	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)
Complaint Response	Develop organizational responsibility, train staff	Existing staff adequate, need direction and training	0.1 FTE time to plan and train	10,000	existing staff
Inspections and Illicit Connections	Develop and implement inspection program	none	0.1 FTE to plan, coordinate and implement		10,000
Spill Response	Provide materials, train staff	Existing staff	0.1 FTE once to provide training	10,000	5,000
Maintenance and Operations	See Maintenance and Operations Section		0.5 FTE	-	50,000
Education	See Table 5-1	Knowledgeable staff but limited availability	Watershed Keeper 0.5 FTE	168,000	75,000

TABLE 5-4. BIRCH BAY PROPOSED PROGRAM COSTS

Program Element	Actions	Existing County Resource	Additional County resources needed	One-time Cost of additional need ($)	Annual Cost of additional need ($)
Monitoring	See Table 5-2	Knowledgeable staff but limited availability	Watershed Keeper 0.2 FTE	100,500	30,000
Regulatory	Revise existing regulations	Knowledgeable staff but limited availability	0.5 FTE one time	50,000	-
Record Keeping and Annual Reporting		Knowledgeable staff but limited availability	0.1 FTE	-	10,000
Administration	Develop, implement and manage billing system, manage overall program	Knowledgeable staff but limited availability	0.1 FTE Administrative Support, one time cost to implement billing system	150,000	10,000
Total				488,500	190,000

TABLE 5-5. PRIORITY CAPITAL PROJECTS FOR WHATCOM COUNTY CIP

Capital Project Name	Capital Project Description	Type of Problem (Drainage, Water Quality, or Habitat)	Concept-Level Cost Estimate of Preferred Capital Solution[a]
CC-02[b]	Birch Bay Drive Roadway Improvements *[Project already underway]*	Drainage or Erosion / Stability	--
CT-06	Drainage Improvements, Cottonwood Neighborhood	Drainage	$225,000
CT-01	Drainage Improvements, Shintaffer at Richmond Park	Drainage	$125,000
CC-12	Terrell Creek Improvements for Water Quality	Water Quality and Habitat	$50,000
BR-12	Drainage Improvements, Birch Point, Various Locations	Drainage	$250,000 for each individual location (up to 4 locations)
CC-11	Terrell Creek Culvert at Grandview Road	Habitat	$460,000
BV-01	Drainage Improvements, Rogers Slough at Birch Bay Drive	Drainage	$425,000

[a]Preliminary cost estimates include construction costs with +50% contingency and +25% for “soft” costs such as permitting and engineering/design.
[b]Birch Bay Drive Roadway Improvements are part of a project that is currently underway within Whatcom County. Therefore, this problem is not addressed in this analysis.

TABLE 5-6. SUMMARY OF ANNUAL FTES AND CASH OUTLAY				
	FTE			
Program:	**Watershed Keeper**	**Technical or Management**	**Maintenance**	**Office or Financial**
Education	0.5			
Monitoring	0.2	0.1		
Complaint Response			x	
Inspection and Illicit Connections	0.1			
Spill Response			0.1	
Maintenance and Operations			0.5	
Regulatory				
Record Keeping and Annual Report	0.1			
Administration and Financial		0.1		0.1
TOTAL FTEs	**0.9**	**0.2**	**0.6**	**0.1**
Annual Cash Outlay:				
Conservation District			$5,000	
Spill Response Materials			$5,000	
Small Grant Program			$20,000	
TOTAL			$30,000	

6 Financial Analysis and Funding Recommendations

6.1 Introduction

Whatcom County currently has a county-wide flood control zone district (FCZD). The FCZD is funded by taxes on real property county-wide. Funds from the FCZD have been used primarily to address flooding issues along the Nooksack River. Several sub flood control zone districts have also been created to provide additional funding and focus on local flooding issues. Operations and maintenance for drainage in Birch Bay are currently funded primarily from the County's road fund. To date, the County has been able to provide a minimal level of drainage service with its existing road fund revenues; however, continued growth and increasing regulatory requirements (see Chapter 2 for description) necessitate additional funding.

Additional funding will allow the County to protect public health and safety, meet public expectations regarding surface water, and address the regulatory requirements of the state, the Clean Water Act, and the Endangered Species Act while preparing a long-term strategy for operating these programs. The goals of the recommended funding sources are focused on maximizing customer services and assuring that the charges are assessed in a manner that is credible, defensible, equitable, and administratively feasible.

This chapter presents a description of planning data, an evaluation of revenue needs and available financing mechanisms, a description of the storm and surface water utility user rate development, and a summary of recommendations. The planning data section includes the basis for the storm and surface water system impervious area and system growth projections. The proposed SWMP and CIP are described in Chapter 5 of this plan. Chapter 2 is an overview of the regulations and impacts to the SWMP. Section 6.3, Program Description and Revenue Needs, includes a more detailed description of the regulatory impacts and the cost of individual program elements. The evaluation of available financing mechanisms (Section 6.4) includes alternatives for funding operation and maintenance (O&M) and capital expenses. The surface water management user rate development section (6.5) includes a description of administrative policy considerations and a recommended storm and surface water utility rate structure.

6.2 Planning Data

6.2.1 Equivalent Residential Units

The recommended rate structure is based on the amount of impervious area of a property (discussed in Section 6.5). A property's surface water rate is defined by the number of equivalent residential units (ERUs) it contains. One ERU is equal to the impervious area of an average single-family residential unit. Impervious area for each non-single-family residential unit is defined in terms of ERUs. A flat rate per ERU can then be applied to all properties.

An ERU of 3,000 square feet (ft^2) of impervious area is used for this analysis (same as City of Bellingham). For planning purposes, ERUs for non-residential properties were estimated by determining the total area of properties with similar existing types of land use (e.g., multi-residential, commercial, industrial, institutional, public, duplex, and other) and applying estimates of percent impervious area. The data were obtained from the County's GIS layers for land use, parcels, and impervious coverage (from satellite interpretation). As shown in Table 6-1, an estimate of 12,161 ERUs was identified in the Birch Bay watershed.

Note that these ERU totals are very preliminary numbers and they will likely change if additional analysis is performed before the final adoption of a rate. In addition, under provisions of the existing stormwater development regulations and development standards, duplexes have been treated the same as single family residential development. These ERU totals and their distribution among land uses could be revised based on a decision of how duplexes should be incorporated into the totals.

TABLE 6-1. SUMMARY OF EQUIVALENT RESIDENTIAL UNIT CALCULATION[A]

Land-Use	Total Area (ft^2)	% Impervious	Impervious Area (ft^2)	ERUs[b] (3000 ft^2)
Single Family Residential[c]	219,619,599	7	15,157,991	5,053
Multi-Residential[a]	40,710,212	11	4,300,505	1,434
Commercial[a]	29,130,800	32	9,273,965	3,091
Industrial[a]	94,112,722	17	15,579,232	5,193
Agricultural[a]	227,829,382	2	3,683,864	1,228
Forest[a]	48,068,729	1	307,801	103
Park[a]	38,763,953	3	1,187,100	396
TOTAL ERUs (excl. roadway)				**16,498**
TOTAL ROADWAY ERUs[d]	14,644,549	14	1,992,201	664
TOTAL ERUs (incl. Roadway)			36,324,667	**17,161**
Adjusted Total without BP (Cherry Point)				**12,161**
Water	12,153,477	0	36,272	**12**

[a]Source: Whatcom County GIS
[b]Source: Current City of Bellingham ERU
[c]Correlates well with census data from Birch Bay Subarea Plan
[d]ERUs are based on 30% of total impervious area, which assumes 30% of ROW impervious area will be billed.

6.2.2 Projected Service Area Growth

Population projections were obtained from the Birch Bay Sub Area Plan, which describes a year 2000 population for the census area 4,961 and a projected 2022 population of 9,619. This projected growth averages 4 percent over the 22-year period 2000 to 2022. Throughout this report, residential growth is projected to be 4 percent per year, and non-residential growth is projected to occur at the same rate as residential growth. No increase in the ERUs charged to the County's road fund and WSDOT is forecast.

6.3 Program Description and Revenue Needs

The purpose of this section is to summarize the recommended programmatic elements for the Birch Bay Surface Water Management Program. These are described more fully in Chapter 5. Program elements include the type of service to be offered and the level of effort for each service. Some of the program elements are necessary to meet various state and federal regulatory requirements and to meet public expectations, and some are recommended to meet the County's obligation to protect public health and safety. The following sections discuss public expectations for service and basic assumptions about the level of effort and costs of the SWMP.

6.3.1 Public Expectations for Surface Water Program

Independent of state and federal regulatory requirements, the community has expectations for management of the storm and surface water system by the County. At a minimum, citizens expect to be protected from flood hazards and water quality hazards. Until basic drainage and flooding problems are addressed, the citizens will not be interested in paying more for compliance with state and federal regulations. Thus, a top priority for any surface water program must be to protect citizens and property from flood and water quality related human health hazards. Once these basic issues are addressed, the citizens will be more interested in water quality impacts to fish, fish habitat, and community values such as aesthetics and education.

The completion of a comprehensive plan by the citizens of Birch Bay that called for a stormwater plan is a good example of local public expectations. This planning effort provides evidence to support an underlying assumption of this Stormwater Plan, that the citizens of Birch Bay place a relatively high value on environmental issues. This plan assumes therefore that the County's program must at least meet the requirements for the various state and federal regulations. The recommended alternative includes basic regulatory compliance and additional protection of water quality and aquatic habitat.

6.3.2 Program Elements and Level of Effort

Table 5-1 in Section 5 lists the recommended programmatic activities and their estimated costs. These costs are used for purposes of analysis in the following sections regarding finance.

6.4 Evaluation of Available Financing Mechanisms

This section reviews alternatives for financing the SWMP for the watersheds of Birch Bay. It begins with a review of special districts and stormwater utilities, which are entities that can be established to assume responsibility for funding and management of watershed programs. It then addresses specific mechanisms to fund or finance improvements to the system as well as its ongoing operations, including debt, grants, taxes, developer financing, fees, and charges. The section presents each alternative, identifies pros and cons, and closes with broad recommendations.

There are several mechanisms available to generate revenue targeted to specific services. These revenue source options have been created over time to provide services for specific local circumstances that do not get funded by counties because they are not county-wide issues. They have the advantage that they address local issues and are funded by those that are interested in the services. While citizens often resist increases in general taxes, they often support revenues that target specific services they want.

For a reference on funding stormwater programs, see:
http://www.nafsma.org/Guidance%20Manual%20Version%202X.pdf

6.4.1 Special Service Districts[1]

In Washington, special purpose districts (85.38 RCW) are limited-purpose local government entities, separate from a city, town, or county government. Generally they perform a single function, although some perform a limited number of functions not otherwise available from city or county governments. Special purpose districts are generally created through the county legislative authority to meet a specific need of the local community, such as a new or higher level of service. Once formed, many of the fiscal and administrative functions of special purpose districts are handled by the county government.

Most special purpose districts in Washington derive revenues from real property assessments and are taxing districts. Most have the power to impose taxes upon district property in proportion to property value, as opposed to obtaining revenue for public purposes in proportion to the benefits accruing to it. Some special districts (such as diking and drainage districts) are authorized to levy *benefit assessments*, which are charges to land owners based on the benefits their property receives from the project being funded with the proceeds of the assessment. Other special districts (such as flood control [86.09 RCW], flood control zone [RCW 86.15 RCW], and shellfish protection districts [90.72 RCW]) are authorized to *charge fees* directly for services. Revenues of special districts typically may be used for the ongoing operations and maintenance of facilities, as well as for capital costs. Whatcom County already has a county-wide flood control district, certain sub-flood control districts, and shellfish protection districts. Addition of a sub-flood control district for Birch Bay would be relatively straight-forward.

The Washington State legislature provides authority and specifies general procedures for the formation of special districts. The majority are formed by a resolution of or petition to the county legislative authority. Almost all formations require a formal public hearing to determine the need for the district, and in some instances a feasibility study is required. The formation generally requires an election to determine whether the majority of residents or landowners wish to form a district and pay taxes to receive the service.

Table 6-2 provides a summary of the different types of special districts in Washington of relevance to stormwater management. The table includes type of district, enabling statute and date it was created, purpose, formation, governance, and revenues.

[1] Portions of this section, and Table 6-2, were drawn from the Municipal Research & Services Center (MRSC), a non-profit, independent organization located in Seattle, Washington. Website: http://www.mrsc.org/index.aspx.

TABLE 6-2. SELECTED SPECIAL DISTRICTS AND A STORMWATER UTILITY IN WASHINGTON STATE AND THEIR KEY COMPONENTS

Type of District, Enabling Statute & Date Created	Purpose	Formation	Governance	Revenues
Diking District Ch. 85.05 RCW 1895	Straighten, widen, deepen, and improve all rivers, watercourses, or streams, construct diking system to protect land from overflow	Resolution or petition of 10 property owners; feasibility determination by county engineer; hearing; election pursuant to Ch. 85.38 RCW	Board of 3 elected commissioners	Special benefit assessments (based on the benefit to property rather than value of the property); bonds; participating counties/cities may appropriate funds for the district; participating cities may levy an assessment on property
Drainage District Ch. 85.06 RCW 1895	Establish drainage system	Same as Diking District	Board of 3 elected commissioners; consolidated districts could retain 5-member board	Same as Diking District
Flood Control District Ch. 86.09 RCW 1937	Protect life and property, preserve public health, and conserve and develop the natural resources; includes improvement, replacement, repair, or acquisition of works/ property to control floods	Same as Diking District; if less than 500 acres, petition of 50% of acreage	Board of 3 district commissioners, initially appointed; elected per Ch. 85.38 RCW (Special district creation and operation)	Special assessments (proportionate to benefits); fees and charges; bonds
Flood Control Zone District Ch. 86.15 RCW 1961	Undertake, operate, or maintain flood control projects/stormwater control projects of special benefit to specified areas of the county	Action of board or petition - 25% vote cast in proposed zone at last county general election; once established, the district may divide any or all of the zone into separately designated subzones, operated and legally established as a flood control zone district	Board of county commissioners; option to elect 3 zone supervisors if district of over 2,000 residents	Annual property tax (not to exceed fifty cents per $1000 assessed value); fees and charges; voluntary assessments; local improvement districts to finance capital projects that benefit only a portion of the district's area – with assessments proportionate to benefit property receives; bonds

TABLE 6-2. SELECTED SPECIAL DISTRICTS AND A STORMWATER UTILITY IN WASHINGTON STATE AND THEIR KEY COMPONENTS

Type of District, Enabling Statute & Date Created	Purpose	Formation	Governance	Revenues
Shellfish Protection District - "Clean Water District" Ch. 90.72 RCW 1985	Curb the loss of productive shellfish beds from nonpoint sources of pollution	Motion of county; election	County legislative authority	County tax revenues; fees and charges; priority for state water quality financial assistance to implement shellfish protection programs, including grants and loans
Stormwater Utility Ch. 36.89 RCW	Establish, acquire, develop, construct and improve open space, stormwater control facilities…	County legislative authority by resolution	County legislative authority	County legislative authority "by resolution for revenues by fixing rates and charges for the furnishing of service to those served or receiving benefits…from any storm water control facility or contributing to an increase of surface water runoff."

The value of special districts as a separate governmental form has been debated in many states. Critics question whether there are too many districts and whether they are accountable. Advocates favor providing focused services that respond to special needs and give local control. Some states, not including Washington, have created a uniform set of statutes to govern special districts and provide accountability.

Pros of special districts include that they:

- Concentrate on effectively providing limited services
- Are responsive to constituents, as districts are often geographically small with low population density
- Link those who pay to those who benefit (although not necessarily equitably)
- Offer the same "pros" as a stormwater utility when they are authorized to generate revenue through charges (as per Shellfish and Flood Control districts). These include:
  - Revenues generated are stable, and can increase with community growth and with rate hikes and special fees, allowing for stability of operations and maintenance, long-term planning, and improved ability to comply with NPDES regulations
  - Costs can be directly linked to benefits, enhancing equity.
  - They present a new source of funds, freeing up existing funding for other purposes.

  - Bonds for capital improvements can be issued and repaid through revenues generated.

Cons of special districts include that they:

- Can result in too many units of government, with duplication of costs and weakened consolidated planning
- Tend to lack visibility, confusing residents regarding who is in charge
- Often have limited voter participation in the election of special district officers, detracting from their representative nature
- Entail added administrative complexity, where charges may be established (as per a stormwater utility)

Note that the County is required to form a shellfish protection district and develop a program to address causes of pollution if a shellfish harvesting area is closed or downgraded by the Department of Health as a result of water pollution. This happened in Whatcom County in Portage Bay and Drayton Harbor and a shellfish protection district was formed in each location.

Administratively, the simplest mechanism to fund the SWMP would be to increase the tax rate of the FCZD either county-wide or in the Birch Bay watershed. However, a rate system based on property value is generally less equitable (and therefore, more difficult to defend if challenged) than a system based on impervious surface. Impervious surface is directly related to the amount of runoff from a property. A high value property does not necessarily discharge more surface water or cause more impact than a property with less value.

6.4.2 Birch Bay Water and Sewer District

Water and sewer districts are authorized to provide stormwater service if they choose. An amendment to the district’s general sewerage plan is required, followed by action to revise utility rates. Representatives of the Birch Bay Water and Sewer District have stated that the district has no interest in assuming responsibility for stormwater.

6.4.3 Stormwater Utility

Stormwater utilities (36.89 RCW) are a relatively recent development in municipal stormwater management, with the first established in Washington and Colorado in the early 1970s. A stormwater utility is an enterprise fund that can provide stable funding, through establishment of rates and charges, for stormwater operations and capital projects. Stormwater utilities generally have a variety of objectives, such as funding ongoing or improved maintenance and capital investments, improved flood management capacity and water quality prior to discharge, ecological preservation, as well as planning, education, and outreach.

Most stormwater utilities are designed to provide the majority of a community's stormwater funding, thereby offsetting other funding sources such as the General Fund. Stormwater utility charges are generally based on a user fee per unit of impervious surface area; thus, the amount of impervious surface area and the fee per unit are central factors in revenue generation. Other policy issues that will affect revenue generation include whether undeveloped as well as developed properties are charged, and whether the community charges itself for streets and other public properties.

Pros of a stormwater utility, with associated rates and charges, include:

- Revenues generated are stable, and can increase with community growth and with rate hikes and special fees, allowing for stability of operations and maintenance, long-term planning, and improved ability to comply with NPDES regulations.
- Costs can be directly linked to benefits, enhancing equity.
- They present a new source of funds, freeing up existing funding for other purposes.
- Bonds for capital improvements can be issued and repaid through revenues generated.

Cons of a stormwater utility include:

- They require a commitment of time, resources, and public acceptance to develop.
- They require billing and other administrative functions to operate.

6.4.4 Debt

6.4.4.1 Debt Issuance Repaid by Utility (or Special District) Revenues

6.4.4.1.1 Revenue Bonds

Storm and surface water utility revenue bonds may be backed by revenues of a stormwater utility (or revenue-generating special districts). Interest rates available for revenue bond debt fluctuate with market conditions. *Pros* of issuing revenue bonds include the ability to fund large capital projects where costs exceed available current revenues; they also maintain intergenerational equity. *Cons* of revenue bonds include interest costs, bond issuance costs, bond reserve requirements, and debt service coverage requirements – and the risk that projections for community growth and associated revenue generation may prove overly optimistic.

6.4.4.1.2 State Revolving Fund and Centennial Clean Water Fund

The Department of Ecology's Water Quality Program administers two major funding programs that provide low-interest loans for projects that protect and improve water quality in Washington State. These include the State Revolving Fund (SRF) and the Centennial Clean Water Fund (Centennial) loan program, for which projects that reduce nonpoint sources of water pollution are eligible. Loans are available for up to 100 percent of eligible project costs. Ecology provides financial hardship consideration for facility construction projects that would cause user fees to exceed 1.5 percent of the median household income in the local area. Hardship is addressed through variable interest rates, longer loan terms, partial grants, or a combination of all of these. Separate applications, in separate years, are required for pre-construction and construction funding. These loans are typically considered junior lien to revenue bonds. *Pros* of such loans include favorable financing and the hardship consideration; *cons* include debt-related costs.

6.4.4.1.3 Public Works Trust Fund

The Washington State Department of Community, Trade, and Economic Development administers Public Works Trust Fund (PWTF) loans. PWTF funding may be used for the repair, replacement, or improvement of existing storm and surface water facilities. The interest rate depends on the amount of local financial participation. The construction loan term is 20 years, and loan repayments consist of equal principal payments in years 2 through 20 and interest payments on the unpaid principal. PWTF loans are typically considered junior lien to revenue bonds. *Pros* of such loans include favorable financing; *cons* include debt-related costs.

6.4.4.2 Debt Issuance Repaid by Assessments or Taxes

6.4.4.2.1 General Obligation Bonds

General obligation (G.O.) bonds are backed by the taxing power of the County. *Pros* include that G.O. bonds typically offer lower interest rates than revenue bonds. On the *cons* side, use of G.O. bonds is less common than revenue bonds in utility systems where rate revenues are collected, as G.O. bonds impinge on the borrowing capacity and may affect the bond rating of the County, compete with other projects for which no specific revenue source is available, and may require voter approval. G.O. bonds repaid through property tax assessments may result in distributional inequities, as the cost of a project may not be paid by its beneficiaries.

6.4.4.2.2 Utility Local Improvement Districts

Another potential source of funds for improvements comes through formation of local improvement districts (LIDs). This involves an assessment made against the properties benefiting from the improvements. Utility local improvement districts (ULIDs) are also backed by the revenues of the utility. This type of financing is most commonly applied to extensions of facilities into previously undeveloped areas. *Pros* include distributional equity, the ability to avoid interest costs via early payment of assessments, and the ability of grant funding and/or assessment deferral for low-income and/or low-income senior property owners. *Cons* include that ULIDs are often difficult to form, because the process may be stopped if owners of 40 percent of the property within the ULID boundary protest its formation.

6.4.5 Grant Programs

Assorted federal and state grants for stormwater projects are available. Grant funding is highly competitive, so it should be factored into stormwater capital or financial plans with contingency considerations, in case it does not materialize. The *pros* of grant funding include the infusion of external funding for community benefit; the *cons* include the uncertainty of funding and that it is typically earmarked for specific uses – which may or may not include priority needs. Administrative costs for grant applications and reporting may be high relative to other available funding.

6.4.6 Developer Financing and Latecomers Agreements

Developers may be required, by policy, to cover costs associated with the construction of stormwater system improvements, particularly within new plats. Developer extensions in public rights-of-way would then be deeded to the County upon completion. The County may choose to require, in some cases, construction of oversized conveyance and detention facilities to serve future upstream extensions beyond the development. In these cases, the County may, by policy, reimburse the developer either through direct financial participation or latecomers' agreements. These agreements provide up to 10 years or more for developers to receive payment from future developed properties that receive benefit from the developer-financed improvements. *Pros* of such financing include the equity of linking project costs with users; *cons* may include the lack of direct County or utility control of such projects.

6.4.7 Taxes and Other County Funds

Taxes, including sales tax, fuel tax, and *ad valorem* property tax, may be used to fund stormwater systems. These revenue sources are fully committed to other uses. Therefore, another County service would need to be cut to provide additional funding for Birch Bay surface water issues. *Pros* include a stable source of funding and relative administrative simplicity of collecting the funds. *Cons* include the difficulty of gaining public support, and inequities due to the disconnect between costs and benefits.

Use of other County funds for stormwater capital, operations, and maintenance costs presents *pros* such as relative administrative simplicity; *cons* include lack of distributional equity and potential fluctuations in the level of funding due to competition with other County priorities.

6.4.8 System Development Charges

A system development charge (SDC) is a one-time fee payable by new development. SDC revenue can be used to finance growth-related capital improvements, including improvements for stormwater systems, and to repay debt service on projects on which the SDC is based. SDC revenue cannot be used to fund O&M expenses. *Pros* are that with SDCs, "growth pays for growth," reducing rate impacts on existing customers, who have already invested in the system; this is particularly advantageous in a municipality undergoing rapid growth. *Cons* are that SDC revenues are not guaranteed and have potential economic development impacts.

6.4.9 Miscellaneous Charges and Fees

Other fees may be established to cover costs for specific services. Examples include:

- **Permit review and inspection fees** designed to recover all or a portion of the costs to review development plans and inspect projects under construction, to assure compliance.
- **Special service fees,** which recover the costs of services performed for specific clients, as opposed to the entire service area. This may include annual inspections of onsite detention systems, discharge monitoring, water quality enforcement investigations, and similar specialized activities which have evolved with the expansion of regulatory requirements.

Pros of such fees include that they can enhance equity, whereby those benefiting from the service pay for it. *Cons* include that such fees are not guaranteed revenue, and can fluctuate.

6.4.10 Public Support

Creation of any new revenue source generates opposition. To create public support for a new revenue source, it is imperative to provide a thorough public education program and an opportunity for community dialogue. Public education must clearly explain the need for additional revenue, the specific services that will be provided, and why the fee is fair (provides equity among property owners). The need in Birch Bay can likely be understood by property owners because of rapid growth, the recognition of the value of the shellfish resource, and local drainage issues. Chapter 7 provides a description of a public involvement program.

6.4.11 Governance

Creation of a new funding source can be independent of the question of governance. For example, a sub-flood control zone may be governed by the County Council or by an independent board that could be appointed or elected separately. Another option would be for the Council to appoint an advisory board that would recommend the annual priorities for the program.

Communities often want to see more accountability and to have more control over provision of services. There may be a perception that a county is too large to address the specific needs of the local community. Provision of a structure to address specific community priorities can address the issue.

The fees collected in Birch Bay must be used to provide services to the area (Birch Bay watershed) that generates the revenue. Therefore, the issue of local control may be somewhat reduced, particularly if there is a good public education program to explain the proposed services.

Provision of local control creates the potential for a conflict between the local area and the County at large. For example, if a local community decides to spend all of the revenue on drainage problems, certain regulatory requirements to address water quality might not be addressed. That could create a problem for the County and inequity between local communities in the County. A separate governing board may also increase costs because some of the administrative functions would be duplicated.

6.4.12 Service Delivery

Similar to governance, the creation of a revenue source does not obligate any particular organization to provide the service, as long as the service is provided. For example, the County Public Works Department could provide the service, or the County might be able to contract with the Whatcom Conservation District, the City of Blaine or Ferndale, the Birch Bay Water and Sewer District, or a private company to provide some or all of the services.

There may be certain efficiencies within the County because it already has staff and equipment that do similar or identical work. This might be balanced by cost savings of reduced travel time and local knowledge of another organization.

Contracting with a separate entity creates the potential for conflicts with other County programs or services. For example, a technical recommendation by a separate entity may conflict with County policies or recommendations.

6.4.13 Implementation

Implementation generally requires the following steps:

1. Develop and implement a public education and citizen participation program.
2. Develop a plan of the services to be provided.
3. Develop a rate structure (defining specifically who pays, how much), and select the legal authority for the revenue mechanism.
4. Adopt an ordinance to create the revenue mechanism.
5. Adopt an ordinance to set the rates.
6. Develop the billing system in cooperation with the County treasurer (for the billing format) and the County assessor (for property data).
7. Send the billings and train staff (including all those who answer phones in the treasurer’s office, public works, and Executive and Council offices) on how to properly respond to telephone calls and answer basic questions.

6.4.14 Recommendations

There are many alternatives for funding stormwater management programs. To secure adequate funding, Birch Bay decisionmakers should incorporate a combination of mechanisms that take into consideration both immediate and long-term needs. Any funding plan should also be guided by broad goals, such as customer acceptability, defensibility, revenue sufficiency and stability, equity, administrative ease, and consistency/compatibility with local policies, practices, and long-term strategies. It should include public education and involvement to help ensure ultimate support and success.

Although originally written to address different issues, the laws for stormwater utilities and those for flood control zone districts have been amended and now there is very little difference in the process for formation, the potential revenue-generating mechanism, or the type of services that can be provided by these two types of entities. Each can be formed by the County Council, each can provide a broad range of drainage and flooding related services, and each can generate revenue through assessed valuations, benefits received, or contributions to the need for services. A Flood Control Zone District can assess taxes or utility fees while a stormwater utility is limited to service fees.

Additional funding is needed to address the issues raised by citizens and addressed in this Comprehensive Stormwater Plan for Birch Bay. Additional analysis and public debate are needed before adoption. Stormwater funding mechanisms for Birch Bay should include a combination of:

1. Establishing a sub-flood control zone district with authority to levy fees and charges.
2. Introducing stormwater service rates and charges, and associated policies that include incentives and development financing.
3. Exploring the availability of County funding, as well as federal, state, and other grant funding sources, and pursuing suitable options.

A sub-flood control zone district is recommended because additional revenues are needed and Whatcom County residents and County staff are familiar with the concept. Administration by County staff for creation, billing, financial tracking, and operations would be consistent with other areas of the County and therefore easier.

Billing for the sub-flood control district should be based on the percent of impervious surface on a property as this is directly related to the amount of runoff created on the property. The amount of runoff is directly related to the need for stormwater services. A flat rate for single-family residences should be established to simplify and reduce the costs of the billing system.

The recommendations are to provide revenue sources which by themselves do not result in the need for more staff or changes in the County organizational structure.

Additional discussion is recommended among County departments, legal council, and citizens to evaluate the recommendations and the assumptions listed above. Further refinement of the recommendations and more specific information are needed. For instance, the boundaries of Birch Bay Watershed are hydrological rather than political. The watershed boundaries include part of the Blaine UGA to the north and a small part of the Ferndale UGA to the east. A more detailed survey of the Birch Bay Watershed is needed to finalize actual watershed boundaries for funding purposes.

6.5 Sub-Flood Control Zone District Rate Development

6.5.1 Administrative Policy Considerations

6.5.1.1 Issue: How Should Single-Family Residences and Duplexes Be Charged?

6.5.1.1.1 Background

The basic approach to establishing a surface water rate in this analysis is based on impervious area. Single-family residences (SFRs), of which there are approximately 5,000 within the Birch Bay watershed, contain variable amounts of impervious area. Applying a single amount of impervious area, and therefore a uniform storm and surface water rate, to every single-family residence is an industry standard. This is done to minimize the administrative complexity associated with defining and maintaining records of impervious areas for each household in the watershed. For purposes of this plan, an ERU is defined as 3,000 square feet of impervious area.

6.5.1.1.2 Recommendation

Adopt a single surface water rate for all single-family residences and duplexes. The County may wish to consider adopting a duplex surface water rate if subsequent evaluation of duplexes indicates that they usually contain a greater amount of impervious area than a typical single-family residence.

6.5.1.2 Issue: How Should Properties Other Than Single-Family Residences and Duplexes Be Charged?

6.5.1.2.1 Background

Properties other than single-family residences would include multi-unit residential, commercial, industrial, and institutional properties. Some utilities choose to charge these areas based on total impervious area, that is, establishing a stormwater rate in terms of an ERU and defining, for each non-SFR property, the number of ERUs based on impervious area. This alternative generally balances equity and administrative complexity. Some utilities also base storm and surface water rates on the intensity of development expressed as percent of the parcel that is impervious. This method recognizes a finding by some utilities that, for a given impervious square footage, a smaller parcel (higher % impervious) has higher runoff volumes than a larger parcel (lower % impervious).

6.5.1.2.2 Recommendation

Because of the desire to minimize administrative complexity wherever feasible, base surface water rates for non-SFR and duplex properties on impervious area.

6.5.1.3 Issue: Should Pervious Areas Be Charged?

6.5.1.3.1 Background

Pervious areas include forested areas, pastures, or landscaped open spaces that do not have paving or rooftops and have 0 percent impervious area.

Undeveloped land is a property classification that may or may not be charged. If the property is in its natural state (e.g., forested) then it does not contribute to changes in stream flow or water quality or habitat degradation. However, if the land has been developed (changed from its natural state, e.g., agricultural use, golf course, athletic field), then it contributes to changes in stream flows and degradation of water quality and aquatic habitat. Although the site is still pervious, the change in site conditions has likely changed the amount of natural infiltration and evaporation and transpiration processes, thus increasing the amount of runoff and the degradation of water quality (e.g., sediment loading). If landscaped, the site is likely contributing water quality pollutants in the form of nutrients and pesticides. Parks and cemeteries typically have parking, buildings, and walkways associated with them. The impervious areas within them are thus likely to be subject to the surface water rate. Therefore, these areas are minimal and would generate minimal impacts and minimal revenues for the County overall. Addition of pervious areas to a billing structure raises administrative complexities considerably, because the amount of pervious area for a residential customer would need determination, and the policy of establishing a single rate for single-family residences would need review. Further, because the amount of runoff from pervious areas is less than from impervious areas, a cost-allocation between impervious and pervious areas would typically be completed to establish a pervious storm and surface water rate. Finally, there may be less public acceptance of a storm and surface water rate for pervious areas.

6.5.1.3.2 Recommendation

Charge parcels of pervious area with altered vegetation for surface water service. Apply a flat rate equivalent to one ERU per month per parcel (the same as the SFR rate). Provide an exemption for areas that remain in native forest cover and parcels entirely covered by wetlands.

6.5.1.4 Issue: Should Road Rights-of-Way Be Billed?

6.5.1.4.1 Background:

Road rights-of-way contain large areas of impervious surfaces for streets, sidewalks, and parking. These areas are likely to be large sources of impervious surfaces and therefore large contributors to changes in stream flows and increased streambank erosion and the largest contributor of pollutants to stormwater in the watershed. Ditches associated with roads intercept groundwater and accelerate the velocity of surface water as it moves toward the bay. This increases total surface discharge and peak flows that cause erosion and flooding. These impacts cannot be fully mitigated.

The County road fund currently pays for maintenance and upgrade of the streets. This includes limited maintenance and repair of the streets’ drainage system and street sweeping. The need for the drainage system is caused by the need to drain water from street surfaces for public safety of motorists. However, the existing street storm drainage system also conveys runoff from private property.

Since the street funds pay for maintenance of the streets’ drainage system there is an issue of whether or not the streets should also be subject to the surface water rate.

RCW 90.03.525 states that counties are authorized to charge the Washington State Department of Transportation for storm and surface water services, at a rate equal to 30 percent of that for comparable real property, and only if the County’s streets are also billed. Thus, not billing the County’s streets would prevent the County from billing state highways and would result in a loss of revenue to the watershed. Yet, state highways contribute to the watershed’s stormwater runoff and pollutants.

Billing the streets creates administrative costs to create the billings and collect the funds. Some persons could view billing the streets as simply shuffling revenues from one pot to another, resulting in increased administrative costs overall. Others point out that not billing roads amounts to a subsidy of automobile use, which is contrary to the goals of surface water management and creates inequity in the rate system.

6.5.1.4.2 Recommendation

Bill County roads and WSDOT highways for storm and surface water services.

6.5.1.5 Issue: Should the Surface Water Revenue be Used to Fund Street Sweeping?

6.5.1.5.1 Background

Street sweeping removes large material from the street surfaces. If not picked up by street sweepers, such large material is typically trapped by catch basin grates or catch basins. The majority of pollutants in stormwater are either dissolved or attached to fine particles and are not collected by conventional street sweepers. Thus, street sweeping with conventional street sweepers provides no measurable benefit to water quality. During a brief period in the fall of each year, leaves can collect on catch basin grates and block them causing street flooding. During this period of time, street sweeping can provide a benefit to the public by removing leaves from catch basin grates and preventing localized flooding. Since the street drainage systems are necessary to provide street drainage, the question remains of why the surface water program should pay for street sweeping. Arguably, a small portion of the costs of street sweeping with conventional street sweepers could be justified for funding by the surface water program.

High-efficiency vacuum type sweepers are now available that pick up fine particles. They have been demonstrated to provide significant benefits to water quality. These units can reduce the annual loading of pollutants from the street system by up to 50 percent. If the goal of the County’s street sweeping program is to reduce pollution in stormwater, the County should purchase one of these units. These units are particularly beneficial in industrial and commercial areas and on streets with high traffic volumes where pollutant loadings are higher. The unit could be shared with other watersheds with special water quality sensitivities such as Drayton Harbor or Lake Whatcom.

6.5.1.5.2 Recommendation

The County’s road fund should continue funding conventional street sweeping expenses. The surface water revenues should reimburse the road fund for the purchase, operation, and maintenance costs of the proposed high-efficiency street sweeper at such time as this can be justified for multiple watersheds.

6.5.1.6 Issue: Should a Rate Credit Be Offered To Owners of Onsite Drainage Facilities That Meet Current Code Requirements?

6.5.1.6.1 Background

New developments are required to incorporate stormwater treatment and detention facilities to partially mitigate the impacts of the development. As a result, new development has an added expense and creates less impact overall to the County’s resources. Owners of property with stormwater facilities believe that they should pay less than owners of properties that have no on-site stormwater facilities, and allowing this credit may increase support for the utility fee.

Onsite stormwater facilities can not completely mitigate the impacts of development. Conveyance facilities are still required, and County programs are still needed to compensate for cumulative impacts of existing and new development. Even new facilities require inspection and water quality monitoring, and education is still needed. Thus, a fee is justified and equitable even for new development with onsite stormwater mitigation facilities.

6.5.1.6.2 Recommendation
At this time, no rate reduction should be offered to owners of properties with an onsite stormwater facility.

6.5.1.7 Issue: Should Differential Rates Be Applied To Address Water Quality Issues?

6.5.1.7.1 Background
A portion of the rate will be used for providing services related to water quality. It is possible to quantify the services related to water quality and identify that portion of the utility rate that is due to water quality services. Certain portions of the watershed or certain land uses within the watershed may require more water quality related services. Those portions of the watershed could have a higher rate based on the increased demand for water quality services.

Creating such a proportionate billing system would create additional administrative costs to develop the rate and track expenditures by category and area. Costs related solely to water quality services are difficult to differentiate from water quantity and aquatic habitat services. Benefits associated with water quality services are also difficult to quantify and very little data are available on this subject.

6.5.1.7.2 Recommendation
Because of administrative complexity concerns, do not adopt differential rates to address water quality issues. Include the cost of water quality services in the basic rate without identifying a proportionate share. Do not differentiate the cost of water quality services from water quantity or aquatic habitat related services.

6.5.1.8 Issue: Should Geographically Differentiated Rates Be Applied if Capital Project Expenses Are Distributed Unequally Throughout the Watershed?

6.5.1.8.1 Background
Some areas of the watershed may require more capital improvements than other areas to address flooding, water quality, or aquatic habitat issues. It is possible to quantify these costs by area and charge some areas more than others to pay for the capital facilities needed to address the respective area. While the demand for capital facilities may be related to the development within the basin, it may also be due to other factors such as when the development occurred and the level of existing infrastructure available to serve certain areas. For example, it may not be fair to charge some areas more just because they have been historically under-served by capital facilities and now require more.

Creating a proportionate billing system would also create additional administrative costs to develop the rate and track expenditures by category and area.

6.5.1.8.2 Recommendation
Do not apply a differential rate based on capital improvement needs.

6.5.1.9 Issue: Should Direct Discharges to Birch Bay Receive a Rate Reduction?

6.5.1.9.1 Background
Properties that discharge directly to Birch Bay have no impact to streams. The reasoning follows that since the property owner is not “using” the system, then the property owner should not have to pay; however, all property owners share in the benefits of a surface water program which provides cleaner water and improves and enhances habitat in the watershed’s streams and lakes

and in Birch Bay. In addition, through direct discharge to the bay the runoff from the site may not be treated and may still create water quality impacts and the need for water quality services.

6.5.1.9.2 Recommendation

At this time, no rate reduction should be offered to owners of properties that discharge directly to Birch Bay. In the future, they should receive the same rate discount, if any, that properties with functioning onsite stormwater detention facilities receive.

6.5.1.10 Issue: Should Low-income Seniors Receive a Rate Reduction?

6.5.1.10.1 Background

Low-income seniors may find additional rates and charges create a financial hardship due to fixed incomes. Imposing additional fees on low-income seniors may generate public opposition to the overall program. Low-income seniors are unlikely to own large properties that create disproportionate impacts to the stormwater system. However, tracking incomes and granting reductions will create an additional administrative cost to the County. The County already has a program offering property tax reductions to low-income seniors.

Properties owned by low-income seniors create the same impacts and demand for services as other comparable properties. The decision to grant exemptions is primarily a social policy issue.

6.5.1.10.2 Recommendation

At this time, no rate reduction is anticipated. This matter should be brought before the County Council for further review.

6.5.1.11 Issue: Should Tax-Exempt Properties Receive an Exemption or Reduction in the Stormwater Rates?

6.5.1.11.1 Background

Some owners of tax-exempt properties, such as public or private schools and churches, will not understand the distinction between taxes and utility rates and may believe that they are exempt from the utility rates. These properties impose demands on the stormwater system, and therefore should be required to pay the utility fee like other users of the system. Granting a credit would violate the fundamental basis of the utility fee, which is a user-based fee. Schools and churches generally have large parking areas and large areas of impervious surfaces. Because of this, they create high peak runoff rates and volumes during storm events. As a result, they place particularly high demand on drainage systems and cause significant degradation of streams and other aquatic habitat. However, schools sometimes provide educational services related to water quality and aquatic resources.

6.5.1.11.2 Recommendation

Do not provide a rate exemption or reduction for tax-exempt properties. Do not provide a rate reduction for schools unless a demonstrated benefit and cost savings to the County can be established.

6.5.1.12 Issue: How Should the County Address Account Delinquencies?

6.5.1.12.1 Background

Based on the experience of other utilities, a small percentage of properties can be expected to become delinquent on stormwater utility payments. This creates an issue for the County. If owners are allowed not to pay, it creates an unfair situation for those that do pay. Options for enforcing collections include foreclosing on the property or terminating utility services for the property. Terminating stormwater service to an individual property may not be feasible or effective in inducing payment of the rate. Foreclosing on the property can be expensive and time-consuming for the County.

6.5.1.12.2 Recommendation

If neither taxes nor utility fees are paid, the County should foreclose on the property to collect taxes and utility fees. If partial payments are received, the payments should be applied to the utility bills first and any extra should be applied to the taxes. Then, if necessary, the property can be foreclosed to collect the taxes due.

6.5.2 Surface Water Rate Projection

The following draft financial plan was prepared to estimate the rates needed to fund the recommended SWMP through 2012. This draft financial plan is based on the system planning data (ERUs and system growth projections) shown in Section 6.2, revenue requirements described in Chapter 5, and fiscal policy decisions discussed in Section 6.4. In addition to the maintenance and operations (M&O) and capital revenue requirements described in Chapter 5, surface water rate revenue will be subject to a 1.5 percent state tax.

Tables 6-3 and 6-4 show program expense projections and capita improvement plan costs.

Table 6-5 shows the projected surface water rate through 2012 and a calculation of projected rate revenue from single-family residences, other non-residential accounts, County right-of way (ROW), and WSDOT ROW. The projected monthly surface water rate of $7.00 per ERU would be applicable for purposes of this analysis for January 1, 2007, through 2012. As shown in the table, approximately $1,000,000 of revenue would be generated annually in the watershed with a rate of $7.00 per month per ERU.

Table 6-6 is a 6-year cash flow projection, showing sources and uses of surface water funds. Sources of funds include beginning year reserve balances, surface water rate revenue, permit fees, SDCs, and interest income. Real estate excise tax (REET) revenues are not shown. Table 6-6 includes revenues to illustrate the sources of funds used to cover surface water operating and capital expenses.

Uses of funds in Table 6-6 include operation and maintenance expenses, County and state taxes, capital projects, and end year fund balances. The projected 2012 ending fund balance is approximately $1,537,545, which exceeds the proposed reserve balance policy of exceeding three months of operation and maintenance expenses and one-half the average capital improvement budget. Based on this preliminary analysis a lower rate would be feasible or additional capital projects could be completed.

Prior to implementing a surface water rate, it is assumed that the County will identify impervious areas for each non-residential customer. The financial plan should be revised as these impervious areas for non-SFR customers are defined and as the proposed SWMP is refined.

For purposes of this preliminary analysis only, a single rate source was assumed. If a shellfish Protection District is also adopted it would not change the overall amount of revenue available or the overall expenses.

TABLE 6-3. PROGRAM EXPENSE PROJECTIONS

	Projected 2007	Projected 2008	Projected 2009	Projected 2010	Projected 2011	Projected 2012	Total
Administration							
Financial Management	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$64,684
Rate Reviews	$0	$0	$0	$0	$0	$0	$0
Oversight/Coordination	$20,000	$20,600	$21,218	$21,855	$22,510	$23,185	$129,368
Billing	$160,000	$10,300	$10,609	$10,927	$11,255	$11,593	$214,684
Regulatory							
Inspection and Enforcement (funded by permit fees)	$0	$0	$0	$0	$0	$0	$0
Source Control	$0	$0	$0	$0	$0	$0	$0
Monitoring	$130,500	$30,900	$31,827	$32,782	$33,765	$34,778	$294,552
Record keeping and annual reports	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$64,684
Revise existing regulations (funded by existing sources)	$0	$0	$0	$0	$0	$0	$0
Illicit Connections	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$64,684
Operation and Maintenance							
Operations	$20,000	$20,600	$21,218	$21,855	$22,510	$23,185	$129,368
Street Sweeping	$0	$0	$0	$0	$0	$0	$0
Ditch and culvert cleaning and repair	$50,000	$51,500	$53,045	$54,636	$56,275	$57,964	$323,420
Complaint Response	$20,000	$10,300	$10,609	$10,927	$11,255	$11,593	$74,684
Emergency Response	$15,000	$5,150	$5,305	$5,464	$5,628	$5,796	$42,342
Capital Project Review	$0	$0	$0	$0	$0	$0	$0
Planning							
Update Plan	$0	$50,000		$50,000		$0	$100,000
Inventories	$0	$0	$0	$0	$0	$0	$0
Mapping	$0	$0	$0	$0	$0	$0	$0
Management Zones	$0	$0	$0	$0	$0	$0	$0

TABLE 6-3. PROGRAM EXPENSE PROJECTIONS

	Projected 2007	Projected 2008	Projected 2009	Projected 2010	Projected 2011	Projected 2012	Total
Biological Evaluation	$0	$0	$0	$0	$0	$0	$0
Public Involvement and Education	$243,000	$77,250	$79,568	$81,955	$84,413	$86,946	$653,131
							$2,155,602
Total Non-Capital Cost	**$688,500**	**$307,500**	**$265,225**	**$323,182**	**$281,377**	**$289,819**	**$2,155,602**
Note: Some expenses shown beginning in 2007 may in fact be phased in between 2007 and 2009.							

TABLE 6-4. CAPITAL IMPROVEMENT PLAN - NOT ADJUSTED FOR INFLATION

Project	Dollar Basis	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CC-02 Birch Bay Drive Roadway Improvements	2006 $	$0									
CT-06 Drainage Improvements, Cottonwood neighborhood	2006 $					$125,000	$100,000				
Stormwater Inventory Program	2006 $	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CT-01 Drainage Improvements, Shintaffer at Richmond Park	2006 $						$125,000				
CC-12 Terrell Creek Improvements for Water Quality	2006 $	$50,000									
BR-12 Drainage Improvements, Birch Point	2006 $	$50,000	$150,000		$50,000	$150,000	$215,000				
CC-11 Terrell Creek Culvert at Grandview Road	2006 $	$0					$460,000				
BV-01 Drainage Improvements, Rogers Slough at Birch Bay Drive	2006 $	$0	$50,000	$200,000	$175,000						
Future identified CIP	2006 $	$0	$0	$0	$250,000	$250,000	$250,000				
Total		**$100,000**	**$200,000**	**$200,000**	**$475,000**	**$525,000**	**$1,150,000**	**$0**	**$0**	**$0**	**$0**

TABLE 6-5. PROJECTED RATE SCHEDULE AND RATE REVENUE

	2007	2008	2009	2010	2011	2012
Monthly Rate, $/ERU	$7.00	$7.00	$7.00	$7.00	$7.00	$7.00
Rate Revenue:						
Single-Family Residences	$425,000	$442,000	$459,680	$478,067	$497,190	$517,077
Non-SFR, Excluding Rights-of-Way	$540,000	$561,600	$584,064	$607,427	$631,724	$656,993
County ROW	$55,775	$58,006	$60,326	$62,739	$65,249	$67,859
WSDOT ROW	$0	$0	$0	$0	$0	$0
Projected Annual Rate Revenue	$1,020,775	$1,061,606	$1,104,070	$1,148,233	$1,194,162	$1,241,929

TABLE 6-6. SIX-YEAR CASH FLOW PROJECTION

	2007	2008	2009	2010	2011	2012
Sources of Funds:						
Beginning Balance	$0	$190,095	$701,585	$1,297,378	$1,603,939	$1,947,793
Stormwater Rate Revenue	$1,020,775	$1,061,606	$1,104,070	$1,148,233	$1,194,162	$1,241,929
Permit Fees	$0	$0	$0	$0	$0	$0
SDC Revenue	$0	$0	$0	$0	$0	$0
Real Estate Excise Tax	$0	$0	$0	$0	$0	$0
Interest Income	$15,312	$15,771	$16,244	$16,731	$17,233	$17,750
Total Sources of Funds	$1,036,087	$1,267,472	$1,821,900	$2,462,343	$2,815,334	$3,207,472
Uses of Funds:						
Non-Capital Expenses	$688,500	$307,500	$265,225	$323,182	$281,377	$289,819
Capital Projects	$100,000	$200,000	$200,000	$475,000	$525,000	$1,150,000
Utility 9.5% Tax	$30	$0	$0	$0	$0	$0
State 1.5% Tax	$57,492	$58,386	$59,296	$60,222	$61,165	$62,124
Debt Service	$0	$0	$0	$0	$0	$0
Ending Fund Balance	$195,095	$701,585	$1,297,378	$1,603,939	$1,947,793	$1,705,529
Total Uses of Funds	$1,036,087	$1,267,472	$1,821,900	$2,462,343	$2,815,334	$3,207,472

6.6 Summary of Recommendations

The following recommendations are offered to assist the County in implementing the topics discussed in this section:

- Adopt a sub flood control zone rate to provide revenues to cover the surface water program.
- Complete a public involvement program prior to implementation of the surface water rate.
- Prior to implementing a surface water rate, identify the specific properties that would receive the largest surface water bills, and notify these properties of the key components and milestones of the public involvement program.
- Discuss with the County Council the feasibility of providing a rate reduction for low-income seniors.
- Adopt permit fees that recover the County's expenses associated with permitting, reviewing, and inspection of new development.
- Pursue low-interest loans, such as those from the Public Works Trust Fund and Ecology State Revolving Fund program for eligible capital projects.
- Consider adopting a formal policy dedicating a portion of the County's REET revenues to storm drainage capital projects.
- Prior to implementation of a surface water rate, the County should determine the impervious areas associated with non-SFR properties in order to accurately bill these properties.

7 Recommendations

Several recommendations are made within this Birch Bay Comprehensive Stormwater Plan, summarized below.

7.1 Programmatic Solutions

A Stormwater Management Plan (SWMP) should include the following programmatic elements:

- **Complaint Response:** The public should be provided with a single number to call with complaints regarding drainage, erosion, or water quality issues.
- **Inspections and Identification of Illicit Connections:** An inspection program to detect and eliminate illicit connections should be developed and implemented.
- **Spill Response:** Spill kits should be placed on service vehicles and staff trained in how to identify spills.
- **Regulatory and Policy:**
  - The Stormwater Special District Requirements under WCC 20.80.636 do not specifically require the use of LID techniques. Because of this, new development in the watershed has not been required to maximize LID techniques. Development and adoption of an LID ordinance should be considered.
  - Update Whatcom County Development Standards to meet requirements in 2005 Ecology *Stormwater Manual for Western Washington.* Conduct thorough design review to ensure minimal impacts. Adopt requirements for infiltration and reduced impervious surface and remove regulatory barriers to this.
  - Implement programs and policies to gain compliance with NPDES Phase II. (Birch Bay is not currently required to be covered by the permit, although Whatcom County is.)
  - Encourage local health authorities to identify and correct failing septic systems according to recent legislation. (HB 1458 requires local health authorities to identify and correct failing septic systems by 2012.)
  - Prohibit discharge of pollutants to the stormwater system.
- **Maintenance and Operations:**
  - Conduct inspections and enforcement on existing private developments for proper maintenance of stormwater facilities (detention ponds and treatment) as well as County road drainage systems.
  - Establish maintenance standards according to Chapter 2 of Volume IV of the *Stormwater Management Manual for Western Washington* (Ecology, 2005).
  - Establish maintenance program to ensure inspection and maintenance frequency suggested in the NPDES Phase II Draft permit.

  - Document all inspections and maintenance activities. A database should be created/kept showing all historical maintenance and rehabilitation/repair activities conducted at a site or on a specific drainage infrastructure element.
  - Upgrade M&O equipment and increase drainage crews as necessary to meet increasing maintenance demands.

- **Education:** Educate residents and staff on proper practices to reduce discharge of pollutants to the stormwater system; change behavior patterns by increasing understanding of cause and effect of actions taken.
- **Public Involvement**: Involve residents in watershed activities to promote water quality, source controls, etc.
- **Monitoring**: In accordance with the NPDES permit conditions, develop a coordinated monitoring program. Since the primary water quality issue in the watershed is coliform bacteria, monitoring should be focused on that.
- **Record-Keeping and Annual Reporting**: The NPDES Phase II draft permit requires keeping records of all activities, including SWMP development and implementation, number of inspections and enforcement actions, and educational activities.

Whatcom County has previously implemented most or all of these recommendations at one time or another in various locations in the county. Therefore, these actions could be implemented as an extension of existing activities or programs.

Significant resources should be dedicated to identification of sources of bacteria contamination in Birch Bay that has led to shellfish restrictions. The following actions should be undertaken:

- Inspect pump-out facilities and coordinate with marina owners to develop a system of inspecting all boats in the marina. Boats should be inspected to assure that discharge valves for holding tanks are closed and waste is not discharged to the water.
- Conduct periodic inspections of trailers and RVs to require proper disposal of holding tank wastes.
- The Birch Bay Water and Sewer District should sustain an annual inspection program to detect and eliminate exfiltration and leakages from their pipe system. This may include dye tests.
- The Whatcom County Health Department recommends that homeowners have their septic tank and drainfield inspected yearly and septic tank pumped once every 3 to 5 years. The Public Works Department should coordinate with the Health Department to develop a program of onsite sewage system inspections at least once every 5 years.

7.2 Structural (Capital) Solutions

The structural projects outlined in this Birch Bay Comprehensive Stormwater Management Plan should be included in the 6-year Whatcom County Capital Improvement Program. These projects include the following:

- Drainage Improvements, Cottonwood Neighborhood

- Drainage Improvements, Shintaffer at Richmond Park
- Terrell Creek Improvements for Water Quality
- Drainage Improvements, Birch Point, Various Locations
- Terrell Creek Culvert at Grandview Road
- Drainage Improvements, Rogers Slough at Birch Bay Drive

7.3 Funding

Chapter 6 discussed funding mechanisms and projected needs. The recommendations outlined in Chapter 6 are summarized here:

- Adopt a sub flood control zone rate to provide revenues to cover the surface water program discussed in Chapter 5.
- Complete a public involvement program prior to implementation of the surface water fee.
- Prior to implementing a surface water fee, identify the specific properties that would receive the largest surface water bills, and notify these properties of the key components and milestones of the public involvement program.
- Discuss with the County Council the feasibility of providing a rate reduction for low-income seniors.
- Adopt permit fees that recover the County’s expenses associated with permitting, reviewing, and inspection of new development.
- Pursue low-interest loans, such as those from the Public Works Trust Fund and Ecology State Revolving Fund program, for eligible capital projects.
- Consider adopting a formal policy dedicating a portion of the County’s REET revenues to storm drainage capital projects.
- Prior to implementation of a surface water rate, the County should determine the impervious areas associated with non-SFR properties in order to accurately bill these properties.

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Appendix A

Birch Bay Comprehensive Stormwater Plan, Summary of Public Workshop 1

PREPARED FOR: Roland Middleton, Whatcom County

PREPARED BY: Bill Derry, CH2M HILL
Amy Engstrom, CH2M HILL

DATE: January 5, 2006

On October 1, 2005, Whatcom County held a public workshop to solicit input on stormwater quantity and quality problems in the Birch Bay area for a Comprehensive Stormwater Plan. This Workshop Summary presents the workshop agenda, summarizes the comments made during the workshop, and identifies actions to be taken during preparation of the Comprehensive Stormwater Plan to address the stormwater problems identified in the workshop.

Workshop 1 Agenda

9:00 Introductions, purpose, emergency exits, review agenda

9:05 Background presentation

Overall goal of stormwater plan

Premise of beachfront lifestyle

High shellfish and stream value

Growth

Expected product

Overall plan schedule

9:20 Small group "mind map" exercise to define issues by neighborhood,

Explain exercise and rules of brainstorming

9:50 Discuss results at table and identify key issues for each category (water quantity, water quality, habitat and others)

10:10 Neighborhood groups report to whole group

10:40 Break

10:50 Science background presentation

11:05 Neighborhood groups identify specific list of opportunities; how far is your neighborhood willing to go to protect streams and shellfish? (Reduce density, replace forest, increase stream, wetland and shoreline buffers, cluster development, leash laws, confine cats, confine livestock, others?)

11:50 Next steps

Committee meetings

Community field work

Technical studies

Develop draft plan

Public workshop

12:00 Adjourn

Replace chairs and clean-up

Workshop participants filled out comment forms at the meeting and submitted email comments afterward. Workshop participants were residents of the following neighborhoods:

- Birch Point
- Birch Bay Village
- Hillsdale
- Central Reaches
- Central Uplands
- Point Whitehorn
- Cottonwood Reach
- Terrell Creek
- State Park Reach
- Lake Terrell

The neighborhood of West Cherry Point will also be covered in the stormwater plan, but no residents of this neighborhood submitted comments. There are no residences within the West Cherry Point area.

Summary of Comments

This section summarizes the problem statements submitted by the workshop participants and some additional issues identified by reviewing maps of the area. The problems from the workshop related to both water quantity and water quality issues. Several specific comments were made that pertained to localized water quantity issues, including lack of conveyance capacity in the existing drainage system and erosion caused by excessive stormwater runoff velocities and volumes. Other comments pertained to water quality issues such as high numbers of waterfowl and the application of pesticides on large tracts of land. Lack of stormwater conveyance capacity was the most common type of problem identified, followed by inappropriate stormwater management causing erosion and sedimentation. A complete catalog of the comments received is provided in Table 1.

Next Steps

This list of problems identified during the public workshop will provide a starting point for field investigations. Problems will be documented in greater detail, and locations will be verified. This list may be expanded during field efforts as other related and unrelated problems and concerns are identified. As the list of identified problems grows, efforts will be made to group problems by common cause or type of cause in order to build a solid set of alternatives to alleviate the problem(s).

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
Birch Point									
BR-01	x		x						Horizons is putting a regional stormwater detention system. Quantity – no percolation. Quality – needs improvement.
BR-02				x	x				Cory Lane ditches are full. Piping system is overwhelmed. Flooding over Oertel Drive occurred prior to clear cuts (2004) and after and may continue. Road is eroding.
BR-03				x					Trillium clearcut has resulted in greater stormwater runoff into Semiahmoo Bay. Retention ponds may help, but lower piping may not be adjusted.
BR-04					x				Residents are clear-cutting high banks and cutting paths for water access, disposing yard waste into ditches and water.
BR-05	x x x x			x x ? ?					Management of clearcuts and subsequent clearcuts has impacted hydrology of Birch Point: – Water migrates in new ways and greater quantities – Water is under the vapor barriers beneath houses – Retention ponds release to ditches on Semiahmoo Drive, then to drain pipes and to salt water.
BR-06				x					Glacial marine drift blocks water flow, creates surficial aquifers, a challenge to water management.

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
BR-07			x	x					Impacts to Birch Bay Village (BBV) by water coming from Birch Point: – Golf course flooded with overflow from Birch Pt Rd and Selder Rd – Water quality of lakes in BBV
BR-08								x	Need regional stormwater detention working with Blaine.
BR-09								x	Expand the plan to cover area all the way to City of Blaine border.
BR-10						x			(identified from workshop map) Slope stability all along Birch Point.
BR-11								x	(identified from workshop map) What ROW does County have/own? Could this be a regional outfall opportunity?
BR-12		x							(identified from workshop map) Pockets of existing wetlands must be protected.
Birch Bay Village									
BV-01				x					Rogers Slough health/condition is of great concern. Present drainage into slough from slopes above is problematic. The proposed new housing project off Selder Rd should not be allowed to drain into the slough, but should drain directly to the bay.
BV-02		x	x						Beaver pond – impacted by Skeenaway BBV continual auto repair, suspect leaks of oil and/or fuels; habitat destroyed by flooding
BV-03				x					There is major flooding with winter storms – big ponds of standing water form, deep enough and wide enough

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
									for many ducks.
BV-04			x						Water samples have contained high levels of fecal coliform at mouth of marina
BV-05			x						The stream in Birch Bay Village has increased water flow that is very muddy.
BV-06			x						Muddy water and pollution from lakes is draining into BBV marina. Water from lakes and marina should be tested for fecal material and pollutants.
BV-07			x						Sediment in the bottom of the marina indicates extensive flow of muddy water over time.
BV-08			x						Creosoted logs collect on BBV beaches and pollute the bay.
BV-09								x	New development will reduce rainwater percolating into the ground and increase stormwater runoff into Birch Bay.
BV-10		x		x					There are several contamination sources from upper levels in connection with clay soil that doesn't allow absorption, with heavy runoff in winter months.
BV-11		x							There are algae blooms in ponds/lakes from geese fecal matter and fertilizer.
BV-12						x			Movement of sediment from tides in bay impacts marina.
BV-13	x							x	Coordinate long and short term planning for Highlands as they develop around BBV

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
BV-14				x					Flooding has increased in last 5 years.
BV-15				x					Village recommends reroute along Birch Pt Rd with new culvert under Birch Pt Rd Loop to alleviate flooding
BV-16	x		x						(identified from workshop map) Large burn piles from Trillium clearcut input phosphorus/ash to runoff.
BV-17				x					(identified from workshop map) Identified several areas of flooding.
BV-18				x					(identified from workshop map) Identified locations of cross culverts in BBV.
BV-19	x								(identified from map) Identified proposed development.
BV-20						x			Tide is eroding beach at BBV bluff
Hillsdale									
HS-01				x					Drainage into Birch Bay starts 2 miles north at Lincoln Rd; soils appear to be very shallow layer of sand and loam over heavy clay. Indigenous growth is critical to slowing surface velocity; retention ponds may not be as effective.
HS-02				x					In the winter of 2003-2004, Harborview Rd frontage ditch overflowed for the first time in 23 years.
Cottonwood Reach									
CT-01				x					Several photos were supplied showing examples of flooding and drainage concerns in this neighborhood
CT-02			x						Yard waste dumped into the ditch.

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
CT-03			x						Yard waste put into old wood catch basin.
CT-04			x	x					Manholes on the culverts at old wooden catch basin are not cleaned out.
CT-05			x x x						– Large numbers of Canada geese are present late summer through winter, leaving lots of fecal matter – Increasing numbers of brant are present in early spring – Neighbors park on beach berm – Residents throw yard waste into bay – Invasive species of grasses are now on the tide flats – coming from the BBV marina?
CT-06				x					Water is coming off the hill (Fern Lane) behind Halverson Lane. The County did some ditch work on Fern a couple of years ago but properties below are still having lots of water, especially after hard rains. The hill is pretty much solid clay, so the water seeps down through the layers like little streams.
CT-07				x					Drainage ditch along Shintaffer diverts through two 90-degree turns through Richmond Park. A wetland also feeds into this drainage. Area near the park backs up during significant rain – the excess water backs up onto homes and overflows

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
									drainage areas within the park.
CT-08	x								The hillside is being engineered for stormwater from Horizons. Call Craig Parkinson at David Evans Assoc. 647-7151.
CT-09			x						(identified from workshop map) Yard waste areas
CT-10				x					(identified from workshop map) Areas of flooding because of broken culvert/pipe
Central Reaches									
CR-01				x					Broken flood gate needs repair/replacement.
CR-02			x	x					Units are flooded with heavy runoff in winter. There are only 11 people that live there during winter – why is stormwater mixing with sewer?
CR-03				x					Runoff from Seabreeze (?) through pipe down to Lora Lane.
CR-04				x					Retention pond overflows.
CR-05			x						– Large pipe drains onto beach, lots of algae. Where is water coming from? Nutrients? – Sewer backs up into bottom units when it rains. – Bank in back of Mariners Cove seeps water. New condos going in on top of bank.
CR-06				x					Culvert became blocked in 2002, causing flooding of low area toward Alderson. Standing water remains for weeks.
CR-07	x								New construction impacts.
CR-08				x					Where Alderson Rd ends at Beach

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
									and Birch Bay Drive, when extreme high tides meet the creek at the road, it causes flooding.
CR-09			x						RV housing 6 dogs is parked on bank of Terrell Creek south of bridge at Alderson Rd.
CR-10						x			East, uphill, on Alderson Rd from Birch Bay Drive, hill is severely destabilized (many cracks indicating slippage)
CR-11								x x x x	Governance: – Enforcement! – Lines of communication, how to file a complaint – Tree retention, limits on impervious surface – Willingness of County to accept new ideas – developers are discouraged from using low-impact development (LID) for road construction
Central Uplands									
CU-01				x					Lack of regular maintenance leads to periodic flooding emergencies
CU-02			x						Lack of golf course maintenance; rumors are that trash has been dumped in the unmaintained golf course ponds.
CU-03	x			x					Pond overflows onto Sealinks Drive at entrance gate to Sealinks, flows west on North Golf Course Drive flooding cul de sac.
CU-04				x					Pipe drains the entire area all the way

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
									back to the fire house near Blaine Rd. (?)
CU-05	x			x					Three storm ponds reach capacity early in the season. Pond on the corner of Bay and Jackson flows into tributary to Terrell Creek on south side of bay. The other 2 ponds flow into ditch along Key St that empties into ditch on Jackson. Culvert takes water under Jackson and directly to Terrell Creek.
Terrell Creek									
TC-01			x	x					Muddy/silty stormwater drainage from site. Retention ponds should be monitored to make sure they are operating properly.
TC-02				x					Flooding
TC-03			x						BP discharges stormwater to Terrell Creek
State Park Reach									
SP-01			x						Animals may be degrading water quality (Ducks on northern edge of park).
SP-02			x x x x x						– Chlorine from emptying pool and hot tubs drains into Terrell Creek – Fertilizers – Weed killers – Motor oil – Are the two outfalls filtered before emptying into Terrell Creek?
SP-03		x							Creek flow needs to be increased in summer.
SP-04				x					Outfall needs to be checked.

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
Point Whitehorn									
PW-01						x			Slides, ground subsidence along edge of point; slides along the cliffs – at least 11 over the past few years. Large historic slide occurred on Celia Dr after sewer lines installed in the 1980s. Numerous since then.
PW-02						x			Several sites of changing steepness slopes or sinking of land around homes on edge of cliff.
PW-03				x					Drainage pipes not uniformly connected to curtain drains. Several houses have standing water in front after rains. There is a lot of seepage along Whitehorn Way.
PW-04				x					Impacts of massive tree loss – old Trillium property had numerous trees and wetlands, now are fields. Water is pooling.
PW-05				x					Point Whitehorn had a small lake, a stream, and a gravel pit that are no longer apparent but contribute to runoff problems.
PW-06			x	x					Ditch is used as garbage and yard waste dump. Blocks the ditch.
PW-07				x					Permitting problem: new building permit calls for onsite downspout management and the use of a bioswale to manage runoff instead of tight-line drainage; swale will overflow in a heavy rain.
PW-08			x						Broad use of herbicides and other chemicals near drainage to bay.
Lake Terrell									

TABLE 1
Problems Identified at Public Workshop

Problem No.	New Development	Habitat	Water Quality	Drainage, Flooding	Site, Ditch Erosion	Bluff Erosion, Stability	Streambank Erosion	Policy and Planning Issue	Problem Description
LT-01								x	BP has done wetland enhancement work along Terrell Creek and has stormwater data that may be useful. (info from Melissa Stoddard at BP Environmental Group, 371-1500)
LT-02	x								Subdivisions of property have increased greatly in the past 5 years along SR 548 and near Lake Terrell.
West Cherry Point									
--									No comments/problems submitted.

Appendix B

Birch Bay Comprehensive Stormwater Plan, Problem/Issue Identification

PREPARED FOR: Roland Middleton, Whatcom County

PREPARED BY: Bill Derry, CH2M HILL
Amy Engstrom, CH2M HILL

DATE: July 7, 2006

Introduction

This technical memorandum is one element of an overall Comprehensive Stormwater Plan for the watersheds of Birch Bay. Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay completed a Comprehensive Land Use Plan that called for low-impact development (LID) and a Stormwater Plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth. This Comprehensive Stormwater Plan recommends measures to achieve these goals.

The problem/issue identification task involves identifying drainage problems, water quality problems, and problems with aquatic habitat. Drainage problems can include erosion, flooding, and sedimentation. Water quality concerns revolve mainly around fecal coliform bacteria from point and nonpoint sources. Aquatic habitat degradation can be caused by physical alteration through development or other means.

Sources of Data

The following sources of information were used to identify stormwater issues and problems in the Birch Bay area:

- Information from the Washington Department of Ecology (Ecology), Whatcom County, The Birch Bay Steering Committee, the Washington State Department of Health (DOH), and the Nooksack Salmon Enhancement Association (NSEA)
- Studies and reports from previous work conducted in and around the Birch Bay area, including:
  - *Point Whitehorn to Birch Bay State Park Shoreline Reach Analysis, Whatcom County, Washington, Final Report* (Coastal Geologic Services, 2003)
  - *Birch Bay Shoreline Improvement Plan and Conceptual Design, Draft Report* (Philip Williams and Associates, 2002)
  - *Birch Bay Sub-Area Plan, Birch Bay Community Plan Steering Committee* (Kask Consulting, 2004)

- Public Workshop 1, which provided a detailed list of problems identified by local area residents (a workshop summary is provided in Appendix A)
- Correspondence from local area residents reporting continuous issues/problems or wet-weather-specific problems
- Field visits conducted by Whatcom County, CH2M HILL, and local area residents

Lists of problems identified in Public Workshop 1, during field work efforts, and by residents and others via correspondence in the weeks and months following Public Workshop 1, along with problems identified in previous studies and historical information, were combined into a master list included in this memorandum.

Description of Problem Types

The following types of stormwater management issues are identified in this memorandum:

- Water quantity
- Water quality
- Aquatic habitat

Drainage and flooding are examples of water quantity issues. Bluff erosion and stability issues are often caused by increased volume and velocity of runoff and are therefore included as water quantity issues.

Water quality issues may include point source pollution such as stormwater runoff containing a large concentration of suspended sediment discharging from a construction site, or nonpoint source pollution sources such as large numbers of pets, birds, and/or wildlife.

Aquatic habitat in local streams, wetlands, and nearshore areas can be physically altered. These physical alterations could include limited access due to road culverts or channelized sections of creek, each of which is problematic. Habitat can be physically altered by changes in stream flow as a result of clearing and the construction of impervious surfaces.

In addition to the water quantity, water quality, and aquatic habitat problem types, several problems identified by citizens refer to policy and planning issues or generally relate to new development. These problems are also discussed here.

Problems Identified

A total of 27 different water quantity problems were identified by citizens, through field investigations, through conversations with others, or in historical studies. Sixteen water quality problems and six aquatic habitat problems were also identified. Tables 1, 2, and 3 contain a summary of water quantity, water quality, and aquatic habitat problems identified in the Birch Bay area.

The water quality problems are identified in this memorandum by sets of codes: one set for problems the Public Workshop, and another set for problems identified either during field work activities or via correspondence from residents after the workshop. For the workshop-identified problems, the comment codes are associated with the neighborhood in which the problem was identified. Many of the problems identified during Public Workshop 1 overlapped with or were also identified in field work efforts, or were reported as being problematic during wet-weather events experienced in the months following Workshop 1. Therefore, many of the problems listed in Tables 1, 2, and 3 have more than one comment code listed. For simplicity, the problems listed in the text below are referred to by only one code, the Workshop 1 code shown in bold in Tables 1, 2, and 3, as listed in the tables. The numbering system associated with the code should not be taken as an attempt to prioritize or rank the problems. Not all of the problems identified by the citizens have been extensively investigated, and some of the suggested causes may be inaccurate or incomplete.

For the problems identified either during field work activities or via correspondence from residents after the workshop, the assigned code is in the format CC-01. The neighborhood code for Birch Point is BR. The codes for Birch Bay Village, Hillsdale, and Cottonwood are BV, HS, and CT, respectively. The code for the Central Reaches is CR and the codes for the Central Uplands, Terrell Creek, and State Park Reach neighborhoods are CU, TC, and SP. The code for Point Whitehorn is PW and the code for Lake Terrell is LT.

The identified problems are discussed in the subsections below, grouped in the following categories:

- Water quantity problems
- Water quality problems
- Aquatic habitat problems
- Policy/planning issues

Water Quantity Problems

Water quantity challenges in the Birch Bay watershed can be categorized primarily in three groups, as follows:

- Low lying areas along the beach: There are extensive low and flat areas behind the natural dune of the beach. Even without development, these areas were likely inundated during extreme high tides and high wind conditions. Many of the areas that now have homes and roads were once large, natural wetlands. Development has increased runoff and in some cases may have blocked natural flow paths.

- New development: The watershed is experiencing rapid development particularly near the beach. New development is increasing the peak rate and volume of runoff even with onsite detention, resulting in increased downstream flooding and erosion. Existing standards and/or review procedures may need to be improved to reduce the impacts of new development.

- Bluff erosion: There are examples of slides all along the bluffs at both the south and north ends of Birch Bay. Beach erosion and slides along bluffs are natural events, but their occurrence may be accelerated by stormwater that is routed over the bluffs or if additional water is infiltrated near the bluffs from either stormwater or septic tank drainfields.

Many of the problems identified by citizens may be problems caused by individual property owners affecting themselves or other individual property owners. Such problems are often not the responsibility of the government but the responsibility of the individual property owners to resolve. For example, a property owner who routes rooftop runoff over the edge of the bluff would be responsible for the cause of and resolution to any damage to their own property.

Localized flooding problems are a primary water quantity concern of Birch Bay residents. Bluff erosion and hillside stability are also important and relevant concerns. Table 1 contains a listing of the 27 individual problems identified within the Birch Bay area pertaining to drainage, flooding and/or slope erosion/stability issues. Each of these problems is described here.

Water Quantity Problems Identified from the Literature

No water quantity problems were identified from the literature.

Water Quantity Problems Identified by Citizens

BR-02

Drainage issues have been reported along Semiahmoo Drive and across much of the Birch Point area. The ditches along Cary Lane tend to fill with material that then reduces conveyance capacity. The capacity of the stormwater conveyance system was exceeded in both December 2004 and January 2006. The outfall pipe at 8741 Oertel Drive became plugged and blew out at the lower end in December 2004, most likely because of accumulated debris.

The ditch along the southern section of Oertel drive has filled in over a several-year period, which diminishes conveyance capacity. Residents are clear-cutting high banks and cutting paths for water access; Recently, Whatcom County Department of Public Works has cleared out and deepened the channel, which has helped the problem.

In December 2004, water was reported underneath the vapor barrier at the home at 8710 Oertel Drive. There have been no other reports of this occurring.

The natural hydrology in the Birch Point area has been altered such that now stormwater runoff is conveyed through culverts and ditches. Loss of vegetation has increased volumes of runoff and peak flows. Ditch construction has channelized the system and promoted higher runoff velocities and greater volumes of runoff. Roadside ditches intercept both surface water and subsurface flow (groundwater) all along their length, adding volume to the drainage flows. Ditches also accelerate velocities of runoff because they are straight and relatively smooth. Figures 1 and 2 show examples of the current drainage infrastructure across and near the roads in the Birch Point area.

The subsurface geology of the area consists of clay and hard-packed marine sediments. Infiltration capacity is limited because of this. Drainage issues are therefore more pronounced because the soil is less forgiving. This is true throughout the Birch Bay area, but particularly in the northern half where marine soils predominate.

BR-03

A low point exists in road and ditch system near 8621 Semiahmoo Drive near the bend in the road. Two detention ponds (one from the north, one from the south) overflow to the County road ditches here. The ditches converge at this location and flow through a culvert into a ditch along the south property line of 8621 Semiahmoo Drive.

In December 2004, these ditches were overwhelmed and the outflow pipe was destroyed. Trillium Corporation and the Washington State Department of Natural Resources (DNR) replaced the outfall pipe with 24-inchplastic pipe. The resident built a concrete collector to channel flow to the outfall. January 2006, the problem happened again. Many cubic yards of material were eroded away during this event.

BR-05

Increased flows and velocity cause drainage problems along Normar Place off of Semiahmoo Drive. A ditch/outfall pipe is located along the south property line of a homeowner living along Normar Place. The ditch has eroded and sent rocks and mud down the half-pipe into the junction box. The box plugged up and caused a geyser effect (December 2004). The ditch/open channel outfall along the south property line was overwhelmed. The resident placed sandbags to prevent major damage.

This drainage begins at detention ponds on upslope Trillium property that flow into road ditches, and then through a cross-culvert under Semiahmoo Drive and down to the outfall ditch.

Drainage problems have occurred at Hogan Drive, a street with 5 or 6 homes just north of Normar Place along Semiahmoo Drive. Home owners have reported stormwater runoff from County Road ditches that has overtopped the road and flowed down to the homes. Residents have noted that the frequency of these drainage issues has increased. This area is not connected via roadside ditches to the detention ponds on Trillium property.

BR-11

Near the Semiahmoo Drive and Birch Point Road intersection, two detention ponds from Trillium Property flow south in a County road ditch to a cross-culvert under the road. During events in 2004 and 2005, the ditches overflowed and covered the roadway. Residents reported nearly a foot of water over roadway during each of these events.

David Evans and Associates has been investigating each of the drainage courses from the Trillium property to the beach to identify potential capacity, erosion, and slope stability issues. Information will be incorporated when it becomes available.

BR-10

Slope stability is a problem all across the bluffs of Birch Point. Natural processes have been accelerated by increased runoff velocities and volume due to removal of vegetation, the installation of septic tank drain fields, and the construction of impervious surfaces and channelized ditches. Construction of roadways and roadside ditches has altered the surface and subsurface flow. Subsurface flow in the upper portion of soil is intercepted by roadside ditches and is conveyed more quickly and in more concentrated amounts than if the roadway and roadside ditches had not been there. Surface flow is conveyed in cross-culverts and roadside ditches, then flows towards Birch Bay in concentrated flow streams that promote erosion and stability problems.

The westernmost portion of the area at and north of Birch Point itself is a geologically unique area. This portion of Birch Point is a groundwater recharge area where the overlying area is not perched and therefore contributes surface water to the shallow and deep groundwater flow. Land use activities in this contributing area have a great impact on the subsurface flows. Removal of trees and tree stumps has increased the subsurface flows in the area. This increase in subsurface flow has been experienced by residents living along the edge of the steep slopes, who have witnessed increased seepage and groundwater flow underneath their homes and out the sides of the slopes. Increases and changes in subsurface flow can affect the rate of slope movement and increase the risk of landslide action.

BV-01

Drainage ditches discharging to Rogers Slough back up behind the tide gate under high tide and/or wet weather conditions. When these ditches overflow, backyard flooding will occur in the homes within Birch Bay Village that have backyards along Birch Point Road. Ditches also back up along the north side of Birch Point Road. Figure 3 and Figure 4 show the full ditches on both sides of the road on a dry day during January 2006.

Questions have arisen on who is responsible for operations and maintenance of tide gates in the Birch Bay area, including this tide gate near Rogers Slough. Property ownership and locations of street rights-of-way need to be determined, as do operations and maintenance responsibilities for tide gates.

CC-01

Trees and other debris build up within and along the shore of Rogers Slough due to wave action and nearshore currents. Residents have stated that this material prevents adequate drainage and contributes to the localized flooding issues. According to residents, the County had just recently cleared away this material (in early March 2006), which has allowed for more timely drainage of the area. Residents say that this clearing would need to be performed on a regular basis, possibly yearly, to prevent future issues.

Trees and other debris also accumulate on Birch Bay Village beaches and on Cottonwood Beach, also because of natural wave action and nearshore currents.

BV-02

According to residents, drainage issues occur within Birch Bay Village during larger wet-weather events that occur under already-saturated conditions, mainly in the winter. Big ponds of standing water have been reported at various locations within Birch Bay Village.

BV-20

Citizens have reported that the beach at Birch Bay Village Bluff is eroding. It is possible that this is due to wave and rainfall erosion, tidal fluctuations, and naturally occurring sediment transport with the currents. It is also possible that this has been accelerated by human activity.

HS-02

In the winter of 2003-2004, the frontage ditch along Harborview Road overflowed for the first time in 23 years. This may have been due to lack of maintenance, with materials blocking ditch and culvert outlets. Residents have reported flow conveyance a problem if maintenance not performed.

CT-01

The drainage ditch flowing south along the West side of Shintaffer Road conveys runoff from a large area that stretches west and north of Lincoln Road. The ditch along the west side of Shintaffer flows through two 90-degree bends that divert the runoff from the drainage ditch along Shintaffer (off to the left in the picture) towards the Richmond Park Subdivision. Yards in the subdivision are submerged during heavy rains as the system backs up. Figure 5 shows the view to the north across the northern edge of the Richmond Park Subdivision and into the field. Figure 6 shows the drainage ditch along Shintaffer Road across the road from the Richmond Park Subdivision under flooded conditions.

After flowing through the Richmond Park subdivision, the drainage enters an open channel creek system that flows southward towards Birch Bay. The creek runs underneath Fawn Crescent and alongside Deer Creek Trail, two streets in the neighborhood with access from Birch Bay Drive. The system enters a culvert underneath Birch Bay Drive, then enters the bay. The culvert is approximately 400 feet to the east of the tide gate at Rogers Slough and about 300 feet to the west of the intersection of Shintaffer Road and Birch Bay Drive. Rogers Slough is the outlet point of the culvert and outfall. Several hundred feet of slough separate the outlet of this culvert from the primary drainage path in the central part of the slough.

The culverts through the subdivision appear to be undersized for the flows that enter the system. However, simply increasing the size of these culverts will not solve the problem. The open channel creek system downstream of the subdivision is in a ravine with situated homes close together that may be negatively impacted if runoff flow rates and volumes are increased.

Localized drainage issues have also been reported in the lots on the east side of Shintaffer. The ditch along the east side of Shintaffer drains the area east of Shintaffer Road and south of Lincoln Road and flows south along Shintaffer then enters Birch Bay. Adequate drainage is no longer achieved out of the ditch along Shintaffer on the east side of the street. Runoff backs up within the ditch and drains slowly out to the south along the east side of the street.

According to Whatcom County Maintenance and Operations (M&O) staff, no cross culverts connect the west and east sides of Shintaffer near the Richmond Park subdivision. However, the drainage issues on the different sides of the street may be related hydrologically.

CT-06

Flooding problems occur in the Cottonwood subbasin that discharges to Birch Bay along Birch Bay Drive near Cedar Road. Recent documented occurrences were on 1/11/06 and 1/29/06. The runoff from a large contributing area flows through a culvert under Anderson Road, in an open channel through the County-owned park, then in a pipe and through a diversion structure leading to two outfalls discharging to Birch Bay at Cottonwood Beach.

Two different outfalls provide the outlet for this area. These two different outfall pipes receive flow from the same location: a single diversion structure that channels runoff into the two outfalls from a single entry point. This diversion structure is no more than a “hole” that has one incoming pipe and two outgoing outfall pipes. This hole is located behind the home at 8208 Birch Bay Drive. The hole receives flow through a culvert and pipe system that flows underneath Cedar Road from an upstream open channel creek system. Residents report that the creek drainage leading to these two outfalls was once a seasonal creek that now flows year-round.

Of the two different outfall pipes, one pipe heads to the west into Birch Bay along a County easement to the south of the residence at 8208 Birch Bay Drive. The second pipe (to the north of the first) flows west into Birch Bay through private property to the north of the residence at 8210 Birch Bay Drive. This second pipe exits the hole slightly higher than the first, acting as a relief system for the first outfall. This second outfall pipe is concrete and reportedly in multiple pieces along its length.

When the outfall pipe(s) are clogged or otherwise blocked or under extreme high tide conditions, the hydraulic head builds up and may create a backwater condition in the closed-pipe system. Figure 7 shows the hammerhead-type outlet structure of the northern outfall, and Figure 8 shows flooding that has occurred in the area. According to local residents, the lack of regular maintenance may lead to periodic flooding emergencies throughout Birch Bay. In both the January 2006 cases, the outfall had been obstructed by accumulated material that contributed to the drainage issues.

Since the more northern outlet pipe is in pieces, stormwater runoff may be exfiltrating into the surrounding soil. Yard flooding in the area may be the result of this exfiltration. Drains from the houses on both sides tie into this northern outfall pipe. The neighbor to the north at 8212 Birch Bay Drive has a drain tying into this outfall pipe with a flap gate on it to prevent backflow. The resident to the south at 8210 Birch Bay Drive has a perforated pipe leading to the pipe. The resident at 8214 also has a yard drain leading into this same pipe.

These areas along Birch Bay are at low elevation and are near sea level during extreme high tides combined with periods of high winds. Much of this area sits behind and lower than the area right at the shoreline. This "dune effect" may cause drainage issues as the water pools in the lower areas behind the beach berm. In addition, it is also possible that these areas have subsided due to compaction from development and from the removal of natural processes that add sediment and organic matter to the soils. Further analysis is needed to clarify this. Poor drainage conditions exist in this area. Overland flow occurs here because of increased impervious areas and existing development in low areas. Infiltration is also limited due to soils.

During storms and/or high tide conditions, subsurface flow could be a factor in yard flooding. The soil cover in this area contains sand and larger beach cobbles yielding high subsurface flow rates. If groundwater levels are near the surface, there is nowhere for stormwater runoff to go.

CC-02

Citizens have reported erosion of roadway and supporting material at two to three locations along Birch Bay Drive to the south of Cottonwood Beach. In at least one of these locations, the actual road surface has been affected. Pedestrians and bikers can no longer use the side of the road without being in a lane of traffic.

CR-02

Residents have reported that the parking area of the Mariners Cove Condominiums is flooded during the wet season. One large pipe drains to Birch Bay from this area, and the parking lot itself appears to be lower in elevation than the occasional extremely high tide.

Residents have also reported that sewer backups are a problem during rain events in the lower units of the Mariners Cove Condominiums.

CR-03

The area to the south and east of the Leisure Park is low-lying and flat and is part of the sub-basin draining to the ditch along Lora Lane. This ditch then discharges through the tide gate to Terrell Creek and on to Birch Bay. The yards of homes along Pine Drive are routinely full of runoff. Figure 9 shows the view looking east along the ditch along Lora Lane, with the Leisure Park on the left side of the picture. The tide gate to the mouth of Terrell Creek is just west of where the picture was taken (behind the photographer). Figure 10 shows the general low-lying area draining to the drainage ditch and the proximity of several homes in relation to the low-lying area. Figure 11 shows the area to the east and upstream of the home in Figure 10, taken looking to the northwest towards the drainage ditch and tide gate to Terrell Creek. The Birch Bay Subarea Plan Update (Kask Consulting, 2004) indicates that a large portion of this low-lying area is classified as wetlands. Much of the development in this area most likely occurred in areas that were originally wetlands.

Questions have arisen on who is responsible for operations and maintenance of tide gates in the Birch Bay area, including this tide gate. Property ownership and locations of street rights-of-way need to be determined, as do operations and maintenance responsibilities for tide gates.

CR-04

Citizens identified the location of a retention pond overflow in the open area to the south and east of the drainage issues along Pine Drive. This exacerbates the existing flooding due to the low elevations during high tides. Detention ponds in the low-lying areas as currently designed may have little or no value as mitigation for flooding in these areas if any portion of the storage is below the water level in the surrounding area during or following rainfall and/or high tide events.

CR-06

The culvert and tide gate at the corner of Wooldridge and Morrison often becomes blocked and causes road and yard flooding in the area. Water is often present over the roadway. Figure 12 shows the accumulated trash and other material propping open the tide gate during a site visit on 1/4/06. Figure 13 shows the culvert behind the tide gate under flooded conditions on 1/6/06. Because the tide gate was propped open and the picture was taken near the time of the high tide, the flooding shown may represent the approximate natural high tide level that day.

Questions have arisen on who is responsible for operations and maintenance of tide gates in the Birch Bay area, including this tide gate. Property ownership and locations of street rights-of-way need to be determined, as do operations and maintenance responsibilities for tide gates.

CR-08

Residents have reported flooding at the intersection of Alderson Road and Birch Bay Drive corresponding to extreme high tides. Water has been over the roadway.

CR-10

According to local residents, the hill east from Birch Bay Drive just north of and in view from Alderson Road is severely destabilized. Citizens have identified areas of slippage in the hillside.

The generally high water table and saturated nature of the soils during wet weather may have affected ground settling.

CU-03

According to local residents, the retention pond within Latitude 49 overflows into Sealinks Drive at the entrance gate to Sealinks. This drainage then flows west on North Golf Course Drive towards Birch Bay and causes localized drainage issues when the conveyance capacity of the stormwater system is exceeded.

CU-05

According to local residents, the three retention ponds in the Bay Crest Development reach capacity quickly. One pond near Bay and Jackson flows into a tributary to Terrell Creek. The other two ponds discharge to a ditch on Key Street, then to a ditch on Jackson that flows north to Terrell Creek. According to local residents, the discharge from all three ponds has been muddy and/or silty at various times in the past.

CC-03

Yard flooding has been reported along Wooldridge just north of Jackson. This has been documented with photographs taken by local residents. Figure 14 shows an example of this flooding.

TC-02

Street flooding has been reported by local residents at the intersection of Blaine and Grandview Roads in the Terrell Creek area.

SP-04

According to citizen reports, the outfall south of the Jackson Road Bridge needs to be maintained more frequently. The outfall gets clogged easily.

PW-01

Various seeps exist all along the shoreline from the tip of Point Whitehorn to the north end of Birch Bay State Park (Coastal Geologic Services, 2003). According to local residents, the most significant seep is near the state park. Slides and ground subsidence exists at various locations along the edge of the point and along the cliffs. Seepage has been occurring all along Whitehorn Way. Seeps, subsidence, and slides are natural processes, but they may be accelerated by changing drainage patterns due to development and roadway construction.

Slides have occurred along Point Whitehorn just as they have along Birch Point on the north side of Birch Bay. Several of these slides have been documented in the last few years, including one in January of 2005 and another in February 2006 at the same location in the area of the 6900 block of Holeman Avenue.

PW-03

The hydrology and drainage of the upper portion of the Point Whitehorn area has been modified because of development, road construction, and tree loss on the Trillium property. Clearing and grading have changed the hydrology, and runoff is now pooling.

Residents have reported standing water in yards in the Point Whitehorn neighborhood after rains. Local residents have reported that drainage pipes are not uniformly connected to curtain drains in the Point Whitehorn area. (A curtain drain is a type of subsurface drainage system that can be used to drain shallow water tables or perched saturated zones and is similar to a French drain, perimeter drain, or underdrain.) Residents have reported that a new building permit calls for onsite downspout management and bioswales to be used to manage runoff instead of tight-line drainage. Existing swales overflow in heavy rains.

PW-06

Yard waste and garbage can accumulate in roadside ditches and within other stormwater conveyance infrastructure. Yard waste dumped into ditches and near catch basins blocks runoff conveyance.

Residents have reported grass clippings in the ditch along Grandview in the Point Whitehorn neighborhood and at several locations near Cottonwood Beach. This prevents the proper conveyance of stormwater runoff. Yard waste disposal occurs near and within waterways between Birch Bay Village and Beach Way. This may occur here or may occur elsewhere and material is transported here. Residents have reported that yard waste and/or other trash has been dumped into ponds at Sealinks golf course.

Depending on the type of material disposed of, this could be affecting water quality as well as water quantity.

Water Quantity Problems Identified During Field Visits by County Staff and Consultant

No additional water quantity problems were identified during field visits. Water quantity problems identified in previous studies and by citizens were investigated.

TABLE 1
Water Quantity Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Drainage, Flooding and Erosion/Stability	**BR-02** (also BR-04, BR-06)	Cary Lane ditches are full, piping system is overwhelmed; December 2004 and January 2006 documented dates Oertel Drive, December 2004, an outfall pipe at 8741 Oertel Drive became plugged and blew out at the lower end near the outlet. This most likely occurred because of accumulated debris. Resident repaired at own expense.	Birch Point	Oertel Drive off of Semiahmoo Dr. on Birch Point Cary Lane, off of Semiahmoo Dr. on Birch Point
Drainage, Flooding	**BR-03**	A low point exists in road and ditch system near 8621 Semiahmoo Drive. The ditches converge at this location and flow through a culvert into a ditch along the south property line of 8621 Semiahmoo Drive. In December 2004, ditches were overwhelmed and the outflow pipe was destroyed. Trillium Corp. and Washington State DNR replaced outfall pipe with 24”plastic pipe. Resident built concrete collector to channel flow to outfall. January 2006, the problem happened again. Many cubic yards of material were eroded away during this event	Birch Point	Semiahmoo Drive
Drainage, Flooding	**BR-05**	Increased flows and velocity cause drainage problems along Normar Place off of Semiahmoo Drive. The ditch eroded and sent rocks and mud down the half pipe into the junction box. The box plugged up and caused a geyser effect (December 2004). The ditch/open channel outfall along the south property line was overwhelmed. Resident placed sandbags to prevent major damage. The source of this drainage is detention ponds on upslope Trillium property that flow into road ditches, and then through a cross-culvert under Semiahmoo Drive and down to the outfall ditch.	Birch Point	Normar Place off of Semiahmoo Dr. on Birch Point
Drainage, Flooding	**BR-11**	Semiahmoo Drive and Birch Point Road intersection, two detention ponds from Trillium Property flow south in county road ditch to a cross-culvert under road. During events in 2004 and 2005, the ditches overflowed and covered the roadway with water. Residents reported nearly a foot of water over roadway during each of these events.	Birch Point	Semiahmoo Drive and Birch Point Road

TABLE 1
Water Quantity Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Bluff Erosion, Stability	**BR-10**	Slope stability is a problem all across Birch Point. Residents along the high bluff areas of Semiahmoo Drive have reported ongoing slippage and erosion. Increased subsurface flow from Groundwater Recharge Area, special consideration for unique geologic area	Birch Point	Throughout Birch Point area
Drainage, Flooding	**BV-01**	Ditches leading to Rogers Slough back up under high tides and/or heavy rains, cause flooding in backyards along Birch Point Rd and Salish Rd. within Birch Bay Village; *[culvert re-route proposed by Birch Bay Village along Birch Point Rd under Birch Pt. Loop to alleviate flooding]*	Birch Bay Village	Birch Point Rd. and Birch Point Rd. Loop near Birch Bay Village
Drainage	Not reported at Workshop 1; therefore, named **CC-01** (also BV-08)	Trees and other material accumulate within Rogers Slough. Drainage is an issue when this material is present and is not removed frequently. Material also accumulates along Cottonwood Beach.	Birch Bay Village, Cottonwood	East of Birch Bay Village, Rogers Slough Cottonwood Beach
Drainage, Flooding	**BV-02** (also BV-03; BV-05; BV-10; BV-14; BV-17; BV-18; BR-07)	Major flooding with winter storms, big ponds of standing water within Birch Bay Village; stream in Village has increased in flow	Birch Bay Village	Birch Bay Village
Bluff Erosion / Stability	**BV-20**	Eroding beach and bluffs at Birch Bay Village	Birch Bay Village	Beach at Birch Bay Village
Drainage, Flooding	**HS-02**	Residents have reported flow conveyance a problem if maintenance not performed. In the winter of 2003-2004, Harborview Rd frontage ditch overflowed for the first time in 23 years, possibly due to maintenance Issues	Hillsdale	Harborview Road
Drainage, Flooding	**CT-01** (CT-07)	Drainage ditch along Shintaffer Rd. diverts through two 90° bends then through Richmond Park subdivision; conveys runoff from large area, excess backs up into driveways and backyards	Cottonwood Reach	Richmond Park subdivision along Shintaffer Rd. south of Lincoln Rd.

TABLE 1
Water Quantity Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Drainage, Flooding	**CT-06** (also CT-10 and CU-01)	Flooding in yards of 17 homes during 1/29/06 event associated with blocked outfalls along Cottonwood Beach including hammerhead outfall near Cedar Rd. Yard flooding also documented on 1/11/06 (8200 Birch Bay Drive). As head increases, geysering may occur in upstream pipe.	Cottonwood Reach, Central Uplands	Cedar and Birch Bay Drive
Erosion, Stability	not reported at PW#1, therefore named **CC-02**	Citizens have reported erosion of roadway and supporting material at several locations along Birch Bay Drive to the south of Cottonwood Beach. Near at least one of these locations, the actual road surface has been affected. Pedestrians and bikers can no longer use the side of the road without being in a lane of traffic.	Cottonwood Reach	Cottonwood Beach and south
Drainage, Flooding	**CR-02** (also CR-05)	Mariners Cove yards are flooded with heavy runoff in wet season; backs up when it rains; single large pipe drains to beach	Central Reaches	Mariners Cove along Birch Bay Drive
Drainage, Flooding	**CR-03**	Low-lying area, backyards and homes are flooded during wetter months in Pine Drive area	Central Reaches	Outlet along Lora Lane and Birch Bay Drive; Pine Drive
Drainage, Flooding	**CR-04**	The retention pond overflows in the open area to the east of the units along Birch Bay drive just south of the Terrell Creek outlet near Lora Lane.	Central Reaches	Behind units along Birch Bay Drive, south of Terrell Cr. outlet
Drainage, Flooding	**CR-06**	Culvert blocked; standing water for weeks in low areas; often problems with water over roadway; also standing water on N. Morrison, which is the portion of the roadway not maintained by county)	Central Reaches	Corner of Wooldridge and Morrison
Drainage, Flooding	**CR-08**	Flooding occurs corresponding to extreme high tides	Central Reaches	Alderson Rd. at Birch Bay Drive
Bluff Erosion /Stability	**CR-10**	Citizens state that the hill just north of Alderson Rd. near Birch Bay Drive has signs of slippage.	Central Reaches	East on Alderson Rd. from Birch Bay Drive
Drainage, Flooding	**CU-03** (also CU-04)	Latitude 49 drainage pond overflows onto Sealinks Drive at entrance gate to Sealinks, flows west on N. Golf Course Dr. towards Bay	Central Uplands	Sealinks Dr. at entrance gate to Sealinks

TABLE 1
Water Quantity Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Drainage, Flooding	**CU-05** (also TC-01)	Three retention ponds in Bay Crest Development reach capacity quickly; One pond near Bay and Jackson flows into tributary to Terrell Cr.; Two other ponds flow into ditch on Key Street to ditch on Jackson, north to Terrell Cr.; Discharge from all three ponds is muddy/silty;	Central Uplands	Key Street, corner of Bay and Jackson;
Drainage, Flooding	Not reported at Workshop 1; therefore, named **CC-03**	Yard flooding along Wooldridge just north of Jackson (documented with photographs taken 1/6/06 and 1/10/06)	Central Uplands	Corner of Jackson and Wooldridge
Drainage, Flooding	**TC-02**	Flooding of intersection of Blaine and Grandview Roads	Terrell Creek	Intersection of Blaine and Grandview Roads
Drainage, Flooding	**SP-04**	Outfall south of Jackson Rd. Bridge needs to be checked. It gets clogged or blocked easily.	State Park Reach	Jackson Rd and Terrell Creek
Drainage, Flooding Bluff Erosion /Stability	**PW-01** (also PW-02)	Slides, ground subsidence along edge of point and sides along cliffs; Seeps all along shore from tip of Pt. Whitehorn to north end of State Park – most significant one is near State Park; significant seepage along Whitehorn Way	Point Whitehorn	Point Whitehorn along point and cliffs
Drainage, Flooding	**PW-03** (also PW-04, PW-05; PW-07)	Tree loss on Trillium property has changed hydrology, as has residential development; water is now pooling; Former lake, stream, and gravel pit have changed hydrology; drainage is now an issue Several houses have standing water in front after rains; existing swales overflow in heavy rains Drainage pipes not uniformly connected to curtain drains; Citizens' comments: new building permit calls for onsite downspout management and bioswales used to manage runoff instead of tight-line drainage.	Point Whitehorn	Whitehorn Way; Trillium property to the south of Whitehorn Way

TABLE 1
Water Quantity Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Drainage, Flooding	**PW-06** (also BR-04; CT-02; CT-03; CT-04; CT-09; CU-02; PW-06)	Yard waste and garbage blocks stormwater conveyance in ditch and catch basins; contributes to drainage problems Yard waste disposal occurs near and within waterways between Birch Bay Village and Beach Way along Birch Bay shoreline. This may occur here or may occur elsewhere and material is transported here.	Point Whitehorn, Cottonwood and others	Grandview Road, Maple and Cedar Streets off of Beach Way; Birch Bay shoreline between Birch Bay Village and Beach Way

FIGURE 1
Channelized Stormwater Flow along Semiahmoo Drive in Birch Point Area

FIGURE 2
Modifications made to Channelized Stormwater Flow along Semiahmoo Drive in Birch Point Area

FIGURE 3
Flooded drainage ditch along the south side of Birch Point Road to the west of Rogers Slough

FIGURE 4
Flooded drainage ditch along the north side of Birch Point Road to the west of Rogers Slough

FIGURE 5
The drainage channel downstream of the two 90-degree bends entering the Richmond Park Subdivision, looking north

FIGURE 6
The full drainage ditch along Shintaffer Drive looking south

FIGURE 7
Outfall along Birch Bay Drive near Cedar

FIGURE 8
Flooding that occurred in January, 2006 along the 8200 block of Birch Bay Drive

FIGURE 9
Looking east along the drainage ditch behind the tide gate at Lora Lane discharging to the mouth of Terrell Creek. The Leisure Park is shown on the left of the picture. Portions of the area to the right of the drainage ditch are classified as wetlands.

FIGURE 10
Low-lying area upstream of the drainage ditch shown in Figure 9. Note ponding water. Portions of this area are classified as a wetland.

FIGURE 11
Area behind (to the east of) homes shown in Figure 11, shown looking northwest. Portions of this area are classified as a wetland.

FIGURE 12
Material accumulated within the tide gate and culvert at the Corner of Wooldridge and Morrison, 01/04/06.

FIGURE 13
Flooded Ditch on the NE Corner of Wooldridge and Morrison behind tide gate, January 2006

FIGURE 14
Flooding along Wooldridge just north of Jackson, January 2006

Water Quality Problems

Water quality challenges in the Birch Bay watershed can be categorized into the following two primary groups:

- Many of water quality problems reported by the citizens are due to activities of residents. This underscores the need for extensive and focused education of the local residents.
- Several water quality problems are related to new construction. This indicates that regulations should be stronger or more carefully enforced.

Additional descriptions of water quality issues are available in the following sections. For example, coliform bacteria monitoring in Birch Bay has resulted in the listing in 2003 of the bay by the Washington Department of Health (DOH) as "Threatened" for closure to recreational shellfish harvesting.

Residents of Birch Bay are concerned with the composition of stormwater runoff entering Birch Bay. Table 2 contains a listing of the 16 individual problems identified within the Birch Bay area pertaining to water quality. Each of these problems is described here.

Water Quality Problems Identified from the Literature

CC-04

Pollution from failing septic systems is recognized as a source of pollution. The January 1995 reclassification of the shellfish beds in Drayton Harbor attributed the pollution to six sources, including failing septic systems (Meriwether, 1995). The presence of failing septic systems has not been confirmed in Birch Bay. However, it is a possibility that failing septic systems are contributing to declining water quality in Birch Bay.

Washington State Senate House Bill 1458 requiring local health authorities to identify and correct failing septic systems by 2012 passed the Washington State Senate on 2/28/06. This bill builds off of the recent DOH regulations requiring that Puget Sound counties develop plans that outline how they will manage onsite septic systems.

CC-05

Terrell Creek has low dissolved oxygen levels and high temperatures. Dissolved oxygen concentrations below criteria and temperatures above criteria have been recorded during water quality monitoring activities by both NSEA and Ecology (Rachel Vasak, NSEA, personal communication, 11/4/05). Other water quality parameters are also problematic along the length of the creek. Residents have reported algal blooms in several locations in the lower confined reaches of Terrell Creek.

At one time, Terrell Creek followed a natural path through the area. It is natural for a coastal stream to move in the direction of longshore drift and, occasionally during a large storm event, to cut through to a new, more direct outlet to salt water. Then the drift process starts over. As development in Birch Bay proceeded, sections of Terrell Creek were confined and the creek no longer was allowed to find a natural course. Current patterns of development permanently set the location of Terrell Creek. Currently, Terrell Creek follows the beach shoreline from the state park to its outlet.

This entire stretch along with a large portion of the creek within the state park is tidally influenced. The Terrell Creek marsh (within Birch Bay State Park) is one of the few remaining saltwater/freshwater estuaries in northern Puget Sound. The north end of Birch Bay State Park is a natural game sanctuary providing refuge for smaller birds, migratory waterfowl, American bald eagles, and the great blue heron.

The lower confined reaches of Terrell Creek are affected by tidal changes that may cause stagnant conditions under periods of high tide. The reaches of Terrell Creek between Birch Bay State Park and the outlet of the creek into Birch Bay have had measured low dissolved oxygen levels and higher temperatures. This has led to fish kills.

Water Quality Problems Identified by Citizens

BV-04

Water quality problems have been experienced within the marine waters of Birch Bay at a variety of locations. DOH monitors 10 stations throughout the bay for fecal coliform. Results of this coliform monitoring in Birch Bay have resulted in the listing of the bay by DOH as "Threatened" for closure to recreational shellfish harvesting as of July 2003.

BV-02

The water quality within the lakes and stream in Birch Bay Village is problematic. Pollutants entering these bodies of water may include nutrients, fertilizers, sediment, petroleum products from vehicle use, and waste material from ducks and birds. Algae blooms occur seasonally. In addition, these inputs into the marina may carry amounts of suspended sediment.

Large volumes of sediment coat the bottom of the Birch Bay marina. This material may enter the marina via the large volumes of "muddy" water discharging to the marina from the waterways within Birch Bay Village.

BV-12

Residents have reported that tidal currents have eroded the beach at bluffs at Birch Bay Village. It is not clear whether this is a natural event or a result of human disturbance. Although there have been multiple slides in the last few years, no information has been found that indicates whether the rate of beach erosion has changed over time. The movement of this material may affect the Birch Bay Village marina.

BV-16

The Trillium clear cut area along Birch Point may contribute pollutants to Birch Bay. These pollutants could include suspended sediment as well as others.

CT-05

Large numbers of Canada geese are present in late summer through winter. These geese leave wastes behind.

CR-05

Large amounts of algae are present near the large outfall pipe along the beach near Mariners Cove Condominiums. This may indicate excessive nutrients in the runoff. In addition, sewer backups associated with rain events have been reported by residents in the bottom units of the Mariners Cove Condominiums. Localized flooding occurs in this area associated with rain events.

CR-09

Many dogs are present at the residence(s) near the bank of Terrell Creek close to Alderson Road and Birch Bay Drive.

TC-01

Muddy and silty stormwater discharge has been reported from the Bay Crest development site.

SP-01

Large numbers of ducks and/or birds congregate on the north edge of the park. These ducks and birds leave waste behind.

PW-08

The use of herbicides and other chemicals has been reported by residents in the Point Whitehorn area. There is no specific information on location or amount of use. There are also no details on whether this is causing problems.

Water Quality Problems Identified During Field Visits by County Staff and the Consultant

CC-07

Mud has been tracked out of worksite by large trucks and other vehicles. This material coats the roadway for a distance away from the site entrance. This site is along the east-west road just south of Lake Terrell and is most likely a gravel pit or some other related operation.

CC-08

Large numbers of birds and geese populate Lake Terrell, leaving waste behind.

CC-09

Animals kept on properties may still have access to drainage ditches and depressions that eventually discharge to waterways and Birch Bay, as shown in Figure 15.

CC-10

The Sunset Farm Equestrian Center along Birch Road may be a source of animal waste material. Posted rules require users to remove animal waste from graveled area. However, regulations may not be followed. This 70-acre park is managed by Whatcom County Parks and Recreation. Figure 16 shows the Sunset Farm Equestrian Center.

TABLE 2
Water Quality Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Water Quality Problems Identified in the Literature				
Water Quality	Not reported at PW 1; named **CC-04**	Potential for failing septic systems in Birch Bay area based on presence of failing septic systems in Drayton Harbor watershed contributing to shellfish harvesting closures there.	Birch Bay	Regional
Water Quality	Not reported at PW 1; named **CC-05 (also CC-06)**	Low dissolved oxygen concentrations and high temperatures in many reaches of Terrell Creek, most notably in the lower reaches within the last 1.5 miles of the creek outlet to Birch Bay. Other water quality parameters are also problematic. Algal blooms observed by citizens in the lower confined reaches of Terrell Creek may indicate excessive nutrient inputs and poor flushing leading to low dissolved oxygen levels.	Central	Terrell Creek near mouth
Water Quality Problems Identified by Citizens				
Water Quality	**BV-04** (also BV-06)	Water quality in Bitch Bay is problematic; high levels of coliform in various locations sampled by DOH.	Birch Bay	Birch Bay
Water Quality	**BV-02** (also BV-05; BV-07; BV-10; BV-11; BR-07)	Water quality of lakes and stream in Birch Bay Village is problematic; pollutants may include nutrients, fertilizers, sediment, petroleum products from vehicles; algae blooms and fecal matter from ducks/birds. Also, suspended sediment is a problem. Large amount of sediment at bottom of marina could be coming from flow of surface water into marina.	Birch Bay Village	Lakes and stream within Birch Bay Village; Birch Bay Village Marina
Water Quality	**BV-12** (also BV-20)	Beach at Birch Bay Village is eroding, as is Birch Bay Village Bluff; movement of sediment in bay may impact marina - requires more frequent dredging.	Birch Bay Village	Beach at Birch Bay Village
Water Quality	**BV-16**	Clear cut area contributes pollutants to runoff, especially suspended sediment.	Birch Point	Clear cut area on Birch Point

TABLE 2
Water Quality Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Water Quality	**CT-05**	Large numbers of Canada geese present in late summer into winter, leave waste matter behind.	Cottonwood Reach	Between Birch Bay Village and Beach Way, Cottonwood Beach
Water Quality	**CR-05**	Lots of algae present near large pipe outfall along beach may indicate excessive nutrients in runoff.	Central Reaches	Along Beach near Mariners Cove condos
Water Quality	**CR-09**	Presence of many dogs on properties near bank of Terrell Creek may be contributing to coliform bacteria and nutrient inputs into Terrell Creek.	Central Reaches	Alderson and Birch Bay Drive
Water Quality	**TC-01**	Muddy/silty stormwater drainage from Bay Crest Development Site.	Terrell Creek	Bay Crest Development
Water Quality	**SP-01**	Large numbers of ducks/birds on north edge of park may be contributing to water quality problems.	State Park Reach	Within Terrell Creek
Water Quality	**PW-08**	Residents observed use of herbicides and other chemicals (?) observed in close proximity to drainage to bay. May also occur elsewhere in watershed.	Point Whitehorn, others	area-wide
<u>Water Quality Problems Identified by County Staff and Consultant During Field Visit</u>				
Water Quality	Not reported at PW 1; named **CC-07**	Mud tracked out of site by truck tires; material all over roadway; possibly a gravel pit or some other similar operation.	Lake Terrell	Just south of Lake Terrell along east-west road
Water Quality	Not reported at PW 1; named **CC-08**	Large numbers of birds and geese populate Lake Terrell, leave waste behind.	Lake Terrell	Lake Terrell and associated waterways
Water Quality	Not reported at PW 1; named **CC-09**	Animals kept on properties but have access to drainage ditches and depressions that discharge to channels that eventually discharge to Birch Bay.	Central Uplands	Locations throughout Birch Bay watershed

TABLE 2
Water Quality Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Water Quality	Not reported at PW 1; named **CC-10**	The Sunset Farm Equestrian Center along Birch Road may be a source of animal waste material. Posted rules require users to remove animal waste from graveled area. This emphasizes the need for education and enforcement.	Central Uplands	West Side of Blaine Road south of Lynden Rd.

FIGURE 15
Presence of sheep near drainages to Birch Bay

FIGURE 16
Horse use areas at Sunset Farm Equestrian Center

Aquatic Habitat Problems

The streams, wetlands, and near shore marine waters in the Birch Bay area provide aquatic habitat for birds, fish, and shellfish. Residents of Birch Bay are concerned with the preservation of existing aquatic habitat and the restoration of habitat previously lost.

Key aquatic habitat issues in Birch Bay include fish passage and loss of wetlands. Additional habitat issues are described in following sections summarizing existing literature. For example, there are data that show that the low summer flows near the mouth of Terrell Creek may stress or kill juvenile salmon and trout. Table 3 contains a listing of the six individual problems identified within the Birch Bay area pertaining to aquatic habitat degradation and/or preservation.

Aquatic Habitat Problems Identified from the Literature

CC-11

At various locations along its course, Terrell Creek flows through culverts associated with road crossings. At least two of these have been built in a way that prevents fish passage.

The first culvert creating a barrier for fish under certain flow conditions is the culvert at Blaine Road. The Washington State Department of Transportation (WSDOT) currently has plans to replace this culvert. Another culvert, located at Grandview Road, is situated high enough above the creek bed that any fish passage is impossible. Either this culvert would have to be replaced, or the channel downstream from the culvert would have to be built up in elevation to allow for fish passage through the existing culvert (Rachel Vasak, NSEA, personal communication, 11/4/05).

The dam at the outlet of Lake Terrell also prohibits fish passage into the lake. Several smaller streams discharge to Lake Terrell that may provide good spawning habitat if they were accessible to fish.

CC-12

At one time, Terrell Creek followed a natural path through the area. It is natural for a coastal stream to move in the direction of longshore drift and, occasionally during a large storm event, to cut through to a new, more direct outlet to salt water. Then the drift process starts over. As development in Birch Bay proceeded, sections of Terrell Creek were confined and the creek no longer was allowed to find a natural course. Current patterns of development permanently set the location of Terrell Creek. Currently, Terrell Creek follows the beach shoreline from the state park to its outlet near Lora Lane.

This entire stretch along with a large portion of the creek within the State Park is tidally influenced. The Terrell Creek marsh (within Birch Bay State Park) is one of the few remaining saltwater/freshwater estuaries in northern Puget Sound. The north end of Birch Bay State Park is a natural game sanctuary providing refuge for smaller birds, migratory waterfowl, American bald eagles, and the great blue heron.

The stretch of Terrell Creek between the State Park and the outlet near Lora Lane is a confined reach that prevents the creek from achieving a natural pathway. The lower confined reaches of Terrell Creek between Birch Bay State Park and the outlet of the creek into Birch Bay have low dissolved oxygen levels and higher temperatures. The lower reaches of Terrell Creek are affected by tidal changes that may cause stagnant conditions under periods of high tide. Dissolved oxygen concentrations below criteria and temperatures above criteria have been recorded during water quality monitoring activities by both NSEA and Ecology (Rachel Vasak, NSEA, personal communication, 11/4/05).

Aquatic Habitat Problems Identified by Citizens

SP-03

Terrell Creek flows are generally too low during the summer season. Low summer flows reduce available juvenile rearing habitat. In addition, when flows are low, connections to wetlands and beaver ponds are nonexistent. These low flow conditions may also be accompanied by poor water quality and elevated temperatures. Outlet flows from Lake Terrell could be adjusted to prevent summer flows from reaching critical levels. During the summer of 2005, flow rates were kept near or above approximately 100 cubic feet per second (cfs). This appeared to have helped the situation considerably.

BR-12

Pockets of natural areas exist on Trillium property in the Birch Point area. Some of these areas are designated as wetlands on the maps within the Whatcom County Comprehensive Plan (Whatcom County, 2005). Local residents insist that these should be protected as habitat for birds and other wildlife.

Aquatic Habitat Problems Identified During Field Visits by County Staff and Consultant

CC-13

Terrell Creek contains degraded instream and riparian habitat both upstream and downstream from the Jackson Road Bridge. A number of projects have begun with the goal of improving riparian and instream habitat. Invasive reed canarygrass has been removed, and native vegetation has been planted along the banks of the creek. Large woody debris has been placed at various locations along a 2,500-foot stretch of the creek. This large woody debris provides hydraulic diversity and improves salmon habitat. However successful these projects have been, there is room for improvement in the instream and riparian habitat.

CC-14

Tide gates may prevent access for fish to suitable habitat. The tide gate located near the mouth of Terrell Creek that blocks the drainage along Lora Lane by the Leisure Park is an example. The Birch Bay Steering Committee has held discussions on the benefits and the potential negative consequences of the use of tide gates. These will have to be weighed against the potential benefits of using the area behind the tide gate as fish habitat. Habitat surveys would have to be performed in areas behind tide gates to assess the benefits of use for fish.

TABLE 3
Aquatic Habitat Problems Identified

Problem Type	Code from Public Workshop (PW) 1 (if applicable)	Description	Neighbor-hood	Location
Aquatic Habitat Problems Identified in the Literature				
Fish Passage Blockage	Not reported at PW 1, named **CC-11**	Culverts under roadways prevent fish blockage. These culverts are at the Blaine Rd. and Grandview Rd crossings over Terrell Creek.	Terrell Creek	Various locations along Terrell Creek
Habitat Preservation	Not reported at PW 1, named **CC-12**	The stretch of Terrell Creek between the State Park and the outlet near Lora Lane is a confined reach that prevents the creek from achieving a natural pathway. This stretch of the creek backs up during high tides, creating stagnant conditions with low dissolved oxygen for fish.	Terrell Creek	Terrell Creek near outlet, downstream of Birch Bay State Park
Aquatic Habitat Problems Identified by Citizens				
Habitat Preservation	**SP-03**	Terrell Creek flow has not been maintained during summer months, levels are too low and temperatures are too high. However, during the summer of 2005, a minimum of 100 cfs was maintained in the creek (Rachel Vasek of NSEA, personal communication on 11/4/05). This showed positive benefits.	State Park Reach	Entire stretch of Terrell Creek
Habitat Preservation	**BR-12**	Pockets of existing wetlands should be protected as habitat for birds and other wildlife.	Birch Point	Birch Point
Aquatic Habitat Problems Identified by County Staff and Consultant During Field Visit				
Habitat Restoration	Not reported at PW 1, named **CC-13**	Terrell Creek contains degraded instream and riparian habitat both upstream and downstream from the Jackson Road Bridge.	Terrell Creek	Terrell Creek near the Jackson Road bridge
Fish Passage Blockage	Not reported at PW 1, named **CC-14**	Tide gates may prevent access for fish to suitable habitat. The tide gate located near the mouth of Terrell Creek that blocks the drainage along Lora Lane by the Leisure Park is an example.	Cottonwood Reach, others	Near mouth of Terrell Creek; other areas with tide gates

Policy / Planning Issues

Several issues were identified by citizens and others that do not relate to a site-specific water quantity, water quality, or aquatic habitat issue, but have more to do with how policies and plans are created and carried out. These are outlined in this section.

- Citizens expressed concern about stormwater quantity and quality issues surrounding new development projects and how these new projects will influence existing conditions.
- Citizens stressed the importance of working with the City of Blaine on regional stormwater planning and possible stormwater detention projects.
- Citizens questioned the current water quality complaint system. Issues were the lines of communication and the process of enforcement.
- Citizens are concerned about the increase in impervious surface created by new development.
- Citizens expressed interest in LID for new development and redevelopment.
- Citizens are concerned about the rate of tree loss on public and private property.

Summary

Water Quantity

Water quantity challenges in the Birch Bay watershed can be categorized in the following three main groups:

- **Low-lying areas along the beach**: There are extensive low and flat areas behind the natural dune of the beach. Even without development, these areas were likely inundated during extreme high tides and high wind conditions. Many of the areas that now have homes and roads were once large, natural wetlands. Development has increased runoff and in some cases may have blocked natural flow paths.
- **New development:** The watershed is experiencing rapid development, particularly near the beach. New development is increasing the peak rate and volume of runoff even with onsite detention resulting in increased downstream flooding and erosion. Existing standards and, or review procedures may need to be improved to reduce the impacts of new development.
- **Bluff erosion**: There are examples of slides all along the bluffs at both the south and north ends of Birch Bay. Beach erosion and slides along bluffs are natural events, but their occurrence may be accelerated by stormwater that is routed over the bluffs or if additional water is infiltrated near the bluffs from either stormwater or septic tank drain fields.

Many of the problems identified by citizens may be problems caused by individual property owners affecting themselves or other individual property owners. Such problems are often not the responsibility of the government, but the responsibility of the individual property owners to resolve. For example, a property owner who routes rooftop runoff over the edge of the bluff would be responsible for the cause of and resolution to any damage to their own property.

Water Quality

Water quality challenges in the Birch Bay watershed can be categorized in two main groups, as follows:

- **Activities of residents**: The majority of water quality problems reported by the citizens are due to activities of residents. This underscores the need for extensive and focused education of the local residents.
- **New construction**: The occurrence of water quality problems related to new construction indicates that regulations should be stronger or more carefully enforced.

In addition, existing literature identifies other water quality issues identified. For example, coliform bacteria monitoring in Birch Bay has resulted in the listing in 2003 of the Bay by the Washington DOH as “Threatened” for closure to recreational shellfish harvesting.

Aquatic Habitat

Key aquatic habitat issues in Birch Bay include fish passage and loss of wetlands. In addition, water quality issues are identified in existing literature, such as data showing that the low summer flows near the mouth of Terrell Creek may stress or kill juvenile salmon and trout.

Policy / Planning

Citizens are concerned about the potential effects of new development on existing water quantity and water quality conditions. Key issues in Birch Bay include the rate of impervious surface increase and the rate of tree loss due to new and redevelopment.

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Appendix C

Birch Bay Comprehensive Stormwater Plan, Maintenance and Operations Strategy Review

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DATE: July 7, 2006

Introduction

This memorandum is one element of an overall Comprehensive Stormwater Plan for the watersheds of Birch Bay. Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay completed a Comprehensive Land Use Plan that called for low-impact development (LID) and a Stormwater Plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth. This Comprehensive Maintenance Plan recommends measures to achieve these goals.

This memorandum evaluates current Whatcom County Maintenance and Operations (M&O) procedures and programs as they relate to the Birch Bay area. In addition, this memorandum provides recommendations for Whatcom County's M&O program that define levels of service, costs, and implementation approaches.

Sources of Information

The following sources of information were used to identify M&O procedures, methods, and programs applicable to the Birch Bay area:

- Conversations with Whatcom County Drainage M&O staff
- Whatcom County Development Standards, Chapter 2, Stormwater Management: Section 220, Maintenance of Stormwater Facilities, and Section 221, Stormwater Special District Standards
- Whatcom County Comprehensive Plan (2005)
- Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2005)
- National Pollutant Discharge Elimination System (NPDES) and Washington State Waste Discharge General Permit for Discharges from Small Municipal Separate Storm Sewers in Western Washington (Phase II NPDES Stormwater Draft Permit) dated 2/15/06

Maintenance of stormwater facilities is called for in the Whatcom County Comprehensive Plan, Chapter 11, Environment (Whatcom County, 2005):

- Goal 11G: Protect water resources and natural drainage systems by controlling the quality and quantity of stormwater runoff.
  - Policy 11G-7: Establish, as a high priority, a stormwater maintenance program which assures that stormwater systems function at or near design capacity.
- Goal 11M: Protect and enhance shellfish habitat in commercial and recreational areas in order to ensure a productive resource base for long-term use.
  - Policy 11M-9: Modify current roadside ditch maintenance procedures to protect water quality.
- Action Plan: Environment
  - Develop a comprehensive stormwater management program designed to manage runoff from public facilities and industrial, commercial, and urban residential areas including streets and roads in compliance with NPDES requirements….
  - At a minimum, the components of this program shall include: … - programs for operation and maintenance of storm drains, detention systems, ditches and culverts…

Stormwater System Description

Whatcom County stormwater facilities include retention and detention facilities as well as the storm sewer conveyance system of storm sewer pipe, ditches, catch basins, and other structures. Whatcom County is currently engaged in an effort to inventory drainage infrastructure starting with priority watersheds and gradually incorporating the entire county into the database.

Stormwater facilities within the Birch Bay watershed consist of the following:

- Catch basins or related structures
- Public stormwater retention/detention facilities
- Private stormwater retention/detention facilities
- Culverts
- Outfalls
- Tide gates
- Open ditches
- Stormwater conveyance pipe

Existing Whatcom County Maintenance and Operations Program

Responsibility for Maintenance

Public Facilities

Responsibility for maintenance and operations of publicly owned and operated surface drainage facilities within Whatcom County lies with the Whatcom County M&O Division. M&O of roadways, structures, traffic, vegetation, and surface drainage infrastructure are all the responsibility of this division. The Surface Drainage Management Division within the M&O Division handles surface drainage maintenance.

The Road Standards section of the Whatcom County Development Standards (Chapter 5, Road Standards) outlines guidelines for maintenance of culverts under driveways. These standards state that "Maintenance of driveway approaches, including stormwater culverts, shall be the responsibility of the owner(s) whose properties they serve."

Private Facilities

Whatcom County Development Standards outline responsibilities for stormwater maintenance of private facilities (Section 220, Maintenance of Stormwater Facilities). General Provisions are outlined and include minimum standards for maintenance of stormwater facilities, minimum requirements for a maintenance plan and for frequency of inspection, and financial responsibility for inspection, maintenance, operation, and repair of stormwater systems.

These general provisions call for a frequency of inspection as outlined in the Maintenance Plan submitted with the development application, as follows:

- Stormwater facilities are to be inspected annually and cleared of debris, sediment, and vegetation.
- Grass swales and other bio-filters are to be inspected annually and mowed or replaced as necessary.
- Inspection and cleaning of catch basins and manholes are required annually, and inspection is required after major storm events for cleaning of sediment accumulation if the depth of the deposits is greater than one-third the depth from the basin to the invert of the lowest pipe into or out of the basin.
- Flow control facilities should be inspected annually and during major storms, inspected every 2 years for accumulated sediment that exceeds 10 percent of the designed pond depth, and inspected annually for any deterioration threatening the structural integrity of the facility.

The Development Standards specify that property owners are financially responsible for the inspection, maintenance, operation, or repair of stormwater systems not specifically accepted by the County through the development process. In addition, financial responsibility includes reimbursing Whatcom County for its costs to perform routine inspections to verify compliance, as described in the Maintenance Plan submitted with the development application. The owner should maintain appropriate records of all inspection and maintenance activities. Whatcom County is authorized to inspect all stormwater systems to determine compliance with the provisions of the Maintenance Plan submitted with the development application.

Section 220 of the development standards describes the M&O of County-maintained privately owned facilities. Whatcom County may assume maintenance responsibility of a stormwater system if it is in the County's best interest to do so. If Whatcom County decides to assume responsibility, the County shall assume maintenance after the expiration of a 2-year period during which the owner has performed maintenance.

If Whatcom County does not assume maintenance responsibility at the end of the 2-year period, the owner of the private system must arrange for the occupants or owners of the subject property to assume maintenance consistent with the Maintenance Plan submitted with the development plan.

Maintenance Standards and Frequency of Maintenance

Whatcom County M&O crews plan to inspect each catch basin in the Birch Bay area at least twice per year. Roadside ditches are maintained on an as-needed basis, with maintenance efforts concentrated in the summer season with the cutting down and removal of vegetation, and in the winter season with removal of accumulated material that may prevent conveyance.

Several stormwater structures frequently need maintenance attention and are attended to by maintenance crews more frequently than others in the system. For instance, several culverts in the Birch Bay area tend to plug up with accumulated material such as grass clippings and trash.

Documentation of Inspections and Maintenance Activities/Database Management

Drainage crews know the system well and are familiar with the culverts, catch basins, ditches, and other facilities that frequently cause problems. However, no formal documentation process is in effect for Whatcom County. Much of this currently rests with the individual M&O crew members and supervisors who have a wealth of knowledge on how the drainage system works throughout the county.

Response to Customer Inquiries & Complaints

Drainage complaints are directed to the M&O drainage division at Whatcom County. When the complaint is received, a work order is generated and handed over to the drainage crew supervisor for scheduling. The problem is then addressed by the drainage crews. According to Whatcom County M&O staff, up to 50 drainage-related calls have been received per day on busier (wetter) days in the last few years. Complaints are prioritized based on severity.

Costs of Drainage Maintenance and Operations Activities

Limited information is available on the costs per unit to maintain and operate drainage infrastructure elements within Whatcom County. Table 1 includes costs for M&O activities from different jurisdictions. Data from Seattle Public Utilities and King County were used. These data represent costs per unit for various M&O activities conducted in large jurisdictions with relatively short distances between structures. These cost estimates may be underestimating the true cost to perform these activities in Whatcom County, where much of the county is of low density. However, these numbers provide an order-of-magnitude estimate for the cost associated with several M&O activities that are performed within Whatcom County and Birch Bay.

TABLE 1
Drainage M&O Activities

Type of Structure	Activity	Cost per Unit[a]
Drainage Pipes	Jet Rod (for debris)	$2.07/ linear foot (LF)
	Machine Rod (roots)	$0.90/ LF
	Hydrocut (debris and roots)	$1.07 / LF
Culverts	Clean Culvert	$15 / each (EA)
	Hand Clean Culvert	$ 50 / EA
Catch Basins	Inspect Catch basin	$7.00 EA
	Clean Catch Basin	$45.10 EA
Drainage Ditches	Inspect Ditch	$0.25 / LF
	Perform Ditch Maintenance	$1.50 / LF
Facilities (ponds, tanks, vaults)	Inspect Retention/Detention Pond	$300.00 / EA

[a] Costs were derived from both Seattle Public Utilities and King County data. Unit costs for Seattle Public Utilities were based on activities conducted during 2004 and the first three quarters of 2005. Unit costs for King County were based on budget and performance for the years 1999 and 2000 with adjustments to 2005 dollars. Stated costs are estimates and do not include costs of transportation/disposal of waste materials from catch basins, ditches, and other facilities.

Published Guidelines for Maintenance and Operations

NPDES Phase II Stormwater Permit

Whatcom County is an NPDES Phase II jurisdiction (Ecology, 2006a). Currently, Birch Bay is not covered under the NPDES Phase II permit because Birch Bay is not deemed an Urbanized Area by the U.S. Census Bureau. In Washington State, census-defined Urbanized Areas do not line up with city and county boundaries and Urban Growth Areas (UGAs) established by the State's Growth Management Act (GMA). There are requirements for M&O of stormwater systems in the Draft NPDES Phase II Permit for Western Washington. The permit outlines the following performance measures for the M&O program:

a) **Adoption of maintenance standards** that are as protective, or more protective, of facility function as those specified in Chapter 4 of Volume V of the 2005 *Stormwater Management Manual for Western Washington.*

b) **Annual inspection** of all municipally owned or operated permanent stormwater treatment and flow control facilities and taking appropriate maintenance actions in accordance with the adopted maintenance standards.

c) **Spot checks of potentially damaged permanent treatment and flow control facilities** (other than catch basins) **after major** (greater than 24-hour 10-year recurrence interval rainfall) **storm events**

d) **Inspection of catch basins and inlets** owned or operated by the Permittee **at least once before the end of the permit term**. **Clean catch basins if the inspection indicates cleaning is needed** to comply with maintenance standards established in the 2005 *Stormwater Management Manual for Western Washington*.

e) Compliance with the inspection requirements in a, b, c, and d above shall be determined by the presence of an **established inspection program** designed to inspect all sites and achieving inspection of 95 percent of all sites.

f) Establishment and implementation of **practices to reduce stormwater impacts associated with runoff from streets, parking lots, roads, or highways** owned or maintained by the Permittee, and road maintenance activities conducted by the Permittee.

g) Establishment and implementation of policies and procedures to **reduce pollutants in discharges from all lands owned or maintained by the Permittee** and subject to this Permit, including but not limited to parks, open space, road right-of-way, and maintenance yards, and at stormwater treatment and flow control facilities.

h) Develop and implement an **on-going training program** for appropriate employees of the Permittee whose construction, operations, or maintenance job functions may impact stormwater quality.

i) Development and implementation of a **Stormwater Pollution Prevention Plan (SWPPP) for all heavy equipment maintenance or storage** yards, and material storage facilities owned or operated by the Permittee in areas subject to this permit that are not required to have coverage under the Industrial Stormwater General Permit.

j) **Records of inspections and maintenance or repair activities** conducted by the Permittee shall be maintained in accordance with S9 [Reporting Requirements].

Although Birch Bay is currently not a Phase II area, the M&O procedures and practices outlined in the Phase II permit are helpful in formulating a beneficial M&O program.

Stormwater Management Manual for Western Washington

Maintenance standards are described in the *Stormwater Management Manual for Western Washington* (Ecology, 2005). Chapter 2 of Volume IV of the Ecology manual specifies the following best management practices (BMPs)for **maintenance of stormwater drainage and treatment systems**:

- Inspect and clean treatment BMPs, conveyance systems, and catch basins as needed, and determine whether improvements in M&O are needed.
- Promptly repair any deterioration threatening the structural integrity of the facilities. These include replacement of clean-out gates, catch basin lids, and rock in emergency spillways.

- Ensure that storm sewer capacities are not exceeded and that heavy sediment discharges to the sewer system are prevented.
- Regularly removed debris and sludge from BMPs used for peak-rate control, treatment, and so forth; discharge to a sanitary sewer if approved by the sewer authority, or truck to a local or state government approved disposal site.
- Clean catch basins when the depth of deposits reaches 60 percent of the sump depth as measured from the bottom of basin to the invert of the lowest pipe into or out of the basin. However, in no case should there be less than 6 inches clearance from the debris surface to the invert of the lowest pipe…. Where these catch basins are part of a stormwater collection and treatment system, the system owner/operator may choose to concentrate maintenance efforts on downstream control devices as part of a systems approach.
- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catch basin.
- Port warning signs—"Dump no Waste – Drains to Ground Water," "Streams", "Lakes"—or emboss on or adjacent to all storm drain inlets where practical.
- Disposal of sediments and liquids from the catch basins must comply with "Recommendations for Management of Street Wastes" described in Appendix IV-G of this Ecology manual.

The Ecology manual also outlines appropriate BMPs for **maintenance of roadside ditches**. These are the following (Ecology, 2005), also in Volume IV Chapter 2:

- Inspect roadside ditches regularly, as needed, to identify sediment accumulation and localized erosion.
- Clean ditches on a regular basis, as needed. Ditches should be kept free of rubbish and debris.
- Vegetation in ditches often prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (e.g., seeding) in late spring and/or early fall, where possible. This allows vegetative cover to re-establish by the next wet season, thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the "bare earth zone," use grass vegetation wherever possible. Vegetation should be established from the edge of the pavement, if possible, or at least from the top of the slope of the ditch.
- Diversion ditches on top of cut slopes that are constructed to prevent slope erosion by intercepting surface drainage must be maintained to retain their diversion shape and capability.
- Ditch cleanings are not to be left on the roadway surfaces. Sweep dirt and debris remaining on the pavement at the completion of ditch cleaning operations.

- Roadside ditch cleanings not contaminated by spills or other releases and not associated with a stormwater treatment system, such as a bioswale, may be screened to remove litter and separated into soil and vegetative matter. The soil fraction may be handled as "clean soils," and the vegetative matter can be composted or disposed of in a municipal waste landfill.
- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following Dangerous Waste Regulations unless testing determines it is not a dangerous waste.
- Examine culverts on a regular basis for scour and sedimentation at the inlet and outlet, and repair as necessary. Give priority to culverts conveying perennial and/or salmon-bearing streams, and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

The Ecology manual also outlines **maintenance needs for specific types of stormwater treatment facilities** (Section 4.6 of Volume V of the Ecology manual). These standards in Section 4.6 of Volume V are a tool for determining maintenance needs for stormwater facilities. The facility-specific standards outline types of potential defects, conditions of those defects that indicate maintenance is needed, and the results that are expected once maintenance is performed. Facility-specific standards are outlined for the following types of facilities (Ecology, 2005):

1. Detention Ponds
2. Infiltration Pond or Other Structure Promoting Infiltration
3. Closed Detention Systems (tanks/vaults)
4. Control Structure/Flow Restrictor
5. Catch Basins
6. Debris Barriers (ex: trash racks)
7. Energy Dissipaters
8. Typical Biofiltration Swale
9. Wet Biofiltration Swale
10. Filter Strips
11. Wetponds
12. Wetvaults
13. Sand Filters (above ground/open)
14. Sand Filters (below ground/enclosed)
15. StormFilter™ (media filters)
16. Baffle Oil/Water Separators
17. Coalescing Plate Oil/Water Separators
18. Catch Basin Inserts

Recommended Level of Maintenance and Operations Service for Whatcom County

Proper maintenance of stormwater facilities is necessary to ensure continued functionality. Setting standards for maintenance is an important element of a stormwater M&O program, as is documentation. This section describes the recommended level of service for the M&O program in Whatcom County for Birch Bay.

Responsibility for Maintenance

Because surface water maintenance and roads maintenance are performed by two separate divisions in Whatcom County, it is conceivable that surface water maintenance can be performed by the County outside of the road right-of-way. For instance, tide gates located outside of the road right-of-way could be maintained by Whatcom County surface water maintenance crews.

Often, Whatcom County has taken over the maintenance of a structure such as a tide gate because the precedent has already been set for them to do so, and not because they own or installed the tide gate or other stormwater facility or structure. Efforts should be made to delineate what is and is not the responsibility of the County to maintain.

Whatcom County development standards outline the responsibilities of private developers for M&O of stormwater facilities on developed (and developing) properties. During at least the first 2 years after construction, the private developer is responsible for the maintenance of the facilities. After this time, however, Whatcom County can choose whether or not to accept the responsibility of M&O on the property. Whatcom County should review this practice to determine its effectiveness at long-term M&O of these structures. In addition, the drainage M&O crews should be made aware of which facilities are and are not the specific maintenance responsibility of the County. Accurate and updated lists and databases should be kept.

Whatcom County should exert its right to inspect new development sites and recently developed sites for compliance with the M&O plan for stormwater management submitted by the developer with the site development plan. These inspections and any corresponding enforcement actions may help alleviate drainage and water quality issues potentially caused by lack of maintenance of private facilities. These inspections could be scheduled quarterly or at some reasonable interval to ensure compliance. The Ecology manual outlines maintenance needs for specific types of stormwater treatment facilities (Section 4.6 of Volume V of the Ecology manual). These standards in Section 4.6 of Volume V should be used as a tool for determining maintenance needs for these private stormwater facilities. The facility-specific standards outline types of potential defects, conditions of those defects that indicate maintenance is needed, and the results that are expected once maintenance is performed. Current staffing levels may not be adequate for this pursuit**.** Once a level of service is identified, the county should adjust crew size accordingly.

Maintenance Standards

It is recommended that Whatcom County follow the maintenance standards in Chapter 2 of Volume IV of the Stormwater Management Manual for Western Washington (Ecology, 2005). The following list summarizes these standards:

- Inspect and clean catch basins and conveyance systems (including roadside ditches) as needed, and use the opportunity to determine whether improvements in M&O are needed. Note whether capacity has been exceeded or heavy sediment discharges have occurred. Use the following procedures:

  - Clean catch basins when the depth of the deposits reaches 60 percent of the sump depth as measured from the bottom of the basin to the invert of the lowest pipe in or out; if woody debris accumulates, clean as frequently as necessary to ensure proper operation.
  - Keep ditches free of rubbish and debris; conduct vegetation maintenance (e.g., seeding) in late spring or early fall, where possible; promote vegetation where possible; conduct proper handling of ditch cleanings.

- Inspect and clean treatment facilities, as needed, and use the opportunity to determine whether improvements in M&O are needed. Note whether capacity has been exceeded or heavy sediment discharges have occurred. Debris should be regularly removed from surface basins used for either peak-rate control or stormwater treatment; dispose of wastes properly.
- Identify any deterioration threatening structural integrity of facilities and immediately repair (examples: replacement of clean-out gates, catch basin lids, and rock in emergency spillways).
- Determine maintenance needs for specific types of drainage facilities as outlined in Section 4.6 of Volume V of the Ecology Manual (Ecology, 2005).

Frequency of Maintenance

Maintenance frequency describes how often a maintenance function must be performed. Conducting systematic maintenance is important to ensure that stormwater facilities function as designed. Preventive maintenance has the potential to reduce reactive-type emergency work orders. Preventive maintenance in the form of inspections and cleanings should be performed according to the schedule outlined in the NPDES Phase II permit requirements and the Ecology manual. The NPDES Phase II permit outlines the following performance measures related to frequency of maintenance:

- Annual inspection of all municipally owned or operated permanent stormwater treatment and flow control facilities; appropriate maintenance actions in accordance with the adopted maintenance standards
- Established inspection (and enforcement) program for privately owned facilities on an annual or semi-annual basis
- Spot checks of potentially damaged permanent treatment and flow control facilities (other than catch basins) after major storm events (10-year, 24-hour, for example)
- Established inspection (and cleaning) program for catch basins, inlets, and roadside ditches

Documentation of Inspections and Maintenance Activities/Database Management

Each facility or individual component of the surface water drainage system should be documented and given a unique name or code (an ID). Often, a series of numbers is used with a letter identifier indicating the type of facility or asset (such as CB for catch basin or P for pipe). This database of surface drainage assets and facilities can be tied to the geographic information system (GIS) system for graphical interfacing.

All inspections and maintenance activates on surface water facilities should be documented. Information such as time, date, location, type of facility, reason for visit, and weather conditions should all be recorded. This information will be helpful for assessing the long-term maintenance needs of an individual surface water facility and for formulating a proactive and preventative maintenance plan rather than a reactive one.

A centralized database should be created that allows for information associated with any one facility or asset to be pulled up with little effort. Maintenance history, age, condition, and so forth of this asset would all be tied to the unique ID of the asset. Any work performed on the asset could be tracked in this manner.

A comprehensive recording and database management system can be used as a tool for scheduling M&O activities. Keeping track of resources and assets will allow for the prioritization of M&O activities based on information for each asset in the database such as maintenance history and complaint log. The use of resources can be optimized.

Additional Resources

As drainage infrastructure ages, more resources should be dedicated to its upkeep. Existing facilities that may be at or beyond design life should be inspected to determine whether repair or replacement/upgrade is necessary. Many assets that are currently part of the drainage infrastructure system may be undersized or otherwise not able to convey current demands because they were originally sized for pre-development or less developed conditions. This may become more of a problem as Whatcom County continues to grow quickly.

Tools such as an electronic database will allow Whatcom County to be more proactive and less reactive in their M&O program. A planned inspection program can be used to target aging infrastructure and other portions of the drainage system that are often problematic. Repair and rehabilitation activities can be prioritized based on age and risk of failure of any asset in the system.

As Whatcom County continues to grow in population, maintenance demands will increase. Equipment should be replaced and/or upgraded according to these increasing demands. New technologies should be implemented where possible to increase effectiveness. Hiring additional drainage M&O field personnel would also increase M&O capabilities.

References

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Appendix D

Birch Bay Comprehensive Stormwater Plan, Low Impact Development Feasibility and Effectiveness Review

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Introduction

This memorandum is one element of an overall Comprehensive Stormwater Plan for the watersheds of Birch Bay. Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay completed a Comprehensive Land Use Plan that called for low-impact development (LID) and a Stormwater Plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth. This Comprehensive Stormwater Plan will recommend measures to achieve these goals.

This memorandum describes types of LID measures that have been implemented successfully in Western Washington. Factors affecting success of LID measures are also discussed. The current regulatory environment in Whatcom County is discussed as it pertains to the implementation of LID measures. This memorandum also discusses the feasibility and potential benefits of implementing LID measures throughout the Birch Bay Watershed. The Low Impact Feasibility Evaluator (LIFE™) Model was used to evaluate the effectiveness of LID measures in one planned development. Results from this modeling effort are used to discuss the feasibility and potential effectiveness of implementing LID measures basinwide.

Overview of Low-Impact Development

LID is a stormwater management and land development strategy applied at the parcel and subdivision scale that emphasizes conservation and use of onsite natural features integrated with engineered, small-scale hydrologic controls to more closely mimic predevelopment hydrologic functions (Puget Sound Action Team, 2005). LID promotes reduction of stormwater runoff volume through mechanisms such as vegetative filtration, retention, and infiltration. LID measures are implemented at or near the source where surface runoff is generated. Several types of LID measures exist, including amended soils, biofiltration and bioretention swales, rain gardens, reductions in impervious surface, and pervious pavement.

A biofiltration swale is a long, gently sloped ditch or depression designed to treat stormwater as it flows through the swale. Bioretention swales possess specially constructed bottoms and side slopes with engineered soils, which encourage infiltration of stormwater runoff flowing through the swale. These swales often convey stormwater along the edge of a road. However, they can also be used as local depressions that retain stormwater on the site (sometimes referred to as rain gardens).

Rain gardens are vegetated depressions intended to promote infiltration. Runoff is channeled into a rain garden that may or may not have an outlet for overflow once the infiltration capacity of the rain garden has been reached.

Pervious pavement is an open-graded pavement that allows rainwater to pass through the road or sidewalk and infiltrate into the soils beneath rather than contribute to stormwater runoff. Reducing the width (and therefore total area) of paved surface for roadways and driveways can also be an effective LID technique.

LID measures can yield both water quantity and water quality benefits. Grass swales can reduce runoff velocity and act as infiltration devices to reduce peak flowrates and runoff volumes. They can also act as biofilters to remove pollutants from runoff. Pollutants are removed by sedimentation, but also by infiltration, biofiltration, and adsorption. In a literature review conducted by the U.S. Environmental Protection Agency (EPA), bioretention areas were found to be effective in reducing runoff volume and in treating the first portion of the storm before reaching infiltration capacity of the swale (EPA, 2000). Several studies included in this literature review also showed good removal efficiencies for both metals and nutrients, ranging from 50 to 90 percent for total copper, lead, and zinc and up to 80 percent for total phosphorus and total nitrogen. Generally speaking, the removal of metals was found to be directly related to the removal rate of total suspended solids.

Performance of bioretention swales is dependent upon channel length and longitudinal slope. Slopes greater than 3 to 4 percent require the use of check dams to slow the flows and allow for greater infiltration (EPA, 2000). Generally, biofiltration swales are most appropriate for smaller drainage areas with mildly sloping topography (Center for Watershed Protection, 1998). The soils on the swale bottoms and sides are amended with sand and organic matter to encourage infiltration. Amended soil mixes are capable of achieving an infiltration rate of up to 2 inches per hour.

Potential Effectiveness of LID Measures within the Birch Bay Watershed

Estimates of the effectiveness of LID measures can be made using measured data from existing LID sites, or effectiveness can be extrapolated from studies performed in other locations. However, due to the unique topography, geology, and hydrology of the Birch Bay Area, it was necessary to perform a study on LID effectiveness based on Birch Bay soil and hydrologic conditions.

To best characterize the density, character, and pattern of development in Birch Bay, the site plans for a development currently proposed for the area were used in the formulation of the study. Preliminary site plans and stormwater drainage plans from the Horizons at Semiahmoo Project were used to assess the feasibility and effectiveness of LID measures in the Birch Bay area.

CH2M HILL's Low Impact Feasibility Evaluation (LIFE™) model was used to assess the potential effectiveness of LID measures within Birch Bay. The LIFE™ Model is a hydrologic simulation tool that was developed to evaluate the performance of various LID techniques such as bioretention, infiltration systems, rainwater capture/reuse systems, and green roofs. The LIFE™ model has been used to test the performance of LID techniques for different land uses, rainfall patterns, and soil characteristics. Attachment 1 to this memorandum contains a detailed description of LIFE™ Model capabilities and setup.

The preliminary site plans for the Horizons at Semiahmoo Project indicate that various LID measures such as rain gardens, reduced pavement widths, and sand filters are already planned for this project. For the purposes of this study, the LIFE™ Model was set up with all LID measures removed to accurately portray the hydrologic conditions of a traditional development scenario. This traditional development scenario was run through the LIFE™ Model in order to quantify the "traditional" development conditions.

LID measures of rain gardens, reduced pavement widths, pervious pavement, and amended soils were then added to the LIFE™ Model Setup. Model results from the scenario of Development with LID were compared to the Traditional Development scenario.

LIFE™ Model Setup

The LIFE™ Model was used as both a continuous and single event model. The continuous simulation was used to estimate the total annual reduction in runoff volume and peak flow from LID measures. The precipitation data used in the model were from the National Climatic Data Center (NCDC) gage at Bellingham International Airport. Average annual rainfall for the areas is approximately 35 inches per year. The pan evaporation data input to the model was obtained from Puyallup, Washington, the closest station with a long-term record of pan evaporation data. Continuous rainfall data from the year 2001 were used to calculate total annual runoff and annual pollutant loads because the rainfall for this year was 36.03 inches and was close to the long-term average rainfall. The model was run in one-hour time steps over the one-year timeframe modeled.

The 2-year, 10-year, and 100-year 24-hour events were run through the model to estimate the difference in required detention volume with implementation of LID measures. The single storm event model used the same setup as the continuous event model except using the SCS Type 1A precipitation distribution. The 24-hour precipitation amounts for the 2-year 24-hour, 10-year 24-hour, and 100-year 24-hour events were 2.1 inches, 3.1 inches, and 4.5 inches, respectively.

The soils of the Horizons at Semiahmoo Development consist of Birch Bay, Blainegate, Everett, and Whitehorn Soils representing soil classes 14, 15, 28, and 184, respectively. Everett soils are soil Type B, Birch Bay soils are soil Type C, and Blainegate and Whitehorn soils are soil type D (*Whatcom County Soil Survey Report* [NRCS, May 1992]). Nearly all of the area under the proposed development consists of the Type D soils of Whitehorn and

Blainegate. The infiltration rate of the subsurface soil was assumed to be 0.05 inch per hour for Hydrological Type D soil.

The LIFE™ Model was set up according to the two different scenarios: Traditional Development, and Development with LID. The lot size and total number of lots did not change between the scenarios of Traditional Development and Development with LID. The total width of the road right-of-way did not differ between scenarios, but the distribution of pervious versus impervious surface did change. The scenario with LID had rain gardens and pervious landscaping. This decreased the total percentage of impervious surface in the right-of-way for this scenario. Rain gardens were placed along the sides of the minor access roads where possible, depending on driveway and intersection locations. Pervious pavement was used in the scenario with LID measures for all driveways plus all minor access roads with less than 3 percent longitudinal slope. All pervious areas were modeled as having amended soils in the top 12 inches of the soil column versus the 4 inches of native fill for the Traditional Development scenario. This assumption of 4 inches of native fill present in the Traditional Development scenario represents an estimate of the total depth of topsoil present. In many cases, depth of top soil is less than this. Table 1 summarizes these input parameters for the LIFE™ Model Scenarios.

TABLE 1
Input Parameters for the LIFE™ Model

Input Parameter	Traditional Development	Development with LID	Difference
Lots	Number of lots, lot type, and lot size as specified in project plan The imperviousness of each lot is approximately 25%, including driveway and rooftop	Number of lots, lot type, and lot size as specified in project plan The imperviousness of each lot is approximately 25%, including driveway and rooftop	No difference
Road Width	Width as specified in project plan, but with impervious surface from back of sidewalk to back of sidewalk	Width as specified in project plan, but with rain gardens and pervious landscaping	Rain gardens and pervious landscaping instead of full width of impervious roadway surface
Bioretention (Rain Gardens)	No rain gardens	Rain gardens on all minor access roads	Rain garden length equal to approximately 30% of minor access road length
Pervious Pavement	No pervious pavement	Pervious pavement for all minor access roads with a slope less than 3% and for all driveways and sidewalks	Impervious area converted to pervious pavement
Soil	All pervious surface consists of native soil (4 inches of native fill)	Amended soil instead of native soil for all pervious surface within each lot	Pervious surface within each lot consists of top layer of 12 inches of amended soil instead of native soil
Rooftop and	Sheet flow across lot	Sheet flow across lot	No difference

TABLE 1
Input Parameters for the LIFE™ Model

Input Parameter	Traditional Development	Development with LID	Difference
Driveway Runoff	pervious area before entering street storm drainage system	pervious area before entering street storm drainage system	

Subbasin objects were set up according to the land use of each individual subbasin within the project area. The development was divided into 11 subbasin areas based on the proposed grading and the storm drainage layout provided by the developer. Total modeled area is 33.8 acres. Under the LID scenario, the impervious surface area is reduced by 8 percent compared with the Traditional Development scenario. The area breakdown of each subbasin object is shown in Table 2.

TABLE 2
Characteristics of Sub-basin Areas in the LIFE™ Model

		Impervious Area (%)	
LIFE™ Model Catchment	Total Area (acres)	Traditional Development	Development with LID
B1	1.9	58%	58%
B2	4.8	37%	36%
C1	1.6	34%	30%
C2	4.3	40%	32%
D1	6.7	43%	38%
EN	2.5	41%	38%
ES	2.7	37%	37%
F1	1.7	46%	38%
F2	4.6	38%	35%
G	1.8	39%	39%
H	1.2	45%	33%
TOTAL	**33.8**		

LIFE™ Model Results

Once potential locations for LID were identified as described in the previous section, the LIFE™ Model was used to evaluate the potential reduction in stormwater volume and peak flow using LID measures. The model was used to quantify the peak flow and volume reductions attributable to the LID measures as well as the change in required detention volume.

Continuous Model

LIFE™ Model results from the continuous model setup show that, on an annual basis, only a relatively small fraction of the total rainfall becomes surface runoff. Results indicate that 17 percent of annual precipitation runs off under the Traditional Development scenario. The remainder infiltrates or is evaporated (Table 3).

TABLE 3
LIFE™ Model Results for Continuous Simulation Under Traditional Development and Development with LID Measures Scenarios

	Traditional Development	Development with LID	Difference	Difference (%)
Runoff Volume				
Volume of Infiltration (cubic feet [ft^3]/yr) (acre-feet/year)	2,049,552 (47.1)	1,769,967 (40.6)	-279,585 (-6.4)	-13.6%
Volume of Evapotranspiration plus Volume of Storage within Soil Column (ft^3/yr) (acre-feet/year)	1,602,530 (36.8)	2,452,579 (56.3)	+850,049 (+19.5)	+53.0%
Volume of Runoff[a] (ft^3/yr) (acre-feet/year)	768,583 (17.6)	198,119 (4.5)	-570,464 (-13.1)	-74.2%
Runoff Rate				
Peak Rate of Runoff from Largest Storm of the Year[b] (cubic feet per second)	5.5	1.9	-3.6	-65.5%

[a]Total annual rainfall volume in the 33.8 acres modeled area in 2001: 4,420,665 ft^3 (101.5 acre-ft).
[b]The peak rate of runoff is from the largest storm over the modeled year of 2001. This largest storm is approximately equal to the 1-year 24-hour event.

Under the Development with LID scenario, total surface runoff volume in the modeled area reduces from 17.4 to 4.5 percent of annual precipitation volume. This translates into a 74 percent reduction in total runoff volume from the modeled area (Table 3). The volumes that would have otherwise become surface runoff either infiltrate or evapotranspire.

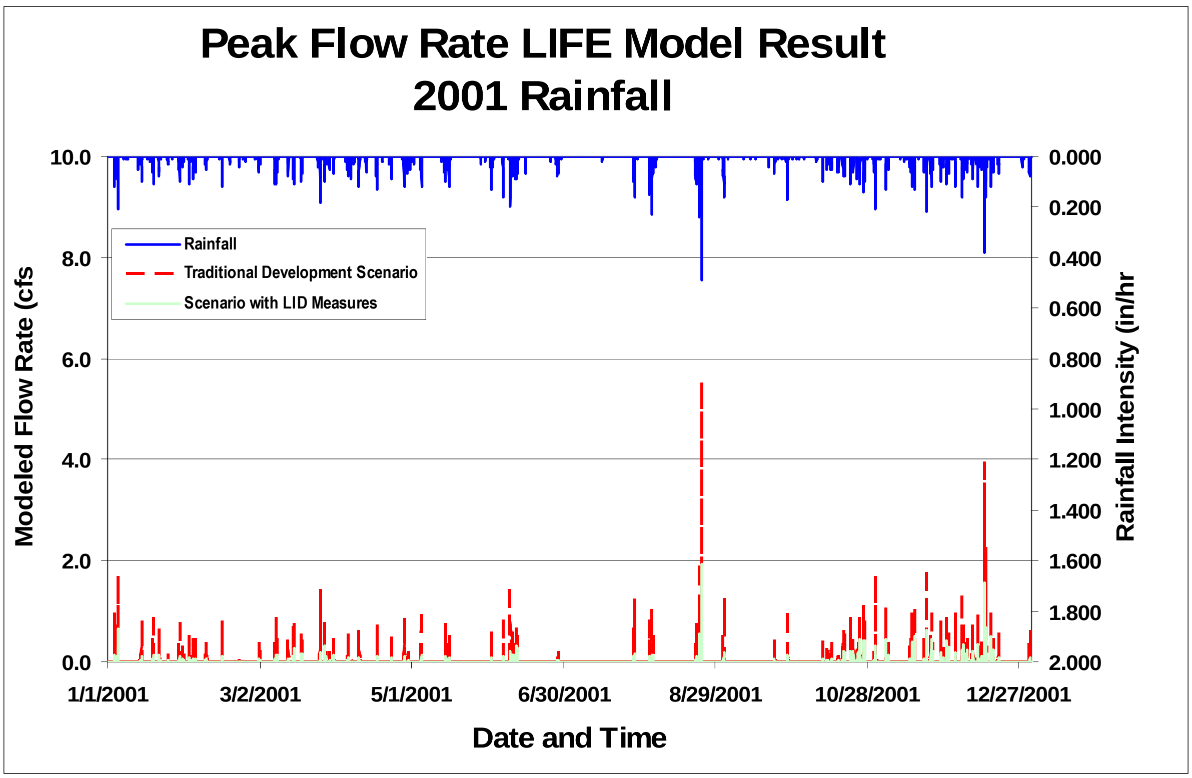
The reduction of runoff volume and peak flow rate is due to the decrease in total impervious area, the storage volume in the swales, the installation of pervious pavement, and the amended soils on the lawn of each lot. The reduction is mainly from the amended soils used for the pervious area with each lot, representing 49 percent of the total site area. The LIFE™ Model results show that the storage volume available within the soil column, especially within the 12 inches of amended soils, is contributing to the reduction in runoff volume.

The estimates for evapotranspiration also include the volume of storage available in the soil column. This value is significant due to the 12 inches of amended soils. The quantity of water retained in the soil in the LID scenario is much more than in the Traditional Development scenario.

The underlying soil is Hydrological Group D, so the infiltration of the runoff is limited. The performance of the rain garden is sensitive to infiltration conditions, which can vary considerably from one location to the next. The storage volume on the surface and within the soil is the main benefit that a rain garden provides.

LID measures also yield a reduction in peak rate of runoff over the year. Under the Traditional Development scenario, the peak rate of runoff from the largest event of the year (approximately equal to the 1-year 24-hour event) was 5.5 cubic feet per second (cfs) (see Table 3). With LID measures, the peak runoff rate from this event was 1.9 cfs. This is a reduction in peak runoff rate of nearly 66 percent. Figure 1 shows the hydrographs under both the Traditional Development and Development with LID scenarios.

FIGURE 1
LIFE™ Model Output Hydrographs for Continuous Model for both Modeled Scenarios



Single Event Model

The LIFE™ Model was run using the 2-year, 10-year, and 100-year 24-hour design storm events of 2.1, 3.1, and 4.5 inches. Three different scenarios were modeled: the predevelopment condition, the traditional development condition, and the LID development condition. Table 4 shows the results of these model runs in terms of peak event flowrates and required detention volumes.

TABLE 4
LIFE™ Model Results for Continuous Simulation Under Pre-Development, Traditional Development, and LID Development Conditions

	Pre-Development	Traditional Development	LID Development	Difference	Difference (%)
Peak flowrate (cfs)					
2-year 24-hour event	0.02	3.40	1.07	2.33	-68.5%
10-year 24-hour event	2.1	35.7	6.8	28.9	-81.0%
100-year 24-hour event	11.9	49.2	15.2	34.0	-69.1%
Required Detention Volume (ft^3)					
2-year 24-hour event[a]	--	--	--	--	--
10-year 24-hour event	--	131,214	6,630	124,584	-94.9%
100-year 24-hour event	--	174,136	19,789	154,347	-88.6%

[a]The 2-year 24-hour event did not produce enough runoff volume to perform the detention volume portion of this study.

The LIFE™ Model results indicate large reductions in peak flowrates generated by the 2-year, 10-year, and 100-year 24-hour events. The peak flowrates are reduced by 69 percent or more between the Traditional Development and Development with LID scenarios for each of three storm events run through the LIFE™ Model. Figure 2 shows the hydrographs corresponding to the 100-year 24-hour event for pre-development conditions and the two development scenarios of Traditional Development and Development with LID. Figure 2 shows hydrographs both upstream and downstream from the detention ponds modeled for both the Traditional Development and Development with LID scenarios.

These event-specific results from the LIFE™ Model indicate that implementing LID in a development could reduce the required detention volume for a development by about 88 percent based on the 100-year event.

Effects of LID on a Subbasin Scale

To demonstrate the cumulative impacts of implementing LID basinwide, results from the modeled development of 33.8 acres were applied several times within the same subbasin. The Horizons at Semiahmoo Project is sited within the Rogers Slough subbasin. This development covers approximately 33.8 acres (7.1 percent) of the 473-acre (0.74 square mile) subbasin. The modeled development was “copied” fourteen times over the sub-basin.

The implementation of LID reduces both total runoff volume and peak runoff rate. To quantify the reduction in total annual runoff volume over the entire sub-basin, the volume reduction in the 33.8 acres was multiplied by fourteen to represent the annual volume reduction in the 473 acres. (Routing and hydrograph timing does not affect volume reduction, only flowrate.) A total runoff volume reduction of 7,986,496 cubic feet

(183.3 acre-feet) could be expected on an annual basis from a 473-acre watershed if LID measures were implemented subbasin wide. This represents an annual reduction of 74.2 percent, the same as that for the individual development (Table 5).

FIGURE 2
LIFE™ Model Output Hydrograph for the 100-year 24-hour event for all Modeled Scenarios

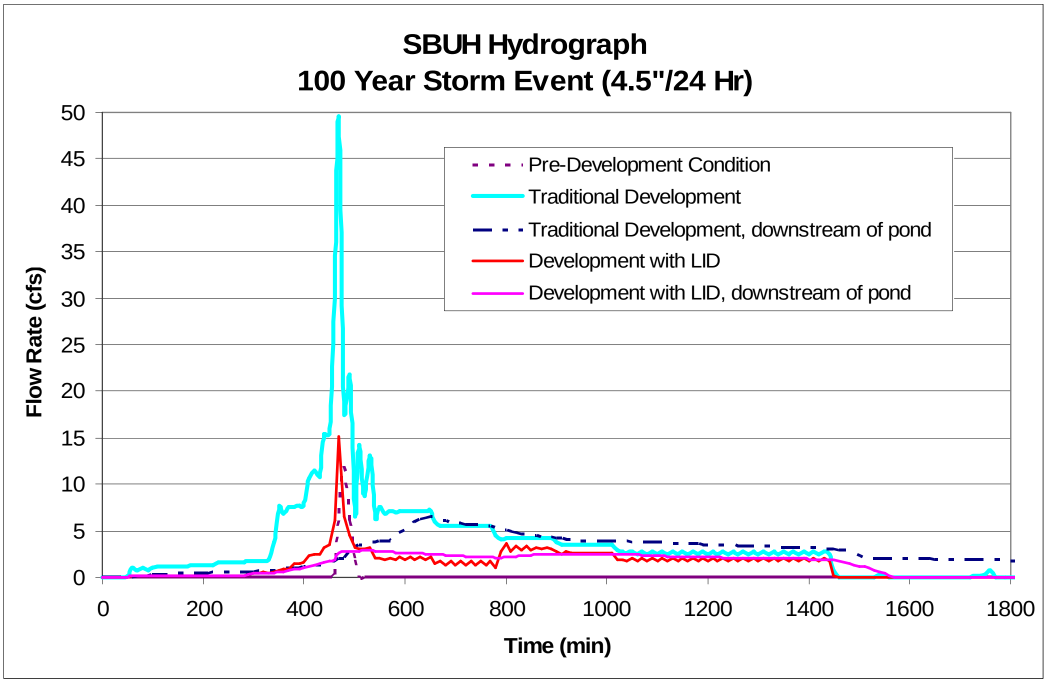


TABLE 5
Effects of LID Implementation Subbasin Wide

	Traditional Development	Development with LID Measures	Difference	Difference (%)
Peak flowrate (cfs)[a]				
10-year 24-hour event	29.7	28.2	-1.5	-5.1%
100-year 24-hour event	91.4	83.1	-8.3	-9.1%
Volume (ft^3) [b]				
Annual Volume of Runoff (ft^3/yr) (acre-ft/yr)	10,760,162 (247.0)	2,773,666 (63.7)	7,986,496 (183.3)	-74.2%

[a] Estimated peak flowrate reduction due to LID subbasin wide was determined by modeling the appropriate routing (and timing) depending on development location in subbasin.
[b] Estimated volume reduction due to LID subbasin wide was determined by applying modeled development over entire subbasin and adding up the total volume.
Note: The subbasin is approximately 473 acres; the modeled basin of 33.8 acres was applied 14 times over the subbasin.

To quantify the reduction in peak flowrate from the subbasin, the appropriate routing and timing are applied. Peak flowrate is affected by how long it takes runoff to reach the outlet point from different areas of the watershed. The 33.8-acre development was applied

14 times throughout the subbasin. The timing of each contributing hydrograph was determined based on soil, slope, and channel conditions. This was done for each of 14 contributing developments within the subbasin. Hydrographs for each of the contributing areas were combined to form a cumulative hydrograph for both the 10-year 24-hour and the 100-year 24-hour events. The peak flow reduction for the 10-year 24-hour event is approximately 5percent, and the peak flow reduction for the 100-year 24-hour event is approximately 9percent. These peak flow reduction percentages are less than those for the individual developments because of the effects of timing and routing between all the contributing areas. These percent reductions in peak flowrate are minimal. However, they only represent the reduction in the highest flowrate. These numbers do not reflect the reduction in the duration of high flowrates because of the significant volume reduction. With LID measures, the reduction in peak flowrate is not large. However, the length of time that these higher flows are occurring is much less.

Opportunities and Constraints for LID Implementation in the Birch Bay Area

LIFE™ Model results indicate that LID measures would be effective at reducing total annual runoff volumes and maximum annual peak flowrates in Birch Bay. This study was performed based on one planned development of approximately 34 acres. It is likely that LID measures implemented to the scale and density as modeled with the LIFE™ Model in this study would have comparable results elsewhere in the watershed.

Implementing LID measures subbasin wide would yield reductions in annual runoff volume proportional to those from modeling the 33.8-acre Horizons development. Subbasin wide implementation of LID could yield 5percent and 9percent reductions in peak flowrate from the 10-year 24-hour and 100-year 24-hour events, respectively. These reductions in peak flowrate may be minimal, but the corresponding reduction in duration of high flows is significant. These reductions could have significant positive impacts on downstream receiving water bodies.

The feasibility of using individual types of LID measures would have to be analyzed based on conditions in the immediate area of any planned project. For instance, biofiltration swales are not effective along slopes greater than about 8 percent, and pervious pavement has similar limitations on its use.

Current Whatcom County regulations and requirements could be updated to reflect requirements for LID in new and redevelopment situations. For instance, a certain depth (such as 12 inches) of amended soils could be required on all pervious surfaces in new developments. Requirements could be set up to promote LID.

These event-specific results from the LIFE™ Model indicate that implementing LID in a development could reduce the required detention volume for a development by about 88 percent based on the 100-year event. These results have political and regulatory implications. Detention requirements for new development could be amended to allow "credits" to developers for the implementation of LID measures in the form of reduced detention requirements.

Reducing the detention volume requirements by exactly the reduction in runoff volume due to LID would be risky. Detention volume requirements could be reduced based on some fraction of the total runoff volume reduction due to LID. Implementing a safety factor of perhaps 50 or 100 percent would be more appropriate, because it would allow for potential system malfunctions, design overestimates, or maintenance issues that may cause problems with the system.

Implementing LID measures provides an opportunity to go above and beyond current development practices. Translating all the benefits of LID into reduced detention requirements would only address runoff to current regulatory levels rather than exceeding them in an environmentally beneficial manner. "Credits" of reduction in detention requirements could be given to developers who implement LID, but at a more conservative level.

For the implementation of LID measures to truly be feasible in the Birch Bay area, the demand for "green" homes and LID must be known to developers and regulators alike. Developers would be more likely to incorporate LID measures into future developments if they are marketable and therefore more cost-effective.

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Attachment 1: LIFE™ Model Overview

CH2M HILL's Low Impact Feasibility Evaluation (LIFE™) model is a hydrologic simulation tool that was developed to evaluate the performance of various LID techniques (e.g., bioretention, infiltration systems, rainwater capture/reuse systems, green roofs). The LIFE™ model has been used to test the performance of LID techniques for different land uses, rainfall patterns, and soil characteristics. The LIFE™ model enables site level analysis of spatially distributed stormwater source controls (i.e., LID). This is its primary advantage over other hydrologic models.

The LIFE™ model provides a continuous simulation of the runoff and infiltration from a development (or redevelopment) area, or from a watershed (or subcatchment) with multiple land uses, given the following inputs:

- *Continuous rainfall data* (typically in time increments of one hour or less) and *evapotranspiration data* (daily), typically for a time period of one year or more. Evapotranspiration (ET) can also be calculated from temperature data.
- *Site design parameters and land cover characteristics* for each land use type being modeled (e.g., road width, rooftop coverage, surface parking coverage, population density).
- *Information on LID techniques* that are applied for each land use type, including:
  - Extent of source control application (e.g., percent of road and percent of building lots with certain types of source controls)
  - Source control design parameters (e.g., area and depth of infiltration facilities, soil depth for green roofs or absorbent landscaping, volume of rainwater reuse cisterns)
- *Soils information, including:*
  - Surface soil parameters (e.g., maximum water content, vegetation rooting depth)
  - Subsurface soil parameters (e.g., saturated hydraulic conductivity)

The model has seen numerous applications both in the United States and Canada. The model has been used for the development of two master-planned communities in the Vancouver, British Columbia area. It has been used for redevelopment projects in Idaho, North Carolina, and Virginia. It is being used for site characterization project in Prince George County, Maryland. It is also being used by the Tennessee Valley Authority to evaluate best management practices (BMPs) for new development.

There have been several applications of the LIFE™ Model in Western Washington. The model was applied to a 70-acre urban basin (Venema Creek) in Seattle in support of the City of Seattle's Natural Drainage System Program, whose early SEAStreet Project has gained national recognition for retro-fitting LID measures in an urban area. The LIFE™ model results demonstrated that intensive application of enhanced bioretention swales in the lower portion of the basin was capable of providing water quality treatment for the 6-month storm and reducing runoff to forested conditions for flows up to the 2-year storm event

(CH2M HILL, 2004a). That project is currently under design by the City of Seattle. In a study conducted for the Puget Sound Action Team, the LIFE™ Model was used to evaluate the capability of LID measures in meeting the state's flow control (detention) requirements for a series of prototypical residential and commercial developments (CH2M HILL, 2004b). The study determined that, under favorable conditions (infiltrative soils, and relatively less rainfall due to the Olympic rain shadow), LID measures alone could fulfill flow control requirements. In the remainder of cases, LID measures would significantly reduce the detention requirements of a project.

The LIFE™ model runs on an object-oriented dynamic simulation software platform called Extend. LIFE™ models are developed as a series of interconnected objects that represent different surface types within the modeled area. This modeled area can be any scale, but LIFE™ is particularly well suited for site-level analysis.

The following types of objects govern the hydrologic simulations within LIFE™:

- **Global objects**, which store information that can be accessed by all other objects within the model (e.g., rainfall data).
- **Physical objects,** which simulate the various components of the physical landscape (including impervious surfaces, pervious surfaces, and stormwater control facilities).
- **Flow routing objects**, which perform overland flow routing and simple channel routing using a kinematic wave approach

Each of these objects is described further in the following subsections.

Global Objects

Every LIFE™ model must have an object that defines environmental conditions, and will typically also have an object that stores data on the hydrologic properties of the various soil types within the modeled area.

The LIFE™ continuous simulation hydrologic model runs for a user-defined time period using a user-defined time step (typically 15 minutes to 1 hour). In order for the LIFE™ model to run, continuous rainfall data and ET data must be input to the global *environmental conditions* object. Rainfall data should be obtained from the nearest tipping bucket rainfall gauge to the project site. ET data can either be estimated directly based on pan evaporation data (if available), or calculated from daily minimum and maximum temperature data using a modified Penman-Monteith equation. If ET data is calculated from temperature, the latitude and elevation of the climate station are required as model inputs.

A reduction factor will typically be applied to the pan evaporation data to derive ET values because the former is substantially higher than the latter.

Physical Objects

The heart of the LIFE™ model simulations is the objects that represent the various components of the physical landscape, including LID techniques. The various types of physical objects used by the LIFE™ model are described below.

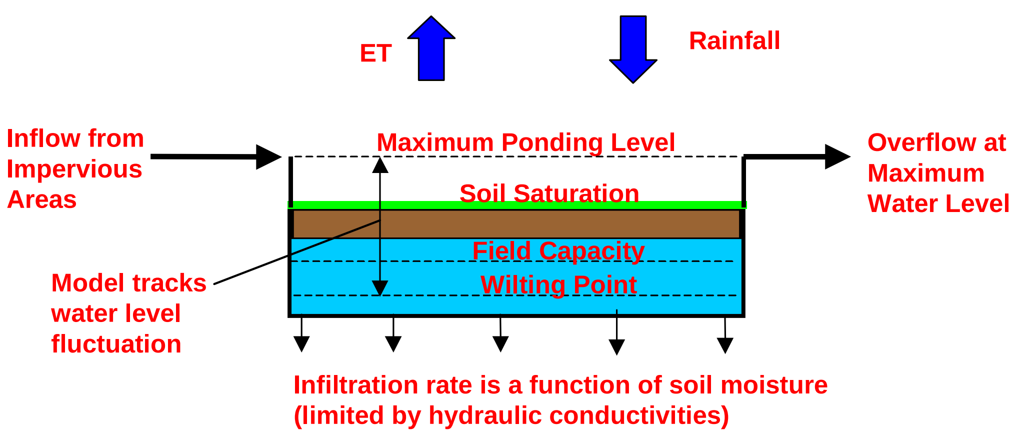
Impervious Surface Objects

Impervious surface objects are used to simulate noninfiltrating surfaces within the modeled area (e.g., rooftops, driveways, roads, sidewalks). These objects must be given an area and a runoff coefficient that defines the fraction of rainfall that becomes runoff from the surface. These objects must be connected to a *rainfall* object that passes in rainfall data from the global *environmental conditions* object. For models of LID scenarios, runoff output from an *impervious surface* object would typically be connected as inflow to a *pervious surface* object (see below); for example, to simulate capture of roadway runoff by a bioretention swale dispersion of rooftop runoff over part of the adjacent lawn area.

Pervious Surface Objects

Pervious surface objects are used to simulate all surfaces within the modeled area that are covered by soil (or other growing media), including various types of pervious surfaces (e.g., lawns, landscaped areas, forest) and many types of stormwater source control facilities (e.g., bioretention cells, swales, green roofs, planter boxes). These objects must be connected to a *rainfall* object and an *ET* object, which pass in rainfall and ET data from the global *environmental conditions* object. An areas and a series of hydrologic properties must be defined for each *pervious surface* object.

Simulating of the movement of water through pervious surface objects is at the heart of most LIFE™ model simulations. This process is described in more detail in the following chart.



Soil depth is the assumed size of the soil "reservoir." Water flows into this 'reservoir' from direct rainfall and inflow from other objects (e.g., impervious surface runoff). If the rate of input exceeds the saturated hydraulic conductivity (SHC) of the surface soil, the excess becomes surface runoff. When the soil moisture is between wilting point and field capacity, water loss occurs through ET only. When the soil moisture is between field capacity and maximum water content (e.g., between 30 and 50 percent water content for the above swale), water will infiltrate out of the soil layer (in addition to ET losses). The rate of infiltration varies linearly between field capacity (where the rate is zero) and maximum water content. The slope of this line is governed by the soil water half-life (SWHL) value selected (slope = $1\text{-}e^{(-0.69 \times \text{time step})/\text{SWHL}}$). This value is typically selected so that the predicted infiltration rate at soil saturation is equivalent to the SHC of the surface soil. The rate of infiltration can never exceed the SHC of the surface or subsurface soil, and the subsurface SHC is often much less than the surface SHC. Therefore, **saturated hydraulic conductivity of the subsurface soil tends to govern long-term infiltration rates in the LIFE™ model simulations.** Surface runoff occurs when the surface soil reservoir is full (saturated soil plus any allowable ponding depth exceeded).

Note that a certain percentage of the infiltrated water can be assumed to emerge to the surface runoff as interflow (thus contributing to the modeled flow hydrographs), and the rest would be "lost" to deep groundwater.

Media Infiltration

Media infiltration objects are used to simulate infiltrating areas that behave as simple storage reservoirs, such as gravel infiltration trenches, pervious paving with reservoir base course, infiltration chambers, and bioretention underdrain layers. These objects may be connected to a *rainfall* object (if there is rainfall input) and may be connected to an *ET* object (if there is any evaporation assumed). An area must be defined for each *pervious surface* object along with the following hydrologic properties:

- **Retention depth**, which is the average depth from the bottom of the facility to the overflow level.
- **Void space ratio**, which is the fraction of the total media volume available for water storage (e.g., typically between 0.3 and 0.4 for gravel).
- **Saturated hydraulic conductivity (subsurface)**, which governs the maximum rate that water can move out of the media into the underlying soil.
- **Saturated hydraulic conductivity (media infiltration)**, which governs the maximum rate that water can move through the media. This does not tend to be a limiting factor and is typically assumed to be very large.
- **ET multiplier,** which is the multiplication factor that is applied to the reference ET data (or pan evaporation data) contained in the global environmental conditions object to determine evaporation losses during each time step (may be zero).

Media infiltration objects operate very similarly to a simple reservoir model, with inflow defined by the connected objects (e.g., rainfall, impervious surface runoff, infiltration from overlying bioretention cell or swale), outflow defined by the infiltration rate (subsurface SHC), and storage capacity defined by the above dimensions (area x retention depth x void space ratio).

Flow Routing Objects

The physical objects described above produce volume outputs (i.e., runoff and infiltration volumes per time increment), which can be expressed as average flowrates. *Flow routing* objects can be placed at any level within a LIFE™ model to perform overland flow routing or simple channel routing using a kinematic wave approach. These objects require only an inflow connection (runoff volume to be routed) and the following inputs:

- **Total contributing area**, which is the assumed area over which flow occurs (overland flow area or channel area)
- **Average width of flow path**
- **Average slope of flow path**
- **Manning's roughness coefficient (n) for flow path**
- **Initial depression storage** (storage characteristics are best defined by adjusting the retention properties of the physical objects; therefore, this parameter is often set to zero)
- **Convergence criterion** for flow continuity iteration (typically a very small number)

For each time step, *flow routing* objects convert runoff volumes to flowrates by combining Manning's equation with a flow continuity equation—the same kinematic wave approach used by other common hydrologic models (e.g., SWMM, MOUSE). Flow depth is initially estimated by dividing input runoff volume by total area. Manning's equation is combined with a flow continuity equation (i.e., flow in = flow out plus change in storage) to provide a differential equation that can be solved iteratively. Flow is then calculated using Manning's equation.

Appendix E

Birch Bay Comprehensive Stormwater Plan, Priority Capital Projects

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DATE: July 7, 2006

Introduction

This memorandum is one element of an overall Comprehensive Stormwater Plan for the watersheds of Birch Bay. Birch Bay is a rapidly growing community that is experiencing increasing flooding and erosion, declining water quality, and loss of aquatic habitat. Historically, Birch Bay has been primarily a recreational beach community. The citizens of Birch Bay completed a Comprehensive Land Use Plan that called for low-impact development (LID) and a Stormwater Plan to protect their lifestyle and aquatic resources while accommodating the anticipated growth. This Comprehensive Stormwater Plan recommends measures to achieve these goals.

Water quantity, water quality, and habitat issues identified within Birch Bay were outlined and prioritized in Chapter 3, Surface Water Issues and Problems, of the Birch Bay Stormwater Plan. This prioritization of problems was performed using criteria reflecting the goals and action items outlined in both the Whatcom County Comprehensive Plan and the Birch Bay Sub-Area Plan. Several of these identified problems can be addressed with structural solutions. These structural (nonprogrammatic) projects may be suitable candidates for the Whatcom County Capital Improvements Program (CIP).

This memorandum identifies and prioritizes projects for inclusion in a 6-year Whatcom County Stormwater CIP for Birch Bay. Estimated capital costs, maintenance costs, and potential funding sources are outlined for each proposed CIP project. Attached fact sheets provide detailed information for each proposed project.

Identification of Potential Capital Projects

Potential solutions have been identified for each water quantity, water quality, and habitat problem identified in the Birch Bay area. Chapter 4, Alternatives, of the Birch Bay Stormwater Plan describes what type(s) of solution(s) would be appropriate for each identified problem. Solutions can range from structural solutions such as enlarging or rerouting a drainage pipe to nonstructural (programmatic) solutions such as increasing maintenance or public education. Problems can be addressed by several types of solutions, often by combinations of solutions. Twelve of the identified issues in Birch Bay call for some degree of capital (structural) project as a solution, either as a stand-alone CIP project or paired with a nonstructural solution such as increased maintenance, public education, inspection, or enforcement.

Not all of the problems identified in this process can or should be addressed. Of the problems identified as having CIP solutions, five were ranked in the bottom half of all the 41 water quality, water quantity, and habitat problems identified initially. These problems were rated lower than other problems, indicating they are relatively less important than other problems. Also, many of these problems can be addressed by programmatic solutions such as increased M&O or more frequent inspection and enforcement rather than CIP projects.

After prioritization and elimination, seven problems remain. Table 1 at the end of this memorandum contains a listing of the seven priority problems that may be addressed with a CIP project.

Descriptions of Priority Capital Projects

This section contains a brief description of the identified problem and a corresponding description of alternative and preferred solutions. Each project has been given a name along with the original problem code. Additional details of each project are included in the attached fact sheets, one for each proposed project. Figure 1 shows the location of each project.

Birch Bay Drive Roadway Improvements (CC-02)

Erosion of the Birch Bay Drive road surface will be addressed in a future Whatcom County project already in the planning stages. Therefore, this problem was eliminated from this CIP prioritization analysis. Additional description or analysis is not provided here.

Drainage Improvements, Cottonwood Neighborhood (CT-06)

Problem Description

The runoff from a large contributing area flows through a culvert under Anderson Road, in an open channel through the County-owned park, then into a pipe/culvert system leading to a single diversion structure that splits into two outfalls discharging to Birch Bay at Cottonwood Beach. The diversion structure is located behind the home at 8208 Birch Bay Drive.

Two different outfalls provide the outlet for this area. These two different outfall pipes receive flow from the same location: a single diversion structure, or "hole," that channels runoff into the two outfalls from a single entry point. This hole, located behind the home at 8208 Birch Bay Drive, receives flow through a culvert and pipe system that flows underneath Cedar Road from an upstream open channel creek system. This pipe from the open channel creek system to the hole may be located underneath the trailer home just to the north of Cedar Road to the southeast of the hole.

Of the two different outfall pipes, one pipe heads to the west into Birch Bay along a County easement to the south of the residence at 8208 Birch Bay Drive. The second pipe (to the north of the first) flows west into Birch Bay through private property to the north of the residence at 8210 Birch Bay Drive. This second pipe exits the "hole" (described above) slightly higher than the first, acting as a relief system for the first outfall. This second outfall pipe is concrete and reportedly in multiple pieces along its length.

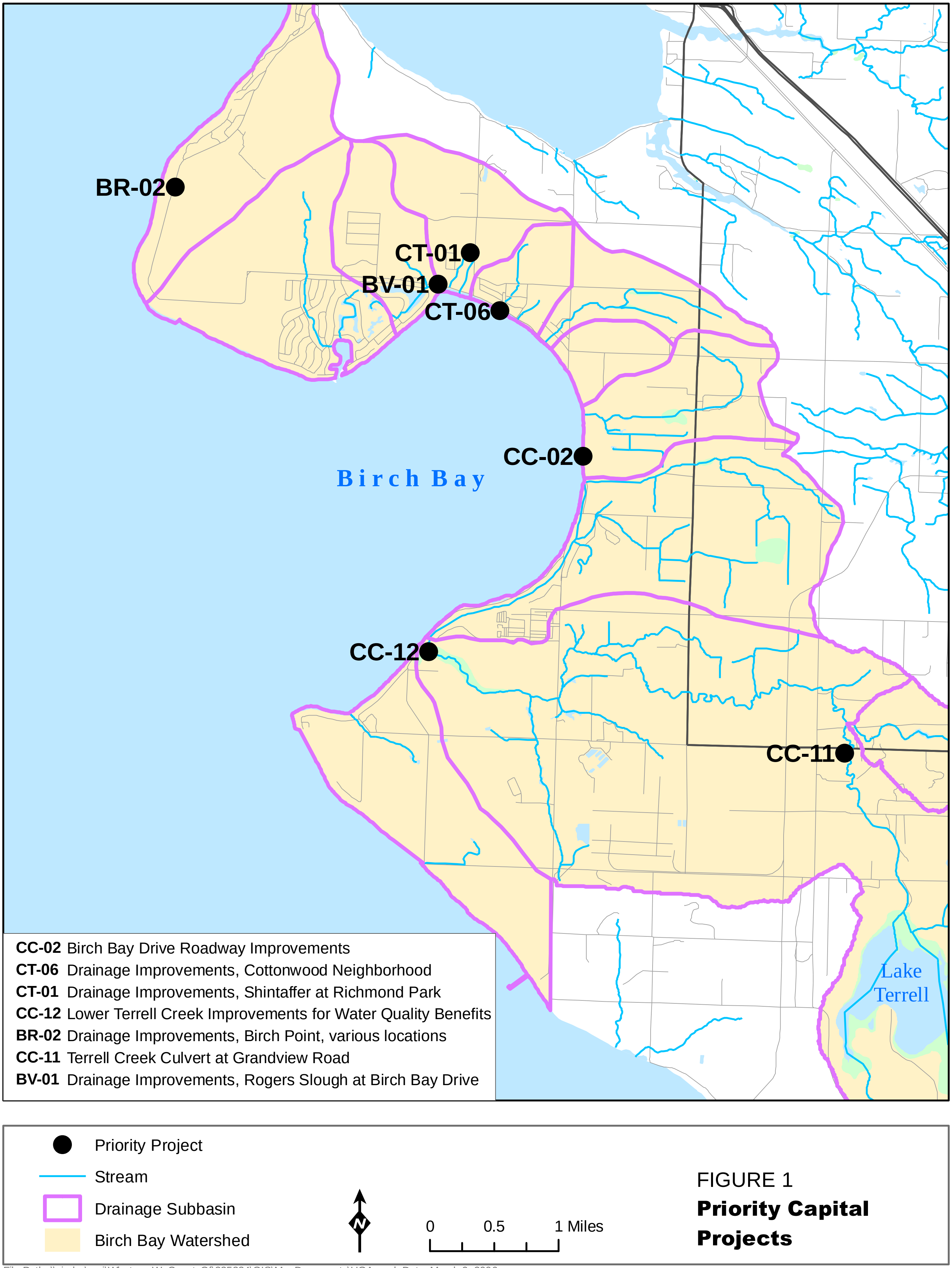

FIGURE 1
Priority Capital Projects

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Drains from houses on both sides tie into the northern outfall pipe. The neighbor to the north at 8212 Birch Bay Drive has a drain tying into this outfall pipe with a flap gate on it to prevent backflow. The neighbor to the south at 8210 Birch Bay Drive has a perforated pipe leading to the pipe. The resident at 8214 also has a yard drain leading into this same pipe.

Because the more northerly outlet pipe is in pieces, stormwater runoff may be exfiltrating into the surrounding soil. Yard flooding in the area may be the result of this exfiltration combined with a high groundwater table. Sand and beach cobbles are part of the soil mix in the area. This material has a high transmissivity that allows for rapid changes in groundwater levels with the season and perhaps with tidal fluctuations. If groundwater levels are near the surface, there is nowhere for stormwater runoff to go. Movement of sand along the beach periodically blocks the outlet and causes backwater conditions in the pipes. This condition is made worse under high tide and high landward wind conditions.

The yard at 8212 Birch Bay Drive periodically floods, as do yards to the north and south. If the outlet pipe becomes blocked with beach material and high groundwater levels exist, any stormwater runoff will have nowhere to go and will cause yard flooding in the area. The gaps in the concrete pipe (northern outfall) allow for exfiltration from the outfall pipe, plus saturated ground conditions prevent infiltration.

The runoff from the contributing area can overwhelm the system. As development continues in the upper portion of the watershed, runoff volumes and peak flowrates may increase. A preferred solution should incorporate the potential impacts that future development will have on the hydrologic regime of this system.

The owner/resident at 8212 stated that this drainage system was built by the former owner of the property. This portion of the system is on private property and is therefore a private system. Although the County may have taken responsibility thus far for maintenance, they may not be under obligation to perform such maintenance activities or to provide for improvements to the system.

Potential Alternatives

One solution to this problem is to reroute the outlet of the system west along Cedar Road under Birch Bay Drive to Birch Bay. This alternative would require construction of a new inlet structure with a trash grate, installation of several hundred feet of buried pipe, and construction of a new outfall out to Birch Bay. Portions of the existing system could not be abandoned because the system would still have to provide drainage for the cluster of homes down the hill from the new inlet. Permit requirements and construction requirements for constructing a new outfall would be significant.

A second solution would be to create an open channel instead of a piped system. The open channel portion of the current system would be extended down to Birch Bay. The inlet of the current closed-pipe system would be abandoned.

A third solution would be to re-route all flows through the southernmost outfall pipe, the outlet that flows through the County easement to the south of 8208 Birch Bay Drive. This pipe would have to be dug up and replaced with a larger diameter pipe, and the outfall structure would have to be improved. However, this alternative solution would not require the construction of a new outlet structure.

A fourth potential solution would involve installing a cast-in-place lining in one or both of the outlet pipes. The outlet pipe flowing west through private property between 8212 and 8210 Birch Bay Drive has reportedly broken into sections, with gaps in between as surrounding soils have settled. This condition may allow exfiltration of runoff into the surrounding soil, thereby increasing flooding potential. Lining this drainage pipe would prevent stormwater runoff from upstream from exfiltrating into the surrounding soil. Any flooding that would then take place in the surrounding yards would be the result of local drainage issues rather than from upstream. Infiltration could also be occurring into the pipe, depending on conditions both inside and outside the pipe. More information should be gathered to determine whether the existing system currently benefits from the exfiltration/infiltration situation. The system may be currently operating as a French drain. Like any other alternative that involves accessing this northernmost outlet pipe system, this alternative would require an easement for construction and maintenance access because it is on private property.

A fourth potential solution is to replace existing outlet structures with types that self-clean or are less prone to clogging. The existing system drains better if material is not clogging the outlets. Installation of self-cleaning outlet structures may alleviate some of the drainage issues by maintaining the design conveyance capacity of the structure. A duckbill-type outlet structure is one potential type. Any additional outlet structure would have its own set of expected head losses through the system. Detailed analysis should be performed to determine design constraints of the existing system to avoid increased flooding and backwater conditions.

An additional solution would be to fill in the yards to raise the ground elevation. This may also help alleviate yard flooding.

Preferred Solution

The solutions involving full trenching and pipe rerouting/replacement would be the most cost-intensive potential alternatives. Installation of cast-in-place lining in the northernmost outlet pipe and replacement of outfall structures on both the outlet pipes appear to be the most cost-effective structural options.

Additional analysis of the system and the flows is needed, followed by design and construction of improvements. Additional analysis may include a hydrologic and hydraulic model of the system. Further hydrologic study would allow designers to quantify the contributing area and corresponding design flows through the system. The hydraulics of the system should be analyzed to determine current head losses and other flow characteristics when the system is running at capacity. Site investigation techniques such as closed-circuit television (CCTV) pipe inspections, dye-testing, and/or survey should be used to further characterize the system before a preferred solution is implemented.

The concept-level cost estimate for this preferred solution is $225,000, including construction costs (plus 50 percent contingency) and soft costs (such as permitting, engineering/design) of 30 percent.

Drainage Improvements, Shintaffer Road at Richmond Park (CT-01)

Problem Description

The drainage ditch flowing south along the West side of Shintaffer Road conveys runoff from a large area that stretches west and north of Lincoln Road. The ditch along the west side of Shintaffer Road flows through two 90-degree bends that divert the runoff from the drainage ditch along Shintaffer Road towards the Richmond Park Subdivision. Yards in the subdivision are submerged during heavy rains as the system backs up. Runoff is then conveyed in ditches and culverts through the subdivision before discharging to an open channel/creek system and flowing to the south towards Birch Bay. The flow enters a culvert under Birch Bay Drive, then enters Birch Bay within Rogers Slough.

At the location of the two 90-degree flow diversions, runoff backs up behind the seemingly undersized culvert system in the subdivision. Yards and driveways are inundated with water. Because more development is planned for the open area to the north of the existing Richmond Park subdivision, this drainage problem has the potential to become worse. In addition, lots to the east of Shintaffer Road across the street from the Richmond Park subdivision have also had drainage issues recently, even though there are reportedly no cross-culverts across Shintaffer in that area.

After flowing through the Richmond Park Subdivision, the drainage enters an open channel creek system that flows southward towards Birch Bay. The creek crosses Fawn Crescent and then alongside Deer Creek Trail, two streets in the neighborhood with access from Birch Bay Drive. The system enters a culvert underneath Birch Bay Drive, then enters the bay.

It is not clear what the original flow path was before development of the Richmond Park Subdivision and other developments in the area. Residents have reported that an original outlet may have been through a creek system flowing south and discharging to Birch Bay somewhere between Shintaffer Road and the existing creek system by Fawn Crescent and Deer Creek Trail. Currently, this is not an outlet for the system. Runoff from a small portion of the contributing area could have originally flowed to Birch Bay along Shintaffer Road.

The culverts through the subdivision appear to be undersized for the flows that enter the system. However, simply increasing the size of these culverts will not solve the problem and will cause harm to downstream properties. The open channel creek system downstream from the subdivision is in a ravine with homes close together that are currently experiencing erosion and slope stability problems. This problem could worsen if runoff flow rates and volumes are increased.

The roadside ditches along Shintaffer Road are large and appear to have been designed to convey large amounts of flow. The ditches to the south of the pipe diversion appear to be sized to handle the flow that is currently diverted through the subdivision. However, a detailed site investigation and possibly hydrologic modeling would indicate whether flow diversions down Shintaffer or other route are feasible and indeed the preferred alternative.

Preliminary development plans for the open area to the north and west of the Richmond Park Subdivision indicate that runoff from most of that area will be rerouted away from the current outlet through the subdivision. Approximately 1.5 acres of the currently contributing area will then drain through the subdivision.

Potential Alternatives

One alternative is to increase the capacity of the culverts through the Richmond Park subdivision to alleviate flooding in the area. However, this action would yield higher peak flows downstream. These higher peak flows could potentially increase slope erosion and stream bed incision occurring within the ravine and creek system.

Another alternative would be to redistribute flows between the current drainage path through the Richmond Park subdivision and the drainage ditches along the west side of Shintaffer Road. These drainage ditches are relatively large and appear to have a capacity greater than the ditch and culvert system through the Richmond Park subdivision. However, the capacity of these ditches would have to be analyzed before any flows are rerouted. A third potential flow path could be identified through detailed site investigation. The area indicated by residents to be the original outlet of the system has been identified as a potential third flow path.

A third alternative is to create a detention facility in the upstream portions of the contributing area. This facility could accept flows from a portion of the area currently contributing to the ditch and culvert system through the Richmond Park subdivision. This detention facility or a portion of it could be a required part of any future development planned for that area (above and beyond their site-specific requirements), or it could be implemented by Whatcom County, and capacity could be "sold back" to the developers through a system development charge.

Because of the preliminary development plans for rerouting runoff from the open area, a potential solution is to promote this re-routing of flows and to maximize the current conveyance capacity of the system. The existing drainage ditches along the east side of Shintaffer Road should be re-formed and maintained. The drainage system through the Richmond Park Subdivision should also be inspected and maintained.

Additional analysis of the system and the flows may be needed to assess the long-term affects this hydrologic regime may have on the erosion and slope degradation occurring in the backyards along the ravine downstream of the Richmond Park Subdivision. The preferred solution should incorporate the potential impacts that future development will have on the hydrologic regime of this system.

Preferred Solution

Because of the preliminary development plans for rerouting flows, the preferred solution is to promote the rerouting of flows and to maximize the current conveyance capacity of the system. The existing drainage ditches along the east side of Shintaffer Road should be re-formed and maintained. The drainage system through the Richmond Park Subdivision should also be inspected and maintained.

Additional analysis of the system and the flows may be needed to assess the long-term affects this hydrologic regime may have on the erosion and slope degradation occurring in the backyards along the ravine downstream of the Richmond Park subdivision. The preferred solution should incorporate the potential impacts that future development will have on the hydrologic regime of this system.

The concept-level cost estimate for this preferred solution is $125,000, including construction costs plus 50 percent contingency and soft costs (e.g., permitting, engineering/design) of 30 percent.

Lower Terrell Creek Improvements for Water Quality Benefits (CC-12)

Problem Description

Terrell Creek has low dissolved oxygen levels and high temperatures. Dissolved oxygen concentrations below criteria and temperatures above criteria have been recorded during water quality monitoring activities by both the Nooksack Salmon Enhancement Association (NSEA) and the Washington State Department of Ecology (Ecology). Other water quality parameters are also problematic along the length of the creek.

At one time, Terrell Creek followed a natural path through the area. It is natural for a coastal stream to move in the direction of longshore drift. Occasionally, during a large storm event, the creek would cut through to a new, more direct outlet to salt water, and the drift process started over. As development in Birch Bay proceeded, sections of Terrell Creek were confined and the creek no longer was allowed to find a natural course. Current patterns of development permanently set the location of Terrell Creek. Currently, Terrell Creek follows the beach shoreline from Birch Bay State Park to the outlet.

This entire stretch along with a large portion of the creek within the state park is tidally influenced. The Terrell Creek marsh (within Birch Bay State Park) is one of the few remaining saltwater/freshwater estuaries in northern Puget Sound. The north end of the state park is a natural game sanctuary providing refuge for smaller birds, migratory waterfowl, American bald eagles, and the great blue heron.

The lower confined reaches of Terrell Creek are affected by tidal changes that may cause stagnant conditions under periods of low stream flow and warm weather. The reaches of Terrell Creek between Birch Bay State Park and the outlet of the creek into Birch Bay have had measured low dissolved oxygen levels and higher temperatures. This has led to fish kills.

Potential Alternatives

A potential programmatic solution to the low dissolved oxygen problem in Terrell Creek is to reduce the input of nutrients and organic matter from the watershed. Excessive nutrient inputs yield algal blooms that have significant impacts on dissolved oxygen levels in the water column. Organic matter uses up the available oxygen in decomposition processes. A second programmatic solution is to plant trees at various points along the length of the creek to increase shade and therefore reduce temperatures.

One structural alternative is to relocate the mouth of the creek to provide a more direct path to Birch Bay. This would allow Terrell Creek to “find” its natural pathway to Birch Bay, responding to natural process. A feasibility study would be required for both the creek realignment and for the most appropriate use for the current pathway of Terrell Creek from Birch Bay State Park to the current mouth. This would eliminate extensive fish, bird, and other wildlife habitat in and along the existing channel.

The benefits of a more direct pathway for Terrell Creek would have to be weighed against current habitat use and other factors. Currently, much of the lower reaches of Terrell Creek are tidally influenced and provide estuarine habitat for several species of birds and waterfowl. Realignment of the creek may negatively affect current habitat conditions. In addition, the tidal influence (and corresponding backwater conditions under high tide) may be propagated upstream with the creek realignment. This may have negative impacts on upstream people and properties.

Another solution would be to aerate the water in known problem areas to increase the dissolved oxygen content. This solution is expensive, and it is not a sustainable alternative. Permitting would be difficult because it does not address the cause of the problem, only the symptoms.

Preferred Solution

Poor water quality conditions in Terrell Creek should be addressed by programmatic solutions such as source control efforts instead of by the structural alternative of realigning the mouth of the creek. Details of these programmatic solutions are included in Chapter 4, Alternatives, of the Birch Bay Stormwater Plan.

The structural alternative may have more of a negative impact than a positive one. Although conditions in Terrell Creek under the current alignment are not ideal, realigning the mouth of the creek has the potential to negatively affect the current habitat conditions in the creek. Programmatic solutions would provide more benefit for less cost (both financial and environmental) than would this structural solution. A concept-level cost estimate for the structural alternative of re-aligning Terrell Creek is close to $2 million, including construction costs (plus 50 percent contingency) and soft costs (including permitting and legal costs) of 30 percent of construction costs and engineering study/design at an additional 30 percent. These higher costs for permitting and engineering study/design reflect the specific issues of a construction project along a shoreline and within a salmon-bearing stream such as Terrell Creek.

Planting trees along the length of Terrell Creek would increase shade and therefore reduce temperatures. A concept-level cost estimate for this preferred solution is $50,000.

Drainage Improvements, Birch Point, Various Locations (BR-02)

Problem Description

The natural hydrology in the Birch Point area has been altered such that stormwater runoff is now conveyed through culverts and ditches. Surface flow is conveyed towards Birch Bay in concentrated flow streams that may contribute to erosion and stability problems at the point of discharge. Ditches accelerate velocities of runoff because they are straight and relatively smooth. Ditch construction has channelized the system and promoted higher runoff velocities and greater volumes of runoff.

Construction of roadways and roadside ditches has altered the surface and subsurface flow throughout Birch Point. Subsurface flow in the upper portion of soil is intercepted by roadside ditches and is conveyed more quickly and in more concentrated amounts than if the roadway and roadside ditches had not been there. By intercepting horizontal flow and removing water from shallow soils, roadside ditches reduce the amount of water moving across private properties toward the bluff.

The subsurface geology of the area consists of clay and hard-packed marine sediments. Infiltration capacity is limited because of this. Drainage issues are therefore more pronounced because the soil is less forgiving. This is true throughout the Birch Bay area but particularly in the northern half where marine soils predominate.

Specific surface drainage problems identified in the Birch Point area are as follows:

- Oertel Drive ditch overwhelmed, loss of capacity due to accumulated material; residents have cut paths for water access.
- 8621 Semiahmoo Drive drainage ditches overwhelmed, low point in roadway.
- Normar Place, erosion of ditch and surrounding material during storm, plugged up outlet and overwhelmed system.
- Ditches along Cary Lane
- Localized road flooding at the Semiahmoo Drive and Birch Point Road intersection.

Slope stability is a problem all across the bluffs of Birch Point. Natural processes have been accelerated by increased runoff velocities and volume due to removal of vegetation, the installation of septic tank drain fields, and the construction of impervious surfaces and channelized ditches.

The westernmost portion of the area at and north of Birch Point itself is a geologically unique area. This portion of Birch Point is a groundwater recharge area where the overlying area is not perched and therefore contributes surface water to the shallow and deep groundwater flow. Land use activities in this contributing area have a great impact on the subsurface flows. Removal of trees and tree stumps may have increased the subsurface flows in the area. This increase in subsurface flow has been experienced by residents living along the edge of the steep slopes, and the residents have witnessed increased seepage and groundwater flow underneath their homes and out the sides of the slopes. Increases and changes in subsurface flow can affect the rate of slope movement and may increase the risk of landslide action.

Potential Alternatives

A structural alternative to this set of problems is for improvements in the conveyance of runoff from upstream contributing areas. This project would involve the design and construction of tight-line drainage from an upstream contributing area across a road to the edge of the slope, then down the slope. This setup would be repeated up to three additional times depending on location and magnitude of runoff flows from upstream areas. David Evans and Associates have identified each specific surface runoff outlet from Trillium Property. This inventory should be incorporated into the design/engineering of any drainage improvements.

Programmatic solutions include public education on proper drainage techniques, stricter requirements on addition of impervious surface and tree removal, increased inspection and enforcement of land clearing and drainage requirements, and implementation of projects such as LID that have the potential for limiting runoff.

Preferred Solution

The preferred solution is the structural alternative of constructing tight-line drainage from the edge of the bluff (including steep slopes) and down to the beach. This solution could be applied at any or all of the specific identified surface runoff outlets from upstream property.

Several of these problem spots may be addressed with structural projects such as drainage reroutes and capacity increases. However, these capital project solutions should be performed concurrently with programmatic solutions such as public education on proper drainage techniques, stricter requirements on addition of impervious surface and tree removal, increased inspection and enforcement of land clearing and drainage requirements, and implementation of projects such as LID that have the potential for limiting runoff. These programmatic solutions are addressed Chapter 4, Alternatives, of the Birch Bay Stormwater Plan. These programmatic solutions will address subsurface flow and erosion/stability issues around Birch Point that are not specifically addressed with this structural surface runoff improvement project.

The concept-level cost estimate for this preferred solution is $250,000 for each location. This estimate includes construction costs plus 50 percent for contingency and 30 percent for soft costs (e.g., permitting, engineering/design). Addressing four locations is estimated to cost $1,000,000.

Terrell Creek Culvert at Grandview Road (CC-11)

Problem Description

The Grandview Road crossing of Terrell Creek is currently a fish passage barrier under low-flow conditions. The culvert is situated high enough above the creek bed that any fish passage under low flows is impossible. Either this culvert would have to be replaced or the channel downstream from the culvert would have to be built up in elevation to allow for fish passage through the existing culvert. (The culvert at Blaine Road is also a fish passage barrier along Terrell Creek. However, the culvert at Blaine Road is currently slated for replacement by the Washington Department of Transportation and is therefore not addressed here.)

Potential Alternatives

One potential alternative is the installation of a series of weirs downstream from the existing culvert to increase the elevation of the stream bed. This could allow passage of fish during all flow regimes including low flow. However, the most direct approach to this problem would be the installation of a fish-friendly culvert such as a box culvert that would allow passage under low flow conditions.

Preferred Solution

The preferred solution is the replacement of the existing culvert with a box culvert to allow for year-round fish passage under all flow regimes.

The concept-level cost estimate for this preferred solution is $460,000, including construction costs plus 50 percent contingency and soft costs (e.g., permitting, engineering/design) of 30 percent.

Drainage Improvements, Rogers Slough at Birch Bay Drive (BV-01)

Problem Description

Drainage ditches discharging to Rogers Slough back up behind the tide gate under high tide and/or wet weather conditions. When these ditches overflow, backyard flooding occurs in the homes within Birch Bay Village that have backyards along Birch Point Road. Ditches also back up along the north side of Birch Point Road.

Much of this area may be at or just above high tide level. During wet periods, runoff will back up behind the existing tide gate until the tide recedes and this runoff can discharge through the gate. However, this drainage is prevented by a nonfunctioning tide gate, or an excess of runoff into the system, or lack of maintenance of the tide gate. Accumulated material within Rogers Slough also may prevent adequate drainage from the system. Note that the flooded areas are low and historically are likely to have been wet even before homes and roads were built in the area. It may be appropriate to prevent further home construction in wet areas.

Potential Alternatives

Potential solutions include structural and programmatic alternatives. Structural alternatives consist of improvements to the drainage system or filling yards that experience the flooding. Improvements to the drainage system may include a reconfiguration of the existing tide gate, drainage ditches, and cross-culverts in the area. For example, Birch Bay Village representatives have proposed a culvert reroute along Birch Point Road under the Birch Point Loop to alleviate flooding.

The alternative of filling in portions of the area that are below high tide level would have permitting difficulties and may not alleviate the problems.

Material such as trees tend to accumulate within Rogers Slough and prevent adequate drainage. Therefore, increasing frequency of maintenance as a programmatic method may alleviate some of the flooding.

The preferred solution should incorporate the potential impacts that future development will have on the hydrologic regime of this system.

Preferred Solution

Accumulated material such as trees should be removed from Rogers Slough more frequently to help alleviate the drainage problems. This programmatic solution is addressed Chapter 4, Alternatives, of the Birch Bay Stormwater Plan.

A detailed study of the area and the problem should be conducted as part of the preferred solution. A survey would yield detailed elevations of homes, yards, roadways, drainage ditches, pipes, and the tide gate in relation to tidal elevations within Rogers Slough. Further hydrologic study would allow designers to quantify the contributing area and corresponding design flows through the system. In addition, the formulation of a hydrologic model would enable planners to determine adequate detention requirements for future developments. This may include increased detention requirements for any additional developments planned for the contributing area that would exceed the current detention capabilities of the existing system.

Drainage ditches, culverts, and pipes may be upgraded to maximize conveyance capacity. The tide gate may be replaced, depending on the results of the initial study. As an initial estimate, this preferred structural solution (if required, depending on results of detailed study) would cost $425,000, including construction costs plus 50 percent contingency and soft costs (e.g., permitting, engineering/design) of 30 percent.

Any capital project should be coordinated with updated M&O procedures and plans associated with tide gates and tide gate operation. In addition, any updates to planning requirements and requirements on LID and other source control should be made with this problem and project in mind as it relates to new development in the area.

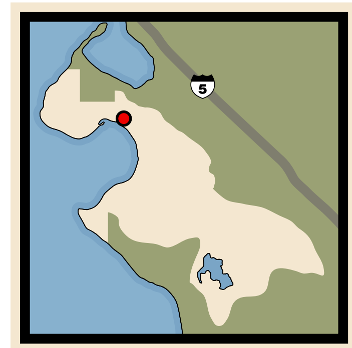
TABLE 1
Priority Capital Projects for Whatcom County CIP

Capital Project Name (Rank)	Capital Project Description	Recom-mended Capital Project?	Problem Rank (out of 41)	Problem Description	Type of Problem (Drainage, Water Quality, or Habitat)	Concept-Level Cost Estimate of Preferred Capital Solution[a]
CC-02 (1)[b]	Birch Bay Drive Roadway Improvements (project already underway)[b]	NO	1	Erosion of material supporting roadway of Birch Bay Drive	Drainage or Erosion / Stability	--
CT-06 (2)	Drainage Improvements, Cottonwood Neighborhood	YES	4	Drainage/flooding issues at Cedar and Birch Bay Drive at Cottonwood Beach; discharging through two outfalls along beach	Drainage	$225,000
CT-01 (2)	Drainage Improvements, Shintaffer Road at Richmond Park	YES	4	Drainage/flooding Issues along Shintaffer Road along north side of Richmond Park subdivision	Drainage	$125,000
CC-12 (4)	Terrell Creek Improvements for Water Quality	YES	6	Terrell Creek Confined in lower reaches – poor water quality	Water Quality and Habitat	$50,000
BR-02 (5)	Drainage Improvements, Birch Point, Various Locations	YES	16	Drainage/flooding Issues, various places along Birch Point Area (Cary Lane, Semiahmoo Drive, Normar Place, Semiahmoo/Birch Point Roads)	Drainage	$250,000 for each individual location (up to four locations)
CC-11 (6)	Terrell Creek Culvert at Grandview Road	YES	17	Road Culvert as blockage to fish habitat, Blaine and Grandview Roads	Habitat	$460,000
BV-01 (7)	Drainage Improvements, Rogers Slough at Birch Bay Drive	YES	20	Drainage/flooding behind tide gate at Rogers Slough	Drainage	$425,000

[a] Preliminary cost estimates include construction costs with 50% contingency and 30% for “soft” costs such as permitting and engineering/design.
[b] Birch Bay Drive Roadway Improvements are part of a project that is currently underway within Whatcom County. Therefore, this problem is not addressed in this analysis.

Drainage Improvements, Cottonwood Neighborhood (CT-06)

CT-06



PROJECT DESCRIPTION

Stormwater runoff for a large portion of the Cottonwood Neighborhood is conveyed through the open channel through the County Park and into a closed-pipe system consisting of one pipe leading to a structure diverting flow to two different outfalls along Cottonwood Beach. Flooding occurs in the yards along Birch Bay Drive close to the system outlets. Development is expected to continue in the upstream portions of the drainage basin. This system must be capable of handling any additional flows due to these new developments. The failing system is on private property and was constructed by private property owners.

EXPECTED BENEFITS

Provide adequate drainage for contributing area

Decrease magnitude and frequency of flooding

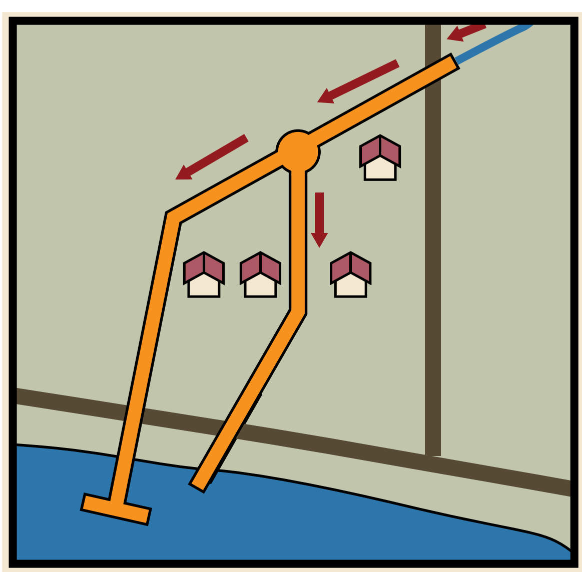
Improve health and safety

DESIGN OBJECTIVES AND REQUIREMENTS

Increase capacity of system to convey runoff from contributing area

Create design that accommodates sand and other material that accumulates within outlets at beach

Maintain aesthetically-pleasing appearance of beachfront area



POTENTIAL ALTERNATIVES

Construct system re-route, requiring more than a hundred feet of new drainage pipe plus new outfall to Birch Bay

Re-route all flows to one outlet rather than two; increase capacity of existing outlet, requires construction of more than a hundred feet of larger diameter pipe, improved outfall structure

Install cast-in-place pipe liner in the northernmost outfall pipe

Upgrade current outfall structures (2) with types that prevent build-up of material and corresponding loss of conveyance capacity

Daylight closed-pipe system; extend open channel creek to Birch Bay

Fill in yards to alleviate flooding

Do nothing. The failing system is private

PREFERRED SOLUTION

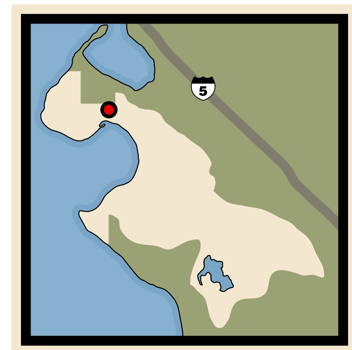
Installation of cast-in-place lining in the northernmost outlet pipe and replacement of outfall structures on both the outlet pipes, pending results from additional analysis/data review; improvements to inlet structures for safety

Perform additional analysis of system conditions and conveyance requirements, site investigation techniques such as CCTV, dye testing, and survey, hydrologic and hydraulic modeling

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*: $225,000

Drainage Improvements, Shintaffer at Richmond Park (CT-01)

CT-01



PROJECT DESCRIPTION

The drainage ditch flowing south along the West side of Shintaffer Road conveys runoff from a large area that stretches west and north of Lincoln Road. The ditch along the west side of Shintaffer flows through two 90-degree bends from the drainage ditch along Shintaffer towards the Richmond Park Subdivision. Runoff is then conveyed in ditches and culverts through the subdivision before discharging to a creek system through a ravine flowing to the south towards Birch Bay. The creek enters a culvert under Birch Bay Drive then enters Birch Bay within Rogers Slough. Yards in the Richmond Park Subdivision are submerged during heavy rains as the system backs up. Residents near the creek have experienced erosion and slope degradation in backyards along the ravine.

EXPECTED BENEFITS

Provide adequate drainage for contributing area

Decrease magnitude and frequency of flooding and erosion

Improve health and safety

Provide adequate storage within the upstream system

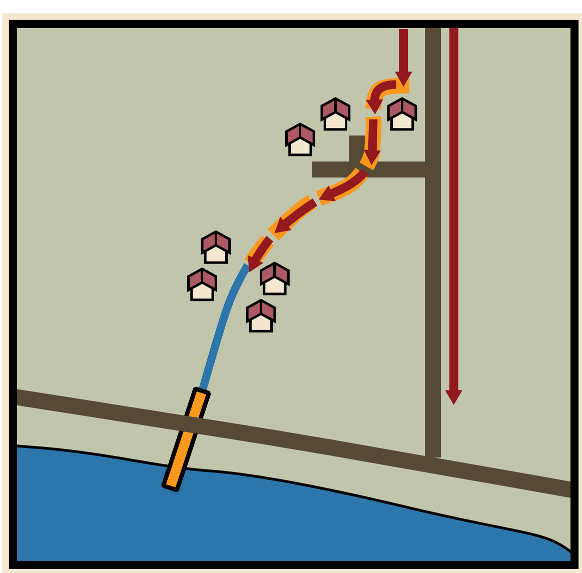
DESIGN OBJECTIVES AND REQUIREMENTS

Increase capability of system to convey runoff from contributing area

Minimize erosion of ravine and creek bank

Optimize allocation between ditches along Shintaffer and ditches in subdivision and other potential outlets

Maintain aesthetically-pleasing appearance of area



POTENTIAL ALTERNATIVES

Increase capacity of ditch and culvert system through Richmond Park Subdivision to convey runoff from contributing area

Optimize allocation between ditches along Shintaffer and ditches in subdivision and other potential outlets

Construct detention in upper portion of sub-basin

PREFERRED SOLUTION

Perform additional analysis of system conditions and conveyance requirements, site investigation including survey, hydrologic modeling

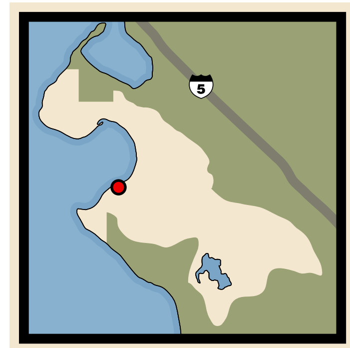
Re-allocate runoff to Richmond Park Subdivision, ditches along Shintaffer, and potential third flow path to Birch Bay

Provide detention in upstream portion of sub-basin, if necessary

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*: $450,000

Lower Terrell Creek Improvements for Water Quality Benefits (CC-12)

CC-12



PROJECT DESCRIPTION

At one time, Terrell Creek followed a natural path through the area. It is natural for a coastal stream to move in the direction of long-shore drift. Then, occasionally during a large storm event, the creek would cut through to a new more direct outlet to salt water and the process starts over. As development in Birch Bay proceeded, sections of Terrell Creek were confined and the creek no longer was allowed to find a natural course. Terrell Creek has low dissolved oxygen levels and high temperatures due to upstream activities within the watershed plus the confined nature of its path that limits circulation.

One alternative under this project would involve a feasibility analysis plus the design and construction of a more direct outlet for Terrell Creek. However, this alternative may be more harmful than it is helpful, as the current configuration of Terrell Creek includes an extensive estuarine area that provides habitat for several species of birds and waterfowl.

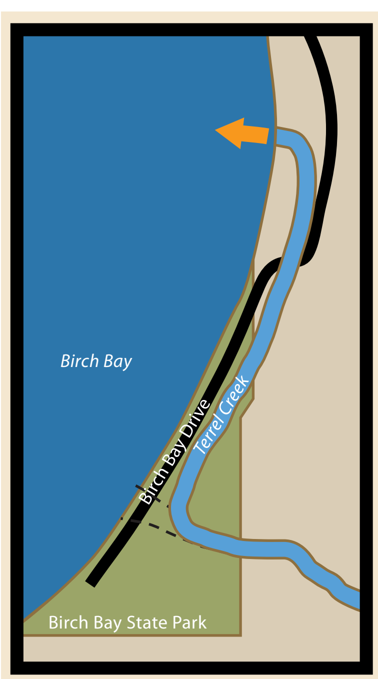
Because of this constraint, the preferred solution for this project is to improve water quality conditions within Terrell creek through programmatic rather than structural means. These programmatic solutions are described in Chapter 4 (Alternatives) of the Birch Bay Stormwater Plan.

EXPECTED BENEFITS

Increase in water movement to allow for higher dissolved oxygen content

Re-create natural conditions that are more suitable for fish

Alleviate current stagnant water conditions in lower confined reach of Terrell Creek



DESIGN OBJECTIVES AND REQUIREMENTS

Conduct assessment of benefits versus loss of current habitat and structure

Assess how project would affect hydraulic and geomorphic conditions

Preserve current uses by people and wildlife

Maintain aesthetically-pleasing appearance of area

POTENTIAL ALTERNATIVES

Conduct physical reconfiguration of creek path to more natural conditions; construct new outlet for Terrell Creek within Birch Bay State Park

Incorporate programmatic solutions such as source control efforts and tree plantings

Consider acquisition of ajoining properties

PREFERRED SOLUTION

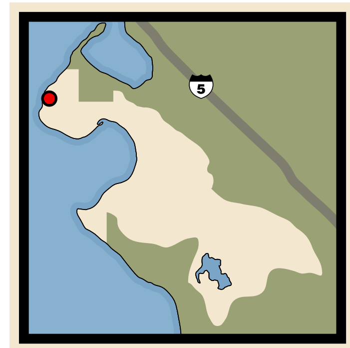
Address water quality problems by programmatic means; plant trees, increase source control efforts, education, evaluate acquisition

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*:

$50,000 for tree planning and aquatic habitat enhancement

Drainage Improvements, Birch Point, Various Locations (BR-02)

BR02



PROJECT DESCRIPTION

The natural hydrology in the Birch Point area has been altered due to past development. Construction of roadways, roadside ditches, and homes has altered the surface and sub-surface flow. Loss of vegetation has increased volumes of runoff and peak flows. Surface flow is conveyed in cross-culverts and roadside ditches then flows towards Birch Bay in concentrated flow streams that may contribute to erosion and stability problems at the bluff.

Several localized surface drainage issues have been identified in the Birch Point Area. This project would involve addressing these issues by increasing capacity of these drainages in a manner consistent with BMPs for active landslide areas. The most immediate need is for proper conveyance of drainage from upstream contributing areas. This project would involve the design and construction of tight-line drainage at the edge of the slope then down the slope. This setup would be repeated up to three additional times depending on location and magnitude of runoff flows from upstream areas.

EXPECTED BENEFITS

Provide adequate drainage for contributing area

Decrease magnitude and frequency of drainage problems

Improve safety by decreasing risk of propagating landslides due to inappropriate drainage practices

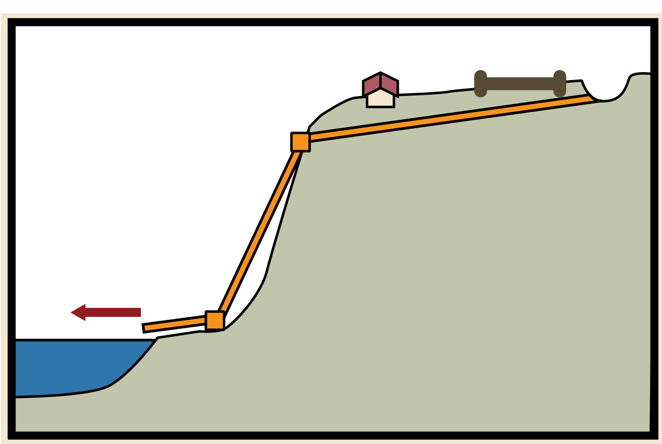
DESIGN OBJECTIVES AND REQUIREMENTS

Increase capability of system to convey runoff from contributing area

Minimize erosion of ravine and creek bank

Optimize allocation between ditches along Shintaffer and ditches in subdivision and other potential outlets

Maintain aesthetically-pleasing appearance of area



PREFERRED SOLUTION

Installation of tight-line drainage from upstream contributing properties to edge of bluff and over to water's edge

Coordination with programmatic (non-structural) alternatives such as public education on proper drainage techniques, stricter development/land clearing requirements, etc.

POTENTIAL ALTERNATIVES

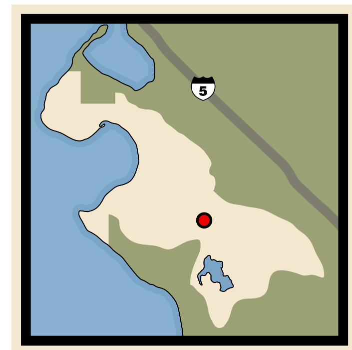
Installation of adequate drainage from upstream contributing properties to edge of bluff and tight-linedto the water's edge

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*:

$250,000 for each site addressed, $1,000,000 for four sites

Terrell Creek Culvert at Grandview Road (CC-11)

CC-11



PROJECT DESCRIPTION

The Grandview Road crossing of Terrell Creek is currently a fish passage barrier under low flow conditions. The culvert is situated high enough above the creek bed that any fish passage is impossible under low flows.

The preferred alternative is the installation of a fish-friendly culvert such as a box culvert that would allow passage under low flow conditions.

EXPECTED BENEFITS

Provide opportunities for fish passage

Promote spawning in creek stretches upstream of Grandview Road

DESIGN OBJECTIVES AND REQUIREMENTS

Allow for fish passage in all seasons

Design culvert to achieve hydraulic capacity requirements

POTENTIAL ALTERNATIVES

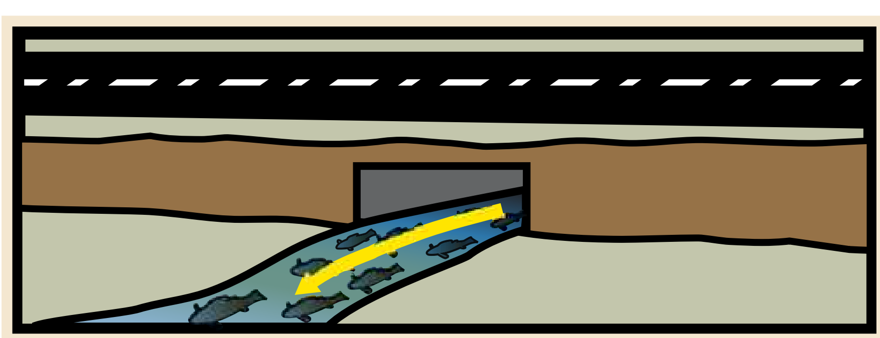
Installation of step-weirs to raise the elevation of the stream bed downstream of the Grandview Road culvert to allow for fish passage

Replacement of existing culvert under Grandview Road with "fish-friendly" culvert

PREFERRED SOLUTION

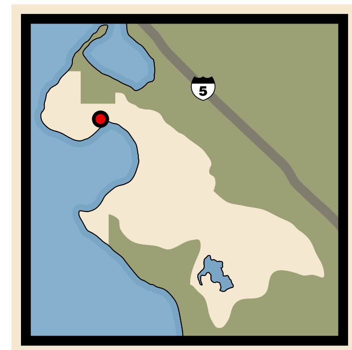
Replacement of existing culvert with "fish-friendly" culvert

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*: $460,000



Drainage Improvements, Rogers Slough at Birch Bay Drive (BV-01)

BV-01



PROJECT DESCRIPTION

Drainage ditches discharging to Rogers Slough back up behind the tide gate under high tide and/or wet weather conditions. When these ditches overflow, backyard flooding occurs in the homes within Birch Bay Village that have backyards along Birch Point Road. Ditches also back up along the north side of Birch Point Road. Much of this area may be at or just above high tide level. During wet periods, runoff will backup behind the existing tide gate until the tide recedes and this runoff can discharge through the gate. Note that the flooded areas are low and historically are likely to have been wet even before homes and roads were built in the area.

EXPECTED BENEFITS

Provide adequate drainage for contributing area

Decrease magnitude and frequency of flooding

Design Objectives and Requirements

DESIGN OBJECTIVES AND REQUIREMENTS

Increase capability of system to convey runoff from contributing area

Create design that accommodates material that accumulates in Rogers Slough and may block flow

Maintain aesthetically-pleasing appearance of area

POTENTIAL ALTERNATIVES

Construct drainage system improvements such as replacement of culverts, ditches, and other infrastructure

Fill in yards and other low spots that flood

Coordination with programmatic solution of increased maintenance – removal of logs other accumulated material within Rogers Slough

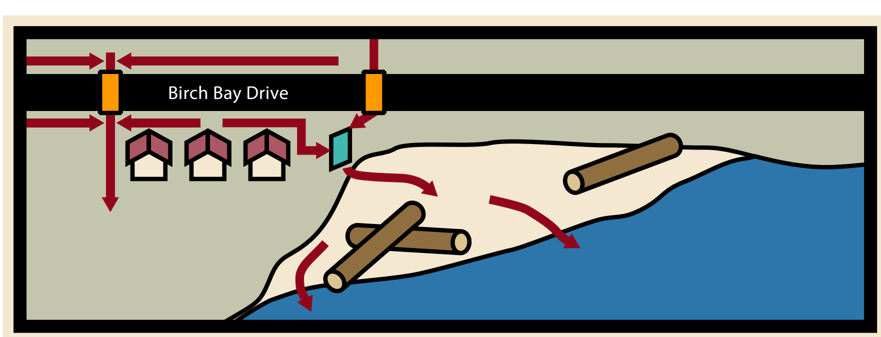
PREFERRED SOLUTION

Conduct site assessment study, including detailed survey of the area to assess elevations in relation to high tide; conduct hydrologic study to assess required capacity of current system

Perform improvements to drainage system and fill in yards and other low spots, pending results from site assessment study

ESTIMATED COSTS *(concept-level only, with construction costs +50% contingency and soft costs of 25%, including permitting, engineering/design, etc.)*:

$425,000



Addendum 1

Birch Bay

Central North Subwatershed Master Plan

Prepared for:

Whatcom County Public Works Department Stormwater Division	Birch Bay Watershed and Aquatic Resources Management District

Prepared by:

TETRA TECH

December 2013

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement PO-00J08301 to Whatcom County Conservation District. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of the trade names or commercial products constitute endorsement or recommendations for use.

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

BIRCH BAY CENTRAL NORTH SUBWATERSHED MASTER PLAN

DECEMBER 2013

Prepared for:

Whatcom County Public Works Department Stormwater Division
322 N. Commercial Street
Bellingham, WA 98225

Birch Bay Watershed and Aquatic Resources Management District

Prepared by:

TETRA TECH

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Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Central North Subwatershed Master Plan

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CHAPTER 1.
INTRODUCTION

The Birch Bay Watershed and Aquatic Resources Management (BBWARM) District is a special purpose district established to manage stormwater in the Birch Bay watershed. A previous basin-wide study for Whatcom County identified sensitive areas in the watershed that should be protected and areas where development should be allowed (ESA Adolfson, 2007). The study recommended strategies to mitigate the effects of development on aquatic resources and wildlife. For developing areas, the study found that watershed master planning is needed to address deficiencies in current stormwater infrastructure and to plan for future infrastructure needs. The study identified the Central North subwatershed (also referred to as the Birch Bay Urban Subwatershed) as a pilot study area for urban subwatershed master planning in the District. Upon adoption, this stormwater master plan for the Central North subwatershed will be used as a template for future urban watershed planning in Birch Bay and other areas of Whatcom County.

PURPOSE AND GOALS

The purpose of the *Birch Bay Central North Subwatershed Master Plan* is to develop a systematic approach to solving stormwater problems in the Central North subwatershed, improving drainage and reducing flooding. Developing the plan consisted of collecting data on the storm drain system, analyzing system capacity, identifying and addressing deficiencies in drainage infrastructure, and developing a capital improvement program. The plan will guide future development activity to minimize impacts on the stormwater system and accommodate future drainage infrastructure needs. The objectives of this plan are as follows:

- Develop an accurate, comprehensive inventory of stormwater facilities in the subwatershed.
- Create a guide for implementing capital projects to address drainage deficiencies in a prioritized and scheduled manner.
- Assess land use impacts on stormwater.
- Document project needs to incorporate into a countywide capital improvement program.

This plan represent conditions in the subwatershed at the time the plan was developed. Interpretation of these conditions may change in the future as new information is obtained and new problems are identified.

STUDY AREA

The Birch Bay watershed is in the northwest corner of Whatcom County along Georgia Straight, approximately 18 miles northwest of Bellingham and just south of Blaine. The watershed covers approximately 27 square miles. The Central North subwatershed covers about 1,000 acres at the northern tip of Birch Bay. It includes the Shintaffer, Cottonwood Beach North, Cottonwood Beach South, Hillsdale and Hillsdale North subbasins, as shown on Figure 1-1. The subwatershed is generally oriented east-west and extends from west of Shintaffer Road to Blaine Road and from north of Lincoln Road to Birch Bay. The area is split between single-family residential housing and trailer homes near the shore and rural, agricultural lands in the upland areas.

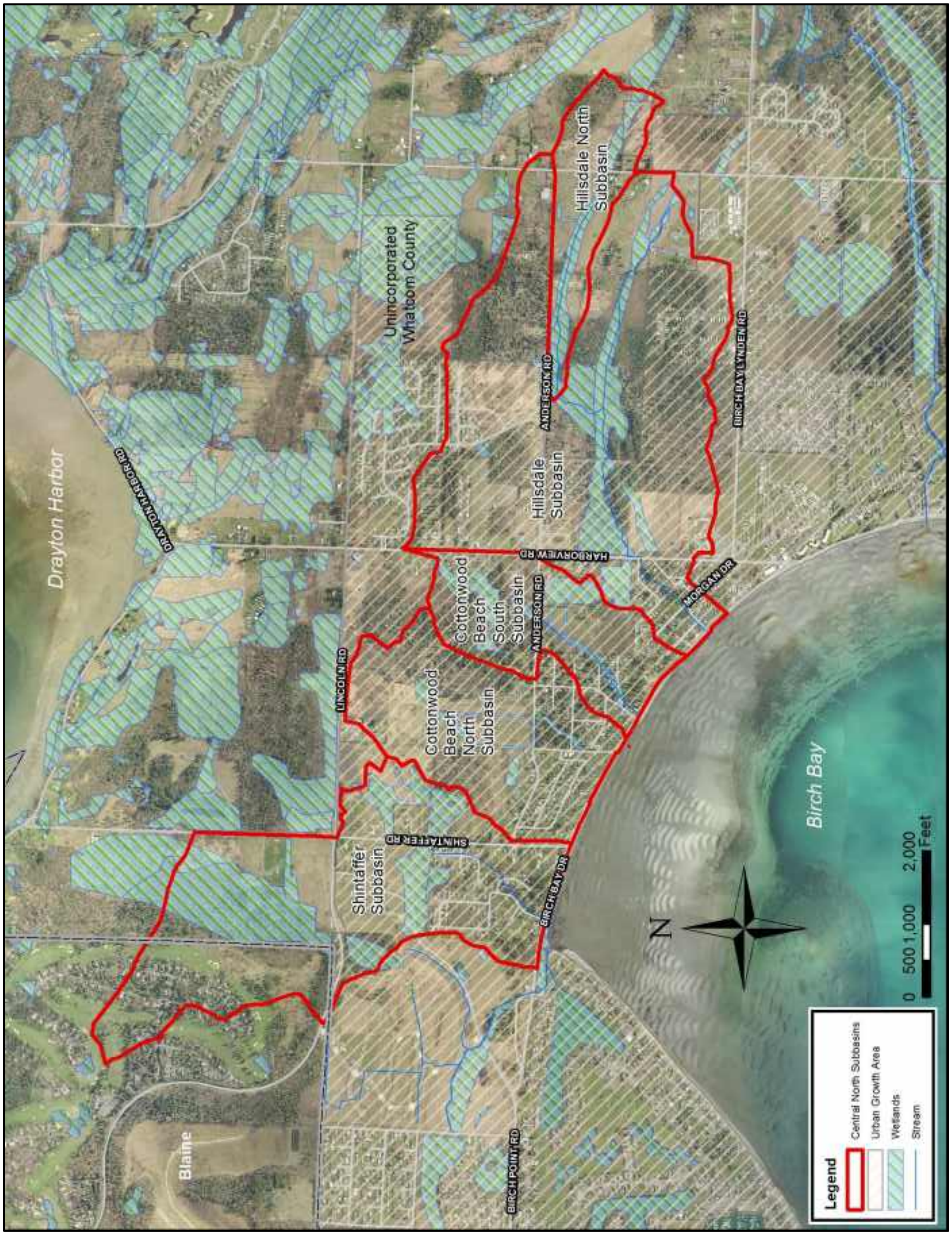

Figure 1-1. Subbasins of the Central North Subwatershed

PREVIOUS PLANNING EFFORTS

Several recent planning efforts focusing on surface water issues in the Birch Bay watershed have provided background and direction for this master plan. This plan differs from the previous planning efforts in that it focuses solely on the Central North subwatershed and includes detailed inventory data collection and quantitative analysis of drainage problems.

The 2006 *Birch Bay Comprehensive Stormwater Management Plan* covered the entire Birch Bay watershed and investigated drainage, water quality, and aquatic habitat issues (CH2M Hill, 2006). This plan also identified policy issues, structural and non-structural capital projects, low-impact development techniques, and operation and maintenance recommendations for the Birch Bay watershed. Specific recommendations for the Central North subwatershed were limited and included two capital projects to solve flooding problems. Because this plan covered the entire watershed, detailed analysis was not performed for each subbasin.

The 2007 *Birch Bay Watershed Characterization and Watershed Planning Pilot Study* evaluated restoration and development potential for all subbasins in the Birch Bay watershed (ESA Adolfson, 2007). This study outlined a comprehensive approach to guiding land use efforts in the Birch Bay watershed by using a science-based watershed characterization to "identify areas within Birch Bay for protection or restoration of ecosystem processes necessary for the long term functioning of marine and freshwater systems while also guiding the location and design of new development." The Central North subwatershed was identified as a priority subbasin suitable for development. The Whatcom County Council approved the *Birch Bay Comprehensive Stormwater Plan* in 2006. The plan recommends the creation of a stormwater management area and funding strategy. Acting on this recommendation, the Whatcom County Flood Control Zone District Board of Supervisors approved the creation of the BBWARM District as a subzone of the countywide flood control zone district in 2007.

REPORT ORGANIZATION

The *Birch Bay Central North Subwatershed Master Plan* is generally organized in two parts. The subwatershed characterization in Chapters 2 through 5 describes the physical characteristics of the subwatershed, presents a storm drain inventory, and identifies drainage problems. Chapters 6 through 8 describe the development and implementation of the stormwater master plan. The content of individual chapters is as follows:

- Chapter 2 describes physical characteristics of the subbasins that make up the study area. Field data collection for the stormwater inventory and the surface water drainage system are also described in this chapter.
- Chapter 3 describes a planning level hydrologic and hydraulic analysis. Continuous simulation modeling was used to develop stormwater runoff hydrographs and estimate peak flow rates for the five subbasins in the Central North subwatershed. Hydraulic analysis was used to identify drainage problems and estimate conveyance capacity of the storm drain system.
- Chapter 4 describes identified drainage problems. Interviews with Whatcom County staff, public meetings, published reports, field data collection, and the planning level hydraulic analysis were used to assemble a database of drainage problems.
- Chapter 5 presents a variety of low-impact development best management practices for reducing stormwater runoff and identifies techniques suitable for the Central North subwatershed.

- Chapter 6 documents problem resolutions and identifies projects to solve stormwater problems, including special studies, operation and maintenance, and small works projects.
- Chapter 7 presents a prioritized plan for implementation stormwater capital projects.

ACKNOWLEDGMENTS

The *Birch Bay Central North Subwatershed Master Plan* was developed with the participation of the BBWARM Advisory Committee:

- Position A - Scott Hulse (Point Whitehorn)
- Position B - Keats Garmen, Vice-Chair (Birch Point)
- Position C - Scott Inloes, Chair (Rate Payer Representative, British Petroleum)
- Position D - Peter Winterfield (Birch Bay Village)
- Position E - LeRoy Smith (Birch Bay Leisure Park).

The Advisory Committee represents the Birch Bay community to ensure that the community's interests are represented in setting strategic goals and work plans.

CHAPTER 2.
SUBBASIN CHARACTERISTICS

SUBBASINS

The *Birch Bay Watershed Characterization and Watershed Planning Pilot Study* (ESA Adolfson, 2007) subdivided the Central North subwatershed into six subbasins; five are covered in this master plan:

- The Shintaffer subbasin is 294 acres on the west side of the Central North subwatershed. The subbasin is west of Shintaffer Road except for a moderately sized area immediately south of Lincoln Road. The Shintaffer subbasin is bisected by Lincoln Road. Land use in the subbasin is primarily agricultural north of Richmond Park and residential to the south. Semiahmoo Highlands in the City of Blaine is in the northwest corner. A golf course is located adjacent to Semiahmoo Highlands.
- The Cottonwood Beach North subbasin covers 157 acres east of the Shintaffer subbasin, between Shintaffer Road and Beachway Drive south of Lincoln Road. Land use in the subbasin is primarily agricultural north of Anderson Road and commercial, residential and resort/condo to the south. Halverson Park, a Whatcom County park, is in the eastern part of the subbasin. The primary drainage pathway for this basin is thorough this park.
- The Cottonwood Beach South subbasin covers 107 acres east of the Cottonwood Beach North subbasin. This subbasin is west of Harborview Drive and is bisected by Anderson Road. Land use in the subbasin is primarily agricultural, with a small commercial, residential and resort/condo area near Birch Bay Drive.
- The Hillsdale subbasin covers 412 acres east of the Cottonwood Beach South subbasin. A large portion of this subbasin east of Harborview Drive around Anderson Road is rural. A smaller, residential area is located west of Harborview Drive and east of Birch Bay Drive. Another residential area is at the north end of the subbasin.
- The Hillsdale North subbasin is 70 acres on the east side of the Central North subwatershed. This subbasin is tributary to the Hillsdale subbasin and is mostly rural and undeveloped.

The subbasins were redrawn for this master plan based on the surface water system and topography, as shown in Figure 1-1.

CLIMATE

Birch Bay experiences a mild marine with cool, dry summers and mild, wet winters. Average monthly temperature ranges from about 37ºF in January to 62ºF in August. However, extreme temperatures can occur, with temperatures below freezing an average of about 70 days per year. Temperature rarely gets above 90ºF (WRCC, 2011). The Birch Bay area receives an average of about 35 inches of rain annually. Some precipitation occurs as snow, with about 14 inches in an average year. Figure 2-1 shows the average monthly rainfall measured at the Birch Bay Water and Sewer District (BBWSD) near Birch Bay State Park. Typically, winter rainfall occurs as long-duration, low-intensity events over a day or more.

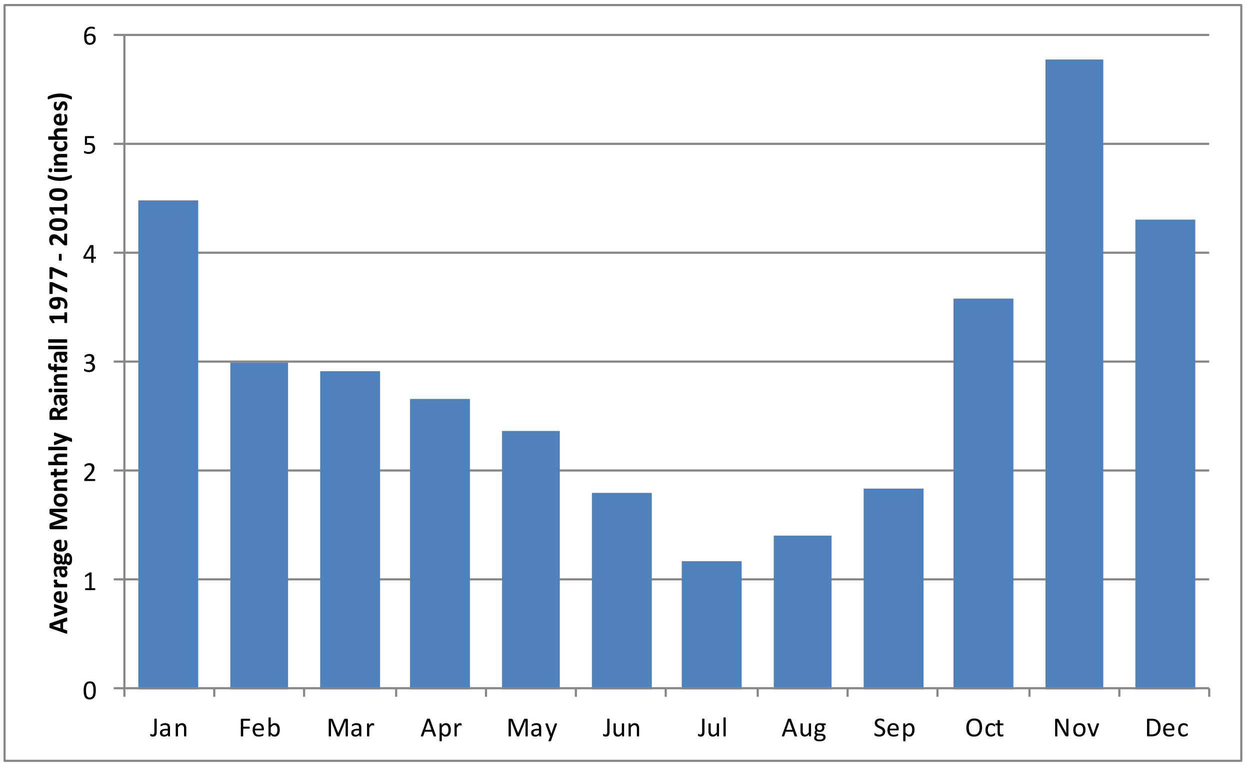

Figure 2-1. Average Monthly Rainfall—Birch Bay (BBWSD, 2011)

TOPOGRAPHY

The Central North subwatershed is a wide, narrow basin about 2.9 miles east to west and 0.75 miles north to south. The subwatershed divide is defined by a low ridge roughly located along a line from the intersection of Snow Goose Lane and Wood Duck Lane to Birch Bay-Lynden Road near West 42nd Place. Surface runoff flows south to Birch Bay through four distinct drainages. Topography is generally flat in the upland, agricultural portion of the subwatershed, with elevation ranging from about 45 to 55 feet NAVD88 (North American Vertical Datum of 1988). The exception is the far western edge of the subwatershed, where the land surface rises to about 180 feet NAVD88. The land surface rapidly drops off to sea level near Birch Bay in the more urbanized area of the subwatershed.

GEOLOGY AND SOILS

Geologic conditions of the Central North subwatershed are primarily the result of continental glaciation and intervening non-glacial periods. Glacial-marine drift deposits (Bellingham Drift) of compressed fine-grained material overlay a submerged marine terrace established 11,300 to 13,000 years ago (ESA Adolfson, 2007). Surficial soils are primarily till, with pockets of outwash. Till soils are densely packed soils deposited and consolidated by glacial activity over 10,000 years ago. They have low permeability and a high potential for surface runoff. Outwash soils are loosely consolidated sand and gravel soil deposits with high permeability and low potential for runoff. Outwash soils are limited to a small area in the northwest part of the basin and along the beach near Birch Bay. The Natural Resources Conservation Service (NRCS) Soil Survey classifies the soils according to Hydrologic Soil Types A through D:

- Type A and B soils are generally outwash soils made of sand and gravel. They are deep, well-drained soils with low runoff potential. Type A and B soils cover about 8 percent of the subwatershed.

- Type C soils are till soils made of fine-textured silts with shallow depths, low permeability, and high runoff potential. Type C soils cover about 27 percent of the subwatershed.
- Type D soils are wetland soils made of saturated silts and clays with a high water table. They are very shallow and have a confining clay or hardpan layer near the surface. Type D soils cover about 65 percent of the subwatershed.

Figure 2-2 shows the distribution of these types in the subwatershed. The *Whatcom County Critical Areas Best Available Science* update (Parametrix, et.al. 2005) has identified a surficial aquifer in the Central North subwatershed, which is also shown on Figure 2-2. This aquifer has been identified as having a high susceptibility to contamination.

SURFACE WATER FEATURES

Surface water runoff in all subbasins in the Central North subwatershed generally starts in the flat, upland area in an extensive network of wetlands. Wetland areas are drained through field ditches that convey water to a network of roadside ditches that empty into natural drainageways. The natural drainageways connect to piped outfalls discharging to Birch Bay. Surface water features are shown on Figure 2-3.

Shintaffer Subbasin

Surface water in the Shintaffer subbasin flows south to Birch Bay from headwaters at the Semiahmoo Highlands. Drainage from the Semiahmoo Highlands discharges to a wetland area east of Shintaffer Road and north of Lincoln Road. A network of field ditches drains the wetland area to roadside ditches along the north side of Lincoln Road and the west side of Shintaffer Road. The main conveyance pathway continues south along Shintaffer Road where it becomes a storm drain pipeline at Richmond Park Road. This 24-inch concrete pipe conveys flow through the Richmond Park subdivision and outfalls to a steep ravine. Ultimately, stormwater is discharged to Birch Bay through an ungated outfall near Deer Trail.

A system of ditches, culverts and storm drains collects runoff from the area east of Shintaffer Road and conveys it to a pipeline south of Anderson Road. This pipeline discharges to Birch Bay through an ungated outfall at Shintaffer Road. Local storm drains collect runoff from along Birch Bay at two locations. One system discharges to Birch Bay west of Deer Trail and the other discharges to Birch Bay west of Shintaffer Road.

Cottonwood Beach North Subbasin

The headwaters of the Cottonwood Beach North subbasin originate in a large pasture/forested wetland area east of Shintaffer Road between Lincoln and Anderson Roads. This wetland is drained through a network of field ditches that outfall to the Cottonwood Beach North drainage system at Anderson Road, midway between Beachway Drive and Cedar Avenue. From Anderson Road, flow is conveyed in a natural channel through Halverson Park and then under Alder Street through a concrete culvert to another open channel where it enters a 30-inch pipeline just north of Fern Street. The pipeline flows south under Cedar Avenue to an outfall in Birch Bay.

Runoff from Seaview Drive, Hazel Lane, and Maple Crest Avenue is collected at the southeast intersection of Seaview Drive and Maple Crest Avenue. Stormwater is conveyed from this point through a stormwater treatment swale that drains into the 30-inch diameter pipeline at Cedar Avenue. Properties immediately adjacent to Birch Bay Drive enter roadside system that outlets into Birch Bay.

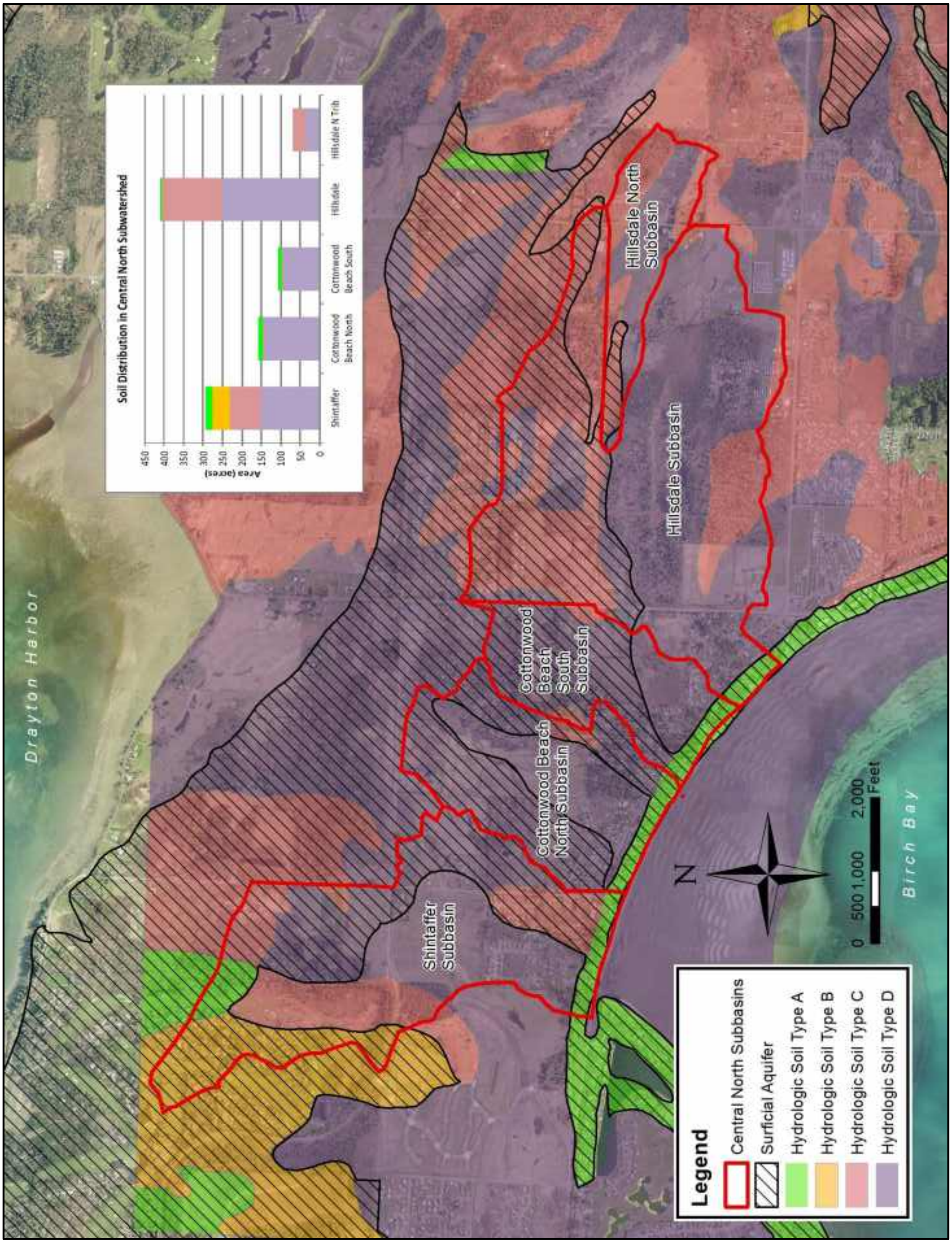

Figure 2-2. Hydrologic Soil Types in the Central North Subwatershed

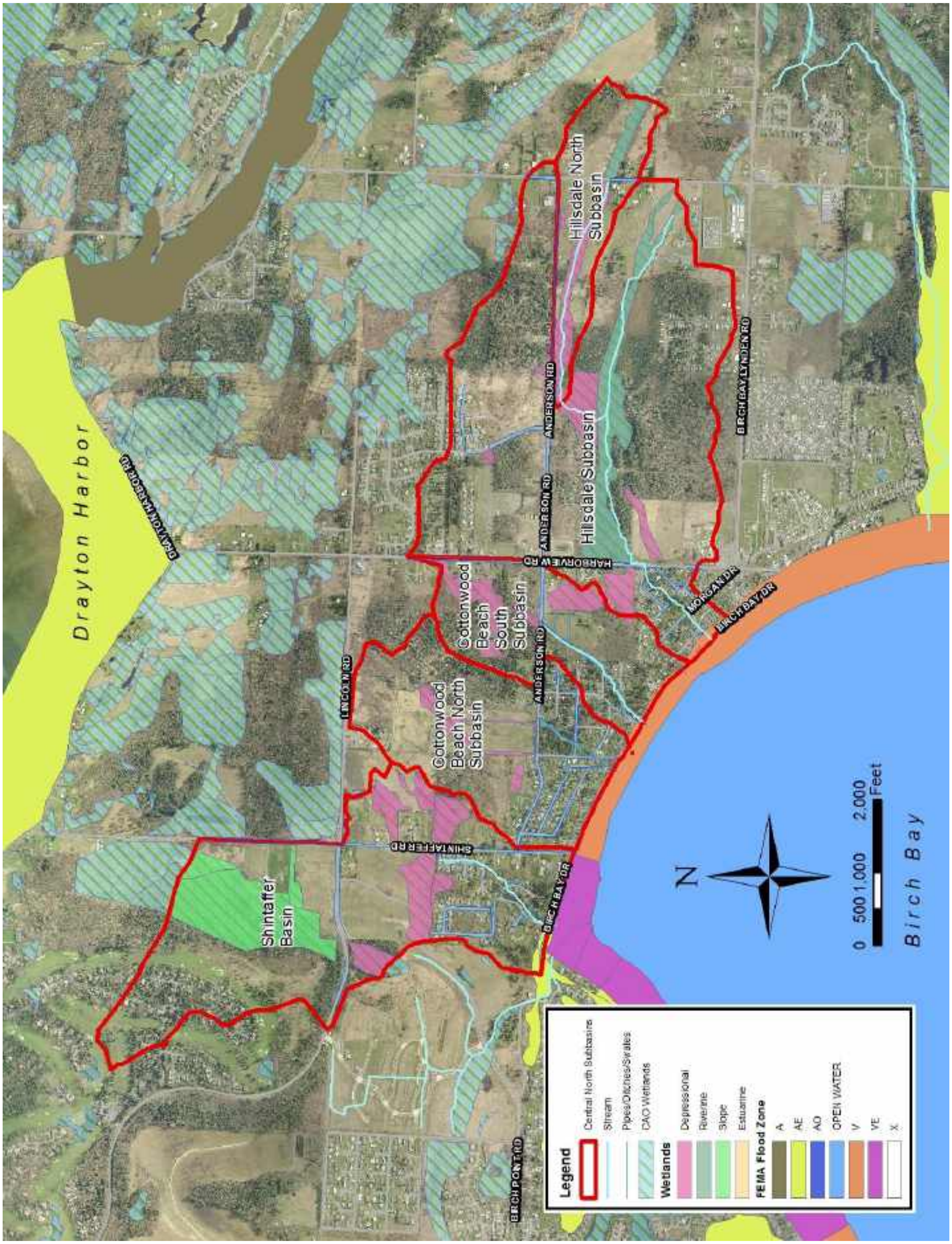

Figure 2-3. Surface Water Features in the Central North Subwatershed

Cottonwood Beach South Subbasin

Drainage from the Cottonwood Beach South subbasin flows south to Birch Bay from headwaters south of Lincoln Road. The headwaters originate in a large pasture/forested wetland west of Harborview Road and north of Anderson Road. This wetland is drained through a network of field ditches and roadside ditches that cross Anderson Road and discharge to a swale that conveys flow southwest through a forested wetland and connects to the Cottonwood Beach South drainage system at Cedar Street. At this point, flow enters a short stretch of 18-inch diameter pipe that outfalls to a natural channel downstream of Cedar Street. Flow is in the natural channel southwest to Maple Street. There, it enters a ditch-and-culvert system. The ditch-and-culvert system connects to an 18-inch pipeline that outfalls to Birch Bay at Beachway Drive. During high flow, stormwater discharges to the Cottonwood Beach North subbasin along the north side of Anderson Road.

Hillsdale Subbasin

Drainage from the Hillsdale subbasin flows southwest to Birch Bay from headwaters east of Harborview Drive. The headwaters consist primarily of relatively flat forested, shrub and pasture areas but contain a small residential area on the northern edge. The headwaters are drained by a forested swale and roadside ditch network that enters the main Hillsdale drainage system at Harborview Road near Forsberg Road through dual 24-inch-diameter culverts under Harborview Road. Surface water is conveyed through a natural open channel from Harborview Road to Cottonwood Drive near Cottonwood Court, where it enters a 30-inch-diameter pipeline. Stormwater runoff from the residential area between Harborview Drive and Morgan Street is conveyed to the main Hillsdale channel though a roadside ditch-and-culvert system. Runoff from the residential area between Morgan Drive and Birch Bay Drive is conveyed to the 30-inch pipeline through a series of direct pipe connections instead of through drainage structures (e.g. catch basins or manholes). The pipeline discharges to Birch Bay at the end of Cottonwood Drive through a nearshore outfall. During high flows, stormwater also discharges out of the Hillsdale subbasin in the roadside ditch on the east side of Harborview Road. A second outfall, east of Cottonwood Drive, discharges stormwater runoff from residences along Birch Bay Drive and the roadway.

Hillsdale North Subbasin

Drainage from the Hillsdale North subbasin flows west to the Hillsdale subbasin. This subbasin straddles Birch Bay Lynden Road (SR 548) south of Anderson Road. It consists almost entirely of agricultural lands with extensive wetlands. The Hillsdale North subbasin forms part of the headwaters of the Hillsdale subbasin and discharges to the Hillsdale subbasin south of Anderson Road near Glendale Drive.

FEMA FLOOD ZONE

Flood hazard mapping by the Federal Emergency Management Agency (FEMA) has identified the coastal areas of the Central North subwatershed as a Flood Zone Type V and Type VE. These flood zone types include areas within the 100-year flood zone with velocity hazards (tidal action), but no base flood elevation has been established. Whatcom County regulates frequently flooded areas as critical areas under its Critical Areas Ordinance (Whatcom County Code 16.16).

WETLANDS

Wetlands are areas inundated or saturated at a frequency and duration sufficient to support typical wetland vegetation. They are defined by the presence of wetland vegetation, standing water and hydric soils. Wetlands are common in Bellingham Drift deposits due to the imperviousness of soils of this type. Significant wetlands are located in upland areas throughout the Central North subwatershed (see Figure 2-3) due to the flat topography and relatively impervious surface soils.

The wetland locations on Figure 2-3 were generated based on information from County sources, using approximate methods; they may not represent actual wetland areas in the subwatershed. Given the extensive distribution of hydric soils in the subwatershed and observations of standing water, it is likely that Figure 2-3 under-represents the true extent of wetlands in the subwatershed.

Whatcom County regulates wetlands through its Critical Areas Ordinance, which requires protection of wetland areas and their buffers depending on classification. Whatcom County has categorized wetlands in the Central North subwatershed as the following types (ESA Adolfson, 2007):

- Depressional wetlands are formed in low areas where surface water from higher elevations pools through overland flow, precipitation or groundwater discharge.
- Riverine wetlands are in stream corridors and are saturated primarily during flood events.
- Slope wetlands are on sloping land where groundwater or interflow discharges to the surface.
- Estuarine wetlands are near the ocean where low-lying areas are inundated by tidal action.

Table 2-1 summarizes wetland coverage in the Central North subwatershed. Wetlands cover about 17 percent of the subwatershed. The most extensive coverage is in the Shintaffer and Hillsdale North subbasins, where wetlands cover nearly 24 percent of the subbasin area. Nearly half of all wetland area in the Central North subwatershed is in the Shintaffer subbasin. Cottonwood Beach North subbasin has the least amount of wetland area, at about 5 percent. Wetlands cover 14 to 17 percent of the area in the Cottonwood Beach South and Hillsdale subbasins.

TABLE 2-1.
WETLANDS IN THE CENTRAL NORTH SUBWATERSHED

	Wetland Area (acres)					
Wetland Type	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin	**Total**
Depressional	27.4	7.0	14.9	18.2	12.1	**79.6**
Riverine	0.0	1.1	3.0	30.7	4.2	**39.0**
Slope	42.3	0.0	0.0	0.0	0.0	**42.3**
Estuarine	0.4	0.0	0.0	0.0	0.0	**0.4**
Total Wetland Area	**70.1**	**8.1**	**17.9**	**48.9**	**16.2**	**161.3**
Percent of Subbasin Area	24%	5%	17%	14%	23%	**17%**

LAND USE

Prior to European settlement, the Birch Bay watershed was covered with a mixture of coniferous and deciduous forest. The watershed was logged in the early 1900s, followed by development as a resort community near the bay and agricultural uses in the upland areas (ESA Adolfson, 2007). A large portion of the Central North subwatershed is in unincorporated Whatcom County, so regulation of development primarily falls under County jurisdiction. A small area on the western edge of the subwatershed north of Lincoln Road falls within the municipal boundary of the City of Blaine. South of Lincoln Road, the subwatershed is in the Birch Bay urban growth area; the area north of Lincoln Road is in the City of Blaine urban growth area. Urban growth boundaries are shown in Figures 2-4 and 2-5.

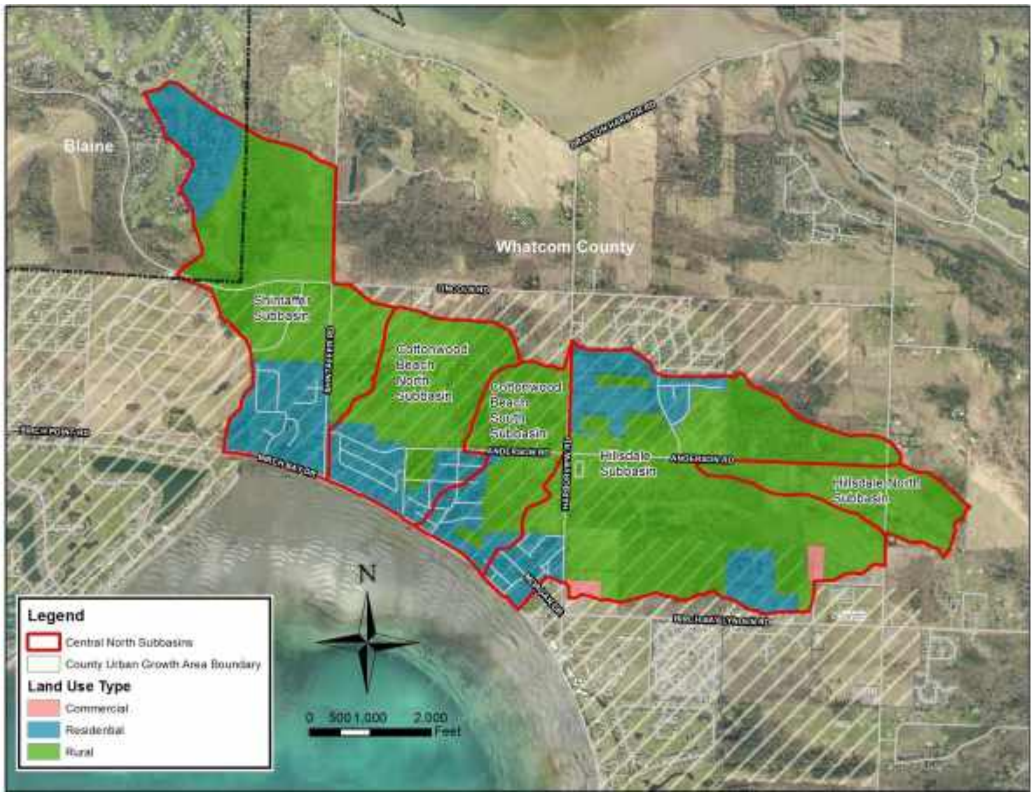

Figure 2-4. Current Land Use (October 2011) in the Central North Subwatershed

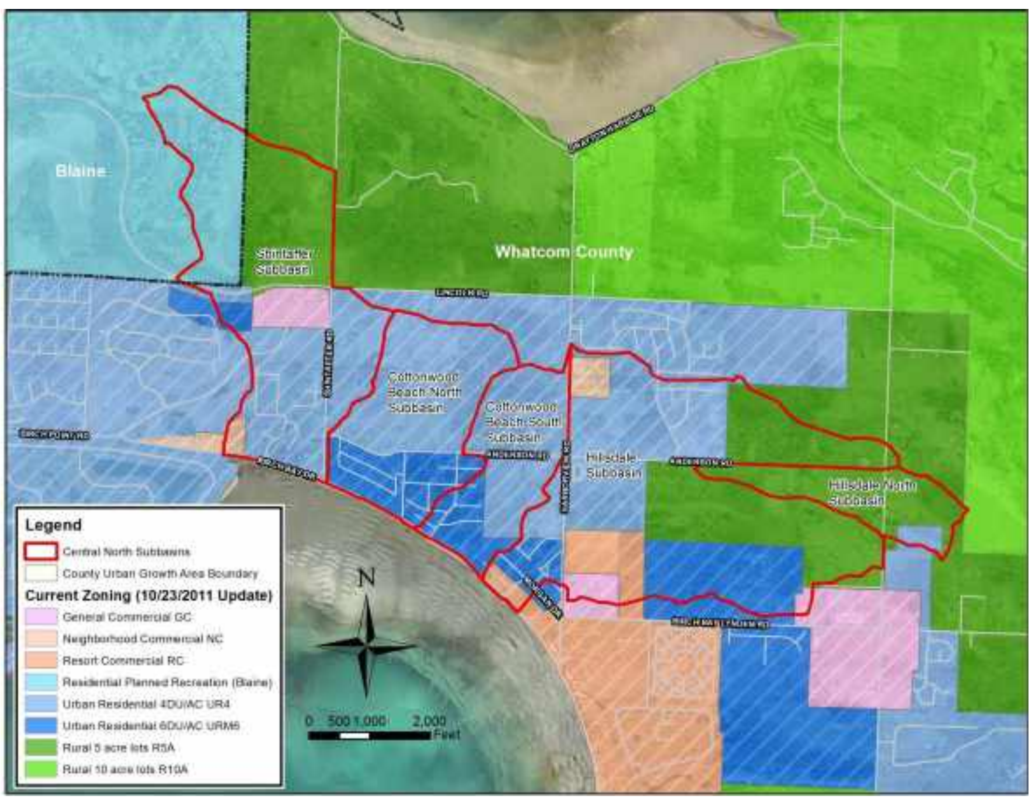

Figure 2-5. Zoning (Future Land Use) in the Central North Subwatershed

Current land use (2011) in the Central North subwatershed is primarily high- and medium-density residential (including mobile homes sites) near Birch Bay, with some commercial land uses such as hotels, shops and restaurants. Residential areas are also located in the area east of Harborview Drive north of Anderson Road. Current land use is shown in Figure 2-4 and listed in Table 2-2.

TABLE 2-2.
CURRENT AND FUTURE LAND USE IN THE CENTRAL NORTH SUBWATERSHED

Land Use Type	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin	**Total Land Use Type**	Percent of Total
Subbasin Area	294.0	157.1	106.7	411.8	70.0	**1039.8**	
Current Land Use Area (acres, 2011)							
Residential	101.3	49.8	27.6	86.2	0.0	**264.9**	25.5%
Commercial	0.0	0.0	0.0	5.2	0.0	**5.2**	0.5%
Rural	192.7	107.3	79.2	320.4	70.0	**769.6**	74.0%
Future Land Use Area (acres, Full Buildout[a])							
Residential	193.0	157.1	106.7	211.3	5.9	**674.1**	64.8%
Commercial	22.8	0.0	0.1	54.0	0.0	**77.0**	7.4%
Rural	78.2	0.0	0.0	146.4	64.1	**288.7**	27.8%

a. Full buildout based on 10/23/2011 update to the zoning plan.

Land use zoning guides future development and can be used as a predictor of how land use will change as the subwatershed becomes more fully developed. The Whatcom County Comprehensive Plan applies six zoning designations in the Central North subwatershed:

- GC—General Commercial
- NC—Neighborhood Commercial
- R5A—Rural 1 Dwelling unit/5 acres
- RC—Resort Commercial
- UR4—Urban Residential 4/acres
- URM6—Urban Residential 6/acre

Current zoning (October 23, 2011 update) in the Central North subwatershed allows for an expansion of the medium and higher density residential area as far north as Lincoln Road except for the eastern half of the Hillsdale subbasin and all of the Hillsdale North subbasin, which will remain at rural development densities. Current zoning will also allow the development of a new commercial area at Lincoln Road west of Shintaffer Road. Zoning is shown in Figure 2-5.

Roadways, parking lots sidewalks, rooftops and other hard surfaces that prevent rainfall from infiltrating into the ground are called impervious surfaces. The effects of impervious surface on stormwater runoff and water quality are well known. Increased impervious cover, if uncontrolled or untreated, affects receiving water bodies by increasing and extending the duration of peak flows and increasing the rate of pollutants washing off the landscape.

Existing impervious area was computed based on the delineation compiled for the watershed characterization study (ESA Adolfson, 2007). Impervious area for future conditions was estimated using representative impervious fractions typical for the type of zoning found in the Central North subwatershed. Increased impervious area is mitigated by the presence of wetlands over large portions of the undeveloped areas, due to protections granted by the Whatcom County Critical Areas Ordinance. The Critical Areas Ordinance also requires buffer protection around regulated wetlands.

Impervious area is summarized in Table 2-3. Impervious area under current land use conditions is relatively consistent across the watershed, ranging from 10 to 14 percent for most subbasins. The exception is the Hillsdale North subbasin where impervious area is about 4 percent of the total area due to the primarily rural land use in this subbasin. Under future land use conditions, the impervious area is expected to double for the four largest subbasins, with the largest increase in the Cottonwood Beach North subbasin. Impervious area in the Hillsdale North subbasin is expected to remain at current levels because land use will not change under current zoning.

**TABLE 2-3.
ESTIMATED IMPERVIOUS AREA (ACRES)**

	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin	**Total Subbasin Area**
Total Area	294.0	157.1	106.8	411.8	70.0	**1039.8**
Impervious Area (acres)						
Current Land Use	29.0	19.7	14.9	52.3	3.0	**118.9**
Future Land Use	61.5	52.3	30.3	98.9	3.0	**246.0**
Impervious Fraction (percent)						
Existing Land Use	10%	13%	14%	13%	4%	**11%**
Future Land Use	21%	33%	28%	24%	4%	**24%**

WATER QUALITY

In 2003, the Washington Department of Health identified Birch Bay as a "threatened" shellfish growing area. Additional investigations identified further degradation to water quality in the bay, which led to restrictions on shellfish harvesting (Whatcom County, 2010). In response to these findings, Whatcom County initiated the Birch Bay/Terrell Creek Water Quality Monitoring Project. As part of this project, the County, the Whatcom County Marine Resources Committee, and the Nooksack Salmon Enhancement Association are monitoring fecal coliform at over 30 locations in the Birch Bay watershed; five of these locations are in the Central North subwatershed:

- Deer Trail (BB11)
- Shintaffer Road (BB12)
- Cedar Street (BB8)
- Beachway Drive (BB7)
- Cottonwood Drive (BB60).

Birch Bay watershed standards for water quality are exceeded at all five locations except Shintaffer Road. The monitoring project identifies priority areas for water quality improvement activities.

STORMWATER SYSTEM INVENTORY

The storm drain system in the Central North subwatershed was inventoried by Whatcom County survey crews in the summer and fall of 2011. Survey crews located drainage features in the field using GPS units and collected information on pipe diameter, material, invert, and flow direction for all public storm drain facilities including catch basins, manholes, storm drain pipes, driveway culverts, roadway culverts and roadside ditches. Survey data was compiled in a geodatabase. Manual and automated routines were applied to the geodatabase to connect the drainage features and create a drainage network. The storm drainage system inventory developed for this project is shown in Appendix A. Tables 2-4 and 2-5 summarize the drainage structure, ditch and pipe data.

TABLE 2-4.
DRAINAGE STRUCTURES

	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin	**Total**
Catch Basins	22	27	9	47	—	**105**
Manholes	3	0	0	0	—	**3**
Break Points	0	6	0	0	—	**6**
Tees	0	0	0	2	—	**2**
Outfalls	4	4	2	2	—	**12**
Total	**29**	**37**	**11**	**51**	**—**	**128**

TABLE 2-5.
DITCH, PIPE AND CULVERT INVENTORY

	Ditch or Pipe Length (feet)					
Conveyance Type	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin	**Total**
Ditch	13,520	6,430	5,370	15,070	3,100	**40,440**
Culvert Pipe						
8” dia. and smaller	—	30	—	20	—	**50**
10”-12” diameter	2,730	4,420	690	2,210	250	**10,060**
15” - 18” diameter	120	240	620	500	30	**1,480**
24” dia. and larger	850	90	—	200	—	**1,150**
Storm Drain Pipe						
8” dia. and smaller	—	760	20	310	—	**1,090**
10”-12” diameter	1,700	2,390	400	3,040	—	**7,54**
15” - 18” diameter	760	540	240	510	—	**2,050**
24” dia. and larger	690	580	160	450	—	**1,890**
Total Pipe Length	**6,850**	**9,000**	**2,140**	**7,240**	**280**	**25,310**

There are almost 130 drainage structures in the Central North subwatershed. Drainage structures include catch basins, manholes, break points, tees, and outfalls to Birch Bay. A break point is a change in pipe alignment in the absence of a connecting structure. Break points and tee connections were not located during the field survey; these structures were approximately located based on assumed field position.

The Hillsdale subbasin contains the largest number of structures, followed by the Cottonwood Beach North subbasin, the Shintaffer subbasin and the Cottonwood South subbasin. No drainage structures were identified in the Hillsdale North subbasin. There are 12 stormwater outfalls discharging to Birch Bay. Six of these outfalls convey stormwater from large storm drain systems; the other six drain small, local areas along Birch Bay Drive and adjacent residential areas.

There are 7.6 miles of ditch in the Central North subwatershed and 4.8 miles of pipeline more than 10 inches in diameter (culvert and storm drain). Culvert and storm drain pipe ranges from 4-inch-diameter yard drains to 36-inch-diameter pipe conveying the main flow through a subbasin, either in trunk pipe systems or roadway culverts. Almost 75 percent of the pipe is between 10 and 12 inches in diameter. Pipes are of several material types: 42 percent thermoplastic (high-density polyethylene or polyvinyl chloride), 47 percent concrete, 10 percent corrugated metal pipe (CMP), and 1 percent ductile iron. Generally, newer pipes are thermoplastic and older ones are concrete or CMP. CMP has a relatively short design life of about 30 years before it starts to rust, usually in the flow line of the pipe. CMP is also susceptible to getting bent and crushed. Thermoplastic pipe may be susceptible to crushing if installed incorrectly.

A cursory condition assessment performed during the drainage inventory found about 30 pipe ends broken or crushed. The condition assessment also found several locations where connection structures (catch basins or manholes) were absent or had inadequate surface access. Additionally, about 28 culverts were found to be blocked with sediment. Missing or inadequate structures and damaged pipe ends are documented in Chapter 4, along with structures blocked by sediment.

CHAPTER 3.
HYDROLOGIC AND HYDRAULIC ANALYSIS

This chapter describes hydrologic and hydraulic modeling of the Central North subwatershed to help quantify existing and future surface water conditions. The modeling was used to identify flooding-related problems and will also be used to evaluate potential solutions. The goals and objectives of the hydrologic and hydraulic modeling are as follows:

- Develop an understanding of the hydrologic regime in the Central North subwatershed.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems.
- Analyze the effects of increased impervious area associated with future development.
- Provide a tool to evaluate flow reduction potential of various low-impact development scenarios.

In general, hydrologic models are used to determine the amount of stormwater runoff that will be generated from a drainage basin during a storm event or a series of storm events. The flow data generated by the hydrologic model are then input into a hydraulic model, which evaluates how the flow is routed through a conveyance system, such as a roadside ditch-and-culvert system, a stream channel or an enclosed storm drain system.

The storm drainage system was analyzed using the HSPF model (U.S. EPA, 2005) and the SWMM5 model (U.S. EPA, 2011). HSPF was used to simulate runoff from each subbasin. SWMM5 was used to analyze the hydraulics of natural and constructed surface water drainage systems in the Central North subwatershed. Models were developed for the Shintaffer subbasin, the Cottonwood Beach North subbasin, the Cottonwood Beach South subbasin, and the combined Hillsdale and Hillsdale North subbasins. Model development is documented in Appendix B.

HYDROLOGIC ANALYSIS

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine long-term runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration and ground infiltration. Routing of runoff from discrete subbasins is modeled with rating tables that represent pipes, channels, lakes, and other flood storage areas. Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to the stream channel at a slower rate than direct runoff. Groundwater discharges to the stream channel where the stream intersects the saturated zone, contributing to long-term base flow in the system. Infiltrated flow can leave the surface watershed by entering deep groundwater.

Stream flow characteristics were computed for existing and future land use conditions in the Central North subwatershed. Stormwater controls were applied to the future-condition model using an assumed regional detention facility sized to represent all detention for each subcatchment where development was assumed to occur.

Flood Frequency

Flood frequency is the probability that a given peak flood event will occur in any year. Flood frequency is commonly expressed as a return-period, which is the inverse of the probability, and represents the average interval between occurrences of a flood of a specified magnitude. For instance, a peak flood with a 50-percent probability of occurring in any given year is equivalent to a 2-year return period (1/0.5 = 2). Flood frequencies for the primary stormwater conveyance for each subbasin outfall to Birch Bay are shown in Table 3-1. The hydrologic analysis showed that most peak flood frequencies will be slightly lower under future land use conditions than under existing conditions, assuming that stormwater detention is built with new development.

**TABLE 3-1.
PEAK FLOOD FREQUENCY IN CENTRAL NORTH SUBWATERSHED**

	Shintaffer Subbasin		Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale/ Hillsdale North Subbasins
	Birch Bay Dr. and Deer Trail Reach SH02[a]	Birch Bay Dr. & Shintaffer Rd. Reach SH06[a]	Birch Bay Drive at Cedar Ave. Reach CN06[a]	Birch Bay Drive at Beachway Dr. Reach CS02[a]	Birch Bay Drive at Cottonwood Dr. Reach HL02[a]
2-Year Peak Flow					
Existing (cfs)	13	2.1	11	6.6	25.3
Future (cfs)	13.4	2.2	10.2	6.2	24.5
Difference (%)	3%	4%	-7%	-5%	-3%
10-Year Peak Flow					
Existing (cfs)	21.4	4.4	25.3	13.5	47.6
Future (cfs)	21.3	4.2	22.7	11.8	45
Difference (%)	-1%	-5%	-10%	-13%	-6%
25-Year Peak Flow					
Existing (cfs)	25.2	5.6	34.4	17.6	58.8
Future (cfs)	24.8	5.3	31	15	55.5
Difference (%)	-2%	-6%	-10%	-15%	-6%
50-Year Peak Flow					
Existing (cfs)	27.9	6.6	42.1	20.8	66.9
Future (cfs)	27.3	6.3	38.1	17.6	63.3
Difference (%)	-2%	-6%	-10%	-16%	-5%
100-Year Peak Flow					
Existing (cfs)	30.4	7.7	50.5	24.2	74.9
Future (cfs)	29.7	7.3	46.1	20.2	71.1
Difference (%)	-2%	-5%	-9%	-16%	-5%

cfs = cubic feet per second

a. See Figure B-1 and Table 2 in Appendix B, Hydrologic and Hydraulic Analysis for reach location.

Flow Duration

Flow duration is the amount of time (generally expressed as a percent of total) for which a given flow is equaled or exceeded. Flow duration analysis provides information on basin hydrology during non-flood events. For example, extended periods of high flow can contribute to stream bank erosion and excessive sediment transport. Conversely, low flow periods can impede fish passage. Table 3-2 shows the flow duration for the 2-year peak flow event at four natural channel locations in the Central North subwatershed. The analysis shows that the duration of high flows will be reduced under future land-use conditions, assuming that stormwater detention is constructed with new development.

TABLE 3-2.
CENTRAL NORTH SUBWATERSHED FLOW DURATION FOR 2-YEAR PEAK FLOW

Subbasin	Location	Model Reach[a]	Ex. Condition 2-Year Peak Flow Rate (cfs)	Flow Duration (days/year)		
				Existing	Future	Change
Shintaffer	Channel downstream of Fern Crescent	SH10	10.0	15.0	15.8	0.8
Cottonwood Beach North	Channel downstream of Anderson Road	CN07	6.4	11.6	9.7	-1.9
Cottonwood Beach South	Channel downstream of Cedar Street	CS03	4.0	14.1	9.3	-4.8
Hillsdale/Hillsdale North	Channel downstream of Harborview Road	HL12	22.8	3.4	3.0	-0.3

cfs = cubic feet per second

a. See Figure B-1 and Table 2 in Appendix B, Hydrologic and Hydraulic Analysis for reach location.

HYDRAULIC ANALYSIS

The variety of elements in the Central North subwatershed storm drainage system (drain pipes, catch basins, roadside culverts and ditches, natural channels and flood storage areas) requires a sophisticated hydraulic model. The SWMM5 model is capable of representing the diverse character and hydraulic features of the drainage system, as well as tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as detention facilities. The model is well suited to estimate flow and depth in the Central North storm drainage system.

A SWMM5 model was developed for the Shintaffer, Cottonwood Beach North, Cottonwood Beach South and Hillsdale/Hillsdale North subbasins. Modeled runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. SWMM5 models the routing of this runoff through a system of pipes, channels, storage and outfalls, tracking the flow of water in each pipe and channel. Birch Bay tidal data from the Cherry Point Station, adjusted for local conditions, were used as the downstream boundary at the pipe outfalls.

System Performance

Design analysis was performed using the SWMM5 models to identify locations where flooding is predicted under existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the assumed overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause of flooding. The analysis showed that flooding is predicted at 19 locations in the Central North subwatershed. Only six flood problem areas had been identified in the past as areas where flooding occurred. Flood problem areas are described in Chapter 4.

The hydraulic analysis showed that the storm drain system in the Central North subwatershed has adequate capacity throughout the basin to convey the 25-year event. However, there are several conveyance systems with significant restrictions. Most notably, flooding was predicted along the entire length of Birch Bay Drive.

Other notable flood locations include the following:

- Richmond Park and Shintaffer Road (Shintaffer subbasin)
- Open pipe connection near Seaview and Maple Crest Avenues (Cottonwood Beach North subbasin)
- Harborview Road near Anderson Road (Cottonwood Beach South subbasin)
- Harborview Road at Anderson Road and north (Hillsdale subbasin)
- Cottonwood Drive (Hillsdale subbasin).

Deep ravines that are the primary drainageways in each subbasin provide limited peak-flow attenuation. Generally, flood problems are not expected to increase with future development if current development standards for large developments are followed. The exception is Alder Street in the Cottonwood Beach North subbasin, where flooding is expected during the future-condition 100-year event.

During peak events, storm runoff overflows from the Cottonwood Beach South subbasin to the Cottonwood Beach North subbasin on the north side of Anderson Road. However, the overflow rate is relatively small. Flow diversion occurs more regularly in the Hillsdale subbasin, where stormwater flows out of the basin on the east side of Harborview Road near Henley Street. Internal diversion occurs extensively in the Hillsdale/Hillsdale North subbasin between Anderson Park, Anderson Road, and Harborview Road.

The model predicts high ponding at Shintaffer Road and Harborview Road. Ponding in this area may be an indication of flow out of the Birch Bay watershed and into the Drayton Harbor watershed. However, runoff from the Drayton Harbor watershed was not included in the model. It is possible that runoff from the Drayton Harbor basin fills the very flat channel in this area and prevents any significant overflow from the Birch Bay basin. Additional data collection and analysis may be needed to reduce uncertainty in the flow simulation for this area.

Output from the hydraulic models was reviewed to evaluate the conveyance capacity of the primary conveyance route for each subbasin. Many of the problem areas identified in Chapter 4 are due to capacity restrictions in the conveyance system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Table 3-3 summarizes the capacity analysis for the Central North subwatershed. This table shows that the 25-year peak flow event exceeds the system conveyance capacity at the Cottonwood Beach North, Cottonwood Beach South, and Hillsdale subbasins. System capacity is exceeded for all events for the 100-year peak flow events.

TABLE 3-3.
SYSTEM CAPACITY

Subbasin	Location	Pipe Size	Predicted Peak Flow (cfs) 25-Year	Predicted Peak Flow (cfs) 100-Year	Estimated Capacity (cfs)
Shintaffer	Deer Trail Road	24”	26.7	31.1	27
Shintaffer	Shintaffer Road	12”	4.4	9.0	9
Cottonwood Beach North	Twin pipes west of Cedar Ave.	24”, 18”	30.6	34.3	20
Cottonwood Beach South	Beachway Drive	18”	19.2	20.2	9
Hillsdale/ Hillsdale North	Cottonwood Drive	30”	51.0	57.6	54

CHAPTER 4.
SURFACE WATER PROBLEMS

COMMON SURFACE WATER PROBLEMS

Drainage conditions are considered to be problems when they negatively affect existing or proposed development. Although drainage problems may be caused by natural conditions such as steep slopes or underlying hardpan, they are exacerbated by development that increases impervious area, reduces vegetative cover, changes runoff routes, accelerates runoff rates, and affects water quality.

Rate and Volume of Stormwater Runoff Flows

The amount of runoff in a watershed is directly proportional to the amount of impervious area. Impervious area is the area covered by hard surfaces such as roofs, streets and sidewalks, which prevent rainfall from infiltrating into the soil. As development increases impervious area, the amount of stormwater runoff increases. Even in built-out areas, impervious area can increase through redevelopment. Increased impervious area can also decrease groundwater recharge and base flow in streams. With a larger percentage of precipitation flowing as runoff, less is available to replenish soil moisture and groundwater storage.

Development also can affect runoff by changing its natural flow pathways. Fill for driveways or homes often eliminates natural depressions. The flow of runoff from streets and roofs is faster than from treed and vegetated areas. The construction of artificial channels, such as storm sewers or ditches, also decreases the lag time between when rain falls and when it enters the flow of a receiving stream, thus increasing the peak runoff rate in the receiving stream, scouring streambeds and destabilizing slopes.

Vegetation loss that occurs with development can have several effects on stormwater runoff. Plants and trees not only improve soil permeability, they also provide a source of precipitation storage. With vegetation loss, rain that would have been evaporated from or absorbed by trees instead falls to the ground and contributes to standing water.

Several neighborhoods in the study area may experience urban redevelopment in the future, potentially increasing the impervious area or decreasing the vegetation. Inclusion of drainage infrastructure would be beneficial in these instances.

Ponding

The following conditions can cause ponding of surface water runoff:

- Lack of drainage infrastructure
- Inadequate capacity in a drainage system
- Inadequate gradient for surface runoff to flow into the collection system
- Inadequate infiltration due to compaction from construction
- Inadequate infiltration due to low permeability or saturated soils
- Inadequate infiltration or surface ponding due to rising seasonal groundwater
- High tide blockage.

Naturally occurring ponding in an undisturbed system is beneficial because it slows the rate of runoff, thus reducing the likelihood of conveyance and erosion problems downstream. However, if ponding poses a safety concern or property damage risk (see Figure 4-1), then correction is required. Most ponding in the Central North subwatershed occurs because of high tide during storm events, lack of drainage infrastructure and low ground slopes.

Figure 4-1. Street Ponding on Birch Bay Drive near Cottonwood Court

Inadequate or Failing Drainage Structures

Drainage structures are considered inadequate when they are too small to accommodate actual stormwater flows, whether by original design or because land use changes upstream increase flows to levels beyond the system's capacity. It is not economical to design systems with capacity for every possible storm, but systems that are inadequate for a reasonable design storm must be improved by performing a hydraulic analysis of the system and designing improvements to meet local design criteria. Within the study area, many of the existing drainage structures were installed fairly recently and are of adequate size. More significant is the lack of any drainage infrastructure in several of the older neighborhoods.

Water Quality

Urban stormwater quality is highly variable, depending on factors such as land use, the level of development, the age of the developed area, and the density of construction. The quality of stormwater runoff has historically been degraded by changes from natural to urbanized conditions. Fecal coliform and trash have been identified as water quality problems in the Central North subwatershed.

The type and amount of pollutants depend on land uses in the drainage area, pollutant source controls, and drainage system maintenance programs. Primary contaminants in stormwater from developed areas are eroded sediment and debris from deteriorating roadways and buildings. Other pollutants associated with runoff are heavy metals, inorganic chemicals, nutrients (nitrogen and phosphorus), petroleum products, and fecal coliform bacteria. Older, poorly maintained urban neighborhoods generally have higher levels of pollutants than newer developments, due to higher levels of traffic, accumulation of debris, and deteriorating housing stock.

In rural or undeveloped areas, stormwater pollutant loadings are low. The stormwater quality of forested areas is often used as a base condition for comparison to developed areas. Stormwater runoff in agricultural areas is generally characterized by high nutrient concentrations, virtually no petroleum products, and only naturally occurring metals.

Since the study area was mostly developed without water quality treatment measures, the urban runoff may be fairly low quality; the opportunity exists for improvements in treatment practices with redevelopment.

Channel Erosion

Channel or stream bank erosion contributes to drainage problems in a number of ways. Water quality is affected due to the contribution of fine sediments, which can increase turbidity. Habitat is also affected when fine sediment deposition smothers spawning areas or shellfish harvesting areas. Transported sediments may be deposited in storm drain pipelines and other conveyances, requiring increased maintenance activity and possibly causing flooding due to flow obstruction. In some cases, stream bank erosion may lead to slope instability, which can threaten public facilities and private residences.

Operation and Maintenance

Drainage structures fill with sediment over time in the absence of a regular cleaning program (see Figure 4-2). When structures become blocked, stormwater may overflow during rainfall events, causing damage to surrounding public and private property. Drainage structures in the Central North subwatershed are especially prone to siltation and blockage due to the ditch-and-culvert configuration, which brings sediment into the system. Sediments from developed areas have been shown to contain high levels of pollutants. Also, stormwater outfalls to Birch Bay are susceptible to blockage due to tidal fluctuation that washes sand and mud into outfall pipes and offshore currents that float debris over the opening.

Figure 4-2. Blocked Culvert

Lack of access may also prevent adequate maintenance of the storm drain system. Proper storm drain design requires a structure, usually a catch basin or manhole, at each point where a pipeline changes grade or alignment direction. Without this access, pipeline inspection and cleaning is difficult or impossible.

PROBLEMS SPECIFIC TO CENTRAL NORTH SUBWATERSHED

Drainage, water quality and habitat problems specific to the Central North subwatershed have been identified from a number of sources. including the Birch Bay Stormwater Comprehensive Plan (CH2M Hill), the watershed characterization and planning pilot study (ESA Adolfson, 2007), the Whatcom County Stormwater Incident Database (Whatcom County, 2011a), the Birch Bay/Terrell Creek Water Quality Monitoring Project, public input provided during advisory group meetings, County staff, and analysis performed to support this report. Problems identified in this plan represent conditions at the time of plan development. Conditions may change in the future as new problems are identified or additional information becomes available that might change the interpretation of the subwatershed characterization.

Table 4-1 summarizes the drainage related problems in the Central North subwatershed and Figure 4-3 shows the location of the problems. Tables 4-2 through 4-6 provide details on each problem type for all subbasins where problems have been identified. Each problem is categorized based on the following:

- **Frequency** is a general indicator of the severity of the problem and has three types:
  - **Storm Event** refers to problems that only occur during storm events—usually with large volume or high-intensity rainfall. The frequency of the problem is quantified where known.
  - **Chronic** problems are problems that occur with or without direct rainfall. Groundwater seepage could be an example of a chronic surface water problem.
  - **Single-occurrence** problems usually only occur once and do not return when resolved. An accumulation of pet waste washing fecal matter into a drainageway may be considered a single-event problem after cleanup.
- **Responsibility** refers to who is responsible for resolving a stormwater problem:
  - Stormwater problems generated on **public** property or with the public storm drain system are the responsibility of public entities, primarily Whatcom County and the BBWARM District. Undersized conveyance storm drains or damaged pipe outfalls in the public right-of-way are examples of surface water problems under the jurisdiction of the County.
  - Problems generated on **private** property are the responsibility of the property owners. County staff may offer advice on how to resolve private property issues but cannot provide capital for these solutions. A rooftop downspout that directs flow onto neighboring property is an example of a private property issue.
  - For some problems, responsibility is shared between **public and private**. Responsibility for these types of problems is sometimes hard to define and usually identified on a case-by-case basis. Public/private problems usually involve cases where the public storm drain conveyance systems cross private property where no easement has been granted.
- **Problem Types** are categorized as drainage, erosion, maintenance, water quality or habitat. Drainage problems are sub-categorized as inadequate conveyance or failing infrastructure.

Almost 60 drainage-related problems were identified in the Central North subwatershed. The Cottonwood Beach North subbasin had the highest number of problems, followed by Hillsdale, Shintaffer, Cottonwood Beach South and Hillsdale North subbasin. Drainage problems make up the greatest number of problems and are about evenly split between inadequate conveyance and failing infrastructure. About a third of the problems are with public facilities, a third are with private facilities, and a third affect both public and private facilities. Solutions developed for the problems are presented in Chapter 6 describes proposed problems solutions and the resolution of projects that have already been addressed.

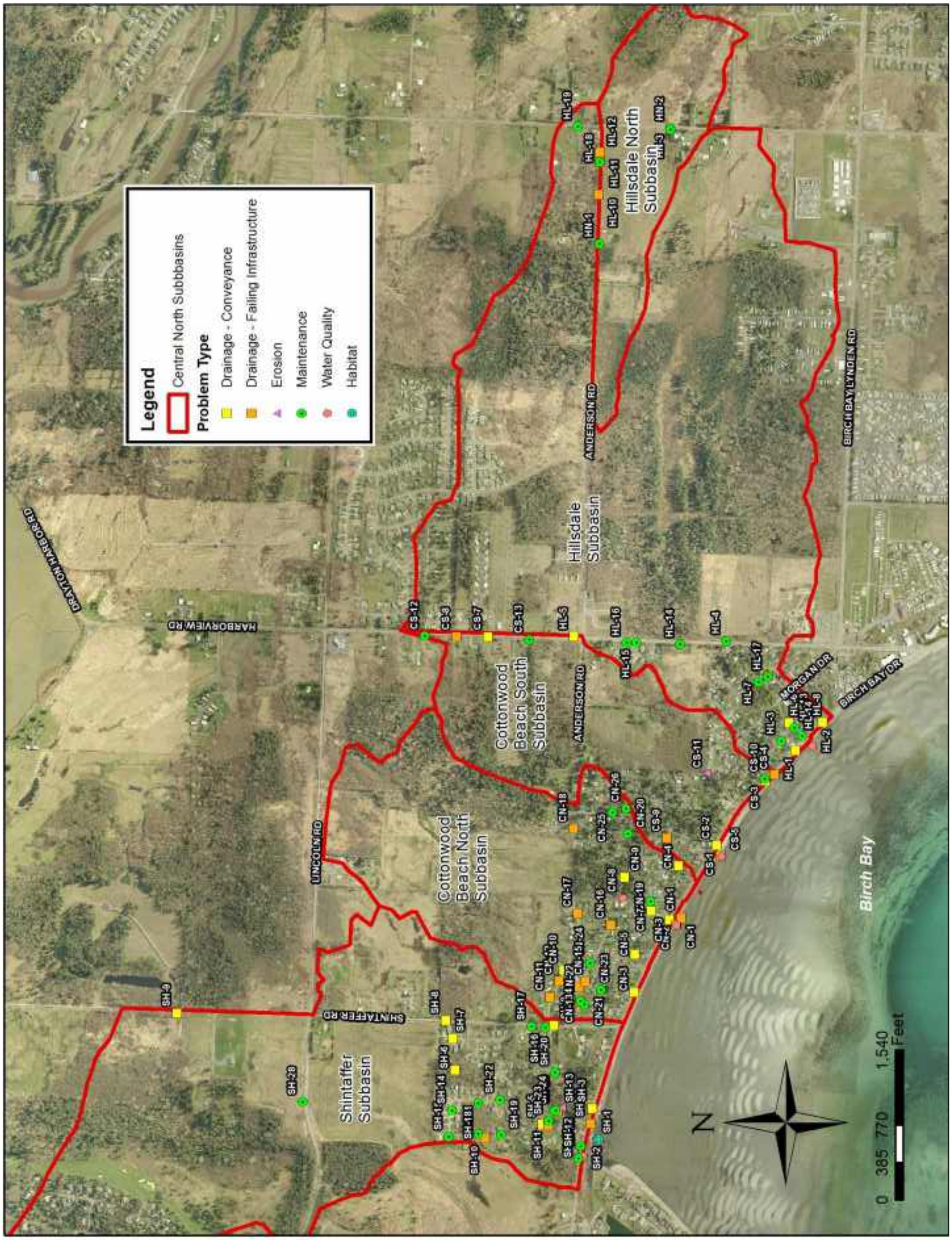

Figure 4-3. Identified Problem Areas in the Central North Subwatershed

TABLE 4-1.
SUMMARY OF DRAINAGE RELATED PROBLEMS IN THE CENTRAL NORTH SUBWATERSHED

Problem Type (No. of problems)	Number of Problems of Each Type: Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale Subbasin	Hillsdale North Subbasin
Drainage: Inadequate Conveyance (19)	7	4	4	4	0
Drainage: Failing Infrastructure (22)	3	11	3	5	0
Erosion (2)	1	0	1	0	0
Maintenance (38)	15	8	3	9	3
Water Quality (7)	1	3	2	1	0
Habitat (1)	1	0	0	0	0
Total Drainage Related Problems (57)	**28**	**26**	**13**	**19**	**3**

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE SHINTAFFER SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
SH-1	ID 06-11	NW end of Birch Bay beach	Single Occurrence	Public/Private	Habitat
Description: Fish kill on beach.					
SH-2	BB/TC WQMP	Storm drain outfall at Birch Bay Dr. and Deer Tr.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed.					
SH-3	ID 26-10 HH Analysis (SH-F-1)	Birch Bay Dr.	Storm Event	Public/Private	Drainage: Conveyance
Description: Flooding occurred on Birch Bay Drive at various locations during the December 12, 2010, rainfall event. The hydraulic analysis predicted flooding for the 100-year event under existing and future conditions.					
SH-4	ID 04-10	Birch Bay outfall at Deer Tr.	Storm Event	Public/Private	Drainage: Conveyance
Description: Storm drain outfall to Birch Bay (DP ID 1354) was obstructed, blocking flow and causing backflow onto Birch Bay Drive and the surrounding area during peak flow events.					
SH-5	ID 20-10 Inventory HH Analysis (SH-F-2)	Cherry Tree Lane near Deer Tr.	Chronic	Public	Drainage: Conveyance
Description: Ponding occurs after heavy rain due to obstructed storm drain system. Inventory identified broken pipes and ditches filled with sediment. The hydraulic analysis predicted minor street flooding during all events.					

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE SHINTAFFER SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
SH-6	ID 07-10 BBCSP CT-01 BBCSP CT-07	Richmond Park Subdivision	Chronic	Private	Drainage: Conveyance
Description: Higher ponding levels for greater frequency of flooding in habitat conservation area have damaged trees. Ponding has also flooded adjacent private property and entered crawl spaces in dwellings.					
SH-7	ID 25-10 HH Analysis (SH-F-5)	Richmond Park Subdivision	Storm Event	Public/Private	Drainage: Conveyance
Description: Storm drain system overflowed during December 12, 2010 rainfall. Flood damage occurred at two to three properties in the subdivision. The hydraulic analysis predicted flooding for the 10-year event under existing and future conditions.					
SH-8	HH Analysis (SH-F-4)	W side Shintaffer Rd. near Anderson Rd.	Storm Event	Public/Private	Drainage: Conveyance
	HH Analysis (SH-F-3)	E side Shintaffer Rd. from 300’ S of Anderson Rd. to 600’ S of Lincoln Rd.			
Description: Undersized culverts and storm drain system restrict flow and cause flooding for the 10-year event under existing and future conditions.					
SH-9	HH Analysis (SH-F-6)	W side Shintaffer Rd. vicinity of Shintaffer Ct.	Storm Event	Public/Private	Drainage: Conveyance
Description: Undersized driveway culvert restricts flow during 10-year event under existing and future conditions.					
SH-10	Inventory	Mid-block W side Pheasant Dr.	Chronic	Private	Drainage: Failing Infrastructure
Description: Both ends of driveway culvert are broken.					
SH-11	Inventory	E end Cherry Tree Lane	Chronic	Private	Drainage: Failing Infrastructure
Description: Both ends of driveway culvert are broken.					
SH-12	Inventory	Deer Trail at Cherry Tree Lane	Chronic	Public	Drainage: Failing Infrastructure
Description: Storm drain outfall pipe is broken.					
SH-13	County	Creek channel east of Deer Trail near Cherry Tree Lane	Chronic	Public/Private	Erosion
Description: Stream bank erosion in creek channel.					
SH-14	County	Grouse Crescent at Pheasant Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-15	County	Pheasant Drive at Grouse Crescent Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-16	County	Shintaffer Rd. at Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-17	County	Shintaffer Rd. at Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE SHINTAFFER SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
SH-18	County	Mid-block W side Pheasant Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-19	County	South end of Pheasant Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-20	County	South side of Fawn Crescent	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-21	County	Mid-block Grouse Crescent Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-22	County	South side of Grouse Crescent Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-23	County	Cherry Tree Lane	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-24	County	Cherry Tree Lane near Deer Trail	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-25	County	Cherry Tree Lane near Deer Trail	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-26	County	Birch Point Rd. near Dear Trail	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-27	County	Birch Point Rd. near Dear Trail	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
SH-28	County	Semiahmoo Parkway near Shintaffer Rd.	Chronic	Public	Maintenance
Description: Stream bank erosion in creek channel.					

a. ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH = Hydrologic and hydraulic analysis (includes flood problem ID from Appendix B), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-3.
DRAINAGE RELATED PROBLEMS IN THE COTTONWOOD BEACH NORTH SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
CN-1	ID 04-09 BBCSP CT-06	Birch Bay Dr. near Cedar Ave.	Storm Event	Public/Private	Drainage: Failing Infrastructure
Description: Storm drain outfalls to Birch Bay (DP ID 729 and 730/731) regularly become obstructed, blocking flow and causing backflow onto Birch Bay Drive and surrounding area during peak flow events. (This problem was resolved with construction of a capital project in the summer of 2013)					
CN-2	BB/TC WQMP	Storm drain outfall at Birch Bay Dr. and Cedar Ave.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed.					
CN-3	ID 09-11	North Birch Bay Dr.	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch basin inlet grates are too low and fill with sediment.					
	HH Analysis	Birch Bay Dr. east of Cedar St.	Chronic	Public/Private	Drainage: Conveyance
Description: Undersized storm drain (4”) restricts flow and causes flooding for the 2-year event under existing and future conditions.					
CN-4	ID 13-10	Halverson Lane	Chronic	Private	Drainage: Conveyance
Description: Increased groundwater flow at base of bluff.					
CN-5	ID 10-11	Cottonwood Beach	Chronic	Private	Drainage: Conveyance
Description: Drainage alterations on private property are causing damage to neighboring properties.					
CN-6	ID 14-10	Hazel Lane	Single Occurrence	Private	Water Quality
Description: Raccoon waste in drainage ditch.					
CN-7	HH Analysis (CN-F-3)	Fern Street extended at Hazel Lane	Storm Event	Public	Drainage: Failing Infrastructure
Description: Undersized storm drain system causes flooding for 100-year event for existing and future condition. No structures installed at locations where the existing outfall pipeline alignment changes direction.					
CN-8	BBCSP CT-04	Cedar Ave. and Alder St.	Chronic	Public/Private	Water Quality
Description: Yard waste and garbage block stormwater conveyance in ditch and catch basins.					
CN-9	HH Analysis (CN-F-4)	Alder St. at Halverson Park	Storm Event	Public/Private	Drainage: Conveyance
Description: Culvert under Alder Street restricts flows and causes road flooding during 100-year event under future conditions.					
CN-10	HH Analysis (CN-F-5)	North side of Anderson Rd. in vicinity of Sunset St.	Storm Event	Public/Private	Drainage: Conveyance
Description: Culvert under Alder Street restricts flows and causes minor road flooding during 100-year event under existing and future conditions.					
CN-11	Inventory	N side Anderson Rd. at Sunset St.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is crushed.					
CN-12	Inventory	N side Anderson Rd. near Sunset St.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is cracked.					

TABLE 4-3.
DRAINAGE RELATED PROBLEMS IN THE COTTONWOOD BEACH NORTH SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
CN-13	Inventory	E side Sunset St. at Hazel Lane	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
CN-14	Inventory	N side Hazel Lane near Sunset St.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
CN-15	Inventory	S side Hazel Lane near Sunset St.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
CN-16	Inventory	N side Hazel Lane near Maple Crest Ave.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
CN-17	Inventory	S side Anderson Rd. near Cedar Ave.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
CN-18	Inventory	N side Anderson Rd. near Beachway Dr.	Chronic	Private	Drainage: Failing Infrastructure
Description: Three driveway culvert ends are broken.					
CN-19	County	Cedar Avenue at Fern St.	Chronic	Public	Maintenance
Description: Vault drainage structure opening is buried or not provided.					
CN-20	County	S side Hazel Ln near Maple Crest Ave.	Chronic	Public	Maintenance
Description: Storm drain system on south side of Hazel Lane is disconnected from the downstream system because the roadside ditch has been filled in the 200-foot-long segment immediately west of Maple Crest Lane. Storm drain discharges as sheet flow to private property.					
CN-21	County	Sunset Dr. near Hazelwood Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
CN-22	County	Sunset Dr. near Hazelwood Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
CN-23	County	West side Seaview Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
CN-24	County	Mid-block Hazel Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
CN-25	County	Beach Way Dr. near Fir St.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
CN-26	County	Alder St. near Beach Way Dr.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					

a. ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH = Hydrologic and hydraulic analysis (includes flood problem ID from Appendix B), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE COTTONWOOD BEACH SOUTH SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
CS-1	BBCSP CT-10 Inventory	Birch Bay Dr. at Beachway Dr.	Storm Event	Public	Drainage: Conveyance
Description: Storm drain outfall to Birch Bay (DP ID 747) blocked during high flow events, causing backflow onto Birch Bay Drive and the surrounding area during peak flow events. Inventory identified cracked outfall pipe.					
CS-2	HH Analysis (CS-F-1)	Birch Bay Dr. at Beachway Dr.	Storm Event	Public	Drainage: Conveyance
Description: Undersized storm drain system causes flooding during 10-year event under existing and future conditions.					
CS-3	HH Analysis (CS-F-2)	Birch Bay Dr. midway between Beachway Dr. and Cottonwood Dr.	Storm Event	Public	Drainage: Conveyance
Description: Undersized storm drain system causes flooding during 10-year event under existing and future conditions.					
CS-4	BBCSP CT-02	Birch Bay Dr. near Cottonwood Beach	Storm Event	Public	Drainage: Failing Infrastructure
Description: Roadway and subgrade erosion prevent pedestrian and bicycle use of road edge.					
CS-5	BB/TC WQMP	Storm drain outfall at Birch Bay Dr. and Beachway Dr.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed.					
CS-6	BBCSP CT-09	Cedar Ave. and Alder St.	Chronic	Public/Private	Water Quality
Description: Yard waste and garbage block stormwater conveyance in drainageway.					
CS-7	HH Analysis (CS-F-3)	Harborview Rd. 1000' north of Anderson Rd.	Storm Event	Public/Private	Drainage: Conveyance
Description: Undersized driveway culverts cause minor flooding during 100-year event under existing and future conditions.					
CS-8	Inventory	W side Harborview Rd. midway between Lincoln Rd. and Anderson Rd.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken at both ends.					
CS-9	HH Analysis (CS-F-4) AC Meeting	N side of Fern St. west of Beachway Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: Storm drain and catch basin are plugged, causing road and private property flooding in neighborhood.					
CS-10	County	Beachway Drive midway between Birch Bay Drive and Halverson Lane.	Chronic	Public	Maintenance
Description: Vault drainage structure opening is buried or not provided.					

TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE COTTONWOOD BEACH SOUTH SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
CS-11	County	W of North Bay Trailer Park	Chronic	Public/Private	Erosion
Description: Concentrated stormwater runoff causing erosion in ditch on west boundary of North Bay Trailer Park.					
CS-12	County	Harborview Rd. near Lincoln Rd.	Chronic	Public	Maintenance
Description: Drainage Pipe Sedimentation.					
CS-13	County	Harborview Rd. near Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage Pipe Sedimentation.					

a. ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH = Hydrologic and hydraulic analysis, BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, AG = BBWARM Advisory Group Quarterly Meeting, County = County Staff

TABLE 4-5.
DRAINAGE RELATED PROBLEMS IN THE HILLSDALE SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
HL-1	ID 26-10HH Analysis (HL-F-1)	Birch Bay Dr. west of Cottonwood Dr.	Storm Event	Public/Private	Drainage: Conveyance
Description: Incident 26-10 documented flooding on Birch Bay Drive at various locations during the December 12, 2010 rainfall event. Hydraulic analysis showed shallow storm drain system causes flooding during 2-year event under existing and future conditions.					
HL-2	BB/TC WQMP	Storm drain outfall at Birch Bay Dr. and Cottonwood Dr.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed.					
HL-3	ID 15-10	Cottonwood Ct.	Chronic	Public	Maintenance
Description: Odor from storm drain system.					
HL-4	BBCSP HS-02	Harborview Rd.	Single Occurrence	Public	Maintenance
Description: Debris in the ditch along Harborview Road ditch caused it to overflow during an event in 2006.					
HL-5	HH Analysis (HL-F-4)	East side Harborview Rd. 300' south to 1,500' north of Anderson Rd.	Storm Event	Public/Private	Drainage: Conveyance
Description: Undersized culvert at Anderson Road and south of Anderson Road causes flooding during 10-year event under existing and future conditions.					
HL-6	County	Pipeline under Cottonwood Dr.	Storm Event	Public	Maintenance
Description: Inlet to pipeline under Cottonwood Drive becomes clogged with debris during storm events.					
HL-7	Inventory	North side of Henley St. west of Comfort Lane	Chronic	Public	Drainage: Failing Infrastructure
Description: Inlet to corrugated metal pipe is crushed, restricting inflow to the pipeline.					

TABLE 4-5.
DRAINAGE RELATED PROBLEMS IN THE HILLSDALE SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
HL-8	HH Analysis (HL-F-2)	Birch Bay Dr. east of Cottonwood Drive	Storm Event	Public/Private	Drainage: Conveyance
Description: Undersized pipeline causes flooding during 2-year event under existing and future conditions.					
HL-9	Inventory	S side of Henley St. at Hinkley St.	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
HL-10	Inventory	N side of Anderson Rd. west of Blaine Rd (SR 548)	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culvert end is broken.					
HL-11	Inventory	N side of Anderson Rd. west of Blaine Rd (SR 548)	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culverts are broken at both ends.					
HL-12	Inventory	N side of Anderson Rd. west of Blaine Rd (SR 548)	Chronic	Private	Drainage: Failing Infrastructure
Description: Driveway culverts are broken at both ends.					
HL-13	County	Cottonwood Dr. & Cottonwood Ct.	Chronic	Public	Maintenance
Description: No opening at tee in storm drain pipeline.					
HL-14	County	Cottonwood Dr. at Birch Bay Dr.	Chronic	Public	Maintenance
Description: No opening at tee in storm drain pipeline.					
HL-15	County	Hazelwood Rd. south of Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HL-16	County	Hazelwood Rd. south of Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HL-17	County	Henley Rd. near Merle Pl.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HL-18	County	Anderson Rd. near Blaine Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HL-19	County	Blaine Rd. near Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					

a. ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH = Hydrologic and hydraulic analysis (includes flood problem ID from Appendix B), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-6.
DRAINAGE RELATED PROBLEMS IN THE HILLSDALE NORTH SUBBASIN

ID	Source[a]	General Location	Frequency	Responsibility	Problem Type
HN-1	County	Anderson Rd. near Blaine Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HN-2	County	Blain Rd. south of Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					
HN-3	County	Blain Rd. south of Anderson Rd.	Chronic	Public	Maintenance
Description: Drainage pipe sedimentation.					

a. ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH = Hydrologic and hydraulic analysis (includes flood problem ID from Appendix B), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

CHAPTER 5.
LOW-IMPACT DEVELOPMENT

Low-impact development (LID) is a stormwater management strategy emphasizing conservation and use of natural site features integrated with distributed, small-scale stormwater controls to more closely mimic natural hydrologic patterns in residential, commercial, and industrial settings (Puget Sound Action Team, 2005). A wide variety of LID techniques may be suitable for a given area, based on soils and topography.

LID best management practices (BMP) suitable for the Birch Bay watershed are outlined in the draft *Low Impact Development Handbook for the Birch Bay Watershed* (Whatcom County, 2011b). The handbook outlines a proposed voluntary program for implementing LID with new development in exchange for flexibility in complying with critical code provisions. Additional guidance can be found in the *LID Technical Guidance Manual for Puget Sound* prepared by the Puget Sound Action Team (PSAT, 2012) and other published guidance documents.

GENERAL DESCRIPTION OF LID TECHNIQUES

LID techniques suitable for the Birch Bay watershed fall into three categories: site design, minimizing impervious areas and stormwater management. These are generally described below; additional detail can be found in the Birch Bay LID Handbook and the LID Technical Manual for Puget Sound.

Site Design

Site design techniques emphasize avoiding impacts on a site by preserving existing vegetation, retaining trees, protecting stream and wetland buffers, and preserving permeable soils. Site design techniques can also include landscaping and vegetation to restore impaired area and improve degraded habitat. Site design techniques have few limitations and can be effective in protecting wetland and riparian areas and associated buffers. Building design should also be considered during site design. Ground disturbance is minimized by positioning structures along topographic contours. Also minimal excavation foundation systems, consisting primarily of driven piles, can preserve the natural drainage characteristics of existing soils. Table 5-1 describes typical site design LID BMPs.

TABLE 5-1.
LID BEST MANAGEMENT PRACTICES FOR SITE DESIGN

BMP	Description
Preserve existing vegetation[a]	Retain existing trees, shrubs, and forested patches to maintain habitat quality. Isolate areas of vegetation during construction to prevent damage.
Preserve permeable soils	Keep permeable outwash and marine soils in place.
Restore impacted areas and improve degraded habitat[a]	Plant native trees and shrubs in areas that lack forest cover.
Minimal excavation foundations[b]	Driven piles support building foundations above grade, limiting ground disturbance and maintaining natural subsurface flow paths.

a. For details, see PSAT, 2012
b. For details, see Whatcom County, 2011b

Minimize Impervious Area

Directly connected impervious area is a large contributor to stormwater peak flow and runoff volume. Minimizing this area reduces stormwater runoff. Minimizing impervious area is an LID technique suitable for all types of land cover, soil type and topography.

Alternatives to traditional site layout configurations can be effective in minimizing impervious surface. These include clustering development, sharing driveways and common areas, developing townhomes, and using smaller lots. Taller building with smaller footprints also reduce impervious area. Roadway improvements to minimize impervious area include reducing street widths (i.e. “skinny” streets). Placing soil and planting ground cover vegetation on roofs converts impervious roof area to pervious area.

Pervious pavement includes porous asphalt and permeable pavers that allow stormwater to drain through the surface and infiltrate into the underlying ground. Pervious pavement requires a separation depth of 12 to 36 inches between the subgrade and groundwater to avoid saturating the soil and to prevent groundwater contamination (PSAT, 2012). Table 5-2 describes LID BMPs to minimize impervious area.

TABLE 5-2.
LID BEST MANAGEMENT PRACTICES TO MINIMIZE IMPERVIOUS AREA

BMP	Description
Alternative site configuration[a]	Minimize impervious area by constructing narrower streets, multi-story residences, shared driveways and common areas and other alternative configurations.
Vegetated roofs[b]	Roofs with shallow, light-weight soil profiles with ground cover plants adapted to the harsh conditions of a roof top environment.
Pervious pavement[a]	Pavement containing voids that allow rainwater to flow through to a storage reservoir under the pavement then slowly infiltrate into the underlying subgrade.

a. For details, see PSAT, 2012
b. For details, see Whatcom County, 2011b

Stormwater Management

Stormwater management uses facilities to control the flow of stormwater running off the land surface. Generally, stormwater runoff from impervious surfaces (and compacted pervious surfaces) is routed to a stormwater management facility where it is retained and slowly released back to the environment either through a control structure or by infiltrating into the ground. Rainwater harvesting, rain gardens, dispersion, bioswales, and amended soils are examples of stormwater management techniques.

Stormwater management techniques that rely on infiltration work well in areas with sandy and gravelly soils but perform poorly where soils have a higher clay content, are saturated or have a high water table. Stormwater management techniques require a separation depth of 12 to 36 inches between the subgrade and the water table (PSAT, 2012). Lower loading rates associated with smaller facilities serving single lots may allow them to be used where the water table is closer to the surface. Table 5-3 describes stormwater management LID BMPs.

TABLE 5-3.
LID BEST MANAGEMENT PRACTICES FOR STORMWATER MANAGEMENT

BMP	Description
Bioswales	Vegetated open channels to convey stormwater. Channels store more rainwater and typically convey storm flow at a slower rate than pipes do.
Rainwater harvesting[a]	Rainwater runoff from roofs is captured and stored for water supply or landscape irrigation.
Rain gardens[a]	Stormwater is stored in shallow depressions containing amended soil and native plantings, and slowly infiltrates into the underlying subgrade.
Dispersion[a]	Stormwater runoff from impervious areas is discharged to existing vegetated areas through splash blocks and dispersion trenches.
Soil amendments[a]	Soil compacted during construction is reworked to break apart the compacted material. Organic material is then tilled in the soil.

a. For details, see Whatcom County, 2011b

LID SUITABILITY FOR CENTRAL NORTH SUBWATERSHED

LID BMPs can be effective in providing control of stormwater and development impacts in the Central North subwatershed if properly sited and designed. Their success is strongly contingent on locating facilities where subsurface conditions are suitable. There are few geotechnical limitations on siting LID BMPs that do not rely on infiltration. However, techniques that do rely on infiltration will only perform well on permeable sandy and gravelly soils with sufficient depth to groundwater.

Evaluation of Infiltration-Based LID BMPs

Due to the widespread distribution of impermeable, saturated soils in the Central North subwatershed, infiltration-based LID techniques such as rain gardens or permeable pavement would likely not provide effective stormwater runoff reduction. As shown on Figure 2-2, poorly drained, saturated soils associated with Hydrologic Soil Group D are located throughout the Cottonwood Beach North and South subbasins and a significant portion of the Shintaffer and Hillsdale subbasins. The rest of the Shintaffer and Hillsdale subbasins consists primarily of Hydrologic Soil Type C soils, which are till soils with low permeability.

Outwash soils (Hydrologic Soil Type A and B) are well drained and have higher infiltration rates, making them suitable for LID techniques that rely on infiltration. Outwash soils are found along the western and northern fringe of the Shintaffer subbasin, but these areas are either in the City of Blaine or outside the urban growth area. Outwash soils are found in a strip of land along Birch Bay Drive, but infiltration facilities in this area probably would not perform because this area is connected to the beach and has groundwater levels that fluctuate with the tide. Furthermore, infiltration facilities would likely be inundated during high tides, which would limit their effectiveness in storing excess stormwater.

The suitability of infiltration-based LID BMPs was evaluated based on the depth of groundwater during the wet months of November through March. Infiltration rates were considered, but depth to groundwater was found to be the limiting factor for site suitability. Depth to groundwater was based on estimated soil properties developed by the U.S. Department of Agricultural (USDA) for the Whatcom County Soil Survey. For the soils in the Central North subwatershed, the USDA estimated that groundwater ranges from 0 to 8 feet below the surface.

To simplify the analysis, only two types of infiltration facilities were assessed:

- Smaller facilities, such as rain gardens serving a single lot or shallow permeable pavement for sidewalks or patios—For this analysis, small facilities were assumed to allow 6 inches of ponding, with 18 inches of planting soil mix and a minimum 12 inch separation between the facility subgrade and the water table (PSAT, 2012). Suitable locations for this type of facility require a total of 36 inches between the ground surface and the water table.
- Larger LID BMP facilities, such as rain gardens serving multiple lots or permeable road pavements or parking lots—For this analysis, large facilities were assumed to allow 6 inches of ponding, with 18 inches of planting soil mix and a minimum 36 inch separation between the facility subgrade and the water table (PSAT, 2012). Suitable locations for this type of facility require a total of 60 inches between the ground surface and the water table.

Based on the assumed facility configurations, suitability for infiltration-based BMPs was defined as follows:

- Unsuitable—Locations with groundwater less than 36 inches below the surface
- Partially Suitable—Locations with groundwater 36 to 60 inches below the surface
- Suitable—Locations with groundwater 60 inches or more below the ground surface.

Site suitability is shown in Figure 5-1.

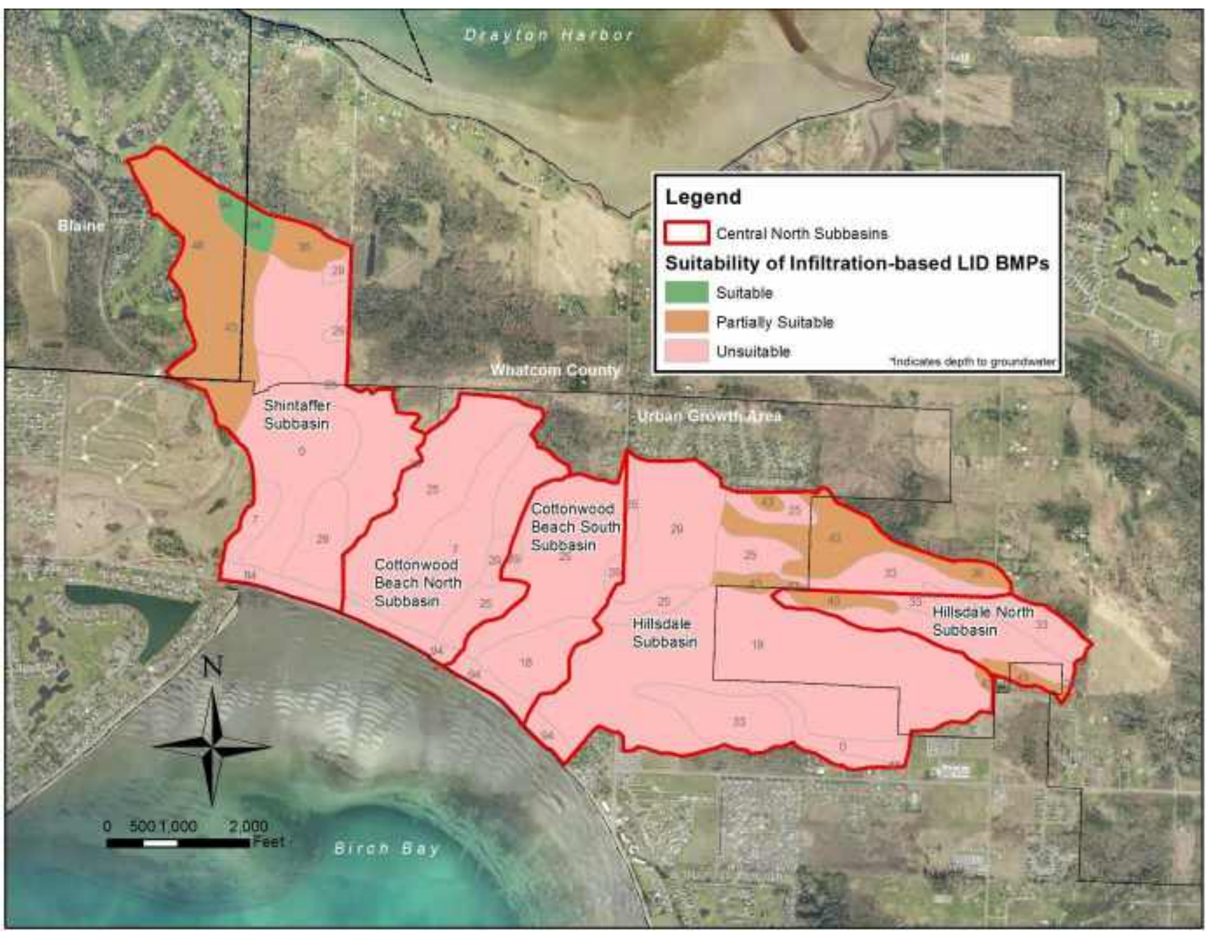

Figure 5-1. Suitability of Infiltration-Based LID BMPs in the Central North Subwatershed

This analysis shows that about 82 percent of the subwatershed is unsuitable for infiltration-based LID BMPs, 14 percent is partially suitable, and 4 percent is suitable. In the urban growth area, about 95 percent of the area is unsuitable, 5 percent is partially suitable, and no area is suitable. It is important to note that this investigation relied on published soil property values; no field investigation was performed to verify these values. Also, this analysis used mid-range design parameters for facility sizing but no design analysis was performed.

Overall Suitability Assessment

For the Central North subwatershed, LID BMPs that rely on site design and limiting impervious area would likely provide the best control of stormwater runoff. This assumption is based on the suitability analysis and the body of knowledge on the performance of standard LID BMPs. These techniques can be sited at any location throughout the subwatershed. Table 5-4 summarizes the overall suitability findings.

TABLE 5-4.
OVERALL LID BMP SITING SUITABILITY IN THE CENTRAL NORTH SUBWATERSHED

BMP	Site Suitability
Site Design BMPs	
Preserve existing vegetation[a]	Suitable for areas with existing forest or shrub cover. Cottonwood Beach North and South subbasins and the Hillsdale subbasin have remnant pockets of forest and shrub area.
Preserve permeable soils	Suitable but likely ineffective due to extensive coverage of relatively impermeable till and saturated soils throughout the subwatershed.
Restore repaired area and improve degrade habitat[a]	Suitable for riparian and wetland buffer areas.
Minimal excavation foundations[b]	Suitable for all areas.
Minimize Impervious Area	
Alternative site configuration	Suitable for all areas.
Vegetated roofs[b]	Suitable for all areas.
Pervious pavement[a]	Unsuitable due to impermeable soils and high groundwater but may have use for small applications, such as sidewalks or patios.
Stormwater Management BMPs	
Bioswales	Suitable for all areas; however, deep channels should be avoided where groundwater is near the surface.
Rainwater harvesting[b]	Suitable for all areas.
Rain gardens[b]	Unsuitable due to impermeable soils and high groundwater but may have use for small sites with underdrains.
Dispersion[b]	Suitable for areas with at least 50 linear feet of vegetated flow path.
Soil amendments[b]	Suitable for residential areas but may not be effective due to high groundwater.

a. For details, see PSAT, 2012
b. For details, see Whatcom County, 2011b

CHAPTER 6.
PROBLEM RESOLUTION

Almost 60 drainage-related problems were identified in the problem investigation documented in Chapter 4. Each problem was evaluated and a determination was made about the manner in which each should be addressed:

- Some problems are not addressed in this plan because they have already been addressed or are outside the jurisdiction of BBWARM and the County.
- Some problems are maintenance-related or more suitably addressed by a small works project.
- The remaining problems are more extensive and require a capital improvement program (CIP) project.

Problem disposition is shown on Figure 6-1.

PROBLEMS NOT ADDRESSED IN THE PLAN

The investigation found that some drainage problems were resolved with an earlier project or activity. Other problems are private issues, outside the jurisdiction of the County or BBWARM. Private property problems not addressed in the plan are usually due to flooding from adjacent properties or occur in privately owned drainage systems. Table 6-1 lists the problems not addressed in the master plan.

SPECIAL STUDY AREAS

Special studies are recommended for five problems whose solution requires resources beyond what is available in the watershed plan. Extended flooding in the habitat conservation area near Richmond Park is an example of this type of problem. Studies under way by others, such as Whatcom County's *Birch Bay\Terrell Creek Fecal Coliform and Nutrient Monitoring* project, also fall into the category of a special study recommendation. Table 6-2 list the special study recommendations.

OPERATION AND MAINTENANCE

Twenty-nine problems were attributed to the need for increased maintenance. The outfall to Birch Bay at Beachway Drive frequently is blocked with flotsam during high flow events. This problem is highlighted because it occurs at most of the outfalls to Birch Bay at some time during the year. The recommendation for increased maintenance is extended to all Birch Bay outfalls. The remaining problems are due to sediment buildup in roadway culverts and pipelines, which interferes with conveyance. Table 6-3 documents maintenance needs.

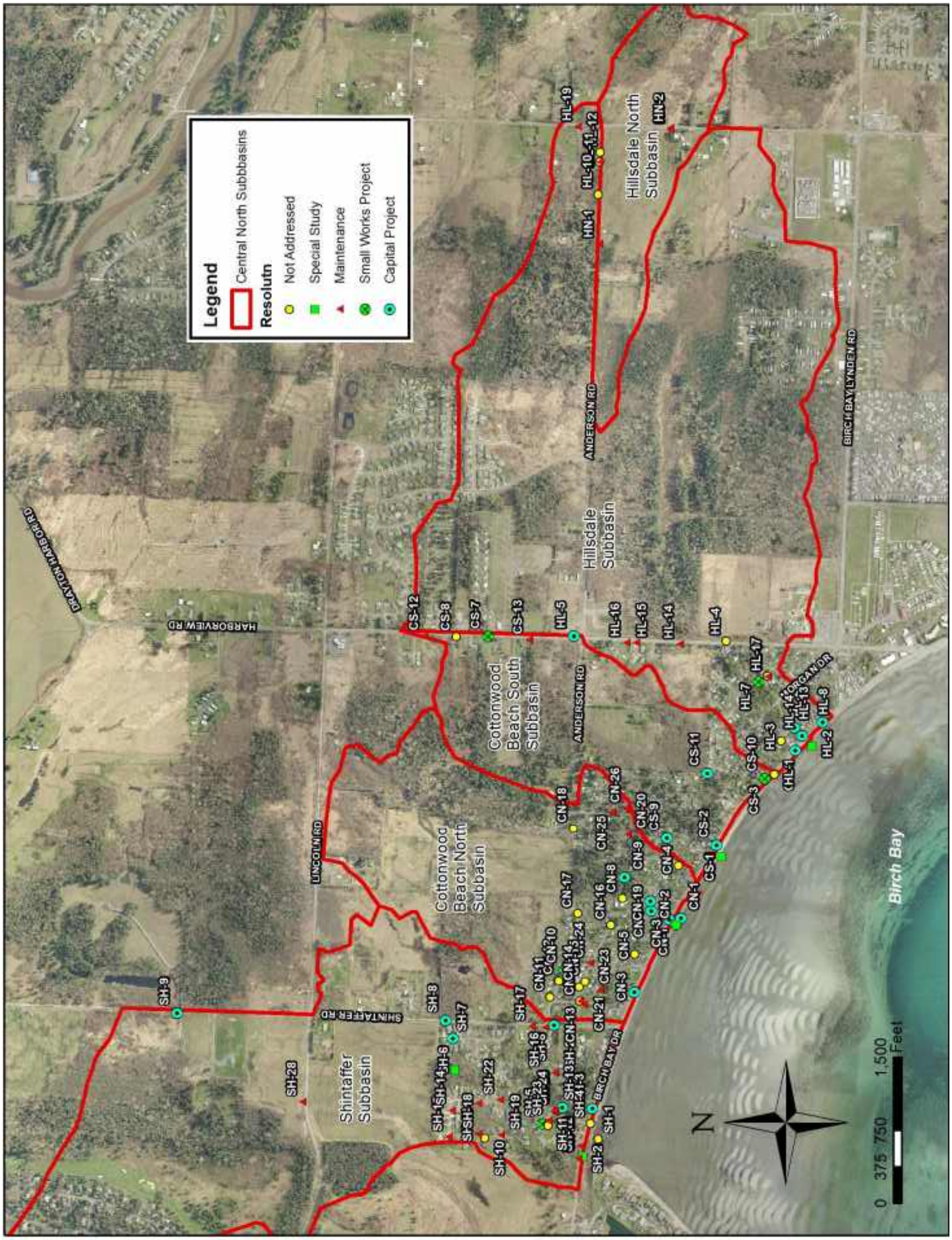

Figure 6-1. Problem Disposition

TABLE 6-1.
PROBLEMS NOT ADDRESSED IN THE PLAN

Problem ID	Problem and Location	Problem Resolution
SH-1	Fish kill at the north end of Birch Bay beach	Outside the jurisdiction of BBWARM and County, referred to the Washington Department of Fish and Wildlife
SH-4	Obstructed storm drain outfall at Deer Trail	County road maintenance crews removed gravel, logs and seaweed from pipe outfall
SH-10	Driveway culvert ends broken, mid-block west side of Pheasant Drive	Maintenance of driveway culverts is the responsibility of property owners
SH-11	Driveway culvert ends broken, east end of Cherry Tree Lane.	Maintenance of driveway culverts is the responsibility of property owners
SH-12	Driveway culvert end broken, Deer Trail at Cheery Tree Lane	Maintenance of driveway culverts is the responsibility of property owners
CN-3	Catch basin inlet grates are too low and become sediment-impounded	Problem Resolved. Maintenance raised catch basin rim and lid in 2011.
CN-4	Increased groundwater flow at the base of the bluff	The property owner is responsible for conveying surface water discharge to the public drainage facility. Drainage connection provided at Beachway Drive. See Table 6-5, Project CS-2.
CN-5	Drainage alterations on adjacent private property are causing damage to neighboring properties	Private property issue
CN-6	Raccoon waste in drainage ditch	Problem resolved. Animal waste, yard waste, and dumping are addressed through a basinwide education/outreach program.
CN-7	Undersized storm drain system causes flooding. No structures installed at locations where the existing outfall pipeline alignment changes direction	Problem resolved with the construction of the Cottonwood Drainage Improvement project completed in the summer of 2013.
CN-8	Yard waste and garbage blocks stormwater conveyance in ditch and catch basins.	Problem resolved. Animal waste, yard waste, and dumping are addressed through a basinwide education/outreach program.
CN-11	Driveway culvert end crushed, north side of Anderson Road at Sunset Street	Maintenance of driveway culverts is the responsibility of property owners
CN-12	Driveway culvert end cracked, north side of Anderson Road near Sunset Street	Maintenance of driveway culverts is the responsibility of property owners.
CN-13	Driveway culvert end broken, east side Sunset Street at Hazel Lane	Maintenance of driveway culverts is the responsibility of property owners
CN-14	Driveway culvert end broken, north side of Hazel Lane near Sunset Street	Maintenance of driveway culverts is the responsibility of property owners
CN-15	Driveway culvert end broken, south side of Hazel Lane near Sunset Street	Maintenance of driveway culverts is the responsibility of property owners

TABLE 6-1.
PROBLEMS NOT ADDRESSED IN THE PLAN

Problem ID	Problem and Location	Problem Resolution
CN-16	Driveway culvert end broken, north side of Hazel Lane near Maple Crest Avenue	Maintenance of driveway culverts is the responsibility of property owners
CN-17	Driveway culvert end broken, south side of Anderson Road near Cedar Avenue	Maintenance of driveway culverts is the responsibility of property owners
CN-18	Three broken driveway culvert ends, north side of Anderson Road near Beachway Drive	Maintenance of driveway culverts is the responsibility of property owners
CN-19	Vault drainage structure at Cedar Avenue at Ferns Street is buried with no surface opening.	Problem resolved with the construction of the Cottonwood Drainage Improvement project completed in the summer of 2013.
CS-3	Modeling predicted flooding	Problem resolved (model error)
CS-4	Roadway and subgrade erosion preventing pedestrian and bicycle use at road edge	Road maintenance is the responsibility of Whatcom County Public Works Maintenance and Operations. Improved pedestrian and bicycle pathways will be addressed in the Birch Bay Drive and Pedestrian Facility Project.
CS-6	Yard waste and garbage blocks stormwater conveyance in ditch and catch basins	Problem resolved. Animal waste, yard waste, and dumping are addressed through a basinwide education/outreach program.
CS-8	Driveway culvert is broken at both ends, west die of Harborview Road midway between Lincoln and Anderson Roads	Maintenance of driveway culverts is the responsibility of property owners
HL-3	Odor from storm drain at Cottonwood Court	Problem resolved
HL-4	Debris in ditch along Harborview Road caused it to overflow in 2006	Problem resolved
HL-9	Driveway culvert end broken, south side of Henley Street at Hinckley Street	Maintenance of driveway culverts is the responsibility of property owners
HL-10	Driveway culvert end broken, north side of Anderson Road west of Blaine Road	Maintenance of driveway culverts is the responsibility of property owners
HL-11	Driveway culvert end broken, north side of Anderson Road west of Blaine Road	Maintenance of driveway culverts is the responsibility of property owners
HL-12	Driveway culvert ends broken, north side of Anderson Road west of Blaine Road	Maintenance of driveway culverts is the responsibility of property owners

TABLE 6-2.
SPECIAL STUDY RECOMMENDATIONS

Problem ID	Problem and Location	Problem Resolution
SH-2	Fecal coliform water quality standards exceeded at storm drain outfall at Deer Trail	Whatcom County's Birch Bay / Terrell Cr. Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
SH-6	Greater frequency of flooding in habitat conservation area adjacent to Richmond Park	Requires special study, estimated cost = $30,000
CN-2	Fecal coliform water quality standards exceeded at storm drain outfall near Cedar Avenue	Whatcom County's Birch Bay / Terrell Cr. Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
CS-5	Fecal coliform water quality standards exceeded at storm drain outfall at Beachway Drive	Whatcom County's Birch Bay / Terrell Cr. Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
HL-2	Fecal coliform water quality standards exceeded at storm drain outfall at Cottonwood Drive	Whatcom County's Birch Bay / Terrell Cr. Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls

TABLE 6-3.
MAINTENANCE NEEDS

Problem ID	Problem and Location	Problem Resolution
CS-1	Outfall to Birch Bay at Beachway Drive blocked during high flow events. Pipe is also cracked.	Increase frequency of maintenance activity
SH-14, SH-15, SH-18, SH-19, SH-21, SH-22	Sediment-filled driveway culverts Pheasant Drive and Grouse Crescent Road	Remove sediment from culverts
SH-16, SH-17	Sediment-filled driveway culverts, Shintaffer Road	Remove sediment from culverts
SH-20	Sediment-filled driveway culverts, Fawn Crescent	Remove sediment from culverts
SH-23, SH-24, SH-25	Sediment-filled driveway culverts, Cheery Tree Lane	Remove sediment from culverts
SH-26, SH-27	Sediment-filled pipeline, Birch Bay Drive	Remove sediment from pipeline
SH-28	Sediment-filled culvert, Lincoln Road	Remove sediment from culvert
CN-21, CN-22, CN-23, CN-24	Sediment-filled driveway culverts, Hazel Lane, Sunset Street, Seaview Drive	Remove sediment from culverts
CN-25, CN-26	Sediment-filled driveway culverts, Alder Street and Beachway Drive	Remove sediment from culverts

TABLE 6-3.
MAINTENANCE NEEDS

Problem ID	Problem and Location	Problem Resolution
CS-12, CS-13	Sediment-filled driveway culvert, Harborview Road	Remove sediment from culvert
HL-6	Inlet to pipeline under Cottonwood Drive becomes clogged with debris	Increase frequency of maintenance activity
HL-14, HL-15, HL-16	Sediment-filled driveway culvert, Harborview Road	Remove sediment from culvert
HL-17	Sediment-filled driveway culvert, Henley Road	Remove sediment from culvert
HL-18, HL-19	Sediment-filled driveway culvert, Anderson Road	Remove sediment from culvert
HN-1	Sediment-filled driveway culvert, Anderson Road	Remove sediment from culvert
HN-2, HN-3	Sediment-filled driveway culvert, Blaine Road	Remove sediment from culvert

SMALL WORKS PROJECTS

Small works projects are projects that can be constructed at relatively low cost and that can be quickly planned and designed. Small works projects have the following characteristics:

- Low or minimal complexity
- Low cost (less than $20,000)
- Easy to permit (e.g. only county permits needed)
- Can be designed in-house by Whatcom County staff
- May be coordinated with other larger projects
- Emergency actions needed to protect life and public safety.

Six problems can be addressed as small works projects. These projects can be aggregated into a single larger project to take advantage of economies of scale or completed singly as County crews come available to implement the project. An annual budget of $50,000 is recommended to address small work projects. Small works projects are listed in Table 6-4.

STORMWATER CAPITAL PROJECTS

Project Types

Capital projects developed for this master plan consist primarily of conveyance improvements in the public right of way. A conveyance system is made up of large and small channels, culverts, and storm drain pipelines. Improvements include building overflow channels, increasing capacity, or increasing system efficiency. Specific structural solutions considered for the CIP are culvert and ditch improvements, storm drain pipelines, and outfall improvements.

TABLE 6-4.
SMALL WORKS PROJECTS

Problem ID	Problem and Location	Problem Resolution	Cost
Group 1			
SH-5	Ponding occurs at the west end of Cherry Tree Lane due to obstructed storm drain and pipes and ditches filled with sediment.	Clean pipes, reestablish ditch.	$3,000
SH-9	Driveway culvert, west side of Shintaffer Road, north of Lincoln Road, restricts flow and causes flooding during 10-year event.	Replace 12-inch driveway culvert with 18-inch diameter pipe.	$10,000
CS-10	No surface opening in vault drainage structure, north side of Birch Bay Drive between Beachway Drive and Cottonwood Drive.	Replace structure with Type 1 CB	$7,000
HL-7	Ditch outfall pipe to channel has crushed inlet, north side of Henley street west of Comfort Lane	Replace pipe with 12-inch diameter pipe	$11,000
Total Cost of Group 1 Small Works Projects			**$31,000**
Group 2			
CN-10	Undersized driveway culvert causes flooding during 100-year event.	Remove culvert on Anderson Road near Sunset Drive	$13,000
CN-20	Sheet flow occurs at Hazel Lane near Maple Crest Avenue due to filling of roadside ditches.	Reestablish 200 feet of ditch and install 12" driveway culverts	$18,000
CS-7	Undersized driveway culvert causes flooding during 100-year event.	Replace 12-inch driveway culvert with 18-inch diameter pipe.	$15,000
Total Cost of Group 2 Small Works Projects			**$46,000**

Culverts are short lengths of pipe that convey stormwater under roadways or other embankments. New or replacement culverts in stream channels at road crossings can increase flow capacity and reduce the potential for upstream flooding. When culverts are too small to convey the stormwater flow, stormwater backs up behind the roadway. This is normally not acceptable if there is a danger of the road failing or if upstream structures are being damaged by floodwaters. Increasing the size or number of culverts reduces the possibility of upstream damage and road failure. A potential negative effect of increasing culvert capacity is the risk of additional flooding downstream of the culvert caused by the loss of storage upstream. However, flood storage behind an undersized culvert is usually very small. At some locations, peak flow increase is attenuated in deep roadside ditches downstream of the replaced culvert.

Underground storm drain lines are commonly installed to convey stormwater runoff from urban developments to a receiving body such as a lake, river or stream. Storm drain pipelines can reduce flooding and standing water during rainfall events but can increase peak flow rates to the receiving water. Small pipes are inexpensive to install, but may result in frequent flooding. This can be alleviated by installing pipelines of adequate size to convey larger flows. Installation of new pipelines in developed areas is always more expensive and disruptive than the installation of pipelines in an undeveloped area.

Storm drains work only where there is adequate gradient to maintain flow rates and keep the pipe from filling with sediment. Typically, these lines are installed in road right-of-ways, so there is little land acquisition cost, although some temporary easements may be required. The proposed CIP projects include a large number of storm drains on Birch Bay Drive because much of this road lacks basic drainage infrastructure.

Capital projects may also include facilities designed to remove pollutants from stormwater flows and improve water quality. Common water treatment facilities include bio-infiltration swales and cartridge vaults. Where feasible, treatment facilities will be included in the proposed capital improvement projects included in this plan.

Project Assumptions

The configuration and size of stormwater capital projects was based on a detailed analysis of tributary area and land cover using the hydraulic models described in Chapter 3 and Appendix B. Pipe materials were assumed to be high-density polyethylene for pipes up to 24 inches in diameter and concrete for larger pipes. When an existing pipe is replaced with a larger diameter pipe, the cost assumes that existing catch basins can be reused. Some pipes were identified as outfalls or laterals. For cost estimating, outfall repair or replacement projects assume the installation of a tide valve.

Unit costs were generally derived from Washington State Department of Transportation bid tabs for recent local projects. Adjustments for planning level assumptions (such as trench excavation and pipe bedding material included in the price of culvert materials) were made using recent unit bid item costs from Whatcom County and other municipalities. Several unique lump sum items, such as pollution control systems, were priced based on engineer's judgment. Unit prices used for the estimates are shown in Appendix C.

Project Descriptions and Estimated Costs

Eleven capital projects were developed to address 18 drainage problems, as listed in Table 6-5. In some locations, a single project addresses more than one problem. The proposed projects include a total of 5,300 feet of new or replacement storm drain pipeline, 500 feet of culvert pipe, regrading or reestablishment of 50 feet of a roadside ditch, 42 new catch basins, 170 feet of water quality swale, and eight new tide valves. Figure 6-2 shows the project locations. Detailed project descriptions are provided in Appendix C. Table 6-6 shows a breakdown of estimated project costs.

TABLE 6-5.
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Project Number	Problem ID	Name[a]	Location	Cost
Shintaffer Subbasin				
SH-1	SH-13	Streambank Stabilization	Upstream of Birch Bay Drive	$228,000
SH-2[b]	SH-7, SH-8, SH-9	Richmond Park Drainage Improvement	Richmond Park and Shintaffer Road	$1,585,000
SH-3	SH-3	Deer Trail Outfall Improvement	Birch Bay Drive at Deer Trail	$165,000
Cottonwood Beach North Subbasin				
CN-2	CN-3	Birch Bay Drive Storm Drain Replacement	Birch Bay Drive between Cedar Avenue and Shintaffer Road	$338,000
Cottonwood Beach South Subbasin				
CS-2	CS-2	Beachway Drive and Birch Bay Road Storm Drain Improvement	Beachway Drive at Birch Bay Road	$216,000
CS-3	CS-9	Fern Street Storm Drain Improvements	Fern Street west of Beachway Drive	$160,000
CS-4	CS-11	Tightline and Storm Drain between North Bay Trailer Park and Birch Bay Drive	Ditch adjacent of west boundary of North Bay Trailer Park	$163,000
Hillsdale Subbasin				
HL-1	HL-5	Harborview Road Culvert Replacement	East side Harborview Rd. south and north of Anderson Road	$230,000
HL-2	HL-1, HL-8	Birch Bay Drive Storm Drain Improvement	Birch Bay Drive near Cottonwood Drive	$183,000
HL-3	HL-13, HL-14	Cottonwood Drive Storm Drain Maintenance Improvement	Cottonwood Drive at Cottonwood Court and Birch Bay Drive	$63,000

a. All projects consist of installation of new/replaced storm drainage pipeline, connection to existing drainage infrastructure, and associated outfall and ditch improvements. See Appendix C for project descriptions.
b. Project developed by Whatcom County staff (Whatcom County, 2012).

TABLE 6-6.
BREAKDOWN OF PROJECT CAPITAL COSTS

Project ID	Construction Cost[a]	State Sales Tax[b]	Engineering/Legal/ Administration[c]	Construction Management[d]	Permitting[e]	**Total**
SH-1	$141,000	$12,000	$42,000	$14,000	$19,000	$228,000
SH-2	$1,010,000	$87,000	$253,000	$101,000	$135,000	$1,586,000
SH-3	$99,000	$9,000	$35,000	$10,000	$13,000	$166,000
CN-2	$218,000	$19,000	$65,000	$22,000	$14,000	$338,000
CS-2	$134,000	$12,000	$40,000	$13,000	$17,000	$216,000
CS-3	$103,000	$9,000	$31,000	$10,000	$7,000	$160,000
CS-4	$105,000	$9,000	$32,000	$11,000	$7,000	$164,000
HL-1	$145,000	$12,000	$44,000	$15,000	$15,000	$231,000
HL-2	$118,000	$10,000	$35,000	$12,000	$8,000	$183,000
HL-3	$36,000	$3,000	$13,000	$4,000	$7,000	$63,000
Total	**$2,109,000**	**$182,000**	**$590,000**	**$212,000**	**$242,000**	**$3,335,000**

a. Includes 50 percent contingency
b. 8.6 percent of construction cost
c. 20 to 35 percent of construction cost
d. 10 percent of construction cost
e. 10 to 20 percent based on need for local, state, or federal permits

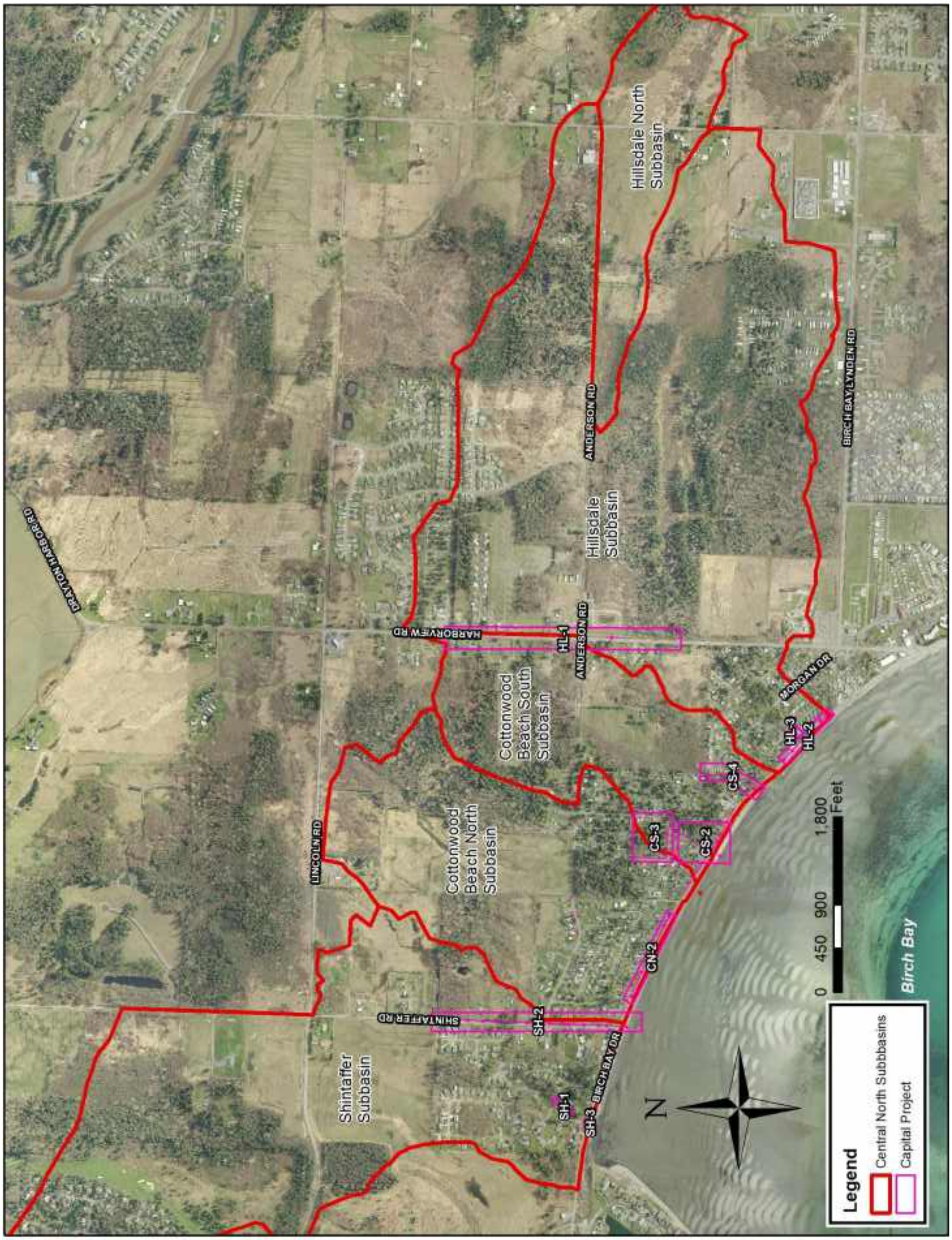

Figure 6-2. Capital Projects

CHAPTER 7.
IMPLEMENTATION PLAN

Stormwater plans typically include an implementation schedule for design and construction of capital projects. The projects are evaluated and scheduled over a 6-year period based on capital funding levels. For larger projects, implementation is typically split into two phases: design and permitting occurs first, followed by construction in a subsequent year. Very large and/or complex projects may require a separate planning phase preceding the design and permit phase.

EVALUATION OF CAPITAL PROJECTS

Capital Project Evaluation Options

Each jurisdiction develops its own project prioritization process to reflect the characteristics and values of its community. There are similarities among jurisdictions as to core criteria addressing the type of problem addressed, associated risk, and implementation. Three approaches are generally recognized for prioritizing capital projects in stormwater plans:

- Identify, evaluate and rank stormwater-related problems, and then develop solutions in order of problem priority. This approach is typically not cost-oriented and does not provide a full consideration of project elements. It was commonly used in the early days of stormwater planning but has been replaced by more sophisticated evaluation methods.
- Develop evaluation criteria that consider the stormwater problem and potential project issues. This method can consider cost as one element in the prioritization. It also considers qualitative factors such as environmental permitting and local enthusiasm for the project. This is the most commonly used approach today.
- Calculate a benefit-cost ratio based on computed financial benefits or using benefit points system. A variation of this approach is used by some utilities, including Pierce County Surface Water Management and the Skagit County Drainage Utility where the benefit-cost ratio is incorporated into the project scoring.

Recommended Criteria and Scoring Method

The evaluation-criteria method was selected for this master plan. This method is a way to rate projects and assign a priority reflecting the goals set by the BBWARM Advisory Committee in 2010. The number of evaluation criteria selected should be kept to a minimum so that the process is as simple as possible. To account for differences in the importance of various evaluation criteria, different weights may be applied to each criterion. However, for this master plan, all categories were weighted equally.

The CIP prioritization process developed for this master plan builds on core categories and a previous prioritization performed by Osborn Consulting (2009). Development of the process included review of methods and criteria used by other stormwater utilities, including Skagit County, Snohomish County, Pierce County, Clark County and numerous cities in Western Washington. Capital projects were prioritized using evaluation criteria in the following categories:

- The environmental benefit category from the 2009 evaluation was expanded to include a sediment reduction score in addition to the shellfish/fish habitat score. Higher scoring projects provide a greater improvement in habitat and greater sediment reduction. No points are awarded for projects that do not improve the current conditions.

- The community benefit category evaluates the reduction in flood frequency and magnitude, property damage (structure flooding), street flooding and public safety issues. No points are awarded for projects that only resolve nuisance property and road flooding.
- The implementation category considers project cost, permitting, property/easement acquisition, and coordination with other project and agencies. No points are assigned for projects that require a complex permitting process or where condemnation is necessary for property acquisition. Projects needed to meet regulatory requirements are scored significantly higher to ensure a high priority.
- Local support was given its own category in recognition of the need for strong support within the community to ensure project success.

Evaluation criteria and scoring assignment are described in Table 7-1. The project scoring and ranking are summarized in Table 7-2. Appendix E presents the full prioritization analysis.

TABLE 7-1.
PROPOSED PROJECT SCORING CRITERIA

Criterion	Scoring Basis	Points
Environmental Considerations		
Shellfish Habitat Benefit	No improvement in shellfish habitat.	0
	Indirect improvement—immediate vicinity (< 100 feet)	2
	Indirect improvement—single outfall to bay	4
	Indirect improvement–multiple outfalls	6
	Direct improvement to shellfish habitat	10
Sediment Source Removal	No improvement	0
	Nuisance removal—removes sediment from stormwater runoff	2
	Removes a minor sediment source—sediment deposition in downstream system restricts flow but does not completely obstruct conveyance	4
	Removes a significant sediment source—sediment deposition in downstream system completely obstructs conveyance	6
Community Benefit		
Current Frequency of Flooding	No flooding	0
	100-year recurrence interval	1
	10-year recurrence interval	3
	2-year recurrence interval	4
	Less than 2-year recurrence interval	5
Current Property Damage	Nuisance yard flooding	0
	1 to 2 homes flooded	1
	3 to 4 homes flooded	2
	5 to 10 homes flooded	3
	More than 10 homes flooded	5
Current Public Infrastructure Damage	No street flooding	0
	Street flooding less than 6 inches	1
	Street flooding greater than 6 inches (hazardous driving conditions)	3

TABLE 7-1.
PROPOSED PROJECT SCORING CRITERIA

Criterion	Scoring Basis	Points
	Access to homes blocked	4
	Emergency access blocked, generally reserved for locations with one access route for emergency vehicles	8
	Critical public safety issue—critical public facility flooded	10
Implementation		
Anticipated Cost of Project	Greater than $500,000	1
	$250,000 to $500,000	2
	$100,000 to $250,000	3
	Less than $100,000	4
Permit Complexity	Local, state, and federal permits required	0
	Local and state permits required	1
	Local permits required	2
	Programmatic permit action	3
	No permits required	5
Property/ Easement Acquisition	Condemnation necessary to obtain property/easements	0
	High cost property acquisition/easements (more than 10 percent of project construction cost)	1
	Easement acquisition only	2
	Low cost property/easement acquisition (less than 10 percent of project construction cost)	4
	No cost property/easement acquisition	5
Coordination with Other Projects/ Agencies	No project link	0
	Project is associated with other projects but not a critical or required element	1
	Associated projects cannot be built until this project is completed	3
	50 percent funding by non-BBWARM fees	5
	100 percent funding by non-BBWARM fees	8
	Regulatory Requirement	10
Local Support		
Local Support	No active support in the community	0
	One or two advocates in the community	2
	Enthusiastic support by the community	5
	Endorsed by the BBWARM Advisory Committee	10

**TABLE 7-2.
PROJECT SCORING AND RANKING**

Subwatershed Rank	Score	Project Name
1	47	SH-2: Richmond Park Drainage Improvement
2	23	CS-3: Fern Street Storm Drain Improvements
3	31	HL-2: Birch Bay Drive Storm Drain Improvement
4	36	SH-1: Streambank Stabilization Upstream of Birch Bay Drive
5	29	CN-2: Birch Bay Drive Storm Drain Replacement
6	26	CS-2: Beachway Drive and Birch Bay Drive Storm Drain Improvement
7	18	HL-3: Cottonwood Drive Maintenance Improvement
8	30	CS-4: Ditch Protection west of North Bay Trailer Park
9	15	SH-3: Deer Trail Outfall Improvement
10	16	HL-1: Harborview Road Culvert Replacement

IMPLEMENTATION SCHEDULE

A schedule for implementation of the capital projects outlined in this subwatershed should be incorporated into the annual BBWARM 6-year review of the improvement program. The implementation schedule for capital projects should consider funding, project priority and coordination with the Birch Bay Drive and Pedestrian Facility project. Generally, project implementation would be spread out over two years, with the engineering and permitting completed the first year and construction completed the following year.

COORDINATION WITH PLANNED BIRCH BAY DRIVE AND PEDESTRIAN FACILITY PROJECT

The Birch Bay Drive and Pedestrian Facility Project (CRP #907001) is a major Whatcom County beach restoration project. Engineering analysis and design options are under development in 2013. Many of the projects identified in this master plan should be coordinated with the proposed project.

This project will improve the nearshore environment along Birch Bay from the mouth of Terrell Creek to Cottonwood Beach. The primary objective for this project is to restore the beach in an ecological and sustainable manner, but other aspects, such as pedestrian and bicycle access, are included as well. Typical options for the project may include the following (Whatcom County, 2012):

- Modification or removal of the riprap, sea walls, groins, and bulkheads along Birch Bay Drive and replace them with a “natural” soft shore beach.
- Reestablish the beach profile and improve flood protection for the roadway and adjacent structures.
- Replace and retrofit substandard stormwater facilities and outfalls to improve water quality for this significant shellfish area.
- Provide beach access and a pedestrian facility as a portion of the Coast Millennium Trail.

The problem investigation and hydraulic analysis completed for this master plan identified several undersized stormwater outfall pipes crossing Birch Bay Drive that would need to be upgraded to safely convey stormwater to Birch Bay. Undersized storm drain outfalls are located at Deer Trail, Beachway Drive, and Cottonwood Drive. Outfall pipe systems will need to be designed to safely convey peak flows from tributary drainages and may need to extend several blocks upstream. In addition, the outfall to Birch Bay east of Beachway Drive is broken and should be repaired.

Outfalls frequently become obstructed with debris or filled with sand and require frequent maintenance to remain free-flowing. Obstructed outfalls are documented in Chapter 4 as a frequent cause of overflows in the system. Outfall replacement should include an evaluation of the need for tide valves to prevent backflow from Birch Bay into the storm drain system. Flexible, neoprene tide valves are recommended because they are self-cleaning and able to function with a minor amount of obstruction. Swing-type tide gates are not appropriate for this condition because sand deposition at the outlet can interfere with free operation of the gate. To ensure operation of the valve, the outfall structure should be configured to prevent sediment from accumulating at the discharge point. As an added safety precaution, a pressure relief and positive overflow path should be in the outfall system near Birch Bay Drive so that overflow can be conveyed to the bay in case the structure does become obstructed.

Roadway improvements should include a dedicated storm drain system that meets Whatcom County drainage design standards (Whatcom County, 2002) and prevents flooding on neighboring properties. The problem investigation identified numerous areas along Birch Bay Drive where topographic depressions collect stormwater runoff during rainfall events and cause adjacent properties to flood. Storm drain improvements should provide drainage of these existing low spots on the landward side of Birch Bay Drive. Capital projects SH-3, CN-2, CS-2 and HL-2 partially address the local drainage issues in the Central North subwatershed.

Storm drain system design should consider provisions to disconnect the upland drainage system from the local road drainage system along Birch Bay Drive. Problem CS-2 identified flooding along Birch Bay Drive, which is aggravated by inflow from the upper level system connecting at Beachway Drive. Separating these systems would also eliminate the upland contribution to flooding that occurs during a high tide event where stormwater backflows through the open-grate catch basin along Birch Bay Drive due to a high tailwater condition. The elevated pressure associated with a separate high-level system would drive the stormwater flow directly to the Birch Bay outfall rather than ponding on Birch Bay Drive.

The Hillsdale tributary has been identified as a Type F stream capable of supporting salmonid habitat. Future replacement of the outfall at Cottonwood Drive will need to consider fish passage in its design. Capital project HL-3 includes the addition of two structures on Cottonwood Drive to eliminate tee connections to the storm drain pipeline but does not include replacement of the pipeline.

Stormwater should be managed using low-impact development techniques to the greatest extent feasible. Water quality treatment is required for a new and replaced impervious area. Retrofit opportunities should be incorporated to the greatest feasible extent to address documented water quality issues.

INCORPORATING THE MASTER PLAN INTO THE OVERALL STORMWATER PROGRAM

As part of its comprehensive planning effort, Whatcom County has adopted the *Birch Bay Comprehensive Stormwater Plan* (CH2M Hill, 2006). Approved subwatershed master plans are incorporated into the Stormwater Plan during plan updates or when added as an addendum. Priorities and timeframes from the comprehensive subwatershed plans must be integrated with other County needs to fit within the overall priorities and budget for the County.

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Birch Bay Central North Subwatershed Master Plan

APPENDIX A.
STORMWATER INVENTORY

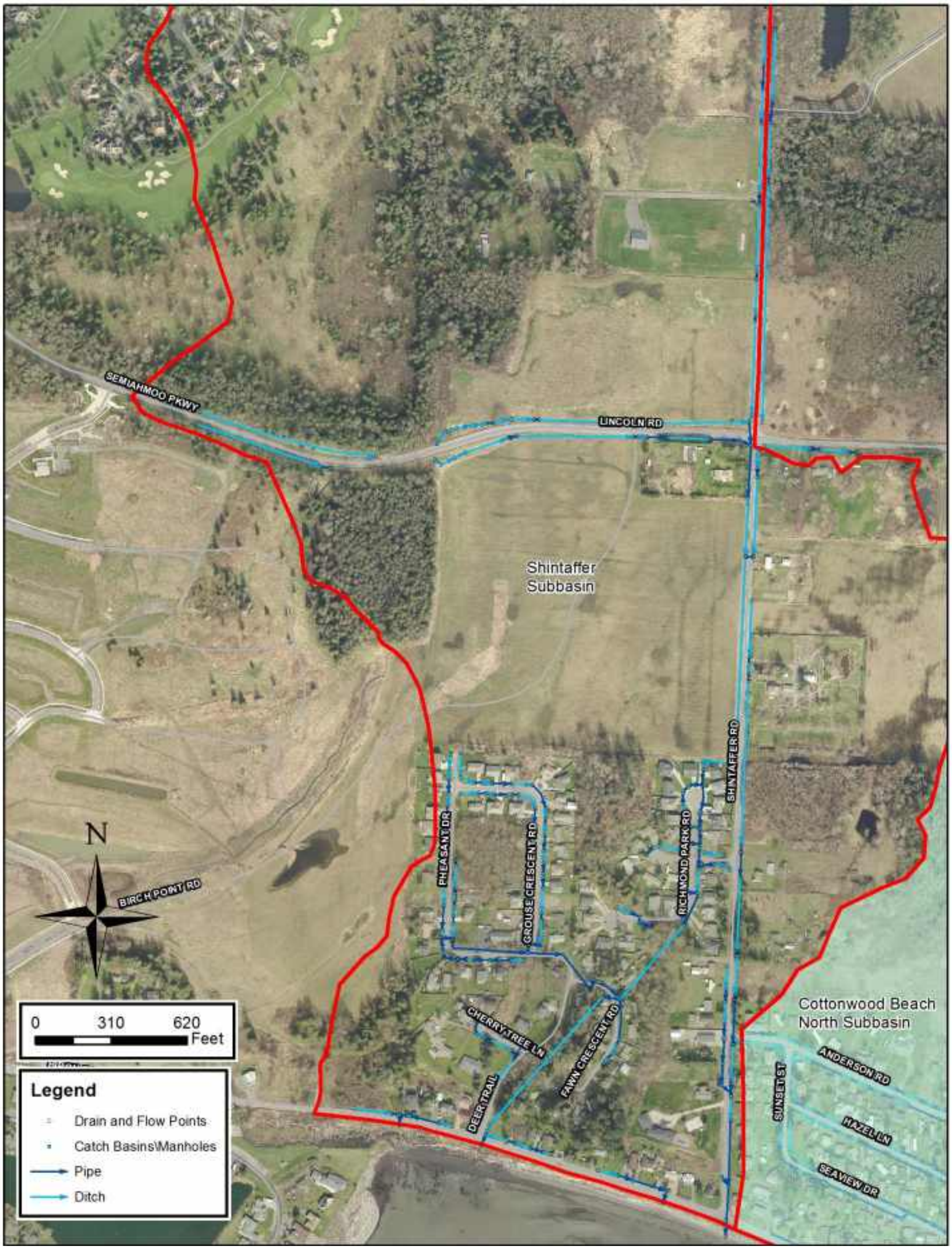

Figure A-1 Stormwater Inventory—Shintaffer Subbasin

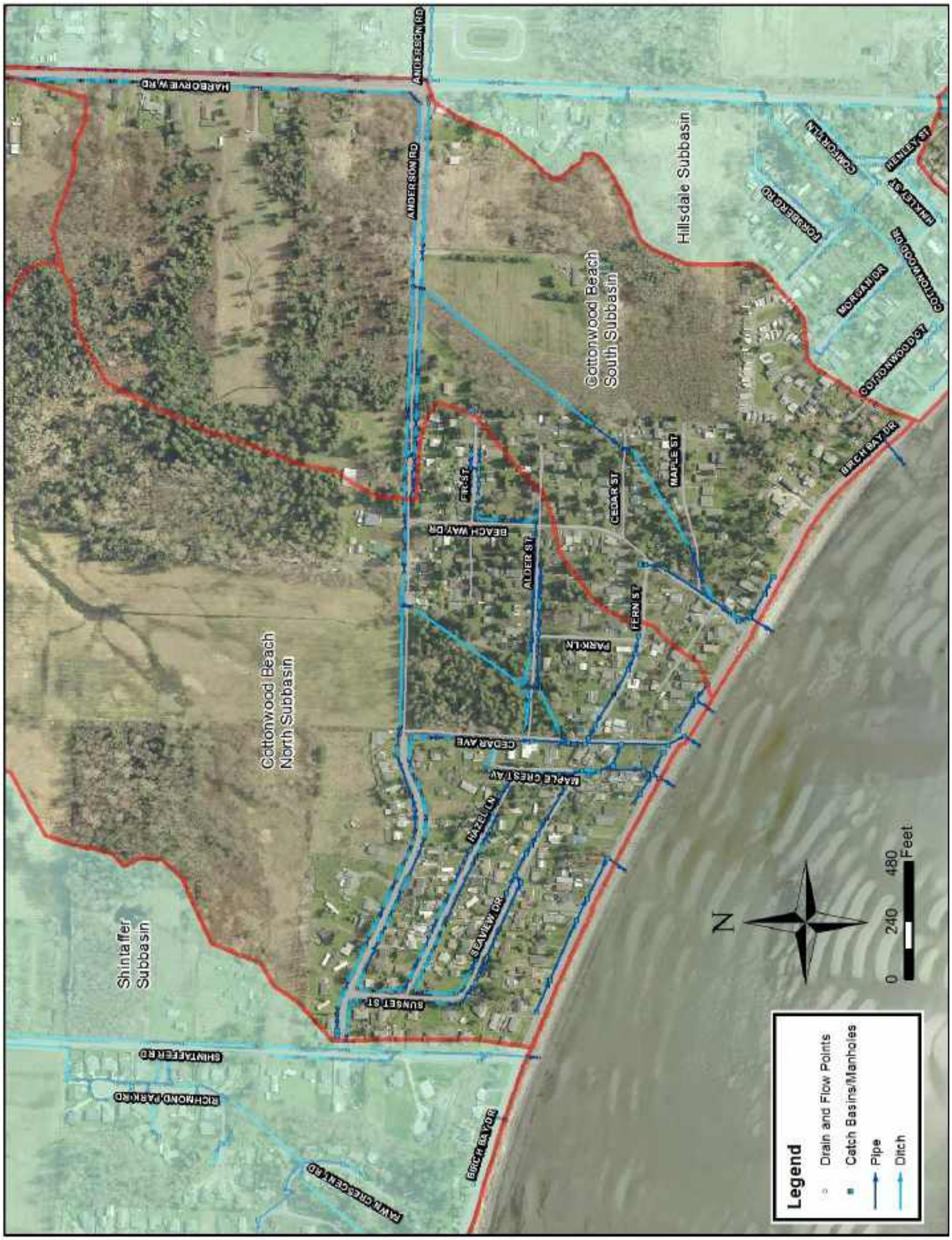

Figure A-2 Stormwater Inventory—Cottonwood Beach North and Cottonwood Beach South Subbasins

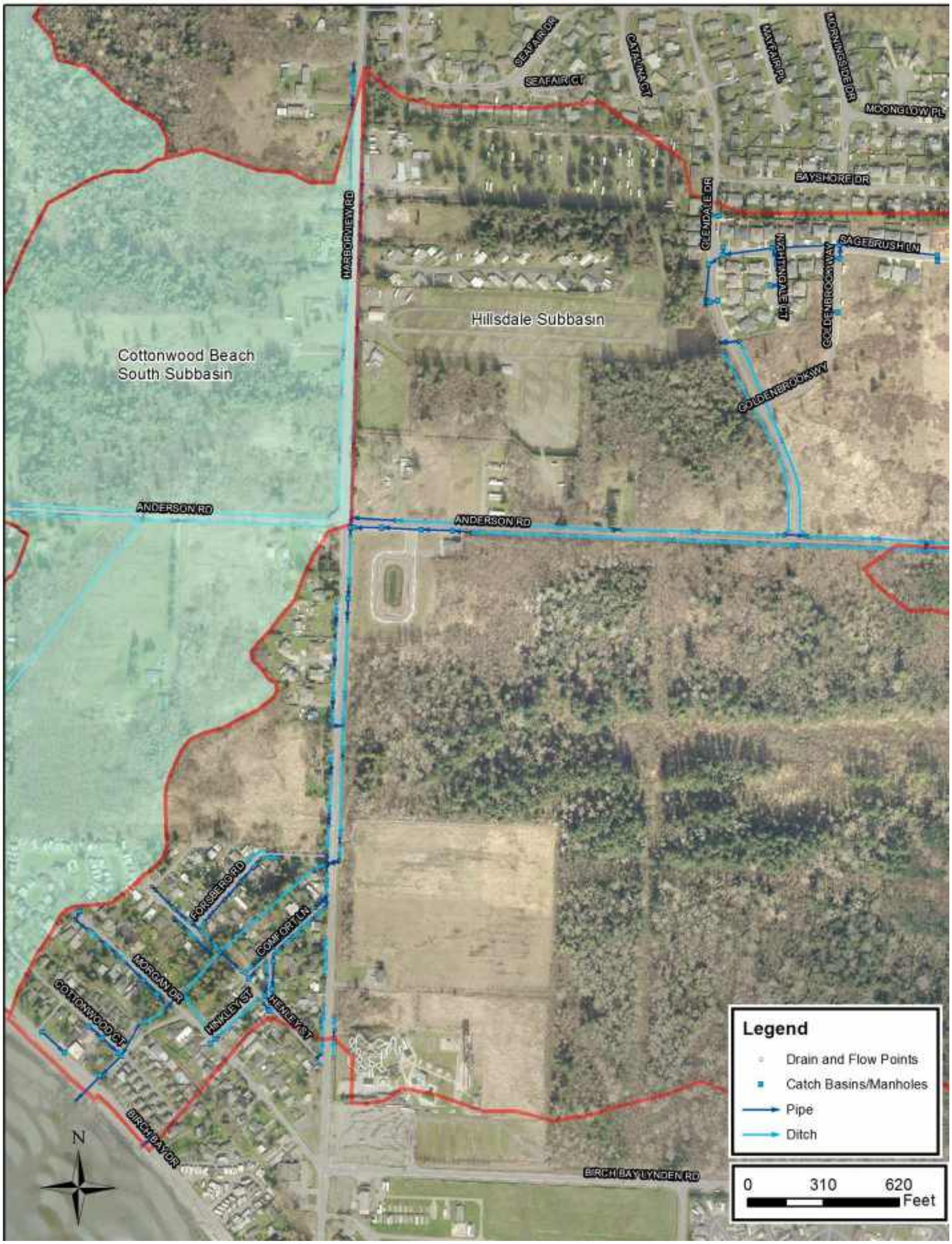

Figure A-3 Stormwater Inventory—Hillsdale Subbasin

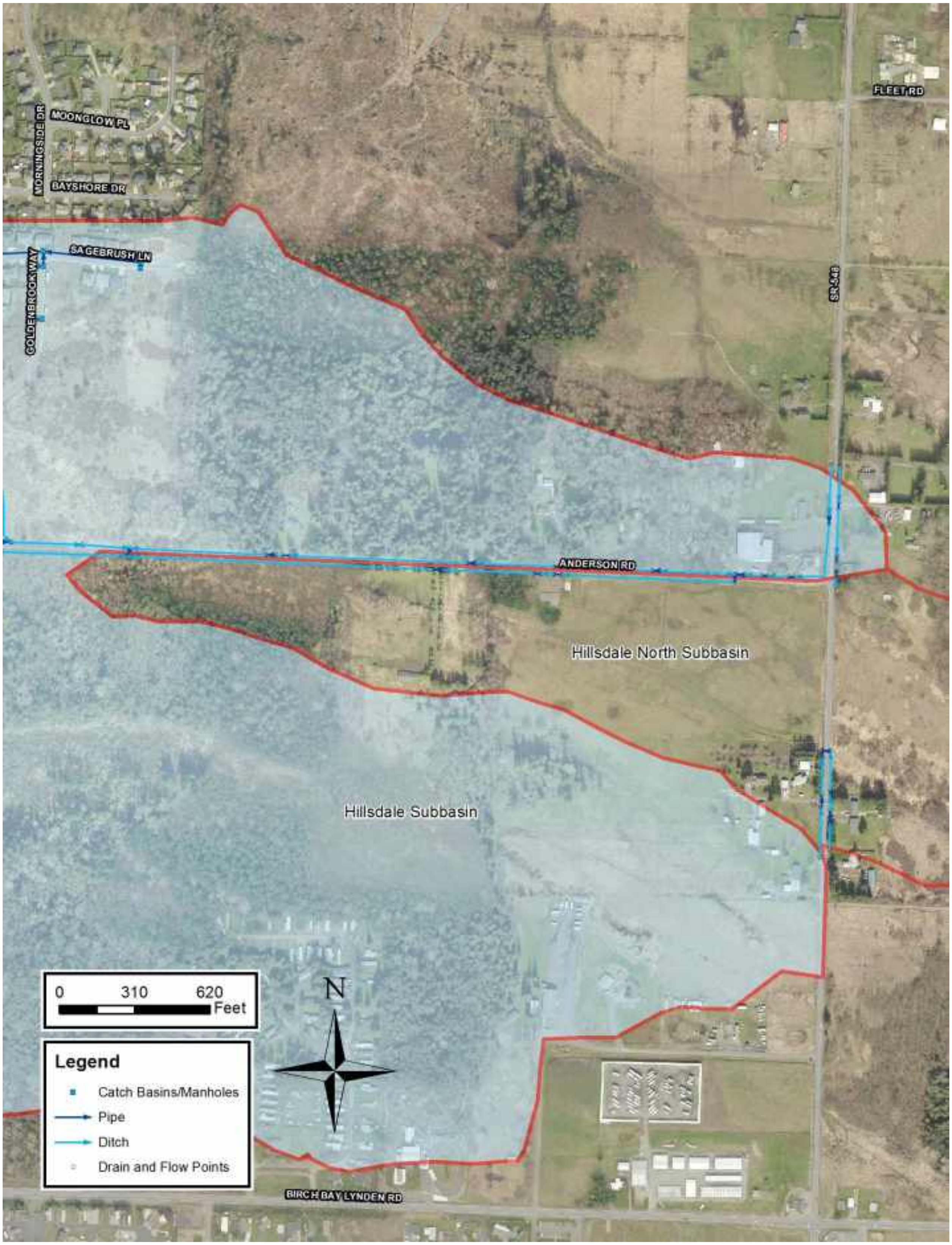

Figure A-4 Stormwater Inventory—Hillsdale North Subbasin

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Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Central North Subwatershed Master Plan

APPENDIX B. HYDROLOGIC AND HYDRAULIC ANALYSIS

Technical Memorandum

Whatcom County Stormwater Division
HYDROLOGIC AND HYDRAULIC ANALYSIS OF THE SURFACE WATER SYSTEM IN THE CENTRAL NORTH SUBWATERSHED

INTRODUCTION

Hydrologic and hydraulic analysis was performed for the Central North subwatershed on the north side of Birch Bay. The purpose of this analysis was to support the Birch Bay Central North Subwatershed Master Plan. The objectives of the hydrologic and hydraulic modeling are as follows:

- Develop an understanding of the hydrologic regime in the Central North subwatershed.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems in the subbasins.
- Analyze the effects of increased impervious area associated with future development activity.
- Evaluate flow reduction potential associated with alternative low-impact development scenarios.

The storm drainage system was analyzed using the HSPF model (USEPA, 2005) to simulate runoff from each subbasins and the SWMM5 model (USEPA, 2011) to analyze the hydraulics of natural and constructed surface water drainage systems. The models developed for this study are planning level models. Planning level models are typically developed at a coarser scale than design models and are useful for estimating system flow rates, identifying potential problem areas, sizing infrastructure improvements for cost estimating purposes, and analyzing relative impacts of land use changes. Detailed survey was used for this analysis, which improves the model accuracy, but care should still be taken in interpreting the results. If the findings from this analysis are used for design, model development should be critically reviewed to be sure the assumptions used are applicable and that appropriate safety factors are incorporated into the design process. No calibration was performed for this analysis.

HYDROLOGIC MODEL DEVELOPMENT

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration and ground infiltration. Runoff from discrete subbasins is routed through rating tables used to represent pipes, channels, lakes, and other flood storage areas.

Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct surface runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to stream channels but at a slower rate than direct runoff. Groundwater also discharges to stream channels that intersect the saturated zone, contributing to long-term base flow in the system. Groundwater can also leave the surface watershed by entering deep groundwater or moving outside the surface watershed basin.

Subcatchment Delineation and Hydrologic Response Unit Assignment

The Central North subwatershed was previously delineated as five subbasins, as shown in Figure B-1. For this modeling study, two are treated as a single subbasin; the resulting four subbasins evaluated in this technical memorandum are Shintaffer, Cottonwood Beach North, Cottonwood Beach South, and Hillsdale/Hillsdale North. These subbasins are divided into 46 subcatchments, based on topography and hydraulic control points. The subcatchments are also shown on Figure B-1.

The basin also was divided into 17 categories of hydrologic response units, which are groupings of land cover types based on soils, land cover and topography. Soils and land slope are shown in Figures B-2 and B-3. Hydrologic response units are categorized in HSPF as pervious or impervious. Impervious area estimates developed for the watershed characterization study (ESA Adolfson, 2007) were used as the impervious area input to the HSPF model. The measured impervious area was assumed to be directly connected, based on a comparison that showed the computed impervious fractions for representative land uses to be close to published values for the same land uses (Ecology, 2005). The exception is subcatchment H-10, where 50 percent of the road area in the Birch Bay Campground (Harborview Road between Lincoln Road and Anderson Road) was assumed to be ineffective impervious area.

The HSPF model used regional input parameters appropriate for the Puget Sound area (Dinicola, 1990 and Clear Creek Solutions, 2006). Attachment A presents input parameters and routing schematics.

Land Use

Flow characteristics were computed for existing and future land use conditions at 17 locations in the Central North subwatershed. Existing conditions land use is based on 2008 aerial photography provided by Whatcom County. Future conditions land use represents the full buildout condition based on October 2011 zoning, with the following assumptions:

- Land cover in currently developed areas will not change from current conditions.
- Land cover in undeveloped areas zoned for rural land use (R10A, R5A) will not change from current conditions.
- Undeveloped areas with residential and commercial zoning will fully develop to these land uses.
- Land use conversion will not occur in wetlands, wetland buffer area, and riparian buffer areas.

Existing- and future-condition land uses are shown in Figures 4 and 5.

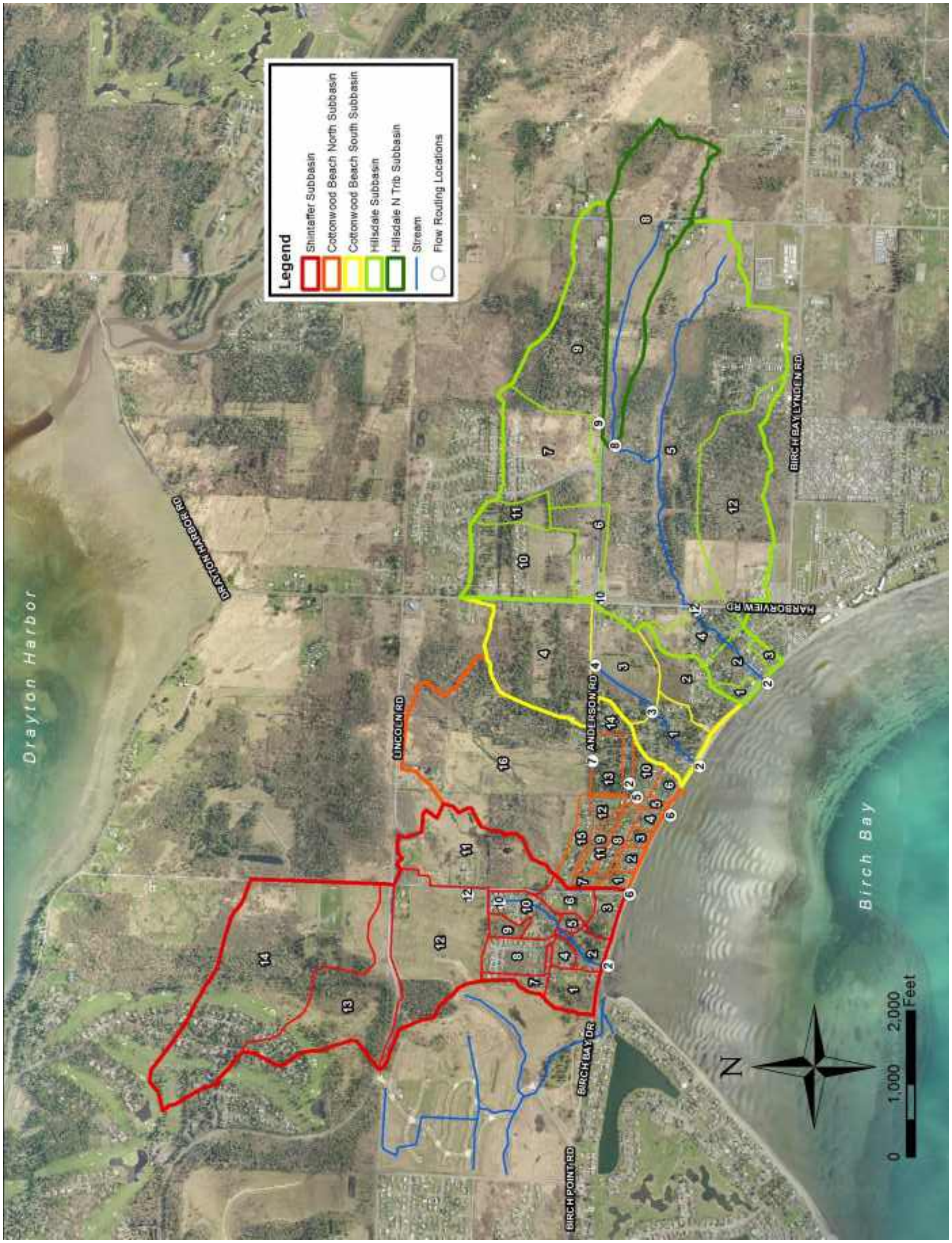

Figure B-1. Subcatchment Delineation

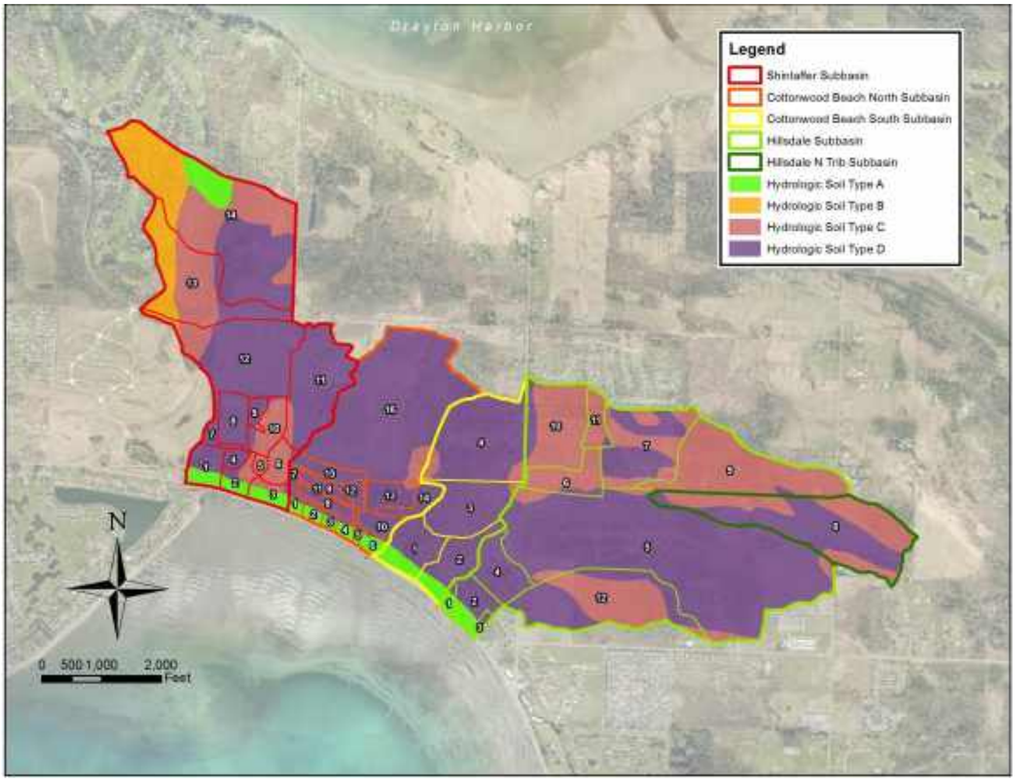

Figure B-2. Soils

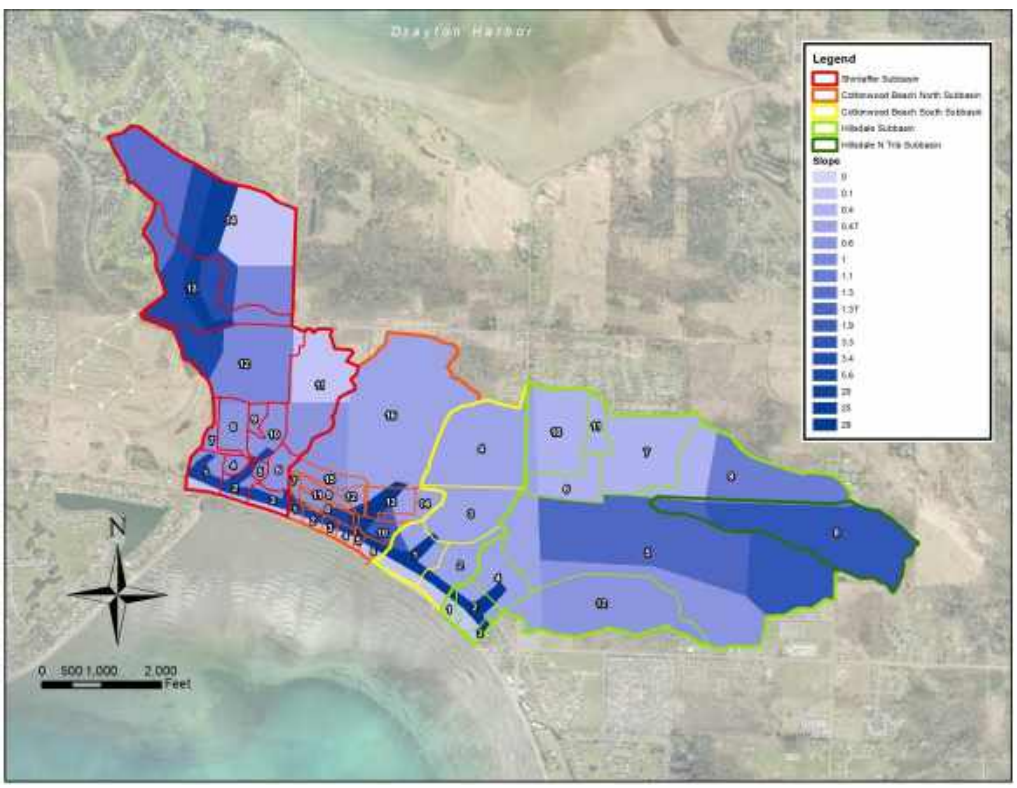

Figure B-3. Slopes

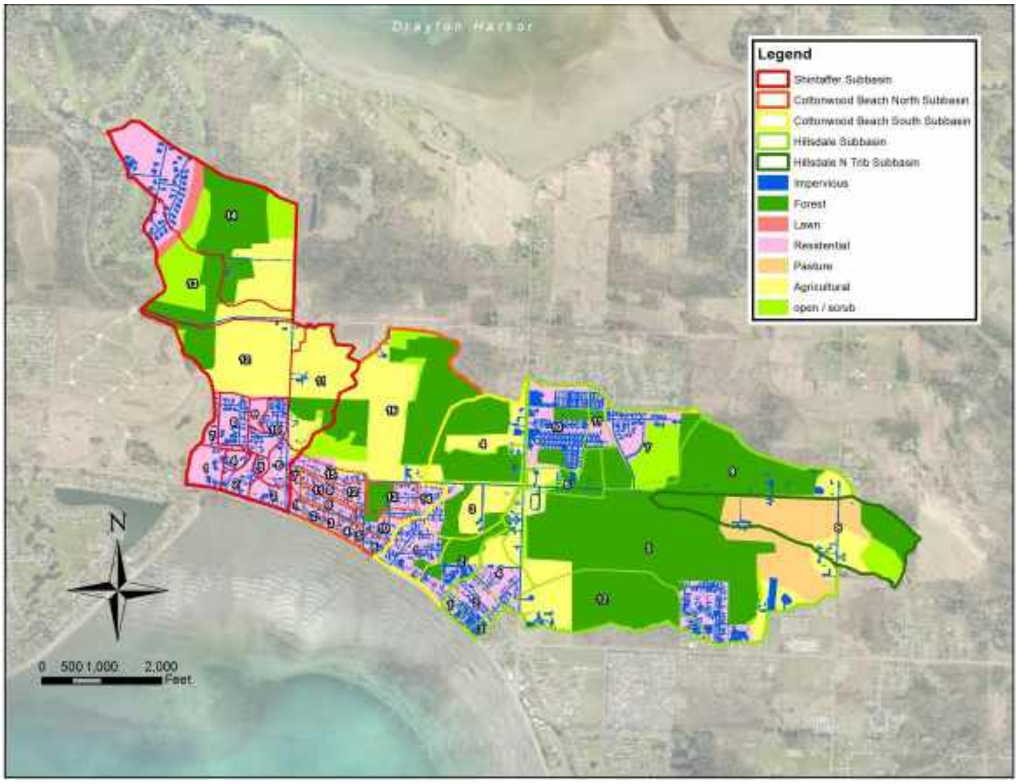

Figure B-4. Existing Land Use

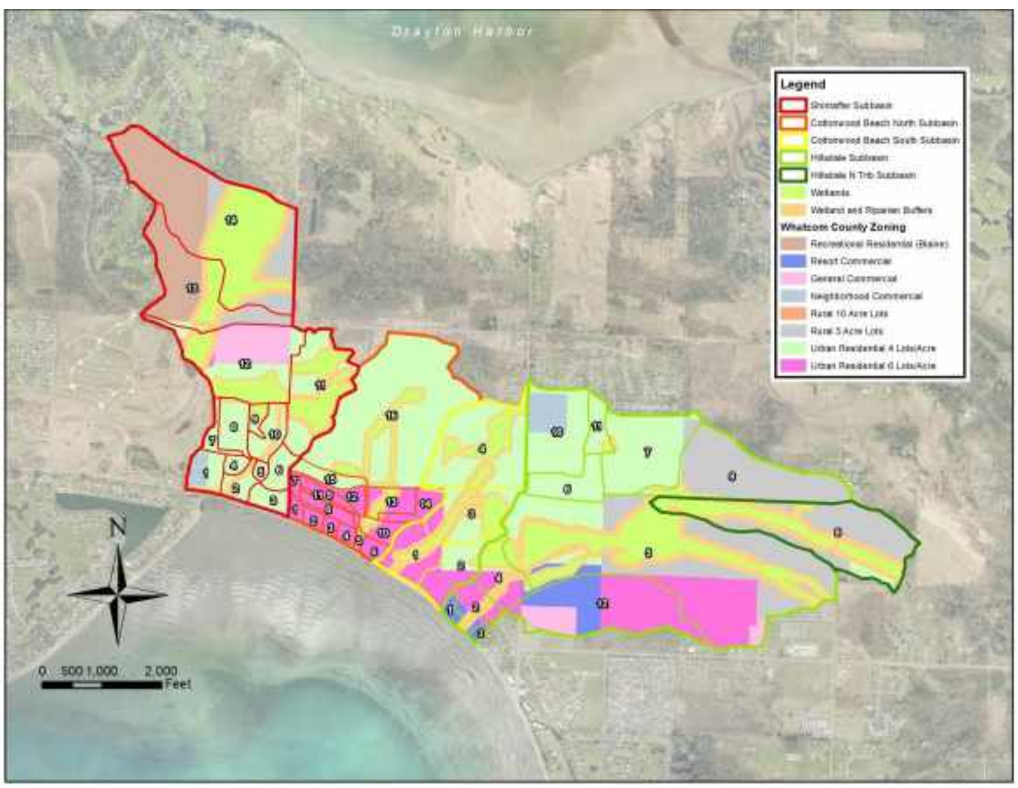

Figure B-5. Future Land Use Allowed by Zoning

Flow Routing Tables

HSPF uses flow routing tables for each subbasin that describe the relationship in a reach between depth, outflow, and surface area, and storage volume. The SWMM5 model of the storm drainage network, described in the next section, was used to develop the flow routing tables for the HSPF model.

Climate Data

Long-term precipitation data collected at Blaine from 1948 to 2010 was used to compute a continuous flow record. The precipitation rainfall record was extended using Bellingham Airport data. Long-term average precipitation data were compared to precipitation data collected by the Birch Bay Water and Sewer District and found to be about equal to the District data. Potential evaporation data was developed from pan evaporation data collected at the Washington State University Extension in Puyallup, Washington, adjusted by a factor 0.76 to account for regional differences in potential evapotranspiration.

Flow Control for Future Development

Chapter 20.80 of the Whatcom County Code (Whatcom County, 2011) requires flow control through stormwater detention for all new development. The flow control standard requires developed-condition peak flow rates to match pre-developed peak flow rates for the 2-, 10-, 25- and 100-year, 24-hour rainfall events. Developments within 1,000 feet of a stream also need to control the 1-year, 24-hour peak flow rate. Pre-developed land cover for the comparison is assumed to be forested or shrub/scrub. The StormShed program (Engenious Software, 1999) was used to compute runoff from each subcatchment for the pre- and post-developed condition, using the Santa Barbara Urban Hydrograph method to be consistent with procedures outlined in the County stormwater design guidance.

A hypothetical regional detention facility was sized for each subcatchment where development was assumed to occur. The developable area was split from the undevelopable or previously developed area and routed through the modeled detention facility. Automatic sizing routines from the StormShed program were used to size the detention pond and flow control structure. HSPF rating tables were developed based on reservoir size and outlet configuration. Table 1 shows the characteristics of the regional reservoirs in the subcatchments where development was assumed to occur.

HYDROLOGIC MODELING RESULTS

Flood Frequency

Flood frequency is the probability that a given flood magnitude will occur in any year. Flood frequency is commonly expressed as a return-period, which is the inverse of the probability, and represents the average interval between occurrences of a specific magnitude flood. For instance, a peak flood with a 50-percent probability of occurring in any given year is equivalent to a 2-year return period ($1 \div 0.5 = 2$). Table 2 shows flood frequency for the primary stormwater conveyance outfall to Birch Bay for each subbasin. Tabulated results for all points where flood frequency was computed are provided in Attachment B.

Flow Duration

Flow duration is the amount of time (generally expressed as a percent of total) for which a given flow is equaled or exceeded. Flow duration analysis provides information on basin hydrology during non-flood events. For example, extended periods of high flow can contribute to streambank erosion and excessive sediment transport. Conversely, low flow periods can impede fish passage. Table 3 shows the flow duration for the 2-year peak flow event in the Central North subwatershed.

TABLE 1
REGIONAL DETENTION STORAGE CHARACTERISTICS FOR FUTURE CONDITIONS

Subcatchment	Storage Volume (acre-feet)	Minimum Peak Control Standard	Release Rate (cfs) 2-Year	Release Rate (cfs) 25-Year	Release Rate (cfs) 100-Year
S-11	0.8	2-year	0.72	2.23	5.08
S-12	2.6	1-year	1.95	7.93	12.66
S-13	2.4	2-year	0.42	2.56	5.38
CBN-16	5.3	1-year	3.88	20.52	34.18
CBS-2	0.7	2-year	0.25	1.39	2.39
CBS-3	0.5	1-year	0.31	1.48	2.44
CBS-4	2.6	2-year	1.03	3.84	9.76
H-5	3.7	1-year	2.57	11.22	18.23
H-6	1.2	2-year	0.25	1.63	3.21
H-7	2.1	2-year	0.73	4.32	7.60
H-12	5.9	2-year	1.39	8.82	15.89

cfs = cubic feet per second

TABLE 2
PEAK FLOOD FREQUENCY IN CENTRAL NORTH SUBWATERSHED

		2-year Peak Flow (cfs)			10-year Peak Flow (cfs)			25-year Peak Flow (cfs)			50-year Peak Flow (cfs)			100-year Peak Flow (cfs)		
ID[a]	Location	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.
Shintaffer Subbasin																
SH02	Birch Bay Drive	13.0	13.4	3%	21.4	21.3	-1%	25.2	24.8	-2%	27.9	27.3	-2%	30.4	29.7	-2%
SH10	Richmond Park	10.0	10.3	3%	16.2	16.2	0%	18.9	18.6	-1%	20.6	20.3	-2%	22.2	21.8	-2%
SH12	Shintaffer West	8.6	8.9	3%	14.1	13.9	-1%	16.4	16.0	-2%	17.9	17.3	-3%	19.2	18.6	-3%
SH06	Shintaffer East	2.1	2.2	4%	4.4	4.2	-5%	5.6	5.3	-6%	6.6	6.3	-6%	7.7	7.3	-5%
Cottonwood Beach North Subbasin																
CN06	Birch Bay Drive	11.0	10.2	-7%	25.3	22.7	-10%	34.4	31.0	-10%	42.1	38.1	-10%	50.5	46.1	-9%
CN05	Fern Street	9.1	8.2	-9%	22.3	20.0	-10%	30.9	28.1	-9%	38.2	35.2	-8%	46.1	43.2	-6%
CN02	Alder Street	7.7	6.8	-11%	20.1	17.9	-11%	28.1	26.0	-7%	34.7	33.2	-4%	41.7	41.5	0%
CN07	Anderson Road	6.4	5.7	-11%	17.8	16.0	-10%	25.3	24.0	-5%	31.6	31.3	-1%	38.3	40.1	5%
Cottonwood Beach South Subbasin																
CS02	Birch Bay Drive West	6.6	6.2	-5%	13.5	11.8	-13%	17.6	15.0	-15%	20.8	17.6	-16%	24.2	20.2	-16%
CS03	Cedar Street	4.0	3.5	-14%	9.8	7.5	-24%	13.1	9.9	-24%	15.6	11.9	-24%	18.2	14.1	-23%
CS04	Anderson Road	2.4	2.0	-17%	6.5	4.4	-33%	8.9	6.0	-32%	10.8	7.5	-31%	12.6	9.1	-28%

TABLE 2
PEAK FLOOD FREQUENCY IN CENTRAL NORTH SUBWATERSHED

		2-year Peak Flow (cfs)			10-year Peak Flow (cfs)			25-year Peak Flow (cfs)			50-year Peak Flow (cfs)			100-year Peak Flow (cfs)		
ID[a]	Location	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.	Ex.	Fu.	Diff.
Hillsdale/Hillsdale North Subbasins																
HL02	Birch Bay Drive	25.3	24.5	-3%	47.6	45.0	-6%	58.8	55.5	-6%	66.9	63.3	-5%	74.9	71.1	-5%
HL12	Harborview at Fosberg	22.8	22.1	-3%	43.5	40.9	-6%	53.6	50.5	-6%	60.9	57.6	-6%	68.0	64.6	-5%
HL05	Harborview	16.4	15.4	-6%	41.1	36.9	-10%	56.5	50.4	-11%	69.0	61.4	-11%	82.3	73.2	-11%
HL08	DS Anderson Road	3.2	3.2	0%	8.3	8.3	0%	11.4	11.4	0%	13.9	13.9	0%	16.6	16.6	0%
HL09	DS Anderson Road	2.3	2.3	0%	5.9	5.1	-15%	8.2	6.9	-16%	10.1	8.5	-16%	12.2	10.3	-16%
HL10	Harborview at Anderson	4.6	4.7	2%	8.5	8.7	3%	11.2	11.6	3%	13.6	14.1	3%	16.4	17.0	3%

Ex. = Existing, Fu. = Future. Diff. = Difference, cfs = cubic feet per second
a. See Figure B-1.

TABLE 3
CENTRAL NORTH SUBWATERSHED FLOW DURATION FOR 2-YEAR PEAK FLOW

			Flow Duration (Days		
ID[a]	Location	Existing-Condition 2-Year Peak Flow Rate (cubic feet/second)	Existing	Future	Change
Shintaffer Subbasin					
SH02	Birch Bay Drive	13.0	10.5	10.6	0.1
SH10	Richmond Park	10.0	15.0	15.8	0.8
SH12	Shintaffer West	8.6	18.5	19.2	0.7
SH06	Shintaffer East	2.1	21.4	21.5	0.1
Cottonwood Beach North Subbasin					
CN06	Birch Bay Drive	11.0	8.4	6.3	-2.1
CN05	Fern Street	9.1	10.1	8.0	-2.1
CN02	Alder Street	7.7	11.3	9.3	-2.0
CN07	Anderson Road	6.4	11.6	9.7	-1.9
Cottonwood Beach South Subbasin					
CS02	Birch Bay Drive West	6.6	8.4	6.0	-2.4
CS03	Cedar Street	4.0	14.1	9.3	-4.8
CS04	Anderson Road	2.4	15.6	7.9	-7.7
Hillsdale/Hillsdale North Subbasins					
HL02	Birch Bay Drive	25.3	17.8	16.5	-1.3
HL12	Harborview at Fosberg	22.8	3.4	3.0	-0.3
HL05	Harborview	16.4	20.3	18.0	-2.3
HL08	DS Anderson Road	3.2	14.8	14.8	0.0
HL10	Harborview at Anderson	4.6	3.1	4.2	1.1

a. See Figure B-1 and Plate 1

HYDRAULIC MODEL DEVELOPMENT

The storm drainage system in the Central North subwatershed is complex hydraulic and requires a sophisticated hydraulic model such as the SWMM5 model (USEPA, 2011). SWMM5 can represent tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as natural and constructed detention facilities. It is well-suited for hydraulic analysis of the Central North storm drainage system.

Runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. The routing portion of SWMM5 conveys this runoff through a system of pipes, channels, storage, and outfalls. SWMM5 tracks the flow rate and flow of water in each pipe and channel.

Model Extents

Separate SWMM5 models were developed for each HSPF subbasin: Shintaffer, Cottonwood Beach North, Cottonwood Beach South and Hillsdale/Hillsdale North. The SWMM5 models generally include all surveyed pipes and ditches, although very short conduits were eliminated to improve stability. Model extents are shown on Plate 1.

Conveyance System Data Inputs

The storm drainage inventory data collected for this project by County surveyors was used as the primary source of data for the SWMM5 model network. This data consisted of pipe, culvert, ditches, manholes, catch basins, and drain points. Other data sources included a topographic grid surface derived from LIDAR mapping and observations made during field reconnaissance.

Storm drain and culvert pipe characteristics were obtained from the inventory data. Data elements included pipe size, upstream and downstream invert elevations, pipe material, and conduit length. Catch basin and manhole information was also obtained from the inventory. Data elements included geographic coordinates (northing and easting), rim elevation and structure invert elevation. Manning’s roughness coefficients for pipes were based on pipe material assuming fair condition. Smooth pipes (e.g. concrete, polyvinyl chloride, high density polyethylene) were assigned a roughness coefficient of 0.013 and rough pipes (e.g. corrugated metal) were assigned a coefficient of 0.024. An entrance loss coefficient was assigned to pipes where flow transitions from open-channel flow to piped flow. An exit loss coefficient of 1.0 was assumed for pipes that discharge to open channels or Birch Bay.

Approximately five structures were included in the model but were not located during inventory data collection because they were either inaccessible or completely buried. These structures were included because they are critical connecting structures, but their location and geometry was approximately defined.

Open channel (roadside ditch and natural channel) characteristics were estimated from approximate field measurements for bottom width, side slope, and depth. Invert elevations were provided in the storm drainage inventory. Roadside ditches and natural channels were assumed to have a trapezoidal shape with varying width and depth. Channel dimensions were based primarily on a windshield survey, with measurements obtained at representative channel sections. Channels were assigned a roughness coefficient of 0.030, assuming an average maintained condition. The level of accuracy used to dimension ditch channel sections is appropriate for this planning-level analysis because flow through the roadside ditch and culvert system in the Central North subwatershed is controlled by culvert size and material rather than channel characteristics.

Generally, overflow channels for roadway culverts were not included in the model unless preliminary model runs indicted surface flooding. For these cases, overflow conduits were added as approximate open channels with a 10-foot bottom width and 10:1 side slopes.

Overtopping elevation for surveyed structures corresponded to the rim elevation of the catch basin or manhole. Overtopping for drain points associated with open channels was estimated from the LIDAR mapping. This elevation was computed by finding the intersection with the LIDAR topographic grid 10 feet left and right perpendicular to the conveyance element. The minimum perpendicular value was assigned to be the overtopping elevation. The LIDAR derived data were adjusted at some locations where it was determined to be inaccurate due to vegetation or other obstructions. For these cases, overtopping elevation was replaced with a value obtained from a nearby point in an unobstructed area.

Model nodes, representing catch basin, manholes, drain points, and other connection points are named using the GPS ID specified during the inventory survey. Nodes with approximate data (i.e. not surveyed) are identified using an upstream or downstream node ID with a letter suffix "A." Suffix letters were incremented by one if more than one node was required. Conduits, representing pipes and channels, are named using the upstream and downstream nodes with a "P-" prefix for pipes and "D-" prefix for open channels. For example, Conduit D-1180-1184 represents a ditch flowing from Node 1180 to Node 1184.

Boundary Conditions

Birch Bay tidal data were used as the downstream boundary at the pipe outfalls. The National Oceanic and Atmospheric Agency measures tides at the Cherry Point station (Cherry Point, WA Station ID 9449424), located about 3 miles south of Birch Bay (NOAA, 2011). Predicted tidal data downloaded from this station was referenced to the mean lower low water datum and was converted to NAVD88 (North American Vertical Datum of 1988) by an adjustment factor of –0.66 feet. The adjustment factor was obtained by comparing measured tide depths at Outfall 747 on November 4, 2011 to observed data at the tide station for the same time period.

Inflow Nodes

Runoff time-series were exported from the HSPF model for each subcatchment shown in Figure B-1. Runoff time-series were input to the SWMM5 model at discrete locations corresponding to the HSPF subcatchments. The SWMM5 model has a higher level of detail for the conveyance system than the HSPF model, so the runoff time series flows were split based on approximate tributary area. Inflow nodes are shown on Plate 1.

Design Events

Design event hydrographs were extracted from the HSPF time-series data to represent the 2-, 10-, and 100-year peak flow conditions. For each subbasin, daily peak flows generated by the existing conditions HSPF model were reviewed to identify days with peak flows corresponding to the peak flood frequency for each return period. For some cases, no peak events occurred with flow rates at the 100-year level, so the largest recorded peak event hydrograph was adjusted to match the 100-year peak flow. Table 4 lists the time periods that correspond to peak flow events in the Central North subwatershed.

TABLE 4 DESIGN EVENTS FOR HYDRAULIC INPUT				
Return Period	Shintaffer Subbasin	Cottonwood Beach North Subbasin	Cottonwood Beach South Subbasin	Hillsdale/Hillsdale North Subbasins
2-year	3/31/1957	12/3/1975	2/21/1992	2/9/1985
10-year	12/29/1996	2/15/1986	2/15/1986	2/10/1985
25-year	12/30/1983	12/29/1983	12/29/1983	12/30/1983
100-year	12/29/1996	12/29/1983	12/29/1983	12/29/1983
Scaling Factor for 100-year	1.21	1.25	1.10	1.18

HYDRAULIC MODELING RESULTS

Design event flow hydrographs described in Table 4 were routed through the SWMM5 hydraulic models to estimate peak flows and depths throughout the Central North subwatershed. The results of the hydraulic analysis were used to evaluate the performance of the stormwater conveyance system, identify flood problem areas in the subwatershed and capacity limitations in the storm drainage network.

System Performance

The hydraulic analysis showed that the storm drain system in the Central North subwatershed has adequate capacity throughout the basin to convey the 25-year event. However, there are several conveyance systems with significant restrictions. Most notably, flooding was predicted along the entire length of Birch Bay Drive. Other notable flood locations include the following:

- Richmond Park and Shintaffer Road (Shintaffer subbasin)
- Open pipe connection near Seaview and Maple Crest Avenues (Cottonwood Beach North subbasin)
- Harborview Road near Anderson Road (Cottonwood Beach South subbasin)
- Harborview Road at Anderson Road and north (Hillsdale subbasin)
- Beachway Drive (Hillsdale subbasin)

Deep ravines that are the primary drainageways in each subbasin provide limited peak flow attenuation. Generally, flood problems are not expected to increase with future development if current development standards for large developments are followed. The exception is Alder Street in the Cottonwood Beach North subbasin, where flooding is expected during the future-condition 100-year event.

During peak events, storm runoff overflows from the Cottonwood Beach South subbasin to the Cottonwood Beach North subbasin on the north side of Anderson Road. However, the overflow rate is relatively small. Flow diversion occurs more regularly in the Hillsdale subbasin, where stormwater flows out of the basin on the east side of Harborview Road near Henley Street. Internal diversion occurs extensively in the Hillsdale/Hillsdale North subbasin between Anderson Park, Anderson Road, and Harborview Road. Inter-subbasin overflow is described in Table 5.

TABLE 5
SUBBASIN OVERFLOWS

Return Frequency	Overflow (cubic feet/second): From Cottonwood South Subbasin to Cottonwood North Subbasin via North Side Anderson Road	Overflow (cubic feet/second): Out of Hillsdale Subbasin via East Side of Harborview Road
2-year	0.2	None
10-year	0.7	2.9
25-year	2.2	5.9
100-year	2.8	8.7

High ponding was predicted at the eastern fringe of the Central North subwatershed at Shintaffer Road and Harborview Road. Ponding in these areas may be an indication of flow out of the Birch Bay watershed and into the Drayton Harbor watershed. However, runoff from the Drayton Harbor watershed was not included in the model. It is possible that runoff from the Drayton Harbor basin may fill the very flat channel in this area and prevent any significant overflow from the Birch Bay basin. Additional data collection and analysis may be needed to reduce the uncertainty in the flow simulation for these areas.

Flood Problem Areas

Design analysis was performed using the SWMM5 models to identify locations where flooding is predicted under existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the assumed overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause of flooding. The analysis showed that flooding is predicted at 19 locations in the Central North subwatershed. Six flood problem areas had been identified as areas were flooding occurred in the past; flood problems had not previously been identified at the other 12 locations. Table 6 lists the flood problem areas by subbasin. Flood problem areas are also shown on Figure 6. Full model output is provided in Attachment C.

System Capacity

Output from the hydraulic models was reviewed to evaluate the conveyance capacity of the primary conveyance route for each subbasin. Many of the problem areas identified in Table 6 are due to capacity restrictions in the conveyance system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Table 7 describes the capacity analysis for the Central North subwatershed. This table shows that the 25-year peak flow event exceeds the system conveyance capacity at the Cottonwood Beach North, Cottonwood Beach South, and Hillsdale subbasins. System capacity is exceeded for all events for the 100-year peak flow events.

TABLE 6
DRAINAGE PROBLEMS IDENTIFIED FROM HYDRAULIC MODELING

ID	Location	Extent	Triggering Flood Event Existing	Triggering Flood Event Future	Probable Cause
Shintaffer Subbasin					
SH-F-1	Birch Bay Drive	Birch Bay drive east of Deer Trail	100-year	100-year	Tailwater from Birch Bay outfall pipe at Deer Trail.
SH-F-2	Cherry Tree Lane	West end Cherry Tree Lane	All	All	Ponding during all events due to adverse grade in downstream ditch and culvert system.
SH-F-3	Shintaffer Road near Anderson Road	East and west side of Shintaffer Road approximately 350' north and south of Anderson Road	10-year	10-year	Undersized culvert and storm drain located approximately 200 and 300 feet south of Anderson Road. Anderson Road culvert may also be undersized. Flow through roadside culverts restricted due tailwater condition.
SH-F-4	Shintaffer Road north of Anderson Road	West side of Shintaffer Road approximately 350' north to 1,500 north of Anderson Road	10-year	10-year	Flow through roadside culverts restricted due to tailwater condition caused by SH-F-3.
SH-F-5	Richmond Park	Richmond Park Road	10-year	10-year	Undersized culverts on east side of Richmond Park Road.
SH-F-6	Shintaffer Road near Shintaffer Court	West side Shintaffer Road in the vicinity of Shintaffer Court	100-year	100-year	Undersized culverts aggravated by high tailwater in downstream system.
SH-F-7	Birch Bay Drive at Shintaffer Road	Birch Bay Drive at Shintaffer Road	100-year	100-year	Overflow from Shintaffer Road (SH-F-3) flows to Birch Bay Drive causing ponding adjacent to roadway.
Cottonwood Beach North Subbasin					
CN-F-1	Birch Bay Drive	Birch Bay Drive east of Shintaffer Road	10-year	10-year	Insufficient cover and tailwater from Birch Bay outfall pipe at Deer Trail.
CN-F-2	Birch Bay Drive	Birch Bay Drive west of Cedar Street	All	All	Undersized storm drain system (4" pipe).
CN-F-3	Seaview Drive and Maple Crest Ave.	100' south of intersection of Seaview Drive and Maple Crest Ave.	100-year	100-year	Undersized outfall pipes.
CN-F-4	Alder Street at Alder Park	Stream crossing at Alder Street	None	100-year	Alder Street culvert undersized to handle increased flow predicted from future development.
CN-F-5	Anderson Road west of Sunset	North side of Anderson Road west of Sunset	100-year	100-year	Undersized culverts aggravated by high tailwater in downstream system.

TABLE 6
DRAINAGE PROBLEMS IDENTIFIED FROM HYDRAULIC MODELING

ID	Location	Extent	Triggering Flood Event: Existing	Triggering Flood Event: Future	Probable Cause
Cottonwood Beach South Subbasin					
CS-F-1	Birch Bay Drive	Birch Bay Drive at Beachway Drive	10-year	10-year	Undersized storm drain, insufficient cover aggravated by tailwater from Birch Bay outfall.
CS-F-2	Birch Bay Drive	Birch Bay drive midway between Beachway Drive and Cottonwood Drive	100-year	100-year	Undersized storm drain, insufficient cover aggravated by tailwater from Birch Bay outfall.
CS-F-3	Harborview Drive	West side Harborview Drive 1,000' north of Anderson Road	100-year	100-year	Undersized culverts.
Hillsdale/Hillsdale North Subbasins					
HL-F-1	Birch Bay Drive	Birch Bay Drive west of Cottonwood Drive	2-year	2-year	Undersized storm drain, insufficient cover aggravated by tailwater from Birch Bay outfall.
HL-F-2	Birch Bay Drive	Birch Bay Drive east of Cottonwood Drive	2-year	2-year	Undersized storm drain, insufficient cover aggravated by tidal tailwater at Birch Bay outfall.
HL-F-3	Cottonwood Drive	Cottonwood Drive from pipeline inlet to Birch Bay Drive	10-year	10-year	Undersized pipeline and restrictive pipeline inlet aggravated by tidal tailwater at Birch Bay outfall.
HL-F-4	Harborview Drive	East side of Harborview Drive from 300' south to 1,500' north of Anderson Road	10-year	10-year	Undersized culvert located approximately 300 feet south of Anderson Road. Other roadside culvert may also be undersized. Flow through roadside culverts restricted due tailwater condition.

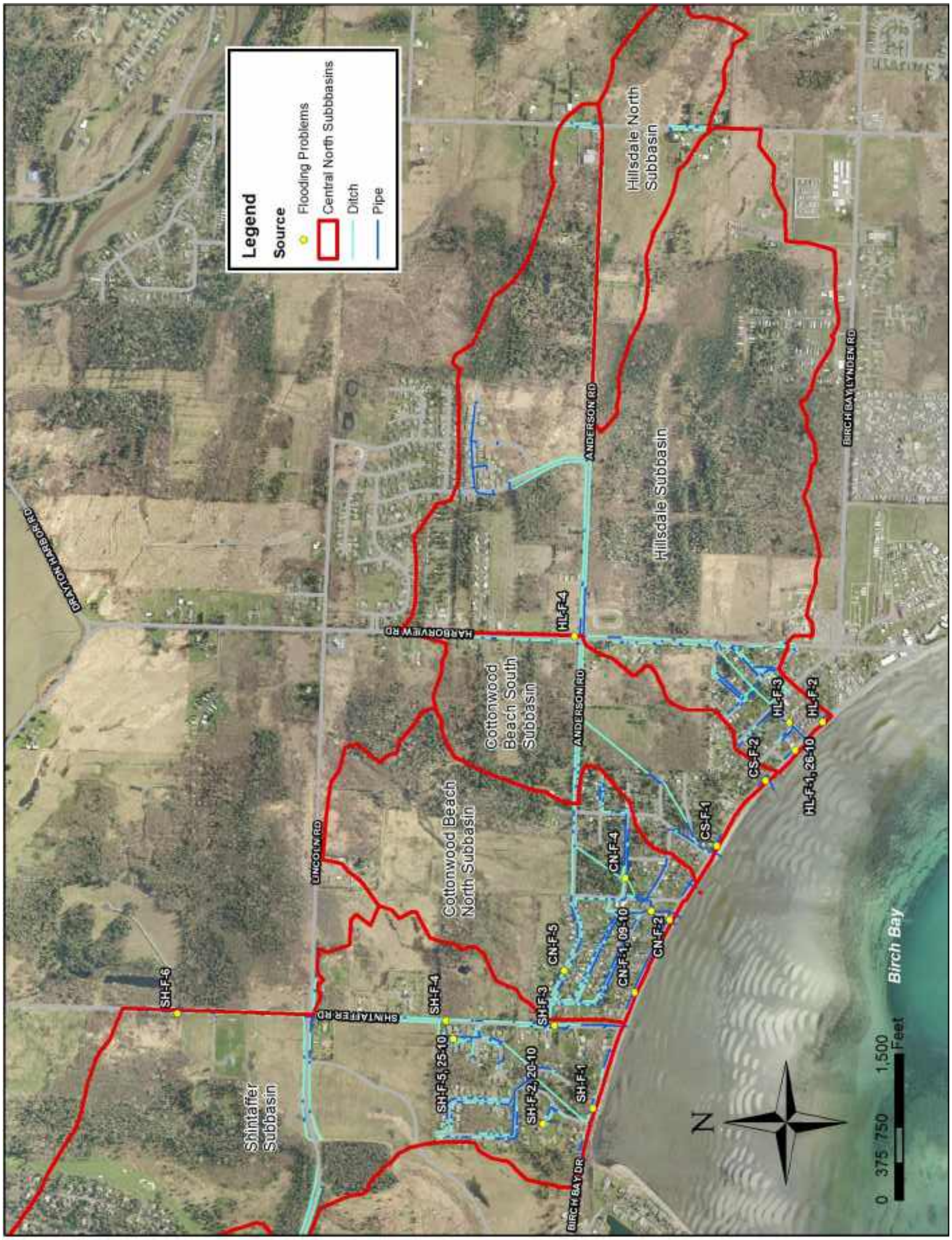

Figure B-6 Flooding Problem Areas

TABLE 7
SYSTEM CAPACITY

Subbasin	Link ID[a]	Location	Pipe Size	Predicted Peak Flow (cfs) 25-Year	Predicted Peak Flow (cfs) 100-Year	Estimated Capacity (cfs)
Shintaffer	P-1353-1354	Deer Trail Road – Outfall 1354	24”	26.7	31.1	27
Shintaffer	P-501-500	Shintaffer Road – Outfall 500	12”	4.4	9.0	9
Cottonwood Beach North	P-700A-730 P-700-726	Twin pipe outfall west of Cedar Ave. - Outfall 726	24”, 18”	30.6	34.3	20
Cottonwood Beach South	P-743-747	Beachway Drive – Outfall 747	18”	19.2	20.2	9
Hillsdale/ Hillsdale North	P-1671-765	Cottonwood Drive - Outfall 765	30”	51.0	57.6	54

cfs = cubic feet per second, ID = Identifier
a. See Plate 1

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ATTACHMENT A.
HSPF LAND CATEGORY ASSIGNMENTS AND ROUTING SCHEMATICS

Table A-1
HSPF Land Category Assignments

	CBN-1	CBN-2	CBN-3	CBN-4	CBN-5	CBN-6	CBN-7	CBN-8	CBN-9	CBN-10	CBN-11	CBN-12	CBN-13	CBN-14	CBN-15	CBN-16	CBS-1	CBS-2	CBS-3	CBS-4	H-1	H-2	H-3
	Cottonwood Beach North Subbasin																ottonwood Beach South Subbasi						
Subbasin	CBN-1	CBN-2	CBN-3	CBN-4	CBN-5	CBN-6	CBN-7	CBN-8	CBN-9	CBN-10	CBN-11	CBN-12	CBN-13	CBN-14	CBN-15	CBN-16	CBS-1	CBS-2	CBS-3	CBS-4	H-1	H-2	H-3
PERLND	2.1	2.4	1.8	2.2	1.1	3.1	2.4	4.2	3.8	5.3	1.1	4.3	8.5	6.6	6.5	101.8	16.6	16.4	25.8	48.0	2.6	10.0	1.9
2 A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
5 A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 A, Lawn, Flat	0.33	0.53	0.49	0.67	0.25	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97	1.66	0.00	0.00	1.09	0.68	0.22
14 A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 A, Lawn, Steep	0.47	0.53	0.18	0.21	0.18	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.23	0.00	0.00	0.04	0.00	0.00
17 B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19 B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20 B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29 B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31 C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93	0.00	0.00	0.00	1.82	0.00	0.00	0.00
32 C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33 C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34 C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.08	0.50	0.00	0.00	0.00
35 C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36 C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37 C, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.53	1.19	0.00	0.00	0.00
39 C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43 C, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.13	0.01	0.05	0.00	0.00	0.03	0.02	0.00	0.00	0.00
44 C, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45 C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46 D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.00	0.16	42.82	0.66	7.35	7.53	29.26	0.00	0.00	0.00
47 D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.14	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48 D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.01	3.26	0.06	0.14	0.02	0.60	0.84	0.00	0.00	0.00	0.00	0.00
49 D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	13.26	0.00	0.00	0.53	1.64	0.00	0.00	0.00
50 D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51 D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52 D, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	39.17	0.00	0.87	11.03	10.89	0.00	0.00	0.00
53 D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54 D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58 D, Lawn, Flat	0.13	0.04	0.00	0.00	0.00	0.00	1.29	1.28	1.99	0.33	0.55	2.62	2.14	3.59	3.67	1.01	3.39	1.27	3.17	0.25	0.03	2.47	0.16
59 D, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00	0.15	0.33	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00
60 D, Lawn, Steep	0.41	0.32	0.39	0.36	0.23	0.34	0.21	1.37	0.32	0.47	0.10	0.31	0.30	0.00	0.00	0.02	2.42	0.40	0.17	0.00	0.35	2.79	0.25
Impervious	0.76	0.94	0.72	0.96	0.47	1.35	0.90	1.58	1.45	1.73	0.49	1.34	1.15	2.23	1.93	1.74	5.96	3.75	2.76	2.39	1.09	4.01	1.22
Hydrologic Soil Type																							
A	2.08	2.36	1.77	2.19	1.13	3.11	2.40	4.23	3.75	5.34	1.13	4.28	8.51	6.56	6.50	101.78	16.71	16.37	25.84	47.96	2.61	9.95	1.86
B	0.79	1.05	0.67	0.88	0.43	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.71	1.90	0.00	0.00	1.13	0.68	0.22
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	0.00	0.00	0.61	3.51	0.00	0.00	0.00
D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.01	4.76	0.41	0.91	95.63	1.26	9.05	19.12	41.81	0.00	0.00	0.00
Land Cover																							
Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.01	4.48	0.29	0.30	44.77	1.34	8.18	7.53	31.08	0.00	0.00	0.00
Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	13.37	0.00	0.00	0.61	2.15	0.00	0.00	0.00
Pasture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	40.82	0.00	0.87	11.56	12.07	0.00	0.00	0.00
Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lawn	1.33	1.42	1.05	1.23	0.65	1.76	1.50	2.66	2.31	2.85	0.65	2.93	2.87	4.05	3.67	1.08	9.33	3.56	3.38	0.27	1.51	5.94	0.64
Slope																							
Flat	0.45	0.57	0.49	0.67	0.25	0.96	1.29	1.28	1.99	0.33	0.55	2.62	3.49	3.72	4.44	99.68	6.01	11.15	22.90	45.57	1.12	3.15	0.39
Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32	0.00	0.00	0.29	0.56	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00
Steep	0.87	0.85	0.57	0.56	0.40	0.80	0.21	1.37	0.32	0.97	0.10	0.32	3.57	0.06	0.14	0.36	3.85	1.47	0.17	0.00	0.39	2.79	0.25
Impervious	0.76	0.94	0.72	0.96	0.47	1.35	0.90	1.58	1.45	1.73	0.49	1.34	1.15	2.23	1.93	1.74	5.96	3.75	2.76	2.39	1.09	4.01	1.22

Table A-1
HSPF Land Category Assignments

		Exsitng Conditions																						
		Hillsdale and Hillsdale N Subbasin									Shintaffer Subbasin													
	Subbasin	H-4	H-5	H-6	H-7	H-8	H-9	H-10	H-11	H-12	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14
	PERLND	15.5	180.0	14.7	39.6	70.0	51.5	33.5	7.5	55.0	8.9	5.9	5.8	2.8	1.7	6.6	3.9	10.1	3.1	9.6	37.2	49.9	44.1	104.5
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.55
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.27	0.42	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.39
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	1.07	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	2.81	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	4.39	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13	21.16
29	B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
31	C, Forest, Flat	0.00	0.92	7.01	4.75	15.47	42.18	5.61	1.33	25.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	4.26	8.27
32	C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.21	2.43	0.00
33	C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.54	5.31
34	C, Shrub, Flat	0.00	0.08	1.03	6.33	2.16	1.13	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.54	6.65
35	C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	4.95	3.10
36	C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	5.42	2.00
37	C, Pasture, Flat	0.00	4.96	3.17	0.48	13.80	5.10	0.52	0.00	1.95	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.59	0.00	0.12	2.24
39	C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00
43	C, Lawn, Flat	0.00	1.03	0.00	4.95	0.00	0.00	11.32	3.45	0.46	0.00	0.56	0.90	0.01	0.98	4.36	0.00	0.00	0.44	4.45	0.62	0.00	0.05	0.45
44	C, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	3.78
45	C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	0.55	0.03	0.08	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00
46	D, Forest, Flat	0.46	21.80	1.43	5.28	0.04	0.03	0.00	0.13	11.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.96	0.00	0.00	8.34
47	D, Forest, Mod	0.00	84.71	0.12	0.00	3.72	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.11	6.53
48	D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
49	D, Shrub, Flat	0.00	1.64	0.00	8.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.88
50	D, Shrub, Mod	0.00	0.77	0.00	0.00	5.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00
52	D, Pasture, Flat	5.74	12.38	0.00	0.00	0.00	0.00	0.00	0.00	11.11	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	26.54	1.47	0.00	6.36
53	D, Pasture, Mod	0.00	28.80	0.00	0.00	26.46	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.00	0.00	0.43	36.66	6.17	12.19
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.55	0.00
58	D, Lawn, Flat	5.07	8.19	0.00	4.20	0.00	0.00	2.30	0.30	1.62	2.53	0.26	0.22	1.88	0.00	0.32	2.51	5.80	2.63	0.93	0.02	0.06	0.00	0.00
59	D, Lawn, Mod	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.70	0.00	0.03	0.00	0.74	0.00	0.00
60	D, Lawn, Steep	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	0.66	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	2.96	14.58	1.94	5.06	2.98	2.30	13.64	2.30	3.22	1.61	1.83	1.55	0.82	0.61	1.62	1.17	3.48	0.00	3.49	1.58	1.35	2.66	7.23
	Hydrologic Soil Type																							
	A	15.48	180.00	14.71	39.64	70.00	51.50	33.53	7.50	55.02	8.89	5.89	5.82	2.77	1.66	6.62	3.89	10.08	3.07	9.60	37.22	49.87	44.10	110.73
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53	1.49	2.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	7.95	3.08
	C	0.00	5.95	11.21	11.56	31.44	48.40	6.26	1.33	27.07	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.88	5.88	24.50	48.77
	D	6.20	151.13	1.56	18.82	35.59	0.80	11.32	3.58	23.11	0.00	1.65	1.45	0.04	1.06	4.62	0.04	0.10	0.44	5.15	34.74	40.87	9.00	39.24
	Land Cover																							
	Forest	0.46	107.43	8.57	10.03	19.23	42.79	5.61	1.46	36.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.13	8.64	13.16	34.84
	Shrub	0.00	2.48	1.03	14.91	7.53	1.13	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	1.31	0.65	16.06	13.15
	Pasture	5.74	46.13	3.17	0.48	40.26	5.28	0.52	0.00	13.06	0.00	0.00	0.00	0.00	0.00	0.13	0.04	0.10	0.00	0.00	27.56	38.44	6.94	20.78
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	6.32	9.38	0.00	9.15	0.00	0.00	13.62	3.74	2.08	7.29	4.06	4.28	1.94	1.06	4.68	2.68	6.50	3.07	6.11	0.64	0.79	5.28	28.53
	Slope																							
	Flat	11.27	50.99	12.64	34.58	31.47	48.43	19.89	5.20	51.80	3.80	1.25	1.78	1.90	0.98	5.00	2.51	5.80	3.07	5.37	35.20	1.53	10.86	55.03
	Mod	0.00	114.44	0.12	0.00	35.55	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.80	0.00	0.03	0.44	46.54	22.97	29.49
	Steep	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.48	2.82	2.50	0.05	0.08	0.00	0.00	0.00	0.00	0.70	0.00	0.45	7.62	12.78
	Impervious	2.96	14.58	1.94	5.06	2.98	2.30	13.64	2.30	3.22	1.61	1.83	1.55	0.82	0.61	1.62	1.17	3.48	0.00	3.49	1.58	1.35	2.66	7.23

Table A-1
HSPF Land Category Assignments

	Subbasin	Total	Shintaffer	CBN	CBS	Hillsdale	Future														
							CBN-16	CBS-2	CBS-3	CBS-4	H-6	H-7	H-12	S-11	S-12	S-13	Total	Shintaffer	CBN	CBS	Hillsdale
	PERLND	1039.7	294.0	157.1	106.8	481.8	101.8	16.4	25.8	48.0	14.7	39.6	55.0	37.2	49.9	44.1	1039.7	294.0	157.1	106.8	481.8
2	A, Forest, Mod	1.1	1.1	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	1.1	0.0	0.0	0.0
3	A, Forest, Steep	4.6	4.6	0.0	0.1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.6	4.6	0.0	0.1	0.0
5	A, Shrub, Mod	0.3	0.3	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3	0.3	0.0	0.0	0.0
6	A, Shrub, Steep	0.2	0.2	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.2	0.0	0.0	0.0
13	A, Lawn, Flat	11.9	3.0	3.2	3.6	2.0	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.9	3.0	3.2	3.6	2.0
14	A, Lawn, Mod	2.4	2.4	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.4	2.4	0.0	0.0	0.0
15	A, Lawn, Steep	7.2	4.1	2.0	1.0	0.0	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.2	4.1	2.0	1.0	0.0
17	B, Forest, Mod	3.7	3.7	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
19	B, Shrub, Flat	0.8	0.8	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
20	B, Shrub, Mod	4.4	4.4	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0
28	B, Lawn, Flat	26.3	26.3	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.97	26.1	26.1	0.0	0.0	0.0
29	B, Lawn, Mod	0.1	0.1	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	4.32	5.0	5.0	0.0	0.0	0.0
31	C, Forest, Flat	118.8	12.7	1.9	1.8	102.4	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.16	0.00	4.08	79.5	12.5	0.0	0.0	67.0
32	C, Forest, Mod	7.6	7.6	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.89	0.86	5.7	5.7	0.0	0.0	0.0
33	C, Forest, Steep	6.9	6.9	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.49	6.9	6.9	0.0	0.0	0.0
34	C, Shrub, Flat	18.9	7.3	0.1	0.6	10.9	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.10	0.00	0.38	10.6	7.1	0.0	0.0	3.5
35	C, Shrub, Mod	8.6	8.6	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.01	3.3	3.3	0.0	0.0	0.0
36	C, Shrub, Steep	7.4	7.4	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.99	3.0	3.0	0.0	0.0	0.0
37	C, Pasture, Flat	36.0	3.0	1.3	1.7	30.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	26.8	2.4	0.0	0.0	24.4
39	C, Pasture, Steep	0.1	0.1	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.1	0.1	0.0	0.0	0.0
43	C, Lawn, Flat	34.5	12.8	0.5	0.1	21.2	2.18	0.00	0.44	2.22	7.42	11.03	11.02	1.01	0.00	0.23	63.9	13.4	2.6	2.7	45.3
44	C, Lawn, Mod	3.9	3.9	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	3.97	8.2	8.2	0.0	0.0	0.0
45	C, Lawn, Steep	2.5	2.5	0.0	0.0	0.0	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.69	5.2	5.2	0.0	0.0	0.0
46	D, Forest, Flat	143.8	14.3	44.1	44.8	40.7	1.42	1.58	5.83	8.91	0.01	0.50	0.00	5.84	0.00	0.00	56.8	14.2	2.7	17.0	23.0
47	D, Forest, Mod	100.8	11.1	0.6	0.0	89.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	2.11	99.9	10.3	0.6	0.0	89.0
48	D, Forest, Steep	6.1	0.7	4.0	1.4	0.0	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.3	0.7	4.0	0.6	0.0
49	D, Shrub, Flat	28.0	2.3	13.3	2.2	10.2	1.05	0.00	0.17	0.99	0.00	0.00	0.00	0.67	0.00	0.00	5.6	1.7	1.1	1.2	1.6
50	D, Shrub, Mod	6.1	0.0	0.0	0.0	6.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.1	0.0	0.0	0.0	6.1
51	D, Shrub, Steep	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.0	0.0	0.0	0.0	0.0
52	D, Pasture, Flat	126.2	34.4	39.7	22.8	29.2	13.30	0.49	7.30	7.21	0.00	0.00	0.00	16.01	0.00	0.00	69.4	22.4	13.9	15.0	18.1
53	D, Pasture, Mod	111.0	55.6	0.0	0.0	55.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	11.42	6.05	85.4	30.0	0.0	0.0	55.4
54	D, Pasture, Steep	1.2	0.9	0.3	0.0	0.0	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.55	1.0	0.8	0.2	0.0	0.0
58	D, Lawn, Flat	68.2	17.2	18.6	8.1	24.3	49.22	4.94	7.07	15.80	0.85	12.29	7.79	7.21	1.01	0.00	162.8	25.3	66.8	31.2	39.4
59	D, Lawn, Mod	5.1	1.6	2.5	0.8	0.2	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.16	8.20	0.04	12.9	9.3	2.5	0.8	0.2
60	D, Lawn, Steep	15.8	3.0	5.1	3.0	4.6	0.11	0.84	0.17	0.00	0.00	0.00	0.00	0.00	0.01	0.00	16.4	3.1	5.2	3.4	4.6
	Impervious	118.9	29.0	19.7	14.9	55.3	34.28	6.61	4.86	12.84	6.35	14.27	36.21	5.86	21.13	11.13	246.0	61.53	52.26	30.26	101.91
	Hydrologic Soil Type																				
	A	27.73	300.2	157.1	106.9	481.8	484.0	488.0	475.3	296.9	288.8	253.1	193.2	193.2	144.7	120.8		145.4	180.6	285.4	307.4
	B	35.28	18.5	5.2	4.6	2.0	4.2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5		7.5	12.9	14.5	47.3
	C	245.36	80.1	3.4	4.1	143.2	143.2	143.2	143.2	137.3	126.1	114.6	83.1	83.1	34.7	28.5		6.8	31.3	80.1	325.4
	D	612.51	138.4	102.5	71.2	252.1	253.7	255.2	249.0	99.0	102.0	83.3	47.8	47.8	47.4	41.2		90.2	99.2	136.7	747.8
	Land Cover																				
	Forest	393.72	62.8	50.6	48.1	232.2	232.2	232.2	231.8	124.3	115.8	105.7	86.5	86.5	43.7	38.1		14.8	27.9	62.8	456.5
	Shrub	74.75	31.4	13.4	2.8	27.2	27.2	27.2	27.2	24.7	23.9	9.0	1.5	1.5	0.3	0.2		2.1	18.2	31.4	106.1
	Pasture	274.54	94.0	41.4	24.5	114.7	114.7	114.7	108.9	62.8	59.7	59.3	19.1	19.1	13.9	13.3		66.3	73.2	94.0	368.5
	Grass	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
	Lawn	177.87	76.9	32.0	16.5	52.4	56.3	59.9	55.5	47.2	51.9	45.4	51.9	51.9	55.0	47.5		43.1	41.1	65.6	239.1
	Slope																				
	Flat	613.41	134.1	122.8	85.6	270.9	271.7	273.1	263.7	213.7	206.1	174.0	148.3	148.3	103.0	88.5		68.2	75.2	129.0	740.7
	Mod	255.33	100.5	3.2	0.8	150.9	150.9	150.9	150.9	36.4	36.3	36.5	1.8	1.8	1.0	1.0		48.0	71.0	100.5	355.8
	Steep	52.14	30.5	11.5	5.5	4.7	7.8	10.0	8.8	8.9	8.9	8.9	8.9	8.9	8.9	9.6		10.1	14.2	24.2	73.8
	Impervious	118.87	29.0	19.7	14.9	55.3	53.6	53.9	51.8	37.8	37.5	33.6	34.1	34.1	31.8	21.7		19.1	20.2	25.6	142.9

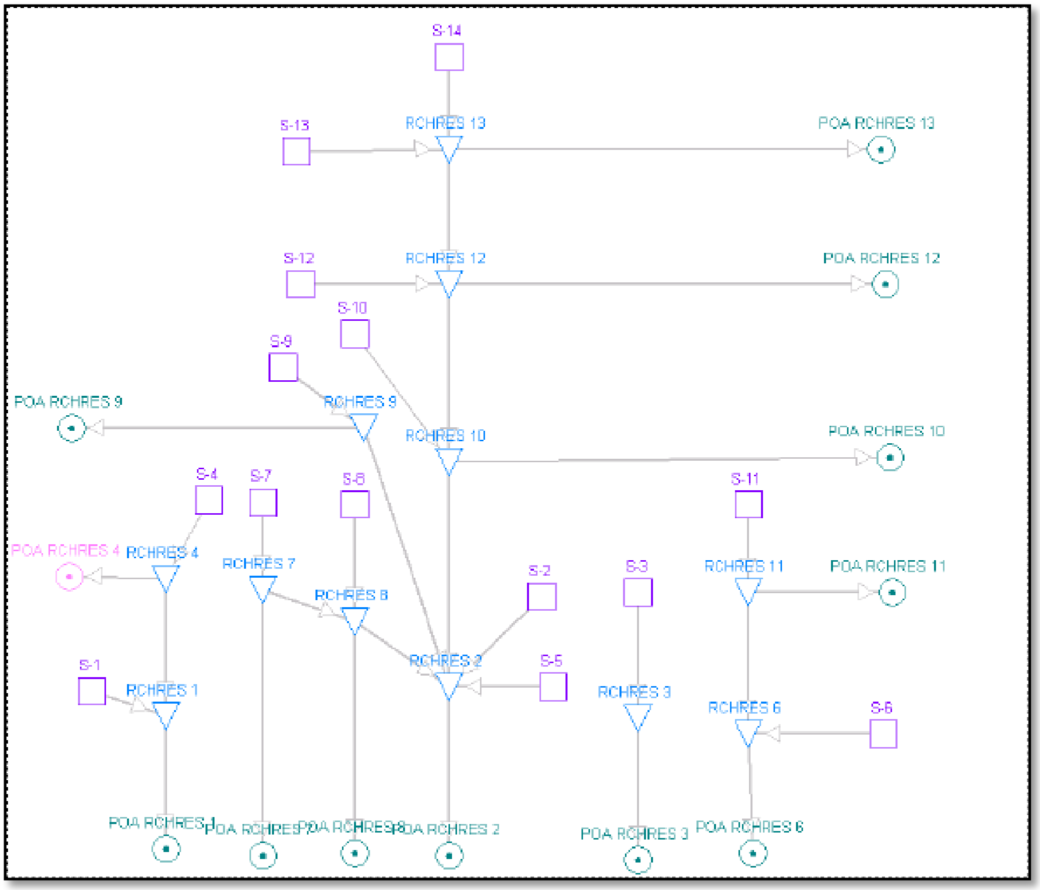


Figure A-1 Shintaffer Subbasin HSPF Routing Schematic

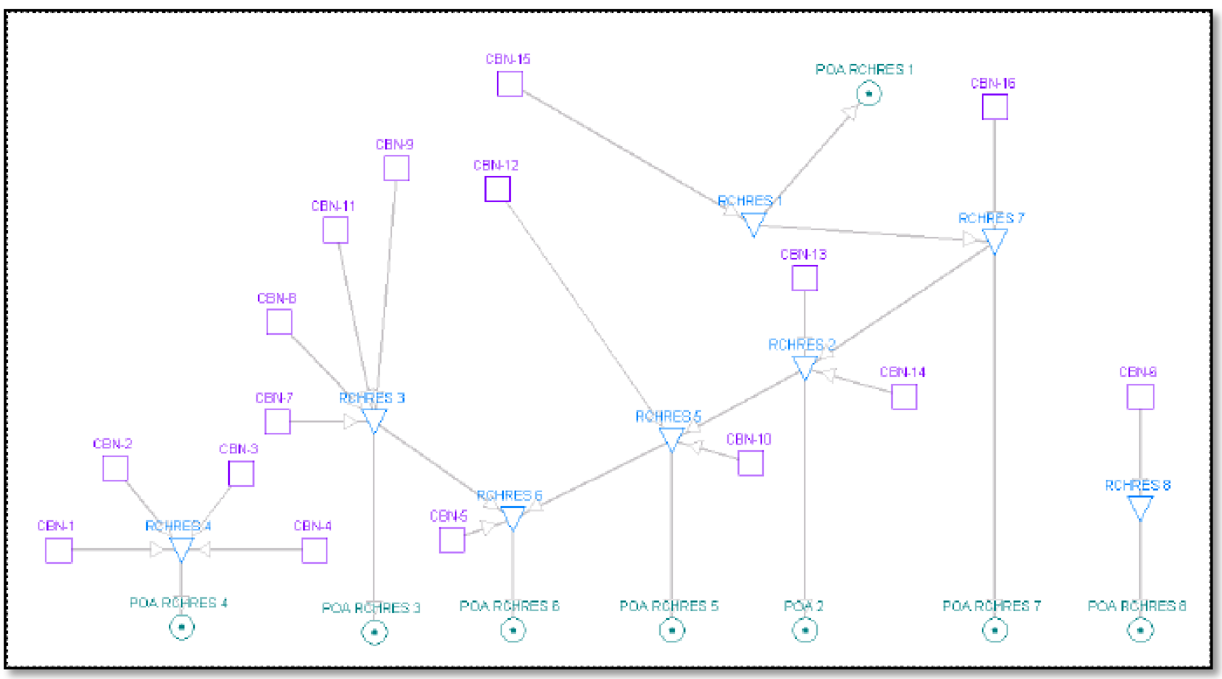


Figure A-2 Cottonwood Beach North Subbasin HSPF Routing Schematic

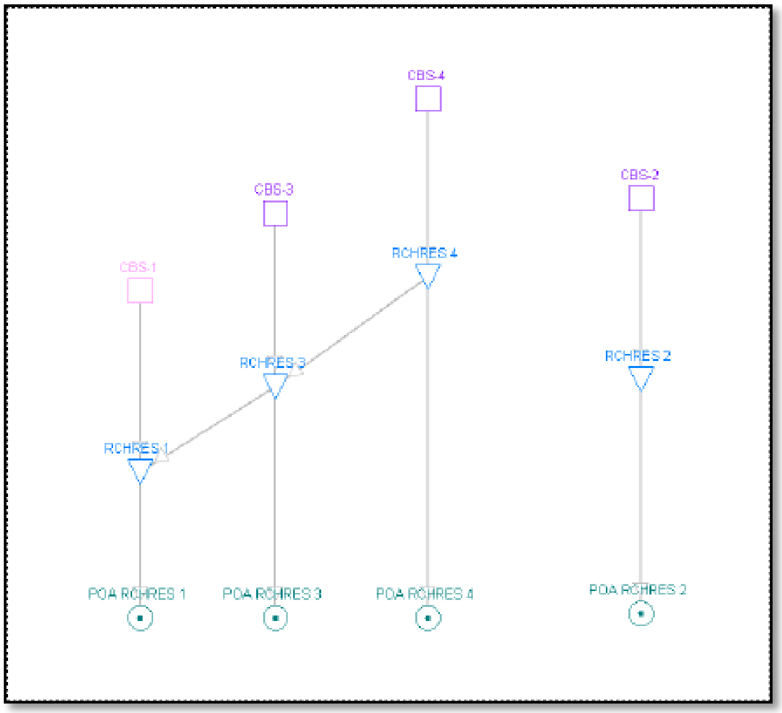


Figure A-3 Cottonwood Beach South Subbasin HSPF Routing Schematic

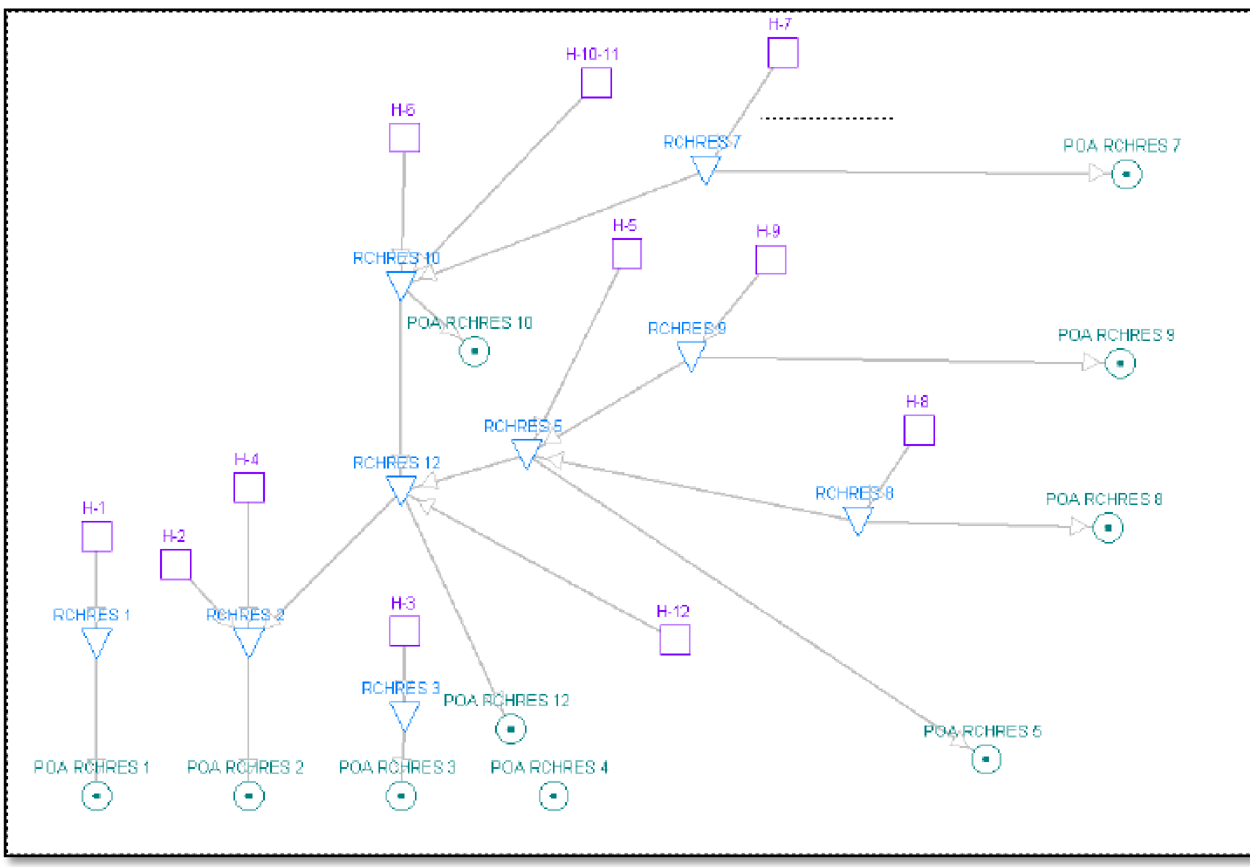
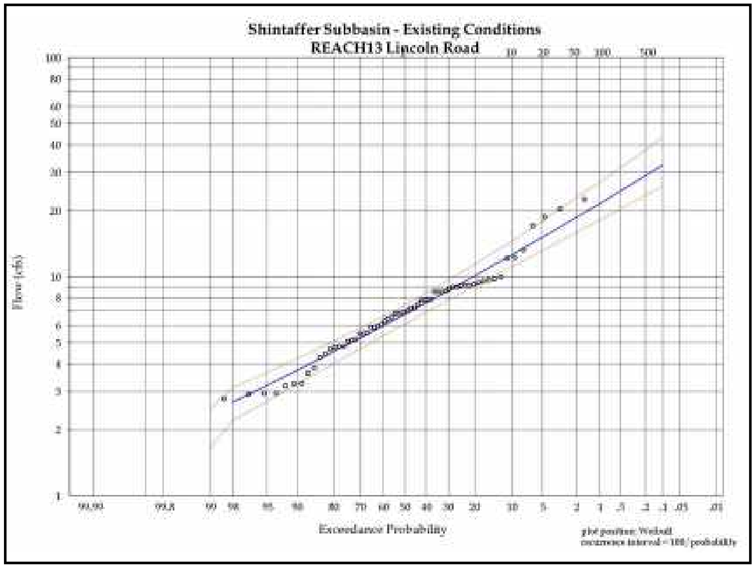
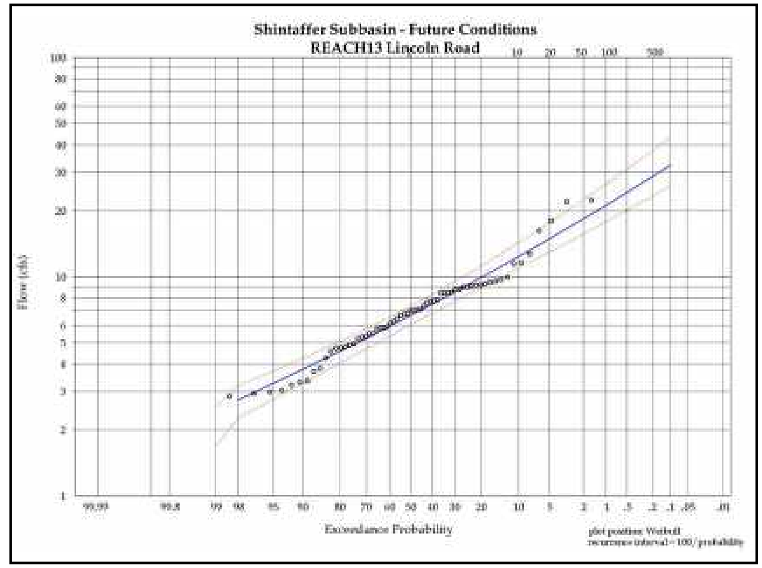


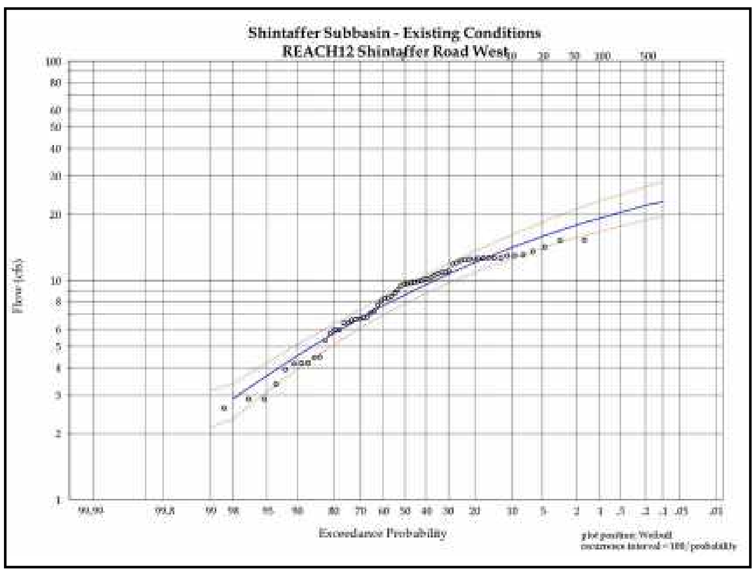
Figure A-4 Hillsdale and Hillsdale North Subbasins HSPF Routing Schematic

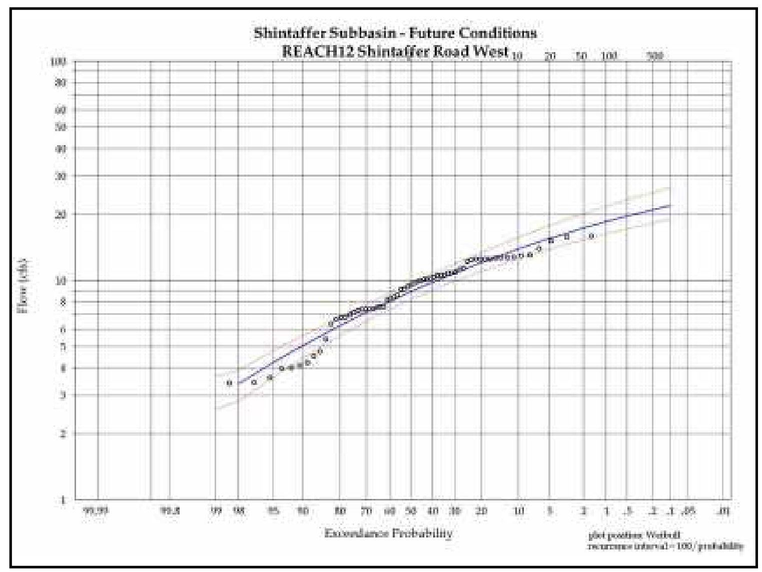
Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Hydrologic and Hydraulic Analysis of the Surface Water System in the Central North Subwatershed of Birch Bay

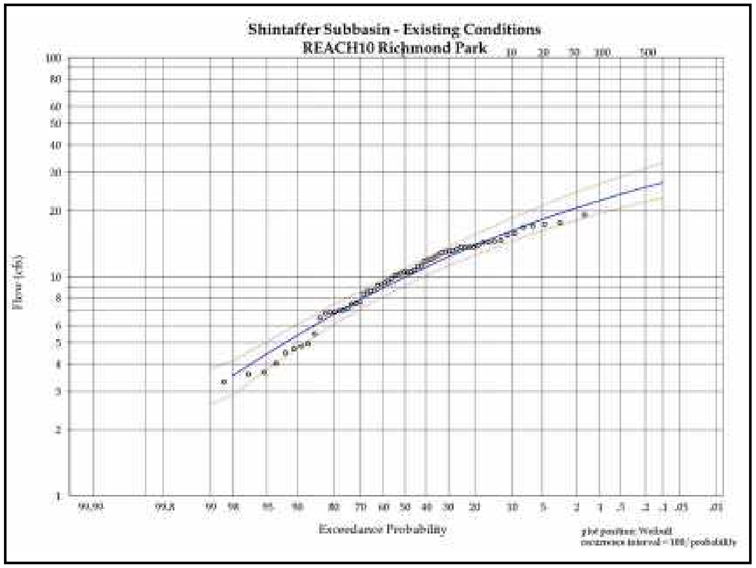
ATTACHMENT B. FLOOD FREQUENCY PLOTS

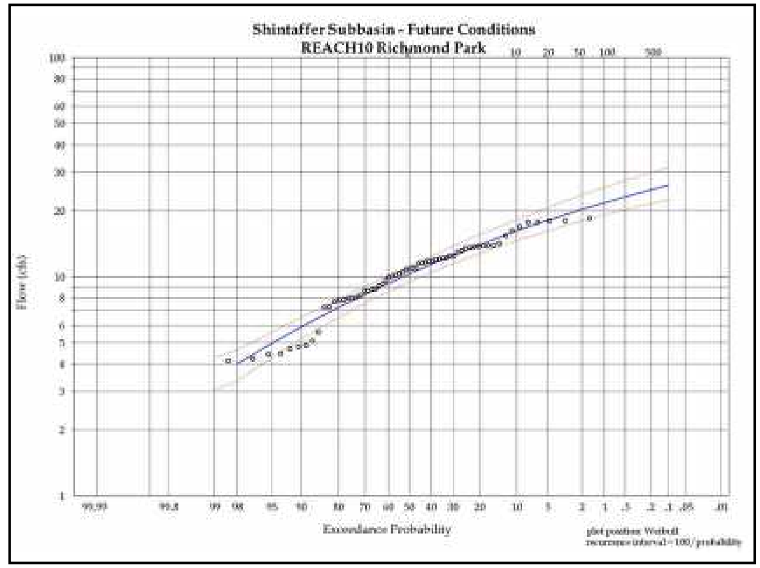

Shintaffer Subbasin - Existing Conditions
REACH13 Lincoln Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

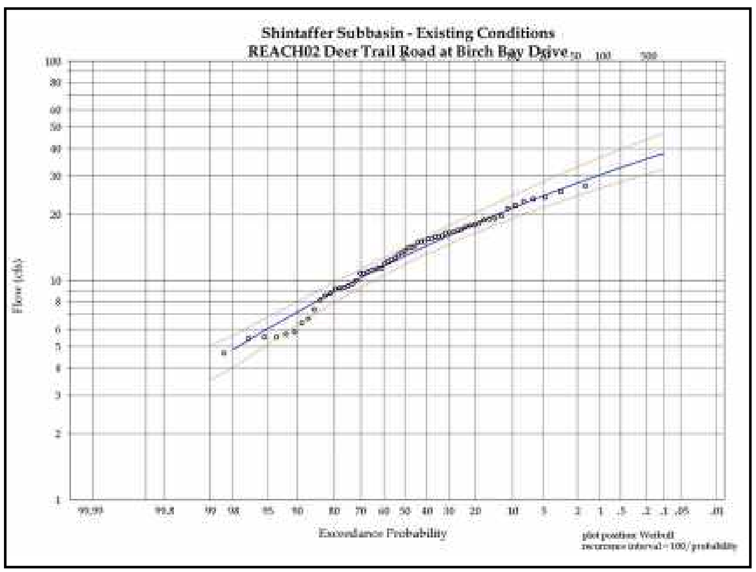

Shintaffer Subbasin - Future Conditions
REACH13 Lincoln Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

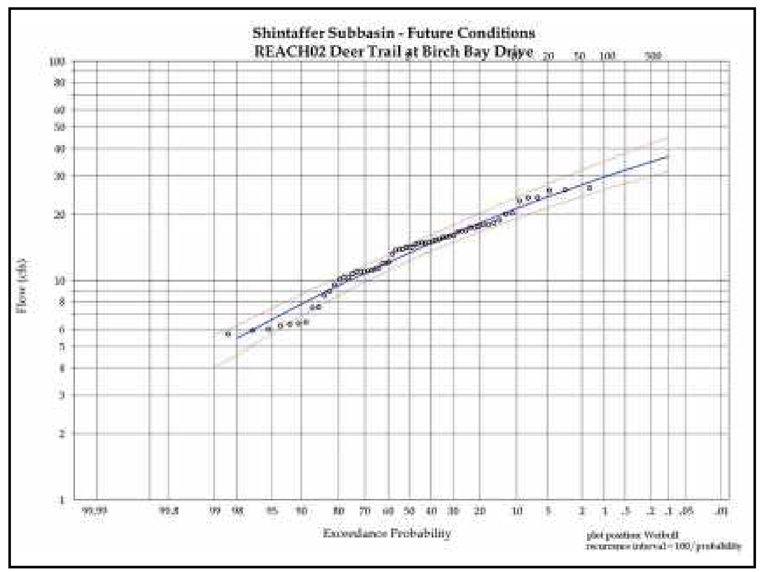

Shintaffer Subbasin - Existing Conditions
REACH12 Shintaffer Road West
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

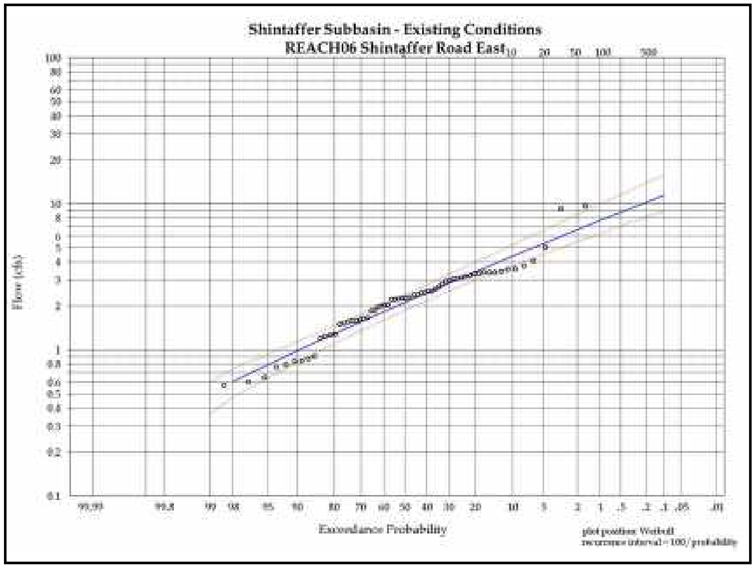

Shintaffer Subbasin - Future Conditions
REACH12 Shintaffer Road West
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

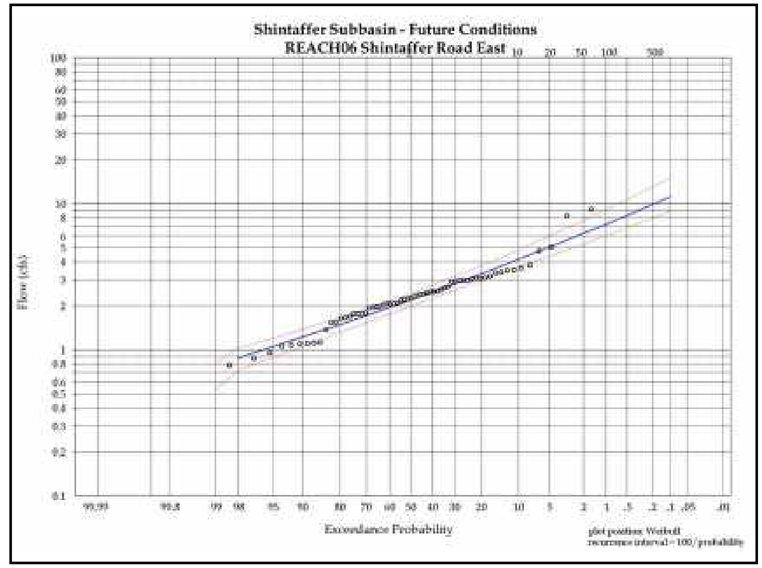

Shintaffer Subbasin - Existing Conditions
REACH10 Richmond Park
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

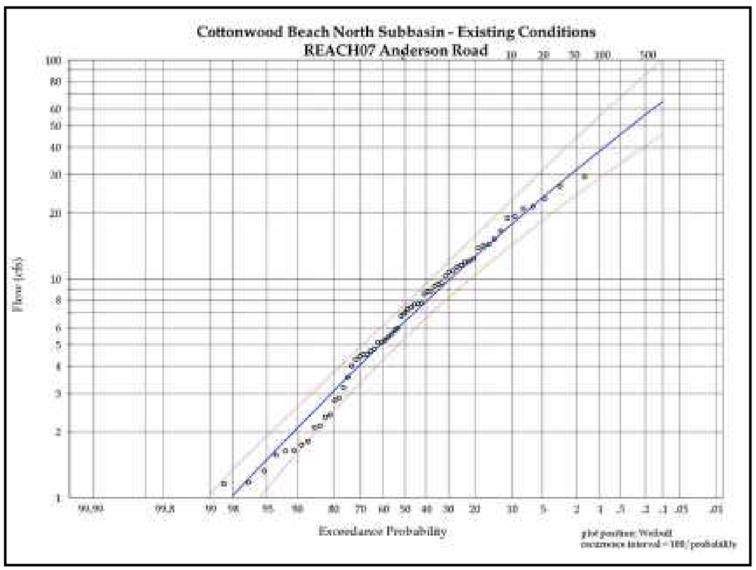

Shintaffer Subbasin - Future Conditions
REACH10 Richmond Park
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

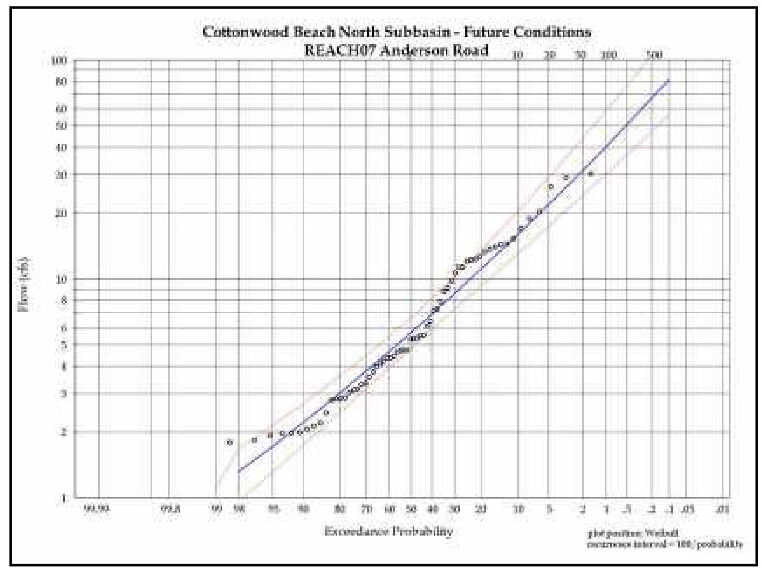

Shintaffer Subbasin - Existing Conditions
REACH02 Deer Trail Road at Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

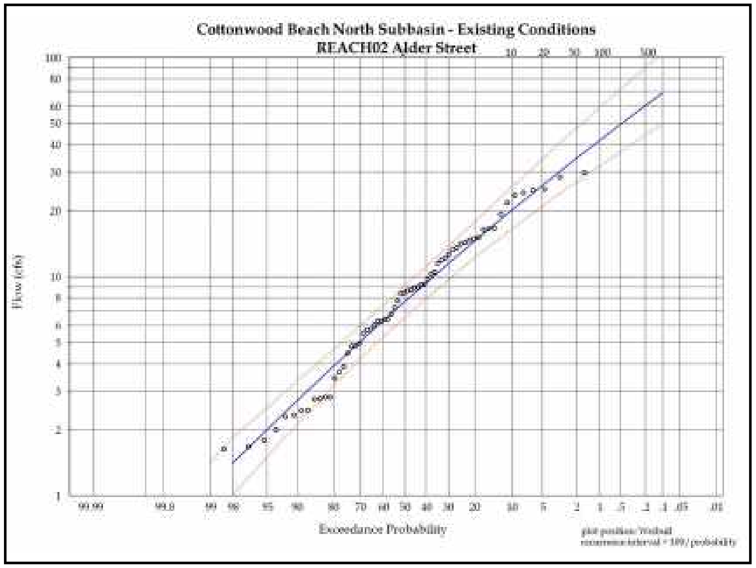

Shintaffer Subbasin - Future Conditions
REACH02 Deer Trail at Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

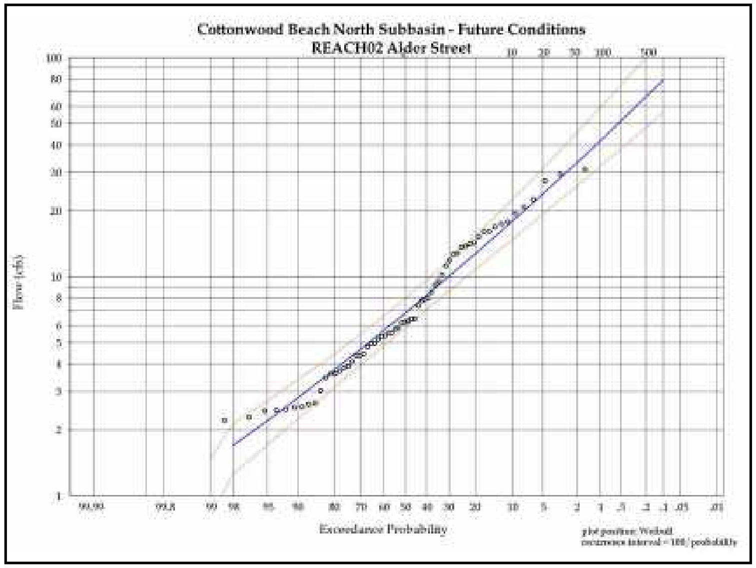

Shintaffer Subbasin - Existing Conditions
REACH06 Shintaffer Road East
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

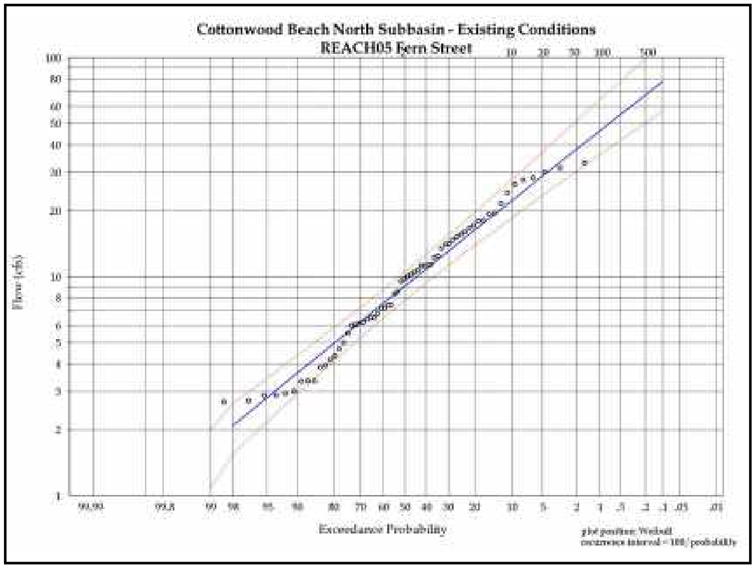

Shintaffer Subbasin - Future Conditions
REACH06 Shintaffer Road East
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

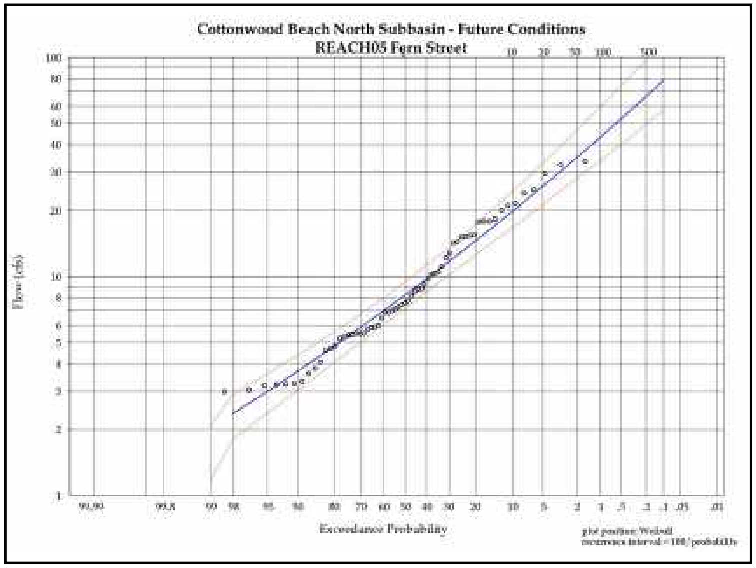

Cottonwood Beach North Subbasin - Existing Conditions
REACH07 Anderson Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

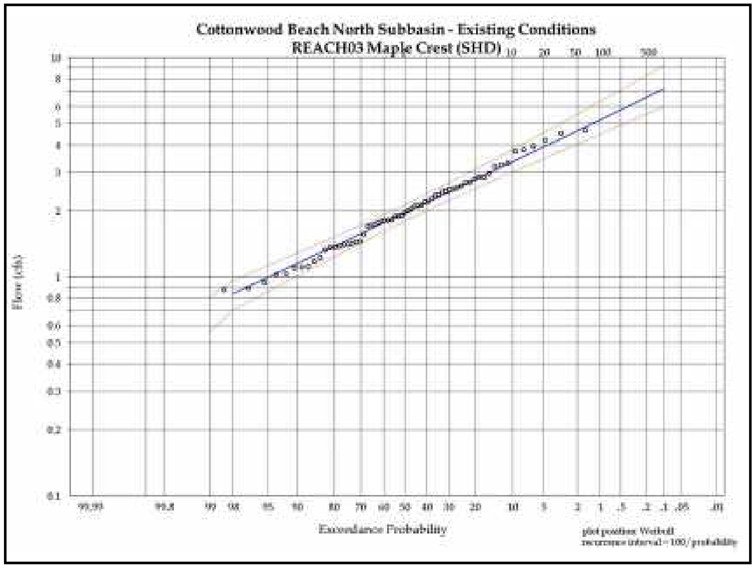

Cottonwood Beach North Subbasin - Future Conditions
REACH07 Anderson Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

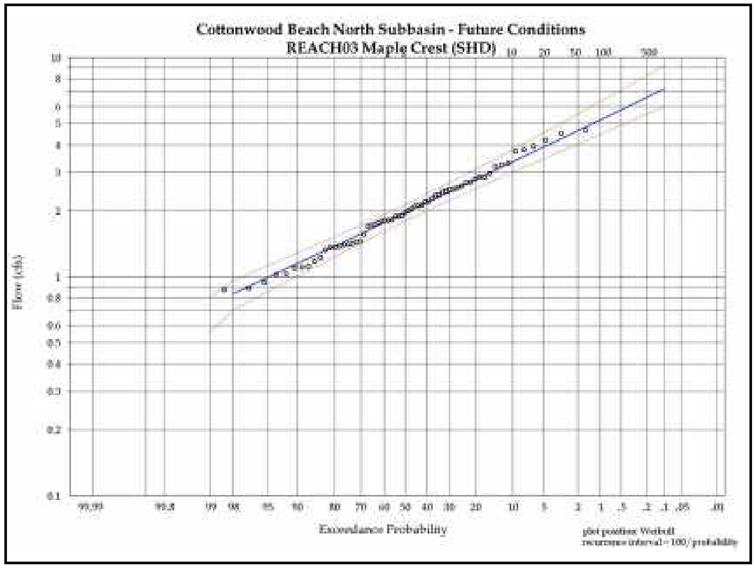

Cottonwood Beach North Subbasin - Existing Conditions
REACH02 Alder Street
Flow (cfs)
Exceedance Probability

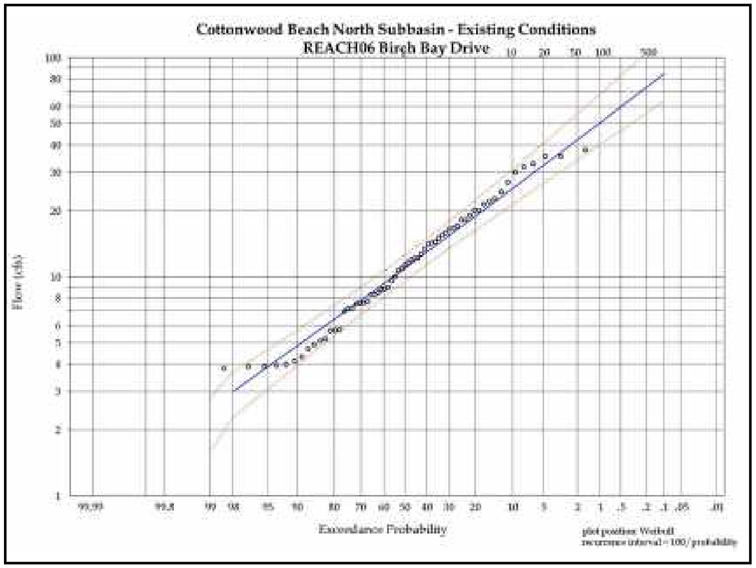

Cottonwood Beach North Subbasin - Future Conditions
REACH02 Alder Street
Flow (cfs)
Exceedance Probability

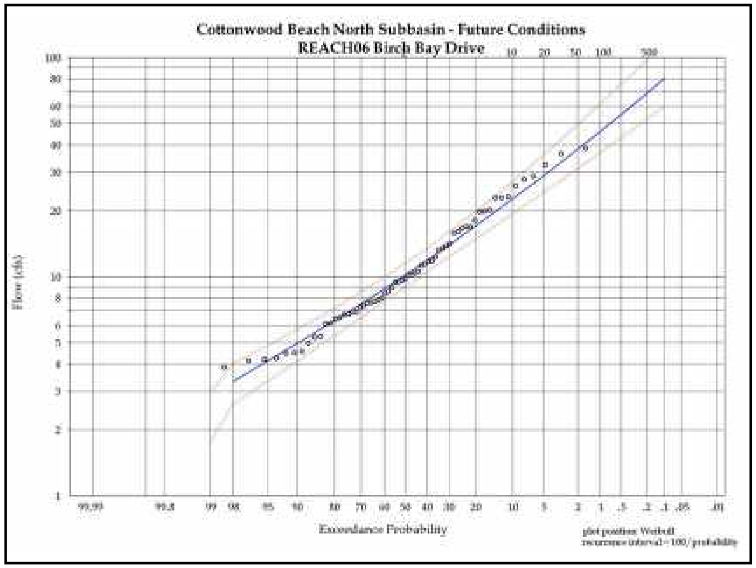

Cottonwood Beach North Subbasin - Existing Conditions
REACH05 Fern Street
Flow (cfs)
Exceedance Probability

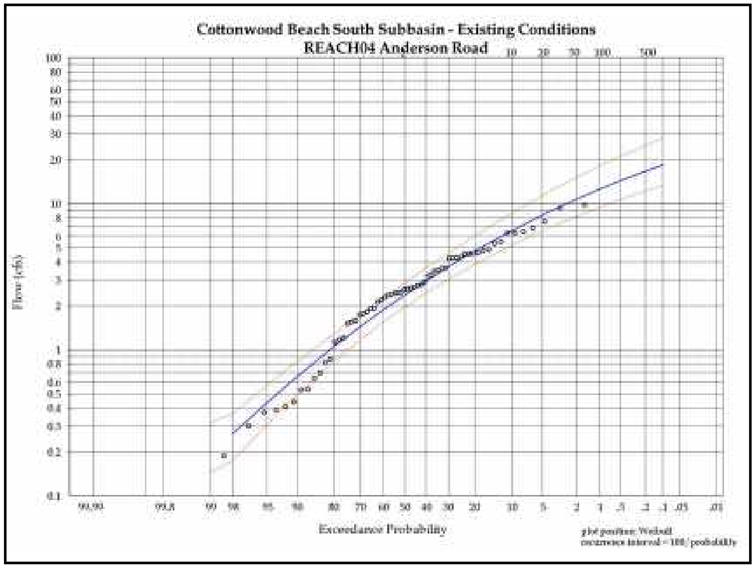

Cottonwood Beach North Subbasin - Future Conditions
REACH05 Fern Street
Flow (cfs)
Exceedance Probability

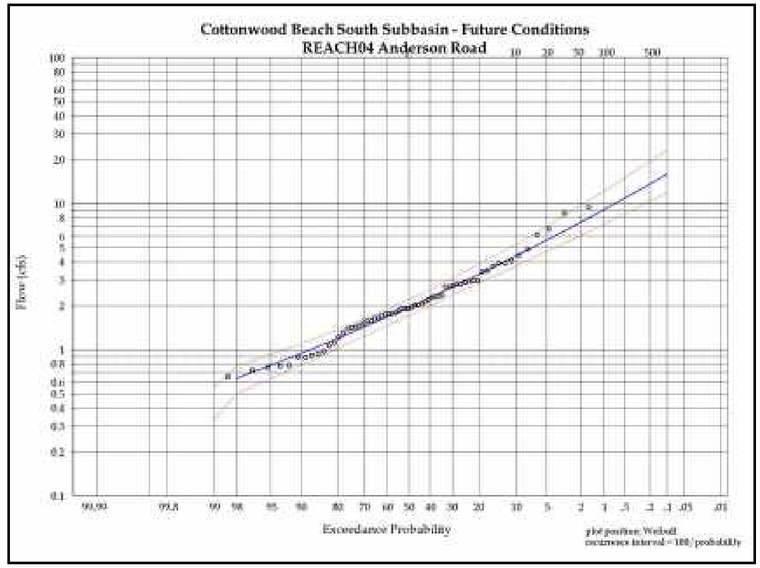

Cottonwood Beach North Subbasin - Existing Conditions
REACH03 Maple Crest (SHD)
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

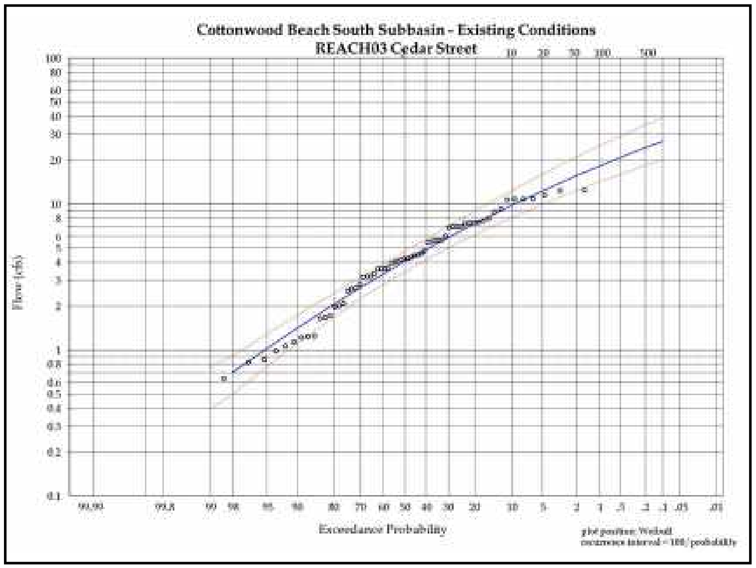

Cottonwood Beach North Subbasin - Future Conditions
REACH03 Maple Crest (SHD)
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

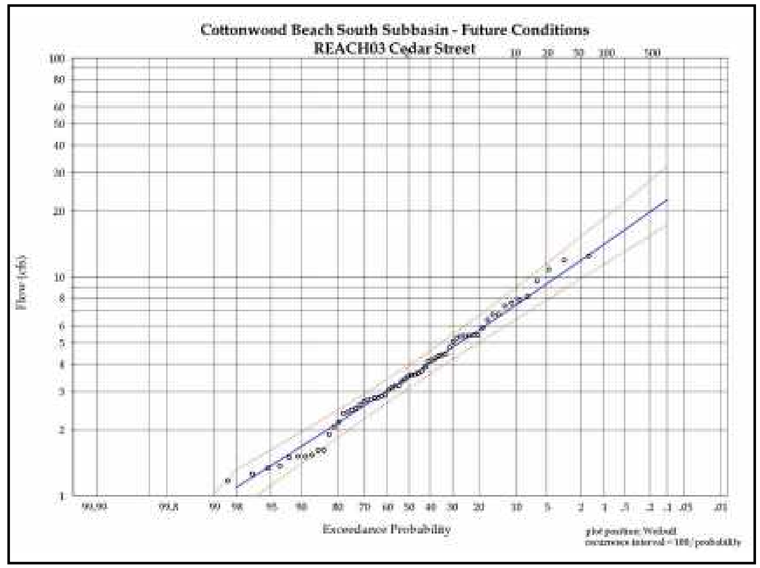

Cottonwood Beach North Subbasin - Existing Conditions
REACH06 Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

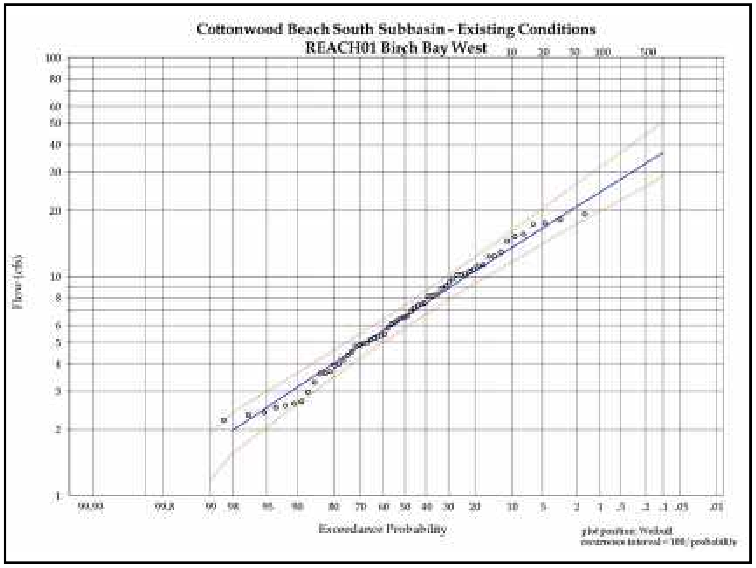

Cottonwood Beach North Subbasin - Future Conditions
REACH06 Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

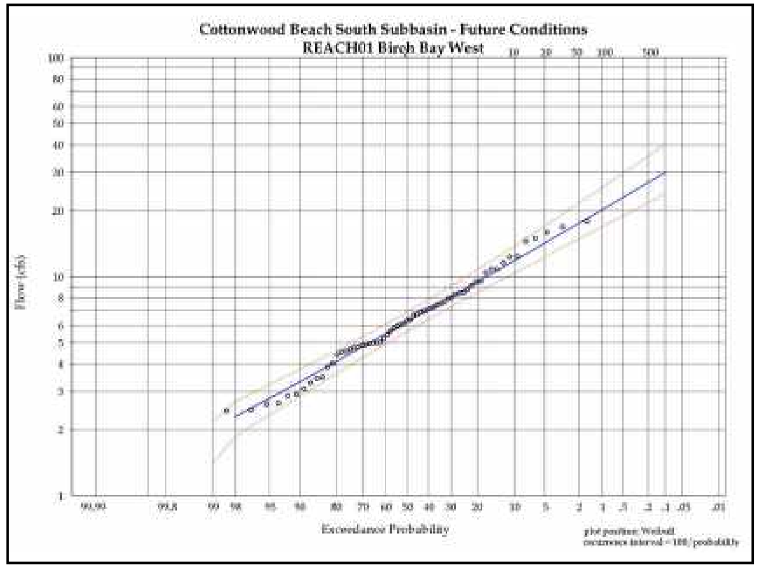

Cottonwood Beach South Subbasin - Existing Conditions
REACH04 Anderson Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

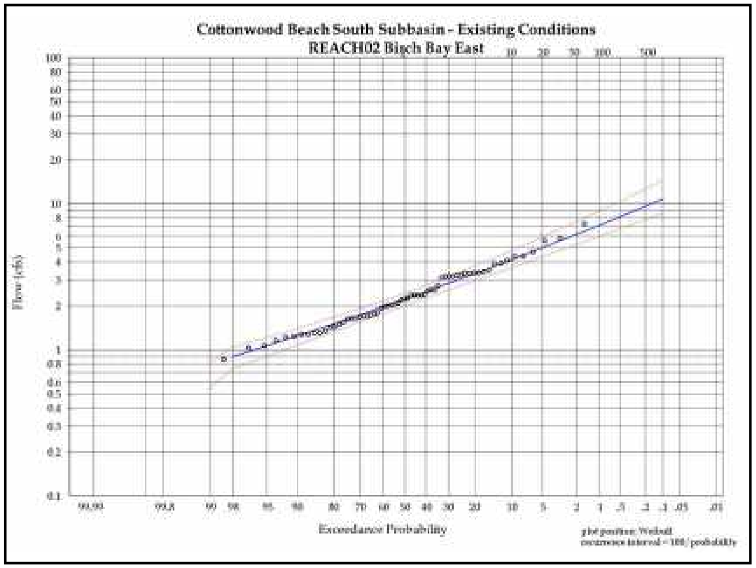

Cottonwood Beach South Subbasin - Future Conditions
REACH04 Anderson Road
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

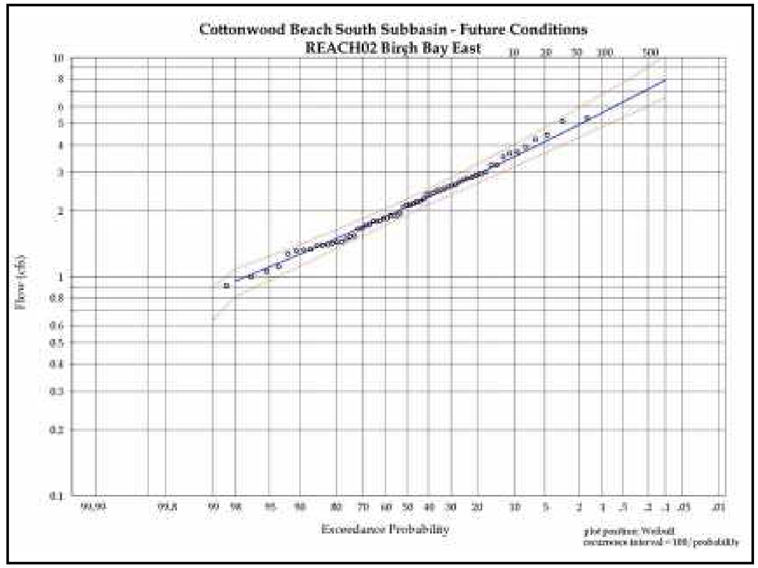

Cottonwood Beach South Subbasin - Existing Conditions
REACH03 Cedar Street
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

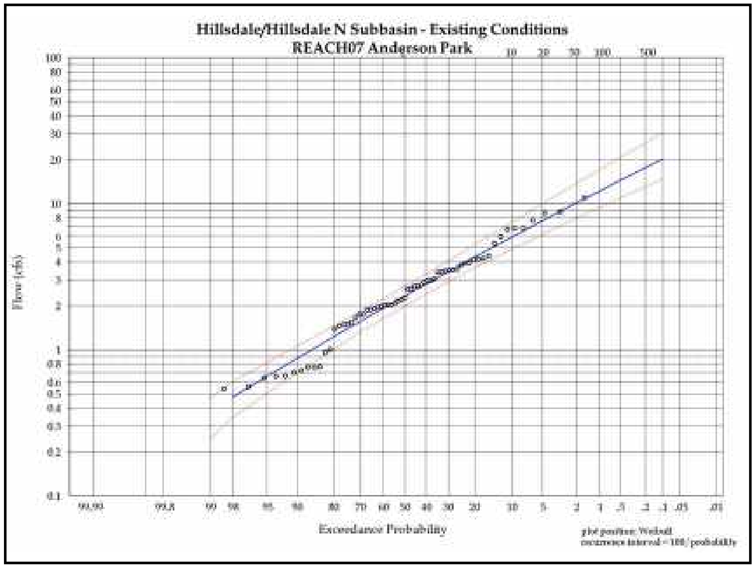

Cottonwood Beach South Subbasin - Future Conditions
REACH03 Cedar Street
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

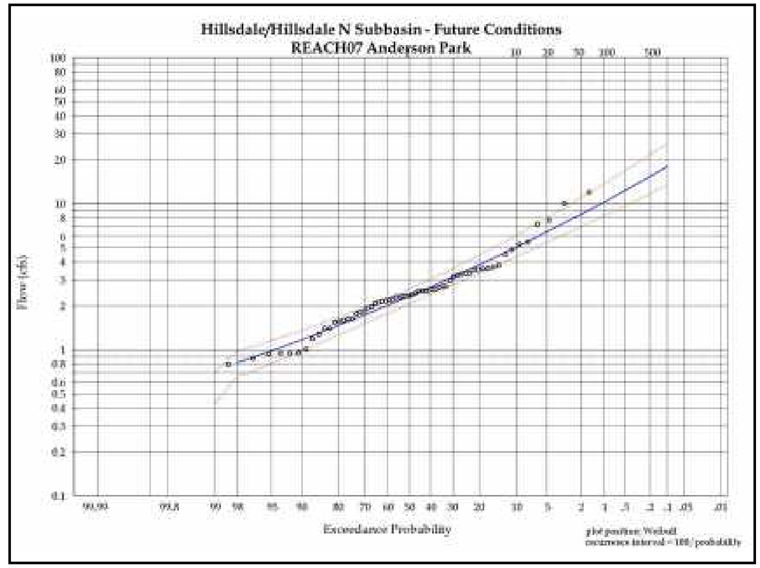

Cottonwood Beach South Subbasin - Existing Conditions
REACH01 Birch Bay West
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

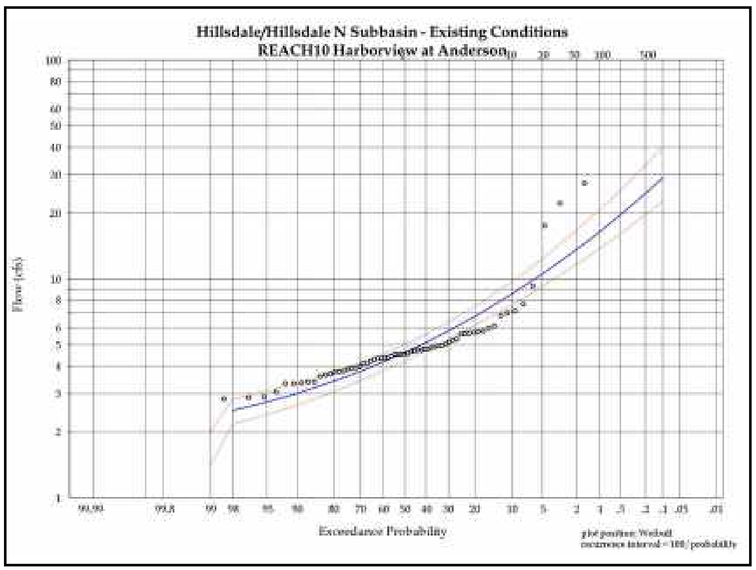

Cottonwood Beach South Subbasin - Future Conditions
REACH01 Birch Bay West
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

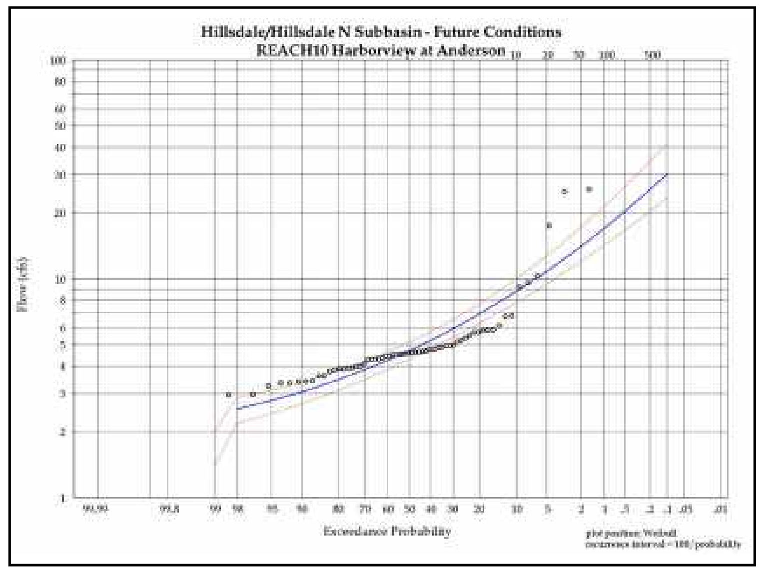

Cottonwood Beach South Subbasin - Existing Conditions
REACH02 Birch Bay East
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

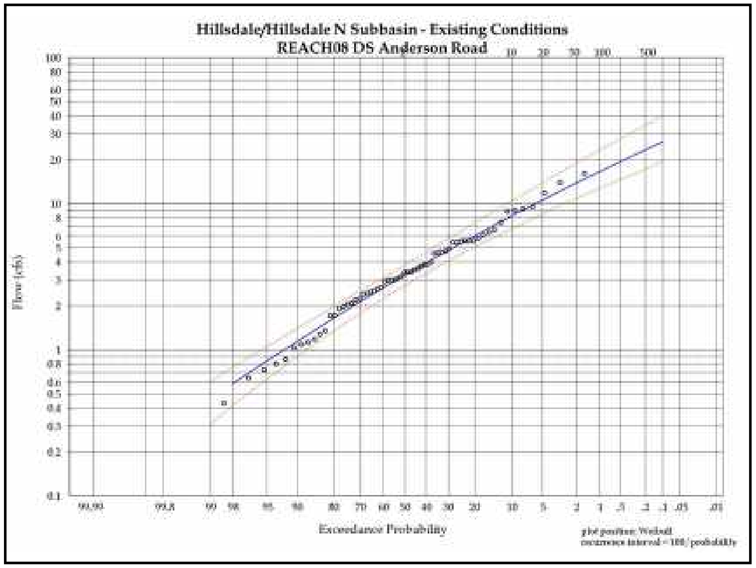

Cottonwood Beach South Subbasin - Future Conditions
REACH02 Birch Bay East
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

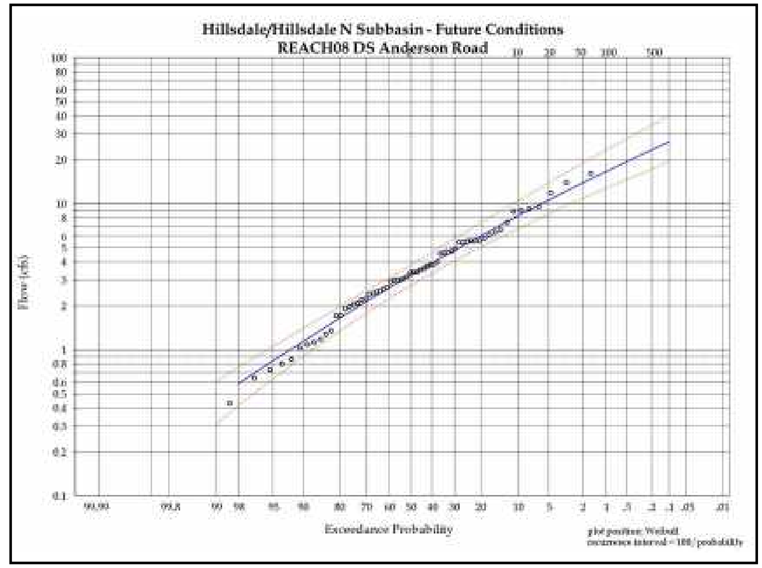

Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH07 Anderson Park
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

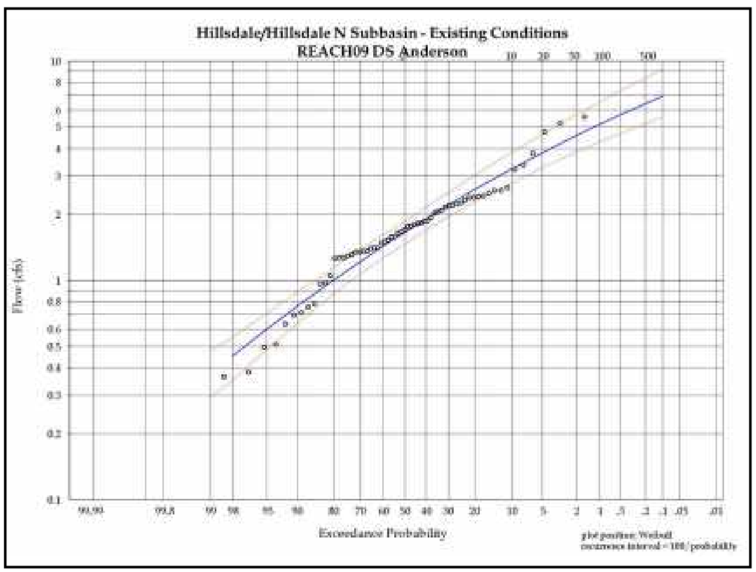

Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH07 Anderson Park
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

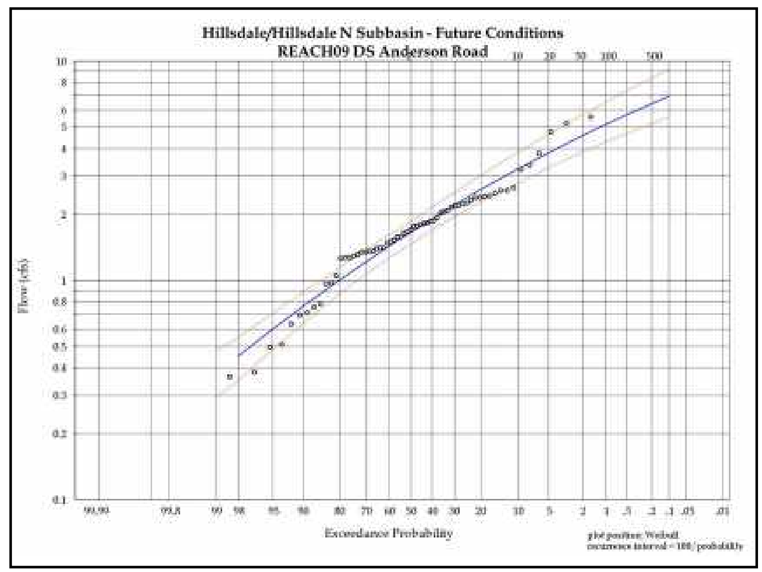

Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH10 Harborview at Anderson
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

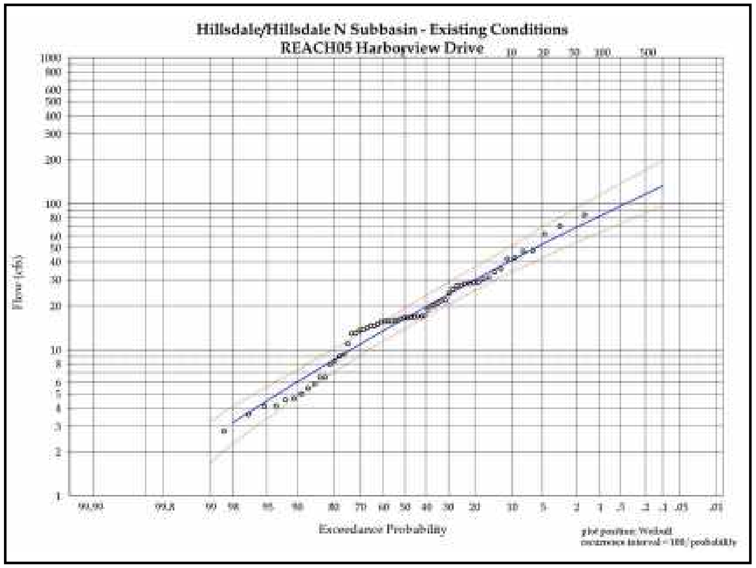

Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH10 Harborview at Anderson
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

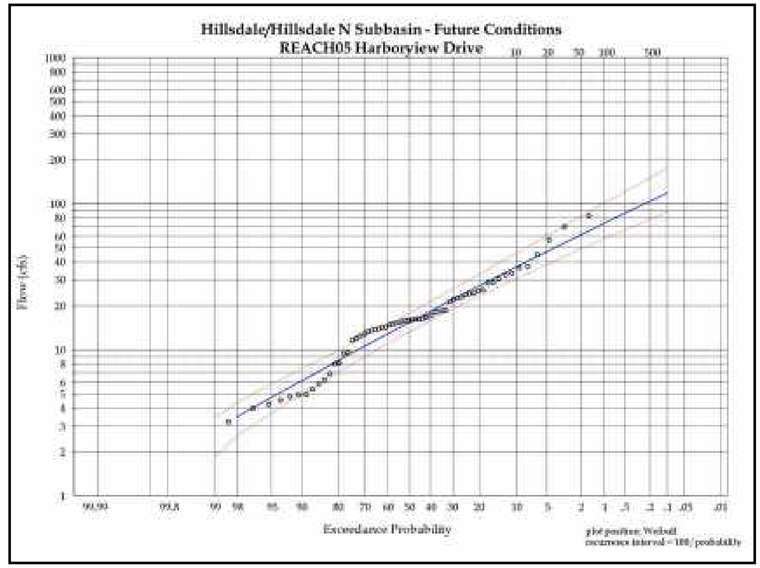

Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH08 DS Anderson Road
Flow (cfs)
Exceedance Probability

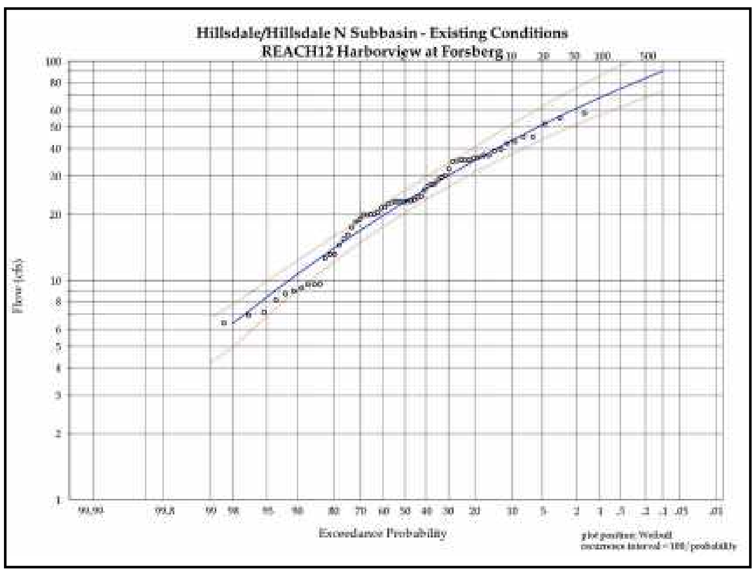

Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH08 DS Anderson Road
Flow (cfs)
Exceedance Probability

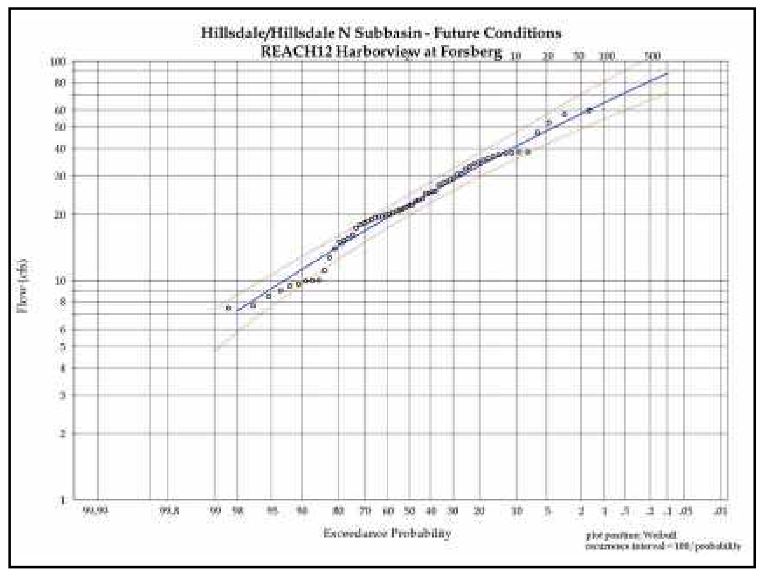

Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH09 DS Anderson
Flow (cfs)
Exceedance Probability

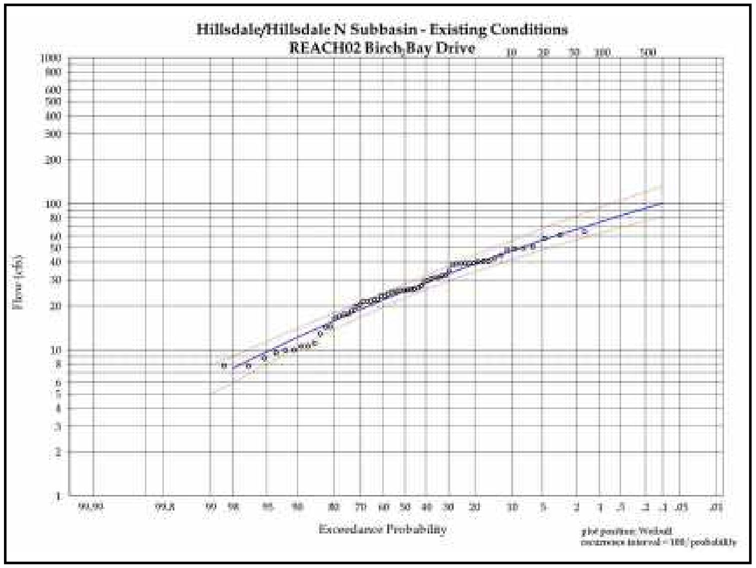

Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH09 DS Anderson Road
Flow (cfs)
Exceedance Probability

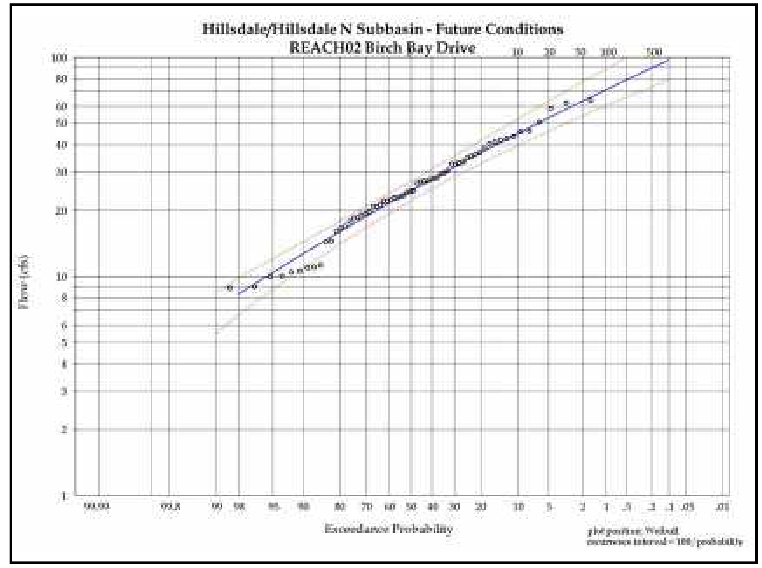

Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH05 Harborview Drive
Flow (cfs)
Exceedance Probability


Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH05 Harborview Drive
Flow (cfs)
Exceedance Probability


Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH12 Harborview at Forsberg
Flow (cfs)
Exceedance Probability


Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH12 Harborview at Forsberg
Flow (cfs)
Exceedance Probability


Hillsdale/Hillsdale N Subbasin - Existing Conditions
REACH02 Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability


Hillsdale/Hillsdale N Subbasin - Future Conditions
REACH02 Birch Bay Drive
Flow (cfs)
Exceedance Probability
plot position: Weibull
recurrence interval = 100/probability

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Hydrologic and Hydraulic Analysis of the Surface Water System in the Central North Subwatershed of Birch Bay

ATTACHMENT C. SUBBASIN FLOODING MODELING RESULTS

Table C-1
Shintaffer Subbasin Flooding

		Existing Conditions								Future Conditions									
	Assumed Overtopping Elevation	Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
Node	(feet NAVD88)	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	Location	ID
527	51.50	48.98	50.03	50.39	52.25	-2.52	-1.47	-1.11	0.75	48.96	50.56	50.15	52.25	-2.54	-0.94	-1.35	0.75	Shintaffer near Anderson - East Side	SH-F-3
1171	51.98	50.38	50.47	50.53	50.60	-1.60	-1.51	-1.45	-1.38	50.38	50.47	50.53	50.60	-1.60	-1.51	-1.45	-1.38		
1172	51.54	49.64	49.72	49.77	49.85	-1.90	-1.82	-1.77	-1.69	49.64	49.72	49.77	49.85	-1.90	-1.82	-1.77	-1.69		
1173	50.73	48.46	48.55	48.64	49.08	-2.27	-2.18	-2.09	-1.65	48.46	48.55	48.64	49.08	-2.27	-2.18	-2.09	-1.65		
1180	50.56	47.75	47.79	47.85	47.93	-2.81	-2.77	-2.71	-2.63	47.75	47.79	47.85	47.93	-2.81	-2.77	-2.71	-2.63		
1181	50.65	48.34	48.44	48.58	49.00	-2.31	-2.21	-2.07	-1.65	48.34	48.44	48.58	49.00	-2.31	-2.21	-2.07	-1.65		
1182	49.33	47.35	47.35	47.77	48.08	-1.98	-1.98	-1.56	-1.25	47.35	47.41	47.71	48.08	-1.98	-1.92	-1.62	-1.25		
1184	51.69	43.90	44.09	44.15	44.19	-7.79	-7.60	-7.54	-7.50	43.86	44.10	44.14	44.19	-7.83	-7.59	-7.55	-7.50		
1188	49.24	47.05	47.29	47.77	48.08	-2.19	-1.95	-1.47	-1.16	47.05	47.41	47.71	48.08	-2.19	-1.83	-1.53	-1.16		
1189	50.11	46.75	47.29	47.77	48.08	-3.36	-2.82	-2.34	-2.03	46.73	47.41	47.71	48.08	-3.38	-2.70	-2.40	-2.03		
1190	50.50	46.69	47.41	48.20	48.62	-3.81	-3.09	-2.30	-1.88	46.59	47.64	48.12	48.62	-3.91	-2.86	-2.38	-1.88		
1191	50.19	46.75	47.33	47.89	48.20	-3.44	-2.86	-2.30	-1.99	46.67	47.49	47.83	48.20	-3.52	-2.70	-2.36	-1.99		
1192	50.69	46.75	47.29	47.77	48.08	-3.94	-3.40	-2.92	-2.61	46.67	47.41	47.71	48.08	-4.02	-3.28	-2.98	-2.61		
1193	50.74	48.21	48.21	48.21	48.21	-2.53	-2.53	-2.53	-2.53	48.21	48.21	48.21	48.21	-2.53	-2.53	-2.53	-2.53		
1194	51.05	47.90	48.17	48.24	48.29	-3.15	-2.88	-2.81	-2.76	47.84	48.19	48.24	48.29	-3.21	-2.86	-2.81	-2.76		
1195	50.94	49.00	49.83	50.14	50.27	-1.94	-1.11	-0.80	-0.67	48.89	49.93	50.12	50.27	-2.05	-1.01	-0.82	-0.67		
1196	51.88	49.12	49.86	50.16	50.29	-2.76	-2.02	-1.72	-1.59	49.03	49.96	50.13	50.28	-2.85	-1.92	-1.75	-1.60	Richmond Park north of Richmond Crescent	SH-F-5
1197	51.20	49.95	50.78	51.28	51.46	-1.25	-0.42	0.08	0.26	49.81	50.97	51.25	51.46	-1.39	-0.23	0.05	0.26	Richmond Park north of Richmond Crescent	SH-F-5
1198	51.07	49.93	50.78	51.28	51.45	-1.14	-0.29	0.21	0.38	49.79	50.96	51.25	51.45	-1.28	-0.11	0.18	0.38	Richmond Park north of Richmond Crescent	SH-F-5
1199	51.97	50.14	51.87	52.35	52.70	-1.83	-0.10	0.38	0.73	49.95	52.20	52.50	52.69	-2.02	0.23	0.53	0.72	Richmond Park north of Richmond Crescent	SH-F-5
1200	51.64	50.13	51.84	52.35	52.69	-1.51	0.20	0.71	1.05	49.94	52.18	52.50	52.68	-1.70	0.54	0.86	1.04	Richmond Park north of Richmond Crescent	SH-F-5
1201	52.49	50.52	52.81	53.69	53.92	-1.97	0.32	1.20	1.43	50.29	53.26	53.68	53.96	-2.20	0.77	1.19	1.47	Richmond Park north of Richmond Crescent	SH-F-5
1202	52.27	50.81	52.90	53.66	53.66	-1.46	0.63	1.39	1.39	50.57	53.21	53.66	53.66	-1.70	0.94	1.39	1.39	Richmond Park north of Richmond Crescent	SH-F-5
1203	52.41	51.09	53.02	53.69	53.92	-1.32	0.61	1.28	1.51	50.77	53.21	53.68	53.96	-1.64	0.80	1.27	1.55	Richmond Park north of Richmond Crescent	SH-F-5
1204	52.40	51.10	53.02	53.69	53.92	-1.30	0.62	1.29	1.52	50.78	53.21	53.68	53.96	-1.62	0.81	1.28	1.56	Richmond Park north of Richmond Crescent	SH-F-5
1205	52.23	50.52	52.81	53.69	53.92	-1.71	0.58	1.46	1.69	50.29	53.20	53.68	53.96	-1.94	0.97	1.45	1.73	Richmond Park north of Richmond Crescent	SH-F-5
1206	53.17	50.52	52.81	53.70	53.92	-2.65	-0.36	0.53	0.75	50.29	53.19	53.69	53.96	-2.88	0.02	0.52	0.79	Richmond Park north of Richmond Crescent	SH-F-5
1207	53.06	50.52	52.81	53.70	53.92	-2.54	-0.25	0.64	0.86	50.29	53.19	53.69	53.96	-2.77	0.13	0.63	0.90	Richmond Park north of Richmond Crescent	SH-F-5
1208	52.60	50.52	52.81	53.70	53.92	-2.08	0.21	1.10	1.32	50.29	53.19	53.69	53.96	-2.31	0.59	1.09	1.36	Richmond Park north of Richmond Crescent	SH-F-5
1209	52.65	50.52	52.81	53.70	53.92	-2.13	0.16	1.05	1.27	50.29	53.19	53.69	53.96	-2.36	0.54	1.04	1.31	Richmond Park north of Richmond Crescent	SH-F-5
1210	52.76	50.52	52.81	53.70	53.92	-2.24	0.05	0.94	1.16	50.29	53.19	53.69	53.96	-2.47	0.43	0.93	1.20	Richmond Park north of Richmond Crescent	SH-F-5
1211	51.81	50.52	52.81	53.70	53.92	-1.29	1.00	1.89	2.11	50.29	53.19	53.69	53.96	-1.52	1.38	1.88	2.15	Richmond Park north of Richmond Crescent	SH-F-5
1220	51.91	49.10	49.86	50.23	50.44	-2.81	-2.05	-1.68	-1.47	49.00	49.96	50.20	50.44	-2.91	-1.95	-1.71	-1.47		
1221	50.96	49.10	49.85	50.16	50.28	-1.86	-1.11	-0.80	-0.68	49.01	49.96	50.13	50.28	-1.95	-1.00	-0.83	-0.68		
1222	51.41	49.98	49.98	50.20	50.37	-1.43	-1.43	-1.21	-1.04	49.98	49.98	50.17	50.37	-1.43	-1.43	-1.24	-1.04		
1227	52.08	50.92	50.92	50.96	51.00	-1.16	-1.16	-1.12	-1.08	50.92	50.92	50.97	51.00	-1.16	-1.16	-1.11	-1.08		
1228	53.49	50.92	50.92	50.96	51.00	-2.57	-2.57	-2.53	-2.49	50.92	50.92	50.97	51.00	-2.57	-2.57	-2.52	-2.49		
1229	52.40	50.92	50.92	50.96	51.00	-1.48	-1.48	-1.44	-1.40	50.92	50.92	50.97	51.00	-1.48	-1.48	-1.43	-1.40		
1230	51.81	50.92	50.92	50.96	51.00	-0.89	-0.89	-0.85	-0.81	50.92	50.92	50.97	51.00	-0.89	-0.89	-0.84	-0.81		
1235	53.23	50.35	53.07	53.43	54.10	-2.88	-0.16	0.20	0.87	50.28	53.47	52.95	54.08	-2.95	0.24	-0.28	0.85	Shintaffer, east side driveway culverts at Richmond Crescent	SH-F-4
1236	53.60	50.42	53.07	53.43	54.26	-3.18	-0.53	-0.17	0.66	50.34	53.47	52.95	54.25	-3.26	-0.13	-0.65	0.65	Shintaffer, east side driveway culverts at Richmond Crescent	SH-F-4
1237	52.85	50.41	53.45	53.64	54.05	-2.44	0.60	0.79	1.20	50.35	53.65	53.31	54.04	-2.50	0.80	0.46	1.19	Shintaffer, east side driveway culverts at Richmond Crescent	SH-F-4
1238	53.88	50.31	53.05	53.42	54.03	-3.57	-0.83	-0.46	0.15	50.25	53.46	52.93	54.02	-3.63	-0.42	-0.95	0.14		SH-F-1
1239	52.39	50.85	50.85	50.85	50.85	-1.54	-1.54	-1.54	-1.54	50.85	50.85	50.85	50.85	-1.54	-1.54	-1.54	-1.54		
1240	52.40	50.60	50.60	50.60	50.60	-1.80	-1.80	-1.80	-1.80	50.60	50.60	50.60	50.60	-1.80	-1.80	-1.80	-1.80		
1241	52.11	50.57	50.57	50.57	50.57	-1.54	-1.54	-1.54	-1.54	50.57	50.57	50.57	50.57	-1.54	-1.54	-1.54	-1.54		
1242	51.97	49.84	49.84	49.84	49.84	-2.13	-2.13	-2.13	-2.13	49.84	49.84	49.84	49.84	-2.13	-2.13	-2.13	-2.13		
1243	50.58	49.93	49.92	49.94	49.97	-0.65	-0.66	-0.64	-0.61	49.93	49.92	49.94	49.97	-0.65	-0.66	-0.64	-0.61		
1244	51.79	49.09	50.14	50.65	52.81	-2.70	-1.65	-1.14	1.02	49.09	50.61	50.51	52.82	-2.70	-1.18	-1.28	1.03	Shintaffer near Anderson - West Side	SH-F-4
1245	52.94	50.14	52.47	53.25	54.02	-2.80	-0.47	0.31	1.08	50.09	53.40	52.36	54.01	-2.85	0.46	-0.58	1.07	Shintaffer near Anderson - West Side	SH-F-4
1246	53.34	50.29	53.05	53.42	54.02	-3.05	-0.29	0.08	0.68	50.23	53.46	52.93	54.02	-3.11	0.12	-0.41	0.68	Shintaffer near Anderson - West Side	SH-F-4
1253	78.64	77.17	77.17	77.17	77.17	-1.47	-1.47	-1.47	-1.47	77.17	77.17	77.17	77.17	-1.47	-1.47	-1.47	-1.47		
1254	82.29	80.43	80.43	80.43	80.43	-1.86	-1.86	-1.86	-1.86	80.43	80.43	80.43	80.43	-1.86	-1.86	-1.86	-1.86		
1256	66.64	63.29	63.29	63.29	63.29	-3.35	-3.35	-3.35	-3.35	63.29	63.29	63.29	63.29	-3.35	-3.35	-3.35	-3.35		
1257	67.05	64.13	64.13	64.13	64.21	-2.92	-2.92	-2.92	-2.84	64.13	64.13	64.13	64.13	-2.92	-2.92	-2.92	-2.92		
1258	80.81	77.45	77.45	77.45	77.45	-3.36	-3.36	-3.36	-3.36	77.45	77.45	77.45	77.45	-3.36	-3.36	-3.36	-3.36		
1259	67.02	62.80	62.80	62.95	64.21	-4.22	-4.22	-4.07	-2.81	62.80	62.80	63.36	64.07	-4.22	-4.22	-3.66	-2.95		
1260	68.64	62.59	62.59	62.95	64.21	-6.05	-6.05	-5.69	-4.43	62.59	62.59	63.36	64.07	-6.05	-6.05	-5.28	-4.57		
1261	64.66	62.88	62.97	63.04	63.15	-1.78	-1.69	-1.62	-1.51	62.81	62.98	63.02	63.16	-1.85	-1.68	-1.64	-1.50		

Table C-1
Shintaffer Subbasin Flooding

	Assumed Overtopping Elevation	Existing Conditions								Future Conditions									
		Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
Node	(feet NAVD88)	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	Location	ID
1262	64.03	62.47	62.54	62.59	62.68	-1.56	-1.49	-1.44	-1.35	62.42	62.55	62.58	62.68	-1.61	-1.48	-1.45	-1.35		
1263	64.90	62.14	62.35	62.95	64.21	-2.76	-2.55	-1.95	-0.69	62.06	62.37	63.36	64.07	-2.84	-2.53	-1.54	-0.83		
1264	65.80	61.94	62.24	62.92	64.21	-3.86	-3.56	-2.88	-1.59	61.83	62.26	63.35	64.07	-3.97	-3.54	-2.45	-1.73		
1265	64.46	61.71	61.84	62.00	62.14	-2.75	-2.62	-2.46	-2.32	61.66	61.85	62.05	62.13	-2.80	-2.61	-2.41	-2.33		
1266	60.01	57.28	57.42	57.64	57.91	-2.73	-2.59	-2.37	-2.10	57.21	57.43	57.74	57.88	-2.80	-2.58	-2.27	-2.13		
1267	60.15	57.22	57.32	57.48	57.66	-2.93	-2.83	-2.67	-2.49	57.15	57.33	57.55	57.65	-3.00	-2.82	-2.60	-2.50		
1268	59.78	57.50	57.68	57.82	58.04	-2.28	-2.10	-1.96	-1.74	57.42	57.69	57.76	58.05	-2.36	-2.09	-2.02	-1.73		
1269	60.22	57.44	57.61	57.74	57.93	-2.78	-2.61	-2.48	-2.29	57.32	57.63	57.69	57.94	-2.90	-2.59	-2.53	-2.28		
1270	60.21	57.41	57.58	57.70	57.88	-2.80	-2.63	-2.51	-2.33	57.31	57.59	57.65	57.89	-2.90	-2.62	-2.56	-2.32		
1271	60.03	57.09	57.22	57.30	57.42	-2.94	-2.81	-2.73	-2.61	57.02	57.23	57.27	57.43	-3.01	-2.80	-2.76	-2.60		
1272	61.10	58.59	59.20	59.29	59.52	-2.51	-1.90	-1.81	-1.58	58.59	59.20	59.29	59.52	-2.51	-1.90	-1.81	-1.58		
1273	60.29	58.64	59.21	59.30	59.53	-1.65	-1.08	-0.99	-0.76	58.64	59.21	59.30	59.53	-1.65	-1.08	-0.99	-0.76		
1274	63.20	59.79	60.92	61.18	61.43	-3.41	-2.28	-2.02	-1.77	59.79	60.92	61.18	61.43	-3.41	-2.28	-2.02	-1.77		
1275	59.66	58.55	59.18	59.27	59.46	-1.11	-0.48	-0.39	-0.20	58.55	59.18	59.27	59.46	-1.11	-0.48	-0.39	-0.20	Shintaffer, 500 feet north of Lincoln	
1276	59.31	57.21	57.37	57.49	57.69	-2.10	-1.94	-1.82	-1.62	57.21	57.37	57.49	57.69	-2.10	-1.94	-1.82	-1.62		
1277	64.10	61.32	61.48	61.67	61.98	-2.78	-2.62	-2.43	-2.12	61.32	61.48	61.67	61.98	-2.78	-2.62	-2.43	-2.12		
1278	64.25	61.17	61.28	61.35	61.67	-3.08	-2.97	-2.90	-2.58	61.17	61.28	61.35	61.67	-3.08	-2.97	-2.90	-2.58		
1279	62.47	61.16	61.28	61.33	61.66	-1.31	-1.19	-1.14	-0.81	61.16	61.28	61.33	61.66	-1.31	-1.19	-1.14	-0.81		
1280	63.66	61.17	61.26	61.29	61.62	-2.49	-2.40	-2.37	-2.04	61.17	61.26	61.29	61.62	-2.49	-2.40	-2.37	-2.04		
1281	64.80	63.34	64.58	64.79	65.25	-1.46	-0.22	-0.01	0.45	63.34	64.58	64.79	65.25	-1.46	-0.22	-0.01	0.45	Shintaffer, first driveway north of Lincoln	SH-F-6
1284	58.15	53.10	53.50	54.60	56.40	-5.05	-4.65	-3.55	-1.75	53.06	53.69	54.65	56.46	-5.09	-4.46	-3.50	-1.69		
1286	56.77	55.54	55.62	55.67	55.76	-1.23	-1.15	-1.10	-1.01	55.48	55.63	55.66	55.78	-1.29	-1.14	-1.11	-0.99		
1291	55.00	52.18	53.17	53.83	54.17	-2.82	-1.83	-1.17	-0.83	52.12	53.34	53.83	54.20	-2.88	-1.66	-1.17	-0.80		
1292	54.60	52.13	53.10	53.78	54.09	-2.47	-1.50	-0.82	-0.51	52.07	53.29	53.78	54.13	-2.53	-1.31	-0.82	-0.47	Shintaffer, east side, first drive south of Lincoln	
1293	55.36	51.66	53.11	53.77	54.07	-3.70	-2.25	-1.59	-1.29	51.55	53.29	53.77	54.11	-3.81	-2.07	-1.59	-1.25		
1294	54.94	53.33	53.38	53.79	54.09	-1.61	-1.56	-1.15	-0.85	53.31	53.38	53.78	54.13	-1.63	-1.56	-1.16	-0.81		
1295	55.86	53.73	53.80	53.85	54.12	-2.13	-2.06	-2.01	-1.74	53.68	53.81	53.83	54.16	-2.18	-2.05	-2.03	-1.70		
1296	56.30	52.38	53.43	54.45	55.83	-3.92	-2.87	-1.85	-0.47	52.29	53.62	54.49	55.88	-4.01	-2.68	-1.81	-0.42	Southwest corner, Shintaffer and Lincoln	
1297	56.38	52.86	53.44	54.48	56.06	-3.52	-2.94	-1.90	-0.32	52.77	53.62	54.54	56.15	-3.61	-2.76	-1.84	-0.23	Southwest corner, Shintaffer and Lincoln	
1298	56.93	54.31	54.40	54.59	56.25	-2.62	-2.53	-2.34	-0.68	54.31	54.40	54.66	56.30	-2.62	-2.53	-2.27	-0.63		
1300	54.93	53.96	53.96	53.96	54.12	-0.97	-0.97	-0.97	-0.81	53.96	53.96	53.96	54.16	-0.97	-0.97	-0.97	-0.77		
1308	65.65	63.35	64.59	64.79	65.26	-2.30	-1.06	-0.86	-0.39	63.35	64.59	64.79	65.26	-2.30	-1.06	-0.86	-0.39	Shintaffer, west side at Shintaffer Ct.	
1309	64.70	63.36	64.59	64.79	#N/A	-1.34	-0.11	0.09	#N/A	63.36	64.59	64.79	#N/A	-1.34	-0.11	0.09	#N/A	Shintaffer, west side at Shintaffer Ct.	SH-F-6
1310	65.55	63.36	64.59	64.79	65.26	-2.19	-0.96	-0.76	-0.29	63.36	64.59	64.79	65.26	-2.19	-0.96	-0.76	-0.29	Shintaffer, west side at Shintaffer Ct.	
1311	66.29	63.75	64.59	64.80	65.28	-2.54	-1.70	-1.49	-1.01	63.75	64.59	64.80	65.28	-2.54	-1.70	-1.49	-1.01		
1316	67.04	64.30	64.61	64.81	65.30	-2.74	-2.43	-2.23	-1.74	64.30	64.61	64.81	65.30	-2.74	-2.43	-2.23	-1.74		
1317	65.47	64.13	64.59	64.80	65.29	-1.34	-0.88	-0.67	-0.18	64.13	64.59	64.80	65.29	-1.34	-0.88	-0.67	-0.18	Shintaffer at CN basin boundary	
1318	54.30	52.11	53.15	53.81	54.14	-2.19	-1.15	-0.49	-0.16	52.05	53.32	53.81	54.17	-2.25	-0.98	-0.49	-0.13	Shintaffer at CN basin boundary	
1319	54.19	50.99	53.55	53.84	55.05	-3.20	-0.64	-0.35	0.86	50.99	53.84	53.41	55.05	-3.20	-0.35	-0.78	0.86	Shintaffer east and south of Lincoln	SH-F-4
1320	53.00	50.46	53.55	53.84	55.05	-2.54	0.55	0.84	2.05	50.40	53.84	53.41	55.05	-2.60	0.84	0.41	2.05	Shintaffer east and south of Lincoln	SH-F-4
1321	53.23	50.46	53.55	53.84	55.05	-2.77	0.32	0.61	1.82	50.40	53.84	53.41	55.05	-2.83	0.61	0.18	1.82	Shintaffer east and south of Lincoln	SH-F-4
1322	52.44	50.45	53.55	53.84	55.05	-1.99	1.11	1.40	2.61	50.39	53.84	53.41	55.05	-2.05	1.40	0.97	2.61	Shintaffer east and south of Lincoln	SH-F-4
1323	52.68	50.42	53.45	53.64	54.05	-2.26	0.77	0.96	1.37	50.36	53.65	53.31	54.05	-2.32	0.97	0.63	1.37	Shintaffer east and south of Lincoln	SH-F-4
1324	53.74	51.18	53.03	53.71	53.95	-2.56	-0.71	-0.03	0.21	50.93	53.22	53.70	53.98	-2.81	-0.52	-0.04	0.24	Shintaffer east and south of Lincoln	SH-F-4
1325	54.80	52.13	53.10	53.78	54.09	-2.67	-1.70	-1.02	-0.71	52.08	53.29	53.78	54.13	-2.72	-1.51	-1.02	-0.67		
1326	55.20	51.62	53.10	53.77	54.07	-3.58	-2.10	-1.43	-1.13	51.53	53.28	53.77	54.11	-3.67	-1.92	-1.43	-1.09		
1327	67.76	63.55	63.55	63.55	64.21	-4.21	-4.21	-4.21	-3.55	63.55	63.55	63.55	64.07	-4.21	-4.21	-4.21	-3.69		
1328	67.69	63.88	63.88	63.88	64.21	-3.81	-3.81	-3.81	-3.48	63.88	63.88	63.88	64.07	-3.81	-3.81	-3.81	-3.62		
1329	66.74	64.00	64.00	64.00	64.21	-2.74	-2.74	-2.74	-2.53	64.00	64.00	64.00	64.07	-2.74	-2.74	-2.74	-2.67		
1330	67.48	64.42	64.42	64.42	64.42	-3.06	-3.06	-3.06	-3.06	64.42	64.42	64.42	64.42	-3.06	-3.06	-3.06	-3.06		
1331	64.52	62.88	62.97	63.04	63.15	-1.64	-1.55	-1.48	-1.37	62.81	62.98	63.02	63.16	-1.71	-1.54	-1.50	-1.36		
1332	65.48	64.06	64.06	64.06	64.06	-1.42	-1.42	-1.42	-1.42	64.06	64.06	64.06	64.06	-1.42	-1.42	-1.42	-1.42		
1333	64.76	62.88	62.97	63.04	63.15	-1.88	-1.79	-1.72	-1.61	62.81	62.98	63.02	63.16	-1.95	-1.78	-1.74	-1.60		
1335	12.00	9.59	9.60	9.66	9.76	-2.41	-2.40	-2.34	-2.24	9.59	9.60	9.66	9.76	-2.41	-2.40	-2.34	-2.24		
1339	13.22	9.98	9.99	10.07	10.20	-3.24	-3.23	-3.15	-3.02	9.98	9.99	10.07	10.20	-3.24	-3.23	-3.15	-3.02		
1340	12.61	10.94	10.94	11.02	11.19	-1.67	-1.67	-1.59	-1.42	10.94	10.94	11.02	11.19	-1.67	-1.67	-1.59	-1.42		
1346	12.93	11.98	11.98	11.98	11.98	-0.95	-0.95	-0.95	-0.95	11.98	11.98	11.98	11.98	-0.95	-0.95	-0.95	-0.95		
1347	12.59	10.60	10.61	10.73	10.94	-1.99	-1.98	-1.86	-1.65	10.60	10.61	10.73	10.94	-1.99	-1.98	-1.86	-1.65		
1348	12.76	12.00	12.00	12.40	13.35	-0.76	-0.76	-0.36	0.59	12.00	12.00	12.29	13.34	-0.76	-0.76	-0.47	0.58	Birch Bay Drive east of Deer Trail	SH-F-1

Table C-1
Shintaffer Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
1349	12.89	12.00	12.00	12.40	13.35	-0.89	-0.89	-0.49	0.46	12.00	12.00	12.29	13.34	-0.89	-0.89	-0.60	0.45	Birch Bay Drive east of Deer Trail	SH-F-1
1350	13.17	11.99	12.00	12.40	13.35	-1.18	-1.17	-0.77	0.18	11.99	12.00	12.29	13.35	-1.18	-1.17	-0.88	0.18	Birch Bay Drive east of Deer Trail	SH-F-1
1351	13.02	11.54	11.65	12.40	13.35	-1.48	-1.37	-0.62	0.33	11.54	11.65	12.29	13.36	-1.48	-1.37	-0.73	0.34	Birch Bay Drive east of Deer Trail	SH-F-1
1352	13.90	11.16	11.63	12.38	13.30	-2.74	-2.27	-1.52	-0.60	11.16	11.64	12.27	13.38	-2.74	-2.26	-1.63	-0.52		
1353	12.92	10.51	11.75	12.58	13.39	-2.41	-1.17	-0.34	0.47	10.40	11.77	12.46	13.50	-2.52	-1.15	-0.46	0.58	Birch Bay Drive east of Deer Trail	SH-F-1
1354	12.00	9.32	9.72	9.94	10.22	-2.68	-2.28	-2.06	-1.78	9.27	9.73	9.90	10.23	-2.73	-2.27	-2.10	-1.77		
1355	15.35	10.57	12.04	13.13	14.21	-4.78	-3.31	-2.22	-1.14	10.53	12.09	12.97	14.21	-4.82	-3.26	-2.38	-1.14		
1356	14.00	12.57	12.62	12.67	12.75	-1.43	-1.38	-1.33	-1.25	12.57	12.62	12.67	12.75	-1.43	-1.38	-1.33	-1.25		
1357	12.43	10.72	10.78	10.97	12.10	-1.71	-1.65	-1.46	-0.33	10.72	10.78	10.97	12.10	-1.71	-1.65	-1.46	-0.33	Birch Bay Drive west of Deer Trail	SH-F-1
1358	12.34	10.45	10.55	10.68	11.35	-1.89	-1.79	-1.66	-0.99	10.45	10.55	10.68	11.35	-1.89	-1.79	-1.66	-0.99		
1359	12.23	10.44	10.54	10.66	11.35	-1.79	-1.69	-1.57	-0.88	10.44	10.54	10.66	11.35	-1.79	-1.69	-1.57	-0.88		
1360	11.83	10.03	10.16	10.34	11.02	-1.80	-1.67	-1.49	-0.81	10.03	10.16	10.34	11.02	-1.80	-1.67	-1.49	-0.81		
1361	11.61	10.03	10.16	10.35	11.02	-1.58	-1.45	-1.26	-0.59	10.03	10.16	10.35	11.02	-1.58	-1.45	-1.26	-0.59		
1362	11.37	10.04	10.17	10.35	11.02	-1.33	-1.20	-1.02	-0.35	10.04	10.17	10.35	11.02	-1.33	-1.20	-1.02	-0.35	Birch Bay Drive west of Deer Trail	SH-F-1
1363	11.23	10.30	10.34	10.40	11.14	-0.93	-0.89	-0.83	-0.09	10.30	10.34	10.40	11.14	-0.93	-0.89	-0.83	-0.09	Birch Bay Drive west of Deer Trail	SH-F-1
1364	11.87	10.65	10.73	10.82	11.17	-1.22	-1.14	-1.05	-0.70	10.65	10.73	10.82	11.17	-1.22	-1.14	-1.05	-0.70		
1365	12.00	9.35	9.44	9.55	9.75	-2.65	-2.56	-2.45	-2.25	9.35	9.44	9.55	9.75	-2.65	-2.56	-2.45	-2.25		
1366	52.46	49.63	49.76	49.91	50.56	-2.83	-2.70	-2.55	-1.90	49.63	49.76	49.91	50.56	-2.83	-2.70	-2.55	-1.90		
1367	52.26	49.67	49.79	49.94	50.56	-2.59	-2.47	-2.32	-1.70	49.67	49.79	49.94	50.56	-2.59	-2.47	-2.32	-1.70		
1368	53.06	49.77	49.97	50.23	51.15	-3.29	-3.09	-2.83	-1.91	49.77	49.97	50.23	51.15	-3.29	-3.09	-2.83	-1.91		
1372	52.95	44.57	44.73	44.92	45.26	-8.38	-8.22	-8.03	-7.69	44.57	44.73	44.92	45.26	-8.38	-8.22	-8.03	-7.69		
1373	52.67	50.02	50.09	50.17	50.96	-2.65	-2.58	-2.50	-1.71	50.02	50.09	50.17	50.96	-2.65	-2.58	-2.50	-1.71		
1374	53.33	50.33	50.43	50.55	51.21	-3.00	-2.90	-2.78	-2.12	50.33	50.43	50.55	51.21	-3.00	-2.90	-2.78	-2.12		
1375	52.48	49.78	49.97	50.24	51.15	-2.70	-2.51	-2.24	-1.33	49.78	49.97	50.24	51.15	-2.70	-2.51	-2.24	-1.33		
1376	52.70	50.06	50.15	50.35	51.36	-2.64	-2.55	-2.35	-1.34	50.06	50.15	50.35	51.36	-2.64	-2.55	-2.35	-1.34		
1377	53.29	50.56	50.60	50.64	51.21	-2.73	-2.69	-2.65	-2.08	50.56	50.60	50.64	51.21	-2.73	-2.69	-2.65	-2.08		
1378	52.84	51.01	51.11	51.23	51.52	-1.83	-1.73	-1.61	-1.32	51.01	51.11	51.23	51.52	-1.83	-1.73	-1.61	-1.32		
1379	53.70	50.44	50.49	50.55	51.36	-3.26	-3.21	-3.15	-2.34	50.44	50.49	50.55	51.36	-3.26	-3.21	-3.15	-2.34		
1380	53.61	50.73	50.83	50.99	51.61	-2.88	-2.78	-2.62	-2.00	50.73	50.83	50.99	51.61	-2.88	-2.78	-2.62	-2.00		
1381	53.30	51.14	51.20	51.29	51.55	-2.16	-2.10	-2.01	-1.75	51.14	51.20	51.29	51.55	-2.16	-2.10	-2.01	-1.75		
1382	54.39	51.46	51.57	51.68	52.01	-2.93	-2.82	-2.71	-2.38	51.46	51.57	51.68	52.01	-2.93	-2.82	-2.71	-2.38		
1383	53.83	50.74	50.84	50.99	51.61	-3.09	-2.99	-2.84	-2.22	50.74	50.84	50.99	51.61	-3.09	-2.99	-2.84	-2.22		
1384	53.87	51.06	51.20	51.39	51.88	-2.81	-2.67	-2.48	-1.99	51.06	51.20	51.39	51.88	-2.81	-2.67	-2.48	-1.99		
1385	54.17	51.47	51.58	51.70	52.02	-2.70	-2.59	-2.47	-2.15	51.47	51.58	51.70	52.02	-2.70	-2.59	-2.47	-2.15		
1386	54.92	51.52	51.65	51.81	52.26	-3.40	-3.27	-3.11	-2.66	51.52	51.65	51.81	52.26	-3.40	-3.27	-3.11	-2.66		
1387	53.67	51.08	51.21	51.40	51.88	-2.59	-2.46	-2.27	-1.79	51.08	51.21	51.40	51.88	-2.59	-2.46	-2.27	-1.79		
1388	53.52	51.49	51.58	51.71	52.23	-2.03	-1.94	-1.81	-1.29	51.49	51.58	51.71	52.23	-2.03	-1.94	-1.81	-1.29		
1389	54.19	51.60	51.65	51.76	52.24	-2.59	-2.54	-2.43	-1.95	51.60	51.65	51.76	52.24	-2.59	-2.54	-2.43	-1.95		
1390	53.64	52.32	52.40	52.50	52.73	-1.32	-1.24	-1.14	-0.91	52.32	52.40	52.50	52.73	-1.32	-1.24	-1.14	-0.91		
1391	53.74	51.55	51.68	51.83	52.28	-2.19	-2.06	-1.91	-1.46	51.55	51.68	51.83	52.28	-2.19	-2.06	-1.91	-1.46		
1392	53.50	51.55	51.68	51.83	52.28	-1.95	-1.82	-1.67	-1.22	51.55	51.68	51.83	52.28	-1.95	-1.82	-1.67	-1.22		
1393	54.15	52.32	52.40	52.50	52.73	-1.83	-1.75	-1.65	-1.42	52.32	52.40	52.50	52.73	-1.83	-1.75	-1.65	-1.42		
1394	54.45	52.32	52.40	52.50	52.73	-2.13	-2.05	-1.95	-1.72	52.32	52.40	52.50	52.73	-2.13	-2.05	-1.95	-1.72		
1395	55.63	51.88	51.88	51.88	52.28	-3.75	-3.75	-3.75	-3.35	51.88	51.88	51.88	52.28	-3.75	-3.75	-3.75	-3.35		
1396	55.52	51.96	51.96	51.96	52.28	-3.56	-3.56	-3.56	-3.24	51.96	51.96	51.96	52.28	-3.56	-3.56	-3.56	-3.24		
1397	55.55	52.02	52.02	52.02	52.28	-3.53	-3.53	-3.53	-3.27	52.02	52.02	52.02	52.28	-3.53	-3.53	-3.53	-3.27		
1398	55.95	52.22	52.22	52.22	52.28	-3.73	-3.73	-3.73	-3.67	52.22	52.22	52.22	52.28	-3.73	-3.73	-3.73	-3.67		
1399	54.81	52.58	52.58	52.58	52.73	-2.23	-2.23	-2.23	-2.08	52.58	52.58	52.58	52.73	-2.23	-2.23	-2.23	-2.08		
1400	55.85	52.97	52.97	52.97	52.97	-2.88	-2.88	-2.88	-2.88	52.97	52.97	52.97	52.97	-2.88	-2.88	-2.88	-2.88		
1401	56.22	53.66	53.66	53.66	53.66	-2.56	-2.56	-2.56	-2.56	53.66	53.66	53.66	53.66	-2.56	-2.56	-2.56	-2.56		
1402	56.28	53.43	53.43	53.43	53.43	-2.85	-2.85	-2.85	-2.85	53.43	53.43	53.43	53.43	-2.85	-2.85	-2.85	-2.85		
1403	55.72	53.33	53.33	53.33	53.33	-2.39	-2.39	-2.39	-2.39	53.33	53.33	53.33	53.33	-2.39	-2.39	-2.39	-2.39		
1404	55.48	53.42	53.42	53.42	53.42	-2.06	-2.06	-2.06	-2.06	53.42	53.42	53.42	53.42	-2.06	-2.06	-2.06	-2.06		
1405	55.02	53.67	53.67	53.67	53.67	-1.35	-1.35	-1.35	-1.35	53.67	53.67	53.67	53.67	-1.35	-1.35	-1.35	-1.35		
1406	55.91	54.15	54.15	54.15	54.15	-1.76	-1.76	-1.76	-1.76	54.15	54.15	54.15	54.15	-1.76	-1.76	-1.76	-1.76		
1407	57.08	55.56	55.56	55.56	55.56	-1.52	-1.52	-1.52	-1.52	55.56	55.56	55.56	55.56	-1.52	-1.52	-1.52	-1.52		
1408	58.36	57.19	57.19	57.19	57.19	-1.17	-1.17	-1.17	-1.17	57.19	57.19	57.19	57.19	-1.17	-1.17	-1.17	-1.17		
1409	57.89	55.10	55.10	55.10	55.10	-2.79	-2.79	-2.79	-2.79	55.10	55.10	55.10	55.10	-2.79	-2.79	-2.79	-2.79		
1410	57.70	54.68	54.68	54.68	54.68	-3.02	-3.02	-3.02	-3.02	54.68	54.68	54.68	54.68	-3.02	-3.02	-3.02	-3.02		

Table C-1
Shintaffer Subbasin Flooding

		Existing Conditions								Future Conditions									
	Assumed Overtopping Elevation	Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
Node	(feet NAVD88)	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	Location	ID
1411	57.50	54.75	54.75	54.75	54.75	-2.75	-2.75	-2.75	-2.75	54.75	54.75	54.75	54.75	-2.75	-2.75	-2.75	-2.75		
1412	57.06	54.37	54.37	54.37	54.37	-2.69	-2.69	-2.69	-2.69	54.37	54.37	54.37	54.37	-2.69	-2.69	-2.69	-2.69		
1413	57.13	54.22	54.24	54.28	54.34	-2.91	-2.89	-2.85	-2.79	54.22	54.24	54.28	54.34	-2.91	-2.89	-2.85	-2.79		
1414	56.94	54.21	54.24	54.28	54.34	-2.73	-2.70	-2.66	-2.60	54.21	54.24	54.28	54.34	-2.73	-2.70	-2.66	-2.60		
1415	56.66	53.29	53.37	53.45	53.58	-3.37	-3.29	-3.21	-3.08	53.29	53.37	53.45	53.58	-3.37	-3.29	-3.21	-3.08		
1416	56.03	53.29	53.37	53.45	53.58	-2.74	-2.66	-2.58	-2.45	53.29	53.37	53.45	53.58	-2.74	-2.66	-2.58	-2.45		
1417	56.15	53.04	53.07	53.11	53.16	-3.11	-3.08	-3.04	-2.99	53.04	53.07	53.11	53.16	-3.11	-3.08	-3.04	-2.99		
1418	56.59	52.51	52.51	52.51	52.51	-4.08	-4.08	-4.08	-4.08	52.51	52.51	52.51	52.51	-4.08	-4.08	-4.08	-4.08		
1419	54.55	52.74	52.83	52.91	53.05	-1.81	-1.72	-1.64	-1.50	52.74	52.83	52.91	53.05	-1.81	-1.72	-1.64	-1.50		
1420	54.95	52.45	52.48	52.51	52.56	-2.50	-2.47	-2.44	-2.39	52.45	52.48	52.51	52.56	-2.50	-2.47	-2.44	-2.39		
1421	56.71	52.42	52.42	52.42	52.42	-4.29	-4.29	-4.29	-4.29	52.42	52.42	52.42	52.42	-4.29	-4.29	-4.29	-4.29		
1422	54.90	52.50	52.50	52.50	52.50	-2.40	-2.40	-2.40	-2.40	52.50	52.50	52.50	52.50	-2.40	-2.40	-2.40	-2.40		
1423	54.53	52.53	52.53	52.53	52.53	-2.00	-2.00	-2.00	-2.00	52.53	52.53	52.53	52.53	-2.00	-2.00	-2.00	-2.00		
1424	54.38	51.78	51.78	51.78	51.78	-2.60	-2.60	-2.60	-2.60	51.78	51.78	51.78	51.78	-2.60	-2.60	-2.60	-2.60		
1425	54.69	51.75	51.75	51.75	51.75	-2.94	-2.94	-2.94	-2.94	51.75	51.75	51.75	51.75	-2.94	-2.94	-2.94	-2.94		
1426	54.45	51.62	51.66	51.70	51.77	-2.83	-2.79	-2.75	-2.68	51.62	51.66	51.70	51.77	-2.83	-2.79	-2.75	-2.68		
1427	53.35	49.59	49.59	49.59	49.59	-3.76	-3.76	-3.76	-3.76	49.59	49.59	49.59	49.59	-3.76	-3.76	-3.76	-3.76		
1428	51.44	48.18	48.18	48.18	48.18	-3.26	-3.26	-3.26	-3.26	48.18	48.18	48.18	48.18	-3.26	-3.26	-3.26	-3.26		
1429	51.88	48.90	48.92	48.93	48.96	-2.98	-2.96	-2.95	-2.92	48.90	48.92	48.93	48.96	-2.98	-2.96	-2.95	-2.92		
1430	49.60	47.23	47.24	47.25	47.46	-2.37	-2.36	-2.35	-2.14	47.23	47.24	47.25	47.46	-2.37	-2.36	-2.35	-2.14		
1431	49.23	46.22	46.30	46.38	46.52	-3.01	-2.93	-2.85	-2.71	46.22	46.30	46.38	46.52	-3.01	-2.93	-2.85	-2.71		
1434	50.16	45.61	45.70	45.80	45.96	-4.55	-4.46	-4.36	-4.20	45.61	45.70	45.80	45.96	-4.55	-4.46	-4.36	-4.20		
1436	49.38	47.95	48.06	48.17	48.25	-1.43	-1.32	-1.21	-1.13	47.95	48.06	48.17	48.24	-1.43	-1.32	-1.21	-1.14		
1437	50.84	48.11	48.14	48.18	48.25	-2.73	-2.70	-2.66	-2.59	48.11	48.14	48.18	48.25	-2.73	-2.70	-2.66	-2.59		
1438	52.23	49.45	49.49	49.53	49.59	-2.78	-2.74	-2.70	-2.64	49.45	49.49	49.53	49.59	-2.78	-2.74	-2.70	-2.64		
1439	52.12	49.61	49.64	49.68	49.75	-2.51	-2.48	-2.44	-2.37	49.61	49.64	49.68	49.75	-2.51	-2.48	-2.44	-2.37		
1440	51.81	49.95	50.00	50.06	50.15	-1.86	-1.81	-1.75	-1.66	49.95	50.00	50.06	50.15	-1.86	-1.81	-1.75	-1.66		
1441	50.39	46.98	47.10	47.21	47.62	-3.41	-3.29	-3.18	-2.77	46.97	47.10	47.21	47.63	-3.42	-3.29	-3.18	-2.76		
1442	48.91	46.25	46.29	46.44	46.60	-2.66	-2.62	-2.47	-2.31	46.25	46.29	46.44	46.60	-2.66	-2.62	-2.47	-2.31		
1443	52.29	50.06	50.12	50.18	50.28	-2.23	-2.17	-2.11	-2.01	50.06	50.12	50.18	50.28	-2.23	-2.17	-2.11	-2.01		
1446	51.31	50.12	50.20	50.29	50.43	-1.19	-1.11	-1.02	-0.88	50.12	50.20	50.29	50.43	-1.19	-1.11	-1.02	-0.88		
1447	52.50	50.12	50.20	50.29	50.43	-2.38	-2.30	-2.21	-2.07	50.12	50.20	50.29	50.43	-2.38	-2.30	-2.21	-2.07		
1448	53.14	51.36	51.36	51.36	51.36	-1.78	-1.78	-1.78	-1.78	51.36	51.36	51.36	51.36	-1.78	-1.78	-1.78	-1.78		
1449	49.60	46.95	47.07	47.17	47.61	-2.65	-2.53	-2.43	-1.99	46.95	47.07	47.17	47.61	-2.65	-2.53	-2.43	-1.99		
1450	48.63	46.23	46.30	46.39	46.52	-2.40	-2.33	-2.24	-2.11	46.23	46.30	46.39	46.52	-2.40	-2.33	-2.24	-2.11		
1451	42.73	36.34	37.64	38.32	38.85	-6.39	-5.09	-4.41	-3.88	36.21	37.81	38.21	38.85	-6.52	-4.92	-4.52	-3.88		
1452	46.16	45.01	45.01	45.01	45.01	-1.15	-1.15	-1.15	-1.15	45.01	45.01	45.01	45.01	-1.15	-1.15	-1.15	-1.15		
1453	49.05	46.30	46.30	46.30	46.30	-2.75	-2.75	-2.75	-2.75	46.30	46.30	46.30	46.30	-2.75	-2.75	-2.75	-2.75		
1454	49.29	47.01	47.01	47.01	47.01	-2.28	-2.28	-2.28	-2.28	47.01	47.01	47.01	47.01	-2.28	-2.28	-2.28	-2.28		
1457	47.94	34.31	34.48	34.55	34.61	-13.63	-13.46	-13.39	-13.33	34.28	34.48	34.54	34.61	-13.66	-13.46	-13.40	-13.33		
1460	53.37	43.12	43.24	43.37	43.57	-10.25	-10.13	-10.00	-9.80	43.12	43.24	43.37	43.57	-10.25	-10.13	-10.00	-9.80		
1463	51.76	50.35	50.37	50.40	50.43	-1.41	-1.39	-1.36	-1.33	50.35	50.37	50.40	50.43	-1.41	-1.39	-1.36	-1.33		
1464	51.99	49.88	49.90	49.93	49.97	-2.11	-2.09	-2.06	-2.02	49.88	49.90	49.93	49.97	-2.11	-2.09	-2.06	-2.02		
1467	51.10	49.46	49.51	49.57	49.67	-1.64	-1.59	-1.53	-1.43	49.46	49.51	49.57	49.67	-1.64	-1.59	-1.53	-1.43		
1468	52.32	50.67	50.67	50.67	50.67	-1.65	-1.65	-1.65	-1.65	50.67	50.67	50.67	50.67	-1.65	-1.65	-1.65	-1.65		
1469	52.48	50.62	50.62	50.62	50.62	-1.86	-1.86	-1.86	-1.86	50.62	50.62	50.62	50.62	-1.86	-1.86	-1.86	-1.86		
1472	50.40	50.62	50.62	50.62	50.62	**0.22**	**0.22**	**0.22**	**0.22**	50.62	50.62	50.62	50.62	**0.22**	**0.22**	**0.22**	**0.22**	Cherry Tree Lane	SH-F-2
1473	51.44	50.62	50.62	50.62	50.62	-0.82	-0.82	-0.82	-0.82	50.62	50.62	50.62	50.62	-0.82	-0.82	-0.82	-0.82		
1474	51.72	50.62	50.62	50.62	50.62	-1.10	-1.10	-1.10	-1.10	50.62	50.62	50.62	50.62	-1.10	-1.10	-1.10	-1.10		
1475	52.58	50.63	50.63	50.63	50.63	-1.95	-1.95	-1.95	-1.95	50.63	50.63	50.63	50.63	-1.95	-1.95	-1.95	-1.95		
1476	52.47	50.69	50.69	50.69	50.69	-1.78	-1.78	-1.78	-1.78	50.69	50.69	50.69	50.69	-1.78	-1.78	-1.78	-1.78		
1477	52.82	50.57	50.59	50.62	50.67	-2.25	-2.23	-2.20	-2.15	50.57	50.59	50.62	50.67	-2.25	-2.23	-2.20	-2.15		
1478	52.68	50.35	50.35	50.35	50.35	-2.33	-2.33	-2.33	-2.33	50.35	50.35	50.35	50.35	-2.33	-2.33	-2.33	-2.33		
1479	52.68	49.89	49.89	49.89	49.89	-2.79	-2.79	-2.79	-2.79	49.89	49.89	49.89	49.89	-2.79	-2.79	-2.79	-2.79		
1481	50.15	47.54	47.57	47.59	47.63	-2.61	-2.58	-2.56	-2.52	47.54	47.57	47.59	47.63	-2.61	-2.58	-2.56	-2.52		
1483	18.00	10.93	11.74	12.38	13.29	-7.07	-6.26	-5.62	-4.71	10.89	11.77	12.29	13.33	-7.11	-6.23	-5.71	-4.67		
1204A	57.00	55.15	55.22	55.28	55.37	-1.85	-1.78	-1.72	-1.63	55.10	55.23	55.26	55.37	-1.90	-1.77	-1.74	-1.63		
1272A	65.00	60.92	60.99	61.08	61.20	-4.08	-4.01	-3.92	-3.80	60.92	60.99	61.08	61.20	-4.08	-4.01	-3.92	-3.80		
1277A	68.00	62.83	62.89	62.97	63.07	-5.17	-5.11	-5.03	-4.93	62.83	62.89	62.97	63.07	-5.17	-5.11	-5.03	-4.93		

Table C-2
Cottonwood Beach North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions								Future Conditions								Location	ID
		Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
		2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year		
543	51.75	48.28	48.39	48.43	48.47	-3.47	-3.36	-3.32	-3.28	48.28	48.39	48.43	48.47	-3.47	-3.36	-3.32	-3.28		
546	50.76	47.00	47.17	47.47	48.29	-3.76	-3.59	-3.29	-2.47	47.00	47.17	47.47	48.35	-3.76	-3.59	-3.29	-2.41		
547	50.32	46.62	47.02	47.40	48.21	-3.70	-3.30	-2.92	-2.11	46.62	47.02	47.40	48.28	-3.70	-3.30	-2.92	-2.04		
550	48.05	46.49	47.00	47.40	48.21	-1.56	-1.05	-0.65	0.16	46.49	47.00	47.40	48.28	-1.56	-1.05	-0.65	0.23	Driveway north side of Anderson 230 feet east of Sunset	CN-F-5
551	47.86	46.44	46.95	47.32	48.13	-1.42	-0.91	-0.54	0.27	46.44	46.95	47.32	48.21	-1.42	-0.91	-0.54	0.35	Driveway north side of Anderson 230 feet east of Sunset	CN-F-5
556	48.18	46.40	46.94	47.32	48.13	-1.78	-1.24	-0.86	-0.05	46.40	46.94	47.32	48.20	-1.78	-1.24	-0.86	0.02	North Side of Anderson west of Sunset	CN-F-5
557	48.08	46.32	46.73	47.02	47.83	-1.76	-1.35	-1.06	-0.25	46.32	46.73	47.02	47.92	-1.76	-1.35	-1.06	-0.16	North Side of Anderson west of Sunset	CN-F-5
560	48.38	45.67	45.79	45.83	45.88	-2.71	-2.59	-2.55	-2.50	45.67	45.79	45.83	45.88	-2.71	-2.59	-2.55	-2.50		
561	47.80	45.65	45.75	45.79	45.83	-2.15	-2.05	-2.01	-1.97	45.65	45.75	45.79	45.83	-2.15	-2.05	-2.01	-1.97		
562	48.10	46.29	46.70	47.01	47.82	-1.81	-1.40	-1.09	-0.28	46.29	46.70	47.01	47.92	-1.81	-1.40	-1.09	-0.18	North Side of Anderson west of Sunset	CN-F-5
563	47.76	46.21	46.53	46.78	47.59	-1.55	-1.23	-0.98	-0.17	46.21	46.53	46.78	47.70	-1.55	-1.23	-0.98	-0.06	North Side of Anderson west of Sunset	CN-F-5
564	48.06	46.20	46.51	46.77	47.59	-1.86	-1.55	-1.29	-0.47	46.20	46.51	46.77	47.70	-1.86	-1.55	-1.29	-0.36	North Side of Anderson west of Sunset	CN-F-5
565	48.50	45.76	46.22	46.54	47.36	-2.74	-2.28	-1.96	-1.14	45.76	46.22	46.54	47.49	-2.74	-2.28	-1.96	-1.01		
566	47.83	45.60	46.21	46.54	47.36	-2.23	-1.62	-1.29	-0.47	45.60	46.21	46.54	47.49	-2.23	-1.62	-1.29	-0.34	North Side of Anderson west of Sunset	CN-F-5
568	47.32	45.49	46.52	46.34	47.10	-1.83	-0.80	-0.98	-0.22	45.49	46.46	46.36	47.26	-1.83	-0.86	-0.96	-0.06	North Side of Anderson west of Sunset	CN-F-5
569	48.22	45.28	45.86	46.00	46.72	-2.94	-2.36	-2.22	-1.50	45.28	45.86	46.00	46.91	-2.94	-2.36	-2.22	-1.31		
570	47.26	45.22	45.39	45.44	45.50	-2.04	-1.87	-1.82	-1.76	45.22	45.39	45.44	45.50	-2.04	-1.87	-1.82	-1.76		
571	47.41	45.21	45.37	45.42	45.47	-2.20	-2.04	-1.99	-1.94	45.21	45.37	45.42	45.47	-2.20	-2.04	-1.99	-1.94		
572	47.27	45.31	45.91	46.02	46.72	-1.96	-1.36	-1.25	-0.55	45.30	45.90	46.01	46.90	-1.97	-1.37	-1.26	-0.37	North Side of Anderson west of Sunset	CN-F-5
574	46.62	45.15	45.30	45.35	45.40	-1.47	-1.32	-1.27	-1.22	45.15	45.30	45.35	45.40	-1.47	-1.32	-1.27	-1.22		
575	46.90	45.15	45.29	45.33	45.38	-1.75	-1.61	-1.57	-1.52	45.15	45.29	45.33	45.38	-1.75	-1.61	-1.57	-1.52		
576	47.59	45.07	45.42	45.54	46.41	-2.52	-2.17	-2.05	-1.18	45.07	45.42	45.59	46.63	-2.52	-2.17	-2.00	-0.96		
577	46.98	44.29	44.53	44.63	45.70	-2.69	-2.45	-2.35	-1.28	44.29	44.53	45.07	46.01	-2.69	-2.45	-1.91	-0.97		
578	47.39	45.08	45.20	45.24	45.28	-2.31	-2.19	-2.15	-2.11	45.08	45.20	45.24	45.28	-2.31	-2.19	-2.15	-2.11		
579	46.95	45.07	45.16	45.18	45.22	-1.88	-1.79	-1.77	-1.73	45.07	45.16	45.18	45.22	-1.88	-1.79	-1.77	-1.73		
580	47.17	44.64	44.80	44.85	44.90	-2.53	-2.37	-2.32	-2.27	44.64	44.80	44.85	44.90	-2.53	-2.37	-2.32	-2.27		
581	46.94	44.64	44.80	44.84	44.89	-2.30	-2.14	-2.10	-2.05	44.64	44.80	44.84	44.89	-2.30	-2.14	-2.10	-2.05		
600	47.55	45.57	45.77	45.82	45.90	-1.98	-1.78	-1.73	-1.65	45.57	45.77	45.82	45.90	-1.98	-1.78	-1.73	-1.65		
601	46.76	45.42	45.55	45.59	45.64	-1.34	-1.21	-1.17	-1.12	45.42	45.55	45.59	45.64	-1.34	-1.21	-1.17	-1.12		
602	47.36	45.30	45.42	45.46	45.52	-2.06	-1.94	-1.90	-1.84	45.30	45.42	45.46	45.52	-2.06	-1.94	-1.90	-1.84		
603	46.97	45.10	45.29	45.34	45.43	-1.87	-1.68	-1.63	-1.54	45.10	45.29	45.34	45.43	-1.87	-1.68	-1.63	-1.54		
604	46.85	45.10	45.28	45.33	45.42	-1.75	-1.57	-1.52	-1.43	45.10	45.28	45.33	45.42	-1.75	-1.57	-1.52	-1.43		
605	46.86	44.89	45.10	45.18	45.31	-1.97	-1.76	-1.68	-1.55	44.89	45.10	45.18	45.31	-1.97	-1.76	-1.68	-1.55		
607	46.17	44.76	44.83	44.85	44.87	-1.41	-1.34	-1.32	-1.30	44.76	44.83	44.85	44.87	-1.41	-1.34	-1.32	-1.30		
608	46.82	44.83	45.10	45.17	45.32	-1.99	-1.72	-1.65	-1.50	44.83	45.10	45.17	45.32	-1.99	-1.72	-1.65	-1.50		
609	46.50	44.77	45.05	45.13	45.27	-1.73	-1.45	-1.37	-1.23	44.77	45.05	45.13	45.26	-1.73	-1.45	-1.37	-1.24		
610	46.33	44.78	45.15	45.24	45.42	-1.55	-1.18	-1.09	-0.91	44.77	45.15	45.24	45.42	-1.56	-1.18	-1.09	-0.91		
611	46.55	44.72	44.95	45.00	45.09	-1.83	-1.60	-1.55	-1.46	44.72	44.95	45.00	45.08	-1.83	-1.60	-1.55	-1.47		
612	46.46	44.70	44.90	44.94	45.01	-1.76	-1.56	-1.52	-1.45	44.70	44.89	44.94	45.01	-1.76	-1.57	-1.52	-1.45		
613	46.63	44.62	44.75	44.78	44.82	-2.01	-1.88	-1.85	-1.81	44.62	44.75	44.78	44.82	-2.01	-1.88	-1.85	-1.81		
614	45.42	44.54	44.66	44.69	44.74	-0.88	-0.76	-0.73	-0.68	44.54	44.66	44.69	44.74	-0.88	-0.76	-0.73	-0.68		
615	46.04	44.53	44.65	44.68	44.72	-1.51	-1.39	-1.36	-1.32	44.53	44.65	44.68	44.72	-1.51	-1.39	-1.36	-1.32		
616	45.82	44.53	44.64	44.66	44.70	-1.29	-1.18	-1.16	-1.12	44.53	44.64	44.66	44.70	-1.29	-1.18	-1.16	-1.12		
617	46.61	44.56	44.65	44.67	44.71	-2.05	-1.96	-1.94	-1.90	44.56	44.65	44.67	44.71	-2.05	-1.96	-1.94	-1.90		
618	46.17	44.17	44.39	44.44	44.52	-2.00	-1.78	-1.73	-1.65	44.17	44.39	44.44	44.52	-2.00	-1.78	-1.73	-1.65		
619	46.18	44.21	44.28	44.30	44.32	-1.97	-1.90	-1.88	-1.86	44.21	44.28	44.30	44.32	-1.97	-1.90	-1.88	-1.86		
620	46.08	44.16	44.38	44.43	44.51	-1.92	-1.70	-1.65	-1.57	44.16	44.38	44.43	44.51	-1.92	-1.70	-1.65	-1.57		
621	45.91	43.93	44.01	44.02	44.05	-1.98	-1.90	-1.89	-1.86	43.93	44.01	44.02	44.05	-1.98	-1.90	-1.89	-1.86		
622	45.76	43.56	43.69	43.72	43.77	-2.20	-2.07	-2.04	-1.99	43.56	43.69	43.72	43.77	-2.20	-2.07	-2.04	-1.99		
623	45.46	42.93	43.07	43.10	43.16	-2.53	-2.39	-2.36	-2.30	42.93	43.07	43.10	43.16	-2.53	-2.39	-2.36	-2.30		
624	45.05	42.83	42.98	43.02	43.08	-2.22	-2.07	-2.03	-1.97	42.83	42.98	43.02	43.08	-2.22	-2.07	-2.03	-1.97		
626	44.55	42.50	42.65	42.69	42.76	-2.05	-1.90	-1.86	-1.79	42.50	42.65	42.69	42.76	-2.05	-1.90	-1.86	-1.79		
629	44.04	41.13	41.23	41.25	41.29	-2.91	-2.81	-2.79	-2.75	41.13	41.23	41.25	41.29	-2.91	-2.81	-2.79	-2.75		
630	45.36	42.50	42.65	42.69	42.76	-2.86	-2.71	-2.67	-2.60	42.50	42.65	42.69	42.76	-2.86	-2.71	-2.67	-2.60		
631	45.54	44.58	44.58	44.58	44.58	-0.96	-0.96	-0.96	-0.96	44.58	44.58	44.58	44.58	-0.96	-0.96	-0.96	-0.96		
632	45.36	43.02	43.02	43.02	43.02	-2.34	-2.34	-2.34	-2.34	43.02	43.02	43.02	43.02	-2.34	-2.34	-2.34	-2.34		
633	46.52	43.14	43.14	43.14	43.14	-3.38	-3.38	-3.38	-3.38	43.14	43.14	43.14	43.14	-3.38	-3.38	-3.38	-3.38		
634	46.52	45.52	45.52	45.52	45.52	-1.00	-1.00	-1.00	-1.00	45.52	45.52	45.52	45.52	-1.00	-1.00	-1.00	-1.00		
662	46.50	45.59	45.66	45.68	45.71	-0.91	-0.84	-0.82	-0.79	45.59	45.66	45.68	45.71	-0.91	-0.84	-0.82	-0.79		

Table C-2
Cottonwood Beach North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
665	34.09	32.24	32.36	32.39	32.43	-1.85	-1.73	-1.70	-1.66	32.24	32.36	32.39	32.43	-1.85	-1.73	-1.70	-1.66		
670	41.53	39.56	39.62	39.63	39.65	-1.97	-1.91	-1.90	-1.88	39.56	39.62	39.63	39.65	-1.97	-1.91	-1.90	-1.88		
675	33.39	31.69	31.81	31.85	31.89	-1.70	-1.58	-1.54	-1.50	31.69	31.81	31.85	31.89	-1.70	-1.58	-1.54	-1.50		
681	30.71	28.82	29.03	29.13	29.26	-1.89	-1.68	-1.58	-1.45	28.82	29.03	29.13	29.26	-1.89	-1.68	-1.58	-1.45		
686	29.75	28.28	28.71	29.03	29.12	-1.47	-1.04	-0.72	-0.63	28.28	28.71	29.03	29.12	-1.47	-1.04	-0.72	-0.63		
687	28.88	27.69	28.65	28.89	28.89	-1.19	**-0.23**	**0.01**	**0.01**	27.69	28.64	28.89	28.89	-1.19	**-0.24**	**0.01**	**0.01**	Seaview Drive	
691	29.44	27.47	28.20	28.35	28.35	-1.97	-1.24	-1.09	-1.09	27.47	28.20	28.35	28.35	-1.97	-1.24	-1.09	-1.09		
692	29.31	27.06	27.29	27.32	27.32	-2.25	-2.02	-1.99	-1.99	27.06	27.29	27.32	27.32	-2.25	-2.02	-1.99	-1.99		
693	29.87	26.69	26.96	27.02	27.07	-3.18	-2.91	-2.85	-2.80	26.69	26.96	27.02	27.07	-3.18	-2.91	-2.85	-2.80		
695	35.94	35.21	35.31	35.33	35.37	-0.73	-0.63	-0.61	-0.57	35.21	35.31	35.33	35.37	-0.73	-0.63	-0.61	-0.57		
696	29.26	24.72	24.84	24.86	24.87	-4.54	-4.42	-4.40	-4.39	24.72	24.84	24.86	24.87	-4.54	-4.42	-4.40	-4.39		
700	16.56	15.82	16.34	16.76	18.13	-0.74	**-0.22**	**0.20**	**1.57**	15.68	16.36	17.09	18.28	-0.88	**-0.20**	**0.53**	**1.72**	SHD	CN-F-3
701	13.37	11.89	13.37	13.37	13.37	-1.48	**0.00**	**0.00**	**0.00**	11.89	13.37	13.37	13.37	-1.48	**0.00**	**0.00**	**0.00**	Birch Bay Drive west of Cedar	CN-F-1
706	12.58	11.56	12.58	12.58	12.58	-1.02	**0.00**	**0.00**	**0.00**	11.56	12.58	12.58	12.58	-1.02	**0.00**	**0.00**	**0.00**	Birch Bay Drive west of Cedar	CN-F-1
707	11.98	10.32	11.09	11.15	11.31	-1.66	-0.89	-0.83	-0.67	10.32	11.10	11.15	11.31	-1.66	-0.88	-0.83	-0.67		
714	11.76	10.22	10.87	10.94	11.11	-1.54	-0.89	-0.82	-0.65	10.22	10.87	10.94	11.12	-1.54	-0.89	-0.82	-0.64	Birch Bay Drive west of Cedar	CN-F-1
715	11.63	9.78	9.17	9.17	9.18	-1.85	-2.46	-2.46	-2.45	9.78	9.17	9.17	9.18	-1.85	-2.46	-2.46	-2.45		
720	12.71	14.53	16.83	16.83	16.83	**1.82**	**4.12**	**4.12**	**4.12**	14.52	16.83	16.83	16.83	**1.81**	**4.12**	**4.12**	**4.12**	Birch Bay Drive west of Cedar (4" pipe)	CN-F-2
723	12.55	14.53	16.80	16.80	16.80	**1.98**	**4.25**	**4.25**	**4.25**	14.56	16.80	16.80	16.80	**2.01**	**4.25**	**4.25**	**4.25**	Birch Bay Drive west of Cedar (4" pipe)	CN-F-2
726	11.91	9.80	10.99	11.07	11.37	-2.11	-0.92	-0.84	-0.54	9.86	11.03	11.07	11.40	-2.05	-0.88	-0.84	-0.51		
733	11.26	10.23	10.37	10.38	10.44	-1.03	-0.89	-0.88	-0.82	10.23	10.37	10.38	10.44	-1.03	-0.89	-0.88	-0.82		
734	11.68	9.78	8.88	8.94	8.95	-1.90	-2.80	-2.74	-2.73	9.78	8.88	8.94	8.95	-1.90	-2.80	-2.74	-2.73		
742	11.95	9.78	9.31	9.32	9.37	-2.17	-2.64	-2.63	-2.58	9.78	9.31	9.32	9.37	-2.17	-2.64	-2.63	-2.58		
773	49.72	47.20	47.32	47.36	47.41	-2.52	-2.40	-2.36	-2.31	47.20	47.32	47.36	47.41	-2.52	-2.40	-2.36	-2.31		
774	50.11	47.17	47.23	47.25	47.27	-2.94	-2.88	-2.86	-2.84	47.17	47.23	47.25	47.27	-2.94	-2.88	-2.86	-2.84		
775	49.28	46.16	46.21	46.23	46.25	-3.12	-3.07	-3.05	-3.03	46.16	46.21	46.23	46.25	-3.12	-3.07	-3.05	-3.03		
776	47.61	45.56	45.62	45.64	45.66	-2.05	-1.99	-1.97	-1.95	45.56	45.62	45.64	45.66	-2.05	-1.99	-1.97	-1.95		
777	46.15	44.05	44.10	44.11	44.13	-2.10	-2.05	-2.04	-2.02	44.05	44.10	44.11	44.13	-2.10	-2.05	-2.04	-2.02		
780	45.04	42.20	42.30	42.33	42.34	-2.84	-2.74	-2.71	-2.70	42.20	42.30	42.33	42.34	-2.84	-2.74	-2.71	-2.70		
782	37.21	28.11	32.70	35.30	36.89	-9.10	-4.51	-1.91	**-0.32**	27.19	33.73	36.13	37.67	-10.02	-3.48	-1.08	**0.46**	Alder Street at Park	CN-F-4
783	37.21	28.11	32.70	35.30	36.90	-9.10	-4.51	-1.91	**-0.31**	27.19	33.73	36.14	37.68	-10.02	-3.48	-1.07	**0.47**	Alder Street at Park	CN-F-4
784	37.45	35.32	35.35	35.36	35.37	-2.13	-2.10	-2.09	-2.08	35.32	35.35	35.36	35.37	-2.13	-2.10	-2.09	-2.08		
785	37.21	25.09	25.20	25.25	25.28	-12.12	-12.01	-11.96	-11.93	25.04	25.22	25.27	25.33	-12.17	-11.99	-11.94	-11.88		
786	37.21	24.54	24.70	24.77	24.80	-12.67	-12.51	-12.44	-12.41	24.47	24.73	24.78	25.14	-12.74	-12.48	-12.43	-12.07		
796	50.19	47.93	48.13	48.19	48.19	-2.26	-2.06	-2.00	-2.00	47.93	48.13	48.19	48.19	-2.26	-2.06	-2.00	-2.00		
797	49.99	48.13	48.33	48.39	48.39	-1.86	-1.66	-1.60	-1.60	48.13	48.33	48.39	48.39	-1.86	-1.66	-1.60	-1.60		
798	50.08	48.19	48.53	48.65	48.65	-1.89	-1.55	-1.43	-1.43	48.19	48.53	48.65	48.65	-1.89	-1.55	-1.43	-1.43		
799	49.72	48.20	48.53	48.66	48.66	-1.52	-1.19	-1.06	-1.06	48.20	48.53	48.66	48.66	-1.52	-1.19	-1.06	-1.06		
800	50.11	48.22	48.65	48.84	48.84	-1.89	-1.46	-1.27	-1.27	48.22	48.65	48.84	48.84	-1.89	-1.46	-1.27	-1.27		
855	47.49	45.01	45.12	45.25	45.30	-2.48	-2.37	-2.24	-2.19	44.99	45.10	45.22	45.73	-2.50	-2.39	-2.27	-1.76		
856	45.40	37.14	37.33	37.42	37.46	-8.26	-8.07	-7.98	-7.94	37.06	37.38	37.44	37.69	-8.34	-8.02	-7.96	-7.71		
857	46.10	39.36	41.80	44.21	45.28	-6.74	-4.30	-1.89	-0.82	38.97	43.03	44.73	45.67	-7.13	-3.07	-1.37	**-0.43**		
858	45.01	42.99	42.99	42.99	42.99	-2.02	-2.02	-2.02	-2.02	42.99	42.99	42.99	42.99	-2.02	-2.02	-2.02	-2.02		
862	43.47	41.24	41.24	41.24	41.24	-2.23	-2.23	-2.23	-2.23	41.24	41.24	41.24	41.24	-2.23	-2.23	-2.23	-2.23		
863	42.95	40.88	40.98	41.01	41.05	-2.07	-1.97	-1.94	-1.90	40.88	40.98	41.01	41.05	-2.07	-1.97	-1.94	-1.90		
867	41.83	38.94	39.11	39.15	39.22	-2.89	-2.72	-2.68	-2.61	38.94	39.11	39.15	39.22	-2.89	-2.72	-2.68	-2.61		
871	40.02	38.49	38.54	38.56	38.58	-1.53	-1.48	-1.46	-1.44	38.49	38.54	38.56	38.58	-1.53	-1.48	-1.46	-1.44		
872	31.15	29.53	29.72	29.77	29.85	-1.62	-1.43	-1.38	-1.30	29.53	29.72	29.77	29.85	-1.62	-1.43	-1.38	-1.30		
877	30.98	29.33	29.49	29.54	29.60	-1.65	-1.49	-1.44	-1.38	29.33	29.49	29.54	29.60	-1.65	-1.49	-1.44	-1.38		
878	30.87	29.04	29.15	29.18	29.22	-1.83	-1.72	-1.69	-1.65	29.04	29.15	29.18	29.22	-1.83	-1.72	-1.69	-1.65		
882	31.80	20.66	21.35	23.26	24.58	-11.14	-10.45	-8.54	-7.22	20.43	21.59	23.71	25.15	-11.37	-10.21	-8.09	-6.65		
885	41.01	37.52	37.61	37.64	37.67	-3.49	-3.40	-3.37	-3.34	37.52	37.61	37.64	37.67	-3.49	-3.40	-3.37	-3.34		
887	44.27	40.51	40.60	40.63	40.67	-3.76	-3.67	-3.64	-3.60	40.51	40.60	40.63	40.67	-3.76	-3.67	-3.64	-3.60		
890	45.63	41.83	41.94	41.97	42.01	-3.80	-3.69	-3.66	-3.62	41.83	41.94	41.97	42.01	-3.80	-3.69	-3.66	-3.62		
891	45.23	42.56	42.76	42.83	42.92	-2.67	-2.47	-2.40	-2.31	42.56	42.76	42.83	42.92	-2.67	-2.47	-2.40	-2.31		
892	45.72	43.17	43.28	43.31	43.35	-2.55	-2.44	-2.41	-2.37	43.17	43.28	43.31	43.35	-2.55	-2.44	-2.41	-2.37		
893	45.84	43.47	43.70	43.78	43.88	-2.37	-2.14	-2.06	-1.96	43.47	43.70	43.78	43.88	-2.37	-2.14	-2.06	-1.96		
894	45.99	43.50	43.74	43.82	43.92	-2.49	-2.25	-2.17	-2.07	43.50	43.74	43.82	43.92	-2.49	-2.25	-2.17	-2.07		
895	45.91	43.54	43.83	43.97	44.17	-2.37	-2.08	-1.94	-1.74	43.54	43.83	43.97	44.17	-2.37	-2.08	-1.94	-1.74		

Table C-2
Cottonwood Beach North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
896	45.86	43.82	43.89	43.98	44.17	-2.04	-1.97	-1.88	-1.69	43.82	43.89	43.98	44.17	-2.04	-1.97	-1.88	-1.69		
897	45.79	43.96	44.09	44.11	44.22	-1.83	-1.70	-1.68	-1.57	43.96	44.09	44.11	44.22	-1.83	-1.70	-1.68	-1.57		
898	45.13	44.28	44.36	44.39	44.42	-0.85	-0.77	-0.74	-0.71	44.28	44.36	44.39	44.42	-0.85	-0.77	-0.74	-0.71		
899	47.16	44.18	44.44	44.57	45.70	-2.98	-2.72	-2.59	-1.46	44.18	44.44	45.07	46.01	-2.98	-2.72	-2.09	-1.15		
900	47.20	43.32	43.49	44.30	45.28	-3.88	-3.71	-2.90	-1.92	43.32	43.49	44.73	45.67	-3.88	-3.71	-2.47	-1.53		
901	47.20	43.20	43.39	44.21	45.28	-4.00	-3.81	-2.99	-1.92	43.20	43.39	44.73	45.67	-4.00	-3.81	-2.47	-1.53		

Table C-3
Cottonwood Beach South Subbasin

	Assumed Overtopping	Existing Conditions								Future Conditions									
	Elevation	Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
Node	(feet NAVD88)	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	Location	ID
743	11.23	9.47	11.54	12.20	12.40	-1.76	**0.31**	**0.97**	**1.17**	9.41	10.92	12.16	12.34	-1.82	**-0.31**	**0.93**	**1.11**	Birch Bay Drive and Beachway Drive	CS-F-2
747	10.00	9.21	8.11	8.94	8.94	-0.79	-1.89	-1.06	-1.06	9.21	8.11	8.94	8.94	-0.79	-1.89	-1.06	-1.06		
750	12.01	10.08	11.86	12.17	12.25	-1.93	**-0.15**	**0.16**	**0.24**	10.09	11.52	12.15	12.23	-1.92	**-0.49**	**0.14**	**0.22**	Birch Bay Drive and Beachway Drive	CS-F-1
751	11.59	10.38	12.09	12.15	12.17	-1.21	**0.50**	**0.56**	**0.58**	10.38	11.94	12.14	12.16	-1.21	**0.35**	**0.55**	**0.57**	Birch Bay Drive and Beachway Drive	CS-F-1
755	12.66	10.66	11.32	12.66	12.66	-2.00	-1.34	**0.00**	**0.00**	10.59	10.91	12.30	12.66	-2.07	-1.75	**-0.36**	**0.00**	Birch Bay Drive midway between Beachway Drive and Cottonwood Dri	CS-F-2
756	11.70	9.22	8.75	8.96	8.96	-2.48	-2.95	-2.74	-2.74	9.22	8.69	8.95	8.96	-2.48	-3.01	-2.75	-2.74		
760	10.00	9.21	8.11	8.94	8.94	-0.79	-1.89	-1.06	-1.06	9.21	8.11	8.94	8.94	-0.79	-1.89	-1.06	-1.06		
787	17.36	15.77	17.59	17.62	17.64	-1.59	**0.23**	**0.26**	**0.28**	15.33	17.55	17.62	17.63	-2.03	**0.19**	**0.26**	**0.27**		
790	12.23	10.80	12.99	13.20	13.25	-1.43	**0.76**	**0.97**	**1.02**	10.80	12.11	13.19	13.24	-1.43	**-0.12**	**0.96**	**1.01**	Birch Bay Drive and Beachway Drive	CS-F-2
791	13.78	12.96	13.18	13.22	13.24	-0.82	-0.60	-0.56	-0.54	12.93	13.14	13.22	13.23	-0.85	-0.64	-0.56	-0.55		
826	55.00	52.34	52.34	52.34	52.34	-2.66	-2.66	-2.66	-2.66	52.34	52.34	52.34	52.34	-2.66	-2.66	-2.66	-2.66		
827	52.69	50.00	50.00	50.00	50.00	-2.69	-2.69	-2.69	-2.69	50.00	50.00	50.00	50.00	-2.69	-2.69	-2.69	-2.69		
828	52.32	49.20	49.20	49.20	49.20	-3.12	-3.12	-3.12	-3.12	49.20	49.20	49.20	49.20	-3.12	-3.12	-3.12	-3.12		
829	51.80	49.25	49.25	49.25	49.25	-2.55	-2.55	-2.55	-2.55	49.25	49.25	49.25	49.25	-2.55	-2.55	-2.55	-2.55		
830	51.45	49.12	49.12	49.12	49.12	-2.33	-2.33	-2.33	-2.33	49.12	49.12	49.12	49.12	-2.33	-2.33	-2.33	-2.33		
831	51.98	49.34	49.34	49.34	49.34	-2.64	-2.64	-2.64	-2.64	49.34	49.34	49.34	49.34	-2.64	-2.64	-2.64	-2.64		
832	52.01	48.67	48.67	48.67	48.67	-3.34	-3.34	-3.34	-3.34	48.67	48.67	48.67	48.67	-3.34	-3.34	-3.34	-3.34		
833	52.42	49.17	49.17	49.17	49.22	-3.25	-3.25	-3.25	-3.20	49.17	49.17	49.17	49.20	-3.25	-3.25	-3.25	-3.22		
834	52.94	49.54	49.54	49.54	49.54	-3.40	-3.40	-3.40	-3.40	49.54	49.54	49.54	49.54	-3.40	-3.40	-3.40	-3.40		
835	52.88	49.38	49.38	49.38	49.38	-3.50	-3.50	-3.50	-3.50	49.38	49.38	49.38	49.38	-3.50	-3.50	-3.50	-3.50		
836	53.04	49.34	49.34	49.34	49.34	-3.70	-3.70	-3.70	-3.70	49.34	49.34	49.34	49.34	-3.70	-3.70	-3.70	-3.70		
837	53.39	49.48	49.48	49.48	49.48	-3.91	-3.91	-3.91	-3.91	49.48	49.48	49.48	49.48	-3.91	-3.91	-3.91	-3.91		
838	52.96	49.66	49.66	49.66	49.66	-3.30	-3.30	-3.30	-3.30	49.66	49.66	49.66	49.66	-3.30	-3.30	-3.30	-3.30		
839	51.90	49.85	49.85	49.85	49.85	-2.05	-2.05	-2.05	-2.05	49.85	49.85	49.85	49.85	-2.05	-2.05	-2.05	-2.05		
840	52.92	49.90	49.90	49.90	49.90	-3.02	-3.02	-3.02	-3.02	49.90	49.90	49.90	49.90	-3.02	-3.02	-3.02	-3.02		
841	51.51	49.37	49.54	49.98	50.20	-2.14	-1.97	-1.53	-1.31	49.32	49.50	49.92	50.14	-2.19	-2.01	-1.59	-1.37		
843	51.83	49.39	49.56	49.98	50.20	-2.44	-2.27	-1.85	-1.63	49.35	49.52	49.92	50.14	-2.48	-2.31	-1.91	-1.69		
844	52.02	48.99	49.17	49.50	49.60	-3.03	-2.85	-2.52	-2.42	48.94	49.13	49.47	49.58	-3.08	-2.89	-2.55	-2.44		
845	51.64	48.85	48.96	49.16	49.22	-2.79	-2.68	-2.48	-2.42	48.84	48.94	49.14	49.20	-2.80	-2.70	-2.50	-2.44		
846	50.38	48.85	48.96	49.16	49.22	-1.53	-1.42	-1.22	-1.16	48.81	48.94	49.14	49.20	-1.57	-1.44	-1.24	-1.18		
847	52.42	48.82	48.92	49.09	49.14	-3.60	-3.50	-3.33	-3.28	48.79	48.89	49.07	49.13	-3.63	-3.53	-3.35	-3.29		
848	52.52	48.76	48.81	48.90	48.93	-3.76	-3.71	-3.62	-3.59	48.75	48.80	48.89	48.93	-3.77	-3.72	-3.63	-3.59		
849	50.34	48.82	48.93	49.10	49.15	-1.52	-1.41	-1.24	-1.19	48.79	48.90	49.08	49.14	-1.55	-1.44	-1.26	-1.20		
850	52.95	48.23	48.32	48.47	48.52	-4.72	-4.63	-4.48	-4.43	48.20	48.30	48.46	48.51	-4.75	-4.65	-4.49	-4.44		
851	50.45	48.10	48.16	48.27	48.30	-2.35	-2.29	-2.18	-2.15	48.09	48.15	48.25	48.29	-2.36	-2.30	-2.20	-2.16		
852	50.13	47.93	47.98	48.09	48.12	-2.20	-2.15	-2.04	-2.01	47.91	47.97	48.07	48.11	-2.22	-2.16	-2.06	-2.02		
853	49.23	47.04	47.07	47.13	47.15	-2.19	-2.16	-2.10	-2.08	47.03	47.06	47.12	47.15	-2.20	-2.17	-2.11	-2.08		
854	48.95	45.84	45.89	45.99	46.02	-3.11	-3.06	-2.96	-2.93	45.82	45.88	45.98	46.01	-3.13	-3.07	-2.97	-2.94		
855	47.49	44.98	45.04	45.11	45.14	-2.51	-2.45	-2.38	-2.35	44.97	45.02	45.10	45.13	-2.52	-2.47	-2.39	-2.36		
902	47.59	43.39	43.39	43.39	43.39	-4.20	-4.20	-4.20	-4.20	43.39	43.39	43.39	43.39	-4.20	-4.20	-4.20	-4.20		
903	46.27	44.69	44.69	44.69	44.69	-1.58	-1.58	-1.58	-1.58	44.69	44.69	44.69	44.69	-1.58	-1.58	-1.58	-1.58		
909	44.85	41.43	41.51	41.54	41.55	-3.42	-3.34	-3.31	-3.30	41.43	41.51	41.54	41.55	-3.42	-3.34	-3.31	-3.30		
910	46.56	43.24	43.33	43.36	43.37	-3.32	-3.23	-3.20	-3.19	43.24	43.33	43.36	43.37	-3.32	-3.23	-3.20	-3.19		
911	17.80	16.29	17.59	17.62	17.64	-1.51	**-0.21**	**-0.18**	**-0.16**	16.27	17.56	17.62	17.63	-1.53	**-0.24**	**-0.18**	**-0.17**		
912	50.12	48.15	48.62	49.25	49.48	-1.97	-1.50	-0.87	-0.64	48.04	48.54	49.20	49.42	-2.08	-1.58	-0.92	-0.70		
913	50.50	48.14	48.59	49.22	49.44	-2.36	-1.91	-1.28	-1.06	48.03	48.51	49.17	49.39	-2.47	-1.99	-1.33	-1.11		
914	51.20	48.48	49.39	50.32	50.58	-2.72	-1.81	-0.88	-0.62	48.32	49.14	50.24	50.50	-2.88	-2.06	-0.96	-0.70		
915	51.20	48.30	49.19	49.98	50.21	-2.90	-2.01	-1.22	-0.99	48.13	48.97	49.92	50.15	-3.07	-2.23	-1.28	-1.05		
916	50.21	48.13	48.58	49.22	49.44	-2.08	-1.63	-0.99	-0.77	48.02	48.50	49.17	49.39	-2.19	-1.71	-1.04	-0.82		
917	51.37	48.28	49.19	49.98	50.20	-3.09	-2.18	-1.39	-1.17	48.11	48.97	49.92	50.15	-3.26	-2.40	-1.45	-1.22		
919	51.50	48.10	48.53	49.21	49.43	-3.40	-2.97	-2.29	-2.07	48.00	48.46	49.16	49.39	-3.50	-3.04	-2.34	-2.11		
937	56.57	52.87	53.95	55.31	55.88	-3.70	-2.62	-1.26	-0.69	52.73	53.52	55.07	55.61	-3.84	-3.05	-1.50	-0.96		
938	55.52	52.87	53.95	55.31	55.88	-2.65	-1.57	**-0.21**	**0.36**	52.73	53.52	55.07	55.61	-2.79	-2.00	**-0.45**	**0.09**	Harborview Road 1000 feet north of Anderson Road	CS-F-7
945	56.45	52.87	53.95	55.31	55.88	-3.58	-2.50	-1.14	-0.57	52.73	53.52	55.07	55.61	-3.72	-2.93	-1.38	-0.84		
946	54.89	52.15	52.15	52.15	52.15	-2.74	-2.74	-2.74	-2.74	52.15	52.15	52.15	52.15	-2.74	-2.74	-2.74	-2.74		
947	55.83	52.87	53.95	55.31	55.88	-2.96	-1.88	-0.52	**0.05**	52.73	53.52	55.07	55.61	-3.10	-2.31	-0.76	**-0.22**	Harborview Road 1000 feet north of Anderson Road	CS-F-7
948	55.70	52.87	53.95	55.31	55.88	-2.83	-1.75	**-0.39**	**0.18**	52.73	53.52	55.07	55.61	-2.97	-2.18	-0.63	**-0.09**	Harborview Road 1000 feet north of Anderson Road	CS-F-7
951	55.60	52.87	53.95	55.31	55.88	-2.73	-1.65	**-0.29**	**0.28**	52.73	53.52	55.07	55.61	-2.87	-2.08	-0.53	**0.01**	Harborview Road 1000 feet north of Anderson Road	CS-F-7
952	54.75	52.49	53.39	54.24	54.65	-2.26	-1.36	-0.51	**-0.10**	52.38	53.13	54.08	54.49	-2.37	-1.62	-0.67	**-0.26**	Harborview Road 1000 feet north of Anderson Road	

Table C-3
Cottonwood Beach South Subbasin

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
953	54.85	52.48	53.39	54.23	54.65	-2.37	-1.46	-0.62	**-0.20**	52.37	53.12	54.08	54.49	-2.48	-1.73	-0.77	**-0.36**	Harborview Road 1000 feet north of Anderson Road	
954	56.00	51.73	52.18	52.97	53.22	-4.27	-3.82	-3.03	-2.78	51.70	51.83	52.91	53.16	-4.30	-4.17	-3.09	-2.84		
957	54.86	51.23	52.18	52.97	53.22	-3.63	-2.68	-1.89	-1.64	51.11	51.79	52.90	53.16	-3.75	-3.07	-1.96	-1.70		
958	54.05	51.22	52.10	52.83	53.06	-2.83	-1.95	-1.22	-0.99	51.10	51.73	52.77	53.01	-2.95	-2.32	-1.28	-1.04		
962	54.36	51.20	52.09	52.83	53.06	-3.16	-2.27	-1.53	-1.30	51.08	51.72	52.77	53.00	-3.28	-2.64	-1.59	-1.36		
963	54.24	51.12	51.91	52.53	52.72	-3.12	-2.33	-1.71	-1.52	51.03	51.60	52.48	52.68	-3.21	-2.64	-1.76	-1.56		
966	54.51	51.09	51.90	52.52	52.72	-3.42	-2.61	-1.99	-1.79	51.00	51.57	52.47	52.67	-3.51	-2.94	-2.04	-1.84		
967	54.80	50.83	51.46	51.79	51.90	-3.97	-3.34	-3.01	-2.90	50.73	51.29	51.77	51.87	-4.07	-3.51	-3.03	-2.93		
968	54.75	50.83	51.46	51.79	51.90	-3.92	-3.29	-2.96	-2.85	50.73	51.29	51.77	51.87	-4.02	-3.46	-2.98	-2.88		
969	52.95	50.42	50.82	51.02	51.11	-2.53	-2.13	-1.93	-1.84	50.37	50.71	51.01	51.08	-2.58	-2.24	-1.94	-1.87		
970	54.52	50.31	50.79	50.99	51.09	-4.21	-3.73	-3.53	-3.43	50.19	50.68	50.98	51.06	-4.33	-3.84	-3.54	-3.46		
971	54.45	50.03	50.43	50.60	50.72	-4.42	-4.02	-3.85	-3.73	49.93	50.35	50.57	50.66	-4.52	-4.10	-3.88	-3.79		
972	52.98	51.41	51.57	51.68	51.71	-1.57	-1.41	-1.30	-1.27	51.39	51.55	51.68	51.71	-1.59	-1.43	-1.30	-1.27		
982	45.85	38.24	38.61	38.69	38.71	-7.61	-7.24	-7.16	-7.14	38.17	38.55	38.68	38.71	-7.68	-7.30	-7.17	-7.14		
983	45.86	39.26	39.38	39.41	39.41	-6.60	-6.48	-6.45	-6.45	39.24	39.37	39.40	39.41	-6.62	-6.49	-6.46	-6.45		
911A	32.40	24.28	24.39	24.41	24.42	-8.12	-8.01	-7.99	-7.98	24.25	24.37	24.41	24.42	-8.15	-8.03	-7.99	-7.98		
982A	44.90	36.07	36.13	36.14	36.14	-8.83	-8.77	-8.76	-8.76	36.06	36.12	36.14	36.14	-8.84	-8.78	-8.76	-8.76		
983A	45.90	47.09	48.13	49.15	49.40	**1.19**	**2.23**	**3.25**	**3.50**	46.98	47.66	49.10	49.35	**1.08**	**1.76**	**3.20**	**3.45**	Problem status unknow, no survey	CS-F-4

Table C-4
Hillsdale / Hillsdale North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
761	12.61	12.54	12.61	12.61	12.61	-0.07	0.00	0.00	0.00	12.49	12.61	12.61	12.61	-0.12	0.00	0.00	0.00	Birch Bay Drive and Cottonwood Drive	HL-F-1
764	11.95	11.95	11.95	11.95	11.95	0.00	0.00	0.00	0.00	11.95	11.95	11.95	11.95	0.00	0.00	0.00	0.00	Birch Bay Drive and Cottonwood Drive	HL-F-1
765	10.00	9.38	9.29	8.68	8.94	-0.62	-0.71	-1.32	-1.06	9.38	9.29	8.68	8.94	-0.62	-0.71	-1.32	-1.06		
767	12.22	12.22	12.22	12.22	12.22	0.00	0.00	0.00	0.00	12.22	12.22	12.22	12.22	0.00	0.00	0.00	0.00	Birch Bay Drive east of Cottonwood Drive	HL-F-2
768	12.48	9.54	9.54	9.54	9.54	-2.94	-2.94	-2.94	-2.94	9.54	9.54	9.54	9.54	-2.94	-2.94	-2.94	-2.94		
772	10.00	9.38	9.29	9.05	9.05	-0.62	-0.71	-0.95	-0.95	9.38	9.29	9.05	9.05	-0.62	-0.71	-0.95	-0.95		
930	55.37	53.72	55.87	56.71	58.01	-1.65	0.50	1.34	2.64	53.72	55.85	56.71	57.75	-1.65	0.48	1.34	2.38	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
931	55.40	53.72	55.87	56.71	58.07	-1.68	0.47	1.31	2.67	53.72	55.85	56.71	57.74	-1.68	0.45	1.31	2.34	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
934	55.54	53.72	55.87	56.71	58.07	-1.82	0.33	1.17	2.53	53.72	55.85	56.71	57.74	-1.82	0.31	1.17	2.20	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
935	55.45	53.46	55.30	56.71	58.07	-1.99	-0.15	1.26	2.62	53.46	55.26	56.71	57.74	-1.99	-0.19	1.26	2.29	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
939	54.20	53.46	55.30	56.71	58.07	-0.74	1.10	2.51	3.87	53.46	55.26	56.71	57.74	-0.74	1.06	2.51	3.54	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
941	55.34	53.27	55.30	56.71	58.07	-2.07	-0.04	1.37	2.73	53.27	55.26	56.71	57.74	-2.07	-0.08	1.37	2.40	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
942	55.17	53.01	54.80	55.94	56.99	-2.16	-0.37	0.77	1.82	53.01	54.74	55.94	56.62	-2.16	-0.43	0.77	1.45	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
943	55.19	53.01	54.80	55.94	56.99	-2.18	-0.39	0.75	1.80	53.01	54.74	55.94	56.62	-2.18	-0.45	0.75	1.43	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
944	55.09	52.65	54.57	55.39	56.28	-2.44	-0.52	0.30	1.19	52.65	54.51	55.39	55.91	-2.44	-0.58	0.30	0.82	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
949	54.97	52.59	54.57	55.39	56.28	-2.38	-0.40	0.42	1.31	52.59	54.51	55.39	55.91	-2.38	-0.46	0.42	0.94	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
950	55.64	52.25	54.54	55.29	56.15	-3.39	-1.10	-0.35	0.51	52.20	54.49	55.29	55.82	-3.44	-1.15	-0.35	0.18	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
955	53.73	52.24	54.54	55.29	56.15	-1.49	0.81	1.56	2.42	52.20	54.49	55.29	55.82	-1.53	0.76	1.56	2.09	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
956	53.56	52.20	54.37	54.97	56.15	-1.36	0.81	1.41	2.59	52.15	54.33	55.01	55.82	-1.41	0.77	1.45	2.26	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
959	53.51	52.20	54.37	54.97	56.15	-1.31	0.86	1.46	2.64	52.15	54.33	55.01	55.82	-1.36	0.82	1.50	2.31	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
960	54.81	52.20	54.36	54.97	56.15	-2.61	-0.45	0.16	1.34	52.15	54.31	55.00	55.82	-2.66	-0.50	0.19	1.01	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
964	54.40	52.20	54.36	54.97	56.15	-2.20	-0.04	0.57	1.75	52.15	54.31	55.00	55.82	-2.25	-0.09	0.60	1.42	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
965	54.12	51.99	53.94	54.42	54.98	-2.13	-0.18	0.30	0.86	51.94	53.88	54.48	54.85	-2.18	-0.24	0.36	0.73	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
973	55.20	51.98	53.94	54.41	54.98	-3.22	-1.26	-0.79	-0.22	51.93	53.88	54.48	54.84	-3.27	-1.32	-0.72	-0.36	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
974	54.50	51.10	52.48	52.81	53.20	-3.40	-2.02	-1.69	-1.30	51.06	52.44	52.82	53.08	-3.44	-2.06	-1.68	-1.42	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
980	54.32	51.96	53.89	54.32	54.32	-2.36	-0.43	0.00	0.00	51.91	53.83	54.32	54.32	-2.41	-0.49	0.00	0.00	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
981	54.84	51.96	53.90	54.35	54.82	-2.88	-0.94	-0.49	-0.02	51.91	53.83	54.40	54.71	-2.93	-1.01	-0.44	-0.13	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
984	52.10	51.09	52.48	52.81	53.20	-1.01	0.38	0.71	1.10	51.05	52.43	52.81	53.08	-1.05	0.33	0.71	0.98	East side Harborview Road 300' south to 1500' north of Ande	HL-F-4
985	52.52	50.31	51.26	51.48	51.74	-2.21	-1.26	-1.04	-0.78	50.28	51.23	51.49	51.62	-2.24	-1.29	-1.03	-0.90		
989	51.25	48.20	48.65	48.89	49.22	-3.05	-2.60	-2.36	-2.03	48.20	48.57	48.89	49.11	-3.05	-2.68	-2.36	-2.14		
990	52.43	50.30	50.30	50.30	50.30	-2.13	-2.13	-2.13	-2.13	50.30	50.30	50.30	50.30	-2.13	-2.13	-2.13	-2.13		
991	51.32	49.66	49.66	49.66	49.66	-1.66	-1.66	-1.66	-1.66	49.66	49.66	49.66	49.66	-1.66	-1.66	-1.66	-1.66		
992	51.90	49.21	49.21	49.21	49.21	-2.69	-2.69	-2.69	-2.69	49.21	49.21	49.21	49.21	-2.69	-2.69	-2.69	-2.69		
993	51.40	49.07	49.07	49.07	49.07	-2.33	-2.33	-2.33	-2.33	49.07	49.07	49.07	49.07	-2.33	-2.33	-2.33	-2.33		
994	51.24	49.07	49.07	49.07	49.07	-2.17	-2.17	-2.17	-2.17	49.07	49.07	49.07	49.07	-2.17	-2.17	-2.17	-2.17		
995	50.91	48.40	48.40	48.40	48.40	-2.51	-2.51	-2.51	-2.51	48.40	48.40	48.40	48.40	-2.51	-2.51	-2.51	-2.51		
996	51.17	48.23	48.23	48.23	48.23	-2.94	-2.94	-2.94	-2.94	48.23	48.23	48.23	48.23	-2.94	-2.94	-2.94	-2.94		
997	52.34	47.81	48.62	48.87	49.21	-4.53	-3.72	-3.47	-3.13	47.73	48.54	48.88	49.10	-4.61	-3.80	-3.46	-3.24		
998	50.40	48.12	48.12	48.12	48.12	-2.28	-2.28	-2.28	-2.28	48.12	48.12	48.12	48.12	-2.28	-2.28	-2.28	-2.28		
999	50.56	47.65	47.65	47.65	47.65	-2.91	-2.91	-2.91	-2.91	47.65	47.65	47.65	47.65	-2.91	-2.91	-2.91	-2.91		
1000	51.50	47.80	48.61	48.86	49.21	-3.70	-2.89	-2.64	-2.29	47.72	48.53	48.87	49.09	-3.78	-2.97	-2.63	-2.41		
1001	50.20	47.14	47.55	47.72	47.96	-3.06	-2.65	-2.48	-2.24	47.07	47.47	47.68	47.85	-3.13	-2.73	-2.52	-2.35		
1002	50.03	48.00	48.00	48.00	48.00	-2.03	-2.03	-2.03	-2.03	48.00	48.00	48.00	48.00	-2.03	-2.03	-2.03	-2.03		
1003	51.24	48.06	48.06	48.06	48.06	-3.18	-3.18	-3.18	-3.18	48.06	48.06	48.06	48.06	-3.18	-3.18	-3.18	-3.18		
1004	48.58	46.29	46.29	46.29	46.29	-2.29	-2.29	-2.29	-2.29	46.29	46.29	46.29	46.29	-2.29	-2.29	-2.29	-2.29		
1005	48.59	45.57	45.57	45.57	45.57	-3.02	-3.02	-3.02	-3.02	45.57	45.57	45.57	45.57	-3.02	-3.02	-3.02	-3.02		
1006	49.97	48.02	48.02	48.02	48.02	-1.95	-1.95	-1.95	-1.95	48.02	48.02	48.02	48.02	-1.95	-1.95	-1.95	-1.95		
1007	50.56	46.47	46.47	46.47	46.47	-4.09	-4.09	-4.09	-4.09	46.47	46.47	46.47	46.47	-4.09	-4.09	-4.09	-4.09		
1008	52.40	47.80	48.62	48.87	49.21	-4.60	-3.78	-3.53	-3.19	47.72	48.53	48.87	49.10	-4.68	-3.87	-3.53	-3.30		
1009	49.00	47.14	47.54	47.72	47.95	-1.86	-1.46	-1.28	-1.05	47.06	47.46	47.68	47.85	-1.94	-1.54	-1.32	-1.15		
1010	47.55	44.12	45.25	45.92	46.82	-3.43	-2.30	-1.63	-0.73	44.02	44.95	45.76	46.46	-3.53	-2.60	-1.79	-1.09		
1011	47.10	43.82	45.12	45.83	46.76	-3.28	-1.98	-1.27	-0.34	43.70	44.79	45.67	46.40	-3.40	-2.31	-1.43	-0.70	East side Harborview Road at Fosburg	
1015	47.24	44.29	44.29	44.29	44.29	-2.95	-2.95	-2.95	-2.95	44.29	44.29	44.29	44.29	-2.95	-2.95	-2.95	-2.95		
1016	47.08	42.78	43.11	43.21	43.32	-4.30	-3.97	-3.87	-3.76	42.73	43.06	43.19	43.28	-4.35	-4.02	-3.89	-3.80		
1018	45.81	43.03	43.11	43.21	43.32	-2.78	-2.70	-2.60	-2.49	43.03	43.06	43.19	43.28	-2.78	-2.75	-2.62	-2.53		
1019	45.73	44.19	44.19	44.19	44.19	-1.54	-1.54	-1.54	-1.54	44.19	44.19	44.19	44.19	-1.54	-1.54	-1.54	-1.54		
1022	43.78	41.82	42.10	42.18	42.28	-1.96	-1.68	-1.60	-1.50	41.78	42.05	42.17	42.24	-2.00	-1.73	-1.61	-1.54		
1023	47.87	46.06	46.06	46.06	46.06	-1.81	-1.81	-1.81	-1.81	46.06	46.06	46.06	46.06	-1.81	-1.81	-1.81	-1.81		
1024	47.09	45.72	45.91	45.97	46.14	-1.37	-1.18	-1.12	-0.95	45.72	45.91	45.97	46.07	-1.37	-1.18	-1.12	-1.02		

Table C-4
Hillsdale / Hillsdale North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
1025	46.92	45.72	45.91	45.97	46.13	-1.20	-1.01	-0.95	-0.79	45.72	45.91	45.97	46.07	-1.20	-1.01	-0.95	-0.85		
1026	47.35	45.72	45.91	45.97	46.13	-1.63	-1.44	-1.38	-1.22	45.72	45.91	45.97	46.06	-1.63	-1.44	-1.38	-1.29		
1027	48.00	45.57	45.66	45.68	45.75	-2.43	-2.34	-2.32	-2.25	45.57	45.66	45.68	45.72	-2.43	-2.34	-2.32	-2.28		
1028	48.31	45.57	45.66	45.68	45.75	-2.74	-2.65	-2.63	-2.56	45.57	45.66	45.68	45.72	-2.74	-2.65	-2.63	-2.59		
1029	46.72	45.72	45.89	45.95	46.08	-1.00	-0.83	-0.77	-0.64	45.72	45.89	45.95	46.03	-1.00	-0.83	-0.77	-0.69		
1030	47.30	45.71	45.89	45.94	46.08	-1.59	-1.41	-1.36	-1.22	45.71	45.89	45.94	46.02	-1.59	-1.41	-1.36	-1.28		
1033	47.39	44.98	45.07	45.09	45.16	-2.41	-2.32	-2.30	-2.23	44.98	45.07	45.09	45.13	-2.41	-2.32	-2.30	-2.26		
1034	47.40	45.72	45.91	45.97	46.13	-1.68	-1.49	-1.43	-1.27	45.72	45.91	45.97	46.06	-1.68	-1.49	-1.43	-1.34		
1036	47.15	45.36	45.45	45.48	45.55	-1.79	-1.70	-1.67	-1.60	45.36	45.45	45.48	45.52	-1.79	-1.70	-1.67	-1.63		
1037	46.00	43.96	44.03	44.05	44.11	-2.04	-1.97	-1.95	-1.89	43.96	44.03	44.05	44.09	-2.04	-1.97	-1.95	-1.91		
1038	45.93	43.47	43.63	43.68	43.79	-2.46	-2.30	-2.25	-2.14	43.47	43.63	43.68	43.74	-2.46	-2.30	-2.25	-2.19		
1039	45.37	42.70	42.95	43.03	43.28	-2.67	-2.42	-2.34	-2.09	42.70	42.95	43.03	43.17	-2.67	-2.42	-2.34	-2.20		
1040	43.32	42.05	42.11	42.13	42.17	-1.27	-1.21	-1.19	-1.15	42.05	42.11	42.13	42.15	-1.27	-1.21	-1.19	-1.17		
1041	45.78	43.42	43.54	43.58	43.67	-2.36	-2.24	-2.20	-2.11	43.42	43.54	43.58	43.63	-2.36	-2.24	-2.20	-2.15		
1042	45.80	43.81	43.91	43.94	44.05	-1.99	-1.89	-1.86	-1.75	43.81	43.91	43.94	43.99	-1.99	-1.89	-1.86	-1.81		
1043	47.02	43.92	44.04	44.07	44.16	-3.10	-2.98	-2.95	-2.86	43.92	44.04	44.07	44.12	-3.10	-2.98	-2.95	-2.90		
1044	45.39	43.79	43.90	43.93	44.04	-1.60	-1.49	-1.46	-1.35	43.79	43.90	43.93	43.98	-1.60	-1.49	-1.46	-1.41		
1045	46.18	44.08	44.18	44.21	44.29	-2.10	-2.00	-1.97	-1.89	44.08	44.18	44.21	44.26	-2.10	-2.00	-1.97	-1.92		
1046	46.16	44.18	44.28	44.31	44.38	-1.98	-1.88	-1.85	-1.78	44.18	44.28	44.31	44.35	-1.98	-1.88	-1.85	-1.81		
1047	46.62	44.34	44.47	44.51	44.61	-2.28	-2.15	-2.11	-2.01	44.34	44.47	44.51	44.57	-2.28	-2.15	-2.11	-2.05		
1050	46.93	43.87	43.98	44.01	44.10	-3.06	-2.95	-2.92	-2.83	43.87	43.98	44.01	44.06	-3.06	-2.95	-2.92	-2.87		
1051	47.15	44.46	44.55	44.58	44.65	-2.69	-2.60	-2.57	-2.50	44.46	44.55	44.58	44.62	-2.69	-2.60	-2.57	-2.53		
1052	47.50	44.53	44.63	44.66	44.73	-2.97	-2.87	-2.84	-2.77	44.53	44.63	44.66	44.70	-2.97	-2.87	-2.84	-2.80		
1053	46.65	44.81	44.95	44.99	45.10	-1.84	-1.70	-1.66	-1.55	44.81	44.95	44.99	45.05	-1.84	-1.70	-1.66	-1.60		
1055	47.12	44.87	45.03	45.08	45.21	-2.25	-2.09	-2.04	-1.91	44.87	45.03	45.08	45.16	-2.25	-2.09	-2.04	-1.96		
1059	46.12	43.40	43.46	43.48	43.53	-2.72	-2.66	-2.64	-2.59	43.40	43.46	43.48	43.51	-2.72	-2.66	-2.64	-2.61		
1060	46.43	43.73	43.85	43.88	43.95	-2.70	-2.58	-2.55	-2.48	43.73	43.85	43.88	43.92	-2.70	-2.58	-2.55	-2.51		
1061	18.01	13.79	15.59	16.26	18.49	-4.22	-2.42	-1.75	0.48	13.71	14.78	15.74	17.59	-4.30	-3.23	-2.27	-0.42	Pipeline inlet at Cottonwood Drive	HL-F-3
1062	14.33	10.43	13.61	13.55	14.34	-3.90	-0.72	-0.78	0.01	10.39	13.19	13.21	14.10	-3.94	-1.14	-1.12	-0.23	Cottonwood Drive	HL-F-3
1065	12.33	11.23	11.98	11.24	11.96	-1.10	-0.35	-1.09	-0.37	11.23	11.71	11.23	11.65	-1.10	-0.62	-1.10	-0.68	Cottonwood Drive	HL-F-3
1067	13.54	10.90	13.54	13.54	13.54	-2.64	0.00	0.00	0.00	10.90	13.20	13.22	13.54	-2.64	-0.34	-0.32	0.00	Cottonwood Drive	HL-F-3
1073	14.05	11.75	13.55	13.55	13.57	-2.30	-0.50	-0.50	-0.48	11.75	13.21	13.23	13.57	-2.30	-0.84	-0.82	-0.48	Cottonwood Court at Cottonwood Drive	HL-F-3
1075	14.60	13.14	13.62	13.62	13.79	-1.46	-0.98	-0.98	-0.81	13.14	13.23	13.25	13.72	-1.46	-1.37	-1.35	-0.88		
1077	13.62	11.61	13.54	13.55	13.55	-2.01	-0.08	-0.07	-0.07	11.61	13.21	13.23	13.55	-2.01	-0.41	-0.39	-0.07	Cottonwood Court at Cottonwood Drive	HL-F-3
1078	14.57	13.24	13.62	13.62	13.80	-1.33	-0.95	-0.95	-0.77	13.24	13.36	13.36	13.73	-1.33	-1.21	-1.21	-0.84		
1083	43.70	39.72	39.79	39.79	39.82	-3.98	-3.91	-3.91	-3.88	39.72	39.79	39.79	39.81	-3.98	-3.91	-3.91	-3.89		
1084	44.39	40.76	40.83	40.83	40.87	-3.63	-3.56	-3.56	-3.52	40.76	40.83	40.83	40.85	-3.63	-3.56	-3.56	-3.54		
1088	43.75	40.09	40.09	40.09	40.09	-3.66	-3.66	-3.66	-3.66	40.09	40.09	40.09	40.09	-3.66	-3.66	-3.66	-3.66		
1089	41.89	39.90	39.94	39.95	39.98	-1.99	-1.95	-1.94	-1.91	39.90	39.94	39.95	39.97	-1.99	-1.95	-1.94	-1.92		
1094	44.38	42.12	42.18	42.19	42.24	-2.26	-2.20	-2.19	-2.14	42.12	42.18	42.19	42.21	-2.26	-2.20	-2.19	-2.17		
1095	45.03	42.90	43.05	43.06	43.20	-2.13	-1.98	-1.97	-1.83	42.90	43.05	43.06	43.14	-2.13	-1.98	-1.97	-1.89		
1096	44.89	42.92	43.07	43.09	43.22	-1.97	-1.82	-1.80	-1.67	42.92	43.07	43.09	43.16	-1.97	-1.82	-1.80	-1.73		
1097	45.00	42.91	43.06	43.07	43.21	-2.09	-1.94	-1.93	-1.79	42.91	43.06	43.07	43.15	-2.09	-1.94	-1.93	-1.85		
1098	45.02	42.96	43.14	43.16	43.32	-2.06	-1.88	-1.86	-1.70	42.96	43.14	43.16	43.24	-2.06	-1.88	-1.86	-1.78		
1099	45.28	42.99	43.16	43.17	43.33	-2.29	-2.12	-2.11	-1.95	42.99	43.16	43.17	43.26	-2.29	-2.12	-2.11	-2.02		
1100	45.21	43.12	43.29	43.31	43.47	-2.09	-1.92	-1.90	-1.74	43.12	43.29	43.31	43.40	-2.09	-1.92	-1.90	-1.81		
1101	44.98	43.21	43.31	43.33	43.49	-1.77	-1.67	-1.65	-1.49	43.21	43.31	43.33	43.42	-1.77	-1.67	-1.65	-1.56		
1102	44.87	43.21	43.31	43.33	43.49	-1.66	-1.56	-1.54	-1.38	43.21	43.31	43.33	43.42	-1.66	-1.56	-1.54	-1.45		
1105	45.42	43.16	43.16	43.16	43.49	-2.26	-2.26	-2.26	-1.93	43.16	43.16	43.16	43.42	-2.26	-2.26	-2.26	-2.00		
1109	43.41	41.36	41.42	41.44	41.48	-2.05	-1.99	-1.97	-1.93	41.36	41.42	41.44	41.46	-2.05	-1.99	-1.97	-1.95		
1110	44.92	41.75	41.87	41.91	42.02	-3.17	-3.05	-3.01	-2.90	41.75	41.87	41.91	41.98	-3.17	-3.05	-3.01	-2.94		
1111	45.35	42.86	42.91	42.93	42.97	-2.49	-2.44	-2.42	-2.38	42.86	42.91	42.93	42.96	-2.49	-2.44	-2.42	-2.39		
1112	45.12	43.57	43.64	43.66	43.72	-1.55	-1.48	-1.46	-1.40	43.57	43.64	43.66	43.69	-1.55	-1.48	-1.46	-1.43		
1117	44.74	43.51	43.67	43.67	43.70	-1.23	-1.07	-1.07	-1.04	43.51	43.67	43.67	43.68	-1.23	-1.07	-1.07	-1.06		
1118	43.67	43.51	43.67	43.67	43.67	-0.16	0.00	0.00	0.00	43.51	43.67	43.67	43.67	-0.16	0.00	0.00	0.00	Henley Street at Merle Place	
1126	44.55	43.49	43.62	43.62	43.64	-1.06	-0.93	-0.93	-0.91	43.49	43.62	43.62	43.63	-1.06	-0.93	-0.93	-0.92		
1127	44.10	43.47	43.58	43.59	43.60	-0.63	-0.52	-0.51	-0.50	43.47	43.58	43.59	43.59	-0.63	-0.52	-0.51	-0.51		
1128	22.88	17.58	17.94	18.02	18.61	-5.30	-4.94	-4.86	-4.27	17.53	17.90	18.00	18.08	-5.35	-4.98	-4.88	-4.80		
1130	33.16	29.23	29.26	29.26	29.28	-3.93	-3.90	-3.90	-3.88	29.23	29.26	29.26	29.27	-3.93	-3.90	-3.90	-3.89		

Table C-4
Hillsdale / Hillsdale North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions								Future Conditions								Location	ID
		Maximum Computed Head (feet NAVD88)				Flood Depth (feet)				Maximum Computed Head (feet NAVD88)				Flood Depth (feet)					
		2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year	2-year	10-year	25-year	100-year		
1131	23.50	19.97	21.09	21.56	22.25	-3.53	-2.41	-1.94	-1.25	19.93	20.86	21.42	22.01	-3.57	-2.64	-2.08	-1.49		
1132	26.28	19.91	21.91	22.60	23.60	-6.37	-4.37	-3.68	-2.68	19.78	21.53	22.42	23.29	-6.50	-4.75	-3.86	-2.99		
1134	44.00	27.72	28.03	28.12	28.23	-16.28	-15.97	-15.88	-15.77	27.67	27.98	28.10	28.19	-16.33	-16.02	-15.90	-15.81		
1135	44.81	43.47	43.59	43.59	43.60	-1.34	-1.22	-1.22	-1.21	43.47	43.59	43.59	43.60	-1.34	-1.22	-1.22	-1.21		
1136	46.01	44.36	44.43	44.45	44.51	-1.65	-1.58	-1.56	-1.50	44.36	44.43	44.45	44.49	-1.65	-1.58	-1.56	-1.52		
1137	46.42	44.62	44.71	44.73	44.80	-1.80	-1.71	-1.69	-1.62	44.62	44.71	44.73	44.77	-1.80	-1.71	-1.69	-1.65		
1140	45.43	44.04	44.19	44.24	44.36	-1.39	-1.24	-1.19	-1.07	44.04	44.19	44.24	44.31	-1.39	-1.24	-1.19	-1.12		
1141	45.44	43.86	43.93	43.96	44.01	-1.58	-1.51	-1.48	-1.43	43.86	43.93	43.96	43.99	-1.58	-1.51	-1.48	-1.45		
1142	44.95	43.51	43.68	43.68	43.69	-1.44	-1.27	-1.27	-1.26	43.51	43.68	43.68	43.69	-1.44	-1.27	-1.27	-1.26		
1143	44.47	43.51	43.68	43.68	43.73	-0.96	-0.79	-0.79	-0.74	43.51	43.68	43.68	43.70	-0.96	-0.79	-0.79	-0.77		
1146	45.47	43.77	43.86	43.89	43.95	-1.70	-1.61	-1.58	-1.52	43.77	43.86	43.89	43.93	-1.70	-1.61	-1.58	-1.54		
1149	45.99	44.25	44.33	44.35	44.41	-1.74	-1.66	-1.64	-1.58	44.25	44.33	44.35	44.39	-1.74	-1.66	-1.64	-1.60		
1150	45.71	44.60	44.60	44.60	44.60	-1.11	-1.11	-1.11	-1.11	44.60	44.60	44.60	44.60	-1.11	-1.11	-1.11	-1.11		
1151	45.26	44.63	44.63	44.63	44.63	-0.63	-0.63	-0.63	-0.63	44.63	44.63	44.63	44.63	-0.63	-0.63	-0.63	-0.63		
1152	46.33	44.13	44.13	44.13	44.13	-2.20	-2.20	-2.20	-2.20	44.13	44.13	44.13	44.13	-2.20	-2.20	-2.20	-2.20		
1153	46.81	43.74	43.74	43.74	43.74	-3.07	-3.07	-3.07	-3.07	43.74	43.74	43.74	43.74	-3.07	-3.07	-3.07	-3.07		
1154	46.51	43.96	43.96	43.96	43.96	-2.55	-2.55	-2.55	-2.55	43.96	43.96	43.96	43.96	-2.55	-2.55	-2.55	-2.55		
1155	46.25	43.89	43.89	43.89	43.89	-2.36	-2.36	-2.36	-2.36	43.89	43.89	43.89	43.89	-2.36	-2.36	-2.36	-2.36		
1156	45.83	43.84	43.84	43.84	43.84	-1.99	-1.99	-1.99	-1.99	43.84	43.84	43.84	43.84	-1.99	-1.99	-1.99	-1.99		
1158	46.25	43.79	43.79	43.79	43.79	-2.46	-2.46	-2.46	-2.46	43.79	43.79	43.79	43.79	-2.46	-2.46	-2.46	-2.46		
1159	45.39	43.69	43.69	43.69	43.69	-1.70	-1.70	-1.70	-1.70	43.69	43.69	43.69	43.69	-1.70	-1.70	-1.70	-1.70		
1160	46.60	44.23	44.23	44.23	44.23	-2.37	-2.37	-2.37	-2.37	44.23	44.23	44.23	44.23	-2.37	-2.37	-2.37	-2.37		
1161	46.42	44.45	44.45	44.45	44.45	-1.97	-1.97	-1.97	-1.97	44.45	44.45	44.45	44.45	-1.97	-1.97	-1.97	-1.97		
1162	46.66	44.46	44.46	44.46	44.46	-2.20	-2.20	-2.20	-2.20	44.46	44.46	44.46	44.46	-2.20	-2.20	-2.20	-2.20		
1164	46.07	44.40	44.40	44.40	44.40	-1.67	-1.67	-1.67	-1.67	44.40	44.40	44.40	44.40	-1.67	-1.67	-1.67	-1.67		
1170	45.46	44.07	44.18	44.21	44.30	-1.39	-1.28	-1.25	-1.16	44.07	44.18	44.21	44.26	-1.39	-1.28	-1.25	-1.20		
1487	58.70	55.97	56.27	56.37	58.08	-2.73	-2.43	-2.33	-0.62	55.97	56.27	56.37	58.04	-2.73	-2.43	-2.33	-0.66		
1490	59.23	57.55	57.78	57.81	59.23	-1.68	-1.45	-1.42	0.00	57.55	57.78	57.81	59.22	-1.68	-1.45	-1.42	-0.01	Anderson Park - Sagebrush Lane	
1491	59.19	57.55	57.78	57.81	59.20	-1.64	-1.41	-1.38	0.01	57.55	57.78	57.81	59.20	-1.64	-1.41	-1.38	0.01	Anderson Park - Sagebrush Lane	
1497	58.02	56.37	56.37	56.37	58.00	-1.65	-1.65	-1.65	-0.02	56.37	56.37	56.37	58.02	-1.65	-1.65	-1.65	0.00	Anderson Park - Sagebrush Lane	
1498	57.98	55.97	56.27	56.37	57.98	-2.01	-1.71	-1.61	0.00	55.97	56.27	56.37	57.98	-2.01	-1.71	-1.61	0.00	Anderson Park - Sagebrush Lane	
1499	58.30	56.56	56.94	57.03	57.87	-1.74	-1.36	-1.27	-0.43	56.56	56.94	57.03	57.53	-1.74	-1.36	-1.27	-0.77		
1500	58.19	55.79	55.94	55.96	56.17	-2.40	-2.25	-2.23	-2.02	55.79	55.94	55.96	56.02	-2.40	-2.25	-2.23	-2.17		
1509	58.28	54.35	54.88	55.14	56.74	-3.93	-3.40	-3.14	-1.54	54.35	54.88	55.14	56.25	-3.93	-3.40	-3.14	-2.03		
1510	56.76	54.56	54.88	55.14	56.75	-2.20	-1.88	-1.62	-0.01	54.56	54.88	55.14	56.25	-2.20	-1.88	-1.62	-0.51	Anderson Park - Nightingale Court	
1511	56.85	54.78	54.88	55.14	56.74	-2.07	-1.97	-1.71	-0.11	54.78	54.88	55.14	56.25	-2.07	-1.97	-1.71	-0.60	Anderson Park - Nightingale Court	
1518	59.16	54.35	54.88	55.14	56.75	-4.81	-4.28	-4.02	-2.41	54.35	54.88	55.14	56.26	-4.81	-4.28	-4.02	-2.90		
1519	57.32	54.11	54.60	54.99	56.45	-3.21	-2.72	-2.33	-0.87	54.11	54.60	55.03	55.94	-3.21	-2.72	-2.29	-1.38		
1520	56.92	54.11	54.60	54.99	56.45	-2.81	-2.32	-1.93	-0.47	54.11	54.60	55.03	55.95	-2.81	-2.32	-1.89	-0.97	Anderson Park - Sagebrush Lane	
1527	57.44	54.09	54.52	54.98	56.34	-3.35	-2.92	-2.46	-1.10	54.09	54.52	55.02	55.89	-3.35	-2.92	-2.42	-1.55		
1538	55.89	54.07	54.47	54.97	55.89	-1.82	-1.42	-0.92	0.00	54.07	54.47	55.01	55.84	-1.82	-1.42	-0.88	-0.05	Anderson Park - Glendale Drive	
1539	55.94	54.07	54.44	54.97	55.93	-1.87	-1.50	-0.97	-0.01	54.07	54.44	55.01	55.84	-1.87	-1.50	-0.93	-0.10	Anderson Park - Glendale Drive	
1543	57.60	54.08	54.46	54.97	56.17	-3.52	-3.14	-2.63	-1.43	54.08	54.46	55.01	55.83	-3.52	-3.14	-2.59	-1.77		
1546	56.30	54.05	54.37	54.97	56.15	-2.25	-1.93	-1.33	-0.15	54.05	54.37	55.01	55.82	-2.25	-1.93	-1.29	-0.48	Anderson Park - Glendale Drive	
1548	57.05	55.38	55.58	55.63	56.17	-1.67	-1.47	-1.42	-0.88	55.38	55.58	55.63	55.83	-1.67	-1.47	-1.42	-1.22		
1549	56.83	55.15	55.39	55.45	56.15	-1.68	-1.44	-1.38	-0.68	55.15	55.39	55.45	55.82	-1.68	-1.44	-1.38	-1.01		
1550	56.26	55.38	55.58	55.62	56.15	-0.88	-0.68	-0.64	-0.11	55.38	55.58	55.62	55.83	-0.88	-0.68	-0.64	-0.43	Anderson Park - Glendale Drive	
1551	57.55	55.38	55.58	55.62	56.15	-2.17	-1.97	-1.93	-1.40	55.38	55.58	55.62	55.83	-2.17	-1.97	-1.93	-1.72		
1552	58.50	55.38	55.53	55.57	56.15	-3.12	-2.97	-2.93	-2.35	55.38	55.53	55.57	55.82	-3.12	-2.97	-2.93	-2.68		
1553	58.42	55.26	55.50	55.55	56.15	-3.16	-2.92	-2.87	-2.27	55.26	55.50	55.55	55.82	-3.16	-2.92	-2.87	-2.60		
1554	55.78	53.07	53.28	53.39	53.44	-2.71	-2.50	-2.39	-2.34	53.07	53.26	53.42	53.44	-2.71	-2.52	-2.36	-2.34		
1555	58.22	55.83	55.83	55.83	56.12	-2.39	-2.39	-2.39	-2.10	55.83	55.83	55.83	55.83	-2.39	-2.39	-2.39	-2.39		
1556	55.74	52.97	53.26	53.44	53.77	-2.77	-2.48	-2.30	-1.97	52.97	53.25	53.44	53.56	-2.77	-2.49	-2.30	-2.18		
1557	55.62	52.73	52.95	53.08	53.29	-2.89	-2.67	-2.54	-2.33	52.72	52.91	53.11	53.23	-2.90	-2.71	-2.51	-2.39		
1558	57.49	54.76	55.30	55.95	56.93	-2.73	-2.19	-1.54	-0.56	54.76	55.30	55.95	56.47	-2.73	-2.19	-1.54	-1.02		
1559	57.02	54.46	54.96	55.34	55.92	-2.56	-2.06	-1.68	-1.10	54.46	54.96	55.34	55.65	-2.56	-2.06	-1.68	-1.37		
1560	57.29	54.45	54.95	55.34	55.92	-2.84	-2.34	-1.95	-1.37	54.45	54.95	55.34	55.65	-2.84	-2.34	-1.95	-1.64		
1561	57.24	54.02	54.21	54.31	54.41	-3.22	-3.03	-2.93	-2.83	54.02	54.21	54.31	54.37	-3.22	-3.03	-2.93	-2.87		
1562	61.00	56.66	56.73	56.77	56.82	-4.34	-4.27	-4.23	-4.18	56.66	56.73	56.77	56.80	-4.34	-4.27	-4.23	-4.20		

Table C-4
Hillsdale / Hillsdale North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions: Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions: Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
1563	60.22	57.03	57.16	57.24	57.35	-3.19	-3.06	-2.98	-2.87	57.03	57.16	57.25	57.30	-3.19	-3.06	-2.97	-2.92		
1564	57.52	54.02	54.02	54.47	55.41	-3.50	-3.50	-3.05	-2.11	54.02	54.02	54.77	55.31	-3.50	-3.50	-2.75	-2.21		
1565	57.50	54.25	54.25	54.47	55.39	-3.25	-3.25	-3.03	-2.11	54.25	54.25	54.77	55.31	-3.25	-3.25	-2.73	-2.19		
1566	56.03	53.24	53.81	54.00	54.10	-2.79	-2.22	-2.03	-1.93	53.24	53.77	54.06	54.10	-2.79	-2.26	-1.97	-1.93		
1567	57.54	53.30	53.63	53.77	53.83	-4.24	-3.91	-3.77	-3.71	53.30	53.60	53.80	53.83	-4.24	-3.94	-3.74	-3.71		
1568	58.73	55.71	55.71	55.71	56.02	-3.02	-3.02	-3.02	-2.71	55.71	55.71	55.71	55.80	-3.02	-3.02	-3.02	-2.93		
1569	54.63	51.96	53.87	54.25	54.28	-2.67	-0.76	**-0.38**	**-0.35**	51.91	53.82	54.26	54.29	-2.72	-0.81	**-0.37**	**-0.34**	South side Anderson Road near Harborview see ID 984	
1573	55.51	52.41	53.97	54.47	55.36	-3.10	-1.54	-1.04	**-0.15**	52.38	53.89	54.77	55.30	-3.13	-1.62	-0.74	**-0.21**	North side Anderson Road near Harborview see ID 984	
1576	54.80	51.96	53.85	54.15	54.20	-2.84	-0.95	-0.65	-0.60	51.91	53.80	54.18	54.23	-2.89	-1.00	-0.62	-0.57		
1577	55.56	51.96	53.83	54.06	54.15	-3.60	-1.73	-1.50	-1.41	51.91	53.78	54.11	54.17	-3.65	-1.78	-1.45	-1.39		
1580	55.60	51.96	53.81	54.01	54.11	-3.64	-1.79	-1.59	-1.49	51.91	53.77	54.07	54.11	-3.69	-1.83	-1.53	-1.49		
1581	55.45	53.34	53.97	54.47	55.39	-2.11	-1.48	-0.98	**-0.06**	53.29	53.89	54.77	55.31	-2.16	-1.56	-0.68	**-0.14**	North side Anderson Road near Harborview see ID 984	
1582	55.93	53.34	53.97	54.47	55.36	-2.59	-1.96	-1.46	-0.57	53.29	53.89	54.77	55.30	-2.64	-2.04	-1.16	-0.63		
1583	65.90	62.41	62.48	62.51	62.57	-3.49	-3.42	-3.39	-3.33	62.41	62.48	62.51	62.54	-3.49	-3.42	-3.39	-3.36		
1584	64.45	62.08	62.11	62.12	62.14	-2.37	-2.34	-2.33	-2.31	62.08	62.11	62.12	62.13	-2.37	-2.34	-2.33	-2.32		
1585	64.37	61.27	61.31	61.33	61.36	-3.10	-3.06	-3.04	-3.01	61.27	61.31	61.33	61.35	-3.10	-3.06	-3.04	-3.02		
1586	64.86	61.06	61.09	61.12	61.15	-3.80	-3.77	-3.74	-3.71	61.06	61.09	61.12	61.14	-3.80	-3.77	-3.74	-3.72		
1587	64.30	61.06	61.09	61.11	61.14	-3.24	-3.21	-3.19	-3.16	61.06	61.09	61.11	61.13	-3.24	-3.21	-3.19	-3.17		
1588	63.69	60.64	60.81	60.91	61.03	-3.05	-2.88	-2.78	-2.66	60.64	60.81	60.95	60.97	-3.05	-2.88	-2.74	-2.72		
1589	64.01	60.63	60.79	60.91	60.98	-3.38	-3.22	-3.10	-3.03	60.63	60.79	60.95	60.93	-3.38	-3.22	-3.06	-3.08		
1590	63.95	60.30	60.37	60.41	60.46	-3.65	-3.58	-3.54	-3.49	60.30	60.37	60.41	60.43	-3.65	-3.58	-3.54	-3.52		
1591	63.54	61.21	61.26	61.28	61.32	-2.33	-2.28	-2.26	-2.22	61.21	61.26	61.28	61.30	-2.33	-2.28	-2.26	-2.24		
1592	62.48	60.12	60.23	60.28	60.36	-2.36	-2.25	-2.20	-2.12	60.12	60.23	60.28	60.32	-2.36	-2.25	-2.20	-2.16		
1593	62.41	59.54	59.58	59.60	59.64	-2.87	-2.83	-2.81	-2.77	59.54	59.58	59.60	59.62	-2.87	-2.83	-2.81	-2.79		
1594	59.59	56.94	57.07	57.18	57.45	-2.65	-2.52	-2.41	-2.14	56.94	57.07	57.18	57.33	-2.65	-2.52	-2.41	-2.26		
1595	59.54	56.68	56.85	57.10	57.40	-2.86	-2.69	-2.44	-2.14	56.68	56.85	57.10	57.27	-2.86	-2.69	-2.44	-2.27		
1596	59.77	57.40	57.60	57.73	57.90	-2.37	-2.17	-2.04	-1.87	57.40	57.60	57.73	57.82	-2.37	-2.17	-2.04	-1.95		
1597	59.08	57.31	57.50	57.61	57.75	-1.77	-1.58	-1.47	-1.33	57.31	57.50	57.61	57.69	-1.77	-1.58	-1.47	-1.39		
1598	59.73	57.31	57.50	57.61	57.75	-2.42	-2.23	-2.12	-1.98	57.31	57.50	57.61	57.68	-2.42	-2.23	-2.12	-2.05		
1599	58.85	56.45	56.85	57.09	57.40	-2.40	-2.00	-1.76	-1.45	56.45	56.85	57.09	57.27	-2.40	-2.00	-1.76	-1.58		
1600	59.69	57.18	57.30	57.39	57.49	-2.51	-2.39	-2.30	-2.20	57.18	57.30	57.39	57.44	-2.51	-2.39	-2.30	-2.25		
1601	59.51	56.15	56.29	56.36	56.95	-3.36	-3.22	-3.15	-2.56	56.15	56.29	56.36	56.51	-3.36	-3.22	-3.15	-3.00		
1608	70.25	68.18	68.20	68.21	68.23	-2.07	-2.05	-2.04	-2.02	68.18	68.20	68.21	68.22	-2.07	-2.05	-2.04	-2.03		
1609	70.33	68.70	68.77	68.80	68.86	-1.63	-1.56	-1.53	-1.47	68.70	68.77	68.80	68.83	-1.63	-1.56	-1.53	-1.50		
1613	72.00	69.03	69.07	69.09	69.12	-2.97	-2.93	-2.91	-2.88	69.03	69.07	69.09	69.11	-2.97	-2.93	-2.91	-2.89		
1614	60.13	56.49	56.87	57.04	57.43	-3.64	-3.26	-3.09	-2.70	56.43	56.67	57.04	57.33	-3.70	-3.46	-3.09	-2.80		
1615	59.00	56.28	56.54	56.64	56.86	-2.72	-2.46	-2.36	-2.14	56.22	56.37	56.64	56.82	-2.78	-2.63	-2.36	-2.18		
1617	61.00	57.31	57.31	57.31	57.31	-3.69	-3.69	-3.69	-3.69	57.31	57.31	57.31	57.31	-3.69	-3.69	-3.69	-3.69		
1618	62.70	60.00	60.00	60.00	60.00	-2.70	-2.70	-2.70	-2.70	60.00	60.00	60.00	60.00	-2.70	-2.70	-2.70	-2.70		
1619	63.17	60.46	60.46	60.46	60.46	-2.71	-2.71	-2.71	-2.71	60.46	60.46	60.46	60.46	-2.71	-2.71	-2.71	-2.71		
1620	63.40	60.24	60.24	60.24	60.24	-3.16	-3.16	-3.16	-3.16	60.24	60.24	60.24	60.24	-3.16	-3.16	-3.16	-3.16		
1621	64.29	61.06	61.06	61.06	61.06	-3.23	-3.23	-3.23	-3.23	61.06	61.06	61.06	61.06	-3.23	-3.23	-3.23	-3.23		
1622	64.03	61.18	61.18	61.18	61.18	-2.85	-2.85	-2.85	-2.85	61.18	61.18	61.18	61.18	-2.85	-2.85	-2.85	-2.85		
1623	64.37	61.86	61.86	61.86	61.86	-2.51	-2.51	-2.51	-2.51	61.86	61.86	61.86	61.86	-2.51	-2.51	-2.51	-2.51		
1624	63.82	63.09	63.09	63.09	63.09	-0.73	-0.73	-0.73	-0.73	63.09	63.09	63.09	63.09	-0.73	-0.73	-0.73	-0.73		
1627	65.61	61.45	61.45	61.45	61.45	-4.16	-4.16	-4.16	-4.16	61.45	61.45	61.45	61.45	-4.16	-4.16	-4.16	-4.16		
1644	47.55	44.32	44.67	44.84	44.97	-3.23	-2.88	-2.71	-2.58	44.32	44.51	44.81	44.93	-3.23	-3.04	-2.74	-2.62		
1645	47.66	44.23	45.10	45.79	46.73	-3.43	-2.56	-1.87	-0.93	44.23	44.79	45.63	46.37	-3.43	-2.87	-2.03	-1.29		
1646	46.72	43.52	43.72	43.92	44.02	-3.20	-3.00	-2.80	-2.70	43.52	43.59	43.88	43.99	-3.20	-3.13	-2.84	-2.73		
1648	47.89	43.82	45.11	45.81	46.74	-4.07	-2.78	-2.08	-1.15	43.70	44.79	45.65	46.38	-4.19	-3.10	-2.24	-1.51		
1659	45.50	43.22	43.22	43.22	43.22	-2.28	-2.28	-2.28	-2.28	43.22	43.22	43.22	43.22	-2.28	-2.28	-2.28	-2.28		
1660	46.90	43.73	43.73	43.73	43.73	-3.17	-3.17	-3.17	-3.17	43.73	43.73	43.73	43.73	-3.17	-3.17	-3.17	-3.17		
1661	43.85	41.65	41.79	41.83	41.95	-2.20	-2.06	-2.02	-1.90	41.65	41.79	41.83	41.90	-2.20	-2.06	-2.02	-1.95		
1671	20.00	9.39	11.98	11.16	11.95	-10.61	-8.02	-8.84	-8.05	9.39	11.71	10.93	11.65	-10.61	-8.29	-9.07	-8.35		
1672	20.00	10.43	13.63	13.55	14.80	-9.57	-6.37	-6.45	-5.20	10.33	13.19	13.21	14.29	-9.67	-6.81	-6.79	-5.71		
1009A	56.00	49.30	49.72	49.95	50.28	-6.70	-6.28	-6.05	-5.72	49.24	49.63	49.89	50.12	-6.76	-6.37	-6.11	-5.88		
1009B	56.00	50.57	51.21	51.52	51.99	-5.43	-4.79	-4.48	-4.01	50.47	51.06	51.45	51.79	-5.53	-4.94	-4.55	-4.21		
1009C	56.00	53.42	53.78	53.91	54.18	-2.58	-2.22	-2.09	-1.82	53.37	53.70	53.86	54.05	-2.63	-2.30	-2.14	-1.95		
1546A	56.00	54.07	54.42	54.97	56.15	-1.93	-1.58	-1.03	**0.15**	54.07	54.42	55.01	55.82	-1.93	-1.58	-0.99	**-0.18**	Anderson Park - Glendale Drive	

Table C-4
Hillsdale / Hillsdale North Subbasin Flooding

Node	Assumed Overtopping Elevation (feet NAVD88)	Existing Conditions – Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Existing Conditions – Flood Depth (feet) 2-year	10-year	25-year	100-year	Future Conditions – Maximum Computed Head (feet NAVD88) 2-year	10-year	25-year	100-year	Future Conditions – Flood Depth (feet) 2-year	10-year	25-year	100-year	Location	ID
1557A	57.00	52.67	52.87	52.98	53.18	-4.33	-4.13	-4.02	-3.82	52.64	52.80	53.00	53.14	-4.36	-4.20	-4.00	-3.86		
964A	58.00	52.37	54.36	54.97	56.15	-5.63	-3.64	-3.03	-1.85	52.37	54.31	55.00	55.82	-5.63	-3.69	-3.00	-2.18		

Whatcom County Public Works Department—Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Central North Subwatershed Master Plan

APPENDIX C. CAPITAL IMPROVEMENT PROJECT DESCRIPTIONS

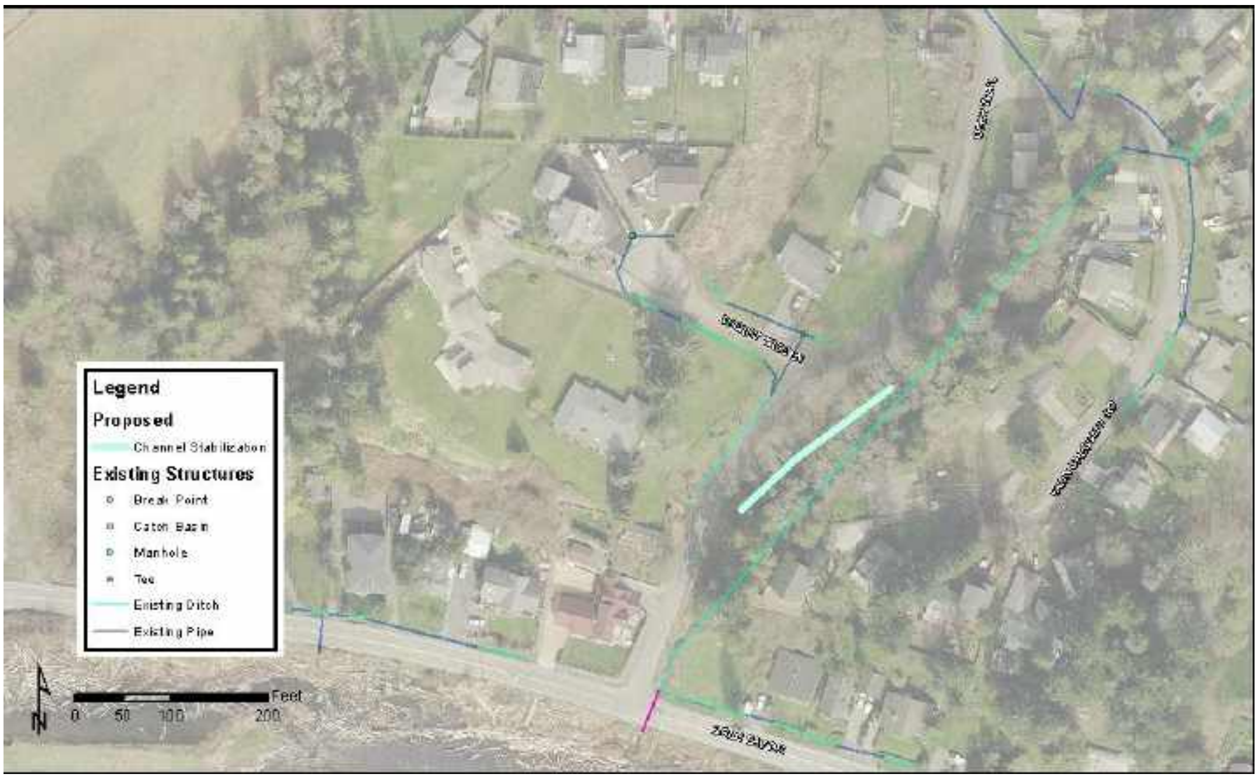
Shintaffer Subbasin

Project SH-1 (Streambank Stabilization Upstream of Birch Bay Drive)

Problem ID:	SH-13
Location:	Stream channel about 200 feet upstream of Birch Bay Drive.
Description:	Bank erosion in stream channel.
Cost:	$171,000
Score:	36
Related Projects:	None

Project Description:

- Stabilize and restore 200 feet of streambank.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: SH-1 (Problem SH-13) **BY:** GMS
DESCRIPTION: Streambank stabilization upstream of Birch Bay Drive **CHECKED BY:**
SUBBASIN: Shintaffer **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
STREAM RESTORATION/STABILIZATION	200	LF	$ 300	$ 60,000
			Material Subtotal	$ 60,000
DEWATERING	5%			$ 3,000
EROSION & SEDIMENTATION CONTROL	10%			$ 6,000
TRAFFIC CONTROL	3%			$ 1,800
CONTINGENCY	30%			$ 18,000
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 8,880
	Construction Subtotal (Rounded)			$ 98,000
STATE SALES TAX	8.6%			$ 8,430
ENGRG/LEGAL/ADMIN < $100K CONST	35%			$ 34,300
CONSTRUCTION MANAGEMENT	10%			$ 9,800
PERMITTING - STREAM	20%			$ 19,540
2012 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 171,000**

Notes:

1. The above cost opinion is in 2012 dollars and does not include future escalation, financing, land acquisition, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

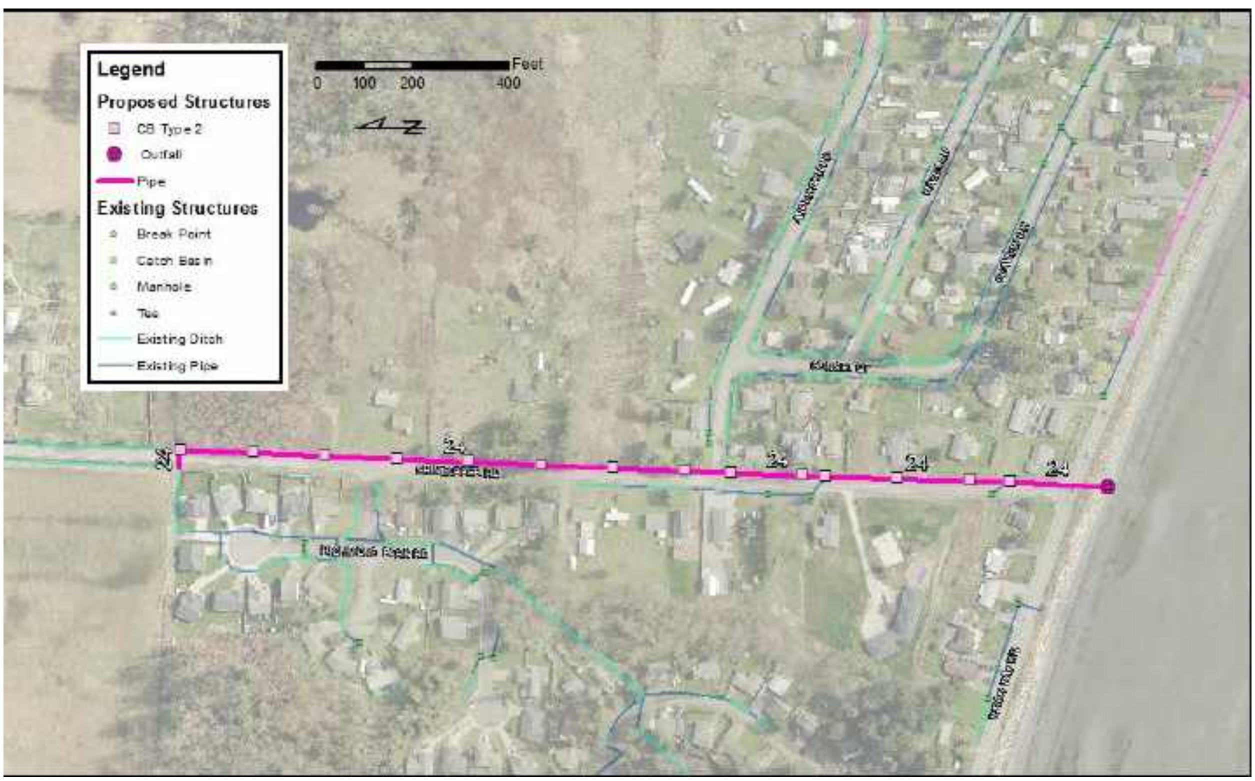
Shintaffer Subbasin

Project SH-2 (Richmond Park Drainage Improvement)

Problem ID:	SH-6, SH-7, SH-8, SH-9
Location:	Richmond Park Subdivision and Shintaffer Road.
Description:	Storm drain system overflowed during December 12, 2010 rainfall. Flood damage occurred at two to three properties in the subdivision. High flows are causing erosion in the ravine downstream of Fawn Crescent Way. High ponding levels in habitat conservation are have damaged trees. The hydraulic analysis predicted flooding for the 10-year event under existing and future conditions. This project was developed by Whatcom County
Cost:	$1,586,000
Score:	47
Related Projects:	None

Project Description:

- Install 40 lineal feet 24-inch diameter cross culvert under Shintaffer Road and north side of Richmond Park subdivision.
- Replace ditch and culvert system on east side of Shintaffer Road with 2,000 lineal feet of 24-inch diameter HDPE.
- Install 15 CB Type 2 structures.
- Install new outfall to Birch Bay.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**SH-2 (Problem SH-7. SH-8, SH-9)**	**BY:**	**AMS**
DESCRIPTION:	**Shintaffer Road Drainage Improvements**	**CHECKED BY:**	
SUBBASIN:	**Shintaffer**	**DATE:**	**May 18, 2012**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	11,185	SF	$ 1	$ 11,185
SAWCUT & REMOVE PAVEMENT	2,237	SY	$ 40	$ 89,480
REMOVE PIPE	828	LF	$ 5	$ 4,140
24-INCH DIAM HDPE	2,000	LF	$ 70	$ 140,000
24-INCH DIAM OUTFALL STRUCTURE	1	LF	$ 4,000	$ 4,000
CATCH BASIN TYPE 2, 48-IN DIAM	16	EA	$ 3,000	$ 48,000
ASPHALT CONCRETE PAVEMENT PATCHING	130	TN	$ 250	$ 32,500
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,675	CY	$ 15	$ 25,125
SHORING AND EXTRA EXCAVATION CLASS B	4,723	CY	$ 15	$ 70,845
LAND ACQUISITION	0.51	AC	$ 150,000	$ 76,500
			Material Subtotal	$ 501,775
CONTINGENCY	50%			$ 250,890
			Material Subtotal with Contingency	$ 752,665
DEWATERING	5%			$ 37,640
ARCHEOLOGICAL MONITORING	5%			$ 37,640
EROSION & SEDIMENTATION CONTROL	10%			$ 75,270
TRAFFIC CONTROL	3%			$ 22,580
SITE RESTORATION	5%			$ 37,640
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 46,290
			Construction Subtotal (Rounded)	$ 1,010,000
STATE SALES TAX	8.6%			$ 86,860
ENGRG/LEGAL/ADMIN > $250K CONST	25%			$ 252,500
CONSTRUCTION MANAGEMENT	10%			$ 101,000
PERMITTING - WITH OUTFALL TO BAY	20%			$ 134,880
2013 Dollars			**Total Estimated Project Cost (Rounded) $**	**1,586,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Shintaffer Subbasin

Project SH-3 (Deer Trail Outfall Improvement)

Problem ID:	SH-3
Location:	Birch Bay at Deer Trail
Description:	Undersized outfall pipeline causes flooding along Birch Bay Drive for 100-year event under existing and future conditions.
Cost:	$165,000
Score:	23
Related Projects:	None

Project Description:

- Install 45 lineal feet 30-inch diameter pipe under Birch Bay Drive.
- Install new 30-inch outfall with tide valve to Birch Bay.

BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**SH-3 (Problem SH-3)**	**BY:**	**GMS**
DESCRIPTION:	**Birch Bay Deer Trail Outfall Replacement**	**CHECKED BY:**	
SUBBASIN:	**Shintaffer**	**DATE:**	**September 12, 2012**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	460	SF	$ 1	$ 460
SAWCUT & REMOVE PAVEMENT	20	SY	$ 40	$ 800
REMOVE PIPE	46	LF	$ 5	$ 230
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	46	CY	$ 15	$ 690
SHORING OR EXTRA EXCAVATION CLASS B	92	SF	$ 3	$ 276
30-INCH DIAM RCP	46	LF	$ 120	$ 5,520
30-INCH TIDE VALVE	1	EA	$ 10,800	$ 10,800
TIDE BOX	1	EA	$ 30,000	$ 30,000
CRUSHED SURFACING BASE COURSE	4	TN	$ 10	$ 40
CRUSHED SURFACING TOP COURSE	2	TN	$ 60	$ 120
ASPHALT CONCRETE PAVEMENT PATCHING	1	TN	$ 250	$ 250
			Material Subtotal	$ 49,186
CONTINGENCY	50%			$ 24,600
			Material Subtotal with Contingency	$ 73,786
DEWATERING	5%			$ 3,690
ARCHEOLOGICAL MONITORING	5%			$ 3,690
EROSION & SEDIMENTATION CONTROL	10%			$ 7,380
TRAFFIC CONTROL	3%			$ 2,220
SITE RESTORATION	5%			$ 3,690
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 4,540
			Construction Subtotal (Rounded)	$ 99,000
STATE SALES TAX	8.6%			$ 8,520
ENGRG/LEGAL/ADMIN < $100K CONST	35%			$ 34,650
CONSTRUCTION MANAGEMENT	10%			$ 9,900
PERMITTING - WITH OUTFALL TO BAY	20%			$ 12,710
2013 Dollars			**Total Estimated Project Cost (Rounded) $**	**165,000**

Notes:

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2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

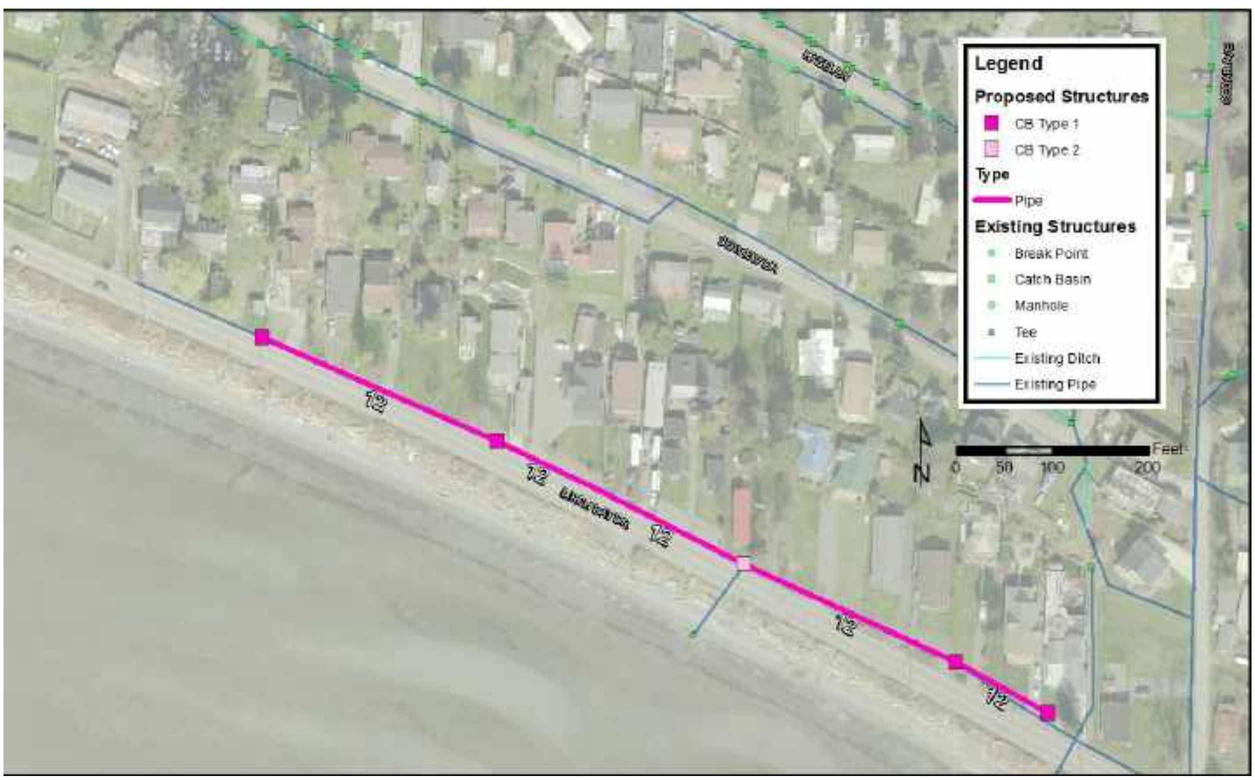
COTTONWOOD BEACH NORTH SUBBASIN

Project CN-2 (Birch Bay Drive Storm Drain Replacement)

Problem ID:	CN-3
Location:	Birch Bay Drive between Cedar Avenue and Shintaffer Road.
Description:	Undersized storm drain east of outfall causes flooding during 2-year event and during 10-year west of the outfall under existing and future conditions.
Cost:	$338,000
Score:	34
Related Projects:	None

Project Description:

- Replace 355 lineal feet of 4-inch diameter pipe with 12-inch diameter HDPE pipe
- Replace 287 lineal feet of 12-inch diameter CMP with 12-diamter HDPE pipe.
- Replace 267 lineal feet of 8-inch diameter HDPE pipe with 12-diamter HDPE pipe.
- Install 4 CB Type 1 and 1 CB Type 2 structures.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**CN-2 (Problem CN-3)**	**BY:**	**GMS**
DESCRIPTION:	**Replace storm drain on Birch Bay Drive**	**CHECKED BY:**	
SUBBASIN:	**Cottonwood Beach North**	**DATE:**	**May 8, 2012**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	4,705	SF	$ 1	$ 4,705
SAWCUT & REMOVE PAVEMENT	418	SY	$ 40	$ 16,720
REMOVE PIPE	168	LF	$ 5	$ 840
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	732	CY	$ 15	$ 10,978
SHORING OR EXTRA EXCAVATION CLASS B	1,882	SF	$ 3	$ 5,646
12-INCH DIAM HDPE	941	LF	$ 50	$ 47,050
CATCH BASIN TYPE 1	4	EA	$ 1,400	$ 5,600
CATCH BASIN TYPE 2, 72-IN DIAM	1	EA	$ 6,000	$ 6,000
CRUSHED SURFACING BASE COURSE	85	TN	$ 10	$ 850
CRUSHED SURFACING TOP COURSE	42	TN	$ 60	$ 2,520
ASPHALT CONCRETE PAVEMENT PATCHING	29	TN	$ 250	$ 7,250
			Material Subtotal	$ 108,159
CONTINGENCY	50%			$ 54,080
			Material Subtotal with Contingency	$ 162,239
DEWATERING	5%			$ 8,120
ARCHEOLOGICAL MONITORING	5%			$ 8,120
EROSION & SEDIMENTATION CONTROL	10%			$ 16,230
TRAFFIC CONTROL	3%			$ 4,870
SITE RESTORATION	5%			$ 8,120
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 9,980
			Construction Subtotal (Rounded)	$ 218,000
STATE SALES TAX	8.6%			$ 18,750
ENGRG/LEGAL/ADMIN $100-250K CONST	30%			$ 65,400
CONSTRUCTION MANAGEMENT	10%			$ 21,800
PERMITTING - COUNTY ONLY	10%			$ 13,970
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 338,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

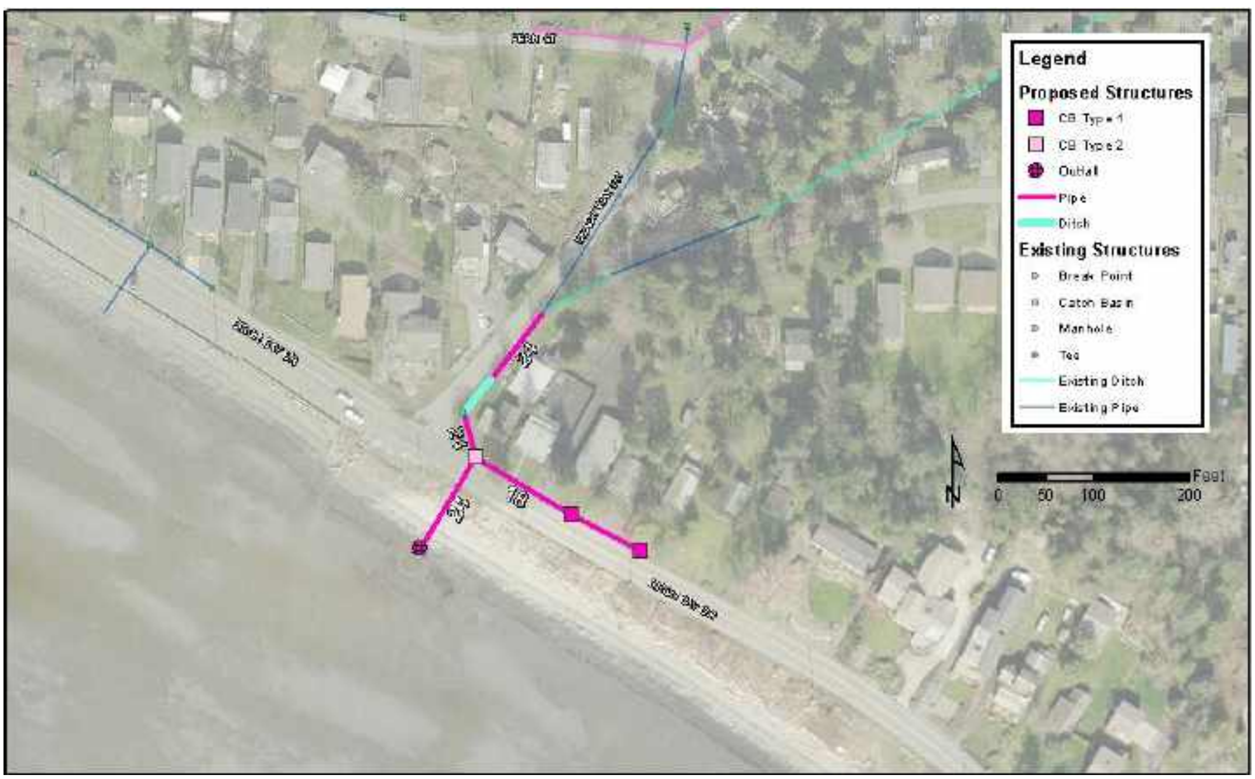
COTTONWOOD BEACH SOUTH SUBBASIN

Project CS-2 (Beachway Drive and Birch Bay Road Storm Drain Improvement)

Problem ID:	CS-2
Location:	Beachway Drive at Birch Bay Road.
Description:	Undersized storm drain system causes flooding during 10-year event under existing and future conditions.
Cost:	$217,000
Score:	33
Related Projects:	CS-2

Project Description:

- Replace 200 lineal feet of 12-inch diameter storm drain with 18-inch diameter HDPE on north side of Birch bay Road
- Replace 18-inch diameter driveway culvert and 18-inch diameter storm drain and outfall with 240 lineal feet of 24-inch diameter HDPE pipe.
- Regrade 45 lineal feet of roadside ditch
- Construct 24-inch diameter outfall with tide valve.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CS-2 (Problem CS-2) **BY:** GMS
DESCRIPTION: Beachway Drive and Birch Bay Drive Storm Drain Impr **CHECKED BY:**
SUBBASIN: Cottonwood Beach South **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	4,400	SF	$ 1	$ 4,400
SAWCUT & REMOVE PAVEMENT	89	SY	$ 40	$ 3,560
REMOVE PIPE	440	LF	$ 5	$ 2,200
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	369	CY	$ 15	$ 5,533
SHORING OR EXTRA EXCAVATION CLASS B	880	SF	$ 3	$ 2,640
18-INCH DIAM HDPE	200	LF	$ 60	$ 12,000
24-INCH DIAM HDPE	240	LF	$ 70	$ 16,800
CATCH BASIN TYPE 1	2	EA	$ 1,400	$ 2,800
CATCH BASIN TYPE 2, 72-IN DIAM	1	EA	$ 6,000	$ 6,000
24-INCH TIDE VALVE	1	EA	$ 8,200	$ 8,200
REESTABLISH DITCH	45	LF	$ 5	$ 225
CRUSHED SURFACING BASE COURSE	18	TN	$ 10	$ 180
CRUSHED SURFACING TOP COURSE	9	TN	$ 60	$ 540
ASPHALT CONCRETE PAVEMENT PATCHING	6	TN	$ 250	$ 1,500
			Material Subtotal	$ 66,578
CONTINGENCY	50%			$ 33,290
			Material Subtotal with Contingency	$ 99,868
DEWATERING	5%			$ 5,000
ARCHEOLOGICAL MONITORING	5%			$ 5,000
EROSION & SEDIMENTATION CONTROL	10%			$ 9,990
TRAFFIC CONTROL	3%			$ 3,000
SITE RESTORATION	5%			$ 5,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 6,150
			Construction Subtotal (Rounded)	$ 134,000
STATE SALES TAX	8.6%			$ 11,530
ENGRG/LEGAL/ADMIN $100-250K CONST	30%			$ 40,200
CONSTRUCTION MANAGEMENT	10%			$ 13,400
PERMITTING - WITH OUTFALL TO BAY	20%			$ 17,200
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 217,000**

Notes:

1. The above cost opinion is in 2013 dollars and does not include future escalation, financing, land acquisition, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

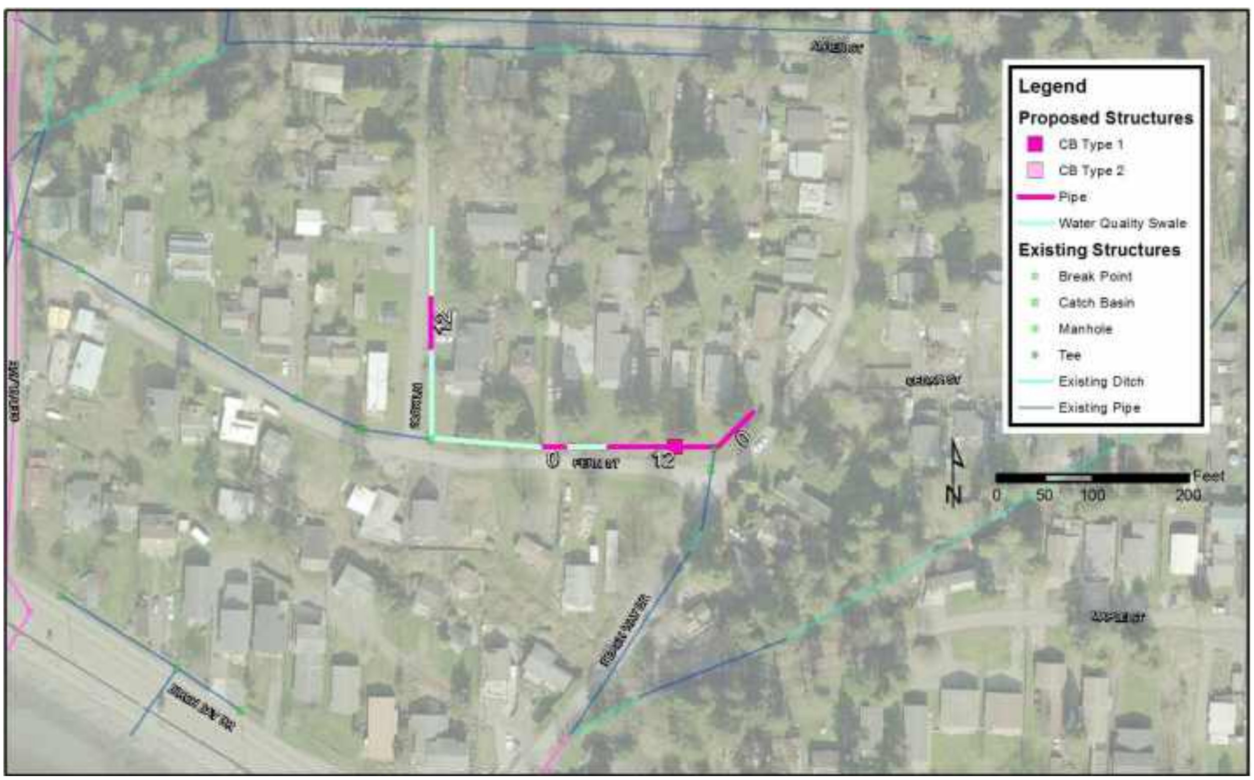
COTTONWOOD BEACH SOUTH SUBBASIN

Project CS-3 (Fern Street Storm Drain Improvements)

Problem ID:	CS-9
Location:	Fern Street west of Beachway Drive.
Description:	No storm drain infrastructure on Fern Street and Park Lane causes flooding after rainfall events.
Cost:	$124,000
Score:	42
Related Projects:	CN-1

Project Description:

- Install 290 lineal feet of new 12-inch diameter HDPE
- Install 330 lineal feet of water quality swale
- Install 1 CB Type 1.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CS-3 (Problem CS-9) **BY:** GMS
DESCRIPTION: Fern Street Storm Drain System **CHECKED BY:**
SUBBASIN: Cottonwood Beach South **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	5,000	SF	$ 1	$ 5,000
SAWCUT & REMOVE PAVEMENT	107	SY	$ 40	$ 4,280
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	187	CY	$ 15	$ 2,800
SHORING OR EXTRA EXCAVATION CLASS B	480	SF	$ 3	$ 1,440
12-INCH DIAM HDPE	240	LF	$ 50	$ 12,000
CATCH BASIN TYPE 1	1	EA	$ 1,400	$ 1,400
WATER QUALITY SWALE	170	LF	$ 50	$ 8,500
CRUSHED SURFACING BASE COURSE	22	TN	$ 10	$ 220
CRUSHED SURFACING TOP COURSE	11	TN	$ 60	$ 660
ASPHALT CONCRETE PAVEMENT PATCHING	7	TN	$ 250	$ 1,750
			Material Subtotal	$ 38,050
CONTINGENCY	50%			$ 19,030
			Material Subtotal with Contingency	$ 57,080
DEWATERING	5%			$ 2,860
ARCHEOLOGICAL MONITORING	5%			$ 2,860
EROSION & SEDIMENTATION CONTROL	10%			$ 5,710
TRAFFIC CONTROL	3%			$ 1,720
SITE RESTORATION	5%			$ 2,860
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 3,520
			Construction Subtotal (Rounded)	$ 77,000
STATE SALES TAX	8.6%			$ 6,630
ENGRG/LEGAL/ADMIN < $100K CONST	35%			$ 26,950
CONSTRUCTION MANAGEMENT	10%			$ 7,700
PERMITTING - COUNTY ONLY	10%			$ 4,920
2012 Dollars			**Total Estimated Project Cost (Rounded) $**	**124,000**

Notes:

1. The above cost opinion is in 2012 dollars and does not include future escalation, financing, land acquisition, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

COTTONWOOD BEACH SOUTH SUBBASIN

Project CS-4 (Ditch Protection west of North Bay Trailer Park)

Problem ID:	CS-11
Location:	Ditch adjacent of west boundary of North Bay Trailer Park.
Description:	Concentrated stormwater runoff causing erosion in ditch on west boundary of North Bay Trailer Park.
Cost:	$163,000
Score:	27
Related Projects:	None

Project Description:

- Install 600 lineal feet of 12-inch diameter HDPE pipe.
- Install 1 new Type 1 CB, 2 new Type 2 CBs and 1 new Type 2 CB as energy dissipater.

BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CS-4 (Problem CS-11) **BY:** GMS
DESCRIPTION: Tightline and Storm Drain between North Bay Trailer P **CHECKED BY:**
SUBBASIN: Cottonwood Beach South **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	9,000	SF	$ 1	$ 9,000
12-INCH DIAM HDPE	600	LF	$ 50	$ 30,000
CATCH BASIN TYPE 1	1	EA	$ 1,400	$ 1,400
CATCH BASIN TYPE 2, 48-IN DIAM	2	EA	$ 3,000	$ 6,000
CATCH BASIN TYPE 2, 72-IN DIAM	1	EA	$ 6,000	$ 6,000
			Material Subtotal	$ 52,400
CONTINGENCY	50%			$ 26,200
	Material Subtotal with Contingency			$ 78,600
DEWATERING	5%			$ 3,930
ARCHEOLOGICAL MONITORING	5%			$ 3,930
EROSION & SEDIMENTATION CONTROL	10%			$ 7,860
TRAFFIC CONTROL	3%			$ 2,360
SITE RESTORATION	5%			$ 3,930
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 4,840
	Construction Subtotal (Rounded)			$ 105,000
STATE SALES TAX	8.6%			$ 9,030
ENGRG/LEGAL/ADMIN $100-250K CONST	30%			$ 31,500
CONSTRUCTION MANAGEMENT	10%			$ 10,500
PERMITTING - COUNTY ONLY	10%			$ 6,770
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 163,000**

Notes:

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HILLSDALE SUBBASIN

Project HL-1 (Harborview Road Culvert Replacement)

Problem ID:	HL-5
Location:	East side Harborview Rd. 300’ south to 1,500’ north of Anderson Rd.
Description:	Undersized culvert at Anderson Road and south of Anderson Road causes flooding during 10-year event under existing and future conditions.
Cost:	$230,000
Score:	22
Related Projects:	None

Project Description:

- Replace six 12- and 18-inch diameter road and driveway culverts (280 lineal feet) with 24-diamter HDPE pipes. Total replacement culvert pipe length is 280 feet.
- Replace four 12- inch diameter road and driveway culverts (200 lineal feet) with 18-diamter HDPE pipes.
- Replace two catch basins with Type 2 CBs.
- A local peak flow increase of about 9 percent would occur in the reach downstream of Harborview Drive. The average channel velocity is also predicted to increase slightly by 3 percent in this reach also. Flow and velocity increase are attenuated and not transferred downstream.

BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**HL-1 (Problem HL-5)**	**BY:**	**GMS**
DESCRIPTION:	**Replace 10 culverts, east side Harborview Rd.**	**CHECKED BY:**	
SUBBASIN:	**Hillsdale**	**DATE:**	**May 8, 2012**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	5,000	SF	$ 1	$ 5,000
SAWCUT & REMOVE PAVEMENT	222	SY	$ 40	$ 8,880
REMOVE PIPE	499	LF	$ 5	$ 2,495
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	419	CY	$ 15	$ 6,290
SHORING OR EXTRA EXCAVATION CLASS B	998	SF	$ 3	$ 2,994
18-INCH DIAM HDPE	218	LF	$ 60	$ 13,080
24-INCH DIAM HDPE	281	LF	$ 70	$ 19,670
CATCH BASIN TYPE 2, 54-IN DIAM	2	EA	$ 4,000	$ 8,000
CRUSHED SURFACING BASE COURSE	45	TN	$ 10	$ 450
CRUSHED SURFACING TOP COURSE	22	TN	$ 60	$ 1,320
ASPHALT CONCRETE PAVEMENT PATCHING	15	TN	$ 250	$ 3,750
			Material Subtotal	$ 71,929
CONTINGENCY	50%			$ 35,970
			Material Subtotal with Contingency	$ 107,899
DEWATERING	5%			$ 5,400
ARCHEOLOGICAL MONITORING	5%			$ 5,400
EROSION & SEDIMENTATION CONTROL	10%			$ 10,790
TRAFFIC CONTROL	3%			$ 3,240
SITE RESTORATION	5%			$ 5,400
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 6,640
			Construction Subtotal (Rounded)	$ 145,000
STATE SALES TAX	8.6%			$ 12,470
ENGRG/LEGAL/ADMIN $100-250K CONST	30%			$ 43,500
CONSTRUCTION MANAGEMENT	10%			$ 14,500
PERMITTING - COUNTY ONLY	10%			$ 14,500
2013 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 230,000**

Notes:

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HILLSDALE SUBBASIN

Project HL-2 (Birch Bay Drive Storm Drain Improvement)

Problem ID:	HL-1, HL-8
Location:	Birch Bay Drive near Cottonwood Drive.
Description:	Flooding occurred on Birch Bay Drive at various locations during the December 12, 2010, rainfall event. Undersized pipeline causes flooding during 2-year event under existing and future conditions.
Cost:	$183,000
Score:	36
Related Projects:	None

Project Description:

- Replace 325 lineal feet of 6- and 8-inch diameter storm drain with 12- diameter HDPE pipe.
- Install 175 lineal feet of 12- inch diameter HDPE pipe.
- Replace 4 catch basins with Type 1 CBs.
- Install 2 new Type 1 CBs
- Install 1 new Type 2, 72-inch diameter CB to connect new storm drain to existing 30-inch diameter pipeline outfall.

BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: HL-2 (Problem HL-1 and HL-8) **BY:** GMS
DESCRIPTION: Replace storm drain, Birch Bay Dr. at Cottonwood Dr. **CHECKED BY:**
SUBBASIN: Hillsdale **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	7,500	SF	$ 1	$ 7,500
SAWCUT & REMOVE PAVEMENT	222	SY	$ 40	$ 8,880
REMOVE PIPE	300	LF	$ 5	$ 1,500
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	389	CY	$ 15	$ 5,833
SHORING OR EXTRA EXCAVATION CLASS B	1,000	SF	$ 3	$ 3,000
12-INCH DIAM HDPE	500	LF	$ 50	$ 25,000
CATCH BASIN TYPE 1	1	EA	$ 1,400	$ 1,400
CATCH BASIN TYPE 2, 72-IN DIAM	0	EA	$ 6,000	$ 0
CRUSHED SURFACING BASE COURSE	45	TN	$ 10	$ 450
CRUSHED SURFACING TOP COURSE	23	TN	$ 60	$ 1,380
ASPHALT CONCRETE PAVEMENT PATCHING	15	TN	$ 250	$ 3,750
			Material Subtotal	$ 58,693
CONTINGENCY	50%			$ 29,350
	Material Subtotal with Contingency			$ 88,043
DEWATERING	5%			$ 4,410
ARCHEOLOGICAL MONITORING	5%			$ 4,410
EROSION & SEDIMENTATION CONTROL	10%			$ 8,810
TRAFFIC CONTROL	3%			$ 2,650
SITE RESTORATION	5%			$ 4,410
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 5,420
	Construction Subtotal (Rounded)			$ 118,000
STATE SALES TAX	8.6%			$ 10,150
ENGRG/LEGAL/ADMIN $100-250K CONST	30%			$ 35,400
CONSTRUCTION MANAGEMENT	10%			$ 11,800
PERMITTING - COUNTY ONLY	10%			$ 7,590
2013 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 183,000**

Notes:

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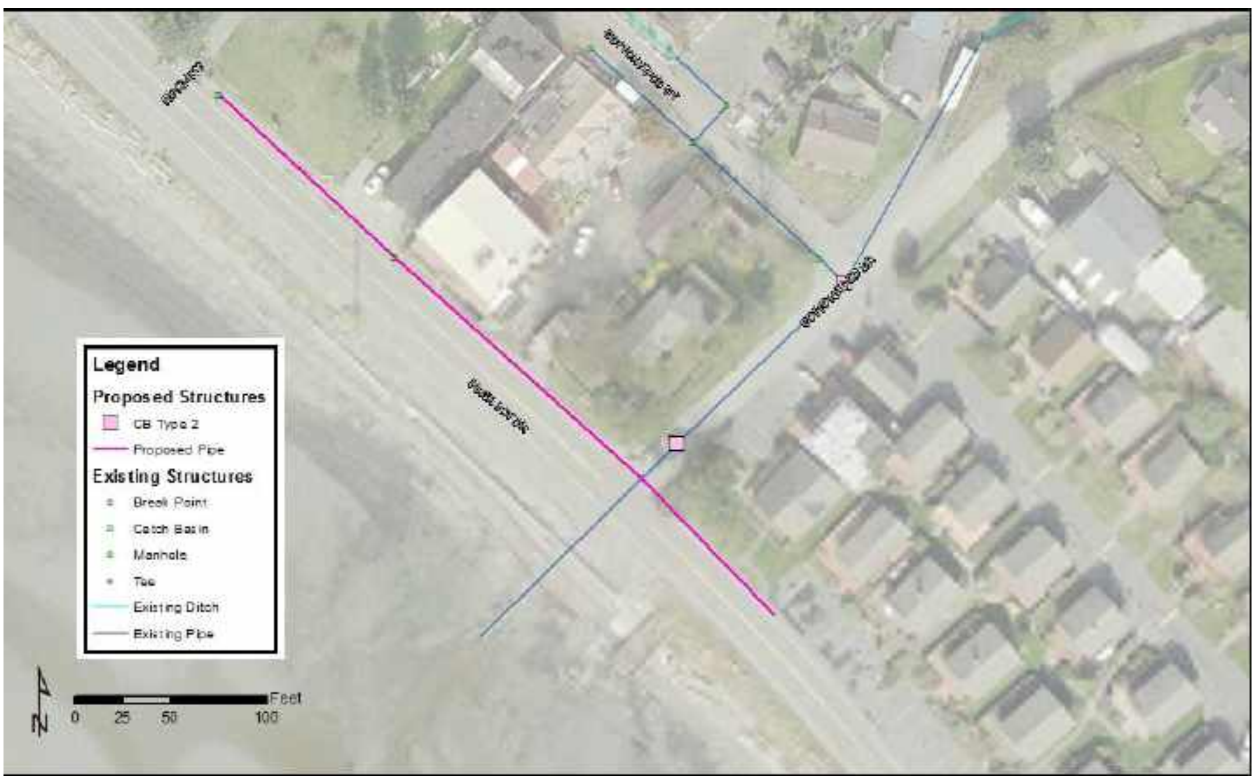
HILLSDALE SUBBASIN

Project HL-3 (Cottonwood Drive Strom Drain Maintenance improvement)

Problem ID:	HL-13, HL-14
Location:	Cottonwood Drive near Birch Bay Drive.
Description:	Blind tee lateral connections in storm drain trunk line cannot be maintained.
Cost:	$63,000
Score:	31
Related Projects:	None

Project Description:

- Replace two blind tee connections with type 2 CBs.
- Connect existing pipe to CBs.



BIRCH BAY URBAN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: HL-3 (Problem HL-13 and HL-14) — **BY:** GMS
DESCRIPTION: Cottonwood Drive Maintenance Improvements — **CHECKED BY:**
SUBBASIN: Hillsdale — **DATE:** May 8, 2012

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	2500	SF	$ 1	$ 2,500
SAWCUT & REMOVE PAVEMENT	6	SY	$ 40	$ 240
CATCH BASIN TYPE 2, 72-IN DIAM	2	EA	$ 6,000	$ 12,000
CONNECT EXISTING PIPE	6	EA	$ 500	$ 3,000
CRUSHED SURFACING BASE COURSE	0.2	TN	$ 10	$ 2
CRUSHED SURFACING TOP COURSE	0.2	TN	$ 60	$ 12
ASPHALT CONCRETE PAVEMENT PATCHING	0.2	TN	$ 250	$ 50
			Material Subtotal	$ 17,804
CONTINGENCY	50%			$ 8,910
	Material Subtotal with Contingency			$ 26,714
DEWATERING	5%			$ 1,340
ARCHEOLOGICAL MONITORING	5%			$ 1,340
EROSION & SEDIMENTATION CONTROL	10%			$ 2,680
TRAFFIC CONTROL	3%			$ 810
SITE RESTORATION	5%			$ 1,340
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 1,650
	Construction Subtotal (Rounded)			$ 36,000
STATE SALES TAX	8.6%			$ 3,100
ENGRG/LEGAL/ADMIN < $100K CONST	35%			$ 12,600
CONSTRUCTION MANAGEMENT	10%			$ 3,600
PERMITTING - WITH OUTFALL TO BAY	20%			$ 7,200
2013 Dollars	**Total Estimated Project Cost (Rounded)**		**$**	**63,000**

Notes:

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APPENDIX D.
CAPITAL IMPROVEMENT PROJECT PRIORITY EVALUATION

Birch Bay Urban Subwatershed Plan Draft Prioritization Worksheet	Project	SH-1		SH-2		SH-3		CN-2
	SH-1: Streambank Stabilization Upstream of Birch Bay Drive		SH-2: Richmond Park Drainage Improvement		SH-3: Deer Trail Outfall Improvement		CN-2: Birch Bay Drive Storm Drain Replacement	
Category	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit	Weighting = 1							
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Indirect improvement - single outfall to bay	4	No Improvement	0	Indirect improvement - single outfall to bay	4
Sediment source removal	Removes a minor sediment source	4	No Improvement	0	No Improvement	0	No Improvement	0
	Subtotal	8	Subtotal	4	Subtotal	0	Subtotal	4
	Weighted Score	8.0	Weighted Score	4.0	Weighted Score	0.0	Weighted Score	4.0
Community Benefit	Weighting = 1							
Frequency of Flooding	No flooding	0	10-year recurrence interval	3	100-year recurrence interval	1	2-year recurrence interval	4
Property Damage	3 to 4 homes flooded	2	5 to 10 homes flooded	3	Nuisance yard flooding	0	1 to 2 homes flooded	1
Public Infrastructure	Critical public safety issue / critical public facility flooded	10	Emergency access blocked	8	Access to homes blocked	4	Access to homes blocked	4
	Subtotal	12	Subtotal	14	Subtotal	5	Subtotal	9
	Weighted Score	12.0	Weighted Score	14.0	Weighted Score	5.0	Weighted Score	9.0
Implementation	Weighting = 1							
Anticipated Cost of Project	$100,000 to $250,000	3	$500,000 +	1	$100,000 to $250,000	3	$250,000 to $500,000	2
Permit Complexity	Local and state permits required	1	Local, state, and federal permits required	0	Local, state, and federal permits required	0	Local and state permits required	1
Property/Easement Acquisition	Easement Acquisition only	2	No cost property/easement acquisitic	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	Critical project link	3	Critical project link	3	Critical project link	3	Critical project link	3
	Subtotal	9	Subtotal	9	Subtotal	11	Subtotal	11
	Weighted Score	9.0	Weighted Score	9.0	Weighted Score	11.0	Weighted Score	11.0
Local support	Weighting = 1							
	Low	2	High	10	Low	2	Medium	5
	Weighted Score	2.0	Weighted Score	10.0	Weighted Score	2.0	Weighted Score	5.0
Predesign	Weighting = 1							
	Identified in a subwatershed master plan	5	Engineering feasibility evaluation with survey	10	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5
	Weighted Score	5.0	Weighted Score	10.0	Weighted Score	5.0	Weighted Score	5.0
	Total Score	36.0	Total Score	47.0	Total Score	23.0	Total Score	34.0
	Rank	6		2		16		7
Notes and comments							This project would be directly linked to any roadwork associated with the berm project.	

Birch Bay Urban Subwatershed Plan
Draft Prioritization Worksheet

Category	CS-2: Beachway Drive and Birch Bay Drive Storm Drain Improvement		CS-3: Fern Street Storm Drain Improvements		CS-4: Tightline west of North Bay Trailer Park		HL-1: Harborview Road Culvert Replacement	
	CS-2		CS-3		CS-4		HL-1	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit								
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Direct improvement to shellfish habitat	10	Indirect Improvement - immediate vicinity (< 100 feet)	2	No Improvement	0
Sediment source removal	No Improvement	0	No Improvement	0	Removes a significant sediment source	6	No Improvement	0
	Subtotal	4	Subtotal	10	Subtotal	8	Subtotal	0
	Weighted Score	4.0	Weighted Score	10.0	Weighted Score	8.0	Weighted Score	0.0
Community Benefit								
Frequency of Flooding	10-year recurrence interval	3	2-year recurrence interval	4	Less than 2-year recurrence interval	5	10-year recurrence interval	3
Property Damage	Nuisance yard flooding	0	1 to 2 homes flooded	1	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Access to homes blocked	4	Street flooding greater than 6 inches	3	No street flooding	0	Access to homes blocked	4
	Subtotal	7	Subtotal	8	Subtotal	5	Subtotal	7
	Weighted Score	7.0	Weighted Score	8.0	Weighted Score	5.0	Weighted Score	7.0
Implementation								
Anticipated Cost of Project	$100,000 to $250,000	3	$0 to $100,000	4	$100,000 to $250,000	3	$100,000 to $250,000	3
Permit Complexity	Local and state permits required	1	Local permits required	2	Local permits required	2	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisitio	5	No cost property/easement acquisition	5	Easement Acquisition only	2	No cost property/easement acquisitio	5
Coordination with other projects/agencies	Critical project link	3	Non-critical project link	1	No project link	0	No project link	0
	Subtotal	12	Subtotal	12	Subtotal	7	Subtotal	10
	Weighted Score	12.0	Weighted Score	12.0	Weighted Score	7.0	Weighted Score	10.0
Local support								
	Medium	5	Low	2	Low	2	None	0
	Weighted Score	5.0	Weighted Score	2.0	Weighted Score	2.0	Weighted Score	0.0
Predesign								
	Identified in a subwatershed master plan	5	Engineering feasibility evaluation with survey	10	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5
	Weighted Score	5.0	Weighted Score	10.0	Weighted Score	5.0	Weighted Score	5.0
	Total Score	33.0	Total Score	42.0	Total Score	27.0	Total Score	22.0
		9		3		14		18
Notes and comments								

Birch Bay Urban Subwatershed Plan Draft Prioritization Worksheet		HL-2		HL-3
	HL-2: Birch Bay Drive Storm Drain Improvement		HL-3: Cottonwood Drive Maintenance Improvements	
Category	Rating	Score	Rating	Score
Environmental Benefit				
Shellfish Habitat (WQ)	No Improvement	0	No Improvement	0
Sediment source removal	No Improvement	0	No Improvement	0
	Subtotal	0	Subtotal	0
	Weighted Score	0.0	Weighted Score	0.0
Community Benefit				
Frequency of Flooding	2-year recurrence interval	4	No flooding	0
Property Damage	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Access to homes blocked	4	Emergency access blocked	8
	Subtotal	8	Subtotal	8
	Weighted Score	8.0	Weighted Score	8.0
Implementation				
Anticipated Cost of Project	$100,000 to $250,000	3	$0 to $100,000	4
Permit Complexity	Local permits required	2	Local and state permits required	1
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	Critical project link	3	Critical project link	3
	Subtotal	13	Subtotal	13
	Weighted Score	13.0	Weighted Score	13.0
Local support				
	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0
Predesign				
	Engineering feasibility evaluation with survey	10	Identified in a subwatershed master plan	5
	Weighted Score	10.0	Weighted Score	5.0
	Total Score	36.1	Total Score	31.0
		5		10
Notes and comments			This project area has significant flooding problems on a regular basis and should be considered as a neighborhood improvement project	

Addendum 2

Birch Bay
Central South Subwatershed Master Plan

Prepared for:

Prepared by:

TETRA TECH

January 2015

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN

FINAL DRAFT

JANUARY 2015

Prepared for:

Whatcom County Public Works Department Stormwater Division
322 N. Commercial Street
Bellingham, WA 98225

Birch Bay Watershed and Aquatic Resources Management District

Prepared by:

TETRA TECH

1420 Fifth Avenue, Suite 600, Seattle, WA 98101-2357
Tel 206.883.9300 Fax 206.883.9301 www.tetratech.com

Tetra Tech Project Number: 100-SWW-T30404

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

Birch Bay Central South Subwatershed Master Plan

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CHAPTER 1.
INTRODUCTION

The Birch Bay Watershed and Aquatic Resources Management (BBWARM) District is a special purpose district established to manage stormwater in the Birch Bay watershed. A previous basin-wide study for the District identified sensitive areas in the watershed that should be protected and areas where development should be allowed (ESA Adolfson, 2007). The study recommended strategies to mitigate the effects of development on aquatic resources and wildlife. For developing areas, the study found that watershed master planning is needed to address deficiencies in current stormwater infrastructure and to plan for future infrastructure needs. The *Central South Subwatershed Master Plan* is the second in a series of these master plans planned for the Birch Bay watershed.

PURPOSE AND GOALS

The purpose of the *Central South Subwatershed Master Plan* is to develop a systematic approach to solving stormwater problems in the Central South Subwatershed, improving drainage infrastructure, reducing flooding, and improving water quality. Developing the plan consisted of collecting data on the storm drain system, analyzing system capacity, identifying and addressing deficiencies in drainage infrastructure, and developing a capital improvement program. The plan will guide future development to minimize impacts on the stormwater system and accommodate future drainage infrastructure needs. The objectives of this plan are as follows:

- Develop an accurate, comprehensive inventory of stormwater facilities in the subwatershed.
- Create a guide for implementing capital projects to address drainage deficiencies in a prioritized and scheduled manner.
- Assess land use impacts on stormwater.
- Document project needs to incorporate into a countywide capital improvement program.

STUDY AREA

The Birch Bay watershed covers 27 square miles in the northwest corner of Whatcom County along Georgia Straight, 18 miles northwest of Bellingham and just south of Blaine. The Central South Subwatershed covers about 2,400 acres along the east side of Birch Bay. It includes the Central Reaches, Central Uplands North, Central Uplands South, Lower Terrell Creek Tributary 1, Lower Terrell Creek Tributary 2, and Bog Tributary 1 subbasins, as shown on Figure 1-1. The subwatershed extends north-south from Birch Bay Lynden Road to Bay Road and east-west from Kickerville Road to Birch Bay. Portions of the subwatershed near the shore generally consist of single-family residential housing, trailer parks and condominiums. Rural and agricultural lands characterize the upland areas.

PREVIOUS PLANNING EFFORTS

Several recent planning efforts focusing on surface water issues in the Birch Bay watershed have provided background and direction for this master plan. This plan differs from the previous planning efforts in that it focuses solely on the Central South Subwatershed and includes detailed inventory data collection and quantitative analysis of drainage problems.

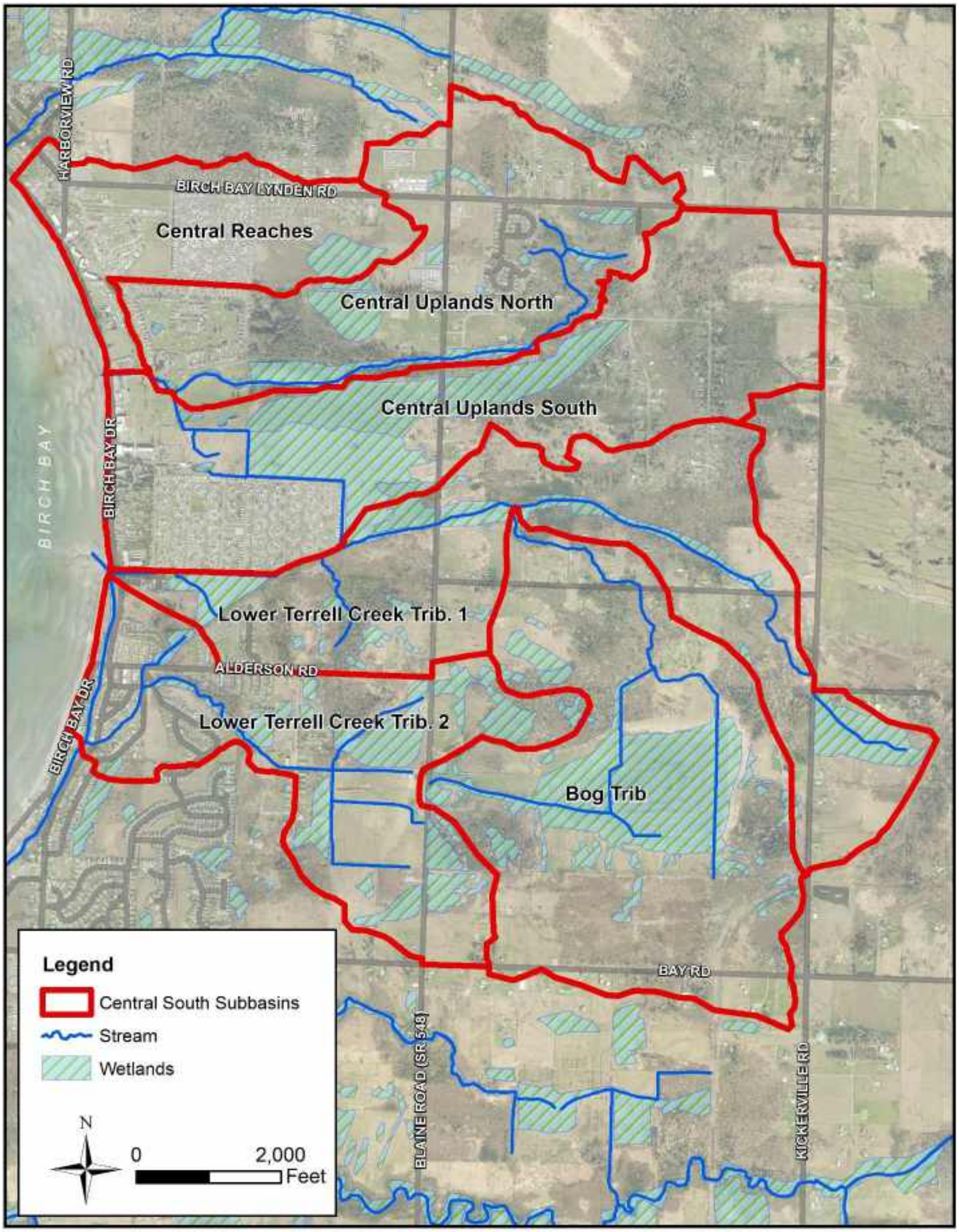

Figure 1-1. Subbasins of the Central South Subwatershed

The 2006 *Birch Bay Comprehensive Stormwater Management Plan* covered the entire Birch Bay watershed and investigated drainage, water quality, and aquatic habitat issues (CH2M Hill, 2006). This plan also identified policy issues, structural and non-structural capital projects, low-impact development techniques, and operation and maintenance recommendations for the Birch Bay watershed. Specific recommendations for the Central South Subwatershed were limited and included two capital projects to solve flooding problems. Because this plan covered the entire watershed, detailed analysis was not performed for each subbasin.

Whatcom County Council adopted the *Birch Bay Comprehensive Stormwater Plan* in 2006. The plan recommends the creation of a stormwater management area and funding strategy. Acting on this recommendation, the Whatcom County Flood Control Zone District Board of Supervisors approved the creation of the BBWARM District as a subzone of the countywide flood control zone district in 2007.

The 2007 *Birch Bay Watershed Characterization and Watershed Planning Study* evaluated restoration and development potential for all subbasins in the Birch Bay watershed (ESA Adolfson, 2007). This study outlined a comprehensive approach to guiding land use efforts in the Birch Bay watershed by using a science-based watershed characterization to "identify areas within Birch Bay for protection or restoration of ecosystem processes necessary for the long term functioning of marine and freshwater systems while also guiding the location and design of new development." The Central South Subwatershed was identified as a priority subbasin suitable for development.

Birch Bay Central North Subwatershed Master Plan (Tetra Tech, 2013) was the first in a series of subwatershed master plans for the Birch Bay watershed. The Central North subwatershed is generally located between Shintaffer Road and Birch Bay Lynden Road. This plan included storm drainage inventory data collection and assessment, subwatershed characterization, problem evaluation and analysis, and development of capital projects. The Central North Subwatershed Master Plan is the template for future Birch Bay subwatershed master planning efforts, including the Central South Subwatershed documented in this plan.

REPORT ORGANIZATION

The Central South Subwatershed Master Plan is generally organized in two parts. Chapters 2 through 4 describe the physical characteristics of the subwatershed, present a storm drain inventory, and identify drainage problems. Chapters 5 and 6 identify capital projects for solving stormwater problems and present the proposed project prioritization. The content of individual chapters is as follows:

- Chapter 2 describes physical characteristics of the subbasins that make up the study area. Field data collection for the stormwater inventory and the surface water drainage system are also described in this chapter.
- Chapter 3 describes a planning level hydrologic and hydraulic analysis. Continuous simulation modeling was used to develop stormwater runoff hydrographs and estimate peak flow rates for the five subbasins in the Central South Subwatershed. Hydraulic analysis was used to identify drainage problems and estimate conveyance capacity of the storm drain system.
- Chapter 4 describes identified drainage problems. Interviews with Whatcom County staff, public meetings, published reports, field data collection, and the planning level hydraulic analysis were used to assemble a database of drainage problems.
- Chapter 5 documents problem resolutions and identifies projects to solve stormwater problems, including special studies, operation and maintenance, and small works projects.
- Chapter 6 presents a prioritized plan for implementation of stormwater capital projects.

ACKNOWLEDGMENTS

The *Birch Bay Central South Subwatershed Master Plan* was developed with the participation of the BBWARM Advisory Committee:

- Position A—Scott Hulse (Point Whitehorn)
- Position B—Keats Garmen (Birch Point)
- Position C—Scott Inloes (Rate Payer Representative, British Petroleum)
- Position D—Peter Winterfield (Birch Bay Village)
- Position E—Vacant.

The Advisory Committee represents the Birch Bay community to ensure that the community's interests are represented in setting strategic goals and work plans.

CHAPTER 2.
SUBBASIN CHARACTERISTICS

SUBBASINS

The *Birch Bay Watershed Characterization and Watershed Planning Study* (ESA Adolfson, 2007) divided the Central South Subwatershed into six subbasins comprising 2,400 acres (see Figure 1-1). The names and general locations were altered for this report, with boundaries re-delineated based on LiDAR mapping, flow paths from the storm drain inventory, and field investigation. Subbasin location and land-use are as follows:

- The Central Reaches subbasin covers 193 acres at the north edge of the Central South Subwatershed near Birch Bay Lynden Road, from Blaine Road (SR-548) to Birch Bay. It is bordered on the north by the Hillsdale subbasin of the Central North Subwatershed. Land use is primarily residential, with some agricultural land use, wetland and forested area on the fringe. During large rainfall events, stormwater is diverted from the Hillsdale subbasin to the Central Reaches subbasin along Harborview Road. The Central Reaches subbasin has two primary drainage paths: along Birch Bay Lynden Road to Harborview Road and along the perimeter of Latitude 49, Birch Bay RV Resort and Mariners Cove.
- The Central Uplands North subbasin covers 366 acres in an arc from the intersection of Blaine Road and Birch Bay Lynden Road to Sea Links Golf Course near Birch Bay Drive. Land use is primarily rural, with pockets of forested area and two high-density developments: Sea Links and Anchor Manor. The subbasin is drained by a natural stream to the Sea Links Golf Course ponds where the stream joins with the Central Uplands South channel.
- The Central Uplands South subbasin covers 489 acres directly south of the Central Uplands North subbasin. The subbasin is bisected by Blaine Road and bordered by Kickerville Road to the east. Land use is predominantly scrubland with areas of forest and rural development, except for Leisure Park, a medium-density residential community on the lower western end. A significant wetland area is located in the central part of the subbasin. The subbasin drains through the wetland and the Sea Links Golf Course ponds to an outfall at Club House Drive. The wetland is also connected via an open ditch around the perimeter of Leisure Park to the drainageway for the Lower Terrell Creek Tributary 1 subbasin.
- The Lower Terrell Creek Tributary 1 subbasin covers 468 acres south of the Central Uplands South subbasin. The subbasin is north of Alderson Road and extends east around Bog Creek to the tributary headwaters near Kickerville Road. Land use in the area is primarily rural, with a mixture of forest, pasture and scrubland. The subbasin drains Lower Terrell Creek Tributary 1 from its headwaters to the mouth at the Lora Lane tide gate.
- The Lower Terrell Creek Tributary 2 subbasin covers 355 acres at the south end of the Central South Subwatershed. It is bordered by Bay Road to the south and Alderson Road to the north and is bisected by Blaine Road. Near the headwaters on the east side, land use is primarily pasture. The west side of the subbasin is primarily residential, with pockets of rural development and scrubland. The subbasin drains via Birch Creek through a culvert under Birch Drive to Terrell Creek and to the tide gate near the intersection of Wooldridge Avenue and Morrison Avenue before entering the main stem of Terrell Creek.
- The Bog Creek subbasin is tributary to the Lower Terrell Creek Tributary 1 and covers 533 acres. The confluence is located east of Blaine Road near Arnie Road. Land cover in the

Bog Creek subbasin is primarily a mixture of pasture, scrubland, and forest, with a large wetland capturing a majority of the surface water in the area.

CLIMATE

Birch Bay experiences a mild marine climate with cool, dry summers and mild, wet winters. Average monthly temperature ranges from about 37ºF in January to 62ºF in August. However, extreme temperatures can occur, with temperatures below freezing an average of about 70 days per year. Temperature rarely gets above 90ºF (WRCC, 2011). The Birch Bay area receives an average of about 35 inches of rain annually. Some precipitation occurs as snow, with about 14 inches in an average year. Figure 2-1 shows the average monthly rainfall measured by the Birch Bay Water and Sewer District (BBWSD) near Birch Bay State Park. Typically, winter rainfall occurs as long-duration, low-intensity events over a day or more.

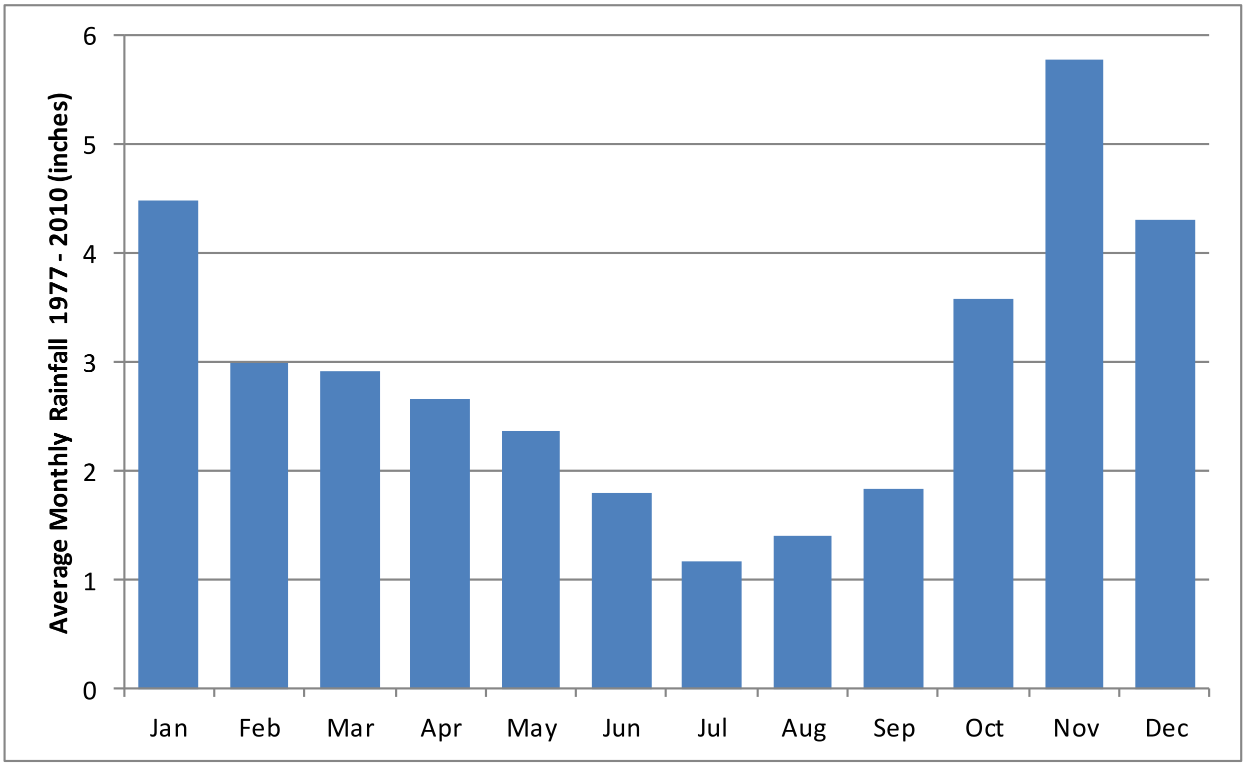

Figure 2-1. Average Monthly Rainfall—Birch Bay (BBWSD, 2011)

TOPOGRAPHY

The Central South Subwatershed is a rectangular basin extending 1.75 miles east to west and 2.0 miles north to south. Surface runoff flows east to west to Birch Bay through six distinct drainages. The elevation is higher on the northern and southern edges of the subwatershed, with a distinct trough through the center. The elevation of the lowland area ranges from 10 to 30 feet NAVD88 (North American Vertical Datum 1988). The higher southern and northern portions are much steeper and have elevations up to 60 feet NAVD88 at the northern end and 120 feet NAVD88 at the southern end. Figure 2-2 shows the topography of the Central South Subwatershed.

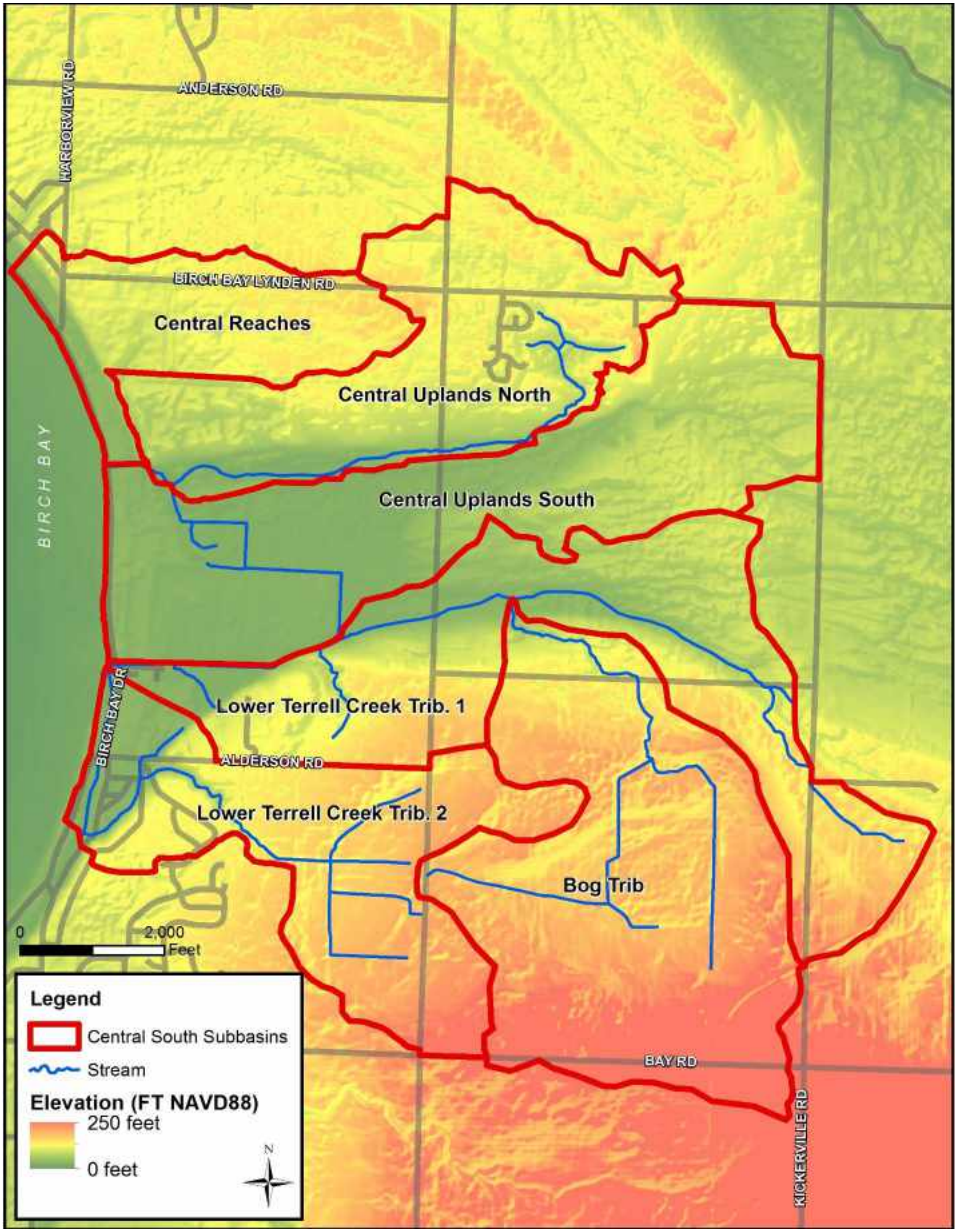

Figure 2-2. Topography of the Central South Subwatershed

GEOLOGY AND SOILS

Geologic conditions of the Central South Subwatershed are primarily the result of continental glaciation and intervening non-glacial periods. Glacial-marine drift deposits (Bellingham Drift) of compressed fine-grained material overlay a submerged marine terrace established 11,300 to 13,000 years ago (ESA Adolfson, 2007). Surficial soils are primarily till, with pockets of outwash. Till soils are densely packed soils deposited and consolidated by glacial activity over 10,000 years ago. They have low permeability and a high potential for surface runoff. Outwash soils are loosely consolidated sand and gravel deposits with high permeability and low potential for runoff. The Natural Resources Conservation Service Soil Survey classifies the soils according to Hydrologic Soil Types A through D:

- Type A and B soils are generally outwash soils made of sand and gravel. They are deep, well-drained soils with low runoff potential. Type A and B soils cover about 14 percent of the subwatershed. Type A and B soils are found in the central trough area, in the southeast corner, and along the beach near Birch Bay.
- Type C soils are till soils made of fine-textured silts with shallow depths, low permeability, and high runoff potential. Type C soils cover the largest area in the subwatershed at about 81 percent.
- Type D soils are wetland soils made of saturated silts and clays with a high water table. They are very shallow and have a confining clay or hardpan layer near the surface. Type D soils cover about 5 percent of the subwatershed. Type D soils are found at the northeast and northwest corner of the subwatershed.

High groundwater in the surficial aquifer is found in the entire area covered with outwash soils; it also spreads to adjacent till areas at the same elevation. Figure 2-3 shows the surficial aquifer and the distribution of hydrologic soil types in the subwatershed.

SURFACE WATER FEATURES

Surface water drainage patterns are from east to west, starting in the rural, undeveloped upland areas and flowing through the more developed, lowland portions of the subwatershed near Birch Bay. Natural drainageways connect to constructed drainage systems with outfalls discharging to Birch Bay. Surface water features are shown on Figure 2-4.

Central Reaches Subbasin

In the Central Reaches subbasin, surface water runoff flows west to Birch Bay from the intersection of Birch Bay Lynden Road and Graham Drive. Surface runoff collects in the roadside ditch alongside Birch Bay Lynden Road and is transported west, crossing Harborview Road through a 24-inch concrete pipe. The main conveyance pathway continues south along Harborview Road to the intersection of Harborview and Birch Bay Drive. Surface runoff crosses Birch Bay Drive through a 24-inch concrete pipe and is discharged into Birch Bay adjacent to Harborview Road. Stormwater runoff at Birch Bay Drive and Harborview Road is collected in a local storm drain system connected to the Harborview Road outfall through a flap gate.

The Central Reaches subbasin also captures runoff from south of Birch Bay Lynden Road in the Sunburst Drive area, the Latitude 49 residential community, and the Birch Bay RV Resort. The primary stormwater conveyance is through a 24-inch storm drain on the south side of Latitude 49 continuing on the south property line of the Birch Bay RV Resort to Mariners Cove and then out to Birch Bay through a 24-inch outfall with tide gate at Mariners Cove. An offline dry detention pond is located mid-way between Birch Bay Drive and Sea Links Drive adjacent to the 24-inch pipeline.

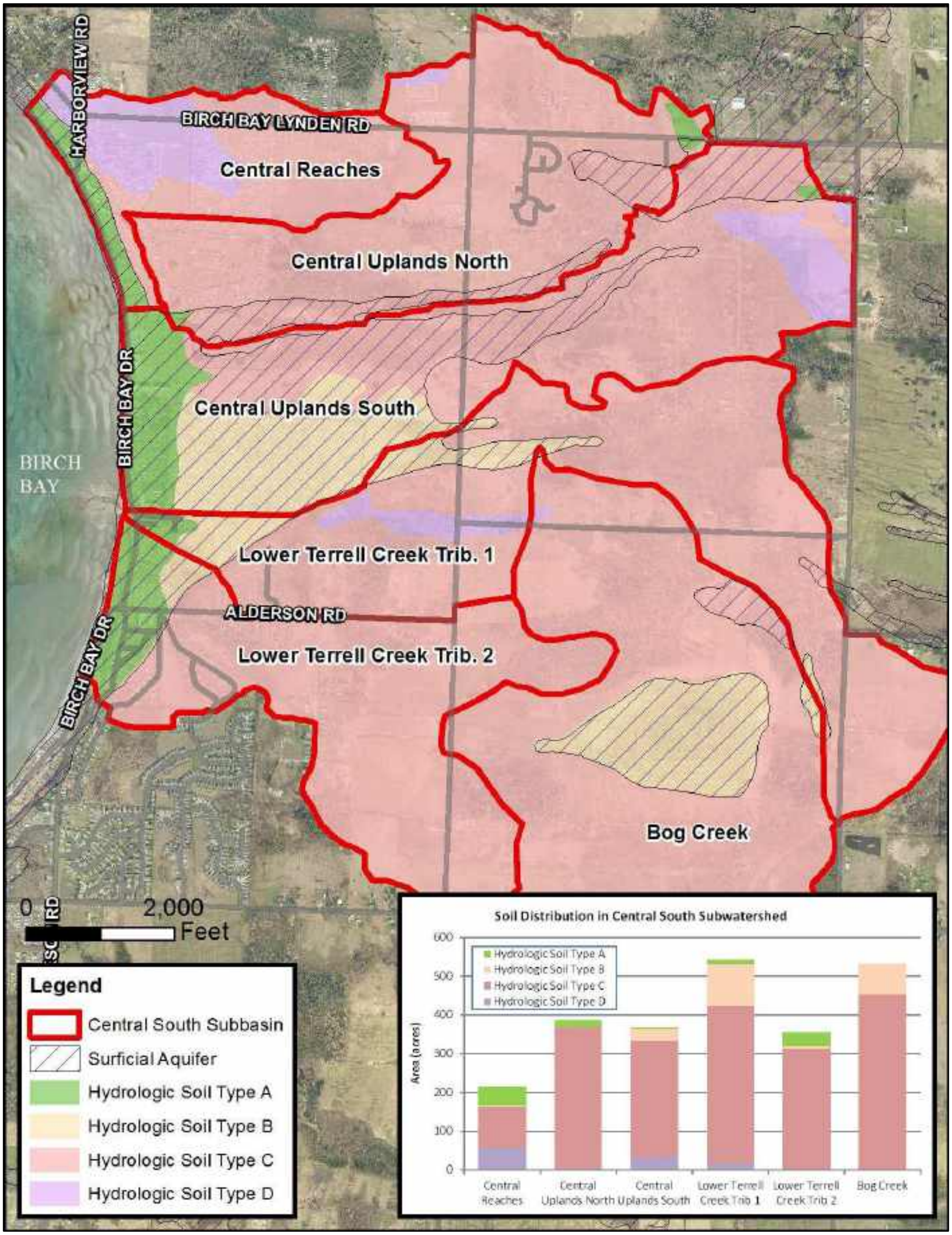

Figure 2-3. Hydrologic Soil Types in the Central South Subwatershed (USDA, 2013)

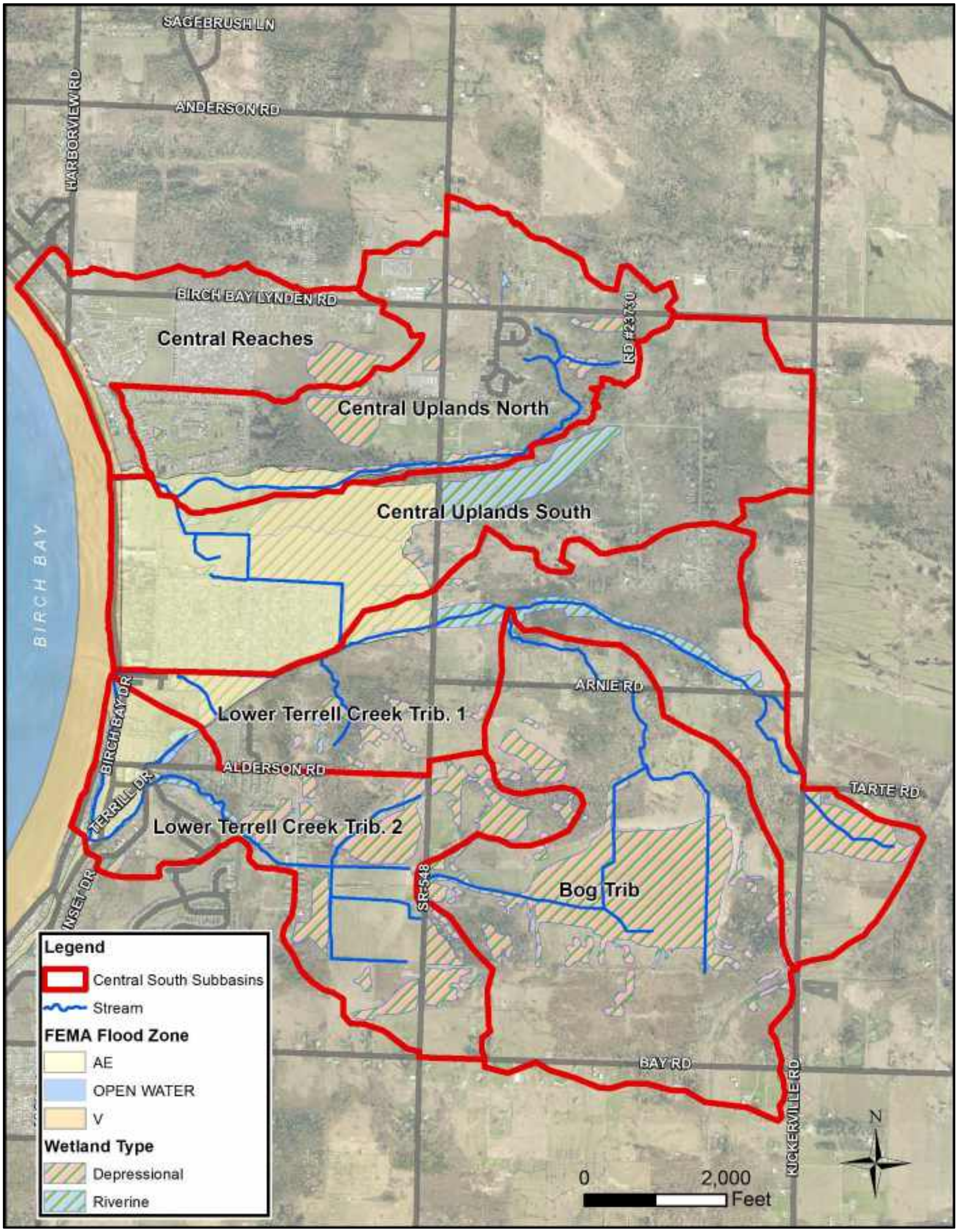

Figure 2-4. Surface Water Features in the Central South Subwatershed

Surface water runoff from the Latitude 49 development is collected through a storm drain system and conveyed to a 9.5-acre-foot detention pond at the southwest corner of the property that serves only the Latitude 49 community. Flow control is provided by a 2-orifice control structure with emergency overflow. The pond has filled with sediment over the years and overflows during large rainfall events. Overflow from the pond is conveyed south out of the subbasin to the Central Uplands North subbasin through the Sea Links neighborhood and ultimately discharging to the Sea Links Golf Course ponds.

The Central North Subwatershed Plan (Tetra Tech, 2013) documented an overflow at Harborview Road at Forsberg Road from the Hillsdale subbasin to the Central Reaches Subbasin starting with the 25-year peak runoff event.

Central Uplands North Subbasin

The primary surface water conveyance in the Central Uplands North subbasin is a natural channel with headwaters near Birch Bay Lynden Road at Anchor Manor. The natural channel flows along the south subbasin boundary and crosses under Blaine Road through an 18-inch concrete culvert and into the Sea Links Golf Course ponds. Stream flow passing through the Sea Links Golf Course discharges to an open ditch and then into Birch Bay through a 36-inch concrete pipe near Club House Drive.

A field ditch from the large wetland area in the Central Uplands South subbasin is connected to the Sea Links Golf Course ponds in the Central Uplands North subbasin, which allows interflow between the two subbasins. The direction of stream flow in the field ditch is dependent on flow and tidal conditions. Interflow between subbasins may also occur through a topographic low in the wetland area west of Blaine Road. Anchor Manor contains two small detention ponds with control structures to attenuate peak stormwater runoff.

Central Uplands South Subbasin

The headwaters of the Central Uplands South subbasin are at the intersection of Birch Bay Lynden Road and Kickerville Road. Surface water flows west through a scrubland and forest before collecting in a low wetland area east of Blaine Road. The drainageway crosses Blaine Road through parallel 18-inch and 24-inch concrete culverts and enters the large low-gradient wetland area west of Blaine Road bordering Leisure Park. Water from the wetland area can drain north to the Sea Links Golf Course or south around Leisure Park to connect with the main drainage conveyance for Lower Terrell Creek Tributary 1.

The large wetland area bordered by Sea Links Golf Course, Leisure Park, and Blaine Road is likely due to high groundwater in the area. A groundwater level monitoring gage near Cedar Drive in the Central North subwatershed indicated that the groundwater surface elevation in the area is at about 10 feet, which corresponds to the ground surface elevation in this area. Standing water has been observed year-round at this location, which supports the groundwater observation. The large wetland area generates significant interflow between the Central Uplands North and Lower Terrell Creek Tributary 1 subbasins.

Lower Terrell Creek Tributary 1 Subbasin

Surface water runoff in the Lower Terrell Creek Tributary 1 subbasin originates near Kickerville Road and flows west in a natural channel through a mix of meadows and forested areas. The stream flows under Arnie Road in a 24-inch diameter culvert and Blaine Road through a 30-inch diameter culvert. The subbasin is bounded by Alderson Road to the south and a low ridgeline east of Leisure Park. Stream flow enters a constructed ditch at Leisure Park and flows along the south boundary to a 48-inch-diameter pipe at Lora Lane. The pipeline outfalls to Terrell Creek through the Lora Lane outfall and tide gate at Birch Bay Drive immediately upstream of Birch Bay, where Terrell Creek enters the bay. The tide gate structure has two steel gates in series, both about 6 feet high by 4 feet wide. Surface water from the Central

Uplands South subbasin is connected to the Lower Terrell Creek Tributary 1 drainage on the east side of Leisure Park.

Lower Terrell Creek Tributary 2 Subbasin

Stormwater in Lower Terrell Creek Tributary 2 originates along the west edge of Blaine Road and is confined between Alderson Road and Bay Road on the north and south. The stream is conveyed west to Birch Creek through multiple open ditches. Birch Creek conveys runoff from about Gemini Street to Leeside Drive. Birch Creek enters a 48-inch-diameter pipeline at Leeside Drive, is conveyed west, and discharges to Terrell Creek.

Drainage from Alderson Road and the Morrison Avenue/Terrill Drive neighborhood is conveyed south through a series of open ditches and driveway culverts, ranging from 12 to 48 inches. Runoff from the local system is discharged into Terrell Creek through a tide gate at the intersection of Wooldridge Avenue and Morrison Avenue. North of Alderson Road, a low-elevation wetland is shared with the Terrell Creek Tributary 1 subbasin. The wetland receives large storm overflows from both Alderson Road and the drainage ditch on the south side of Leisure Park.

Bog Creek Tributary

Stormwater in the Bog Creek subbasin originates along Bay Road and is confined between Blaine Road to the west and Kickerville Road to the east. The subbasin contains a large wetland area attenuating runoff as it travels north toward Arnie Road. Outflow from the bog discharges to the north through field ditches to Arnie Road and is conveyed under the road in a 30-inch concrete culvert. From Arnie Road, the main creek discharges directly into the Terrell Creek Tributary 1 subbasin.

FEMA FLOOD ZONE

Flood hazard mapping by the Federal Emergency Management Agency (FEMA) has identified the coastal areas of the Central South Subwatershed as Flood Zone Type V near Birch Bay along Birch Bay Drive and Type AE in the central low topographic area extending from Birch Bay Drive toward Blaine Road. Type V flood zones include areas within the 100-year flood zone with velocity hazards (tidal action) and established base flood elevations. Flood Zone Type AE is special flood hazard area associated with raising waters from rivers, lakes, streams or other water bodies. Whatcom County regulates frequently flooded areas as critical areas under its Critical Areas Ordinance (Whatcom County Code 16.16).

WETLANDS

Wetlands are areas inundated or saturated at a frequency and duration sufficient to support typical wetland vegetation. They are defined by the presence of wetland vegetation, standing water and hydric soils. Wetlands are common in Bellingham Drift deposits due to the imperviousness of soils of this type. Significant wetlands are located in lowland areas throughout the Central South Subwatershed (see Figure 2-4) due to the flat topography, potentially high groundwater and relatively pervious surface soils.

The wetland locations on Figure 2-4 were generated using approximate methods based on information from County sources; they may not represent actual wetland areas in the subwatershed. Whatcom County regulates wetlands through its Critical Areas Ordinance, which requires protection of wetland areas and their buffers depending on classification. Whatcom County has categorized wetlands in the Central South Subwatershed as the following types (ESA Adolfson, 2007):

- Depressional wetlands are formed in low areas where surface water from higher elevations pools through overland flow, precipitation or groundwater discharge.

- Riverine wetlands are in stream corridors and are saturated primarily during flood events.

Table 2-1 summarizes wetland coverage in the Central South Subwatershed. Wetlands cover about 20 percent of the subwatershed. The most extensive coverage is in the Terrell Creek Tributary 1 where wetlands cover 30 percent of the subwatershed area. The Central Reaches subbasin has the least amount of wetland area at 6 percent.

TABLE 2-1.
WETLANDS IN THE CENTRAL SOUTH SUBWATERSHED

	Wetland Area (acres)			*Percent of*
Subbasin	Depressional	Riverine	**Total**	*Total Area*
Central Reaches	10.7	0.0	**10.7**	*6%*
Central Uplands North	46.0	0.0	**46.0**	*13%*
Central Uplands South	80.2	27.0	**107.2**	*22%*
Terrell Creek Tributary 1	33.9	42.5	**76.5**	*30%*
Terrell Creek Tributary 2	67.9	9.5	**77.4**	*22%*
Bog Creek	127.8	1.4	**129.2**	*24%*
Total	**366.6**	**80.4**	**447.0**	***20%***

LAND USE

Prior to European settlement, the Birch Bay watershed was covered with a mixture of coniferous and deciduous forest. The watershed was logged in the early 1900s, followed by development as a resort community near the bay and agricultural uses in the upland areas (ESA Adolfson, 2007).

The entire Central South Subwatershed is in unincorporated Whatcom County, so regulation of development falls under County jurisdiction. Urban growth boundaries are shown in Figures 2-5 and 2-6. Current land use (2011) is primarily high- and medium-density residential (including mobile home sites) near Birch Bay, with some commercial land uses such as hotels, shops and restaurants. Residential areas are spread through the entire subwatershed but are predominantly located along arterial roadways. Current land use is shown in Figure 2-5 and listed in Table 2-2.

Land use zoning guides future development and can be used as a predictor of how land use will change as the subwatershed becomes more fully developed. The Whatcom County Comprehensive Plan applies six zoning designations in the Central South Subwatershed:

- GC—General Commercial
- NC—Neighborhood Commercial
- R5A—Rural 1 Dwelling unit/5 acres
- RC—Resort Commercial
- UR4—Urban Residential 4/acre
- URM6—Urban Residential 6/acre
- URM24—Urban Residential 24/acre

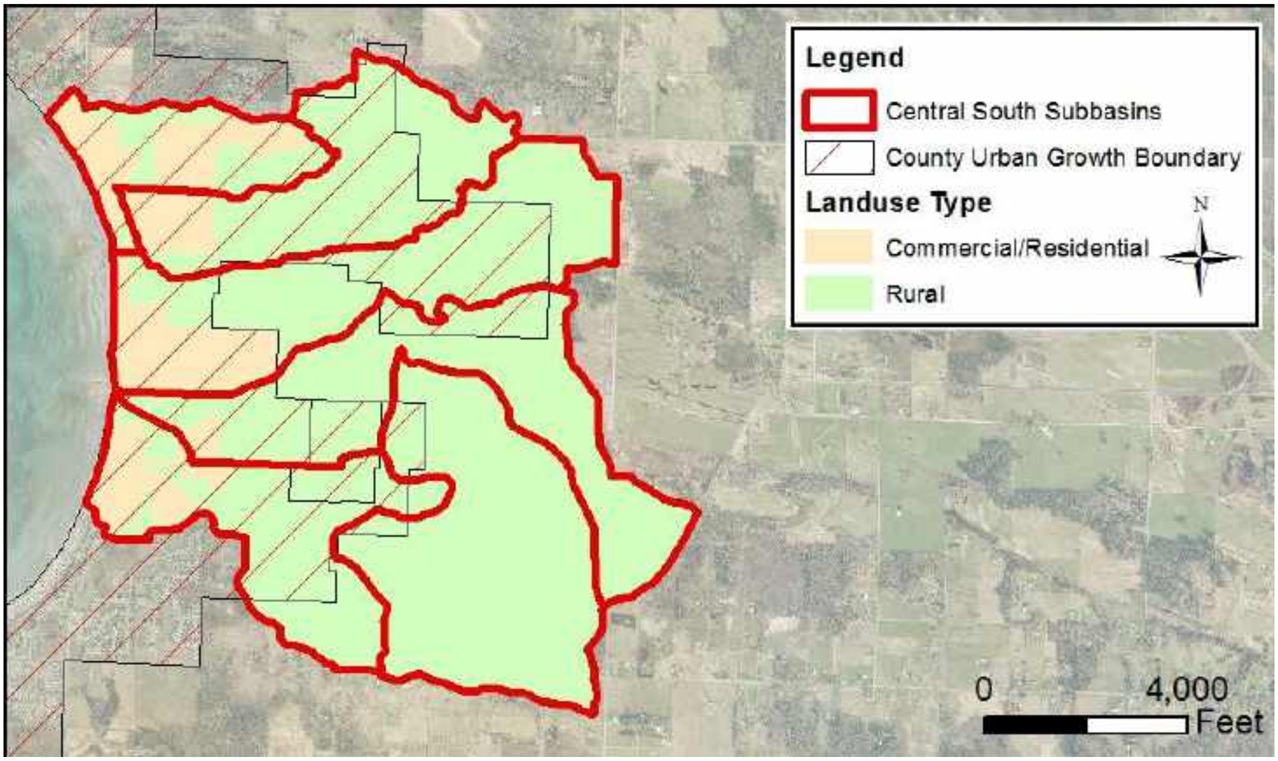

Figure 2-5. Current Land Use (October 2013) in the Central South Subwatershed

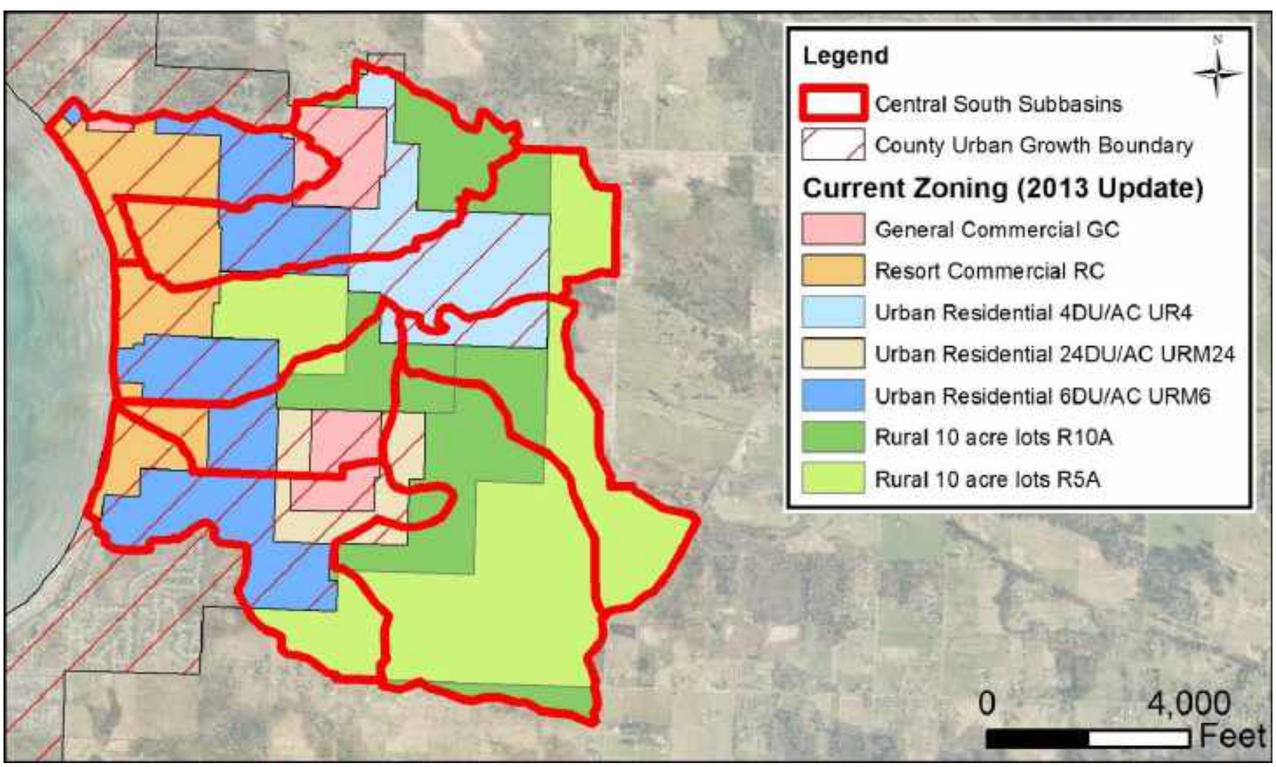

Figure 2-6. Zoning (Future Land Use) in the Central South Subwatershed

TABLE 2-2.
CURRENT AND FUTURE LAND USE IN THE CENTRAL SOUTH SUBWATERSHED

Subbasin	Subbasin Area	Current (2011) Land Use (acres) Residential	Commercial	Rural	Future (buildout[a]) Land Use (acres) Residential	Commercial	Rural
Central Reaches	192.9	113.1	0.0	79.8	64.9	128.0	0.0
Central Uplands North	366.3	46.8	0.0	319.5	145.9	129.4	91.0
Central Uplands South	489.2	110.1	0.0	379.1	228.4	59.8	201.0
Terrell Creek Tributary 1	467.8	13.1	0.0	454.6	122.2	64.3	281.3
Terrell Creek Tributary 2	354.8	72.4	0.0	282.4	195.9	74.2	84.8
Bog Creek	532.8	0.0	0.0	532.8	35.8	0.0	497.0
Total	**2,403.8**	**355.5**	**0.0**	**2,048.2**	**793.0**	**455.6**	**1,155.1**
Percent of Total Area	—	14.8%	0.0	85.2%	33.0%	19.0%	48.1%

a. Full buildout based on 2013 update to the Whatcom County zoning plan.

Current zoning (January 2013) in the Central South Subwatershed allows for an expansion of the medium- and higher-density residential zoning to Blaine Road for the Central Reaches subbasin, Central Uplands North subbasin, and Terrell Creek Tributary 1 and 2 subbasins. Medium- and higher-density residential zoning extends beyond Blaine Road in the Central Upland South subbasin but is restricted from the large wetland area in the center the subbasin (see Figure 2-4). Zoning is shown in Figure 2-6.

Roadways, parking lots, sidewalks, rooftops and other hard surfaces that prevent rainfall from infiltrating into the ground are called impervious surfaces. The effects of impervious surface on stormwater runoff and water quality are well known. Increased impervious cover, if uncontrolled or untreated, affects receiving water bodies by increasing and extending the duration of peak flows and increasing the rate of pollutants washing off the landscape.

Existing impervious area was computed based on the delineation compiled for the watershed characterization study (ESA Adolfson, 2007). Impervious area for future conditions was estimated using representative impervious fractions typical for the type of zoning applied in the Central South Subwatershed. Increased impervious area is mitigated by the presence of wetlands over large portions of the undeveloped areas, due to protections granted by the Whatcom County Critical Areas Ordinance. The Critical Areas Ordinance also requires buffer protection around regulated wetlands.

Impervious area is summarized in Table 2-3. Impervious surfaces currently cover about 12 percent of the Central South Subwatershed area. Impervious area ranges from 2 percent of subbasin area for the Bog Creek subbasin to 37 percent for the Central Reaches subbasin. The Central Reaches subbasin contains the most significant amount of commercial and residential land use; Bog Creek, on the other hand, is 100-percent undeveloped. Under future land use conditions, the impervious area is expected to more than double, to cover 27 percent of the subwatershed area; all subbasins but Bog Creek will experience significant increases in impervious area.

TABLE 2-3.
ESTIMATED IMPERVIOUS AREA

		Current Land Use		Future Land Use	
Subbasin	Total Subbasin Area (acres)	Impervious Area (acres)	% of Total Area	Impervious Area (acres)	% of Total Area
Central Reaches	193	72	37%	118	61%
Central Uplands North	366	55	15%	142	39%
Central Uplands South	489	91	19%	155	32%
Terrell Creek Tributary 1	467	24	5%	94	20%
Terrell Creek Tributary 2	355	40	11%	104	29%
Bog Creek	533	13	2%	56	5%
Total	**2,404**	**294**	**12%**	**638**	**27%**

WATER QUALITY

In 2003, the Washington Department of Health identified Birch Bay as a “threatened” shellfish growing area. Additional investigations identified further degradation to water quality in the bay, which led to restrictions on shellfish harvesting (Whatcom County, 2010). In response to these findings, Whatcom County initiated the Birch Bay/Terrell Creek Water Quality Monitoring Project. As part of this project, the County, in cooperation with the Whatcom Conservation District and the Nooksack Salmon Enhancement Association, is monitoring fecal coliform at approximately 30 locations in the Birch Bay watershed; eight of these locations are located in the Central South Subwatershed:

- Birch Creek at Morrison Avenue and Wooldridge Avenue (Trib Ter BC1)
- Birch Creek at Leeside Drive (Trib Ter BC2)
- Birch Bay Drive near Club House Drive (BB3)
- Birch Bay Drive near Mariners Cove (BB4)
- Birch Bay Drive near Harborview Road (BB5)
- Mouth of Terrell Creek near Lora Lane (Ter 0.1 & Ter 0.1*)
- Leisure Park tributary north of Lora Lane (TribTer LP1)

Fecal coliform bacteria is the primary pollutant monitored, and current (September 2014) average fecal coliform bacteria levels exceed state water quality standards at all eight locations. The monitoring project identifies priority areas for water quality improvement activities.

STORMWATER SYSTEM INVENTORY

The storm drain system in the Central South Subwatershed was inventoried by Wilson Engineering survey crews in the spring of 2013. Survey crews located drainage features in the field using GPS units and collected information on pipe diameter, material, invert, and flow direction for all public storm drain facilities, including catch basins, manholes, storm drain pipes, driveway culverts, roadway culverts and roadside ditches. Survey data was compiled in a geo-database and automated. Hand routines were applied to the geo-database to connect the drainage features and create a drainage network. The storm drainage system inventory developed for this project is shown in Appendix A. Tables 2-4 and 2-5 summarize the drainage structure, ditch and pipe data.

TABLE 2-4.
DRAINAGE STRUCTURES

Subbasin	Catch Basins	Outfalls to Birch Bay	Outfalls to Terrell Cr.	Total
Central Reaches	53	2	0	55
Central Uplands North	54	1[a]	0	55
Central Uplands South	0	4	1[b]	5
Terrell Creek Tributary 1	6	0	1	7
Terrell Creek Tributary 2	58	0	3	61
Bog Creek	0	0	0	0
Total	**171**	**7**	**5**	**183**

a. Outfall at Club House Drive assigned to Central Uplands South Subbasin because is the primary conveyance for this subbasin.

b. Outfall on north bank of Terrell Creek at Lora Lane collects road drainage for Birch Bay Drive in the Central Uplands South Subbasin.

TABLE 2-5.
DITCH, PIPE AND CULVERT INVENTORY

	Drainage Facility Length (feet)									
	Roadside	Storm Drain (by Diameter)				Culvert				
Subbasin	Ditch	≤8”	10”-12”	15”-18”	≥24”	≤8”	10”-12”	15”-18”	≥24”	**Total**
Central Reaches	6,306	748	1,628	2,719	1,332	0	505	255	358	**7,545**
Central Uplands North	10,460	672	1,656	1,281	1,591	371	3,090	867	168	**9,695**
Central Uplands South	2,457	969	0	367	98	137	338	98	422	**2,430**
Terrell Creek Tributary 1	16,769	56	6	0	517	35	1,183	656	465	**2,918**
Terrell Creek Tributary 2	12,966	785	1,339	1,674	168	168	3,229	527	983	**8,874**
Bog Creek	8,030	0	0	0	0	155	694	278	39	**1,166**
Total	**56,988**	**3,230**	**4,629**	**6,040**	**3,707**	**867**	**9,040**	**2,681**	**2,435**	**32,628**

There are 183 drainage structures in the Central South Subwatershed, including catch basins, manholes, break points, tees, control structures, and outfalls to Birch Bay and Terrill Creek. A break point is a change in pipe alignment in the absence of a connecting structure. Break points and tee connections were not located during the field survey.

The Terrell Creek Tributary 2 subbasin contains the largest number of structures, followed by the Central Uplands North subbasin, the Central Reaches subbasin and the Terrell Creek Tributary 1 subbasin. No drainage structures were identified in the Bog Creek subbasin, except for culverts. There are seven stormwater outfalls discharging to Birch Bay and five to Terrell Creek. Three of the Birch Bay outfalls convey stormwater from large storm drain systems; the others drain surface water runoff from areas adjacent to Birch Bay Drive.

There are 11 miles of ditch and 6 miles of pipeline (culvert and storm drain) in the Central South Subwatershed. Culverts and storm drain pipes range from 4-inch-diameter yard drains to 36-inch-diameter pipe conveying the main flow through a subbasin (trunk pipes or roadway culverts). Approximately 30 percent of the pipe is between 10 and 12 inches in diameter. Pipes are of several material types: thermoplastic (high-density polyethylene or polyvinyl chloride), concrete, corrugated metal pipe (CMP), and smooth black pipe. Generally, newer pipes are thermoplastic and older ones are concrete or CMP. CMP has a relatively short design life of about 30 years before it starts to rust, usually in the flow line of the pipe. CMP is also susceptible to bending and crushed pipe ends. Thermoplastic pipe may be susceptible to deformation if installed incorrectly.

A cursory condition assessment performed during the drainage inventory identified about 25 structures as being in poor condition. The condition assessment also found several locations where connection structures (catch basins or manholes) were absent, had inadequate surface access, or needed grout replaced. Missing or inadequate structures and damaged pipe ends are documented in Chapter 4.

CHAPTER 3.
HYDROLOGIC AND HYDRAULIC ANALYSIS

This chapter describes hydrologic and hydraulic modeling of the Central South Subwatershed to help quantify existing and future surface water conditions. The modeling was used to identify flooding-related problems and to evaluate potential solutions. The goals and objectives of the hydrologic and hydraulic modeling are as follows:

- Develop an understanding of the hydrologic regime in the Central South Subwatershed.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems.

In general, hydrologic models are used to determine the amount of stormwater runoff that will be generated from a drainage basin during a storm event or a series of storm events. The flow data generated by the hydrologic model are then input into a hydraulic model, which evaluates how the flow is routed through a conveyance system, such as a roadside ditch-and-culvert system, a stream channel or an enclosed storm drain system.

The storm drainage system was analyzed using the HSPF model (U.S. EPA, 2005) and the SWMM5 model (U.S. EPA, 2011). HSPF was used to simulate runoff. SWMM5 was used to analyze the hydraulics of natural and constructed surface water drainage systems in the Central South Subwatershed. A joint model was developed to encompass all subbasins, due to uncertainty in subbasin overflow. Model development is documented in Appendix B.

HYDROLOGIC ANALYSIS

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine long-term runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration and ground infiltration. Routing of runoff from discrete subwatersheds is modeled with rating tables that represent pipes, channels, lakes, and other flood storage areas. Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to the stream channel at a slower rate than direct runoff. Groundwater discharges to the stream channel where the stream intersects the saturated zone, contributing to long-term base flow in the system. Infiltrated flow can leave the surface watershed by entering deep groundwater.

Flow characteristics were computed for existing land use conditions in the Central South Subwatershed and used to compute peak runoff rates from the subwatershed. Flood-frequency was computed using the peak runoff rates to identify design events that correspond to the 2-, 25-, and 100-year peak runoff events. The design events were extracted from the hydrologic data set and routed through the hydraulic model.

In 2013, the Birch Bay UGA, which includes portions of the Central South subwatershed, was added to Whatcom County's National Pollutant Discharge Elimination System (NPDES) Phase II permit coverage area. Coverage under this permit requires the County to implement minimum standards for maintenance of the existing stormwater system. Flow control and water quality treatment for new development will be required to meet more stringent minimum technical requirements specified in the 2012 *Stormwater Manual for Western Washington* by December 31, 2016. Until that time, Whatcom County has specified the use of the 2005 manual (Ecology, 2005). Stormwater flow control requirements have the potential to significantly reduce stormwater runoff from developing areas. For this reason, future conditions flow rates would not provide useful information on drainage problems and were not analyzed for this plan.

HYDRAULIC ANALYSIS

The variety of drainage elements in the Central South Subwatershed storm drainage system (drain pipes, catch basins, roadside culverts and ditches, natural channels and flood storage areas) requires a sophisticated hydraulic model. The SWMM5 model is capable of representing the diverse character and hydraulic features of the drainage system, as well as tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as detention facilities. The model is well-suited to estimate flow and depth in the Central South storm drainage system.

A SWMM5 model was developed to represent all drainages within the Central South Subwatershed. Modeled runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. SWMM5 models the routing of this runoff through a system of pipes, channels, storage and outfalls, tracking the flow of water in each pipe and channel. Birch Bay tidal data from the Cherry Point Station, adjusted for local conditions, were used as the downstream boundary at the pipe outfalls.

Flood Locations

Design analysis was performed using the SWMM5 models to identify locations where flooding is predicted under existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the assumed overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause of flooding. The analysis showed that flooding is predicted at 22 nodes for the 25-year event and 33 nodes for the 100-year event. Flooding has been grouped into 11 flood problem area locations.

The hydraulic analysis showed that the storm drain system in the Central South Subwatershed has adequate capacity throughout the basin to convey the 25-year event. However, there are several conveyance systems with significant restrictions. Most notably, flooding was predicted along the entire length of Birch Bay Drive. Other notable flood locations include the following:

- Harborview Road at Birch Bay Lynden Road (Central Reaches subbasin)
- Mariners Cove / Birch Bay RV Resort drainage line (Central Reaches subbasin)
- Latitude 49 storm pond overtopping (Central Reaches subbasin)
- Birch Bay Lynden Road near Anchor Parkway (Central Uplands North subbasin)
- Flooding along Terrill Drive (Terrell Creek Tributary 2 subbasin).

Flooding also occurs during periods of very high tides (a.k.a. King tide) that coincide with storm events much smaller than the design storm event. Anecdotal observations during these king tide periods suggest flooding occurs when the tidal elevation is greater than 11.7 feet NAVD88 (13.2 feet MLLW). Flooding would be expected to occur along Birch Bay Drive, in the wetland areas surrounding Latitude 49, and the Morrison Avenue/Terrill Drive area.

Transfer Between Subbasins

Stormwater runoff is transferred between subbasins at several locations within the Central South Subwatershed:

- During high flows, overflow occurs from the Hillsdale subbasin in the Central North Subwatershed to the Central Reaches subbasin at Forsberg Road on the east side of Harborview Road. The overflow is contained within the ditch-and-culvert system along Harborview Road.
- The Latitude 49 detention pond, also located in the Central Reaches, overflows to Sea Links Drive and into the Sea Links residential community in the Central Uplands North subbasin. The flow through the Sea Links residential community is uncertain but likely follows downhill along the roadway and eventually connects to the ponds at the Sea Links Golf Course.
- Stormwater overflows from the Central Uplands North subbasin to the Central Uplands South subbasin at the Sea Links Golf Course ponds. The water surface elevation in the ponds is controlled by the Club House Drive outfall. The outlet pipe is higher than the elevation of the interconnecting culverts between the ponds. The ponds essentially function as one storage facility. However, the northern ponds are in the Central Uplands North and the southern ponds are in the Central Uplands South subbasin.
- The Sea Links Golf Course ponds are also connected to a large wetland area through a network of ditches that are also connected to the Terrell Creek Tributary 1 Subbasin along the east border of the Leisure Park residential community. During larger storm events, water from the Central Uplands North subbasin overflows into the wetlands. A 10-inch culvert controls drainage between the wetland and the pond and allows flow to drain back toward the ponds once the storm peak has passed. As the water surface level rises in the wetland, the constructed drainage ditch overflows into both Leisure Park and another low-lying wetland area south of Leisure Park in the Terrell Creek Tributary.
- The Terrell Creek Tributary 1 wetland area is divided between the Terrell Creek Tributary 1 and Tributary 2 subbasins. There is no clear drainage pathway once water enters the lower wetland area, and the true volume of storage is unknown. A culvert under Alderson Road drains the wetland area, but may also allow runoff from Alderson Road to overflow into the wetland area.

Conveyance Capacity

Hydraulic modeling results were reviewed to assess the conveyance capacity of the primary conveyance route in each subbasin. Many of the problem areas in the subwatershed are due to flows exceeding the capacity of the system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Capacity is exceeded when a drainage structure has less than 0.5 feet of freeboard during a storm event.

Table 3-1 summarizes the capacity analysis results at outfalls within the Central South subwatershed. It lists the link ID where peak flow was measured. The system capacity for the Harborview Road and Wooldridge Avenue outfall is exceeded during both the 25- and 100-year peak flow events. The Mariners Cove and Lora Lane outfalls have their capacity exceeded during only the 100-year event. System capacity is not exceeded for the Club House Drive and Birch Creek outfalls.

TABLE 3-1.
SYSTEM CAPACITY AT OUTFALLS BEFORE FLOODING

Subbasin	Location	Pipe Size (in)	Predicted Peak Flow (cfs) 25-Year	Predicted Peak Flow (cfs) 100-Year	Max Flow Before Flooding (cfs)
Central Reaches	Harborview Rd.	18	14.9	17.8	3.7
Central Uplands North	Mariners Cove	30	23.8	26.4	24.3
Central Uplands North	Club House Dr.	36	20.4	27.2	> 100-Year
Terrell Creek Trib. 1	Lora Lane	48	32.7	49.7	44.2
Terrell Creek Trib. 2	Birch Creek	48	53.1	105	>100 Year
Terrell Creek Trib. 2	Wooldridge Avenue	36	7.8	9	6.9

cfs = cubic feet per second

CHAPTER 4.
SURFACE WATER PROBLEMS

COMMON SURFACE WATER PROBLEMS

Drainage conditions are considered to be problems when they negatively affect existing or proposed development. Although drainage problems may be caused by natural conditions such as steep slopes or underlying hardpan, they are exacerbated by development that increases impervious area, reduces vegetative cover, changes runoff routes, accelerates runoff rates, and affects water quality.

Rate and Volume of Stormwater Runoff Flows

The amount of runoff in a watershed is directly proportional to the amount of impervious area. Impervious area is the area covered by hard surfaces such as roofs, streets and sidewalks, which prevent rainfall from infiltrating into the soil. As development increases impervious area, the amount of stormwater runoff increases. Even in built-out areas, impervious area can increase through redevelopment. Increased impervious area can also decrease groundwater recharge and base flow in streams. With a larger percentage of precipitation flowing as runoff, less is available to replenish soil moisture and groundwater storage.

Development also can affect runoff by changing its natural flow pathways. Fill for driveways or homes often eliminates natural depressions. The flow of runoff from streets and roofs is faster than from treed and vegetated areas. The construction of artificial channels, such as storm sewers or ditches, also decreases the lag time between when rain falls and when it enters the flow of a receiving stream, thus increasing the peak runoff rate in the receiving stream, scouring streambeds and destabilizing slopes.

Vegetation loss that occurs with development can have several effects on stormwater runoff. Plants and trees not only improve soil permeability, they also provide a source of precipitation storage. With vegetation loss, rain that would have been evaporated from or absorbed by trees instead falls to the ground and contributes to standing water.

Several neighborhoods in the study area may experience urban redevelopment in the future, potentially increasing the impervious area or decreasing the vegetation. Inclusion of drainage infrastructure would be beneficial in these instances.

Ponding

The following conditions can cause ponding of surface water runoff:

- Lack of drainage infrastructure
- Inadequate capacity in a drainage system
- Inadequate gradient for surface runoff to flow into the collection system
- Inadequate infiltration due to compaction from construction
- Inadequate infiltration due to low permeability or saturated soils
- Inadequate infiltration or surface ponding due to rising seasonal groundwater
- High tide blockage.

Naturally occurring ponding in an undisturbed system is beneficial because it slows the rate of runoff, thus reducing the likelihood of conveyance and erosion problems downstream. However, if ponding poses a safety concern or property damage risk (see Figure 4-1), then correction is required. Most ponding in the Central South Subwatershed occurs because of high tide during storm events, lack of drainage infrastructure and low ground slopes.

Figure 4-1. Street Ponding on Birch Bay Drive Near Harborview Road (Photo by Whatcom County)

Inadequate or Failing Drainage Structures

Drainage structures are considered inadequate when they are too small to accommodate stormwater flows, whether by original design or because land use changes increase flows to levels beyond the system's capacity. It is not economical to design systems with capacity for every possible storm, but systems that are inadequate for a reasonable design storm must be improved by performing a hydraulic analysis of the system and designing improvements to meet local design criteria. Within the study area, many of the existing drainage structures were installed fairly recently and are of adequate size. More significant is the lack of any drainage infrastructure in several of the older neighborhoods. Inadequate infrastructure also includes structures in poor condition and in need of replacement, as shown in Figure 4-2.

Water Quality

Urban stormwater quality is highly variable, depending on factors such as land use, the level of development, the age of the developed area, and the density of construction. The quality of stormwater runoff has historically been degraded by changes from natural to urbanized conditions (Figure 4-3). Fecal coliform and trash have been identified as water quality problems in the Central South Subwatershed.

The type and amount of pollutants depend on land uses in the drainage area, pollutant source controls, and drainage system maintenance programs. Primary contaminants in stormwater from developed areas are eroded sediment and debris from deteriorating roadways and buildings. Other pollutants associated with runoff are heavy metals, inorganic chemicals, nutrients (nitrogen and phosphorus), petroleum products, and fecal coliform bacteria. Older, poorly maintained urban neighborhoods generally have higher levels of pollutants than newer developments, due to higher levels of traffic, accumulation of debris, and deteriorating housing stock.

Figure 4-2. Harborview Road Outfall Near Birch Bay Drive (photo by Wilson Engineering)

Figure 4-3. Catch Basin with Oil Sheen and Odors (photo by Wilson Engineering)

In rural or undeveloped areas, stormwater pollutant loadings are typically low. The stormwater quality of forested areas is often used as a base condition for comparison to developed areas. Stormwater runoff in agricultural areas is generally characterized by high nutrient or fecal coliform bacteria concentrations, virtually no petroleum products, and only naturally occurring metals.

Since the study area was mostly developed without water quality treatment measures, the urban runoff may be fairly low quality; the opportunity exists for improvements in treatment practices with redevelopment.

Channel Erosion

Channel or stream bank erosion contributes to drainage problems in a number of ways. Water quality is affected due to the contribution of fine sediments, which can increase turbidity. Habitat is also affected when fine sediment deposition smothers spawning areas or shellfish harvesting areas. Transported sediments may be deposited in storm drain pipelines and other conveyances, requiring increased maintenance activity and possibly causing flooding due to flow obstruction. In some cases, stream bank erosion may lead to slope instability, which can threaten public facilities and private residences.

Operation and Maintenance

Drainage structures fill with sediment over time in the absence of regular cleaning (see Figure 4-4). When structures become blocked, stormwater may overflow during rainfall events, causing damage to surrounding public and private property. Drainage structures in the Central South Subwatershed are especially prone to siltation and blockage due to backwater in low-gradient drainage systems which allows sediment to settle into the pipe and ditch systems. Sediments from developed areas have been shown to contain high levels of pollutants. Also, stormwater outfalls to Birch Bay are susceptible to blockage due to tidal fluctuation that washes sand and mud into outfall pipes and offshore currents that float debris over the opening.

Figure 4-4. Catch Basin with Sediment and Debris Accumulation (photo by Wilson Engineering)

Lack of access may also prevent adequate maintenance of the storm drain system. Proper storm drain design requires an access structure, usually a catch basin or manhole, at each point where a pipeline changes grade or alignment direction. Without this access, pipeline inspection and cleaning is difficult or impossible.

PROBLEMS SPECIFIC TO CENTRAL SOUTH SUBWATERSHED STUDY AREA

Drainage and water quality problems specific to the Central South Subwatershed have been identified from a number of sources:

- The Birch Bay Stormwater Comprehensive Plan (CH2M Hill, 2006)
- The Birch Bay Watershed Characterization and Watershed Planning Pilot study (ESA Adolfson, 2007)
- The Whatcom County Stormwater Incident Database (Whatcom County, 2013)
- The Birch Bay/Terrell Creek Water Quality Monitoring Project
- Public input provided during BBWARM Advisory Committee meetings
- County staff
- Hydrologic and hydraulic analysis performed to support this report.

Table 4-1 summarizes the drainage problems in the Central South Subwatershed by subbasin and problem type; Figures 4-5 through 4-9 show the problem locations.

TABLE 4-1.
SUMMARY OF DRAINAGE RELATED PROBLEMS IN THE CENTRAL SOUTH SUBWATERSHED

	Number of Problems of Each Type				
Subbasin	Drainage—Conveyance	Drainage—Failing Infrastructure	Maintenance	Water Quality	**Total**
Central Reaches	7	7	2	3	**19**
Central Uplands North	1	2	2	0	**5**
Central Uplands South	3	3	5	1	**12**
Lower Terrell Creek Trib. 1	1	1	1	1	**4**
Lower Terrell Creek Trib. 2	5	6	9	5	**25**
Bog Creek	0	0	3	0	**3**
Total	**17**	**19**	**22**	**10**	**68**

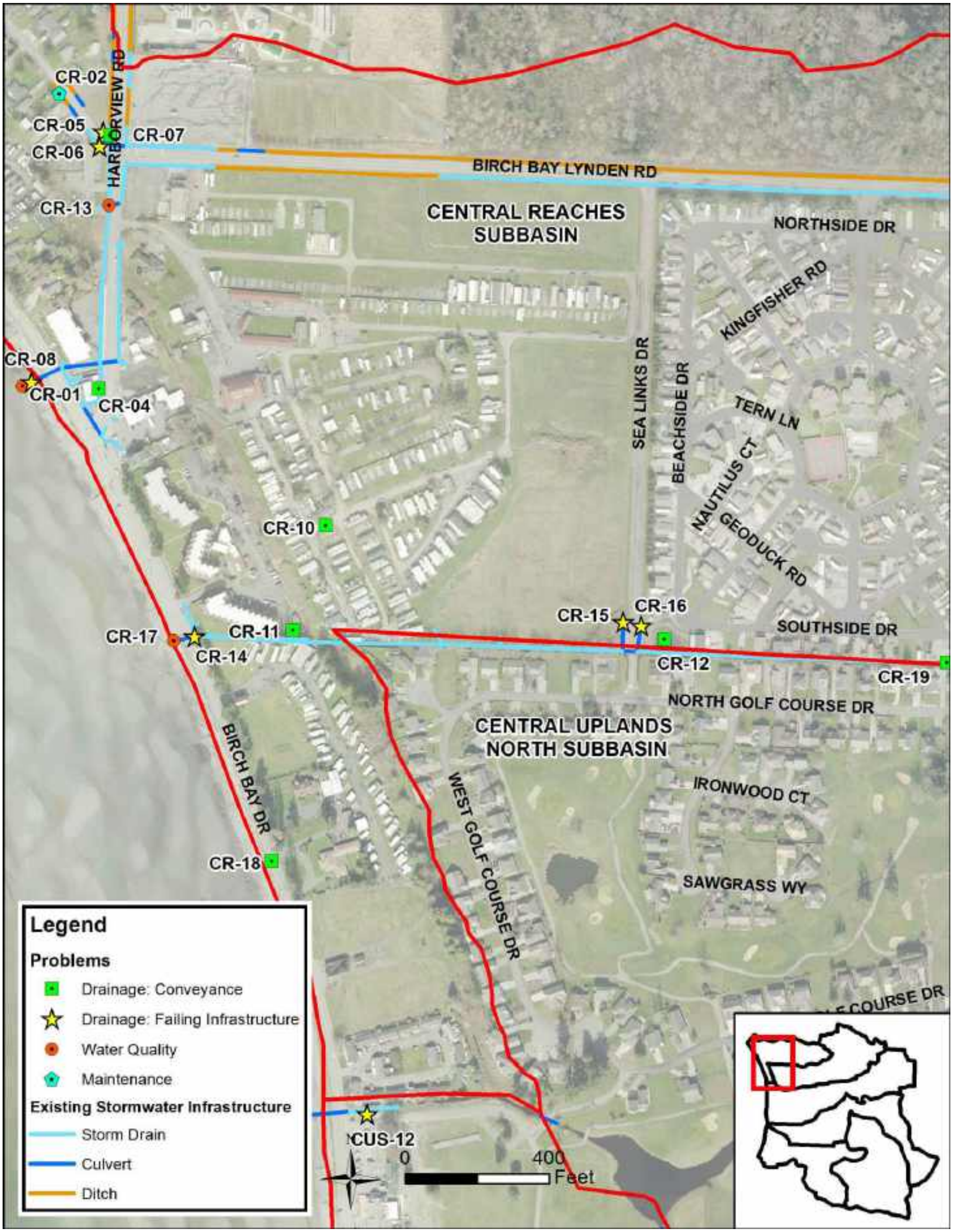

Figure 4-5. Identified Problem Areas in the Central South Subwatershed (Figure 1 of 5)

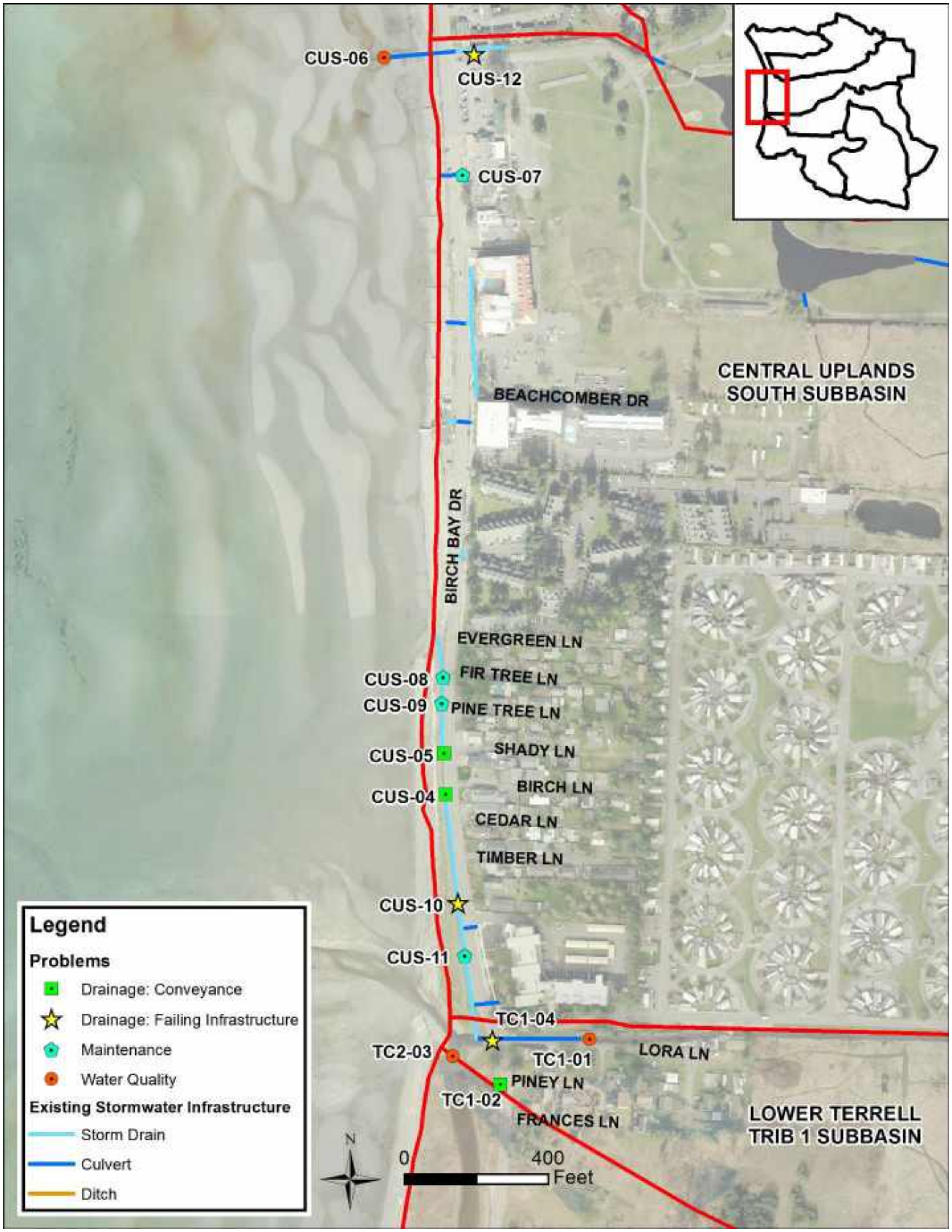

Figure 4-6. Identified Problem Areas in the Central South Subwatershed (Figure 2 of 5)

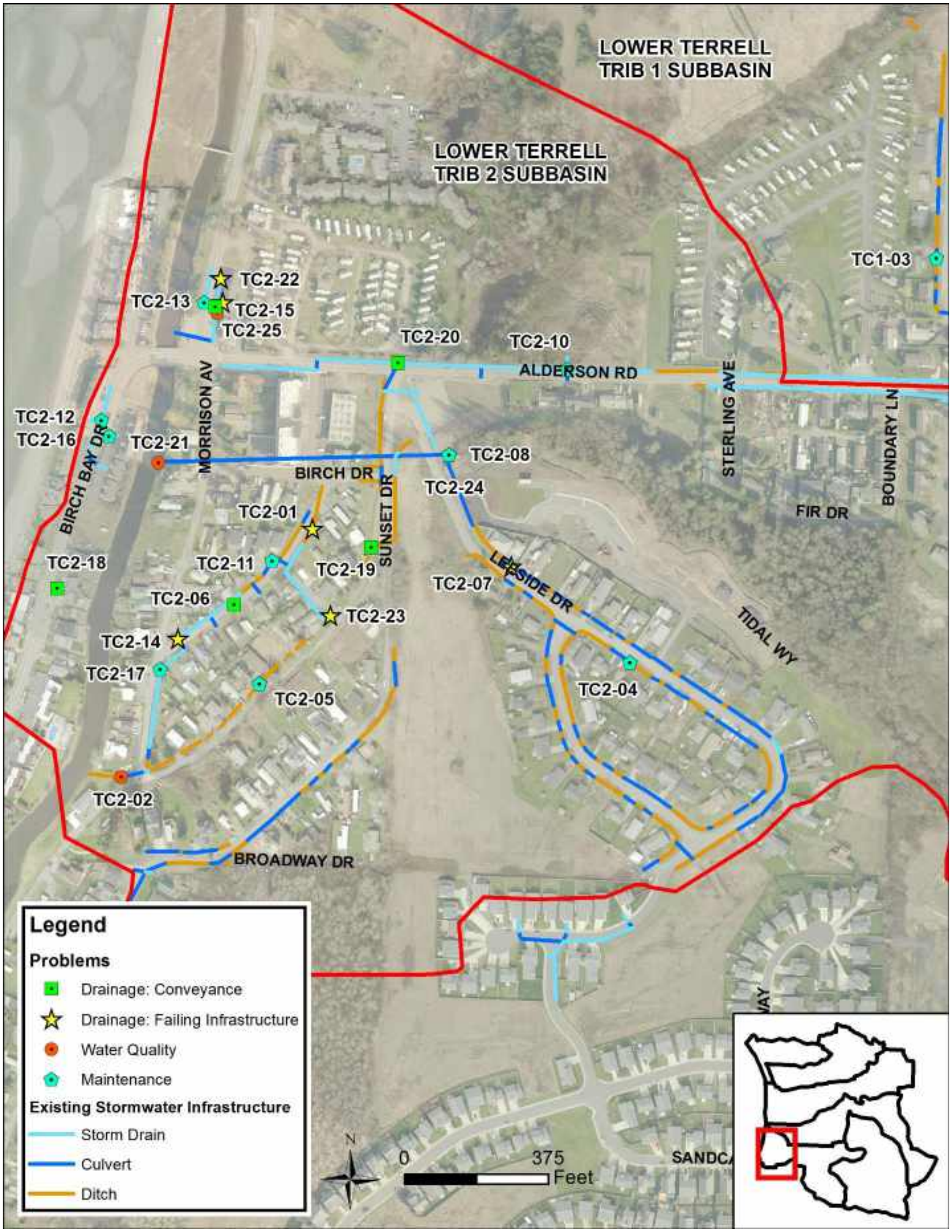

Figure 4-7. Identified Problem Areas in the Central South Subwatershed (Figure 3 of 5)

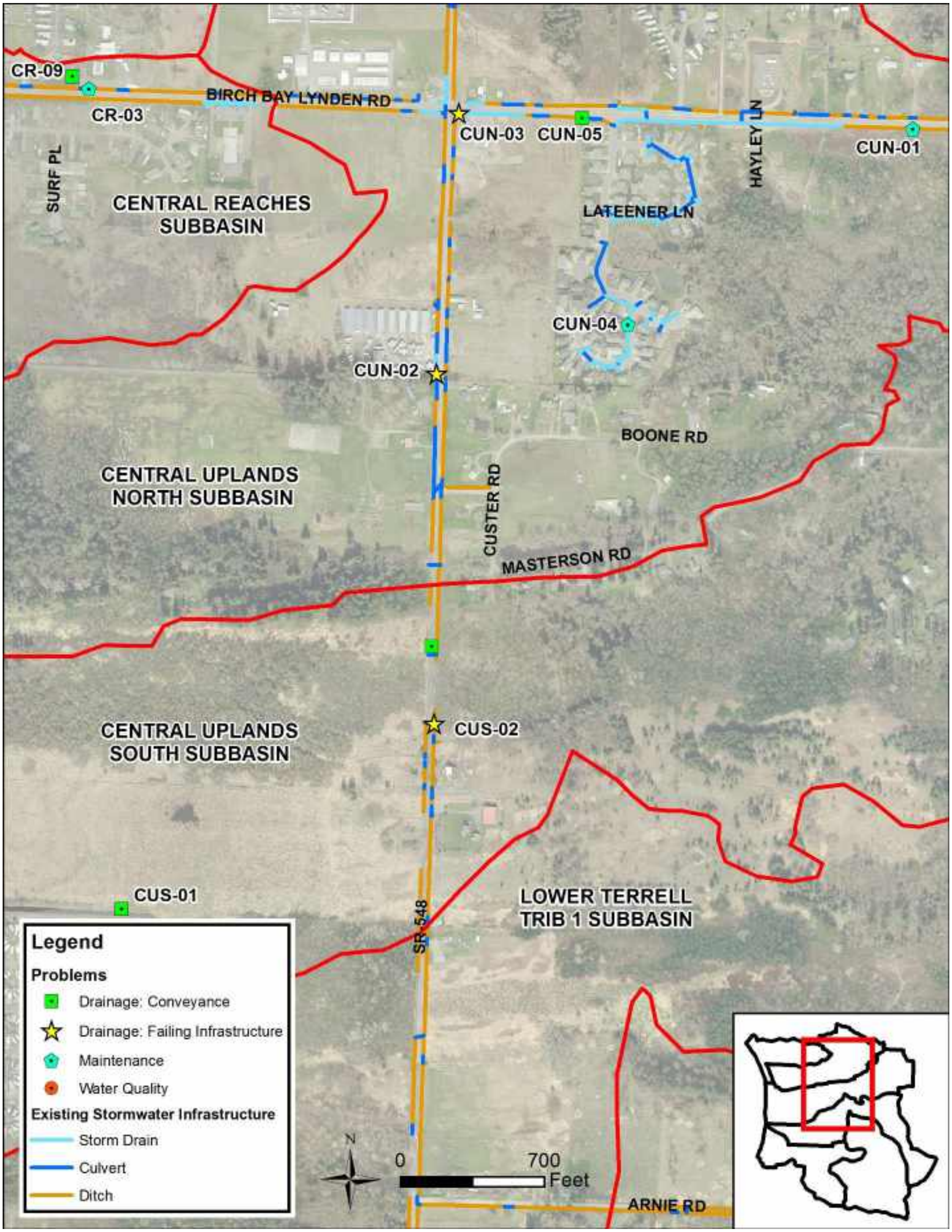

Figure 4-8. Identified Problem Areas in the Central South Subwatershed (Figure 4 of 5)

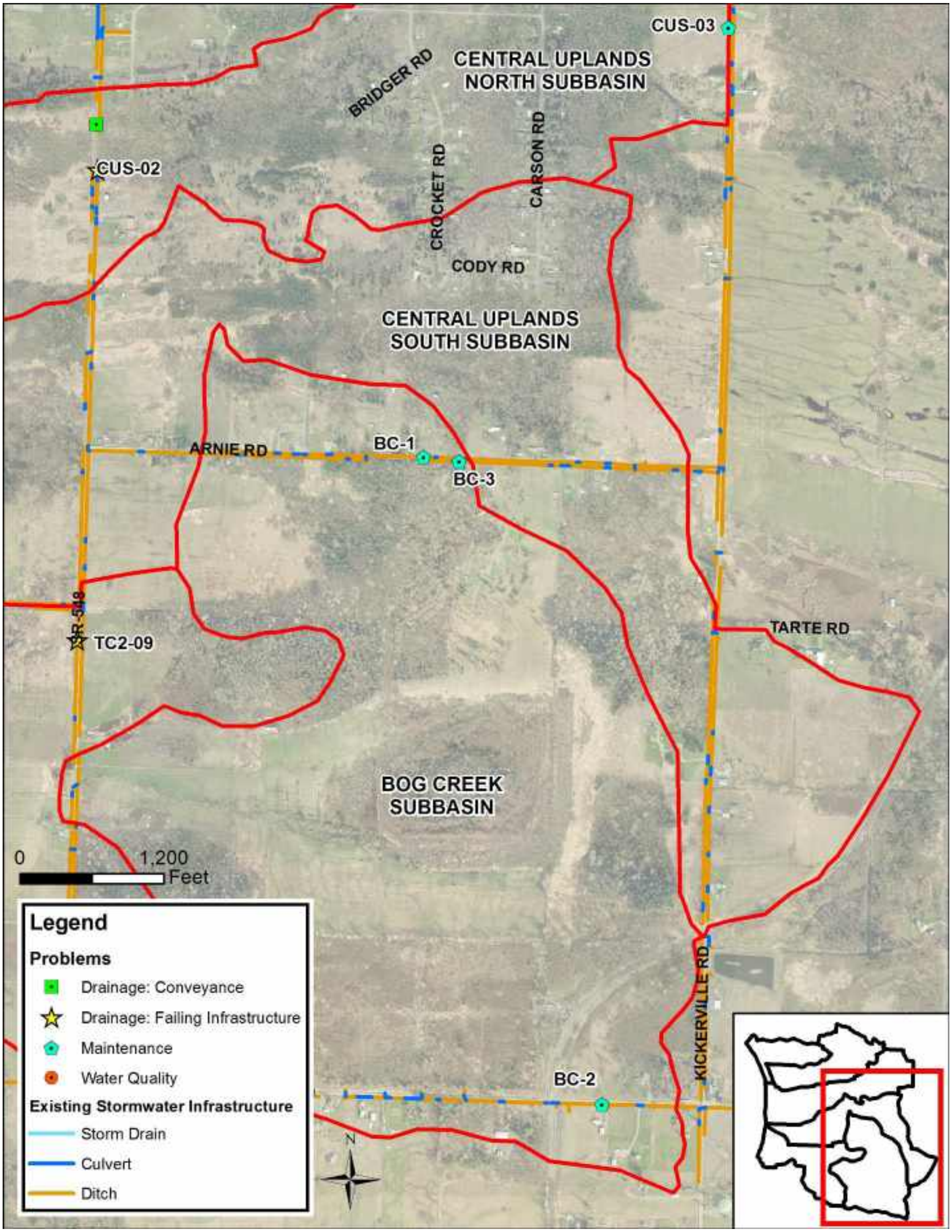

Figure 4-9. Identified Problem Areas in the Central South Subwatershed (Figure 5 of 5)

Tables 4-2 through 4-7 provide details on each problem type for all subbasins where problems have been identified. Each problem listed has been categorized based on the following:

- **Frequency** is a general indicator of the severity of the problem and has three types:
  - **Storm Event** refers to problems that only occur during storm events—usually with large volume or high-intensity rainfall. The frequency of the problem is quantified where known.
  - **Chronic** problems are problems that occur with or without direct rainfall. Groundwater seepage is an example of a chronic surface water problem.
  - **Single-occurrence** problems usually occur only once and do not return when resolved. An accumulation of pet waste washing fecal matter into a drainage path may be considered a single-event problem after cleanup.
- **Responsibility** refers to who is responsible for resolving a stormwater problem:
  - Stormwater problems generated on **public** property or with the public storm drain system are the responsibility of public entities, primarily Whatcom County and the BBWARM District. Undersized conveyance storm drains or damaged pipe outfalls in the public right-of-way are examples of surface water problems under the jurisdiction of the County.
  - Problems generated on **private** property are the responsibility of the property owners. County staff may offer advice on how to resolve private property issues but cannot provide capital for these solutions. A rooftop downspout that directs flow onto neighboring property is an example of a private property issue.
  - For some problems, responsibility is shared between **public and private**. Responsibility for these types of problems is sometimes hard to define and usually identified on a case-by-case basis. Public/private problems usually involve cases where the public storm drain conveyance systems cross private property where no easement has been granted.
- **Problem Types** are categorized as drainage, maintenance, or water quality as the root cause. Drainage problems are sub-categorized as inadequate conveyance or failing infrastructure.

The analysis for this master plan identified 68 problems in the Central South Subwatershed. The Central Reaches subbasin and Terrell Creek Tributary 2 subbasin have the largest number of identified problems. Failing infrastructure makes up the greatest number of problems; however, conveyance capacity is the root cause of identified capital improvement projects. About 70 percent of the problems are with public facilities and 30 percent are either private facilities or split between public and private responsibility.

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE CENTRAL REACHES SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
CR-1	Inventory	Birch Bay Dr. and Harborview Rd.	Chronic	Public	Drainage: Failing Infrastructure
Description: Damaged and separated pipe end on storm drain outfall at Harborview Road (33264).					
CR-2	Inventory	Morgan Drive between Harborview Rd. and Cottonwood Dr.	Chronic	Public	Maintenance
Description: Culvert pipe (38250) is more than 50% obstructed by sediment. Outlet not found and presumed buried.					
CR-3	Inventory	Birch Bay Lynden Rd. west of Blaine Rd.	Chronic	Public	Maintenance
Description: Culvert pipe more than 50 percent obstructed with sediment (38445).					
CR-4	ID 2010-26, HH Analysis	Birch Bay Drive near Harborview Road	Storm Event	Public	Drainage: Conveyance
Description: Standing high water following 12/12/2010 storm event. Hydraulic analysis shows flooding occurs at Harborview Road near Birch Bay Lynden Road during the 2-year event (2864).					
CR-5	Inventory	Harborview Rd. near Birch Bay Lynden Rd.	Chronic	Public	Drainage: Failing Infrastructure
Description: Pipe end is weathered (14977).					
CR-6	Inventory	Morgan Drive near Harborview Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch basin and connecting upstream pipe is cracked (2684) (14976).					
CR-7	HH Analysis	Morgan Drive near Harborview Road	Storm Event	Public	Drainage: Conveyance / Failing Infrastructure
Description: Undersized roadway culvert restricts flow at the 25-year event. Catch basin located downstream is cracked and spalling (2859).					
CR-8	BB/TC WQMP	Birch Bay Drive near Harborview Rd.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site BB5.					
CR-9	ID 2011-07	Birch Bay Lynden Road west of Blaine Road	Chronic	Private	Drainage: Failing Infrastructure
Description: Variety of problems in the Baywood Park area. Sediment is obstructing storm pipes. Residents report a pond odor and a breeding area for insects.					
CR-10	ID 2012-05, ID 2010-10	Birch Bay RV Resort / Mariners Cove	Storm Event	Private	Drainage: Conveyance
Description: Inadequate private storm drainage system at Birch Bay RV Resort. Sheet flows occurring from paved areas and flowing downhill to Mariners Cove.					
CR-11	BBCSP CU-03, ID 2011-03 ID 2012-29, HH Analysis	Mariners Cove near Birch Bay Drive	Storm Event	Private	Drainage: Conveyance
Description: Hydraulic analysis identifies inadequate conveyance in the storm drain line between Mariners Cove and Latitude 49 during the 25-year event. Flooding at Mariners Cove occurs because the depth of flow in the storm drain is higher than the parking lot inlet rim elevation.					

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE CENTRAL REACHES SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
CR-12	BBCSP CR-03, ID 2010-24, HH Analysis	Latitude 49 Storm Pond	Storm Event	Private	Drainage: Conveyance
Description: Latitude 49 storm pond is undersized and filled with sediment. Hydraulic analysis shows the pond overflows at all design events					
CR-13	Inventory	Birch Bay RV Resort south of Harborview Road	Chronic	Public	Water Quality
Description: Odors reported from catch basin (2861) during NPDES inventory.					
CR-14	Inventory	Birch Bay Drive at Mariners Cove	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch Basin (2918) is cracked and concrete is spalling off the structure wall.					
CR-15	Inventory	Sea Links Drive	Chronic	Private	Drainage: Failing Infrastructure
Description: Corrugated metal pipe culvert is deteriorated at pipe ends (39649).					
CR-16	Inventory	Sea Links Drive	Chronic	Private	Drainage: Failing Infrastructure
Description: Corrugated metal pipe culvert is deteriorated at pipe ends (39647).					
CR-17	BB/TC WQMP	Birch Bay Drive near Mariners Cove	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site BB4.					
CR-18	County	Birch Bay Drive between Mariners Cove and Club House Drive	Chronic	Public	Drainage: Conveyance
Description: No storm drain system along Birch Bay Drive between Mariners Cove and Club House Drive.					
CR-19	HH Analysis	Storm Drain Line east of Latitude 49 Storm Pond	Storm Event	Private	Drainage: Conveyance
Description: Catch basin (5014) floods during the 100-year event.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

**TABLE 4-3.
DRAINAGE RELATED PROBLEMS IN THE CENTRAL UPLANDS NORTH SUBBASIN**

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
CUN-1	Inventory	Birch Bay Lynden Road east of Blaine Road	Chronic	Public	Maintenance
Description: Ditch (28231) is 50% obstructed with sediment.					
CUN-2	Inventory	Blaine Road south of Birch Bay Lynden Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Missing grout around pipe ends in catch basin (4420). Sink hole has developed near catch basin lid.					
CUN-3	Inventory	Birch Bay Lynden Road at Blaine Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch Basin (3018) sidewall collapsed around pipe end.					
CUN-4	Inventory	Carstan Loop near Anchor Parkway	Chronic	Public	Maintenance
Description: Catch Basin (2931) grout is cracked around pipe ends.					
CUN-5	HH Analysis	Birch Bay Lynden Road east of Blaine Road	Storm Event	Public	Drainage: Conveyance
Description: Hydraulic analysis shows roadway flooding during 100-year event due to undersized storm drain system on Birch Bay Lynden Road near Anchor Parkway.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

**TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE CENTRAL UPLANDS SOUTH SUBBASIN**

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
CUS-1	County, HH Analysis	Leisure Park	Storm Event	Public / Private	Drainage: Conveyance
Description: Hydraulic analysis indicates the 25-year storm event overtops Leisure Park at multiple locations and inundates the development. Flooding has been reported to occur at a greater frequency than seen in hydraulic analysis likely due to the tidal condition.					
CUS-2	Inventory	Blaine Road between Arnie Rd. and Birch Bay Lynden Rd.	Chronic	Public	Drainage: Failing Infrastructure
Description: Culvert (39532) identified for structure failure due to spalling of interior walls.					
CUS-3	Inventory	Kickerville Road.	Chronic	Public	Maintenance
Description: Ditch (28260) is more than 50% obstructed with sediment.					
CUS-4	HH Analysis	Birch Bay Drive near Cedar Lane	Storm Event	Public	Drainage: Conveyance
Description: Hydraulic analysis shows roadway flooding along Birch Bay Drive between Shady Lane and Cedar Lane during 2-year event due to undersized storm drain.					

TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE CENTRAL UPLANDS SOUTH SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
CUS-5	HH Analysis	Birch Bay Drive near Shady Lane	Storm Event	Public	Drainage: Conveyance
Description: Hydraulic analysis shows roadway flooding during 2-year event due to undersized storm drain on Birch Bay Drive near Shady Lane.					
CUS-6	BB/TC WQMP	Birch Bay Drive near Club House Drive	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site BB3.					
CUS-7	Inventory	Birch Bay Drive south of Club House Drive	Chronic	Public	Maintenance
Description: Catch basin (2916) is filled with sediment. Grate has inadequate capacity to receive stormwater.					
CUS-8	Inventory	Birch Bay Drive near Fir Tree Lane	Chronic	Public	Maintenance
Description: Catch basin (2956) grout is cracked around pipe ends.					
CUS-9	HH Analysis	Birch Bay Drive near Pine Tree Lane	Storm Event	Public	Maintenance
Description: Catch basin (2957) grout is cracked around pipe ends.					
CUS-10	Inventory	Birch Bay Drive near Grand Bay Resort	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch basin (2960) has spalling on structure walls and grout is missing around connecting pipe ends.					
CUS-11	Inventory	Birch Bay Drive near Grand Bay Resort	Chronic	Public	Maintenance
Description: Catch basin (2961) grout is cracked around connecting pipe ends.					
CUS-12	County	Club House Drive near Birch Bay Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: Tide valve at Club House Drive is not functioning properly.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-5.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK TRIBUTARY 1 SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC1-1	BB/TC WQMP	Leisure Park Tributary north of Lora Lane	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site Trib Ter LP1.					
TC1-2	County	Birch Bay Drive near Piney Lane	Chronic	Public	Drainage: Conveyance
Description: No storm drain system along Birch Bay Drive. No public system for private connections currently available for Lora Lane.					
TC1-3	Inventory	Parkland Drive	Chronic	Private	Maintenance
Description: Culvert (39432) is more than 50% obstructed with sediment.					
TC1-4	ID 2010-11	Birch Bay Drive near Lora Lane	Chronic	Public	Drainage: Failing Infrastructure
Description: Tide gate at Birch Bay Drive and Lora Lane is not efficient at regulating flow.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-6.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK TRIBUTARY 2 SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC2-1	ID 2012-09	Terrill Drive near Willow Drive	Chronic	Private	Drainage: Failing Infrastructure
Description: 7562 Terrill Drive landowner installed an unpermitted pipe and filled the conveyance ditch. Pipe was reported to be removed after discovered; however, per an incident report on 11/12/2012, only a portion of the pipe was removed.					
TC2-2	BB/TC WQMP	Wooldridge Ave. at Morrison Ave.	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site Trib Ter BC1.					
TC2-3	BB/TC WQMP	Terrell Creek mouth nr Lora Ln	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at sites Ter 0.1 and Ter 0.1*.					
TC2-4	Inventory	Leeside Drive	Chronic	Public	Maintenance
Description: Culvert (39465) is 50% obstructed by sediment.					
TC2-5	Inventory	Woolridge Drive / Sunset Drive	Chronic	Private	Maintenance
Description: Ditches and culverts along Wooldridge Drive are obstructed by sediment.					
TC2-6	ID 2012-30, ID 2012-35, HH Analysis	Terrill Drive / Willow Drive / Morrison Avenue	Storm Event	Public / Private	Drainage: Conveyance
Description: Significant flooding and standing water in the Terrill Drive / Willow Drive / Morrison Avenue neighborhood. Hydraulic analysis indicates flooding during all design events.					

**TABLE 4-6.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK TRIBUTARY 2 SUBBASIN**

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC2-7	Inventory	Leeside Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: Culvert (39492) pipe end is cracked at the upstream side.					
TC2-8	ID 2010-18	Leeside Drive	Chronic	Public	Maintenance
Description: Inlet to culvert (40015) that drains Birch Creek to Terrell Creek accumulates debris. Incident report identifies frequent maintenance needed to trash rack.					
TC2-9	Inventory	Blaine Road south of Arnie Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Culvert (39575) is cracked in half near midpoint and 75% obstructed by sediment.					
TC2-10	Inventory	Alderson Road	Chronic	Public	Maintenance
Description: Catch Basin (3052) grout is missing around pipe connections.					
TC2-11	Inventory	Terrill Drive near Willow Dr.	Chronic	Public	Maintenance
Description: Catch Basin (4221) grout is missing around pipe connections.					
TC2-12	Inventory	Birch Bay Drive south of Alderson Rd.	Chronic	Public	Maintenance
Description: Catch Basin (2964) is missing spacers and sediment is impounding structure.					
TC2-13	Inventory	Birch Bay Drive north of Alderson Rd.	Chronic	Public	Maintenance
Description: Catch Basin (2962) flagged for structure failure. Grout is missing around pipe connections.					
TC2-14	Inventory	Terrill Drive near Morrison Avenue	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch Basin (2646) is weathered and the interior is spalling. Connecting downstream pipe (32551) identified needs grout around pipe ends.					
TC2-15	Inventory, HH Analysis	Birch Bay Drive north of Alderson Rd.	Chronic	Public	Drainage: Conveyance / Failing Infrastructure
Description: Catch Basin (2911) interior walls are spalling. Downstream connecting storm drain (33351) is also identified for structure failure. Hydraulic analysis indicates flooding during 2-year event.					
TC2-16	Inventory	Birch Bay Drive south of Alderson Rd.	Chronic	Public	Maintenance
Description: Catch Basin (2909) grout is missing around pipe connections.					
TC2-17	Inventory	Morrison Drive at Terrill Drive	Chronic	Public	Maintenance
Description: Catch Basin (2637) has a gap in the spacer between the lid and sidewalls.					
TC2-18	ID 2012-35	Birch Bay Drive	Storm Event	Public / Private	Drainage: Conveyance
Description: Significant flooding and standing water along Birch Bay Drive.					
TC2-19	ID 2010-16	Sunset Drive near Birch Drive	Chronic	Public / Private	Drainage: Conveyance
Description: Ditch on Sunset Drive behind 7576 Terrill Dr. floods during winter storms and is too deep so it holds standing water outside of storm events. Request that ditch-and-culvert system behind 7576 Terrill Drive become County's responsibility for maintenance and become used as a conveyance for public stormwater drainage.					

TABLE 4-6.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK TRIBUTARY 2 SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC2-20	ID 2011-04	Beachside RV Park	Storm Event	Private	Drainage: Conveyance
Description: Pond at Beachside RV Park is no longer draining out under Alderson Road. Ponding and flooding reported at Beachside RV Park and Bay Rim Condominiums.					
TC2-21	ID 2009-01	Birch Creek entering Terrell Creek	Storm Event	Public / Private	Water Quality
Description: Turbid water reported from outfall of Birch Creek into Terrell Creek.					
TC2-22	Inventory	Birch Bay Drive north of Alderson Rd.	Chronic	Public	Drainage: Failing Infrastructure
Description: Catch basin (2940) and connecting downstream pipe (33355) is old and likely beyond its design life.					
TC2-23	ID 2011-13	7551 Wooldridge Drive	Chronic	Private	Drainage: Failing Infrastructure
Description: Collapsed culvert at 7551 Wooldridge Drive has created hole approximately 2 feet deep in private driveway.					
TC2-24	BB/TC WQMP	Birch Creek at Leeside Dr	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site Trib Ter BC2.					
TC2-25	Inventory	Birch Bay Drive north of Alderson Rd.	Chronic	Public	Water Quality
Description: Water quality problem reported for catch basin (2911) during NPDES inventory.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

TABLE 4-7.
DRAINAGE RELATED PROBLEMS IN THE BOG CREEK SUBBASIN

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
BC-1	Inventory	Arnie Road	Chronic	Public	Maintenance
Description: Ditch (60024) is 75% obstructed with sediment.					
BC-2	Inventory	Bay Road	Chronic	Public	Maintenance
Description: Culvert (39507) is 50% obstructed with sediment.					
BC-3	Inventory	Arnie Road	Chronic	Public	Maintenance
Description: Culvert (35390) is 100% obstructed with sediment.					

a. See Figures 4-5 through 4-9 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, HH Analysis = Hydrologic and hydraulic analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

CHAPTER 5.
PROBLEM RESOLUTION

Sixty-eight problems were identified in the problem investigation documented in Chapter 4. Each problem was evaluated and a determination was made about the manner in which each should be addressed:

- Some problems are not addressed in this plan because they have already been addressed or are outside the jurisdiction of BBWARM and the County.
- Some problems are maintenance-related or more suitably addressed by a small works project.
- The remaining problems are more extensive and require a capital improvement program (CIP) project.

Problem disposition is shown on Figure 5-1.

PROBLEMS NOT ADDRESSED IN THE PLAN

The investigation found that some drainage problems were resolved with an earlier project or activity. Other problems are private issues, outside the jurisdiction of the County or BBWARM. Private property problems not addressed in the plan are usually due to flooding from adjacent properties or occur in privately owned drainage systems. Table 5-1 lists the problems not addressed in the master plan.

SPECIAL STUDY AREAS

Special studies are recommended for eight problems whose solution requires resources beyond what is available in the watershed plan. The reported flooding at Birch Bay RV Park (TC2-20) is an example of this type of problem. Studies under way by others, such as the Birch Bay / Terrell Creek Water Quality Monitoring Project under Whatcom County, also fall into the category of a special study recommendation. Table 5-2 lists the special study recommendations.

OPERATION AND MAINTENANCE

Eighteen problems were attributed to the need for increased maintenance. The recommendation for increased maintenance is extended to all Birch Bay outfalls. The remaining problems are due to sediment buildup in roadway culverts and pipelines, which interferes with conveyance. Table 5-3 documents maintenance needs.

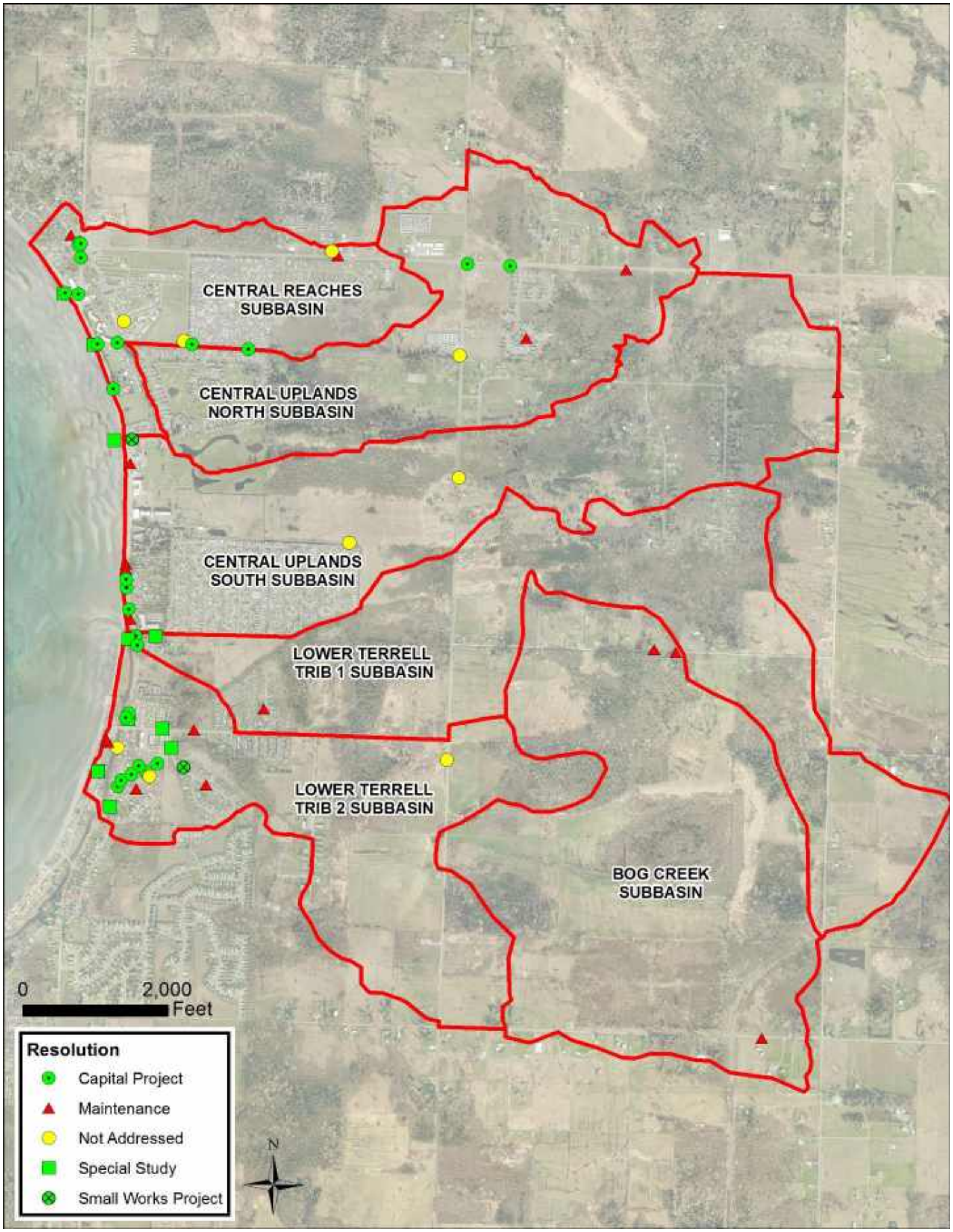

Figure 5-1. Problem Disposition

TABLE 5-1.
PROBLEMS NOT ADDRESSED IN THE PLAN

Problem ID[a]	Problem Description	Problem Resolution
CR-9	Baywood Park storm drain maintenance near Birch Bay Lynden Road	Maintenance of driveway culverts and ditches is the responsibility of property owners
CR-10	Birch Bay RV Resort Storm drain System	Maintenance of private facilities is the responsibility of property owners
CR-15; CR-16	Sea Links Drive near North Club House Drive	Maintenance of driveway culverts and ditches is the responsibility of property owners
CUS-1	High backwater, large volume of inflow at tributary streams and poor drainage in the wetland area adjacent to Leisure Park results in frequent flooding in Leisure Park	Capital project not able to resolve large scale flooding in regulatory floodplain (See Figure 2-4)
CUS-2	Box culvert interior walls are deteriorated at Blaine Road near Birch Bay Lynden Road	Drainage infrastructure located along a state highway is not in the county’s jurisdiction
CUN-2	Catch basin missing grout at connecting pipe ends. Sink hole developing adjacent to structure on Blaine Road	Drainage infrastructure located along a state highway is not in the county’s jurisdiction
TC2-9	Concrete culvert is broken near midpoint at Blaine Road south of Alderson Road.	Drainage infrastructure located along a state highway is not in the county’s jurisdiction
TC2-18	Significant flooding along Birch Bay Drive	Flooding from Terrill Creek and/or high tide is beyond the scope of this plan.
TC2-21	Turbid water reported from outfall of Birch Creek into Terrell Creek.	Sediment from naturally occurring sources, occasional monitoring recommended

a. See Figure 5-1.

TABLE 5-2.
SPECIAL STUDY RECOMMENDATIONS

Problem ID [a]	Problem Description	Problem Resolution
CR-8[b]	Fecal coliform water quality standards exceeded for storm drain outfall near Harborview Road (site BB5)	Whatcom County’s Birch Bay / Terrell Creek Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
CR-17[b]	Fecal coliform water quality standards exceeded for storm drain outfall near Mariners Cove (site BB4)	Whatcom County’s Birch Bay / Terrell Creek Water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
CUS-6[b]	Fecal coliform water quality standards exceeded for storm drain outfall near Club House Drive (site BB3)	Whatcom County’s Birch Bay / Terrell Creek water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
TC1-1[b]	Fecal coliform water quality standards exceeded at Leisure Park Tributary north of Lora Lane (site Trib Ter LP1)	Whatcom County’s Birch Bay / Terrell Creek water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls

TABLE 5-2.
SPECIAL STUDY RECOMMENDATIONS

Problem ID [a]	Problem Description	Problem Resolution
TC2-2[b]	Fecal coliform water quality standards exceeded for storm drain outfall at Wooldridge Avenue (site Trib Ter BC1)	Whatcom County's Birch Bay / Terrell Creek water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
TC2-3[b]	Fecal coliform water quality standards exceeded at Terrell Creek mouth near Lora Lane (sites Ter 0.1 and Ter 0.1 *)	Whatcom County's Birch Bay / Terrell Creek water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
TC2-20	Pond at Beachside RV Park is no longer draining out under Alderson Road	Detailed topographic survey needed to define local drainage patterns in problem area.
TC2-24	Fecal coliform water quality standards exceeded in Birch Creek at Leeside Drive (site Trib Ter BC2)	Whatcom County's Birch Bay / Terrell Creek water Quality Monitoring Project is currently providing a comprehensive water quality study for these outfalls
TC2-25	Water quality issue identified during NPDES inventory.	Special study is needed to identify the root cause of the identified water quality issue.

a. See Figure 5-1.
b. Problem partially addressed with capital improvement projects.

TABLE 5-3.
MAINTENANCE NEEDS

Problem ID [a]	Problem Description	Problem Resolution
CR-2[b]	Sediment obstructing culvert at Morgan Drive	Remove sediment from culvert
CR-3	Sediment obstructing culvert at Birch Bay Lynden Road	Remove sediment from culvert
CUN-1	Sediment obstructing ditch at Birch Bay Lynden Road	Remove sediment from ditch
CUN-4	Catch Basin missing grout around pipe ends on Carstan Loop near Anchor Parkway	Repair grout around connecting pipe ends.
CUS-3	Ditch is obstructed by sediment on Kickerville Road	Remove sediment from ditch.
CUS-7	Catch Basin is obstructed by sediment on Birch Bay Drive near Club House Drive	Remove sediment from catch basin.
CUS-8[b]	Catch Basin missing grout around pipe ends on Birch Bay Drive near Fir Tree Lane	Repair grout around connecting pipe ends.

TABLE 5-3.
MAINTENANCE NEEDS

Problem ID [a]	Problem Description	Problem Resolution
CUS-9[b]	Catch basin missing grout at connecting pipe ends on Birch Bay Drive near Pine Tree Lane	Repair grout around connecting pipe ends.
CUS-11[b]	Catch basin missing grout at connecting pipe ends on Birch Bay Drive near Grand Bay Resort	Repair grout around connecting pipe ends
TC1-3[b]	Culvert is obstructed by sediment on Parkland Drive	Remove sediment from culvert
TC2-4	Culvert is obstructed by sediment on Leeside Drive	Remove sediment from culvert
TC2-5[b]	Ditches and culverts along Wooldridge Drive obstructed by sediment	Remove sediment from culvert
TC2-8	Trash rack at Leeside Drive near Alderson Rd accumulates debris	Increase frequency of maintenance activity
TC2-10	Catch Basin missing grout around pipe ends on Alderson Road	Repair grout around connecting pipe ends
TC2-12	Catch Basin missing lid spacers and obstructed by sediment on Birch Bay Drive south of Alderson Road	Remove sediment from structure and assess structure condition.
TC2-16	Catch Basin missing grout around pipe ends on Birch Bay Drive near Alderson Road	Repair grout around connecting pipe ends
BC-1	Ditch is obstructed with sediment near Arnie Road	Remove sediment from ditch.
BC-2	Ditch is obstructed with sediment near Bay Road	Remove sediment from ditch.
BC-3	Ditch is obstructed with sediment near Arnie Road	Remove sediment from ditch.

a. See Figure 5-1.
b. Problem partially addressed with capital improvement projects.

SMALL WORKS PROJECTS

Small works projects are projects that can be constructed at relatively low cost and that can be quickly planned and designed. Small works projects have the following characteristics:

- Low or minimal complexity
- Low cost (less than $20,000)
- Easy to permit (e.g. only county permits needed)
- Can be designed in-house by Whatcom County staff

- May be coordinated with other larger projects
- Are emergency actions needed to protect life and public safety.

Two problems can be addressed as small works projects and are described in Table 5-4. These projects can be aggregated into a single larger project to take advantage of economies of scale or completed singly as County crews come available to implement the project. An annual budget of $50,000 is recommended to address small work projects.

TABLE 5-4.
SMALL WORKS PROJECTS

Problem ID[a]	Problem Description	Problem Resolution	Cost
Central Uplands South Subbasin			
CUS-12	Tide gate at Club House Drive outfall is not able to close properly and not able to prevent backflow into the system.	Remove tide gate	$3,000
Terrell Creek Tributary 2 Subbasin			
TC2-7	Culvert is longitudinally cracked at upstream end on Leeside Drive	Replace culvert	$7,000
Total Cost of Small Works Projects			$10,000

a. See Figure 5-1.

STORMWATER CAPITAL PROJECTS

Project Types

Capital projects developed for this master plan consist primarily of conveyance improvements in the public right of way. A conveyance system is made up of large and small channels, culverts, and storm drain pipelines. Improvements include building overflow channels, increasing capacity, or increasing system efficiency. Specific structural solutions considered for the CIP are culvert and ditch improvements, storm drain pipelines, and outfall improvements.

Culverts are short lengths of pipe that convey stormwater under roadways or other embankments. New or replacement culverts in stream channels at road crossings can increase flow capacity and reduce the potential for upstream flooding. When culverts are too small to convey the stormwater flow, stormwater backs up behind the roadway. This is normally not acceptable if there is a danger of the road failing or if upstream structures are being damaged by floodwaters. Increasing the size or number of culverts reduces the possibility of upstream damage and road failure. A potential negative effect of increasing culvert capacity is the increased risk of additional flooding downstream of the culvert caused by the loss of storage upstream. However, flood storage behind an undersized culvert is usually very small. At some locations, peak flow increase is attenuated in deep roadside ditches downstream of the replaced culvert.

Underground storm drain lines are commonly installed to convey stormwater runoff from urban developments to a receiving body such as a lake, river or stream. Storm drain pipelines can reduce flooding and standing water during rainfall events but can increase peak flow rates to the receiving water. Small pipes are inexpensive to install, but may result in frequent flooding. This can be alleviated by installing pipelines of adequate size to convey larger flows. Installation of new pipelines in developed areas is always more expensive and disruptive than the installation of pipelines in an undeveloped area.

Storm drains work only where there is adequate gradient to maintain flow rates and keep the pipe from filling with sediment. Typically, these lines are installed in road right-of-ways, so there is little land acquisition cost, although some temporary easements may be required. The proposed CIP projects include a large number of storm drains on Birch Bay Drive because much of this road lacks basic drainage infrastructure.

Capital projects may also include facilities designed to remove pollutants from stormwater flows and improve water quality. Common water treatment facilities include bio-infiltration swales and cartridge vaults. Where feasible, treatment facilities will be included in the proposed capital improvement projects included in this plan.

Project Assumptions

The configuration and size of stormwater capital projects was based on a detailed analysis of tributary area and land cover using the hydraulic models described in Chapter 3 and Appendix B. Pipe materials were assumed to be high-density polyethylene for pipes up to 24 inches in diameter and concrete for larger pipes. When an existing pipe is replaced with a larger diameter pipe, the cost assumes that existing catch basins can be reused. Some pipes were identified as outfalls or laterals. For cost estimating, outfall repair or replacement projects assume the installation of a tide valve.

Unit costs were generally derived from Washington State Department of Transportation bid tabs for recent local projects. Adjustments for planning level assumptions (such as trench excavation and pipe bedding material included in the price of culvert materials) were made using recent unit bid item costs from Whatcom County and other municipalities. Several unique lump sum items, such as water quality facilities were priced based on engineer’s judgment. Unit prices used for the estimates are shown in Appendix C.

Project Descriptions and Estimated Costs

Twelve capital projects were developed to address 33 drainage problems, as listed in Table 5-5. In some locations, a single project addresses more than one problem. The proposed projects include a total of over 11,300 feet of new or replacement storm drain pipeline, 265 feet of roadside ditch, 115 new or replacement catch basins, 290 feet of water quality swale, two new tide valves, and 6 new or replaced outfalls. Figure 5-2 shows the project locations. Detailed project descriptions are provided in Appendix C. Table 5-6 shows a breakdown of estimated project costs.

TABLE 5-5.
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Project Number [a]	Problem ID [b]	Project Name [c]	Location	Cost
Central Reaches Subbasin				
CR-1	CR-4	Birch Bay Drive at Harborview Road Storm Drain Improvements	Birch Bay Drive near Harborview Road	$ 525,000
CR-2	CR-1; CR-2[d]; CR-4; CR-5 CR-6; CR-7; CR-13	Harborview Road Storm Drain and Outfall Improvements	Birch Bay Drive and Harborview Road	$ 536,000
CR-3	CR-11; CR-14	Birch Bay Drive at Mariners Cove Storm Drain Improvements and Outfall Replacement	Birch Bay Drive near Mariners Cove	$ 533,000
CR-4	CR-12: CR-19	Mariners Cove/Latitude 49 Storm Drain Trunk Line Replacement	South property line Birch Bay RV Resort and Latitude 49	$ 436,000
Central Uplands North Subbasin				
CUN-1	CUN-3; CUN-5	Birch Bay - Lynden Road Roadside Storm Drainage Improvements	Birch Bay Lynden Road near Anchor Parkway	$ 452,000
Central Uplands South Subbasin				
CUS-1	CUS-4; CUS-5; CUS-8[d]; CUS-9[d]; CUS-10; CUS-11[d]	Birch Bay Drive Storm Drain Improvements North of Lora Lane	Birch Bay Drive north of Lora Lane	$ 660,000
CUS-2	CR-18	Birch Bay Drive at Club House Drive Storm Drain Improvements	Birch Bay Drive near Club House Drive	$ 349,000
Terrell Creek Tributary 1 Subbasin				
TC1-1	TC1-2, TC1-3[d]; TC2-13; TC2-15; TC2-22	Birch Bay Drive Storm Drain Improvement North of Alderson Road	Birch Bay Drive between Lora Lane and Alderson Road	$ 352,000
TC1-2	TC1-4	Lora Lane Tide Gate Modifications	Lora Lane near Birch Bay Drive	$ 162,000
Terrell Creek Tributary 2 Subbasin				
TC2-1	TC2-1; TC2-5[d] ; TC2-6; TC2-11; TC2-14; TC2-17; TC2-19	Morrison Avenue/Terrell Drive Neighborhood Storm Drain Improvements	Terrill Drive / Morrison Avenue / Willow Drive	$ 582,000
TC2-2	TC2-5; TC2-19; TC2-23	Wooldridge Drive Storm Drain Improvements	Wooldridge Drive between Morrison Avenue and Sunset Drive	$ 277,000

TABLE 5-5.
PROPOSED CAPITAL IMPROVEMENT PROJECTS

Project Number [a]	Problem ID [b]	Project Name [c]	Location	Cost
Birch Central South Subwatershed				
BBCS-1	CR-8; CR-17; CR-18;CUS-6; TC1-1; TC1-1; TC2-2; TC2-3	Subwatershed Water Quality Retrofit	Various locations in the Central South subwatershed	$ 611,000

a. See Figure 5-2.
b. See Figure 5-1.
c. All projects consist of installation of new/replaced storm drainage pipeline, connection to existing drainage infrastructure, and associated outfall and ditch improvements. See Appendix C for project descriptions.
d. Problems also addressed in maintenance needs.

TABLE 5-6.
BREAKDOWN OF PROJECT CAPITAL COSTS

Project ID	Construction Cost[a]	State Sales Tax[b]	Engineering/Legal/ Administration[c]	Construction Management[d]	Permitting[e]	**Total**
CR-1	$ 331,000	$ 28,000	$ 99,000	$ 33,000	$ 33,000	$ 525,000
CR-2	$ 338,000	$ 29,000	$ 101,000	$ 34,000	$ 34,000	$ 536,000
CR-3	$ 336,000	$ 29,000	$ 101,000	$ 34,000	$ 34,000	$ 533,000
CR-4	$ 275,000	$ 23,000	$ 83,000	$ 28,000	$ 28,000	$ 436,000
CUN-1	$ 294,000	$ 25,000	$ 88,000	$ 29,000	$ 15,000	$ 452,000
CUS-1	$ 416,000	$ 35,000	$ 125,000	$ 42,000	$ 42,000	$ 660,000
CUS-2	$ 220,000	$ 19,000	$ 77,000	$ 22,000	$ 11,000	$ 349,000
TC1-1	$ 215,000	$ 18,000	$ 75,000	$ 22,000	$ 22,000	$ 352,000
TC1-2	$ 102,000	$ 9,000	$ 36,000	$ 10,000	$ 5,000	$ 162,000
TC2-1	$ 367,000	$ 31,000	$ 110,000	$ 37,000	$ 37,000	$ 582,000
TC2-2	$ 169,000	$ 14,000	$ 59,000	$ 17,000	$ 17,000	$ 277,000
BBCS-1	$ 402,000	$ 34,000	$ 121,000	$ 40,000	$ 13,000	$ 611,000
				Total Project Capital Costs		$ 5,475,000

a. Includes 50 percent contingency
b. 8.5 percent of construction cost
c. 25 to 40 percent of construction cost
d. 10 percent of construction cost
e. 5 to 10 percent based on need for local, state, or federal permits

Figure 5-2. Capital Projects

CHAPTER 6.
IMPLEMENTATION PLAN

Stormwater plans typically include an implementation schedule for design and construction of capital projects. The projects are evaluated and scheduled over a 6-year period based on capital funding levels. For larger projects, implementation is typically split into two phases: design and permitting occurs first, followed by construction in a subsequent year. Very large and/or complex projects may require a separate planning phase preceding the design and permit phase.

EVALUATION OF CAPITAL PROJECTS

The CIP prioritization process for this master plan used the evaluation-criteria method developed for the Central North Subwatershed Plan. This method rates projects and assigns a score that reflects the priorities set by the BBWARM Advisory Committee in 2010 (see Appendix D). Capital projects were prioritized using equally-weighted evaluation criteria in the following categories:

- The environmental benefit category includes a sediment reduction score in addition to the shellfish/fish habitat score. Higher scoring projects provide a greater improvement in habitat and greater sediment reduction. No points are awarded for projects that do not improve the current conditions.
- The community benefit category evaluates the reduction in flood frequency and magnitude, property damage (structure flooding), street flooding and public safety issues. No points are awarded for projects that only resolve nuisance property and road flooding.
- The implementation category considers project cost, permitting, property/easement acquisition, and coordination with other project and agencies. No points are assigned for projects that require a complex permitting process or where condemnation is necessary for property acquisition. Projects needed to meet regulatory requirements are scored significantly higher to ensure a high priority.
- Local support was given its own category in recognition of the need for strong support within the community to ensure project success.

The project scoring and ranking are summarized in Table 6-1. Appendix D presents the full prioritization analysis.

IMPLEMENTATION SCHEDULE

A schedule for implementation of the capital projects outlined in this subwatershed should be incorporated into the annual BBWARM 6-year capital improvement program plan review. Implementation schedule for capital projects should consider funding, project priority and coordination with the Birch Bay Drive and Pedestrian Facility project. Generally, project implementation would be spread out over two years, with the engineering and permitting completed the first year and construction completed the following year.

TABLE 6-1.
PROJECT SCORING AND RANKING

Subwatershed Rank	Score	Project Name [a]
1	33	TC2-1: Morrison Avenue/Terrell Drive Neighborhood Storm Drain Improvements
2	30	TC2-2: Wooldridge Drive Storm Drain Improvements
3	30	CR-1: Birch Bay Drive at Harborview Road Storm Drain Improvements
4	27	TC1-1: Birch Bay Drive Storm Drain Improvements North of Alderson Road
5	27	CR-2: Harborview Road Storm Drain and Outfall Improvements
6	26	CUS-2: Birch Bay Drive at Club House Drive Storm Drain Improvements
7	26	CR-3: Birch Bay Dr. at Mariners Cove Storm Drain Imp. and Outfall Repl.
8	25	CR-4: Mariners Cove/Latitude 49 Storm Drain Trunk Line Replacement
9	24	CUS-1: Birch Bay Drive Storm Drain Improvements North of Lora Lane
10	23	BBCS-1: Subwatershed Water Quality Retrofit
11	18	TC1-2: Lora Lane Tide Gate Modifications
12	16	CUN-1: Birch Bay – Lynden Road Roadside Storm Drainage Improvements

a. See Figure 5-2 for project location.

COORDINATION WITH PLANNED BIRCH BAY DRIVE AND PEDESTRIAN FACILITY PROJECT

The Birch Bay Drive and Pedestrian Facility Project (CRP #907001) is a major Whatcom County project currently (December 2014) in the preliminary engineering phase which includes right-of-way, permitting, and design. Many of the projects identified in this subwatershed master plan should be coordinated with this proposed project as planning progresses.

This Birch Bay Drive and Pedestrian Facility Project will improve the near-shore environment along Birch Bay from the mouth of Terrell Creek to Cottonwood Beach. The primary objective for this project is to protect Birch Bay Drive in an ecological and sustainable manner. Other aspects include improved pedestrian safety and an off road pedestrian path. The project will entail the following (Whatcom County, 2012):

- Remove the riprap, sea walls, groins, and bulkheads along Birch Bay Drive and replace them with a “natural” soft shore beach.
- Reestablish the beach profile and improve flood protection for the roadway and adjacent structures.
- Replace and retrofit substandard stormwater facilities and outfalls to improve water quality for this significant shellfish area.
- Provide beach access and an off road pedestrian path as a portion of the Coast Millennium Trail.

The problem investigation and hydraulic analysis completed for this master plan identified undersized stormwater outfall pipes crossing Birch Bay Drive that would need to be upgraded to safely convey stormwater to Birch Bay. Outfall pipe systems will need to be designed to safely convey peak flows from tributary drainages and may need to extend some distance upstream of Birch Bay Drive. If the outfall at Club House Drive is replaced, a fish passable structure would need to be installed. In addition, the outfall at Harborview Road is broken and needs to be replaced.

Outfalls frequently become obstructed with debris or filled with sand and require frequent maintenance to remain free-flowing. Outfall replacement should include an evaluation of the need for tide valves to prevent backflow from Birch Bay into the storm drain system. Flexible, neoprene tide valves are recommended because they are self-cleaning and able to function with a minor amount of obstruction. Swing-type tide gates are not appropriate for this condition because sand deposition at the outlet can interfere with free operation of the gate. To ensure operation of the valve, the outfall structure should be configured to prevent sediment from accumulating at the discharge point. As an added safety precaution, a pressure relief and positive overflow path should be in the outfall system near Birch Bay Drive so that overflow can be conveyed to the bay in case the structure does become obstructed.

Roadway improvements should include a dedicated storm drain system that meets Whatcom County drainage design standards (Whatcom County, 2002) and prevents flooding on neighboring properties. The problem investigation identified numerous areas along Birch Bay Drive where topographic depressions collect stormwater runoff during rainfall events and cause adjacent properties to flood. Storm drain improvements should provide drainage of these existing low spots on the landward side of Birch Bay Drive. Capital projects CR-2 and CUS-1 address the local drainage issues in the Central South Subwatershed.

Storm drain system design should consider provisions to disconnect the upland drainage system from the local road drainage system along Birch Bay Drive. Problem CR-11 identified flooding at Mariners Cove and along Birch Bay drive which is aggravated by inflow from the upper level system connection at Mariners Cove. Separating these systems would also eliminate the upland contribution to flooding that occurs during a high tide event where stormwater backflows through the open grate catch basin along Birch Bay Drive due to a high tailwater condition. The elevated pressure associated with a separate high-level system would drive the stormwater flow directly to the Birch Bay outfall rather than ponding on Birch Bay Drive.

The watercourse draining the Central Upland North and Central Uplands South subbasins has been identified as a Type F stream capable of supporting salmonoid habitat. This watercourse also connects to the large wetland area between Leisure Park and the Sea Links Golf Course. Future replacement of the outfall at Club House Drive would need to consider fish passage in its design. Fish passage will also need to be maintained if any modifications are made to the Lora Lane tide gate (see CIP project TC1-2).

Stormwater should be managed using low-impact development techniques to the greatest extent feasible. Water quality treatment is required for a new and replaced impervious area. Retrofit opportunities should be incorporated to the greatest feasible extent to address documented water quality issues.

INCORPORATING THE MASTER PLAN INTO THE OVERALL STORMWATER PROGRAM

As part of its comprehensive planning effort, Whatcom County has adopted the Birch Bay Comprehensive Stormwater Plan (CH2M Hill, 2006). Approved subwatershed master plans are incorporated into the Stormwater Plan during plan updates or when added as an addendum. Priorities and timeframes from the comprehensive subwatershed plans must be integrated with other County needs to fit within the overall priorities and budget for the County.

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APPENDIX A. STORMWATER INVENTORY

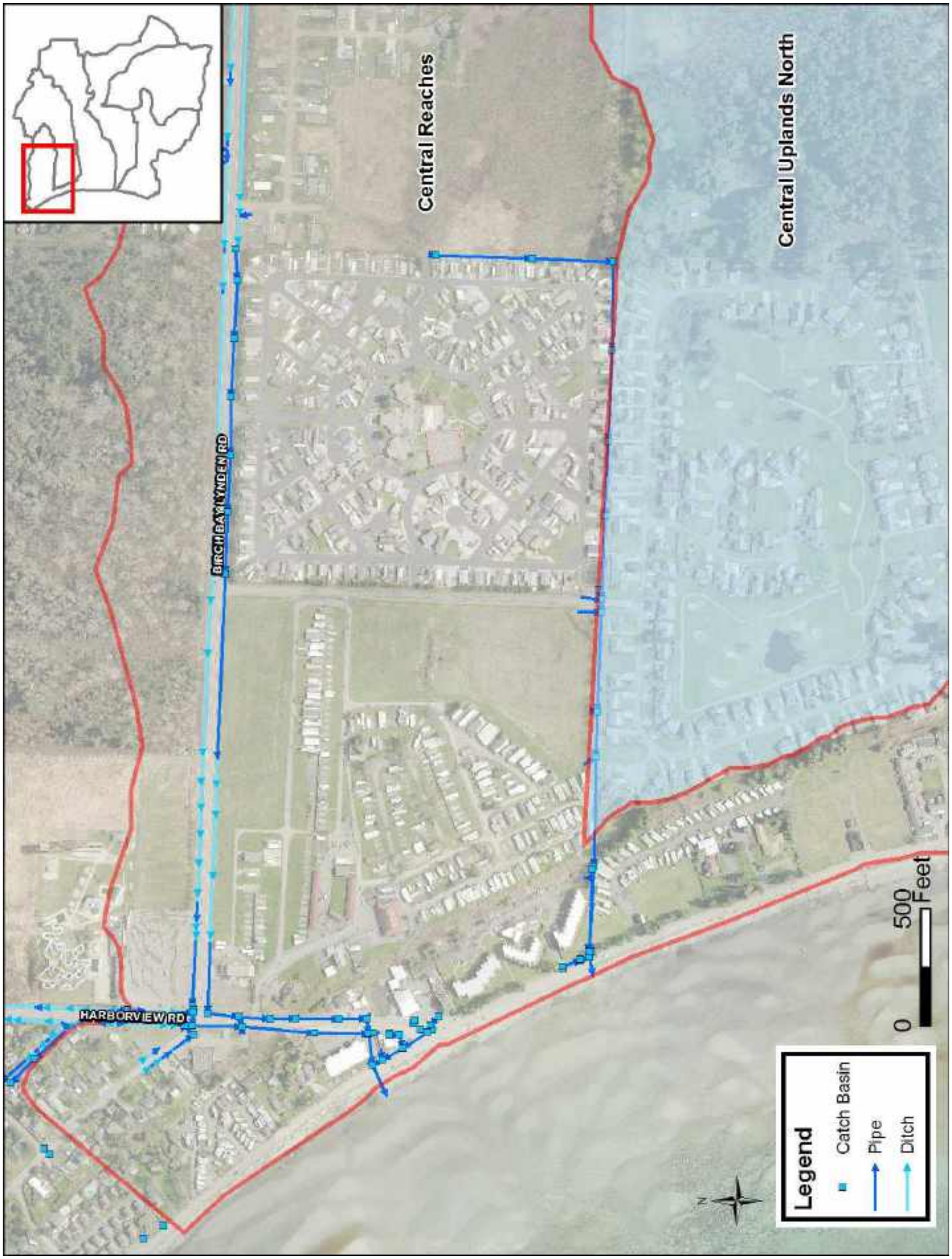

Figure A-1 Stormwater Inventory – Central Reaches Subbasin

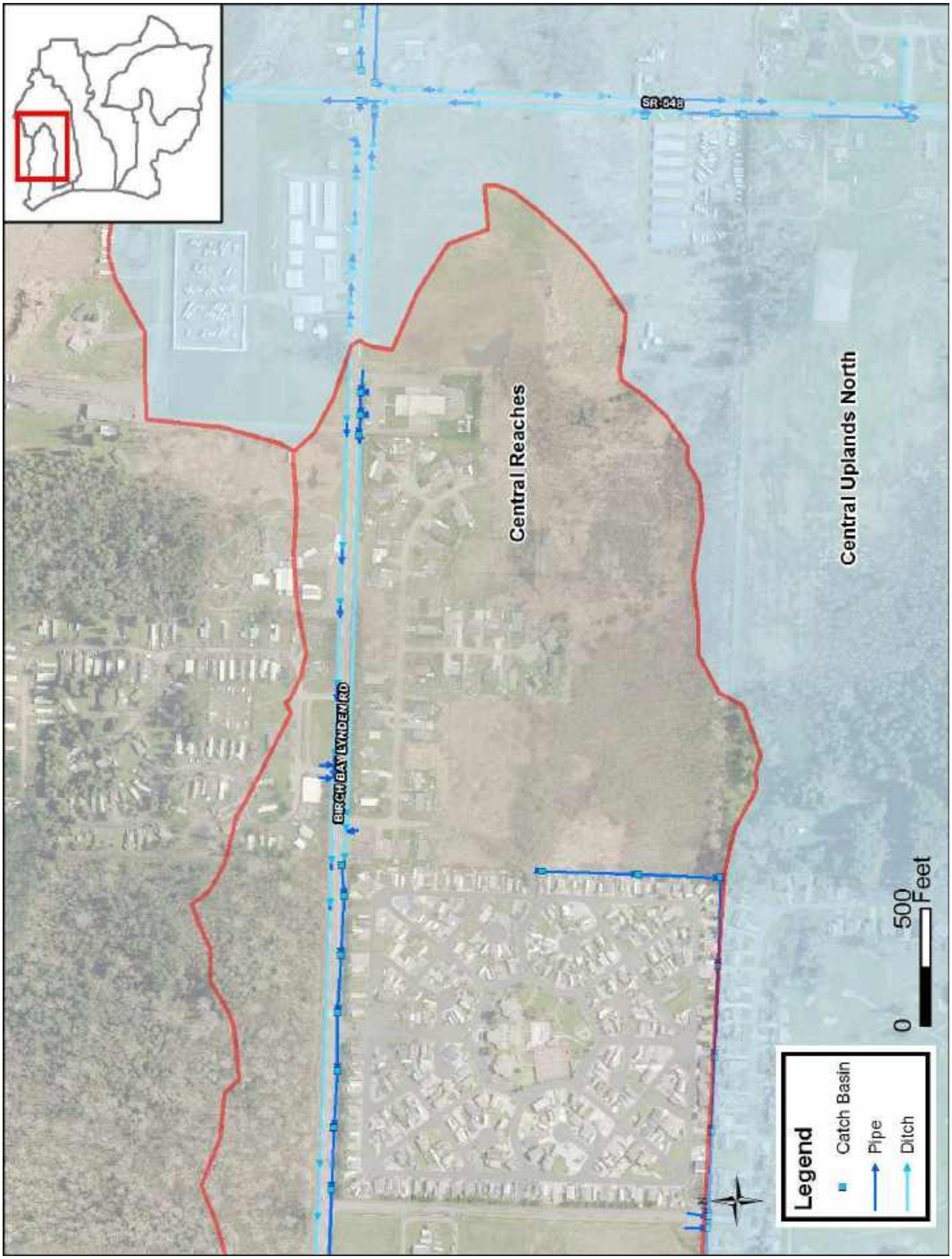

Figure A-2 Stormwater Inventory – Central Reaches Subbasin

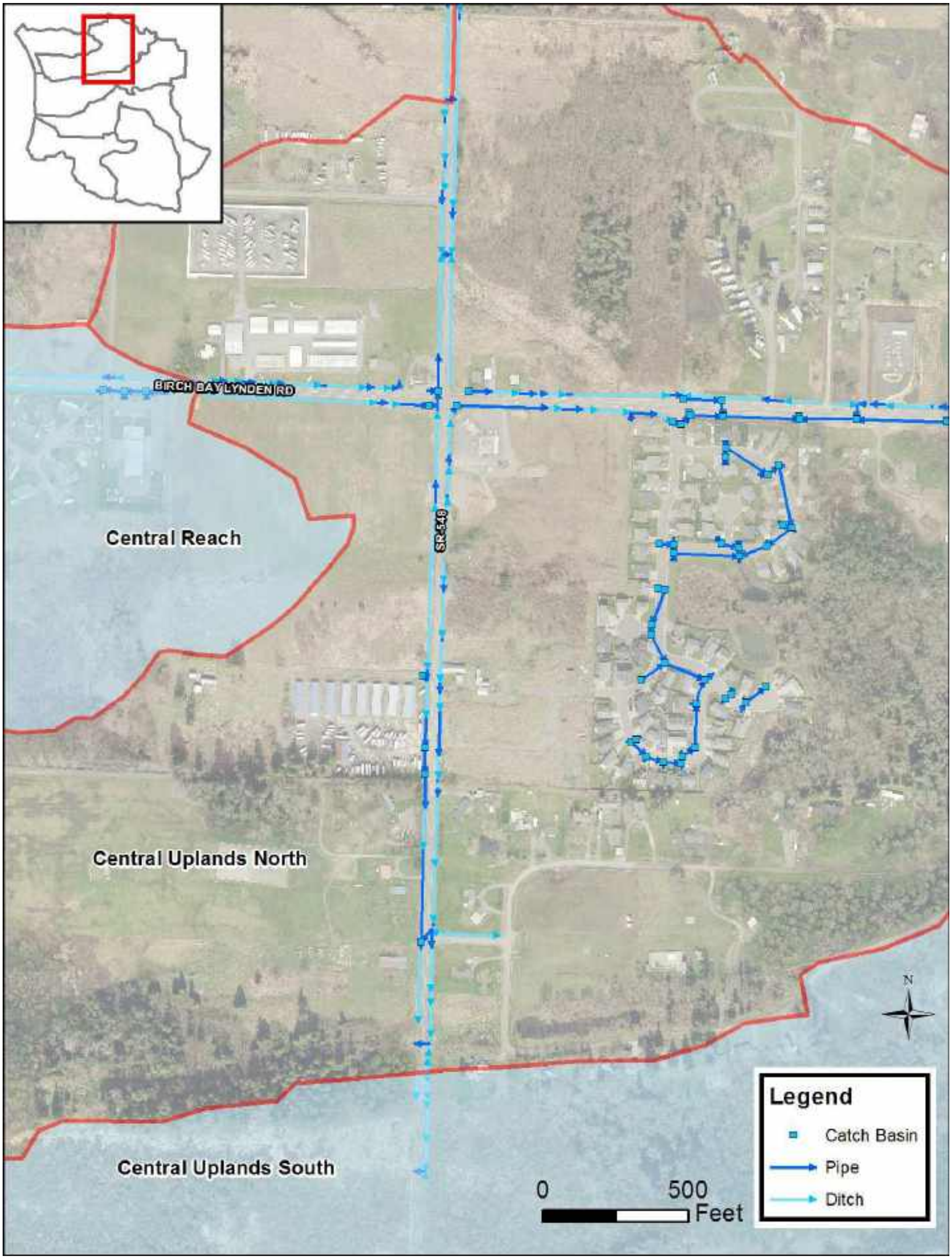

Figure A-3 Stormwater Inventory – Central Uplands North Subbasin

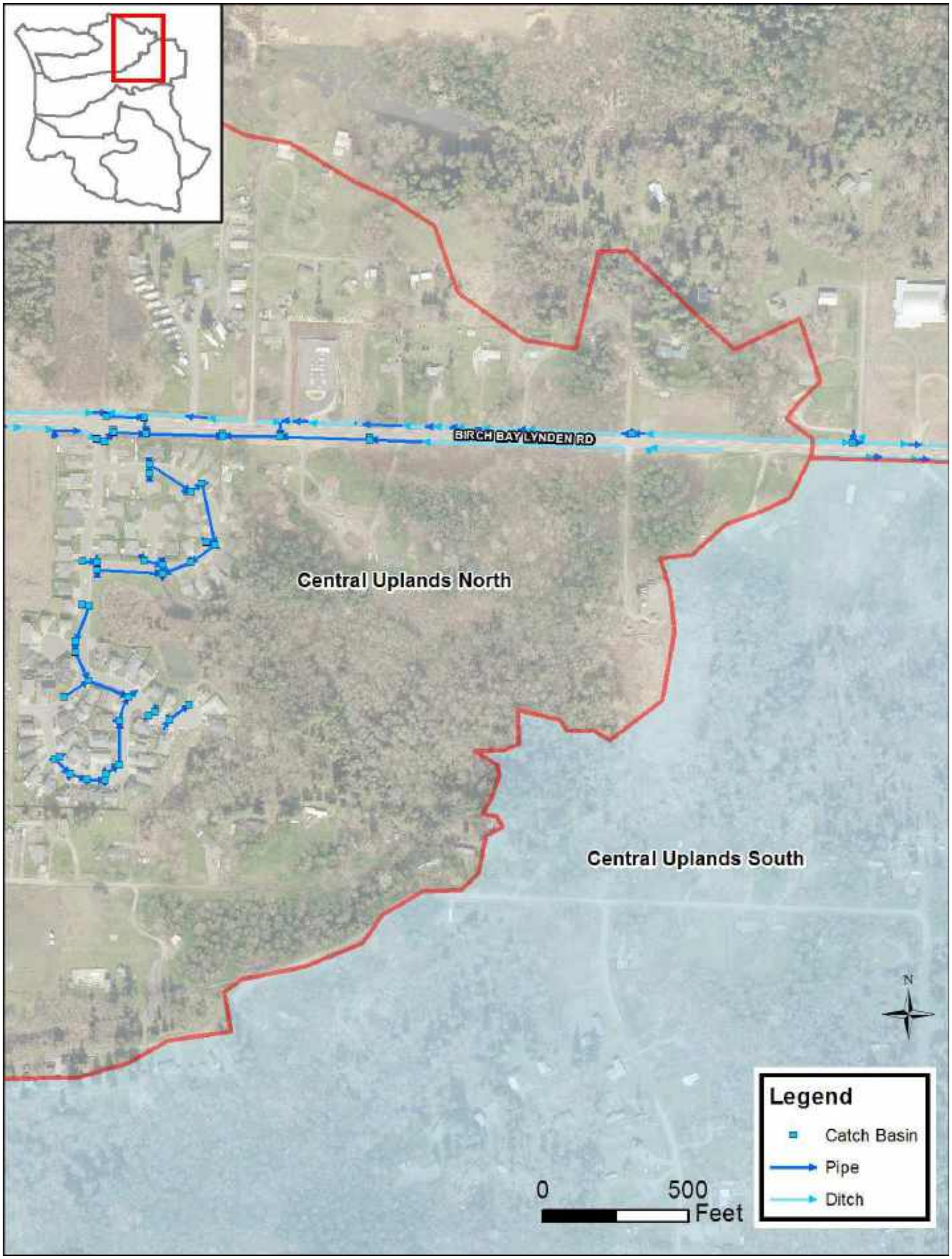

Figure A-3 Stormwater Inventory – Central Uplands North Subbasin

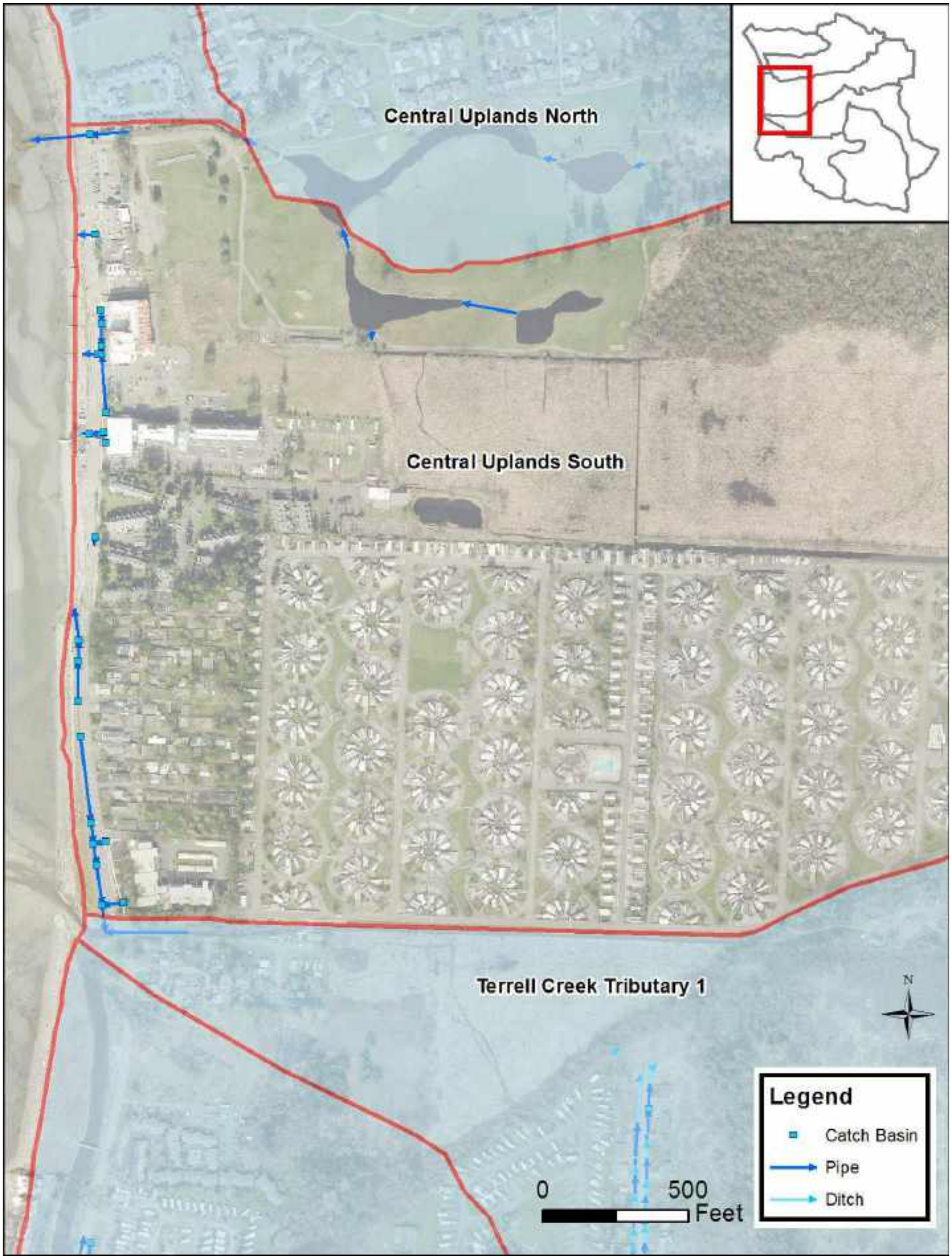

Figure A-4 Stormwater Inventory – Central Uplands South Subbasin

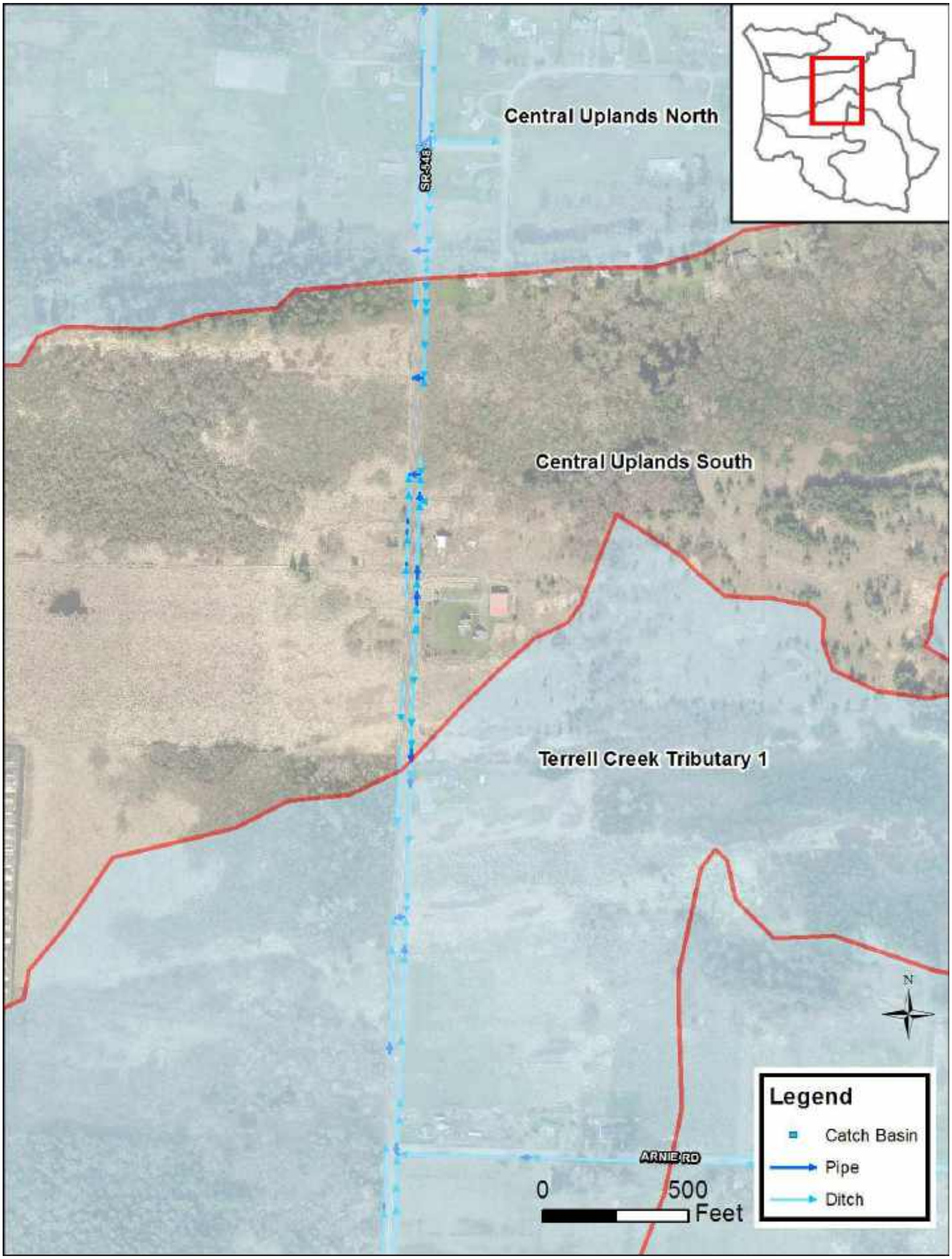

Figure A-5 Stormwater Inventory – Central Uplands South Subbasin

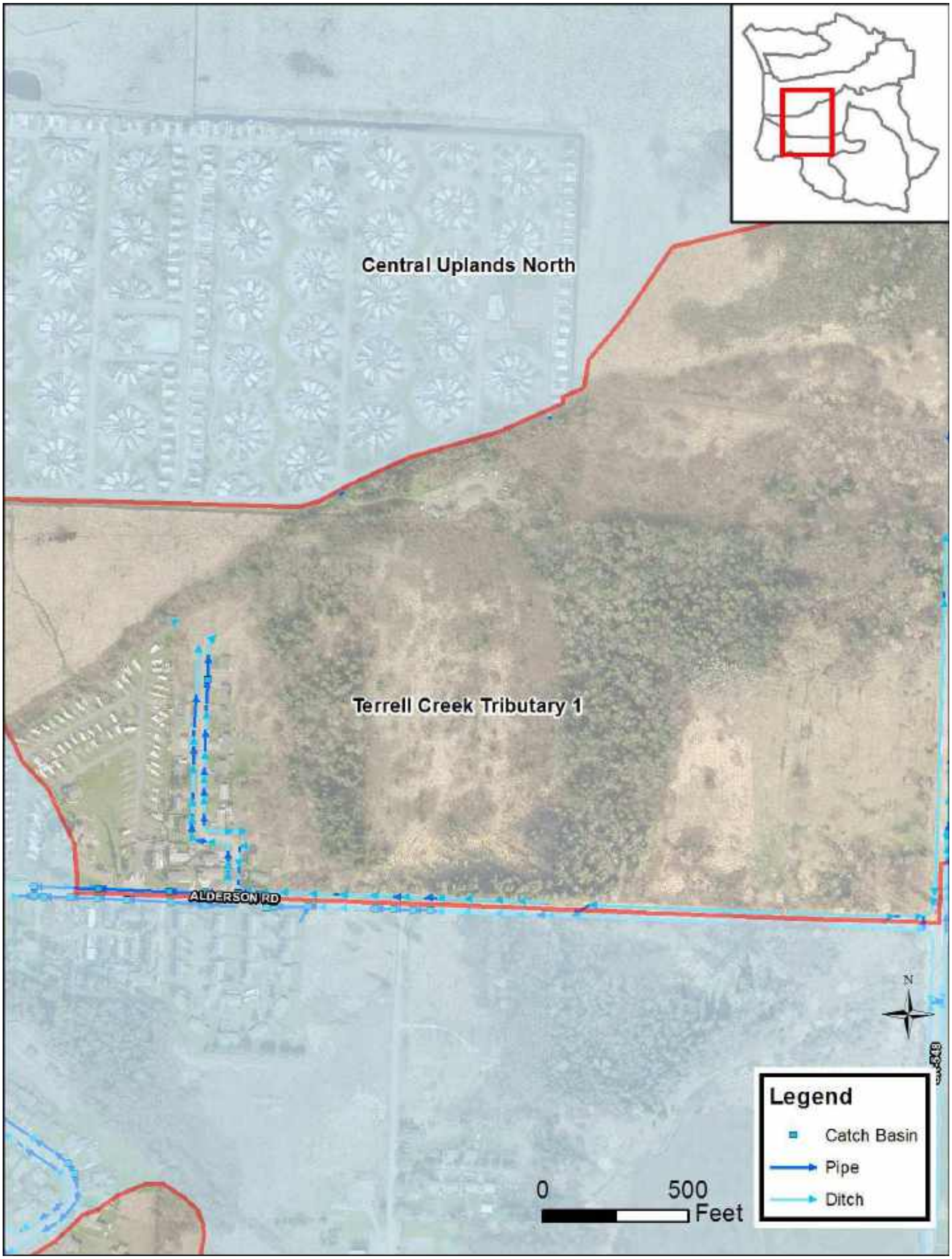

Figure A-6 Stormwater Inventory – Terrell Creek Tributary 1

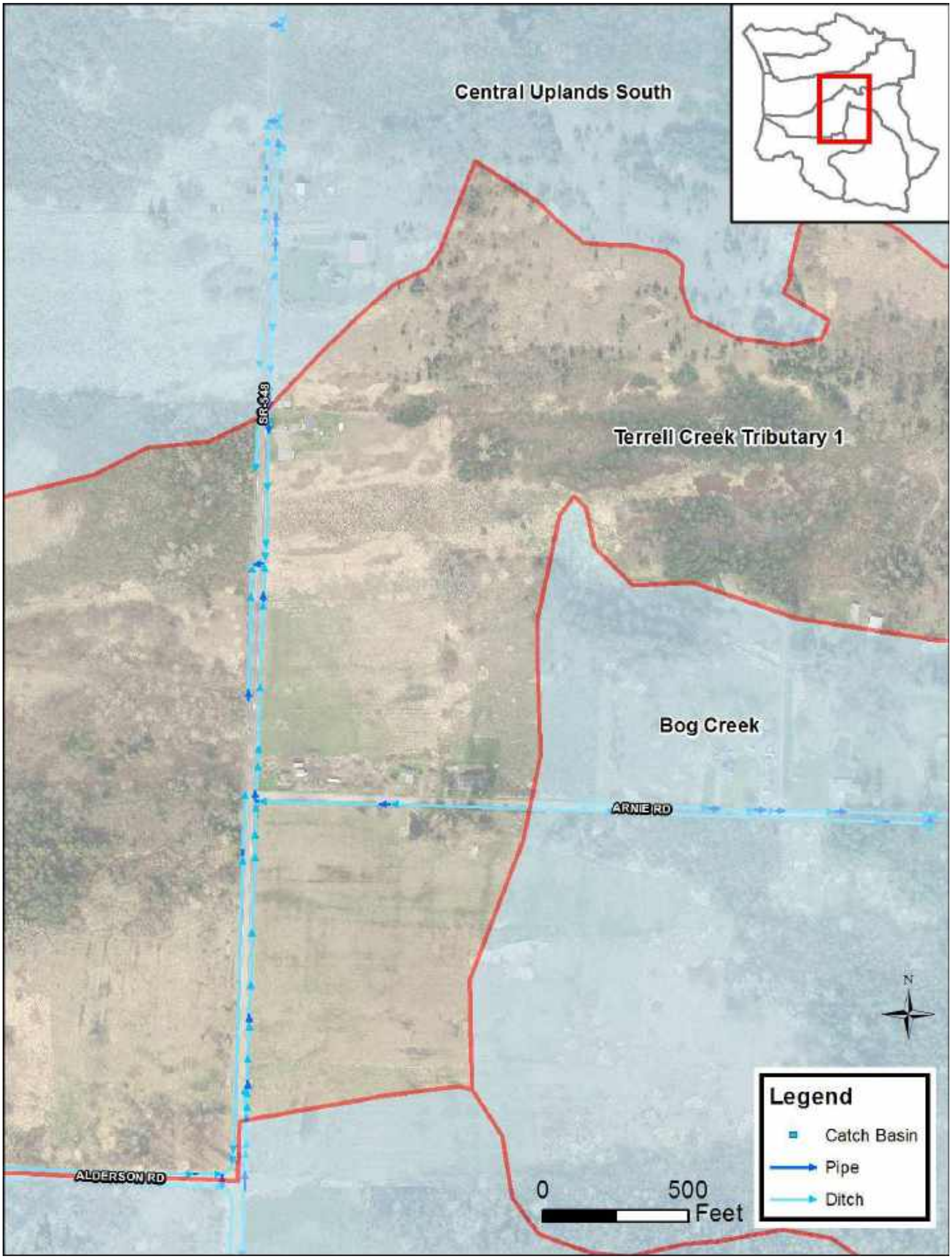

Figure A-7 Stormwater Inventory – Terrell Creek Tributary 1

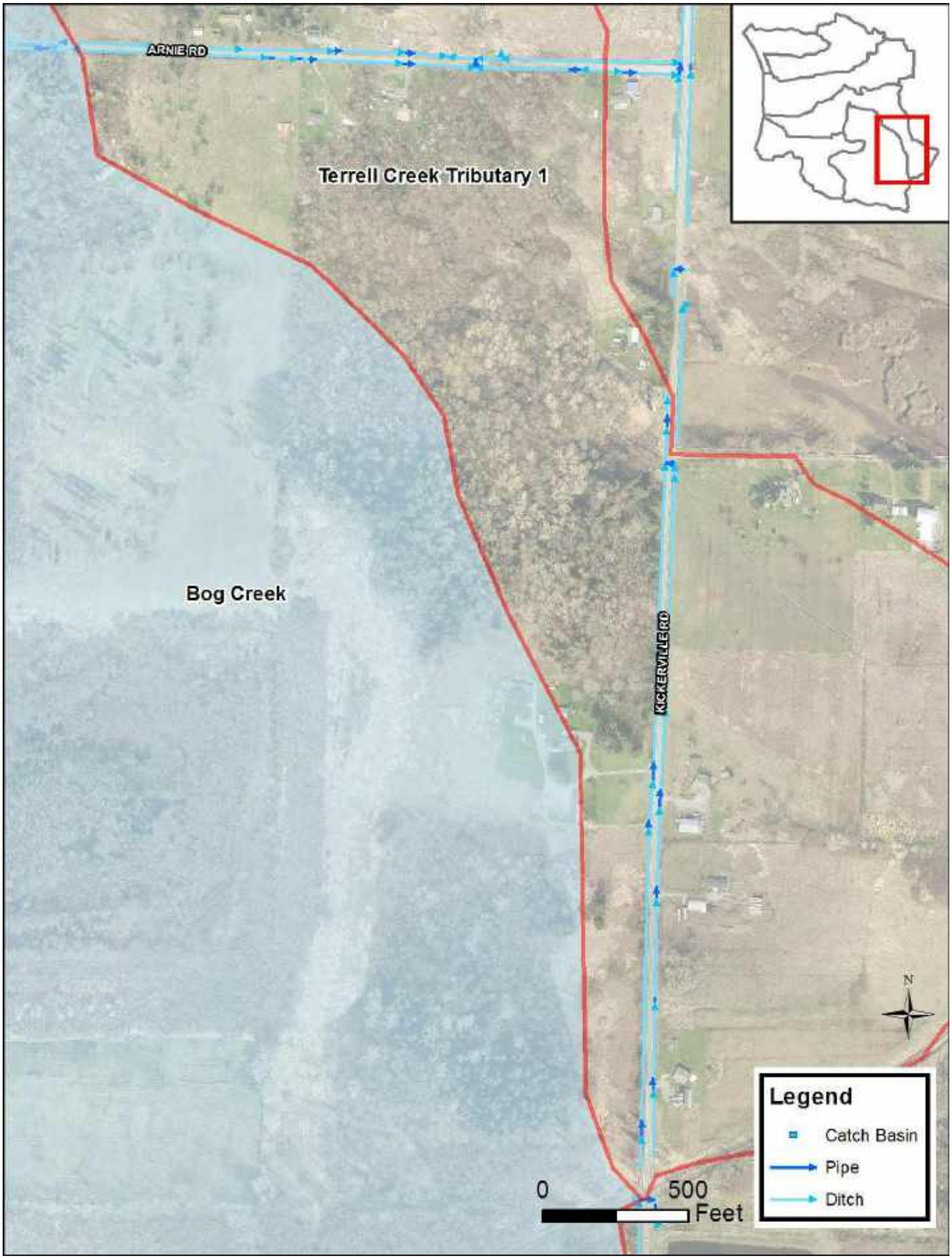

Figure A-8 Stormwater Inventory – Terrell Creek Tributary 1

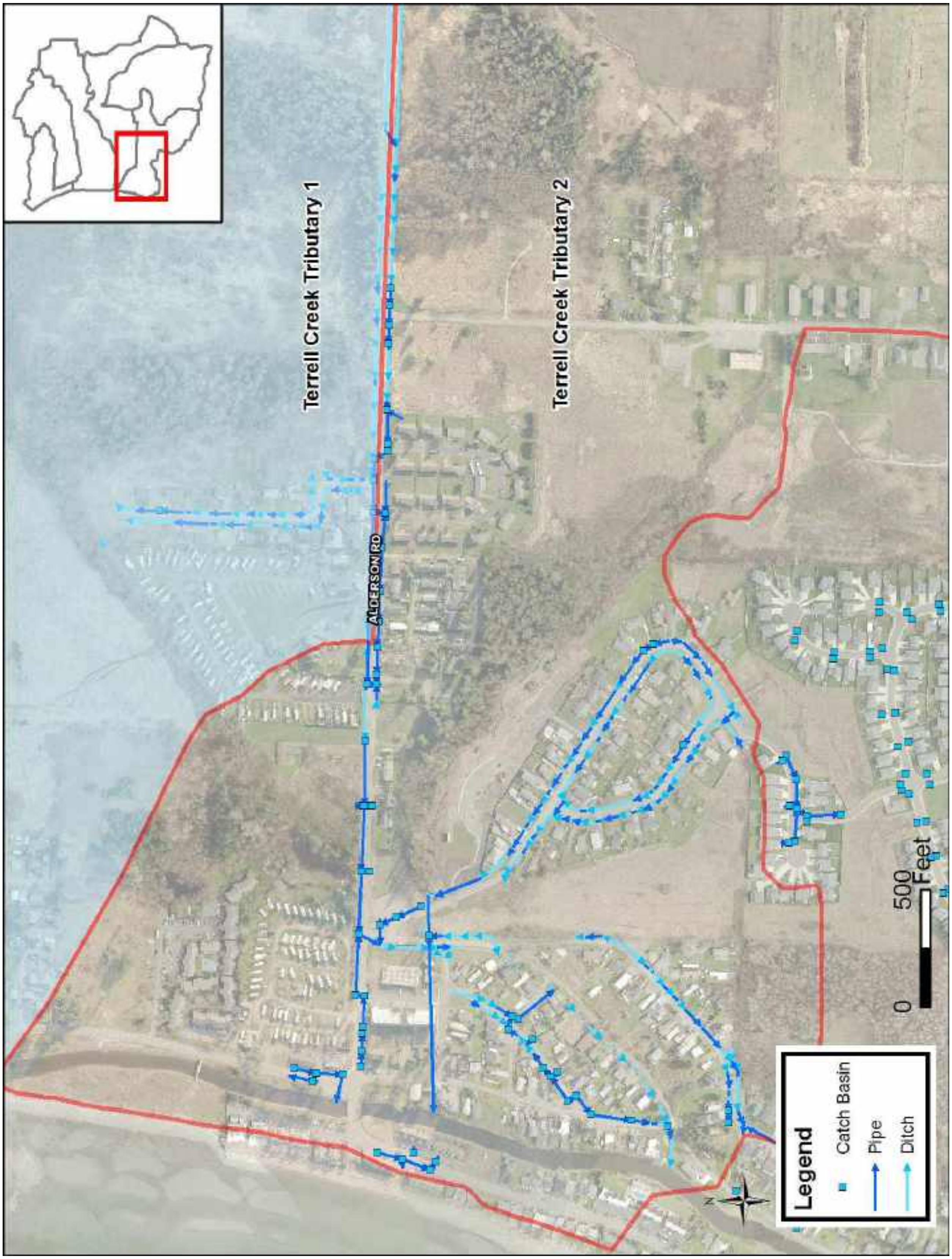

Figure A-9 Stormwater Inventory – Terrell Creek Tributary 2

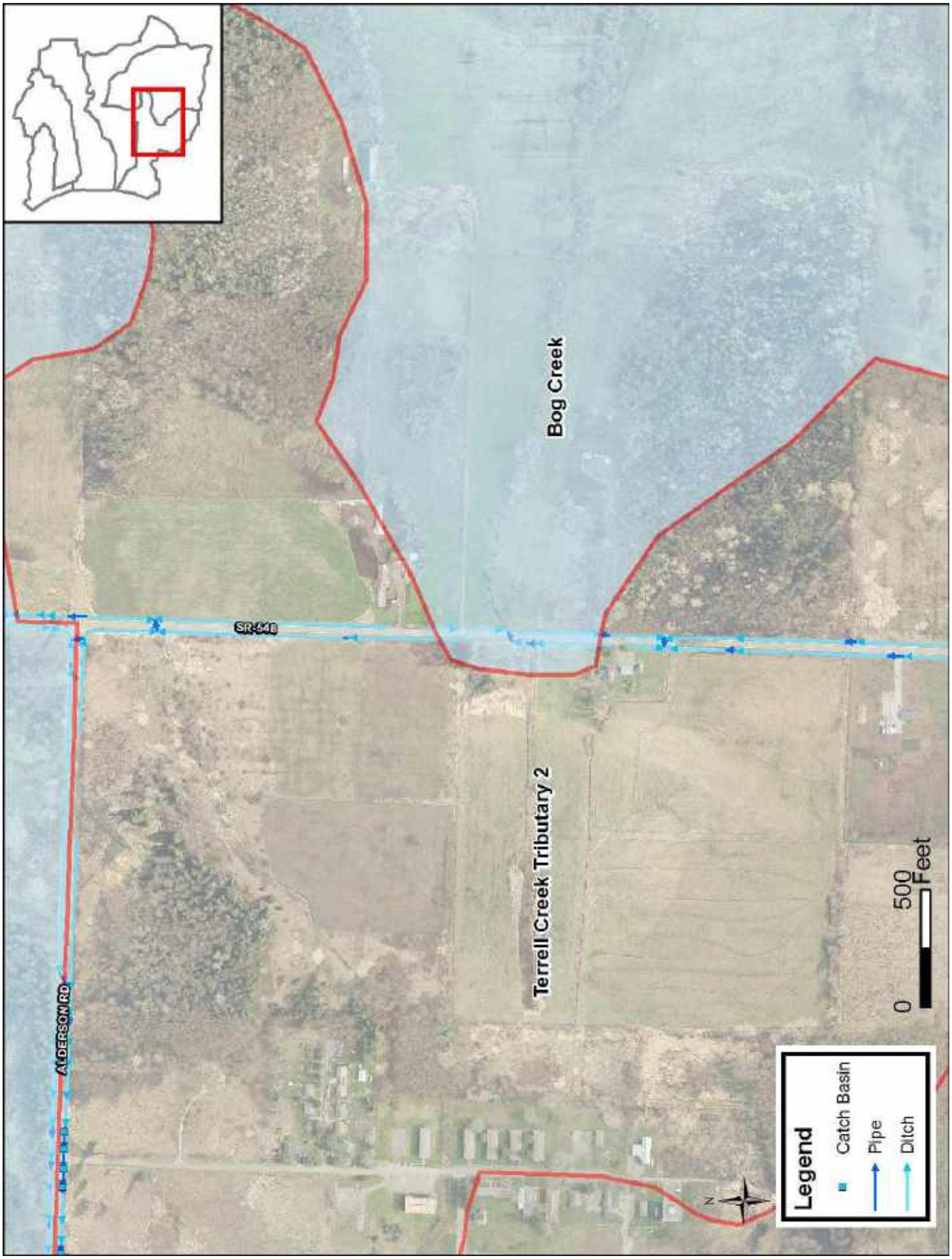

Figure A-10 Stormwater Inventory – Terrell Creek Tributary 2

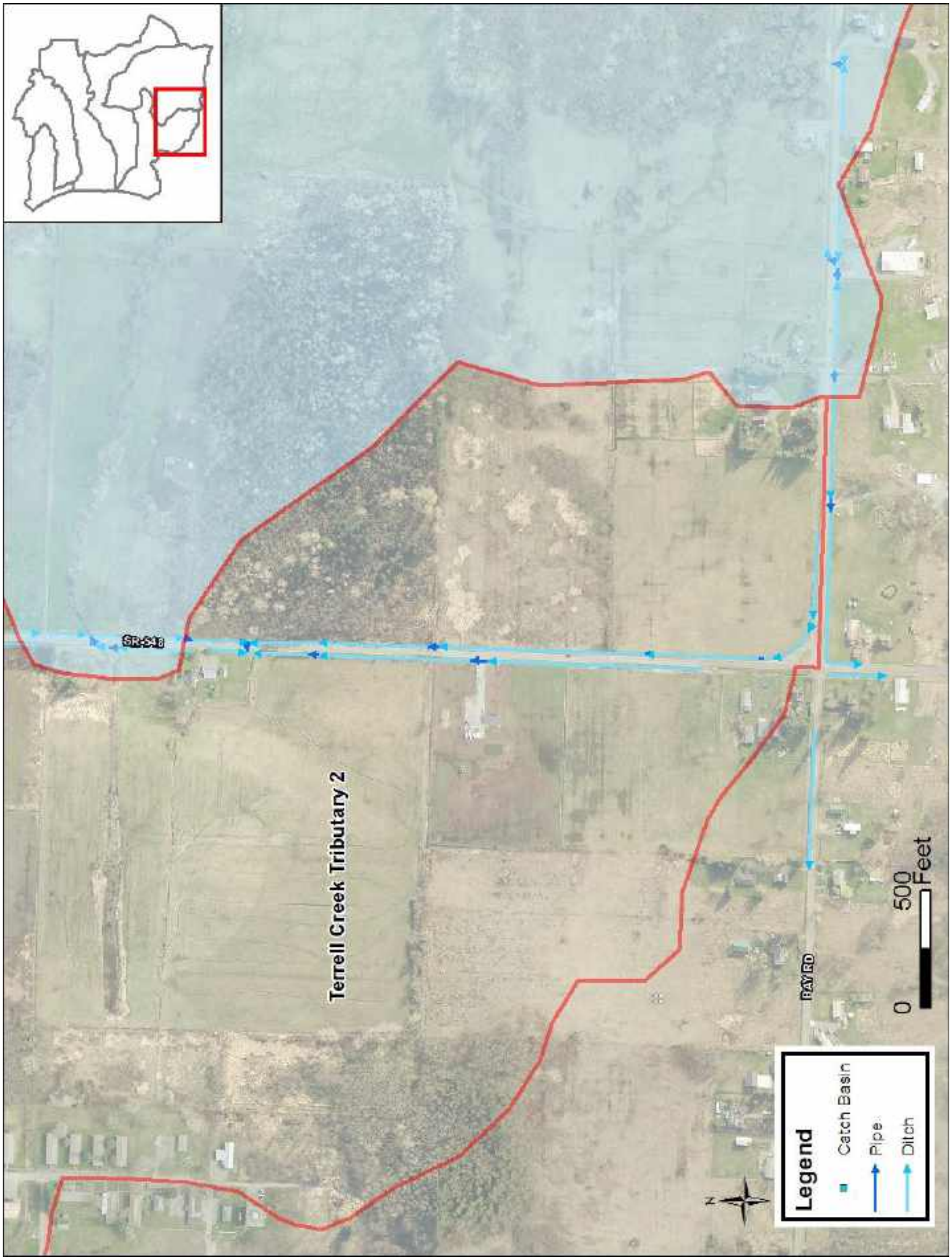

Figure A-11 Stormwater Inventory – Terrell Creek Tributary 2

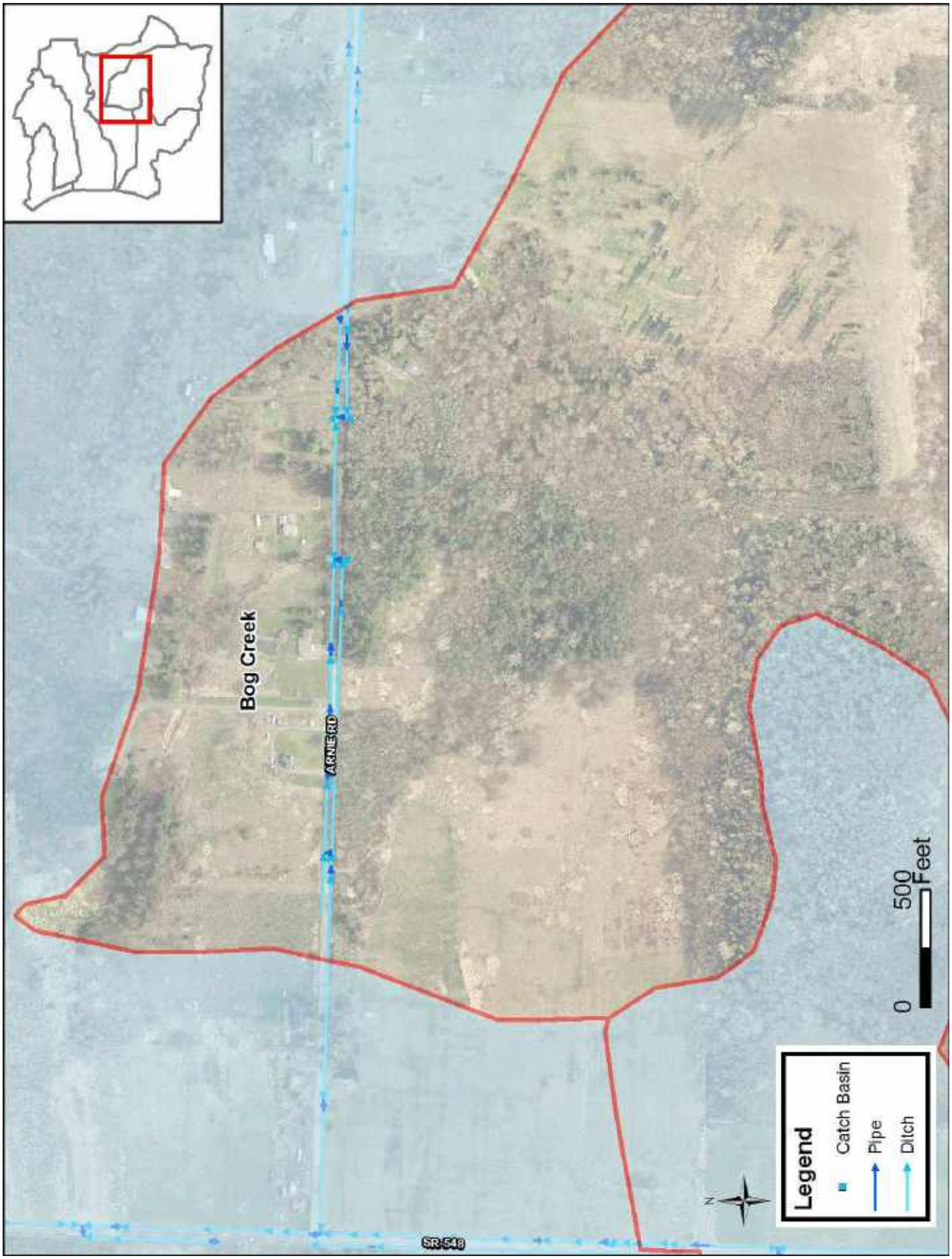

Figure A-12 Stormwater Inventory – Bog Creek

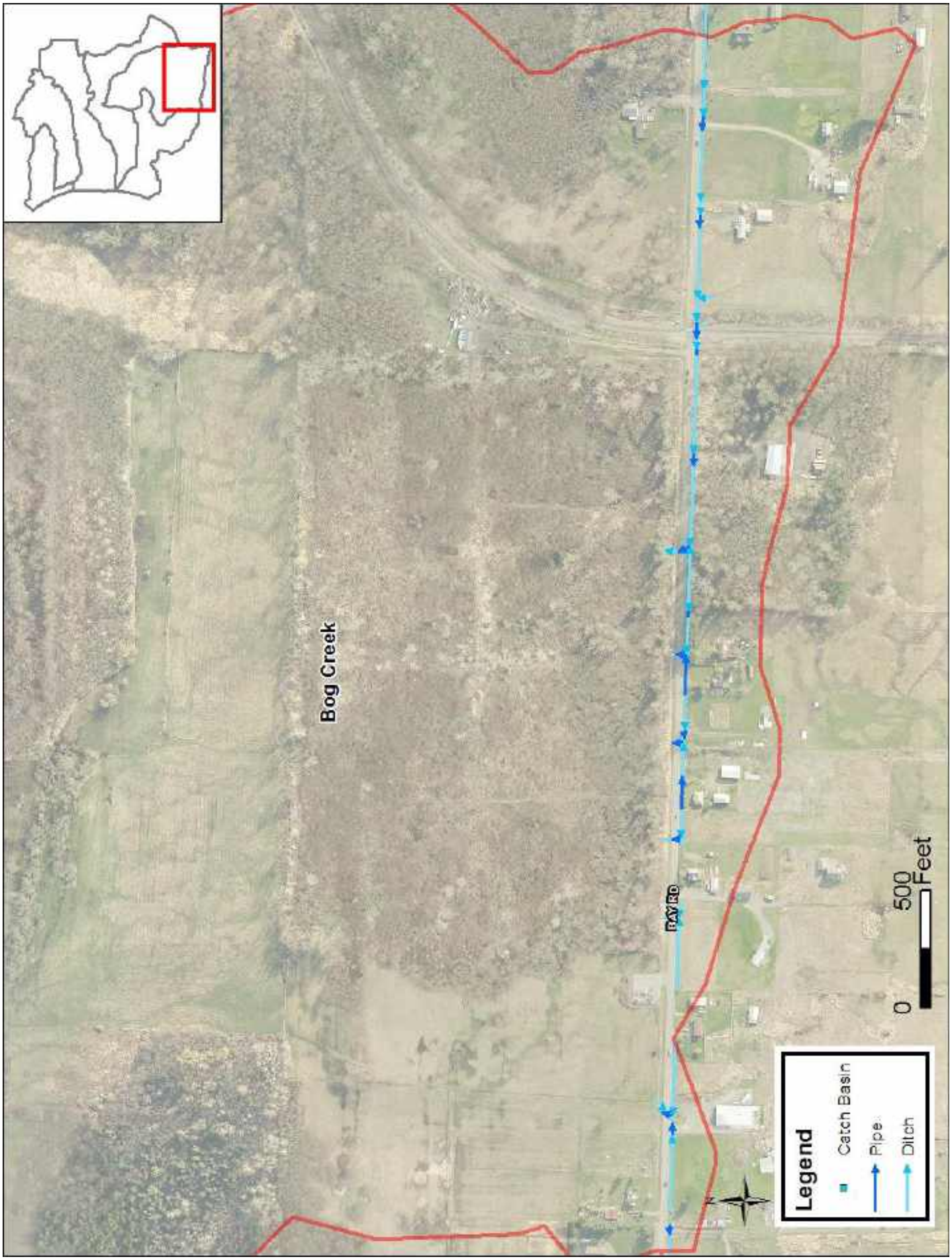

Figure A-13 Stormwater Inventory – Bog Creek

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Central South Subwatershed Master Plan

APPENDIX B.
HYDROLOGIC AND HYDRAULIC ANALYSIS

TETRA TECH

Technical Memorandum

Whatcom County Public Works Stormwater Division
HYDROLOGIC AND HYDRAULIC ANALYSIS OF THE SURFACE WATER SYSTEM IN THE CENTRAL SOUTH SUBWATERSHED

January 2015

INTRODUCTION

Hydrologic and hydraulic analysis was performed for the subbasins of Whatcom County's Central South subwatershed on the east side of Birch Bay. The purpose of this analysis was to support planning efforts for the Central South Subwatershed Master Plan. The objectives of the hydrologic and hydraulic modeling are as follows:

- Develop an understanding of the hydrologic regime in the Central South subwatershed.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems in the subbasins.

The storm drainage system was analyzed using the HSPF model (USEPA, 2005) to simulate runoff from each subbasin and the SWMM5 model (USEPA, 2011) to analyze the hydraulics of natural and constructed surface water drainage systems. The models developed for this study are planning level models. Planning level models are typically developed at a coarser scale than design models and are useful for estimating system flow rates, identifying potential problem areas, sizing infrastructure improvements for cost estimating purposes, and analyzing relative impacts of land use changes. Detailed survey data were used for this analysis, which improves the model accuracy, but care should still be taken in interpreting the results. If the findings from this analysis are used for design, model development should be critically reviewed to be sure the assumptions used are applicable and that appropriate safety factors are incorporated into the design process. No calibration was performed for this analysis.

HYDROLOGIC MODEL DEVELOPMENT

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration, and ground infiltration. Runoff from discrete subbasins is routed through rating tables used to represent pipes, channels, lakes, and other flood storage areas.

Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct surface runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to stream channels but at a slower rate than direct runoff. Groundwater also discharges to stream channels that intersect the saturated zone, contributing to long-term base flow in the system. Groundwater can also leave the surface watershed by entering deep groundwater or moving outside the watershed basin.

Subcatchment Delineation and Hydrologic Response Unit Assignment

The Central South subwatershed was previously delineated as six subbasins; the subbasins evaluated in this technical memorandum are based on the original delineations and include Central Reaches, Central Uplands

North, Central Uplands South, Terrell Creek Tributary 1, Terrell Creek Tributary 2, and Bog Creek. These subbasins are divided into 37 subcatchments based on topography and hydraulic control points. The Central South subwatershed and the resulting subcatchments are shown on Figure 1.

The subwatershed is divided into 34 categories of hydrologic response units, which are groupings of land cover types based on soils, land cover and topography. Soils and land slope are shown in Figures 2 and 3. Hydrologic response units are categorized in HSPF as pervious or impervious. Impervious area estimates developed for the watershed characterization study (ESA Adolfson, 2007) were used as the impervious area input to the HSPF model. The measured impervious area was assumed to be directly connected, based on a comparison that showed the computed impervious fractions for representative land uses to be close to published values for the same land uses (Ecology, 2005). The HSPF model used regional input parameters appropriate for the Puget Sound area (Dinicola, 1990 and Clear Creek Solutions, 2006). Attachment A presents input parameters.

Land Use

Flow characteristics were computed for existing land use conditions at the 37 subcatchments in the Central South subwatershed. Existing conditions land use is based on 2013 aerial photography provided by Whatcom County. Existing condition land use and impervious area is shown in Figure 4.

Climate Data

Long-term precipitation data collected at Blaine from 1948 to 2012 was used to compute a continuous flow record. Long-term average precipitation values were compared to precipitation data collected by the Birch Bay Water and Sewer District and found to be about equal to the District data. Potential evaporation data was developed from pan evaporation data collected at the Washington State University Extension in Puyallup, Washington, adjusted by a factor 0.76 to account for regional differences in potential evapotranspiration.

Existing Conditions Runoff

Runoff time-series computed for existing conditions and were exported from the HSPF model for each subcatchment shown in Figure 1. The HSPF mode did not include drainage elements so routed peak flow rates were not computed for HSPF subbasins.

Flow Control for Future Development

In 2013, the Birch Bay UGA, which includes portions of the Central South subwatershed, was added to Whatcom County's National Pollutant Discharge Elimination System (NPDES) Phase II permit coverage area. Coverage under this permit requires the County to implement minimum standards for maintenance of the existing stormwater system. Flow control and water quality treatment for new development will be required to meet more stringent minimum technical requirements specified in the 2012 *Stormwater Manual for Western Washington* by December 31, 2016. Until that time, Whatcom County has specified the use of the 2005 manual (Ecology, 2005). Stormwater flow control requirements have the potential to significantly reduce stormwater runoff from developing areas. For this reason, future conditions flow rates would not provide useful information on drainage problems and were not analyzed for this plan.

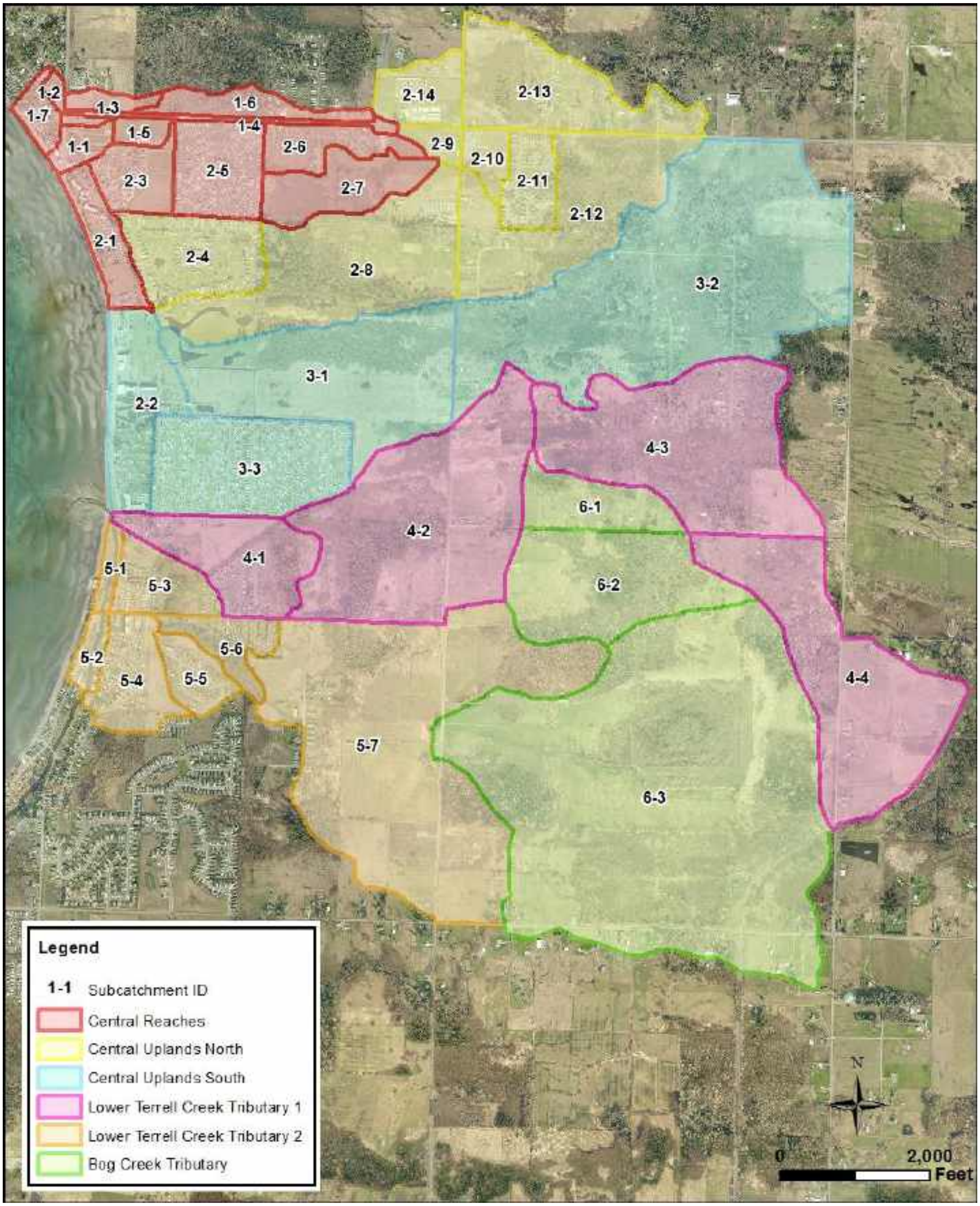

Figure 1. Central South Subwatershed Subcatchments

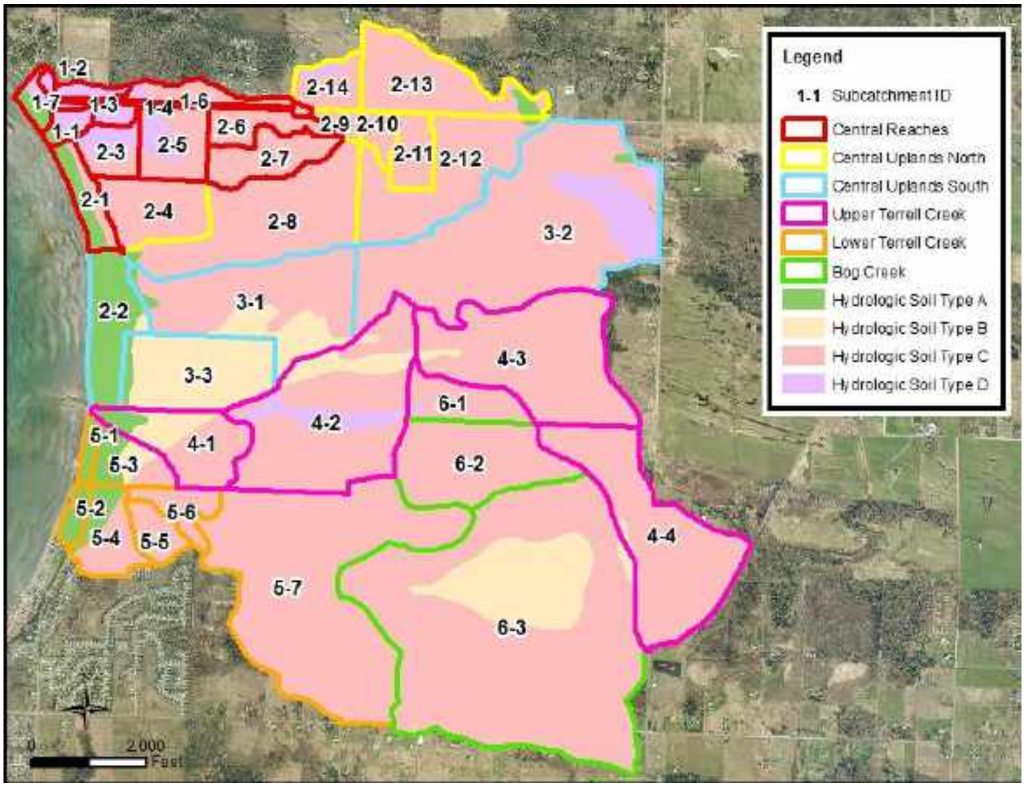

Figure 2. Soils

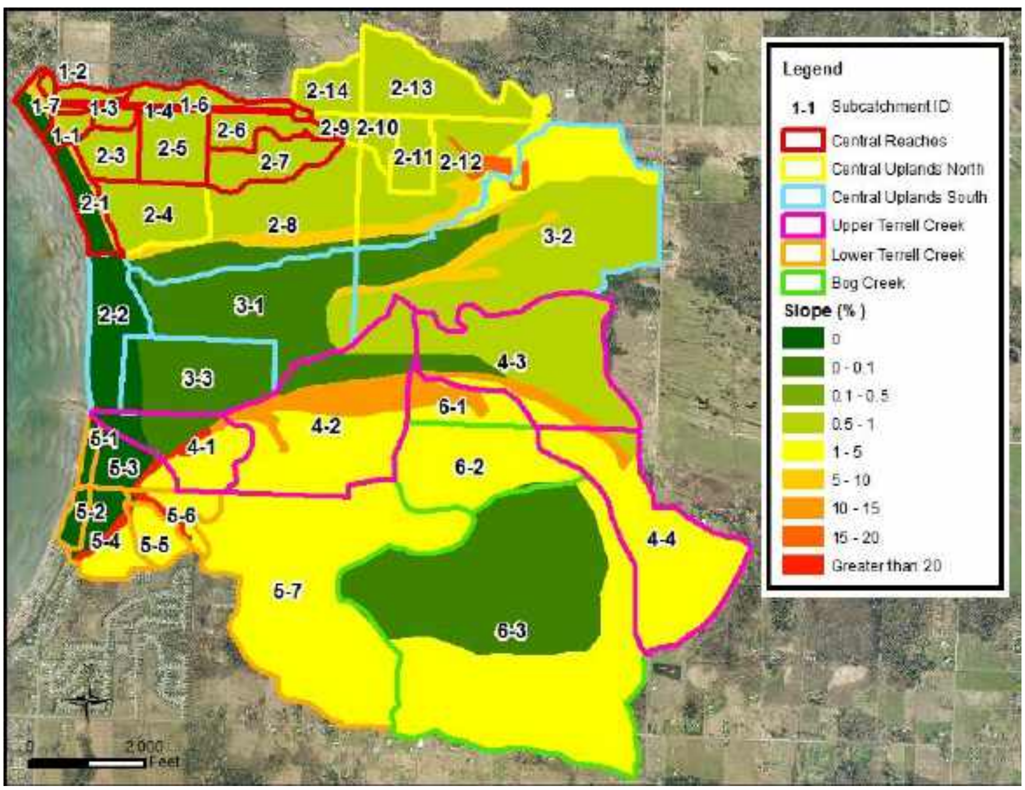

Figure 3. Slopes

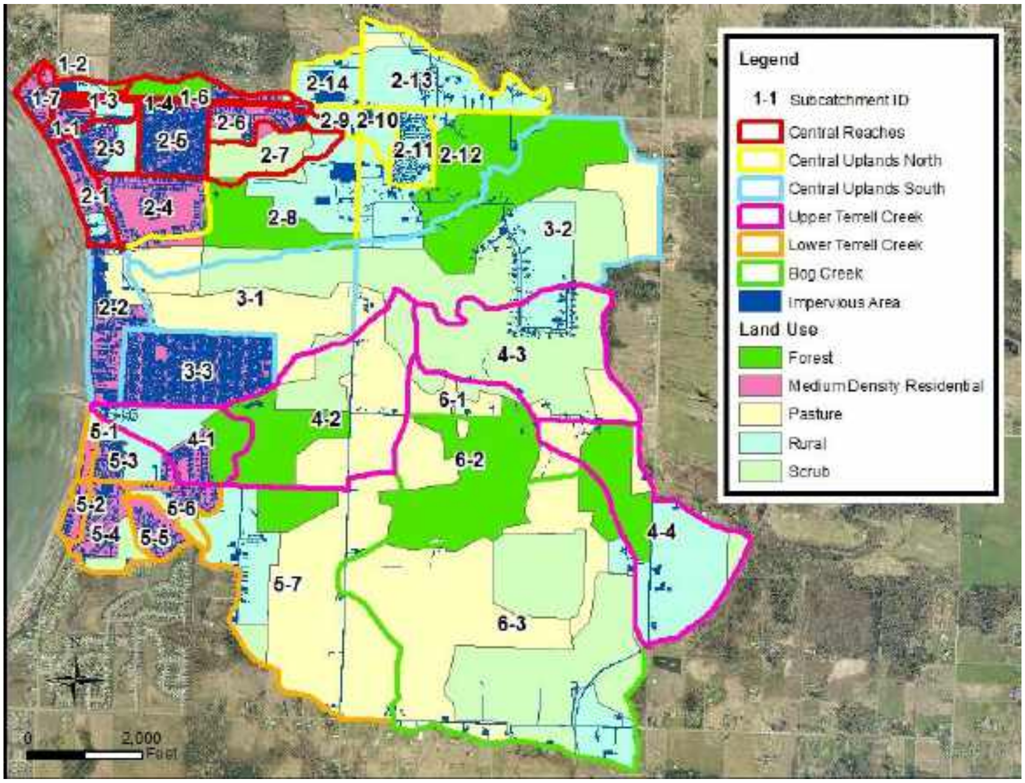

Figure 4. Existing Land Use

HYDRAULIC MODEL DEVELOPMENT

The storm drainage system in the Central South subwatershed is complex and requires a sophisticated hydraulic model such as the SWMM5 model (USEPA, 2011). SWMM5 can represent tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as natural and constructed detention facilities. It is well-suited for hydraulic analysis of the Central South storm drainage system.

Runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. The routing portion of SWMM5 conveys this runoff through a system of pipes, channels, storage, and outfalls. SWMM5 tracks the flow rate and flow of water in each pipe and channel.

Model Extents

A single SWMM5 models was developed for the entire Central South subwatershed and includes: Central Reaches, Central Uplands North, Central Uplands South, Terrell Creek Tributary 1, Terrell Creek Tributary 2, and Bog Creek subbasins. Individual subbasins are assigned independent outfalls to measure water volume at the point of discharge. The SWMM5 models generally include all surveyed pipes and ditches, although very short conduits were eliminated to improve stability. Model extents are shown on Plate 1.

Conveyance System Data Inputs

The storm drainage inventory data collected for this project by Wilson Engineering were used as the primary source of data for the SWMM5 model network. This data consisted of pipe, culvert, ditches, manholes, catch basins, and drain points. Other data sources included a topographic grid surface derived from LIDAR mapping, as-constructed drawings, and observations made during field reconnaissance.

Storm drain and culvert pipe characteristics were obtained from the inventory data. Data elements included pipe size, upstream and downstream invert elevations, pipe material, and conduit length. Catch basin and manhole information was also obtained from the storm drainage inventory. Data elements included geographic coordinates (northing and easting), rim elevation and structure invert elevation. Manning's roughness coefficients for pipes were based on pipe material assuming fair condition. Smooth pipes (e.g., concrete, polyvinyl chloride, high density polyethylene) were assigned a roughness coefficient of 0.012 and rough pipes (e.g., corrugated metal) were assigned a coefficient of 0.024. An entrance loss coefficient was assigned to pipes where transitions from open-channel flow to piped flow exist. An exit loss coefficient of 1.0 was assumed for pipes that discharge to open channels or Birch Bay.

Open channel (roadside ditch and natural channel) characteristics were estimated from approximate field measurements for bottom width, side slope, and depth. Invert elevations were provided in the storm drainage inventory. Roadside ditches and natural channels were assumed to have a trapezoidal shape with varying width and depth. Channel dimensions were based primarily on a windshield survey, with measurements obtained at representative channel sections. Channels were assigned a roughness coefficient of 0.030, assuming an average maintained condition. The level of accuracy used to dimension ditch channel sections is appropriate for this planning-level analysis because flow through the roadside ditch and culvert system in the Central South subwatershed is controlled by culvert size and material rather than channel characteristics.

Generally, overflow channels for roadway culverts were not included in the model unless preliminary model runs indicted surface flooding. For these cases, overflow conduits were added as approximate open channels with a 10-foot bottom width and 10:1 side slopes.

Overtopping elevation for surveyed structures corresponded to the rim elevation of the catch basin or manhole. Overtopping for drain points associated with open channels was estimated from the LIDAR mapping. This elevation was computed by finding the intersection with the LIDAR topographic grid 10 feet left and right perpendicular to the conveyance element. The minimum perpendicular value was assigned to be the overtopping elevation. The LIDAR derived data were adjusted at some locations where they were determined to be inaccurate due to vegetation or other obstructions. For these cases, overtopping elevation was replaced with a value obtained from a nearby point in an unobstructed area.

Model nodes, representing catch basin, manholes, drain points, and other connection points are named using the GPS ID specified during the inventory survey. Nodes with data obtained from the existing Birch Bay stormwater inventory are identified using an upstream or downstream node ID with no alphabetical prefix in the name (ex. 1500). Prefix letters were used if node data were obtained from the Wilson Engineering topographic survey or created by Tetra Tech. Nodes obtained from Wilson Engineering were given a "W" suffix in front on each junction name (ex. W1600). Nodes created by Tetra Tech were assigned a "T" prefix (ex. T6000). Data were supplemented for the Tetra Tech nodes using existing LiDAR and adjacent node data. Conduits, representing pipes and channels, are named using the upstream and downstream nodes. For example, conduit 1800_1900 represents a conduit flowing from node 1800 to node 1900. Overtopping conduits were assigned the suffix "-OF" in the conduit name (ex. 1800_1900-OF).

Boundary Conditions

A fixed tidal elevation boundary condition of 7.9-feet on the Mean Higher High Water (MHHW) datum was chosen as the downstream boundary condition at outfalls to Birch Bay. NOAA continuous tidal data was considered while developing the downstream boundary condition. The National Oceanic and Atmospheric Agency measures tides at Cherry Point station (Cherry Point, WA Station ID 9339424), located approximately 3 miles south of Birch Bay (NOAA, 2011). A fixed boundary condition was chosen as a conservative approach.

Inflow Nodes

Runoff time-series were exported from the HSPF model for each subcatchment shown in Figure 1. Runoff time-series were input to the SWMM5 model at discrete locations corresponding to the HSPF subcatchments. The SWMM5 model has a higher level of detail for the conveyance system than the HSPF model, so the runoff time series flows were split based on approximate tributary area. Inflow nodes are shown on Plate 1.

Design Events

Design event hydrographs were extracted from the HSPF time-series data to represent the 2-, 25-, and 100-year peak flow conditions. Design events were created by performing a Log-Pearson III analysis on the annual maximum flows for the Central South subwatershed. Flows determined through the analysis were cross-referenced with the hourly maximum flow time-series in order to query the total number of events occurring for the period of record. The design event selected for analysis was chosen after reviewing input hydrographs from all candidate events; design events were selected with engineer's best judgment for a uniform hydrograph that maximizes volume under the peak. A scaling factor of 1.15 was used for the 100-year event in order to match peak flows from a previous project work on the Central North subwatershed. Table 4 lists the time periods that correspond to peak flow events in the Central South subwatershed.

HYDRAULIC MODELING RESULTS

Design event flow hydrographs described in Table 4 were routed through the SWMM5 hydraulic models to estimate peak flows and depths throughout the Central South subwatershed. The results of the hydraulic analysis were used to evaluate the performance of the stormwater conveyance system and identify flood problem areas in the subwatershed and capacity limitations in the storm drainage network.

TABLE 4
DESIGN EVENTS FOR HYDRAULIC INPUT

	Start Date	End Date	Duration
2 Year	2/9/1985 0:00	2/10/1985 00:00	24 Hours
25 Year	2/15/1986 03:00	2/16/1986 08:00	28 Hours
100 Year	12/28/1983 20:00	12/31/1983 12:00	40 Hours

System Performance

The hydraulic analysis showed that the storm drain system in the Central South Subwatershed has adequate capacity throughout the basin to convey the 25-year event. However, there are several conveyance systems with significant restrictions. The analysis showed that flooding is predicted at 22 nodes for the 25-year event and 33 nodes for the 100-year event. Most notably, flooding was predicted along the entire length of Birch Bay Drive. Other notable flood locations include the following:

- Harborview Road at Birch Bay Lynden Road (Central Reaches subbasin)
- Mariners Cove / Birch Bay RV Resort drainage line (Central Reaches subbasin)

- Latitude 49 storm pond overtopping (Central Reaches subbasin)
- Birch Bay Lynden Road near Anchor Parkway (Central Uplands North subbasin)
- Flooding along Terrill Drive (Terrell Creek Tributary 2 subbasin).

Stormwater runoff is transferred between subbasins at several locations within the Central South Subwatershed:

- During high flows, overflow occurs from the Hillsdale subbasin in the Central North Subwatershed to the Central Reaches subbasin at Forsberg Road on the east side of Harborview Road. The overflow is contained within the ditch-and-culvert system along Harborview Road.
- The Latitude 49 detention pond, also located in the Central Reaches, overflows to Sea Links Drive and into the Sea Links residential community in the Central Uplands North subbasin. The flow through the Sea Links residential community is uncertain but likely follows downhill along the roadway and eventually connects to the ponds at the Sea Links Golf Course.
- Stormwater overflows from the Central Uplands North subbasin to the Central Uplands South subbasin at the Sea Links Golf Course ponds. The water surface elevation in the ponds is controlled by the Club House Drive outfall. The outlet pipe is higher than the elevation of the interconnecting culverts between the ponds. The ponds essentially function as one storage facility. However, the northern ponds are in the Central Uplands North and the southern ponds are in the Central Uplands South subbasin.
- The Sea Links Golf Course ponds are also connected to a large wetland area through a network of ditches that are also connected to the Terrell Creek Tributary 1 Subbasin along the east border of the Leisure Park residential community. During larger storm events, water from the Central Uplands North subbasin overflows into the wetlands. A 10-inch culvert controls drainage between the wetland and the pond and allows flow to drain back toward the ponds once the storm peak has passed. As the water surface level rises in the wetland, the constructed drainage ditch overflows into both Leisure Park and another low-lying wetland area south of Leisure Park in the Terrell Creek Tributary.
- The Terrell Creek Tributary 1 wetland area is divided between the Terrell Creek Tributary 1 and Tributary 2 subbasins. There is no clear drainage pathway once water enters the lower wetland area, and the true volume of storage is unknown. A culvert under Alderson Road drains the wetland area, but may also allow runoff from Alderson Road to overflow into the wetland area.

Peak Flow Rates

Table shows the routed peak flow rated predicted by the SWMM model using the HSPF flow inputs at selected locations in the watershed.

TABLE 5
EXISTING CONDITIONS PEAK FLOW IN CENTRAL SOUTH SUBWATERSHED

Node[a]	Location	2-year Peak Flow (cfs)	25-year Peak Flow (cfs)	100-year Peak Flow (cfs)
Central Reaches Subbasin				
W3286	Overflow from Central North Subwatershed	0	4.6	6.0
W1538	Harborview Road Outfall	8.4	14.9	17.8
W5075	Mariners Cove Outfall	13.31	23.0	23.4
P-Lat49	Latitude 49 Storm Pond Overflow to Sealinks	1.82	16.8	20.8
T6001	Inflow from Sunburst Drive Area	1.66	3.1	4.6
Central Uplands North Subbasin				
W3102	Inflow North Ponds at Sealinks Golf Course	13.8	29.1	38.4
W1082	Central Uplands North SR-548 Culvert (1)	2.8	7.8	18.0
W1100	Central Uplands North SR-548 Culvert (2)	1.7	6.7	8.7
Central Uplands South Subbasin				
T6008	Inflow to South Ponds at Sealinks Golf Course	8.4	6.9	7.1
W5181	Overflow from Sealinks Golf Course to Wetland	6.9	27.8	86.7
T6003	Lora Lane Outfall	8.9	32.7	49.7
Terrell Creek Tributary 1 Subbasin				
T6025	Inflow to Wetland at Leisure Park	6.3	13.4	22.1
W1675	Overflow Birch Bay RV Park to wetland at Leisure Park	1.6	7.6	9.5
W5103	Terrell Creek Trib. 1 SR-548 Culvert	17.9	55.1	111.6
Terrell Creek Tributary 2 Subbasin				
T6031	Birch Creek Outfall	13.8	53.1	105.0
W1800	Wooldridge Ave. Outfall	5.7	10.1	8.1[b]
Bog Creek Subbasin				
W6028	Bog Creek	6.9	23.0	47.7

a. See Figure 5.
b. Flow reduction occurs because backwater from Terrell Creek limits outflow.

Ex. = Existing, cfs = cubic feet per second

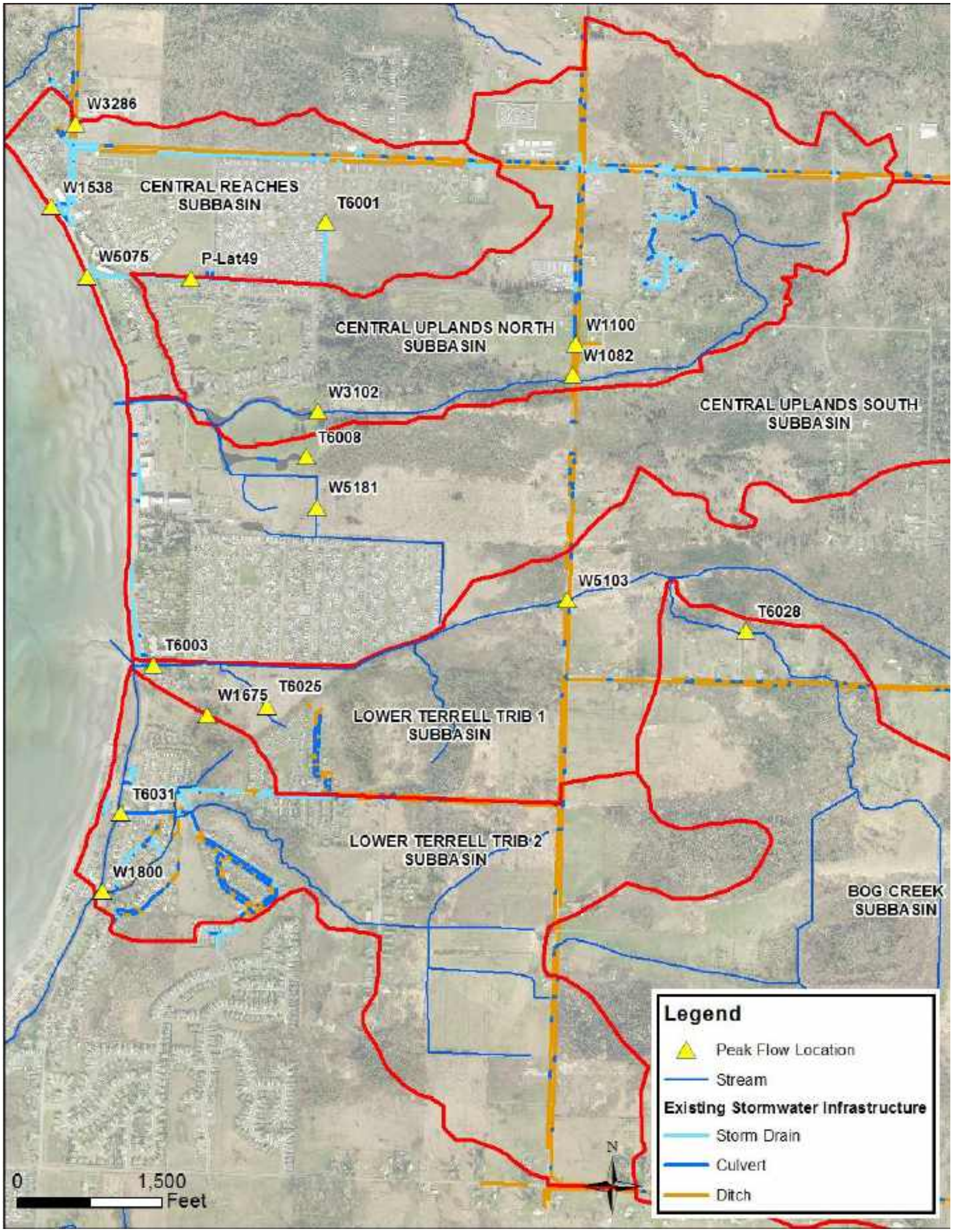

Figure 5. Peak Flow Reporting Locations

Flood Problem Areas

Design analysis was performed using the SWMM5 models to identify locations where flooding is predicted under existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the assumed overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause and location of flooding. The analysis showed that flooding is predicted at 13 locations in the Central South subwatershed. Four problem areas had been identified as areas were flooding occurred in the past as documented by incident reports on-file with the Birch Bay Public Works; flood problems had not previously been identified at the other 4 locations. Table 6 lists the flood problem areas by subbasin. Flood problem areas are also shown on Figure 6. Full model output is provided in Attachment B.

System Capacity

Hydraulic modeling results were reviewed to assess the conveyance capacity of the primary conveyance route in each subbasin. Many of the problem areas in the subwatershed are due to flows exceeding the capacity of the system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Capacity is exceeded when a drainage structure has less than 0.5 feet of freeboard during a storm event.

Table 7 summarizes the capacity analysis results at outfalls within the Central South subwatershed. It lists the link ID where peak flow was measured. The system capacity for the Harborview Road and Wooldridge Avenue outfalls is exceeded during both the 25- and 100-year peak flow events. The Mariners Cove and Lora Lane outfalls have their capacity exceeded during only the 100-year event. System capacity is not exceeded for the Club House Drive and Birch Creek outfalls.

TABLE 6
DRAINAGE PROBLEMS IDENTIFIED FROM HYDRAULIC MODELING

			Triggering Flood Event	
ID	Location	Extent	Existing	Probable Cause
Central Reaches Subbasin				
CR- 4	Birch Bay Drive	Birch Bay Drive near Harborview Road	2-Year	Undersized storm drain system.
CR-7	Harborview Road at Morgan Drive	Harborview Road south toward Birch Bay Drive	25-Year	Undersized storm drain system in heavily developed area.
CR-11	Mariners Cove near Birch Bay Drive	Mariners Cove private property	25-Year	Inlet RIM elevation is below the depth of flow in the stormdrain line.
CR -12	Latitude 49 Storm Pond	SeaLinks Drive into Wedgewood Court	2-Year	Latitude 49 storm pond is undersized and filled with sediment.
CR-19	Mariners Cove storm drain trunk line	Storm Drain Line east of Latitude 49 Storm Pond	100-Year	High flows from Latitude 49 storm pond and undersized storm drain.

TABLE 6
DRAINAGE PROBLEMS IDENTIFIED FROM HYDRAULIC MODELING

ID	Location	Extent	Triggering Flood Event Existing	Probable Cause
CUN-5	Birch Bay Lynden Road east of SR-548	Birch Bay Lynden Road between SR-548 and Anchor Parkway	100-Year	Undersized storm drain system.
Central Uplands South Subbasin				
CUS-1	Leisure Park	Flooding at multiple locations	25-Year	Combination of tidal influence and insufficient drainage from adjacent drainage areas.
CUS-4	Birch Bay Drive near Lora Lane	700' north of Lora Lane extending north 400' to outfall	2-Year	Undersized storm drain system.
CUS-5	Birch Bay Drive near Lora Lane	700' north of Lora lane extending down to Lora Lane	2-Year	Undersized storm drain system.
CUS-6	SR-548 near Hickok Road	SR-548	25-year	Undersized storm drain system
Terrell Creek Tributary 1 Subbasin				
TC1-6	SR-548 north of Arnie Road	SR-548	25-year	Undersized storm drain system
Terrell Creek Tributary 2 Subbasin				
TC2 -6	Terrill Drive / Willow Drive / Morrison Avenue	Wooldridge Neighborhood	2-Year	Existing storm drain system is obstructed by sediment and in poor condition.
TC2-15	Birch Bay Drive near Alderson Road	Beachside RV Park / Birch Bay Drive / Alderson Road	2-Year	Undersized storm drain system.

TABLE 7
SYSTEM CAPACITY BEFORE FLOODING

Subbasin	Location	Pipe Size (in)	Predicted Peak Flow (cfs) 25-Year	Predicted Peak Flow (cfs) 100-Year	Max Flow Before Flooding (cfs)
Central Reaches	Harborview Rd.	18	14.9	17.8	3.7
Central Uplands North	Mariners Cove	30	23.8	26.4	24.3
Central Uplands North	Club House Dr.	36	20.4	27.2	> 100-Year
Terrell Creek Trib. 1	Lora Lane	48	32.7	49.7	44.2
Terrell Creek Trib. 2	Birch Creek	48	53.1	105	>100 Year
Terrell Creek Trib. 2	Wooldridge Ave.	36	7.8	9	6.9

cfs = cubic feet per second

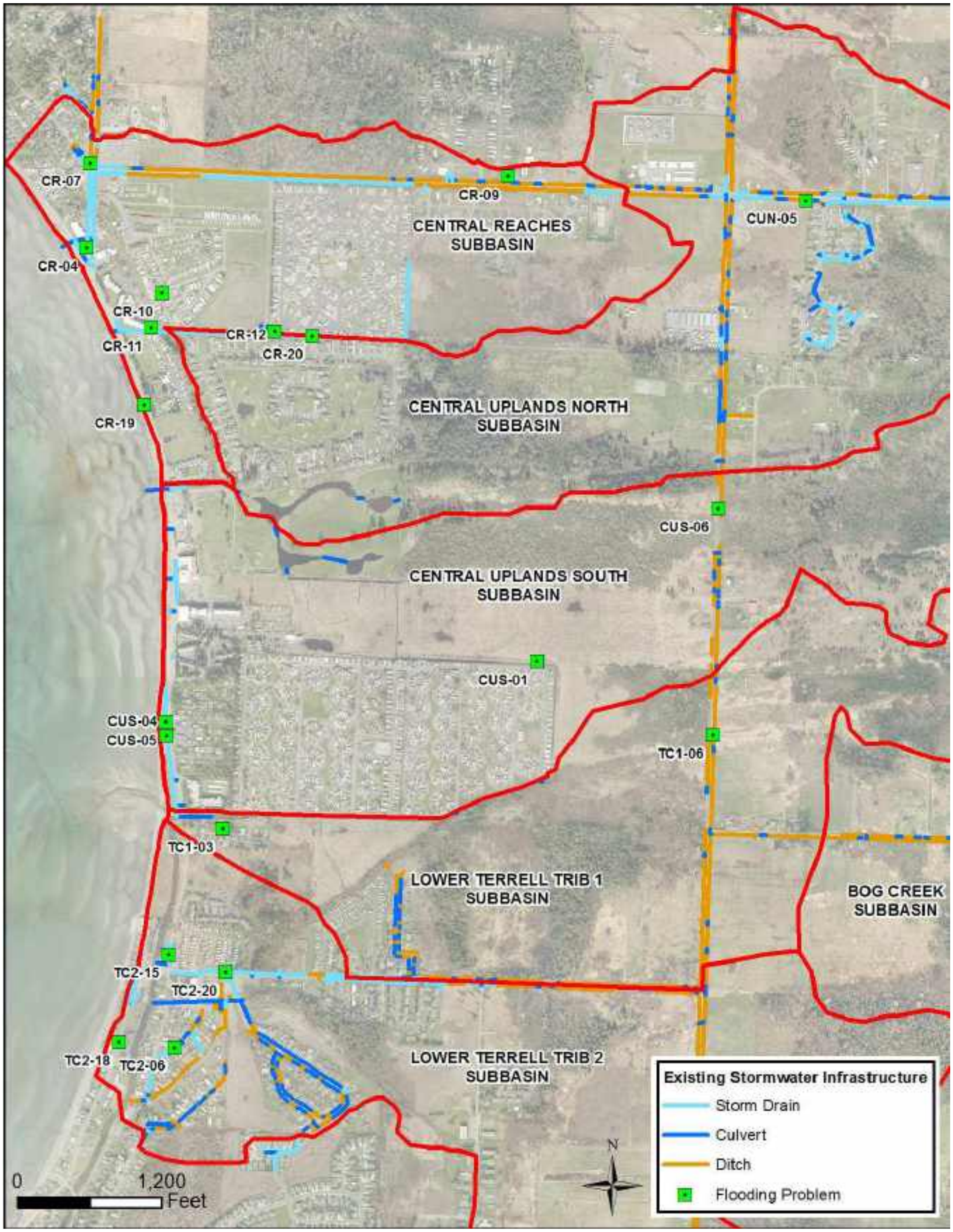

Figure 6. Flooding Problem Areas

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Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Hydrologic and Hydraulic Analysis of the Surface Water System in the Central South Subwatershed

ATTACHMENT A. HSPF LAND CATEGORY ASSIGNMENTS

Table A-1
HSPF Land Category Assignments

	Subbasin	Central Raches												
	PERLND	1-1	1-2	1-3	1-4	1-5	1-6	1-7	2-1	2-3	2-5	2-6	2-7	2-4
		8.83	4.53	6.69	6.97	6.18	18.14	9.19	21.12	21.39	35.06	21.46	33.28	44.13
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.86	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.46	0.00	0.00	0.00	0.00	0.00	2.47	4.78	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.12	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	8.85	0.00	0.00	0.00	0.00	0.00	1.08	1.51
32	C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
33	C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	4.31	25.16	0.00
35	C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	C, Pasture, Flat	0.00	0.00	0.00	0.56	0.00	0.87	0.00	0.70	5.23	0.00	2.40	4.96	0.08
38	C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00
39	C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	C, Lawn, Flat	0.00	0.00	0.00	2.01	0.00	3.01	0.00	1.42	0.81	5.17	8.33	1.71	28.41
44	C, Lawn, Mod	0.19	0.00	0.00	0.00	0.00	0.00	0.00	3.52	0.02	0.00	0.00	0.00	0.66
45	C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	D, Forest, Flat	0.00	0.00	1.36	0.00	0.00	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	D, Pasture, Flat	0.00	0.01	2.54	0.66	4.63	0.17	0.00	0.00	3.60	0.00	0.00	0.00	0.00
53	D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	D, Lawn, Flat	1.85	2.56	0.01	0.60	0.06	0.09	1.02	0.00	2.66	3.45	0.00	0.00	0.00
59	D, Lawn, Mod	0.83	0.00	0.00	0.00	0.00	0.00	1.42	0.07	0.00	0.00	0.00	0.00	0.00
60	D, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	5.38	1.96	2.78	3.14	1.49	2.66	4.03	8.66	9.07	25.85	6.42	0.37	13.43
	Total	8.83	4.53	6.69	6.97	6.18	18.14	9.19	21.12	21.39	35.06	21.46	33.28	44.13
	Pervious	8.83	4.53	6.69	6.97	6.18	18.14	9.19	21.12	21.39	35.06	21.46	33.28	44.13
	A	0.58	0.00	0.00	0.00	0.00	0.00	2.72	6.64	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	0.19	0.00	0.00	2.57	0.00	12.73	0.00	5.76	6.06	5.76	15.04	32.92	30.70
	D	2.68	2.57	3.91	1.26	4.69	2.75	2.44	0.07	6.26	3.45	0.00	0.00	0.00
	Forest	0.00	0.00	1.36	0.00	0.00	11.34	0.00	0.00	0.00	0.00	0.00	1.08	1.55
	Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	4.31	25.16	0.00
	Pasture	0.00	0.01	2.54	1.22	4.63	1.04	0.00	2.69	8.83	0.00	2.40	4.96	0.08
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	3.45	2.56	0.01	2.61	0.06	3.10	5.16	9.78	3.48	8.62	8.33	1.71	29.07
	Flat	2.31	2.57	3.91	3.83	4.69	15.48	3.49	8.75	12.30	9.21	15.04	32.92	29.99
	Mod	1.14	0.00	0.00	0.00	0.00	0.00	1.67	3.72	0.02	0.00	0.00	0.00	0.71
	Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A-1

HSPF Land Category Assignments

	Subbasin			Central Uplands North						Central Upland South			Lower Terrell C	
	PERLND	**2-8**	**2-9**	**2-10**	**2-11**	**2-12**	**2-13**	**2-14**	**2-2**	**3-1**	**3-2**	**3-3**	**4-1**	**4-2**
		109.60	7.14	10.74	20.69	86.00	65.82	22.19	44.66	119.41	250.37	74.76	52.19	156.34
1	**A, Forest, Flat**	0.00	0.00	0.00	0.00	**0.77**	**0.09**	0.00	0.00	0.00	**0.86**	0.00	0.00	0.00
2	**A, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	**A, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**A, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	**0.62**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**A, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	**A, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	**A, Pasture, Flat**	**0.75**	0.00	0.00	0.00	0.00	**2.32**	0.00	**8.66**	**2.45**	**0.58**	0.00	**4.05**	0.00
8	**A, Pasture, Mod**	**0.34**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	**A, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	**A, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	**A, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	**A, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	**A, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**14.29**	**0.03**	0.00	**1.68**	**0.15**	0.00
14	**A, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	**A, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	**B, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.01**	**0.01**
17	**B, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	**B, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	**B, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.89**	0.00	0.00	0.00	**6.33**
20	**B, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	**B, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	**B, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	**26.21**	**0.00**	**0.23**	**15.18**	**11.59**
23	**B, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	**B, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.20**
25	**B, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	**B, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	**B, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	**B, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.72**	**0.76**	0.00	**12.12**	0.00	0.00
29	**B, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	**B, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	**C, Forest, Flat**	**29.86**	0.00	0.00	**1.03**	**34.67**	**0.24**	0.00	0.00	**1.58**	**59.39**	**0.00**	**14.35**	**31.83**
32	**C, Forest, Mod**	**9.54**	0.00	0.00	0.00	**8.56**	0.00	0.00	0.00	0.00	**10.25**	0.00	0.00	0.00
33	**C, Forest, Steep**	0.00	0.00	0.00	0.00	**5.98**	0.00	0.00	0.00	0.00	**2.15**	0.00	**1.67**	**4.75**
34	**C, Shrub, Flat**	**10.62**	0.00	0.00	0.00	0.00	**2.00**	0.00	0.00	**36.96**	**72.47**	0.00	0.00	**14.18**
35	**C, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.46**	**8.42**	0.00	0.00	0.00
36	**C, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**10.84**
37	**C, Pasture, Flat**	**43.83**	**6.47**	**9.21**	**11.92**	**23.02**	**52.30**	**12.37**	**0.02**	**45.45**	**51.31**	0.00	**0.64**	**41.03**
38	**C, Pasture, Mod**	**3.51**	0.00	0.00	0.00	**4.43**	0.00	0.00	0.00	**0.75**	**2.89**	0.00	0.00	0.00
39	**C, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.28**	**14.90**
40	**C, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	**C, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	**C, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	**C, Lawn, Flat**	**1.73**	0.00	0.00	0.00	0.00	0.00	0.00	**0.16**	**0.27**	0.00	**0.21**	**6.21**	**0.32**
44	**C, Lawn, Mod**	**1.81**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	**C, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.85**	0.00
46	**D, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**3.19**	0.00	0.00	**0.02**
47	**D, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.76**	0.00	0.00	**5.45**
48	**D, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.28**
49	**D, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.36**	0.00	0.00	**0.02**
50	**D, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.25**
51	**D, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.52**
52	**D, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	**2.80**	0.00	0.00	**20.08**	0.00	0.00	0.00
53	**D, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.68**	0.00	0.00	**4.59**
54	**D, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.27**
55	**D, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	**D, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	**D, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	**D, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
59	**D, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	**D, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	7.62	0.67	1.53	7.74	8.57	8.25	7.02	20.81	1.61	7.99	60.52	7.78	3.97
	Total	109.60	7.14	10.74	20.69	86.00	65.82	22.19	44.66	119.41	250.37	74.76	52.19	156.34
	Pervious	109.60	7.14	10.74	20.69	86.00	65.82	22.19	44.66	119.41	250.37	74.76	52.19	156.34
	A	1.09	0.00	0.00	0.00	0.77	3.03	0.00	22.95	2.48	1.43	1.68	4.21	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	29.86	0.00	12.36	15.19	18.13
	C	100.89	6.47	9.21	12.95	76.66	54.54	12.37	0.18	85.46	206.88	0.21	25.01	117.84
	D	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.00	34.07	0.00	0.00	16.41
	Forest	39.40	0.00	0.00	1.03	49.98	0.33	0.00	0.00	1.58	76.59	0.00	16.03	44.34
	Shrub	10.62	0.00	0.00	0.00	0.00	2.62	0.00	0.00	40.31	89.25	0.00	0.00	35.14
	Pasture	48.42	6.47	9.21	11.92	27.45	54.62	15.17	8.69	74.86	76.54	0.23	21.16	72.57
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	3.54	0.00	0.00	0.00	0.00	0.00	0.00	15.17	1.06	0.00	14.01	7.22	0.32
	Flat	86.78	6.47	9.21	12.95	58.46	57.57	15.17	23.85	116.59	216.22	14.25	40.60	105.33
	Mod	15.20	0.00	0.00	0.00	12.99	0.00	0.00	0.00	1.21	24.00	0.00	0.00	12.30
	Steep	0.00	0.00	0.00	0.00	5.98	0.00	0.00	0.00	0.00	2.15	0.00	3.81	34.75

Table A-1

HSPF Land Category Assignments

	Subbasin	reek Tributary 1		Lower Terrell Creek Tributary 2							Bog Trib			
	PERLND	**4-3**	**4-4**	**5-1**	**5-2**	**5-3**	**5-4**	**5-5**	**5-6**	**5-7**	**6-1**	**6-2**	**6-3**	Total
		135.26	123.97	6.43	8.19	25.03	31.98	17.00	19.49	246.71	32.13	82.47	418.22	2403.8
1	**A, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.7**
2	**A, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	**A, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	**A, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.6**
5	**A, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	**A, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	**A, Pasture, Flat**	0.00	0.00	**2.69**	0.00	**3.11**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**26.5**
8	**A, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.3**
9	**A, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	**A, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	**A, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	**A, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	**A, Lawn, Flat**	0.00	0.00	**2.67**	**4.85**	**2.98**	**4.95**	0.00	**0.00**	0.00	0.00	0.00	0.00	**39.3**
14	**A, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.4**
15	**A, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	**B, Forest, Flat**	0.00	**1.54**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.30**	**1.9**
17	**B, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18	**B, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19	**B, Shrub, Flat**	**2.63**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.19**	0.00	**50.54**	**62.6**
20	**B, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21	**B, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
22	**B, Pasture, Flat**	0.00	**0.67**	0.00	0.00	**5.18**	0.00	0.00	0.00	0.00	0.00	0.00	**27.82**	**86.9**
23	**B, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
24	**B, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.2**
25	**B, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26	**B, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
27	**B, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
28	**B, Lawn, Flat**	0.00	0.00	0.00	0.00	**0.58**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**14.2**
29	**B, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30	**B, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
31	**C, Forest, Flat**	0.00	**29.07**	0.00	0.00	0.00	0.00	0.00	0.00	**42.40**	**3.27**	**49.96**	**30.71**	**339.8**
32	**C, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**28.4**
33	**C, Forest, Steep**	0.00	**3.19**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**17.7**
34	**C, Shrub, Flat**	**84.72**	**5.40**	0.00	0.00	0.00	**9.77**	**0.53**	**5.10**	**7.04**	**3.51**	0.00	**120.23**	**402.6**
35	**C, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.9**
36	**C, Shrub, Steep**	**12.49**	0.00	0.00	0.00	0.00	**0.11**	**0.11**	**3.60**	0.00	**6.71**	0.00	0.00	**33.9**
37	**C, Pasture, Flat**	**27.89**	**79.14**	0.00	0.00	**2.85**	0.00	0.00	**0.03**	**187.76**	**9.65**	**31.35**	**178.78**	**829.8**
38	**C, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**11.7**
39	**C, Pasture, Steep**	**0.44**	**0.31**	0.00	0.00	**1.83**	0.00	0.00	0.00	0.00	**5.62**	0.00	0.00	**24.4**
40	**C, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41	**C, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
42	**C, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
43	**C, Lawn, Flat**	0.00	0.00	0.00	0.00	**1.19**	**4.66**	**10.69**	**5.73**	**0.35**	0.00	0.00	0.00	**82.4**
44	**C, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**6.2**
45	**C, Lawn, Steep**	0.00	0.00	0.00	0.00	**0.04**	**2.98**	**0.54**	**0.61**	0.00	0.00	0.00	0.00	**5.0**
46	**D, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**7.1**
47	**D, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**6.2**
48	**D, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.3**
49	**D, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.4**
50	**D, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.2**
51	**D, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.5**
52	**D, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**34.5**
53	**D, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.00**	0.00	0.00	**7.3**
54	**D, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	0.00	0.00	**0.3**
55	**D, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
56	**D, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
57	**D, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
58	**D, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**12.3**
59	**D, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.3**
60	**D, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
	Impervious	7.09	4.65	1.07	3.34	7.27	9.52	5.13	4.41	9.16	2.17	1.16	9.83	294.09
	Total	135.26	123.97	6.43	8.19	25.03	31.98	17.00	19.49	246.71	32.13	82.47	418.22	2403.76
	Pervious	135.26	123.97	6.43	8.19	25.03	31.98	17.00	19.49	246.71	32.13	82.47	418.22	0.00
	A	0.00	0.00	5.36	4.85	6.09	4.95	0.00	0.00	0.00	0.00	0.00	0.00	68.83
	B	2.63	2.21	0.00	0.00	5.76	0.00	0.00	0.00	0.00	0.19	0.00	78.67	165.72
	C	125.55	117.11	0.00	0.00	5.91	17.52	11.87	15.07	237.54	28.76	81.31	329.73	1790.75
	D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	84.37
	Forest	0.00	33.80	0.00	0.00	0.00	0.00	0.00	0.00	42.40	3.27	49.96	31.02	405.07
	Shrub	99.84	5.40	0.00	0.00	0.00	9.87	0.64	8.70	7.04	10.41	0.00	170.77	520.67
	Pasture	28.33	80.12	2.69	0.00	12.97	0.00	0.00	0.03	187.76	16.28	31.35	206.61	1021.82
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	0.00	0.00	2.67	4.85	4.79	12.59	11.23	6.35	0.35	0.00	0.00	0.00	162.11
	Flat	115.24	115.82	5.36	4.85	15.89	19.38	11.21	10.86	237.54	16.62	81.31	408.40	1950.42
	Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	73.97
	Steep	12.93	3.50	0.00	0.00	1.87	3.08	0.65	4.21	0.00	12.34	0.00	0.00	85.29

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Hydrologic and Hydraulic Analysis of the Surface Water System in the Central South Subwatershed

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ATTACHMENT B.
SUBBASIN FLOODING MODELING RESULTS

Table B-1
Central South Subwatershed Flooding

		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
1100	45.2	30.0	30.0	32.9	-15.2	-15.2	-12.3		
2623	53.6	49.6	50.8	52.90	-4.0	-2.8	-0.7		
2628	54.0	49.2	49.9	51.47	-4.7	-4.1	-2.5		
2635	11.0	8.4	10.4	10.42	-2.6	-0.6	-0.6		
2636	9.6	8.4	9.6	9.55	-1.1	0.0	0.00	Morrison Avenue	TC2-6
2637	9.7	8.4	9.6	9.59	-1.3	-0.1	-0.09		
2639	9.6	8.4	9.6	9.57	-1.2	0.0	0.00	Terrell Drive	TC2-6
2642	10.0	8.6	9.8	9.84	-1.4	-0.2	-0.16		
2643	9.4	8.6	9.8	9.83	-0.8	0.4	0.44	Terrell Drive	TC2-6
2644	9.9	8.6	9.7	9.70	-1.4	-0.3	-0.23		
2645	9.8	8.5	9.7	9.69	-1.3	-0.1	-0.10		
2646	9.9	8.4	9.6	9.61	-1.4	-0.3	-0.25		
2684	44.3	42.2	44.3	44.27	-2.1	0.0	0.00	Morgan Drive at Harborview Road	CR-7
2851	13.9	10.5	10.6	10.6	-3.4	-3.3	-3.3		
2852	17.2	15.2	15.2	15.3	-2.0	-1.9	-1.9		
2853	35.4	33.3	33.3	33.4	-2.1	-2.1	-2.1		
2854	42.0	38.0	38.1	38.1	-4.0	-3.9	-3.9		
2855	44.6	40.2	40.3	40.4	-4.4	-4.3	-4.2		
2856	45.4	41.8	44.5	45.1	-3.6	-0.9	-0.2	Birch Bay-Lynden Road at Harborview Road	CR-7
2857	46.5	42.2	44.9	45.7	-4.3	-1.5	-0.8		
2860	45.0	41.4	44.3	44.88	-3.6	-0.6	-0.09	Morgan Drive at Harborview Road	CR-7
2861	43.4	36.7	36.8	36.9	-6.7	-6.6	-6.5		
2862	13.6	9.7	10.0	10.2	-4.0	-3.6	-3.4		
2864	11.8	11.9	11.9	11.94	0.1	0.1	0.10	Harborview Road at Birch Bay Drive	CR-4
2865	13.9	10.4	10.9	11.2	-3.6	-3.1	-2.7		
2910	13.2	10.0	10.2	10.94	-3.2	-3.0	-2.25		
2911	11.3	11.3	11.4	11.46	-0.1	0.1	0.12	Birch Bay Drive at Alderson Road	TC2-15
2915	14.9	10.4	10.5	10.64	-4.5	-4.4	-4.26		
2916	12.3	11.5	12.3	12.34	-0.9	0.0	0.00	Birch Bay Drive south of Golf Course Road	
2917	12.5	7.9	8.1	12.53	-4.6	-4.4	0.00	Birch Bay Drive south of Golf Course Road	
2918	13.2	8.8	9.3	9.45	-4.5	-3.9	-3.76		
2919	13.2	8.9	9.4	9.51	-4.3	-3.8	-3.68		
2920	12.6	9.4	9.6	9.90	-3.2	-3.0	-2.65		
2921	12.6	10.6	10.7	10.82	-2.0	-1.9	-1.73		
2922	13.0	10.4	10.7	11.0	-2.6	-2.3	-1.9		
2923	13.1	10.3	10.7	11.0	-2.7	-2.4	-2.1		
2924	12.6	10.3	10.6	10.9	-2.3	-2.0	-1.8		
2925	12.3	9.8	9.9	10.0	-2.5	-2.4	-2.3		
2926	13.0	8.4	8.9	9.1	-4.6	-4.1	-3.9		
2940	11.5	11.6	11.7	11.78	0.1	0.2	0.24	Birch Bay Drive at Alderson Road	TC2-15
2956	12.5	11.9	12.0	12.24	-0.6	-0.5	-0.22		
2957	12.5	12.5	12.5	12.45	0.0	0.0	0.00	Birch Bay Drive north of Lora Lane	CUS-04
2958	12.4	12.4	12.4	12.41	0.0	0.0	0.00	Birch Bay Drive north of Lora Lane	CUS-04
2959	12.6	12.6	12.6	12.62	0.0	0.0	0.00	Birch Bay Drive north of Lora Lane	CUS-05
2960	11.9	11.9	11.9	11.91	0.0	0.0	0.00	Birch Bay Drive north of Lora Lane	CUS-05
2961	11.9	11.5	11.9	11.88	-0.4	0.0	0.00	Birch Bay Drive north of Lora Lane	CUS-05
3009	56.7	53.3	53.4	53.4	-3.4	-3.3	-3.2		
3013	60.3	57.5	57.7	57.7	-2.7	-2.6	-2.6		
3018	61.2	58.5	58.6	59.33	-2.7	-2.6	-1.87		
3019	51.8	48.5	48.8	49.80	-3.2	-3.0	-1.97		
3020	52.4	48.1	48.7	49.34	-4.4	-3.8	-3.08		
3021	53.7	46.2	46.3	46.39	-7.5	-7.4	-7.29		
3024	12.2	9.4	9.4	10.83	-2.8	-2.8	-1.34		
3025	11.8	9.1	9.1	10.83	-2.8	-2.8	-1.00		
3026	11.9	9.2	9.2	10.83	-2.7	-2.7	-1.05		
3027	11.9	9.7	10.0	10.83	-2.2	-1.9	-1.06		
3028	11.6	9.8	10.0	10.82	-1.9	-1.6	-0.81		
3031	48.0	40.7	40.8	40.86	-7.3	-7.2	-7.18		
3032	48.1	41.4	41.6	41.67	-6.7	-6.6	-6.45		
3033	48.6	42.7	42.9	42.97	-5.9	-5.7	-5.58		
3034	48.8	45.1	45.2	45.32	-3.7	-3.5	-3.43		
3035	48.9	46.3	46.5	46.60	-2.6	-2.4	-2.29		
3036	48.9	46.6	47.0	47.20	-2.3	-2.0	-1.73		
3050	48.0	38.7	39.6	40.87	-9.3	-8.4	-7.08		
3051	46.3	42.4	42.5	42.58	-3.9	-3.8	-3.74		
3053	38.7	35.4	35.5	35.53	-3.3	-3.3	-3.21		
3054	26.1	22.8	22.9	22.97	-3.3	-3.2	-3.10		
3055	15.4	9.3	9.7	10.21	-6.1	-5.7	-5.18		
3056	11.7	9.8	10.0	10.82	-1.9	-1.6	-0.83		
3063	50.3	48.2	49.3	50.31	-2.1	-1.0	0.05	Birch Bay - Lynden Road near Anchor Parkway	CUN-05
3064	50.8	48.3	49.3	49.81	-2.5	-1.5	-0.95		
4218	40.9	38.0	38.8	39.60	-2.9	-2.1	-1.26		

Table B-1 Central South Subwatershed Flooding									
		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
4219	57.7	55.8	55.8	55.80	-1.9	-1.9	-1.91		
4220	56.6	55.6	55.6	55.57	-1.0	-1.0	-1.00		
4221	9.7	8.6	9.7	9.71	-1.1	0.0	0.00	Terrell Drive	TC2-6
4223	38.5	33.0	34.2	37.31	-5.5	-4.3	-1.19		
4224	38.3	32.7	34.0	36.90	-5.6	-4.3	-1.40		
4225	36.9	32.0	32.5	34.73	-4.9	-4.4	-2.13		
4226	36.6	30.4	30.6	33.00	-6.3	-6.0	-3.60		
4227	16.1	13.8	14.3	15.71	-2.3	-1.8	-0.41		
4228	15.3	9.2	10.0	10.14	-6.0	-5.3	-5.12		
4229	45.7	42.5	44.5	45.2	-3.2	-1.2	-0.5		
4230	29.1	25.1	25.2	25.2	-4.0	-3.9	-3.9		
5000	20.7	19.4	19.6	19.6	-1.3	-1.1	-1.1		
5001	12.8	10.4	10.8	11.1	-2.5	-2.1	-1.7		
5002	12.5	11.6	11.7	11.77	-0.8	-0.8	-0.69		
5003	13.5	10.0	10.3	11.13	-3.5	-3.2	-2.36		
5007	15.1	10.4	10.6	10.71	-4.6	-4.5	-4.35		
5008	12.6	10.5	10.7	10.79	-2.0	-1.9	-1.76		
5009	13.5	10.7	10.9	10.98	-2.8	-2.6	-2.50		
5010	12.3	10.8	10.9	11.06	-1.5	-1.4	-1.24		
5011	12.2	11.1	11.2	11.24	-1.1	-1.0	-0.92		
5012	13.7	11.9	12.1	12.14	-1.8	-1.6	-1.55		
5013	39.7	35.8	36.3	39.70	-3.9	-3.4	0.00	South property line Latitiude 49	CR-20
5014	41.0	37.0	37.5	41.00	-4.0	-3.5	0.00	South property line Latitiude 49	CR-20
5015	46.5	38.9	39.4	46.50	-7.6	-7.2	0.00	South property line Latitiude 49	CR-20
5016	51.0	48.0	48.3	48.75	-3.0	-2.7	-2.25		
5017	49.8	33.3	34.3	37.32	-16.5	-15.5	-12.48		
5018	38.7	34.7	35.2	38.55	-4.0	-3.5	-0.15		
5019	49.5	46.0	46.2	46.36	-3.5	-3.3	-3.14		
5019-D	41.8	37.3	37.5	37.6	-4.5	-4.3	-4.2		
T3036	14.9	9.5	10.2	10.5	-5.4	-4.7	-4.4		
T3037	44.0	40.2	40.3	40.4	-3.8	-3.7	-3.6		
T6001	60.0	55.6	55.8	55.9	-4.4	-4.3	-4.2		
T6007	11.0	8.1	9.1	10.0	-2.9	-1.9	-1.0		
T6008	11.0	8.1	9.1	10.0	-2.9	-1.9	-1.0		
T6009	12.0	8.1	9.1	10.0	-3.9	-2.9	-2.0		
T6010	12.0	8.1	9.1	10.0	-3.9	-2.9	-2.0		
T6014	71.4	68.8	69.4	69.8	-2.6	-2.0	-1.6		
T6015	25.1	19.4	19.7	20.7	-5.7	-5.4	-4.4		
T6016	28.0	20.5	20.6	20.8	-7.5	-7.4	-7.2		
T6017	49.0	41.5	41.7	41.84	-7.5	-7.3	-7.16		
T6018	53.0	50.1	50.2	50.2	-2.9	-2.8	-2.8		
T6019	41.1	36.5	37.2	37.4	-4.7	-4.0	-3.7		
T6020	39.6	35.3	35.8	36.0	-4.3	-3.8	-3.7		
T6021	17.1	13.6	14.3	15.2	-3.6	-2.9	-2.0		
T6022	22.1	18.2	18.9	19.2	-4.0	-3.3	-2.9		
T6023	60.4	57.6	58.0	58.4	-2.8	-2.4	-2.1		
T6024	10.8	8.0	8.8	9.5	-2.8	-2.0	-1.3		
T6025	15.8	10.4	10.6	10.8	-5.4	-5.2	-5.0		
T6026	31.2	27.2	27.4	27.6	-4.0	-3.8	-3.6		
T6027	15.1	11.4	11.9	12.2	-3.8	-3.2	-2.9		
T6028	35.4	33.0	33.4	33.8	-2.3	-2.0	-1.6		
T6029	33.9	31.2	31.7	32.0	-2.7	-2.2	-1.9		
T6030	28.9	22.2	22.6	23.0	-6.7	-6.3	-6.0		
T6031	11.0	8.2	10.0	10.7	-2.8	-1.0	-0.3		
T6033	13.0	7.9	8.0	8.3	-5.1	-5.0	-4.7		
T6034	53.8	48.3	49.3	50.3	-5.5	-4.5	-3.5		
T6035	59.2	56.0	56.1	56.1	-3.2	-3.1	-3.1		
T6036	11.7	8.5	10.2	10.5	-3.2	-1.5	-1.2		
T6037	13.0	9.2	10.0	10.1	-3.8	-3.0	-2.9		
T6038	10.0	9.3	10.0	10.00	-0.8	0.0	0.00	Mariners Cove	CR-10
T6039	11.7	7.8	8.3	8.6	-3.9	-3.5	-3.2		
T6040	32.1	26.6	27.0	32.1	-5.6	-5.2	0.0	Birch Bay RV Park	CR-12
T6041	34.2	31.3	31.4	34.3	-2.9	-2.8	0.0	Birch Bay RV Park	CR-12
TerrelCreek	9.9	8.6	11.0	11.95	-1.4	1.1	2.03	Morrison Avenue	TC2-6
W1000	76.0	73.1	73.1	73.1	-2.8	-2.8	-2.8		
W1003	78.0	76.1	76.1	76.1	-1.9	-1.9	-1.9		
W1004	77.5	75.6	75.6	75.6	-1.9	-1.9	-1.9		
W1005	77.8	75.4	75.4	75.4	-2.3	-2.3	-2.3		
W1006	77.4	74.4	74.4	74.4	-3.0	-3.0	-3.0		
W1008	76.7	72.2	72.2	72.2	-4.5	-4.5	-4.5		
W1009	76.4	73.5	73.5	73.5	-2.9	-2.9	-2.9		
W1011	75.4	72.4	72.4	72.4	-3.0	-3.0	-3.0		

Table B-1 Central South Subwatershed Flooding									
		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
W1013	74.4	71.7	71.7	71.7	-2.7	-2.7	-2.7		
W1014	73.7	71.0	71.0	71.0	-2.7	-2.7	-2.7		
W1016	71.3	68.5	68.5	68.5	-2.8	-2.8	-2.8		
W1017	68.4	65.5	65.5	65.5	-2.9	-2.9	-2.9		
W1018	65.1	61.6	61.6	61.6	-3.4	-3.4	-3.4		
W1019	62.7	58.2	58.2	58.2	-4.4	-4.4	-4.4		
W1020	58.2	54.0	54.0	54.0	-4.2	-4.2	-4.2		
W1022	57.3	53.0	53.0	53.0	-4.2	-4.2	-4.2		
W1024	54.4	50.3	50.3	50.3	-4.0	-4.0	-4.0		
W1025	53.2	50.0	50.0	50.0	-3.3	-3.3	-3.3		
W1026	47.4	44.0	44.0	44.0	-3.5	-3.5	-3.5		
W1027	43.1	39.9	39.9	39.9	-3.2	-3.2	-3.2		
W1028	32.9	29.1	29.1	29.1	-3.8	-3.8	-3.8		
W1030	18.5	14.9	14.9	14.9	-3.6	-3.6	-3.6		
W1032	17.4	13.9	13.9	13.9	-3.5	-3.5	-3.5		
W1034	13.6	10.0	11.8	13.57	-3.5	-1.7	0.00	Blaine Road north of Arnie Road	TC1-6
W1037	13.2	9.5	10.1	10.5	-3.7	-3.1	-2.8		
W1083	11.6	9.4	11.6	12.70	-2.2	0.1	1.15	Blaine Road	CUS-6
W1086	16.2	12.6	12.8	13.3	-3.6	-3.4	-2.9		
W1087	17.8	15.4	15.6	16.0	-2.5	-2.2	-1.8		
W1088	21.5	19.0	19.4	20.0	-2.5	-2.1	-1.5		
W1089	21.4	18.6	19.7	20.7	-2.8	-1.6	-0.67		
W1093	21.5	17.3	19.7	20.8	-4.2	-1.8	-0.7		
W1094	21.6	18.0	19.7	20.8	-3.6	-1.9	-0.9		
W1095	27.7	25.2	25.4	25.5	-2.5	-2.4	-2.3		
W1096	31.4	28.6	28.8	28.9	-2.8	-2.6	-2.5		
W1097	41.0	38.6	38.8	38.9	-2.4	-2.2	-2.1		
W1099	41.3	38.9	39.1	39.2	-2.4	-2.2	-2.1		
W1100	44.0	41.3	41.6	42.9	-2.6	-2.3	-1.1		
W1109	43.2	41.9	42.2	43.0	-1.3	-1.0	-0.2		
W1111	43.2	42.0	42.4	43.07	-1.2	-0.8	-0.13		
W1155	63.2	60.5	62.5	63.0	-2.7	-0.7	-0.24		
W1158	68.0	65.1	65.2	65.2	-2.9	-2.8	-2.8		
W1159	68.2	65.1	65.2	65.2	-3.1	-3.0	-3.0		
W1161	68.9	66.7	66.7	66.7	-2.2	-2.2	-2.2		
W1165	63.2	60.3	60.3	60.3	-2.9	-2.9	-2.9		
W1169	62.0	59.7	59.7	59.7	-2.4	-2.4	-2.4		
W1172	59.8	56.4	56.4	56.4	-3.4	-3.4	-3.4		
W1175	54.4	51.8	51.8	51.8	-2.7	-2.7	-2.7		
W1179	51.7	48.1	48.1	48.1	-3.6	-3.6	-3.6		
W1181	40.9	37.6	37.7	37.8	-3.4	-3.2	-3.2		
W1183	31.0	28.2	28.3	28.4	-2.8	-2.7	-2.6		
W1184	24.9	21.1	21.2	21.3	-3.8	-3.7	-3.6		
W1203	21.4	17.2	19.7	20.7	-4.2	-1.7	-0.7		
W1204	20.2	16.5	17.0	17.2	-3.8	-3.3	-3.1		
W1253	74.9	71.8	72.3	72.6	-3.1	-2.6	-2.3		
W1254	75.0	71.8	72.3	72.6	-3.2	-2.7	-2.4		
W1277	82.6	79.9	80.4	80.7	-2.6	-2.2	-1.9		
W1313	77.0	74.2	74.2	74.2	-2.8	-2.8	-2.8		
W1504	56.2	53.1	53.3	55.7	-3.1	-2.9	-0.5		
W1506	55.6	52.7	53.2	55.67	-3.0	-2.4	0.03	Birch Bay - Lynden Road near Anchor Parkway	CUN-05
W1508	54.8	51.4	51.5	53.3	-3.4	-3.3	-1.5		
W1510	54.2	51.1	51.3	53.3	-3.2	-3.0	-0.9		
W1512	53.5	50.4	50.9	53.3	-3.1	-2.6	-0.3		
W1514	53.6	49.6	50.8	52.9	-4.0	-2.8	-0.6		
W1654	47.8	45.2	45.2	45.2	-2.7	-2.7	-2.7		
W1656	47.7	45.6	45.6	45.6	-2.1	-2.1	-2.1		
W1677	20.7	17.0	17.1	17.1	-3.7	-3.6	-3.6		
W1679	15.6	12.2	12.2	12.2	-3.4	-3.4	-3.4		
W1680	15.8	11.6	11.7	11.7	-4.2	-4.2	-4.1		
W1681	13.2	10.1	10.2	10.6	-3.0	-3.0	-2.6		
W1682	14.2	9.8	10.3	10.6	-4.3	-3.9	-3.6		
W1683	14.6	9.9	10.3	10.6	-4.7	-4.4	-4.04		
W1686	12.9	8.5	10.2	10.5	-4.4	-2.7	-2.4		
W1688	11.0	8.5	10.2	10.5	-2.5	-0.8	-0.5		
W1691	11.3	8.5	10.2	10.5	-2.8	-1.1	-0.8		
W1692	11.5	8.5	10.2	10.5	-3.0	-1.3	-1.0		
W1693	11.5	8.5	10.2	10.5	-3.0	-1.3	-0.9		
W1695	11.2	8.5	10.2	10.5	-2.7	-1.0	-0.7		
W1697	11.8	8.4	10.2	10.5	-3.4	-1.6	-1.3		
W1698	12.3	8.4	10.2	10.5	-3.9	-2.1	-1.8		
W1700	12.4	8.4	10.2	10.5	-4.0	-2.2	-1.9		

Table B-1 Central South Subwatershed Flooding										
		Existing Conditions								
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
W1703	14.8	8.4	10.2	10.5	-6.4	-4.6	-4.3		
W1705	12.9	8.4	10.2	10.5	-4.5	-2.7	-2.4		
W1712	14.5	11.5	11.6	11.7	-3.0	-2.9	-2.9		
W1713	12.0	8.9	10.2	10.6	-3.1	-1.8	-1.4		
W1716	12.7	8.7	10.2	10.6	-4.0	-2.5	-2.2		
W1720	11.5	8.6	10.2	10.5	-2.9	-1.3	-1.0		
W1729	18.5	10.5	11.4	12.4	-8.0	-7.1	-6.0		
W1730	18.2	10.7	11.4	12.4	-7.5	-6.8	-5.8		
W1736	13.0	8.4	10.2	10.5	-4.6	-2.8	-2.5		
W1739	13.2	8.4	10.2	10.5	-4.7	-3.0	-2.7		
W1743	12.4	8.4	10.2	10.5	-4.0	-2.2	-1.9		
W1747	12.5	8.4	10.2	10.5	-4.1	-2.3	-2.0		
W1748	12.3	8.4	10.2	10.5	-3.9	-2.1	-1.8		
W1751	12.3	8.4	10.2	10.5	-3.9	-2.1	-1.8		
W1754	12.6	8.4	10.2	10.5	-4.1	-2.4	-2.1		
W1756	12.7	8.4	10.2	10.5	-4.3	-2.5	-2.2		
W1762	13.0	8.4	10.2	10.5	-4.6	-2.8	-2.5		
W1764	12.7	8.4	10.2	10.5	-4.3	-2.5	-2.2		
W1766	12.6	8.4	10.2	10.5	-4.2	-2.4	-2.2		
W1767	12.1	8.4	10.2	10.5	-3.7	-1.9	-1.6		
W1770	11.3	8.4	10.2	10.5	-2.9	-1.1	-0.8		
W1773	11.3	8.4	10.2	10.5	-2.9	-1.1	-0.9		
W1776	11.4	8.4	10.2	10.5	-3.0	-1.2	-1.0		
W1777	11.5	8.4	10.2	10.5	-3.1	-1.3	-1.1		
W1780	11.4	8.4	10.2	10.5	-3.0	-1.2	-0.9		
W1782	13.1	8.4	10.2	10.4	-4.7	-2.9	-2.7		
W1783	11.5	8.4	10.2	10.4	-3.0	-1.3	-1.0		
W1785	9.7	8.4	10.2	10.42	-1.3	0.5	0.69	Wooldridge Drive	TC2-6
W1789	11.3	8.4	10.2	10.4	-2.9	-1.1	-0.9		
W1792	11.0	8.4	10.2	10.4	-2.6	-0.9	-0.6		
W1793	11.1	8.4	10.2	10.4	-2.7	-0.9	-0.6		
W1796	11.2	8.4	10.0	10.1	-2.8	-1.2	-1.1		
W1800	12.8	8.4	10.4	10.4	-4.4	-2.4	-2.4		
W1806	10.4	8.4	10.4	10.41	-2.0	0.0	0.00	Morrison Avenue	TC2-6
W1809	12.0	8.4	10.5	11.18	-3.6	-1.5	-0.82		
W1824	10.8	8.6	9.7	9.7	-2.2	-1.1	-1.1		
W1826	10.5	8.6	9.7	9.7	-1.9	-0.8	-0.8		
W1828	10.7	8.6	9.7	9.7	-2.1	-1.0	-1.0		
W1833	10.8	8.6	9.7	9.8	-2.2	-1.0	-1.0		
W1842	11.2	9.4	9.8	9.9	-1.7	-1.4	-1.3		
W1843	10.4	8.9	9.8	9.8	-1.6	-0.7	-0.6		
W1845	8.3	8.6	9.8	9.83	0.3	1.5	1.56	Terrell Drive	TC2-6
W3008	11.6	7.8	8.3	8.7	-3.8	-3.3	-3.0		
W3047	10.0	8.1	9.1	9.95	-1.8	-0.8	0.00	Golf Course	Private
W3062	9.4	8.1	9.1	9.96	-1.3	-0.2	0.60	Golf Course	Private
W3102	10.2	7.9	10.2	10.34	-2.4	0.0	0.10	Golf Course	Private
W3202	48.2	44.4	44.8	45.7	-3.8	-3.5	-2.47		
W3206	48.1	45.2	45.4	45.6	-2.9	-2.8	-2.5		
W3210	48.7	45.8	46.1	46.2	-2.9	-2.6	-2.5		
W3215	48.5	45.9	46.2	46.3	-2.6	-2.3	-2.2		
W3221	48.2	45.9	46.2	46.3	-2.3	-2.0	-1.9		
W3224	48.3	45.9	46.2	46.3	-2.4	-2.1	-2.0		
W3229	48.2	45.9	46.3	46.4	-2.3	-1.9	-1.8		
W3234	48.9	46.1	46.5	46.6	-2.8	-2.4	-2.3		
W3238	47.7	44.0	44.6	45.5	-3.7	-3.0	-2.2		
W3241	47.4	43.9	44.6	45.5	-3.5	-2.7	-1.9		
W3245	47.4	43.3	44.6	45.5	-4.1	-2.7	-1.8		
W3249	47.1	43.4	43.5	43.6	-3.7	-3.5	-3.4		
W3282	48.5	45.6	45.7	45.7	-2.9	-2.8	-2.8		
W3286	45.5	42.1	44.5	45.2	-3.5	-1.0	-0.3		
W3306	46.4	41.6	44.5	45.2	-4.8	-1.9	-1.2		
W3311	46.7	42.2	45.2	46.0	-4.5	-1.5	-0.6		
W3322	46.4	42.4	45.2	46.0	-3.9	-1.2	-0.4		
W3326	46.7	42.9	45.2	46.0	-3.8	-1.5	-0.7		
W33352	9.5	8.1	9.8	10.40	-1.3	0.3	0.95	Terrill Creek at Alderson Road	
W3343	45.1	42.9	44.4	44.5	-2.2	-0.7	-0.6		
W3346	45.1	42.9	44.4	44.50	-2.2	-0.7	-0.55		
W3365	14.5	9.2	10.4	12.3	-5.3	-4.2	-2.3		
W3375	21.8	19.3	19.7	20.5	-2.6	-2.1	-1.3		
W3381	19.8	18.7	18.9	19.4	-1.1	-0.9	-0.4		
W3384	15.9	12.0	12.3	12.8	-3.8	-3.6	-3.0		
W3388	12.5	9.4	11.6	12.71	-3.1	-0.9	0.20	Blaine Road	CUS-2

Table B-1
Central South Subwatershed Flooding

Junction	Flood Elev	Existing Conditions						Location	Problem ID
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				
		2 Year	25 Year	100 Year	2 Year	25 Year	100 Year		
W5008	57.5	55.2	56.2	57.5	-2.3	-1.3	-0.03		
W5009	57.3	54.9	55.3	55.7	-2.4	-2.1	-1.6		
W5028	57.3	54.9	55.2	55.6	-2.4	-2.1	-1.7		
W5041	56.3	51.9	52.0	52.1	-4.4	-4.3	-4.2		
W5047	11.5	7.9	8.6	9.3	-3.6	-3.0	-2.3		
W5051	11.8	7.9	8.5	9.3	-3.9	-3.3	-2.6		
W5062	12.6	7.8	8.3	8.6	-4.8	-4.3	-4.0		
W5103	13.3	10.0	11.8	13.57	-3.3	-1.5	0.24	Blaine Road	TC1-6
W5121	9.0	8.1	9.1	9.89	-0.9	0.1	0.89	Leisure Park	CUS-1
W5129	9.0	8.1	9.0	9.77	-0.9	0.0	0.77	Leisure Park	CUS-1
W5141	9.4	8.1	9.1	9.96	-1.3	-0.3	0.56	Leisure Park	CUS-1
W5145	9.4	8.1	9.1	9.93	-1.3	-0.3	0.53	Leisure Park	CUS-1
W5161	9.3	8.1	9.1	9.97	-1.2	-0.2	0.67	Leisure Park	CUS-1
W5173	9.3	8.1	9.1	9.97	-1.2	-0.2	0.67	Leisure Park	CUS-1
W5181	10.1	8.1	9.1	10.0	-2.0	-0.9	-0.1		

APPENDIX C.
CAPITAL IMPROVEMENT PROJECT DESCRIPTIONS

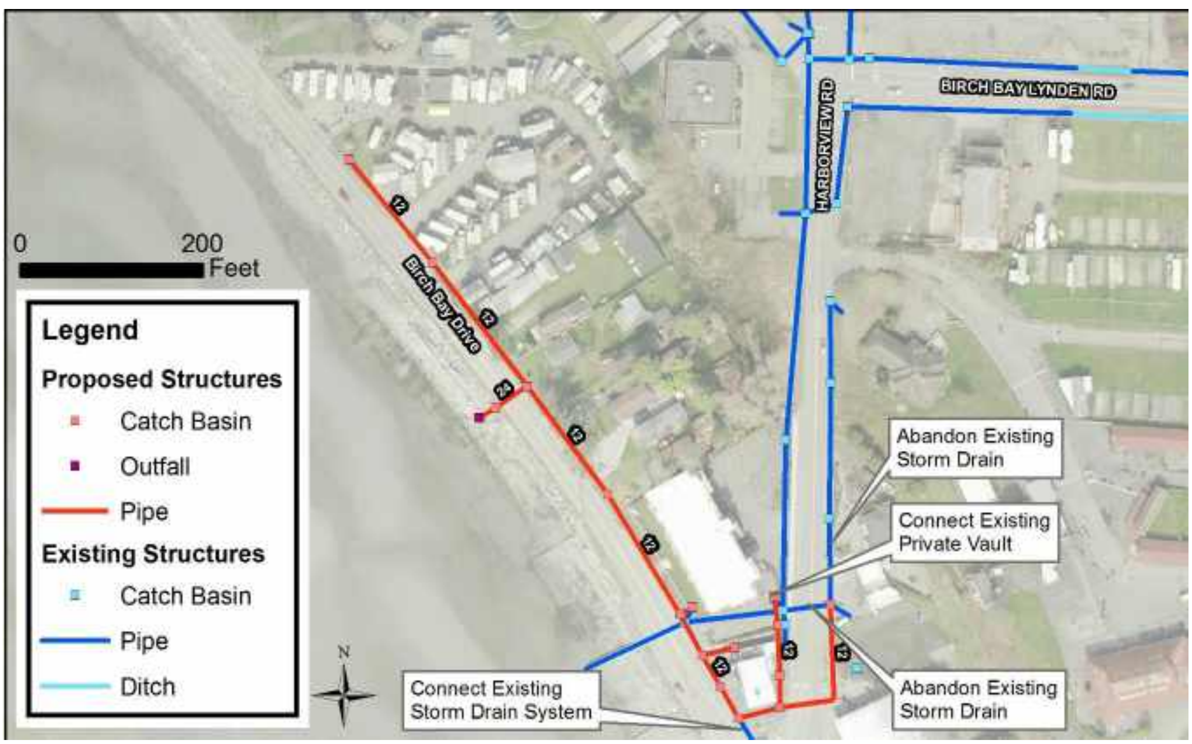
CENTRAL REACHES SUBBASIN

Project CR-1: Birch Bay Drive at Harborview Road Storm Drain Improvements

Problem ID:	CR-4
Location:	Birch Bay Drive and Harborview Road
Description:	The storm drain system on Birch Bay Drive and Harborview Road is undersized and floods during the 2-year event. The storm drain system will be split into a high-level / low-level system. See Project CR-2 for a description of the high-level system improvements. The low level system collects storm drainage occurring near Birch Bay Drive and connects the existing private storm vault.
Cost Estimate:	$525,000
Score:	30
Related Projects:	CR-2

Project Description:

- Replace 266 lineal feet of 6- and 12-inch diameter pipe with 12-inch diameter CPE.
- Replace 10 CB Type 1 structures.
- Install 868 lineal feet of 12-inch diameter CPE pipe and 38 lineal feet of 24-inch diameter CPE pipe.
- Install 5 CB Type 1 structures and 2 CB Type 2 structures.
- Install one 24-inch diameter HDPE outfall (21 lineal feet).



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CR-1 **BY:** GW
DESCRIPTION: Birch Bay Drive at Harborview Road Storm Drain Improvements **CHECKED BY:**
SUBBASIN: Central Reaches **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	586	SY	$ 40	$ 23,440
REMOVE PIPE	1,193	LF	$ 5	$ 5,965
PLUGGING EXISTING PIPE	2	EA	$ 200	$ 400
CONNECT EXISTING PIPE	4	EA	$ 500	$ 2,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	1,134	LF	$ 40	$ 45,360
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	38	LF	$ 60	$ 2,280
24-INCH DIAM HDPE	21	LF	$ 65	$ 1,365
CATCH BASIN TYPE 1	15	EA	$ 1,100	$ 16,500
CATCH BASIN TYPE 2, 48-IN DIAM	2	EA	$ 2,400	$ 4,800
ASPHALT CONCRETE PAVEMENT PATCHING	54	TN	$ 100	$ 5,400
CRUSHED SURFACING BASE COURSE	158	TN	$ 15	$ 2,370
CRUSHED SURFACING TOP COURSE	79	TN	$ 35	$ 2,765
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,193	CY	$ 30	$ 35,790
SHORING OR EXTRA EXCAVATION CLASS B	7,158	SF	$ 1.5	$ 10,737
			Material Subtotal	$ 164,172
CONTINGENCY	50%			$ 82,090
			Material Subtotal with Contingency	$ 246,262
DEWATERING	5%			$ 12,320
ARCHEOLOGICAL MONITORING	5%			$ 12,320
EROSION & SEDIMENTATION CONTROL	10%			$ 24,630
TRAFFIC CONTROL	3%			$ 7,390
SITE RESTORATION	5%			$ 12,320
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 15,770
			Construction Subtotal (Rounded)	$ 331,000
STATE SALES TAX	8.5%			$ 28,140
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 99,300
CONSTRUCTION MANAGEMENT	10%			$ 33,100
PERMITTING - WITH OUTFALL TO BAY	10%			$ 33,100
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 525,000**

Notes:

1. The above cost opinion is in 2014 dollars and does not include future escalation, financing, or O&M costs.

2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

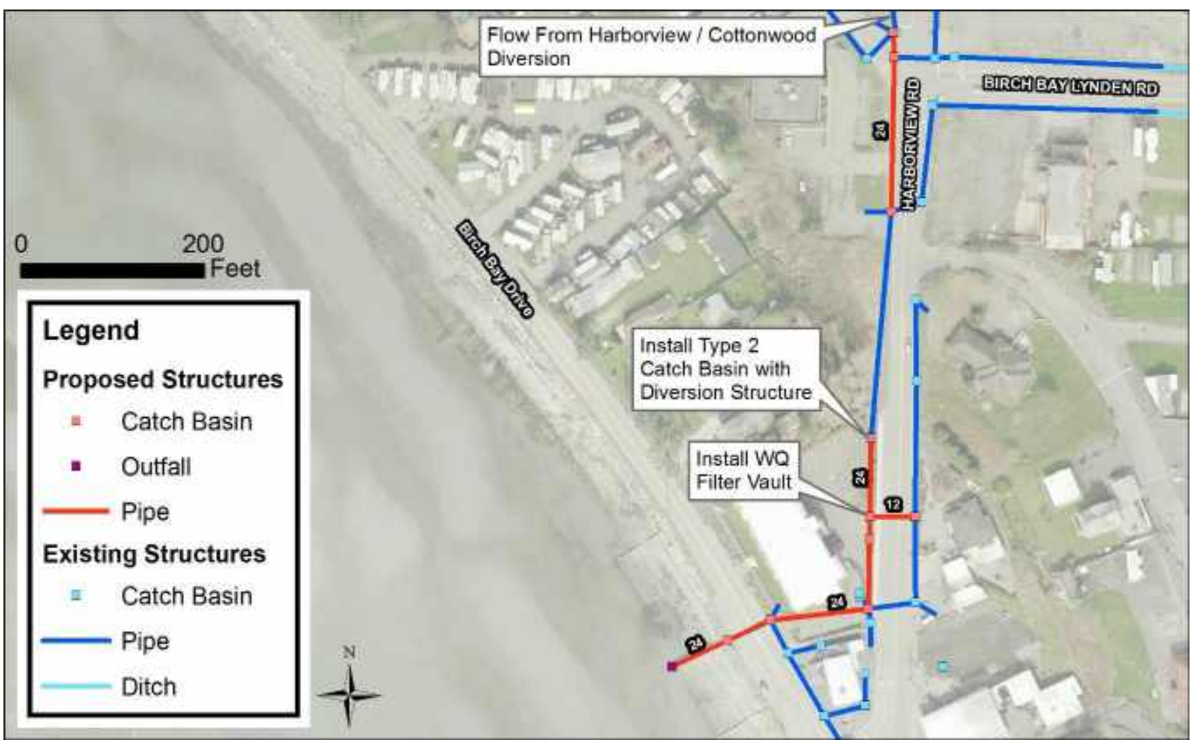
Central Reaches Subbasin

Project CR-2: Harborview Road Storm Drain and Outfall Improvements

Problem ID:	CR-1; CR-2; CR-4; CR-5; CR-6, CR-7; CR-13
Location:	Birch Bay Drive and Harborview Road
Description:	The storm drain system on Harborview Road is undersized and floods during the 25-year and contributes to flooding on Birch Bay Drive during the 100-year event. The storm drain system will be split into a high-level / low-level system. The high level system also conveys storm drainage from the overflow from the Central North subwatershed and Birch Bay Lynden Drive. The outfall to Birch Bay is in poor condition and will be replaced. The low-level system, including the private storm vault near Birch Bay Drive, will be disconnected from the existing Harborview Drive outfall (See Project CR-1).
Cost Estimate:	$536,000
Score:	27
Related Projects:	CR-1

Project Description:

- Replace 541 lineal feet of 12- and 24-inch diameter pipe with 24-inch diameter CPE.
- Replace 2 CB Type 1 structures with CB Type 2 structures.
- Replace 1 CB Type 1 structures and 2 CB Type 2 structures.
- Replace one 24-inch diameter concrete outfall with 24-inch HDPE pipe (67 lineal feet).
- Install 49 lineal feet of 12-inch diameter CPE.
- Install 3 CB Types 2 structures and 1 CB Type 2 catch basin with diversion structure.
- Install 1 water quality filter vault.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CR-2 **BY:** GW
DESCRIPTION: Harborview Road Storm Drain and Outfall Improvements **CHECKED BY:**
SUBBASIN: Central Reaches **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	295	SY	$ 40	$ 11,800
REMOVE PIPE	657	LF	$ 5	$ 3,285
PLUGGING EXISTING PIPE	5	EA	$ 200	$ 1,000
CONNECT EXISTING PIPE	8	EA	$ 500	$ 4,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	49	LF	$ 40	$ 1,960
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	541	LF	$ 60	$ 32,460
24-INCH DIAM HDPE	67	LF	$ 65	$ 4,355
CATCH BASIN TYPE 1	1	EA	$ 1,100	$ 1,100
CATCH BASIN TYPE 2, 48-IN DIAM	7	EA	$ 2,400	$ 16,800
CATCH BASIN TYPE 2, 48-IN DIAM WITH DIVERSION STRUCTURE	1	EA	$ 5,000	$ 5,000
WATER QUALITY FILTER VAULT	1	EA	$ 50,000	$ 50,000
ASPHALT CONCRETE PAVEMENT PATCHING	27	TN	$ 100	$ 2,700
CRUSHED SURFACING BASE COURSE	80	TN	$ 15	$ 1,200
CRUSHED SURFACING TOP COURSE	40	TN	$ 35	$ 1,400
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	657	CY	$ 30	$ 19,710
SHORING OR EXTRA EXCAVATION CLASS B	3,942	SF	$ 1.5	$ 5,913
			Material Subtotal	$ 167,683
CONTINGENCY	50%			$ 83,850
			Material Subtotal with Contingency	$ 251,533
DEWATERING	5%			$ 12,580
ARCHEOLOGICAL MONITORING	5%			$ 12,580
EROSION & SEDIMENTATION CONTROL	10%			$ 25,160
TRAFFIC CONTROL	3%			$ 7,550
SITE RESTORATION	5%			$ 12,580
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 16,100
			Construction Subtotal (Rounded)	$ 338,000
STATE SALES TAX	8.5%			$ 28,730
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 101,400
CONSTRUCTION MANAGEMENT	10%			$ 33,800
PERMITTING - WITH OUTFALL TO BAY	10%			$ 33,800
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 536,000**

Notes:

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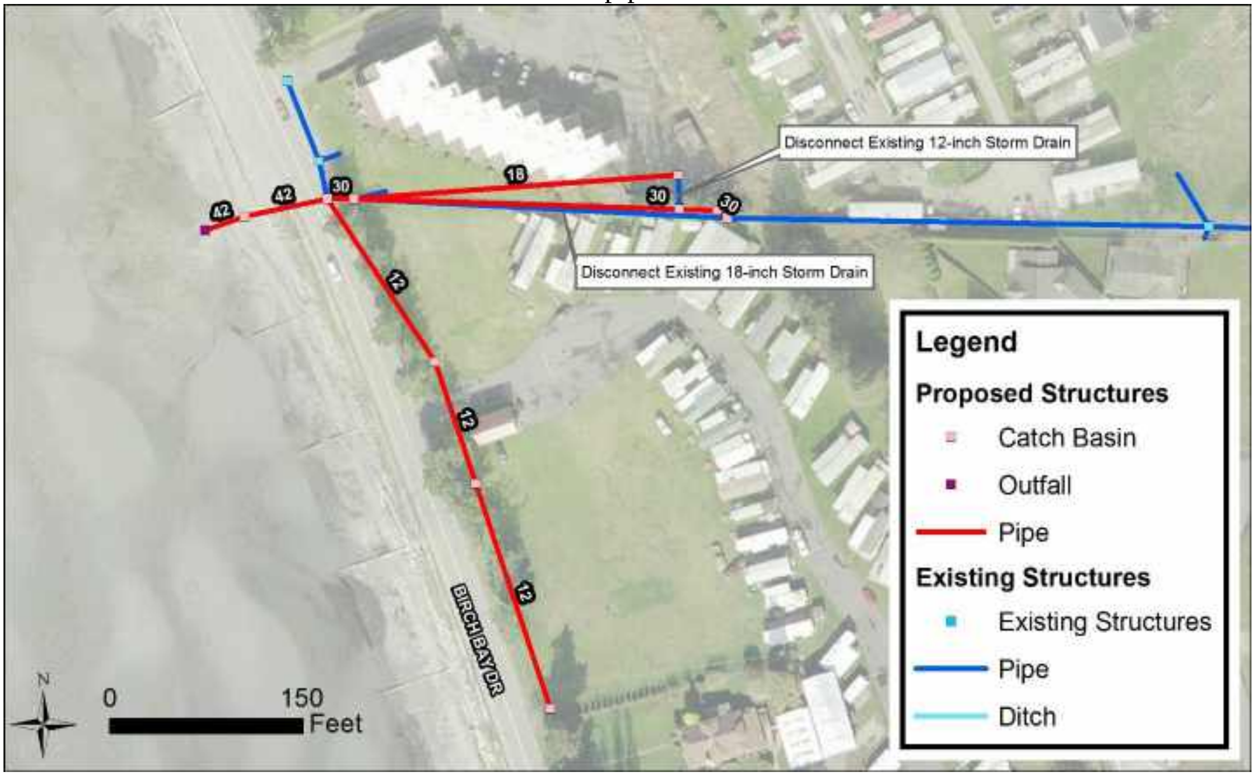
Central Reaches Subbasin

Project CR-3: Birch Bay Drive at Mariners Cove Storm Drain Improvements and Outfall Replacement

Problem ID:	CR-11; CR-14
Location:	Birch Bay Drive near Mariners Cove
Description:	Flooding occurs in the storm drain line between Mariners Cove and Latitude 49 during the 100-year event. Backflow from the trunk storm drain causes flooding in the Mariners Cove parking lot inlet during the 25-year event. Additional investigation is required to confirm actual pipe configuration in the Mariners Cove parking lot. The outfall to Birch Bay will need to be replaced to prior to increasing the conveyance of the upstream system (see Project CR-4). Consider in-line tide valves versus a new outfall for the proposed storm drain along Birch Bay Drive. No storm drain system on Birch Bay Drive.
Cost Estimate:	$533,000
Score:	26
Related Projects:	CR-4

Project Description:

- Replace 315 lineal feet of 12-, 24-, and 30-inch diameter pipe with 30-inch CPE.
- Replace 66 lineal feet of 30-inch diameter pipe with 42-inch CPE.
- Replace 5 CB Type 2 structures and 1 CB Type 1 structure.
- Install 438 lineal feet of 12-inch diameter and 254 lineal feet of 18-inch diameter CPE pipe
- Install 1 CB Type 2 structure 3 CB Type 1 structures.
- Install 33 lineal feet of 42-inch HDPE outfall pipe.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CR-3 **BY:** GW
DESCRIPTION: Birch Bay Drive at Mariners Cove SD Imp. and Outfall Repl. **CHECKED BY:**
SUBBASIN: Central Reaches **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	50	SY	$ 40	$ 1,980
REMOVE PIPE	381	LF	$ 5	$ 1,905
CONNECT EXISTING PIPE	5	EA	$ 500	$ 2,500
PLUGGING EXISTING PIPE	2	EA	$ 200	$ 400
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	438	LF	$ 40	$ 17,520
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	254	LF	$ 55	$ 13,970
CORRUGATED POLYETHYLENE STORM SEWER PIPE 30 IN. DIAM.	315	LF	$ 70	$ 22,050
CORRUGATED POLYETHYLENE STORM SEWER PIPE 42 IN. DIAM.	66	LF	$ 95	$ 6,270
42-INCH DIAM HDPE	33	LF	$ 95	$ 3,135
CATCH BASIN TYPE 1	4	EA	$ 1,100	$ 4,400
CATCH BASIN TYPE 2, 48-IN DIAM	6	EA	$ 2,400	$ 14,400
ASPHALT CONCRETE PAVEMENT PATCHING	5	TN	$ 100	$ 500
CRUSHED SURFACING BASE COURSE	13	TN	$ 15	$ 195
CRUSHED SURFACING TOP COURSE	7	TN	$ 35	$ 245
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,966	CY	$ 30	$ 58,987
SHORING OR EXTRA EXCAVATION CLASS B	8,848	SF	$ 1.5	$ 13,272
			Material Subtotal	$ 166,729
CONTINGENCY	50%			$ 83,370
			Material Subtotal with Contingency	$ 250,099
DEWATERING	5%			$ 12,510
ARCHEOLOGICAL MONITORING	5%			$ 12,510
EROSION & SEDIMENTATION CONTROL	10%			$ 25,010
TRAFFIC CONTROL	3%			$ 7,510
SITE RESTORATION	5%			$ 12,510
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 16,010
			Construction Subtotal (Rounded)	$ 336,000
STATE SALES TAX	8.5%			$ 28,560
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 100,800
CONSTRUCTION MANAGEMENT	10%			$ 33,600
PERMITTING - WITH OUTFALL TO BAY	10%			$ 33,600
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 533,000**

Notes:
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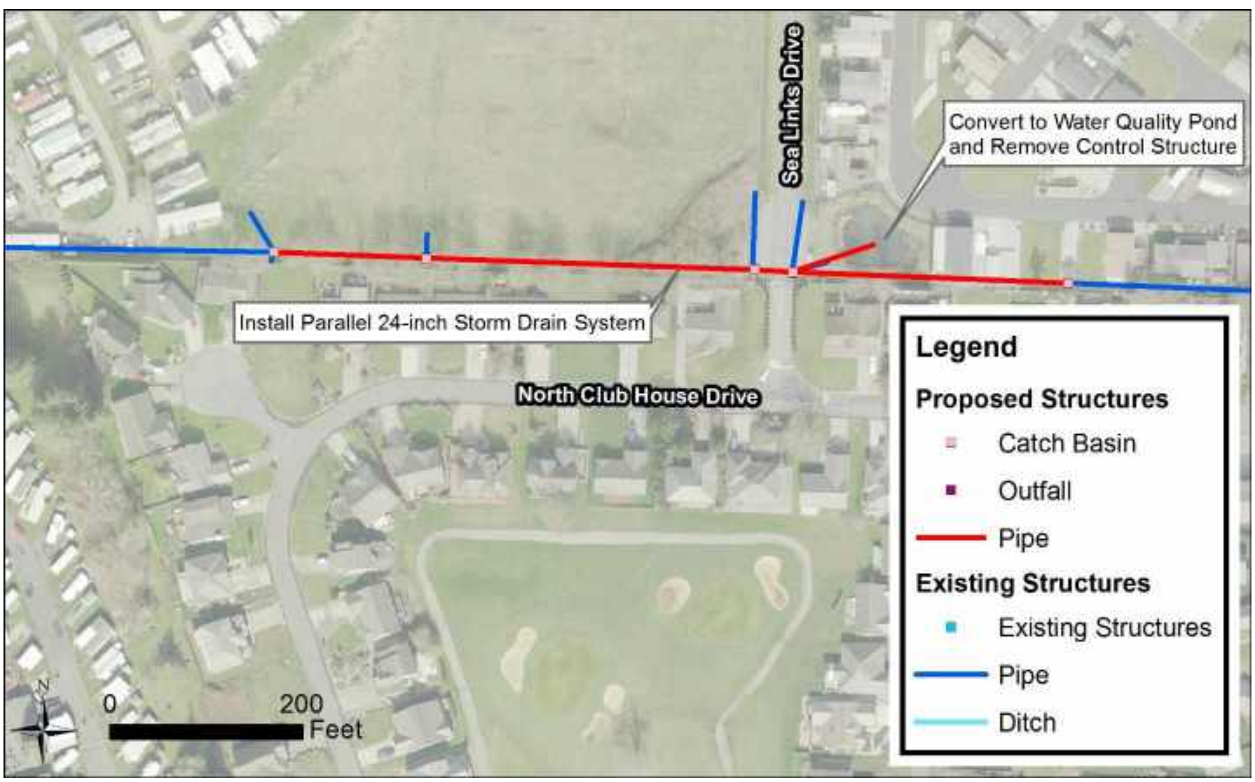
Central Reaches Subbasin

Project CR-4: Mariners Cove/Latitude 49 Storm Drain Trunk Line Replacement

Problem ID:	CR-12; CR-19
Location:	South property line Birch Bay RV Resort and Latitude 49
Description:	Flooding occurs in the storm drain line near Sea Links Drive during the 100-year event. The Latitude 49 stormwater pond overflows during all design storm events. The outfall to Birch Bay included with Project CR-3 will need to be installed prior to construction of this project.
Cost Estimate:	$436,000
Score:	25
Related Projects:	CR-3

Project Description:

- Install 828 lineal feet of 24-inch diameter CPE pipe.
- Replace 38 lineal feet of 12-inch diameter pipe with 24-inch diameter CPE.
- Install 6 CB Type 2 structures.
- Convert Latitude 49 stormwater pond to water quality treatment pond.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CR-4 **BY:** GW
DESCRIPTION: Mariners Cove / Latitude 49 SD Trunk Line Replacement **CHECKED BY:**
SUBBASIN: Central Reaches **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	75	SY	$ 40	$ 3,000
REMOVE PIPE	38	LF	$ 5	$ 190
CONNECT EXISTING PIPE	7	EA	$ 500	$ 3,500
PLUGGING EXISTING PIPE	2	EA	$ 200	$ 400
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	866	LF	$ 60	$ 51,960
CATCH BASIN TYPE 2, 48-IN DIAM	6	EA	$ 2,400	$ 14,400
ASPHALT CONCRETE PAVEMENT PATCHING	7	TN	$ 100	$ 700
CRUSHED SURFACING BASE COURSE	20	TN	$ 15	$ 300
CRUSHED SURFACING TOP COURSE	10	TN	$ 35	$ 350
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,540	CY	$ 30	$ 46,187
SHORING OR EXTRA EXCAVATION CLASS B	6,928	SF	$ 1.5	$ 10,392
			Material Subtotal	$ 136,379
CONTINGENCY	50%			$ 68,190
			Material Subtotal with Contingency	$ 204,569
DEWATERING	5%			$ 10,230
ARCHEOLOGICAL MONITORING	5%			$ 10,230
EROSION & SEDIMENTATION CONTROL	10%			$ 20,460
TRAFFIC CONTROL	3%			$ 6,140
SITE RESTORATION	5%			$ 10,230
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 13,100
			Construction Subtotal (Rounded)	$ 275,000
STATE SALES TAX	8.5%			$ 23,380
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 82,500
CONSTRUCTION MANAGEMENT	10%			$ 27,500
PERMITTING - WITH OUTFALL TO BAY	10%			$ 27,500
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 436,000**

Notes:

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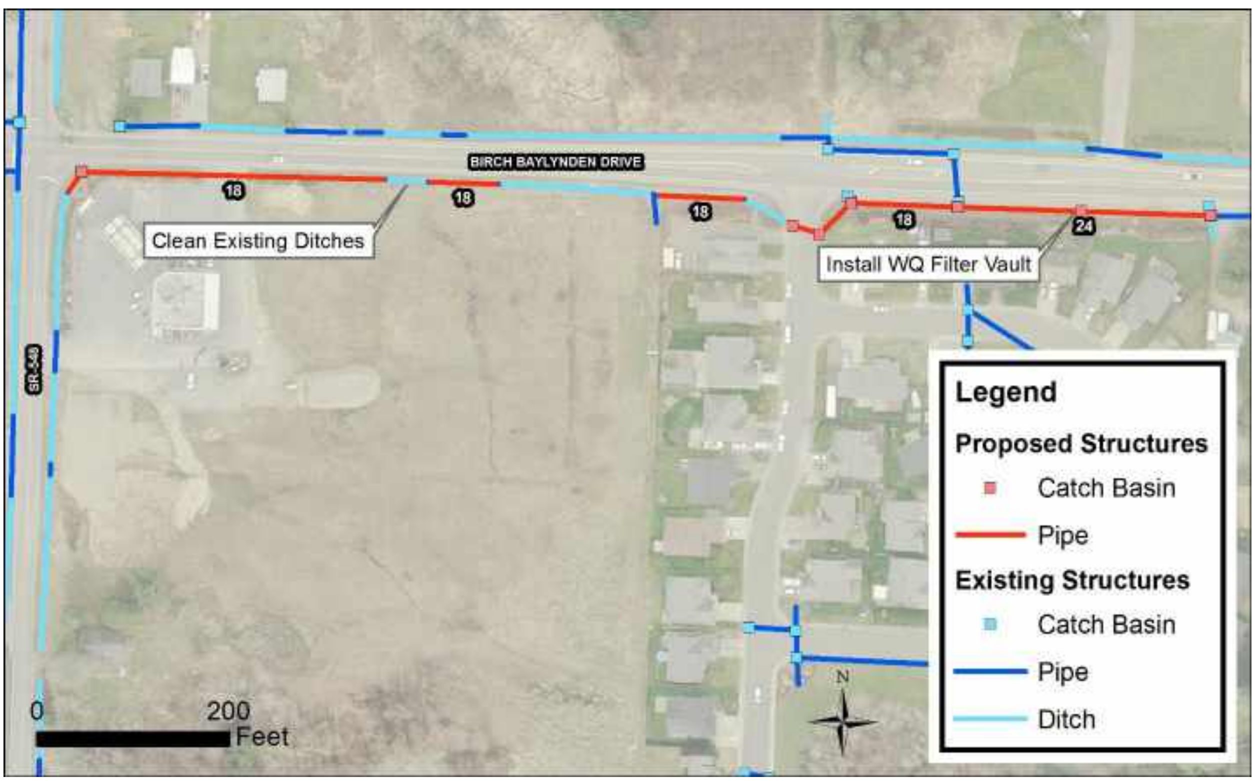
CENTRAL UPLANDS NORTH SUBBASIN

Project CUN-1: Birch Bay – Lynden Road Roadside Storm Drainage Improvements

Problem ID:	CUN-3; CUN-5
Location:	Birch Bay Lynden Road near Anchor Parkway
Description:	Roadside storm drainage system on the south side of Birch Bay Lynden Road west of Anchor Parkway is undersized causing roadway flooding occurs during the 100-year event. Additionally, the existing ditches are obstructed with sediment. There is an adjacent private system that requires further evaluation.
Cost Estimate:	$452,000
Score:	16
Related Projects:	N/A

Project Description:

- Clean 265 lineal feet of roadside ditch.
- Replace 582 lineal feet of 12-inch diameter pipe with 18-inch diameter CPE.
- Replace 264 lineal feet of 24-inch diameter smooth plastic pipe with 24-inch diameter CPE.
- Replace 3 CB Type 1 structures with CB Type 2 structures.
- Replace 3 CB Type 2 structures.
- Install 1 water quality filter vault.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CUN-1 **BY:** GW
DESCRIPTION: Birch Bay – Lynden Road Roadside Storm Drainage Improvements **CHECKED BY:**
SUBBASIN: Central Uplands North **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
REMOVE PIPE	898	LF	$ 5	$ 4,490
SAWCUT & REMOVE PAVEMENT	75	SY	$ 40	$ 3,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	695	LF	$ 55	$ 38,225
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	264	LF	$ 60	$ 15,840
CATCH BASIN TYPE 2, 48-IN DIAM	6	EA	$ 2,400	$ 14,400
CATCH BASIN TYPE 2, 48-IN DIAM WITH DIVERSION STRUCTURE	1	EA	$ 5,000	$ 5,000
WATER QUALITY FILTER VAULT	1	EA	$ 30,000	$ 30,000
ASPHALT CONCRETE PAVEMENT PATCHING	7	TN	$ 100	$ 700
CRUSHED SURFACING BASE COURSE	20	TN	$ 15	$ 300
CRUSHED SURFACING TOP COURSE	10	TN	$ 35	$ 350
REESTABLISH DITCH	265	LF	$ 5	$ 1,325
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	695	CY	$ 30	$ 20,850
SHORING OR EXTRA EXCAVATION CLASS B	4,170	SF	$ 1.5	$ 6,255
			Material Subtotal	$ 145,735
CONTINGENCY	50%			$ 72,870
			Material Subtotal with Contingency	$ 218,605
DEWATERING	5%			$ 10,940
ARCHEOLOGICAL MONITORING	5%			$ 10,940
EROSION & SEDIMENTATION CONTROL	10%			$ 21,870
TRAFFIC CONTROL	3%			$ 6,560
SITE RESTORATION	5%			$ 10,940
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 14,000
			Construction Subtotal (Rounded)	$ 294,000
STATE SALES TAX	8.5%			$ 24,990
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 88,200
CONSTRUCTION MANAGEMENT	10%			$ 29,400
PERMITTING - NO OUTFALL	5%			$ 14,700
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 452,000**

Notes:

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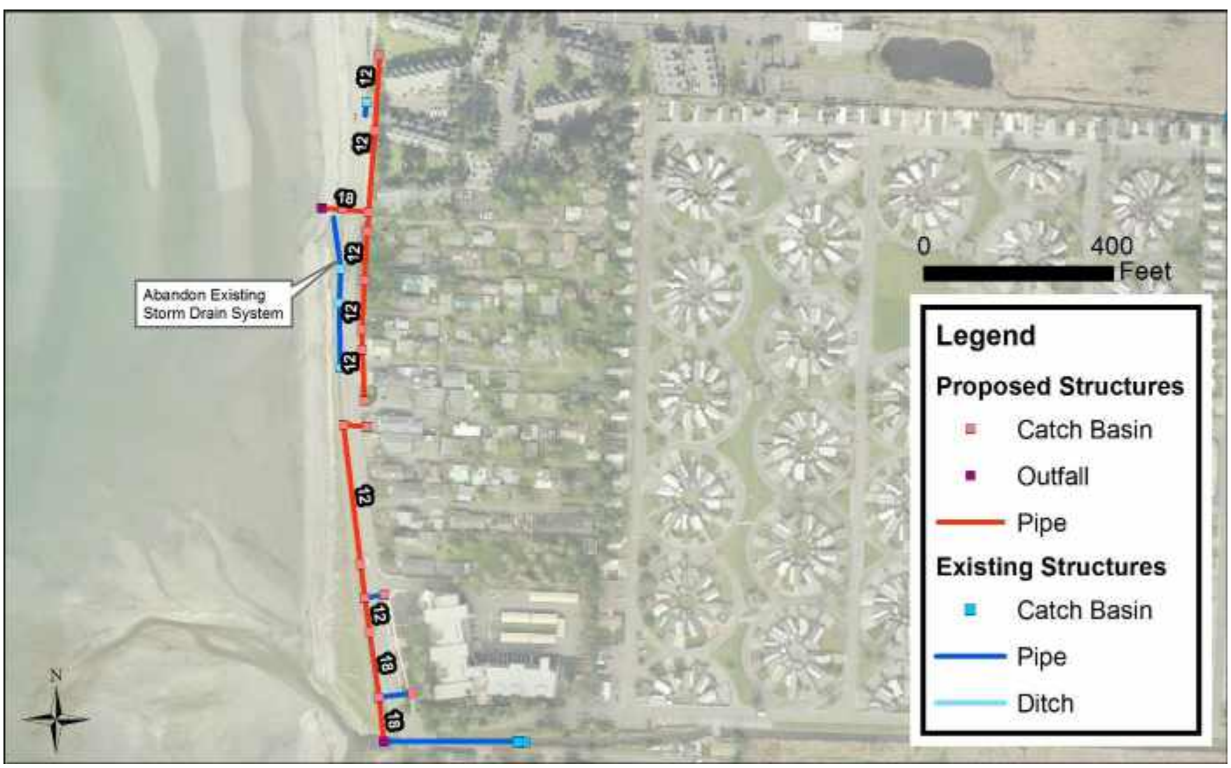
CENTRAL UPLANDS SOUTH SUBBASIN

Project CUS-1: Birch Bay Drive Storm Drain Improvements North of Lora Lane

Problem ID:	CUS-4; CUS-5; CUS-8; CUS-9; CUS-10; CUS-11
Location:	Birch Bay Drive north of Lora Lane.
Description:	Roadway flooding occurs from two separate storm drain systems on Birch Bay Drive. The south system floods during the 2-year event and the north system floods during the 25-year event. The north system will be abandoned and a new storm drain system will be installed to service a larger area of Birch Bay Drive. A new outfall will be constructed and drain into Birch Bay.
Cost Estimate:	$660,000
Score:	24
Related Projects:	TC1-1

Project Description:

- Abandon existing storm drain line.
- Replace 679 lineal feet of 8-inch diameter storm drain with 445 lineal feet of 12-inch CPE and 234 lineal feet of 18-inch CPE.
- Replace 2 CB Type 1 structures with CB Type 2 Structures
- Replace 5 CB Type 1 structures.
- Install 788 lineal feet of 12-inch diameter CPE pipe and 55 lineal feet of 18-inch diameter CPE pipe
- Install 9 CB Type 1 structures and 2 CB Type 2 structures.
- Install one 18-inch HDPE outfall to Birch Bay (30 lineal feet).



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CUS--1 **BY:** GW
DESCRIPTION: Birch Bay Drive Storm Drain Improvements North of Lora Lane **CHECKED BY:**
SUBBASIN: Central Uplands South **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	761	SY	$ 40	$ 30,440
REMOVE PIPE	445	LF	$ 5	$ 2,225
PLUGGING EXISTING PIPE	6	EA	$ 200	$ 1,200
CONNECT EXISTING PIPE	4	EA	$ 500	$ 2,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	1,233	LF	$ 40	$ 49,320
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	289	LF	$ 55	$ 15,895
18-INCH DIAM HDPE	30	LF	$ 60	$ 1,800
CATCH BASIN TYPE 1	13	EA	$ 1,100	$ 14,300
CATCH BASIN TYPE 2, 48-IN DIAM	4	EA	$ 2,400	$ 9,600
ASPHALT CONCRETE PAVEMENT PATCHING	71	TN	$ 100	$ 7,100
CRUSHED SURFACING BASE COURSE	205	TN	$ 15	$ 3,075
CRUSHED SURFACING TOP COURSE	103	TN	$ 35	$ 3,605
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,552	CY	$ 30	$ 46,560
SHORING OR EXTRA EXCAVATION CLASS B	9,312	SF	$ 1.5	$ 13,968
			Material Subtotal	$ 206,088
CONTINGENCY	50%			$ 103,050
			Material Subtotal with Contingency	$ 309,138
DEWATERING	5%			$ 15,460
ARCHEOLOGICAL MONITORING	5%			$ 15,460
EROSION & SEDIMENTATION CONTROL	10%			$ 30,920
TRAFFIC CONTROL	3%			$ 9,280
SITE RESTORATION	5%			$ 15,460
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 19,790
			Construction Subtotal (Rounded)	$ 416,000
STATE SALES TAX	8.5%			$ 35,360
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 124,800
CONSTRUCTION MANAGEMENT	10%			$ 41,600
PERMITTING - WITH OUTFALL TO BAY	10%			$ 41,600
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 660,000**

Notes:

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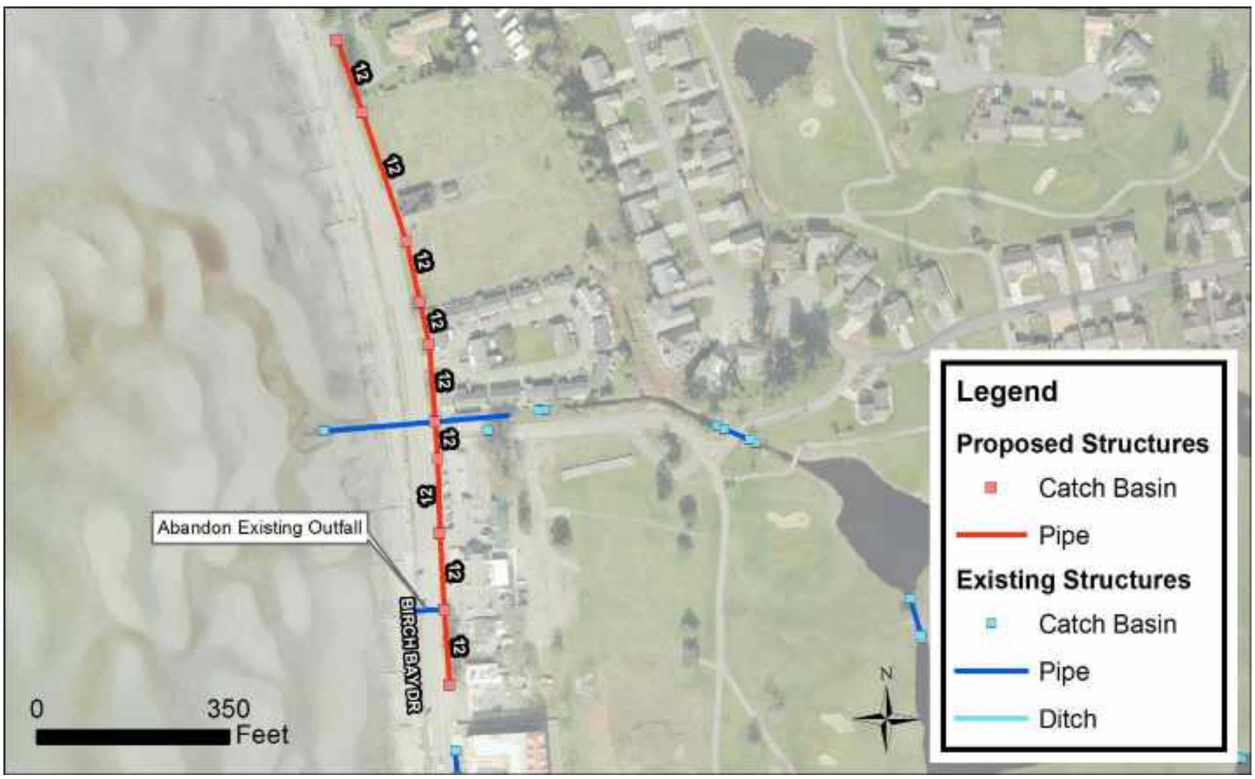
Central Uplands South Subbasin

Project CUS-2: Birch Bay Drive at Club House Drive Storm Drain Improvements

Problem ID:	CR-18
Location:	Birch Bay Drive near Club House Drive
Description:	No existing storm drain system along Birch Bay Drive between Mariners Cove and Club House Drive. A storm drain system will be installed draining the areas directly north and directly south of Club House Drive. The systems will connect to the existing outfall at Club House Drive.
Cost Estimate:	$349,000
Score:	26
Related Projects:	None

Project Description:

- Install 1,200 linear feet of 12-inch CPE pipe.
- Install 9 CB Type 1 structures.
- Replace 1 CB Type 2 structure.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: CUS-2 | **BY:** GW
DESCRIPTION: Birch Bay Drive at Club House Drive Storm Drain Improvements | **CHECKED BY:**
SUBBASIN: Central Reaches / Central Uplands South | **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	142	SY	$ 40	$ 5,667
CONNECT EXISTING PIPE	2	EA	$ 500	$ 1,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	1,200	LF	$ 40	$ 48,000
CATCH BASIN TYPE 1	9	EA	$ 1,100	$ 9,900
CATCH BASIN TYPE 2, 48-IN DIAM	1	EA	$ 2,400	$ 2,400
ASPHALT CONCRETE PAVEMENT PATCHING	13	TN	$ 100	$ 1,300
CRUSHED SURFACING BASE COURSE	38	TN	$ 15	$ 570
CRUSHED SURFACING TOP COURSE	19	TN	$ 35	$ 665
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	800	CY	$ 30	$ 24,000
SHORING OR EXTRA EXCAVATION CLASS B	7,200	SF	$ 1.5	$ 10,800
			Material Subtotal	$ 109,302
CONTINGENCY	50%			$ 54,660
			Material Subtotal with Contingency	$ 163,962
DEWATERING	5%			$ 8,200
ARCHEOLOGICAL MONITORING	5%			$ 8,200
EROSION & SEDIMENTATION CONTROL	10%			$ 16,400
TRAFFIC CONTROL	3%			$ 4,920
SITE RESTORATION	5%			$ 8,200
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 10,500
			Construction Subtotal (Rounded)	$ 220,000
STATE SALES TAX	8.5%			$ 18,700
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 77,000
CONSTRUCTION MANAGEMENT	10%			$ 22,000
PERMITTING - NO OUTFALL	5%			$ 11,000
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 349,000**

Notes:

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TERRELL CREEK TRIBUTARY 1 SUBBASIN

Project TC1-1: Birch Bay Drive Storm Drain Improvements North of Alderson Road

Problem ID:	TC1-2; TC1-3; TC2-13; TC2-15; TC2-22
Location:	Birch Bay Drive between Lora Lane and Alderson Road
Description:	No existing storm drain system at Birch Bay Drive south of Lora Lane. The existing storm drain system along Birch Bay Drive north of Alderson Road has flooding occur during the 2-year event. The existing storm drain system will be replaced and modified to service a larger area. The new storm drain system will include a new outfall to Birch Bay.
Cost Estimate:	$352,000
Score:	27
Related Projects:	CUS-1

Project Description:

- Replace 194 lineal feet of 8- and 10-inch diameter storm drain with 12-inch diameter CPE.
- Install 719 lineal feet of 12-inch diameter CPE pipe.
- Construct 294 lineal feet of water quality swale.
- Replace 3 CB Type 1 structures and install 6 CB Type 1 structures.
- Install two 12-inch diameter HDPE pipe outfalls (145 total lineal feet).

BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC1-1 **BY:** GW
DESCRIPTION: Birch Bay Dr. Storm Drain Improvements North of Alderson Rd. **CHECKED BY:**
SUBBASIN: Terrell Creek Tributary 1 **DATE:** 11/14/14

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	443	SY	$ 40	$ 17,720
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	631	LF	$ 40	$ 25,240
12-INCH DIAM HDPE	100	EA	$ 50	$ 5,000
CATCH BASIN TYPE 1	9	EA	$ 1,100	$ 9,900
ASPHALT CONCRETE PAVEMENT PATCHING	41	TN	$ 100	$ 4,100
CRUSHED SURFACING BASE COURSE	120	TN	$ 15	$ 1,800
CRUSHED SURFACING TOP COURSE	60	TN	$ 35	$ 2,100
WATER QUALITY SWALE	290	LF	$ 50	$ 14,500
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	487	CY	$ 30	$ 14,620
SHORING OR EXTRA EXCAVATION CLASS B	4,386	SF	$ 1.5	$ 6,579
			Material Subtotal	$ 106,559
CONTINGENCY	50%			$ 53,280
			Material Subtotal with Contingency	$ 159,839
DEWATERING	5%			$ 8,000
ARCHEOLOGICAL MONITORING	5%			$ 8,000
EROSION & SEDIMENTATION CONTROL	10%			$ 15,990
TRAFFIC CONTROL	3%			$ 4,800
SITE RESTORATION	5%			$ 8,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 10,240
			Construction Subtotal (Rounded)	$ 215,000
STATE SALES TAX	8.5%			$ 18,280
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 75,250
CONSTRUCTION MANAGEMENT	10%			$ 21,500
PERMITTING - WITH OUTFALL TO BAY	10%			$ 21,500
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 352,000**

Notes:

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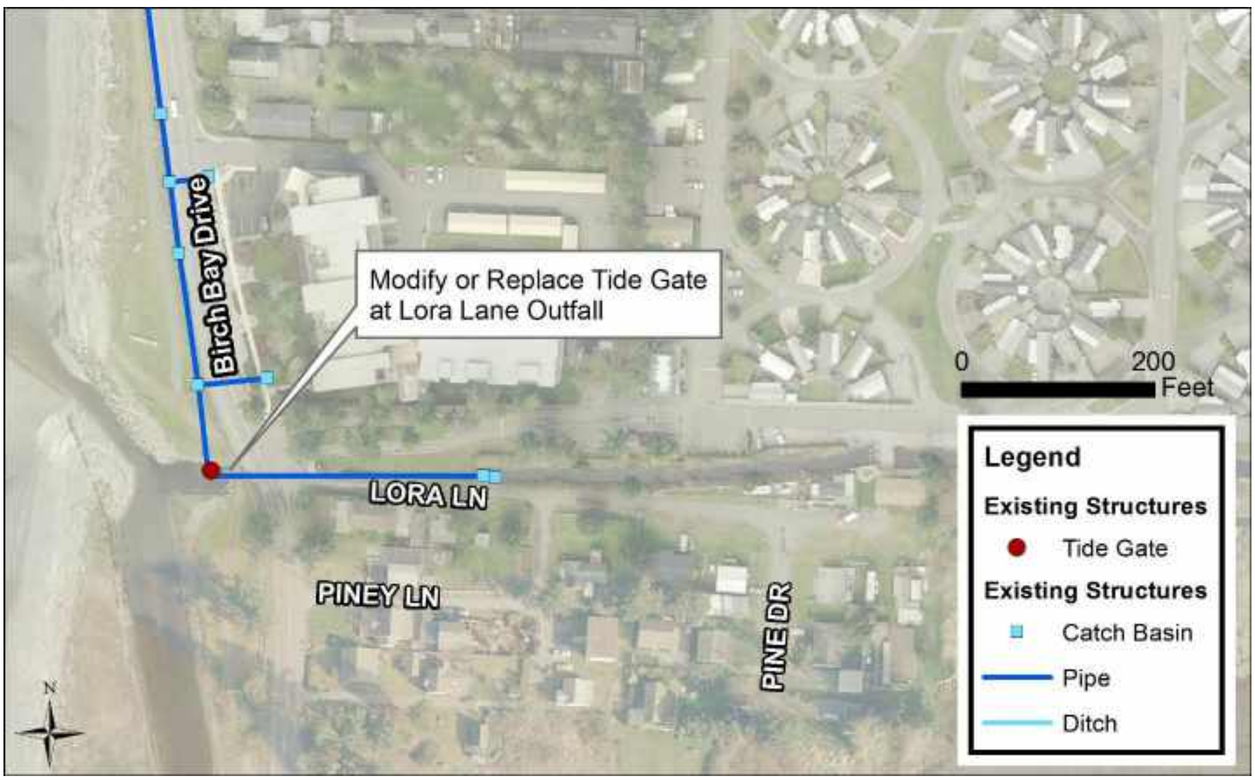
Terrell Creek Tributary 1 Subbasin

Project TC1-2: Lora Lane Tide Gate Modifications

Problem ID:	TC1-4
Location:	Lora Lane near Birch Bay Drive
Description:	The existing tide gate at Lora Lane functions but does not efficiently open or close causing backwater and contributes to flooding in Leisure Park. The existing tide gate will be modified or replaced as a fish passable structure providing more efficient flood protection. Additional study of alternatives will be required.
Cost Estimate:	$162,000
Score:	18
Related Projects:	N/A

Project Description:

- Modify or replace existing tide gate pending an additional evaluation of alternatives.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC1-2 | **BY:** GW
DESCRIPTION: Lora Lane Tide Gate Modifications | **CHECKED BY:**
SUBBASIN: Terrell Creek Tributary 1 | **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CONNECT EXISTING PIPE	1	EA	$ 500	$ 500
TIDE BOX	1	EA	$ 50,000	$ 50,000
			Material Subtotal	$ 50,500
CONTINGENCY	50%			$ 25,250
	Material Subtotal with Contingency			$ 75,750
DEWATERING	5%			$ 3,790
ARCHEOLOGICAL MONITORING	5%			$ 3,790
EROSION & SEDIMENTATION CONTROL	10%			$ 7,580
TRAFFIC CONTROL	3%			$ 2,280
SITE RESTORATION	5%			$ 3,790
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 4,850
	Construction Subtotal (Rounded)			$ 102,000
STATE SALES TAX	8.5%			$ 8,670
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 35,700
CONSTRUCTION MANAGEMENT	10%			$ 10,200
PERMITTING - NO OUTFALL	5%			$ 5,100
2014 Dollars	**Total Estimated Project Cost (Rounded)**			**$ 162,000**

Notes:

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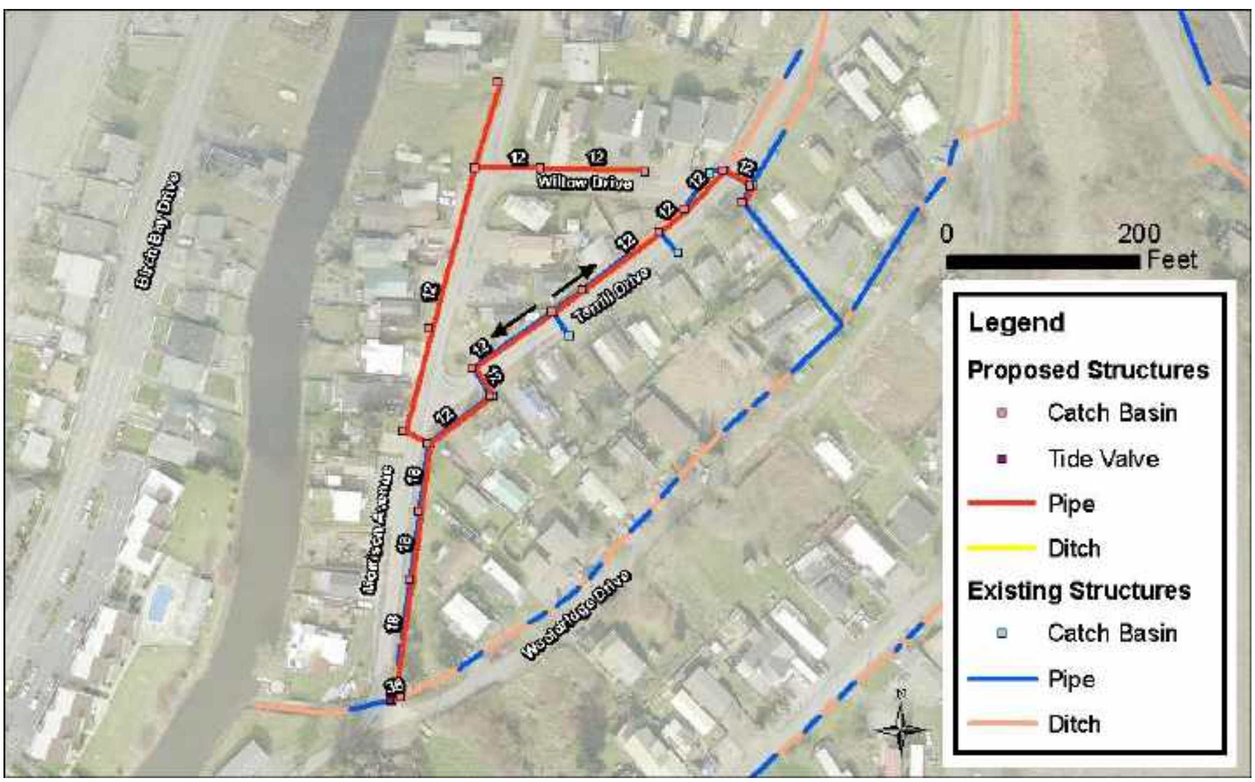
TERRELL CREEK TRIBUTARY 2 SUBBASIN

Project TC2-1: Morrison Avenue/Terrill Drive Neighborhood Storm Drain Improvements

Problem ID:	TC2-1; TC2-6; TC2-11; TC2-14; TC2-17; TC2-19
Location:	Terrill Drive / Morrison Avenue / Willow Drive
Description:	Significant flooding occurs in the Morrison Avenue/Terrill Drive neighborhood. A new storm drain line will be installed on Morrison Avenue and Willow Drive. and the existing storm drain system at Terrill Drive will be replaced and re-graded due to sediment and subsidence.
Cost Estimate:	$582,000
Score:	33
Related Projects:	TC2-2

Project Description:

- Replace 583 lineal feet of 12-inch diameter pipe with 12-inch diameter CPE.
- Replace 225 lineal feet of 12-inch diameter pipe with 267 lineal feet of 18-inch diameter CPE.
- Replace 12 lineal feet of 36-inch diameter concrete pipe with 36-inch diameter CPE.
- Replace 9 CB Type 1 structures and 6 CB Type 1 structures. Replace 4 CB Type 1 structures with CB Type 2 Replace 2 CB Type 2 structures and install new fish passable tide valve.
- Install 581 lineal feet of 12-inch diameter CPE pipe.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC2-1 **BY:** GW
DESCRIPTION: Morrison Ave./Terrell Dr. Neighborhood SD Improvements **CHECKED BY:**
SUBBASIN: Terrell Creek Tributary 2 **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	380	SY	$ 40	$ 15,180
REMOVE PIPE	765	LF	$ 5	$ 3,825
PLUGGING EXISTING PIPE	1	EA	$ 200	$ 200
CONNECT EXISTING PIPE	6	EA	$ 500	$ 3,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	1,084	LF	$ 40	$ 43,360
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	267	LF	$ 55	$ 14,685
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	12	LF	$ 80	$ 960
CATCH BASIN TYPE 1	15	EA	$ 1,100	$ 16,500
CATCH BASIN TYPE 2, 48-IN DIAM	6	EA	$ 2,400	$ 14,400
ASPHALT CONCRETE PAVEMENT PATCHING	35	TN	$ 100	$ 3,500
CRUSHED SURFACING BASE COURSE	102	TN	$ 15	$ 1,530
CRUSHED SURFACING TOP COURSE	51	TN	$ 35	$ 1,785
36-INCH TIDE VALVE	1	EA	$ 15,000	$ 15,000
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	1,022	CY	$ 30	$ 30,668
SHORING OR EXTRA EXCAVATION CLASS B	8,178	SF	$ 1.5	$ 12,267
			Material Subtotal	$ 181,860
CONTINGENCY	50%			$ 90,930
			Material Subtotal with Contingency	$ 272,790
DEWATERING	5%			$ 13,640
ARCHEOLOGICAL MONITORING	5%			$ 13,640
EROSION & SEDIMENTATION CONTROL	10%			$ 27,280
TRAFFIC CONTROL	3%			$ 8,190
SITE RESTORATION	5%			$ 13,640
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 17,460
			Construction Subtotal (Rounded)	$ 367,000
STATE SALES TAX	8.5%			$ 31,200
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 110,100
CONSTRUCTION MANAGEMENT	10%			$ 36,700
PERMITTING - WITH OUTFALL TO BAY	10%			$ 36,700
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 582,000**

Notes:

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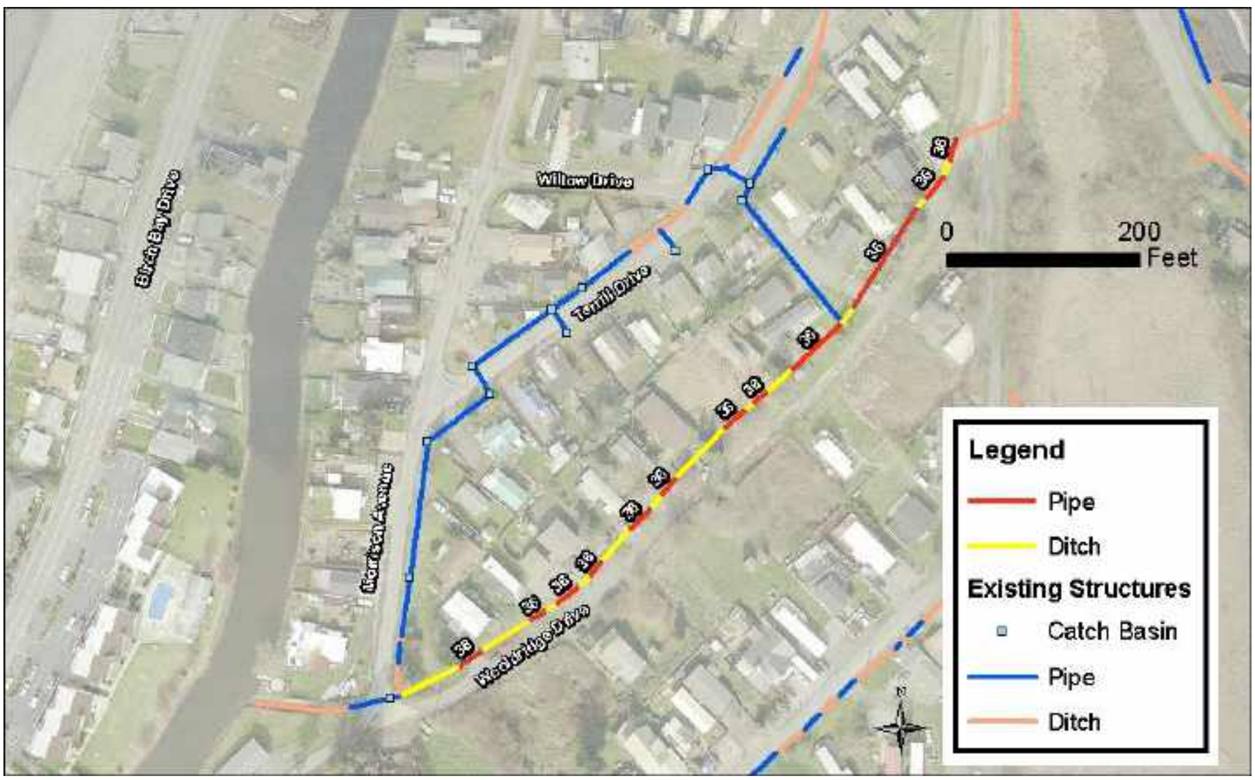
Terrell Creek Tributary 2 Subbasin

Project TC2-2: Wooldridge Drive Storm Drain Improvements

Problem ID:	TC2-5; TC2-19; TC2-23
Location:	Wooldridge Drive between Morrison Avenue and Sunset Drive
Description:	The private roadside storm drain system along Wooldridge Drive is failing and unable to convey peak stormwater flow rates. Easement are required from adjacent property owners before Whatcom County can take responsibility for maintenance of private storm drain system.
Cost Estimate:	$277,000
Score:	30
Related Projects:	TC2-1

Project Description:

- Clean 370 lineal feet of ditch
- Replace 445 lineal feet of 30- and 36-inch diameter pipe with 36-inch diameter CPE.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC2-2 **BY:** GW
DESCRIPTION: Wooldridge Road Storm Drain Replacement **CHECKED BY:**
SUBBASIN: Terrell Creek Tributary 2 **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	297	SY	$ 40	$ 11,867
REMOVE PIPE	445	LF	$ 5	$ 2,225
REESTABLISH DITCH	370	LF	$ 5	$ 1,850
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	445	LF	$ 80	$ 35,600
ASPHALT CONCRETE PAVEMENT PATCHING	28	TN	$ 100	$ 2,800
CRUSHED SURFACING BASE COURSE	80	TN	$ 15	$ 1,200
CRUSHED SURFACING TOP COURSE	40	TN	$ 35	$ 1,400
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	593	CY	$ 30	$ 17,800
SHORING OR EXTRA EXCAVATION CLASS B	2,670	SF	$ 1.5	$ 4,005
			Material Subtotal	$ 83,747
CONTINGENCY	50%			$ 41,880
			Material Subtotal with Contingency	$ 125,627
DEWATERING	5%			$ 6,290
ARCHEOLOGICAL MONITORING	5%			$ 6,290
EROSION & SEDIMENTATION CONTROL	10%			$ 12,570
TRAFFIC CONTROL	3%			$ 3,770
SITE RESTORATION	5%			$ 6,290
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 8,050
			Construction Subtotal (Rounded)	$ 169,000
STATE SALES TAX	8.5%			$ 14,370
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 59,150
CONSTRUCTION MANAGEMENT	10%			$ 16,900
PERMITTING - WITH OUTFALL TO BAY	10%			$ 16,900
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 277,000**

Notes:

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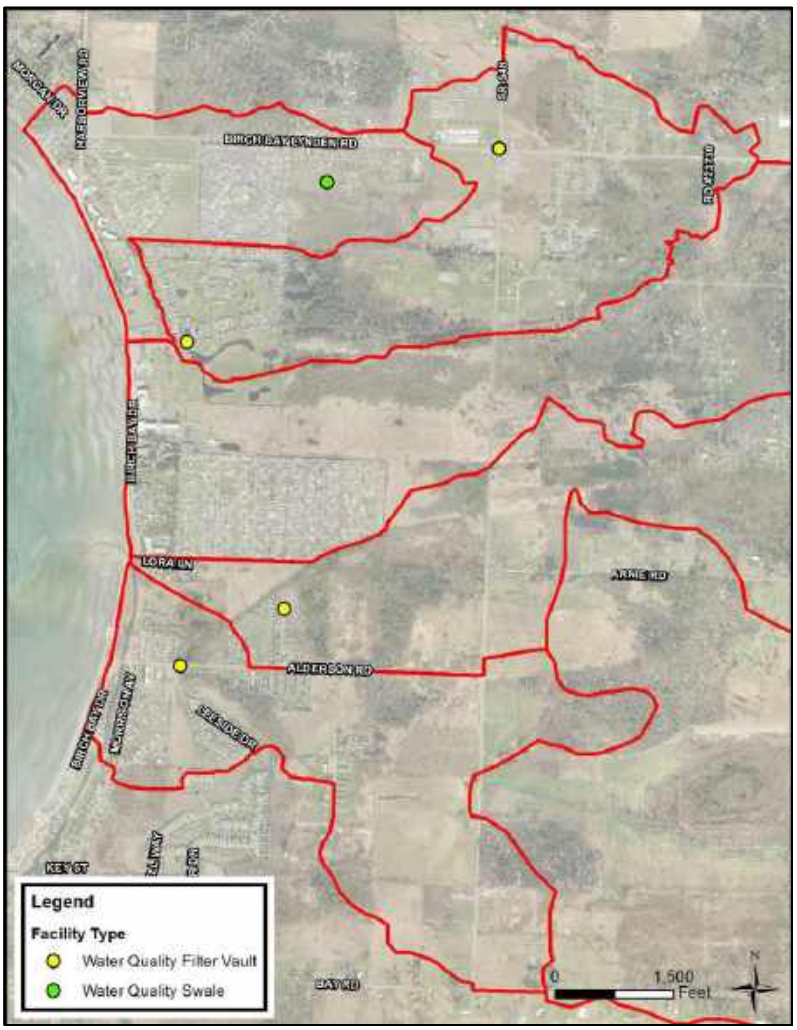
CENTRAL UPLANDS SOUTH SUBWATERSHED

Project BBCS-1: Subwatershed Water Quality Retrofit

Problem ID:	CR-8; CR-17; CR-18; CUS-6; TC1-1; TC1-2; TC2-2; TC2-3
Location:	Various locations in the Central South subwatershed
Description:	Several water quality monitoring locations have been identified to exceed fecal coliform standards as part of the Birch Bay/Terrell Creek Water Quality Monitoring Project.
Cost Estimate:	$611,000
Score:	23
Related Projects:	N/A

Project Description:

- 5 locations have been identified for water quality facility installations. Facility types will be evaluated and selected based on individual opportunity and may include water quality filter vaults and swales.



BIRCH BAY CENTRAL SOUTH SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BBCS-1 — **BY:** GW
DESCRIPTION: Subwatershed Water Quality Retrofit — **CHECKED BY:**
Subwatershed: Birch Bay Central South — **DATE:** 12/20/2014

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
WATER QUALITY FACILITY	5	EA	$ 40,000	$ 200,000
			Material Subtotal	$ 200,000
CONTINGENCY	50%			$ 100,000
			Material Subtotal with Contingency	$ 300,000
DEWATERING	5%			$ 15,000
ARCHEOLOGICAL MONITORING	5%			$ 15,000
EROSION & SEDIMENTATION CONTROL	10%			$ 30,000
TRAFFIC CONTROL	3%			$ 9,000
SITE RESTORATION	5%			$ 15,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 18,450
			Construction Subtotal (Rounded)	$ 402,000
STATE SALES TAX	8.5%			$ 34,170
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 120,600
CONSTRUCTION MANAGEMENT	10%			$ 40,200
PERMITTING - NO OUTFALL	5%			$ 13,440
2014 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 611,000**

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APPENDIX D.
CAPITAL IMPROVEMENT PROJECT PRIORITY EVALUATION

Birch Bay Central South Subwatershed Master Plan Prioritization Worksheet	Project CR-1		CR-2		CR-3	
	CR-1: Birch Bay Drive at Harborview Road Storm Drain Improvements		CR-2: Harborview Road Storm Drain and Outfall Improvements		CR-3: Birch Bay Dr. at Mariners Cove Storm Drain Imp. and Outfall Repl.	
Category	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit	Weighting = 1					
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Indirect improvement - single outfall to bay	4	Indirect improvement - single outfall to bay	4
Sediment source removal	Nuisance removal	2	Nuisance removal	2	Nuisance removal	2
	Subtotal	6	Subtotal	6	Subtotal	6
	Weighted Score	6.0	Weighted Score	6.0	Weighted Score	6.0
Community Benefit	Weighting = 1					
Frequency of Flooding	2-year recurrence interval	4	25-year recurrence interval	3	Less than 2-year recurrence interval	5
Property Damage	3 to 4 homes damaged	2	3 to 4 homes damaged	2	Nuisance yard flooding	0
Public Infrastructure	Access to homes blocked	4	Access to homes blocked	4	Street flooding less than 6 inches	1
	Subtotal	10	Subtotal	9	Subtotal	6
	Weighted Score	10.0	Weighted Score	9.0	Weighted Score	6.0
Implementation	Weighting = 1					
Anticipated Cost of Project	$500,000 +	1	$500,000 +	1	$500,000 +	1
Permit Complexity	Local, state, and federal permits required	0	Local, state, and federal permits required	0	Local, state, and federal permits required	0
Property/Easement Acquisition	No cost property/easement acquisitio	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	Critical project link	3	Non-critical project link	1	Critical project link	3
	Subtotal	9	Subtotal	7	Subtotal	9
	Weighted Score	9.0	Weighted Score	7.0	Weighted Score	9.0
Local support	Weighting = 1					
	Medium	5	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
.	Total Score	30.0	Total Score	27.0	Total Score	26.0
.	Rank	3		5		7

Birch Bay Central South Subwatershed Master Plan Prioritization Worksheet	CR-4		CUN-1		CUS-1	
	CR-3: Mariners Cove Storm Drain Trunk Line Replacement		CUN-1: Birch Bay - Lynden Road Roadside Storm Drainage Improvements		CUS-1: Birch Bay Drive Storm Drain Improvements North of Lora Lane	
Category	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit						
Shellfish Habitat (WQ)	No Improvement	0	No Improvement	0	Indirect improvement - single outfall to bay	4
Sediment source removal	Nuisance removal	2	No Improvement	0	Nuisance removal	2
	Subtotal	2	Subtotal	0	Subtotal	6
	Weighted Score	2.0	Weighted Score	0.0	Weighted Score	6.0
Community Benefit						
Frequency of Flooding	Less than 2-year recurrence interval	5	100-year recurrence interval	1	2-year recurrence interval	4
Property Damage	3 to 4 homes damaged	2	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Street flooding less than 6 inches	1	Street flooding less than 6 inches	1	Street flooding greater than 6 inches	3
	Subtotal	8	Subtotal	2	Subtotal	7
	Weighted Score	8.0	Weighted Score	2.0	Weighted Score	7.0
Implementation						
Anticipated Cost of Project	$250,000 to $500,000	2	$250,000 to $500,000	2	$500,000 +	1
Permit Complexity	Local permits required	2	Local permits required	2	Local, state, and federal permits required	0
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisitio	5
Coordination with other projects/agencies	Non-critical project link	1	No project link	0	No project link	0
	Subtotal	10	Subtotal	9	Subtotal	6
	Weighted Score	10.0	Weighted Score	9.0	Weighted Score	6.0
Local support						
	Medium	5	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
.	Total Score	25.0	Total Score	16.0	Total Score	24.0
.		8		12		9

Birch Bay Central South Subwatershed Master Plan Prioritization Worksheet	CUS-2		TC1-1		TC1-2	
	CUS-2: Birch Bay Drive at Club House Drive Storm Drain Improvements		TC1-1: Birch Bay Drive Storm Drain Improvements North of Alderson Road		TC1-2: Lora Lane Tidegate Modifications	
Category	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit						
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Indirect improvement - multiple outfalls to bay	6	No Improvement	0
Sediment source removal	Nuisance removal	2	Nuisance removal	2	No Improvement	0
	Subtotal	6	Subtotal	8	Subtotal	0
	Weighted Score	6.0	Weighted Score	8.0	Weighted Score	0.0
Community Benefit						
Frequency of Flooding	Less than 2-year recurrence interval	5	Less than 2-year recurrence interval	5	2-year recurrence interval	4
Property Damage	Nuisance yard flooding	0	1 to 2 homes damaged	1	3 to 4 homes damaged	2
Public Infrastructure	Street flooding less than 6 inches	1	Street flooding less than 6 inches	1	No street flooding	0
	Subtotal	6	Subtotal	7	Subtotal	6
	Weighted Score	6.0	Weighted Score	7.0	Weighted Score	6.0
Implementation						
Anticipated Cost of Project	$250,000 to $500,000	2	$250,000 to $500,000	2	$100,000 to $250,000	3
Permit Complexity	Local permits required	2	Local, state, and federal permits required	0	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisitio	5	No cost property/easement acquisition	5	No cost property/easement acquisitio	5
Coordination with other projects/agencies	No project link	0	No project link	0	No project link	0
	Subtotal	9	Subtotal	7	Subtotal	10
	Weighted Score	9.0	Weighted Score	7.0	Weighted Score	10.0
Local support						
	Medium	5	Medium	5	Low	2
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	2.0
.	Total Score	26.0	Total Score	27.0	Total Score	18.0
.		6		4		11

Birch Bay Central South Subwatershed Master Plan Prioritization Worksheet	TC2-1: Morrison Ave./Terrell Dr. Neighborhood Storm Drain Imp.	TC2-1	TC2-2: Wooldridge Drive Storm Drain Improvements	TC2-2	BBCS: Subwatershed Water Quality Retrofit	BBCS-1
Category	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit						
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Indirect Improvement - immediate vicinity (< 100 feet)	2	Indirect improvement - multiple outfalls to bay	6
Sediment source removal	Nuisance removal	2	Nuisance removal	2	Removes a minor sediment source	4
	Subtotal	6	Subtotal	4	Subtotal	10
	Weighted Score	6.0	Weighted Score	4.0	Weighted Score	10.0
Community Benefit						
Frequency of Flooding	Less than 2-year recurrence interval	5	Less than 2-year recurrence interval	5	No flooding	0
Property Damage	5 to 10 homes damaged	3	5 to 10 homes damaged	3	Nuisance yard flooding	0
Public Infrastructure	Access to homes blocked	4	Access to homes blocked	4	No street flooding	0
	Subtotal	12	Subtotal	12	Subtotal	0
	Weighted Score	12.0	Weighted Score	12.0	Weighted Score	0.0
Implementation						
Anticipated Cost of Project	$500,000 +	1	$250,000 to $500,000	2	$500,000 +	1
Permit Complexity	Local and state permits required	1	Local and state permits required	1	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	Critical project link	3	Non-critical project link	1	No project link	0
	Subtotal	10	Subtotal	9	Subtotal	8
	Weighted Score	10.0	Weighted Score	9.0	Weighted Score	8.0
Local support						
	Medium	5	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
.	Total Score	33.0	Total Score	30.0	Total Score	23.0
.		1		2		10

Birch Bay Central South Subwatershed Master Plan Prioritization Scoring				
Category		Criteria	Score	Comments
Environmental Benefit		Weighting	1	
	Shellfish Habitat (WQ?)	No Improvement	0	
		Indirect Improvement - immediate vicinity (< 100 feet)	2	
		Indirect improvement - single outfall to bay	4	
		Indirect improvement - multiple outfalls to bay	6	
		Direct improvement to shellfish habitat	10	
	Sediment source removal	No Improvement	0	
		Nuisance removal	2	Removes sediment from stormwater runoff
		Removes a minor sediment source	4	Sediment deposition in downstream system restricts flow but does not completely obstruct conveyance
		Removes a significant sediment source	6	Sediment deposition in downstream system completely obstructs conveyance
Community Benefit		Weighting	1	
	Frequency of Flooding	No flooding	0	
		100-year recurrence interval	1	Based on hydraulic model
		25-year recurrence interval	3	Based on hydraulic model
		2-year recurrence interval	4	Based on hydraulic model
		Less than 2-year recurrence interval	5	Generally applies to areas with no storm drain system
	Property Damage	Nuisance yard flooding	0	
		1 to 2 homes damaged	1	The relative number of homes flooded has been reduced 0 - 5 OCI compared to the pervious prioritization
		3 to 4 homes damaged	2	5 -20 OCI
		5 to 10 homes damaged	3	20+ OCI
		10 + homes damaged	5	
	Public Infrastructure	No street flooding	0	
		Street flooding less than 6 inches	1	
		Street flooding greater than 6 inches	3	Flooding greater than 6 inches becomes dangerous to drive through
		Access to homes blocked	4	
		Emergency access blocked	8	Generally reserved for locations with only one emergency access route
		Critical public safety issue / critical public facility flooded	10	Swirling hole of death and high landslide risk are examples of the critical public safety issues
Implementation		Weighting	1	
	Anticipated Cost of Project	$500,000 +	1	
		$250,000 to $500,000	2	
		$100,000 to $250,000	3	
		$0 to $100,000	4	
	Permit Complexity	Local, state, and federal permits required	0	
		Local and state permits required	1	
		Local permits required	2	
		Programmatic permit action	3	
		No permits required	5	
	Property/Easement Acquisition	Condemnation necessary to obtain property/easements	0	
		High cost property acquisition/easements	1	> 10 % of construction cost
		Easement Acquisition only	2	
		Low cost property/easement acquisition	3	< 10 % of construction cost
		No cost property/easement acquisition	5	
	Coordination with other projects/agencies	No project link	0	
		Non-critical project link	1	Project is associated with other projects but not a critical or required element
		Critical project link	3	Associated project can not be built until this project is constructed
		50 percent funding by non-BBWARM fees	5	Recognizes funding sources other than BBWARM
		100 percent funding by non-BBWARM fees	8	Project to be built by others
		Regulatory Requirement	10	
Local Support		Weighting	1	
	Local Support	None	0	
		Low	2	One or two advocates
		Medium	5	Enthusiastic community support
		High	10	Identifeid by Advisory Committee as a prority project

Addendum 3

Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

Prepared for:

Prepared by:

November 2016

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN

November 2016

Prepared for:

Whatcom County Public Works Department Stormwater Division
322 N. Commercial Street
Bellingham, WA 98225

Birch Bay Watershed and Aquatic Resources Management District

Prepared by:

TETRA TECH

1420 Fifth Avenue, Suite 550, Seattle, WA 98101
Tel 206.728.9655 **Fax** 206.728.9670 www.tetratech.com

Tetra Tech Project Number: 100-SET-T34645

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

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CHAPTER 1.
INTRODUCTION

The Birch Bay Watershed and Aquatic Resources Management (BBWARM) District is a special purpose district established to manage stormwater in the Birch Bay watershed. A previous BBWARM District basin-wide study identified sensitive areas in the watershed that should be protected and areas where development should be allowed (ESA Adolfson, 2007). The study recommended strategies to mitigate the effects of development on aquatic resources and wildlife. For developing areas, the study found that watershed master planning is needed to address deficiencies in current stormwater infrastructure and to plan for future infrastructure needs. The *Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan* is the third in a series of these master plans for the Birch Bay watershed.

PURPOSE AND GOALS

The purpose of the *Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan* is to develop a systematic approach to solving stormwater problems in the Birch Point, Terrell Creek Urban Area, and Point Whitehorn (BP-TC-PW) Subwatersheds, improving drainage infrastructure, reducing flooding, and improving water quality. Developing the plan consisted of collecting data on the storm drain system, analyzing system capacity, identifying and addressing deficiencies in drainage infrastructure, and developing a capital improvement program. The plan will guide future development to minimize impacts on the stormwater system and accommodate future drainage infrastructure needs. The objectives of this plan are as follows:

- Develop an accurate, comprehensive inventory of stormwater facilities in each of the subwatershed areas.
- Create a guide for implementing capital projects to address drainage deficiencies in a prioritized and scheduled manner.
- Assess land use impacts on stormwater.
- Document project needs to incorporate into a countywide capital improvement program.

STUDY AREA

The Birch Bay watershed covers 27 square miles in the northwest corner of Whatcom County along the Georgia Straight, 18 miles northwest of Bellingham and just south of Blaine. The BP-TC-PW Subwatersheds cover about 2,700 acres along the Birch Bay shoreline (see Figure 1-1). The subwatersheds do not share any boundaries. Each is divided into multiple subbasins. Together they extend from south of Grandview Road to Drayton Harbor Road. Subwatershed areas near the shore generally consist of single-family residential housing, trailer parks and condominiums. The upland areas are rural and agricultural.

PREVIOUS PLANNING EFFORTS

Several recent planning efforts focusing on surface water issues in the Birch Bay watershed have provided background and direction for this master plan. This is the first plan to focus on the BP-TC-PW Subwatersheds, providing detailed inventory data and detailed analysis of drainage problems for those subwatersheds.

Figure 1-1. Location of Subwatershed Master Plan Study Areas

The 2006 *Birch Bay Comprehensive Stormwater Management Plan* covered the entire Birch Bay watershed and investigated drainage, water quality, and aquatic habitat issues (CH2M Hill, 2006). This plan also identified policy issues, structural and non-structural capital projects, low-impact development techniques, and operation and maintenance recommendations for the Birch Bay watershed. Specific recommendations for the BP-TC-PW Subwatersheds were limited. They included two capital projects, both in the Birch Point area, to solve flooding problems. Because this plan covered the entire watershed, detailed analysis was not performed for each subbasin.

Whatcom County Council adopted the *Birch Bay Comprehensive Stormwater Plan* in 2006. The plan recommended the creation of a stormwater management area and funding strategy. Acting on this recommendation, the Whatcom County Flood Control Zone District Board of Supervisors approved the creation of the BBWARM District as a subzone of the countywide flood control zone district in 2007.

The 2007 *Birch Bay Watershed Characterization and Watershed Planning Study* evaluated restoration and development potential for all subbasins in the Birch Bay watershed (ESA Adolfson, 2007). This study outlined a comprehensive approach to guiding land use efforts in the Birch Bay watershed by using a science-based watershed characterization to "identify areas within Birch Bay for protection or restoration of ecosystem processes necessary for the long term functioning of marine and freshwater systems while also guiding the location and design of new development." Portions of the Birch Point and Terrell Creek Urban Area Subwatershed areas were identified as priority subbasins suitable for development. The Point Whitehorn Subwatershed and portions of the Terrell Creek Urban Area Subwatershed were identified as areas of focus for protection and restoration. The northern and western areas of the Birch Point Subwatershed were identified as areas that should be protected (see Figure ES-1 in EAS Adolfson, 2007).

Birch Bay Central North Subwatershed Master Plan (Tetra Tech, 2013) was the first in a series of subwatershed master plans for the Birch Bay watershed. The Central North Subwatershed is generally located between Shintaffer Road and Birch Bay Lynden Road. This plan included storm drainage inventory data collection and assessment, subwatershed characterization, problem evaluation and analysis, and development of capital projects. The Central North Subwatershed Master Plan was the template for subsequent Birch Bay subwatershed master planning efforts.

Birch Bay Central South Subwatershed Master Plan (Tetra Tech, 2014) was the continuation of the series of subwatershed master plans for the Birch Bay watershed. The Central South Subwatershed extends north-south from Birch Bay Lynden Road to Bay Road and east-west from Kickerville Road to Birch Bay. Portions of the subwatershed near the shore generally consist of single-family residential housing, trailer parks and condominiums. Rural and agricultural lands characterize the upland areas. This plan included storm drainage inventory data collection and assessment, subwatershed characterization, problem evaluation and analysis, and development of capital projects.

REPORT ORGANIZATION

The *Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan* is organized in two parts. Chapters 2 through 4 describe the physical characteristics of the subwatersheds, present a storm drain inventory, and identify drainage problems. Chapters 5 and 6 identify capital projects for solving stormwater problems and present the proposed project prioritization. The content of individual chapters is as follows:

- Chapter 2 describes physical characteristics of the subbasins that make up the subwatersheds. Field data collection for the stormwater inventory and the surface water drainage system are also described in this chapter.
- Chapter 3 describes a planning level hydrologic and hydraulic analysis. Continuous simulation modeling was used to develop stormwater runoff hydrographs and estimate peak flow rates for each subbasin. Hydraulic analysis was used to identify drainage problems and estimate conveyance capacity of the storm drain system.
- Chapter 4 describes identified drainage problems. Interviews with Whatcom County staff, public meetings, published reports, field data collection, and the planning level hydraulic analysis were used to assemble a database of drainage problems.
- Chapter 5 identifies projects to solve stormwater problems, including special studies, operation and maintenance, and small works projects.
- Chapter 6 presents a plan for implementation of stormwater capital projects.

ACKNOWLEDGMENTS

The *Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan* was developed with the participation of the BBWARM Advisory Committee:

- Position A—Scott Hulse
- Position B—William Booth
- Position C—Don Brown (Rate Payer Representative)
- Position D—Peter Winterfield
- Position E—Patrick Alesse

The Advisory Committee represents the Birch Bay community to ensure that the community's interests are represented in setting strategic goals and work plans.

CHAPTER 2.
SUBBASIN CHARACTERISTICS

CLIMATE

Birch Bay experiences a mild marine climate with cool, dry summers and mild, wet winters. Average monthly temperatures range from about 37ºF in January to 62ºF in August. However, extreme temperatures can occur, with temperatures falling below freezing an average of about 70 days per year. Temperatures rarely get above 90ºF (WRCC, 2011). The Birch Bay area receives an average of about 35 inches of rain annually. Approximately 14 inches of precipitation occurs as snow in an average year. Figure 2-1 shows the average monthly rainfall measured by the Birch Bay Water and Sewer District (BBWSD) near Birch Bay State Park. Typically, winter rainfall occurs as long-duration, low-intensity events over a day or more.

Source: BBWSD, 2011

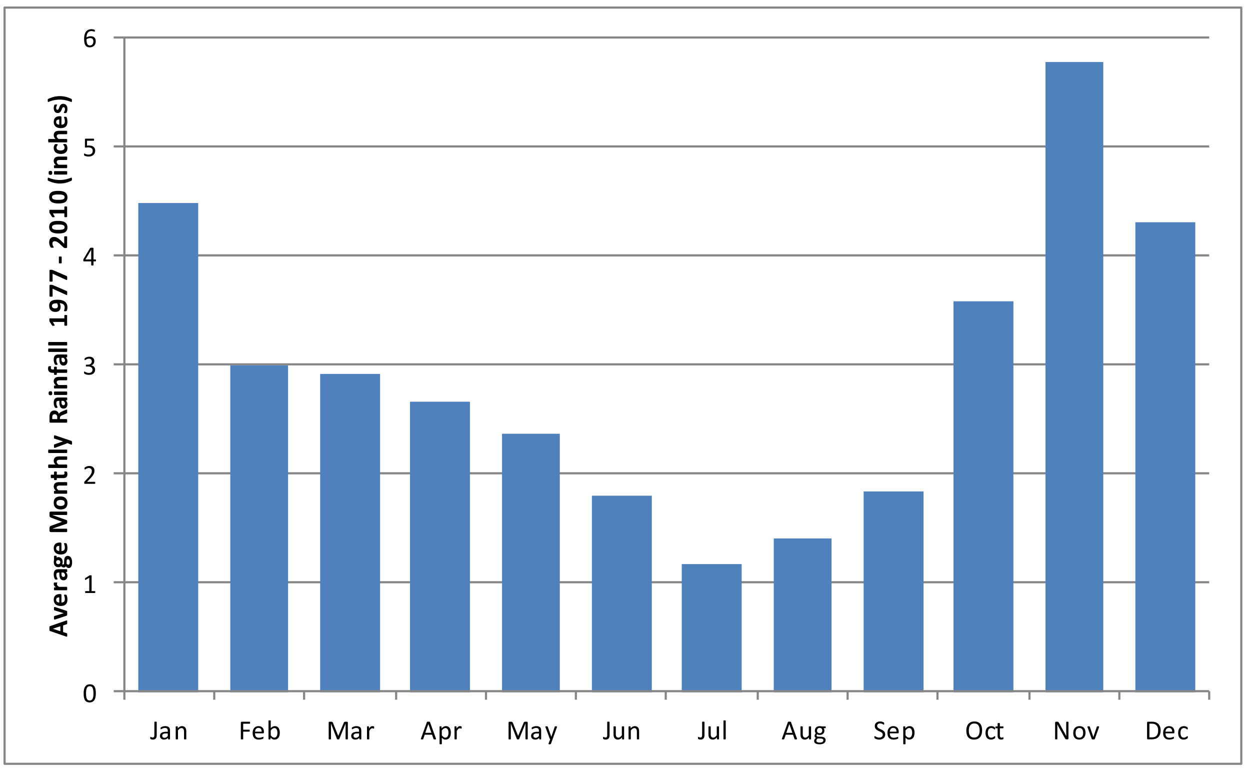

Figure 2-1. Average Monthly Rainfall—Birch Bay

WATER QUALITY

In 2003, the Washington Department of Health identified Birch Bay as a "threatened" shellfish growing area. Additional investigations identified further degradation to water quality in the bay, which led to restrictions on shellfish harvesting (Whatcom County, 2010). In response to these findings, Whatcom County initiated the Birch Bay/Terrell Creek Water Quality Monitoring Project. As part of this project, Whatcom County Public Works coordinates a routine water quality monitoring program at a fixed-network of approximately 30 sites in the Birch Bay watershed that discharge to marine waters. Samples are collected at least monthly and analyzed for fecal coliform bacteria. The data are used to prioritize drainages for water quality improvement programs and to characterize general patterns in declining and improving water quality. Additional sampling is conducted in focus areas where elevated fecal coliform levels have been seen consistently and water quality improvement programs are being implemented. Approximately 15 temporary sites are monitored monthly in the Birch Point subwatershed. Three permanent monitoring sites are located within Terrell Creek Urban Area Subwatershed (sampled twice monthly):

- Terrell Creek at Birch Bay State Park Bridge (Ter1.6)
- Terrell Creek at Helwig Bridge (Ter1.9)
- Lower Terrell Creek at Jackson Road (Ter0.7)

Between August 2013-August 2016, all three sampling sites within the Terrell Creek Urban Area and five of the seven sites within the Birch Point Subwatershed did not meet the state water quality standards set to protect public health. See Whatcom County's Water Quality Monitoring Results webpage for the latest results (updated monthly): http://www.whatcomcounty.us/2170/Water-Quality-Monitoring-Results.

Additionally, the Washington State Department of Health collects data from nine sites in the marine waters of Birch Bay on a monthly basis. Shellfish harvesting is prohibited in two areas due to high levels of fecal coliform – at the mouth of the Birch Bay Marina and the mouth of Terrell Creek. Click here for the Shellfish Growing Area Annual Report from 2016 (WDOH, 2016).

BIRCH POINT SUBWATERSHED

Topography and Subbasins

The Birch Point Subwatershed (Figure 2-2) is a tear-drop shaped basin covering approximately 4 square miles and has been subdivided into six distinct subbasins. Surface runoff for the east side of the subwatershed generally flows south to Birch Bay.. The land falls steadily to the south toward Birch Bay and the west to the Semiahmoo Bay. A steep ridge drops to the water along the basin perimeter. A low-lying area surrounds the golf course and marina in the southeast portion of the subwatershed. Ground elevation ranges from 10 feet NAVD88 (North American Vertical Datum 1988) at the south end of the subwatershed to 260 feet NAVD88 in the northeast.

The *Birch Bay Watershed Characterization and Watershed Planning Study* (ESA Adolfson, 2007) divided each subwatershed area into subbasins. The names and locations were altered for this report, with boundaries re-delineated based on LiDAR mapping, flow paths from the storm drain inventory, and field investigation. The six subbasins in the Birch Point Subwatershed total 2,560 acres:

- The Birch Point North Subbasin covers 501 acres along the northwest shoreline of the Birch Point Subwatershed. This subbasin actually drains to Semiahmoo Bay rather than Birch Bay but was included in the Birch Point Subwatershed because it is within the BBWARM administrative boundary. This subbasin is bordered by the Birch Point South Subbasin to the south and the Semiahmoo Uplands Subbasin on the east. Land use is primarily forest and vacant agricultural land in the uplands, with residential development west of Semiahmoo Drive. Stormwater runoff from the upland areas is collected in ditches that convey runoff to three detention ponds on the east side of Semiahmoo Drive. These ponds outlet to roadside ditch-and-culvert systems along Semiahmoo Drive that discharge to the Strait of Georgia.
- The Birch Point South Subbasin covers 613 acres along the southwest shoreline of the Birch Point Subwatershed. This subbasin partially drains to Semiahmoo Bay rather than Birch Bay but was included in the Birch Point subwatershed because it is within the BBWARM administrative boundary. Land use east of Semiahmoo Drive is primarily undeveloped agricultural. Land use west of Semiahmoo Drive is a mixture of low-density development and undeveloped land. Stormwater runoff from the upland areas is collected in ditches that convey

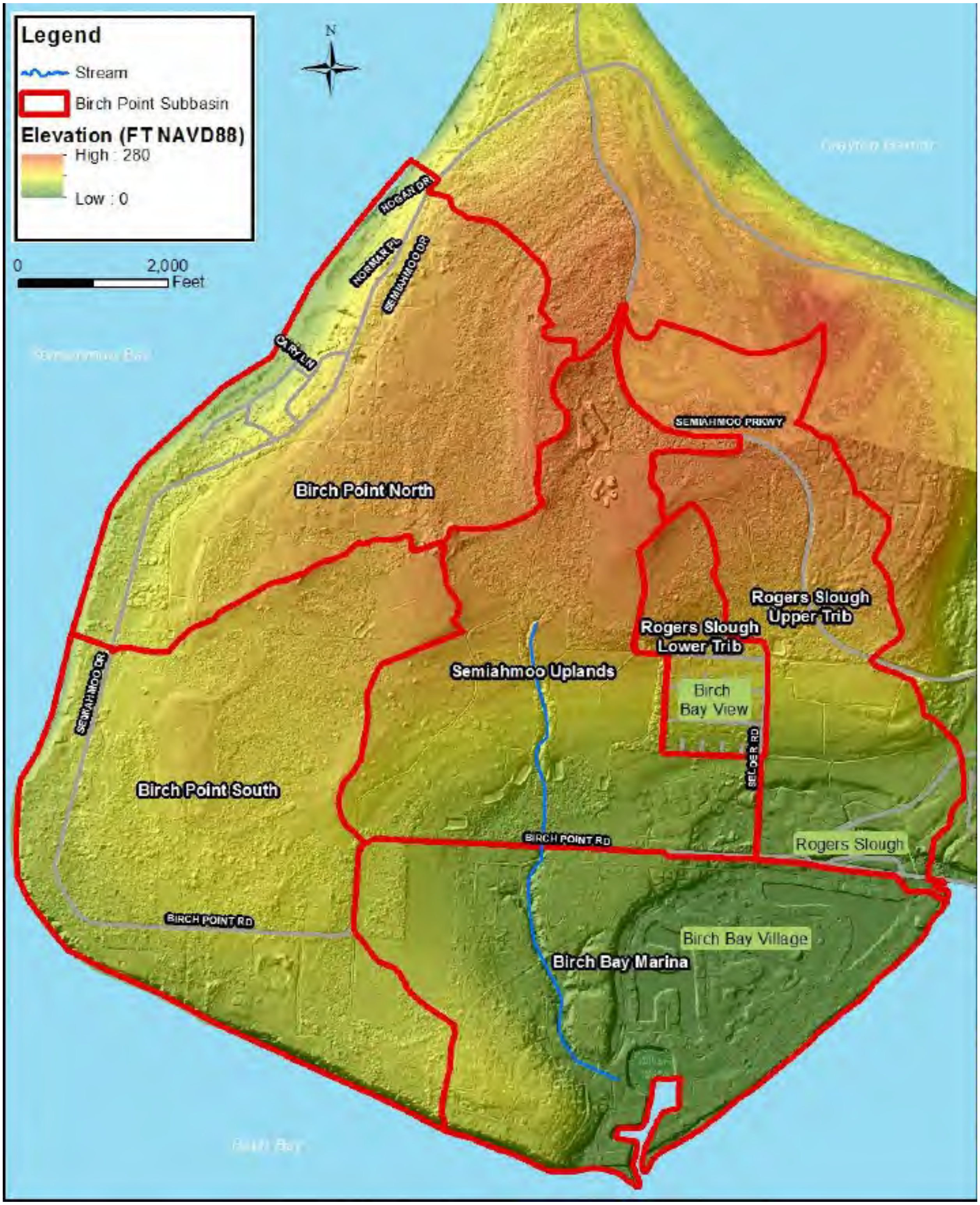

Figure 2-2. Topography of the Birch Point Subwatershed

runoff to two detention ponds on the east side of Semiahmoo Drive. These ponds outlet to roadside ditch-and-culvert systems along Semiahmoo Drive that discharge to the Strait of Georgia.

- The Semiahmoo Uplands Subbasin covers 457 acres between the Birch Point and Rogers Slough Subbasins to the west and east. Semiahmoo Parkway runs along the north border and Birch Point Road along the south border. Most of the land use is undeveloped agricultural, with a forested riparian area surrounding an ephemeral stream that carries stormwater runoff. This stream originates in the subbasin uplands and flows south under Birch Point Road through a 24-inch culvert. The stream continues south through Birch Bay Village and discharges into the Birch Bay Marina. Several detention ponds north of Birch Point Road collect additional runoff. These ponds outlet to the ephemeral stream directly upstream of Birch Point Road.
- The Rogers Slough Upper Tributary Subbasin covers 382 acres along the eastern edge of the subwatershed. The subbasin extends from the north side of Semiahmoo Parkway to Birch Point Road. Land use is medium-density residential north of Semiahmoo Parkway and undeveloped agricultural land to the south. The subbasin drains through roadside ditches and culverts, eventually combining flow with drainage from the Roger Slough Lower Tributary Subbasin near an undeveloped subdivision north of Birch Point Road and east of Selder Road.
- The Rogers Slough Lower Tributary Subbasin covers 87 acres between the Rogers Slough Upper Tributary and Semiahmoo Uplands. The subbasin drains a medium-density residential development west of Selder Road and south of Bayvue Road. Vacant agricultural land is located to the north.
- Birch Bay Marina Subbasin covers 522 acres and is bounded by Birch Point Road on the north and west sides and Birch Bay to the south and east. About 75 percent of this subbasin consists of the medium-density residential of the Birch Bay Village development. The remaining 25 percent is open water. The Birch Bay Village Golf Course is on the eastern side of the subbasin. The northwestern extent of the subbasin includes a forested area separated from Birch Bay Village by an area of the pastureland. The ephemeral stream originating in the Semiahmoo Uplands Subbasin bisects the subbasin and discharges into the Birch Bay Marina. This subbasin also includes the area south of Birch Point Road that drains to Rogers Slough.

Surface Water Features

Surface water drainage features convey stormwater runoff from the undeveloped interior of the subwatershed and discharge into Birch Bay or the Strait of Georgia. On the western half of the subwatershed, upland areas are connected to field ditches that drain to constructed ponds. These ponds discharge stormwater runoff into roadside ditch-and-culvert systems that run parallel to Semiahmoo Road and Birch Point Road. Stormwater runoff is conveyed under the road and discharged down the bluff through either open channel or a piped outfall. There are 10 total outfalls within the Birch Point Subwatershed.

Birch Point North Subbasin

Four primary outfalls discharge surface water to Birch Bay in the Birch Point North Subbasin: the DNR outfall, the Charel Terrace outfall, and two outfalls along Normar Place. Primary outfalls vary from 12 to 24 inches in diameter. Surface water is collected in the uplands east of Semiahmoo Drive and travels as sheet flow or through a series of diversion ditches collected by the detention ponds. Secondary 12-inch diameter outfalls include the Hogan Drive storm pipe and two storm pipes along Oertel Drive.

The DNR outfall on the south side of the subbasin receives surface runoff collected by two detention ponds on the east side of Semiahmoo Drive. The Count recently constructed a project at this location to replace an open flume that was causing erosion on the buff and an undersized cross culvert that was causing flooding on Semiahmoo Drive. This project installed a 36-inch diameter pipeline connecting the roadside ditch system on the east side to a new 36-inch diameter tightline to convey stormwater from the top of the bluff to outfall at the shore about 70 feet below. An energy dissipater was also installed on the beach at the end of the pipeline outfall. The Charel Drive outfall was a retrofit project completed in December 2011. The retrofit included a series of 18-inch pipes and open ditches along Charel Drive and Carey Lane that convey flow from an upstream pond. The storm drain system discharges into Birch Bay at the toe of the slope through a 24-by-22-inch HDPE diffuser tee.

The two Normar Place outfalls near the northern end of the subbasin receive runoff from an upstream detention pond and an upland are north of the ponds. Water is discharged from the ponds into open ditches along Semiahmoo Drive before crossing under Semiahmoo Drive. To the south, a constructed quarry spall cascade acts as an energy dissipater and conveys water into a plastic 12-inch-diameter half-pipe flume. The flume is connected to a junction box at the bottom of Normar Place. A 12-inch polyethylene pipe outlets from the junction box and discharges to the toe of the slope into the Strait of Georgia. The outfall near the north end of Normar Place is a conventional 12-inch storm drain system.

Birch Point South Subbasin

Surface water runoff in Birch Point South Subbasin flows south or southwest through the uplands before crossing under Birch Point Road.

Water draining toward the southwest is routed toward one of two detention ponds before crossing under the road at the intersection of Birch Point Road and Semiahmoo Drive. Surface water flows through an open ditch from there, making its way down the bluff via a rocked ravine and discharging into Birch Bay.

A second outfall is located in the southeastern corner of the subbasin. Runoff enters open ditches along Birch Point Road as sheet flow. It is conveyed south under Birch Point Road through a series of 36-inch HDPE culverts and continues down an open ditch parallel to a private driveway. Runoff crosses under the private driveway through a 36-inch CMP culvert and around the east side of private property through a constructed flume/open ditch.

Semiahmoo Uplands Subbasin

The Semiahmoo Uplands Subbasin is characterized by rural land from Semiahmoo Parkway to Birch Point Road. Stormwater flows as sheet flow or is routed along the perimeter of service roads. A larger stream develops at the center of the subbasin and drains south into a wetland adjacent to the north side of Birch Point Road. Four interconnected sedimentation ponds are located along the outside of the wetland; however, the ponds are assumed to provide insufficient active storage volume to affect peak flow rates. Stormwater drains under Birch Point Road through a 24-inch concrete culvert and discharges into Birch Bay via an open watercourse through Birch Bay Village.

An additional small drainage area is located south of Skyvue Road, east of the primary Semiahmoo Uplands flow path. Stormwater is collected by a storm drainage system along Bay Ridge Drive to a wetland area near Selder Road and then conveyed east along Birch Point Road before discharging through an 18-inch concrete storm pipe under the intersection of Birch Point Road and Selder Road, flowing into the golf course ponds in Birch Bay Village.

Rogers Slough Lower Tributary Subbasin

The Rogers Slough Tributary drains the Bay View residential area adjacent to Selder Road. Runoff is collected along Selder Road and is conveyed down a steep slope of open ditches and driveway culverts to the Semiahmoo Uplands Subbasin at Skyvue Road.

Rogers Slough Upper Tributary Subbasin

The Rogers Slough Upper Tributary drains the eastern perimeter of the subwatershed between Birch Point Road and Semiahmoo Parkway. Stormwater runoff is conveyed as sheet flow or through a series of constructed ditches. The runoff combines with drainage from the Rogers Slough Lower Tributary Subbasin and forms a defined stream near the intersection of Birch Point Road and Horizon Drive. The stream flows under Birch Point Road through a 24-inch concrete culvert at the Rogers Slough tide gate.

Birch Bay Marina Subbasin

The Birch Bay Marina Subbasin contains Birch Bay Village and a small area of pastureland on the west side of the subbasin. The Birch Bay Marina Subbasin is developed as medium density residential with a golf course located on the east side of the subbasin. There are numerous tidally influenced freshwater ponds at lower elevations in the subbasin.

The primary watercourse draining the Semiahmoo Uplands subbasin discharges to the Birch Bay Marina Subbasin through a 24-inch culvert under Birch Point Road west of Bay Ridge Road. This culvert discharges to a ravine watercourse, which flows to a series of ponds and then outfalls to the west side of the Birch Bay Village through a 36-inch diameter pipe.

A smaller portion of the Semiahmoo Uplands Subbasin discharges to the Birch Bay Marina Subbasin at Birch Point Road and Selder Road through a 24-inch pipe. The large pond on the far east side of the subbasin connects to the Selder Road outfall through a 12-inch diameter pipe and outfalls to the north golf course pond through a 36-inch diameter pipe and then to the central pond through a 36-inch diameter pipe. The middle and south golf course ponds are interconnected and also outfall to the central pond through a 36-inch diameter pipe. The central pond discharges to the north side of the marina through a 36-inch diameter pipe with a tide gate. Water level in the central pond is also controlled by a pump system during large volume rain or snowmelt events.

Geology and Soils

Geologic conditions of the Birch Point Subwatershed are primarily the result of continental glaciation and intervening non-glacial periods. Figure 2-3 shows hydrologic soil groups and surficial aquifers.

Glacial-marine drift deposits of compressed fine-grained material (Bellingham Drift) overlay a submerged marine terrace established 11,300 to 13,000 years ago (ESA Adolfson, 2007). Surficial soils are primarily outwash and saturated clays with pockets of till.

The Natural Resources Conservation Service Soil Survey classifies soils according to Hydrologic Soil Types A through D:

- Type A and B soils are generally outwash soils made of loosely consolidated sand and gravel material. They are deep, well-drained soils with low runoff potential. Type A and B soils cover about 45 percent of the subwatershed.
- Type C soils are till soils made of fine-textured silts with shallow depths, low permeability, and high runoff potential. Type C soils cover the smallest area of the subwatershed at about 18 percent.
- Type D soils are wetland soils made of saturated silts and clays with a high water table. They are very shallow and have a confining clay or hardpan layer near the surface. Type D soils cover about 37 percent of the subwatershed.

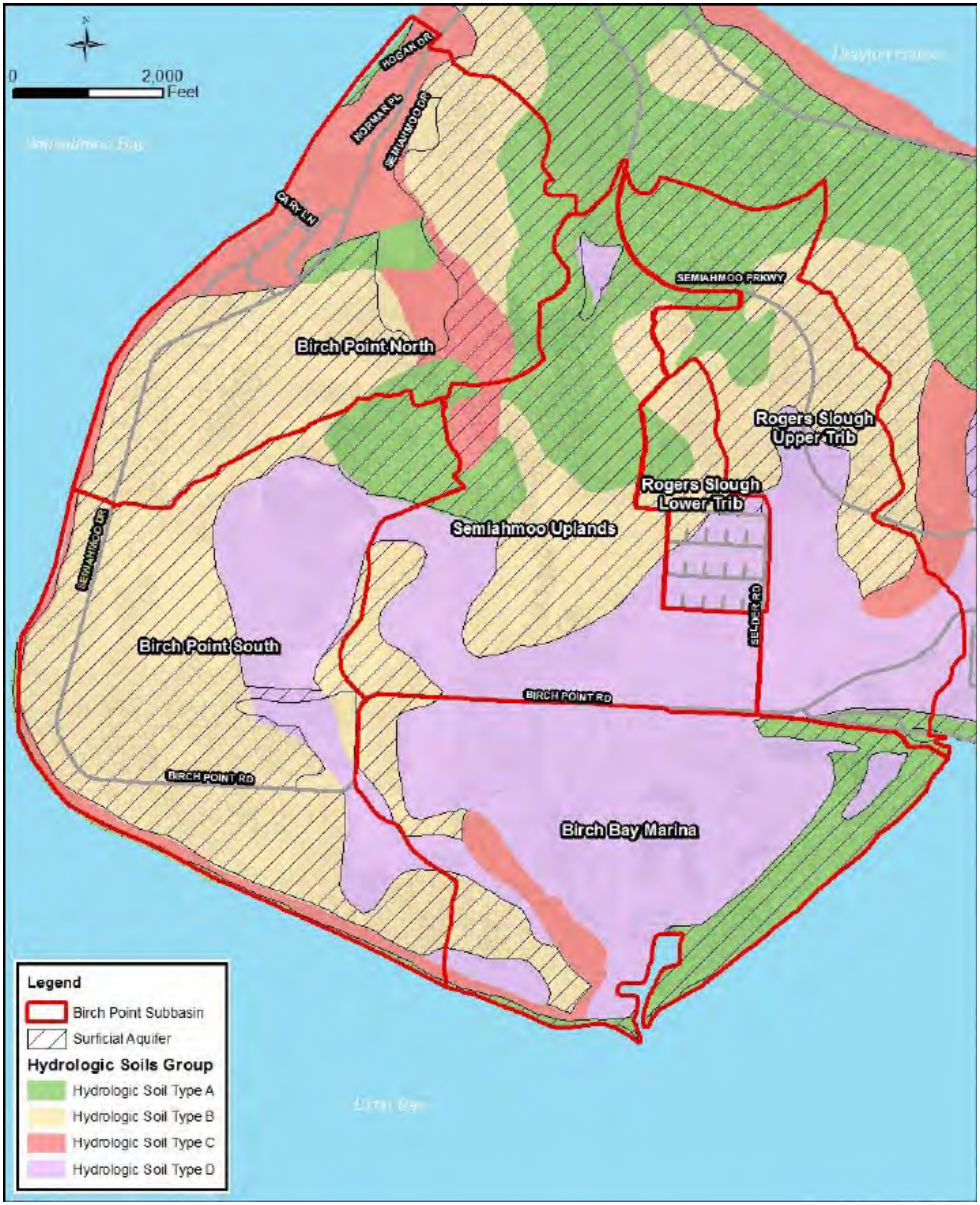

Figure 2-3. Hydrologic Soil Group and Surficial Aquifers in the Birch Point Subwatershed

FEMA Flood Zone

Flood hazard mapping (see Figure 2-4) by the Federal Emergency Management Agency (FEMA) has identified the coastal areas of the Birch Point Subwatershed as Flood Zone Type AE, VE, and V.

- Flood Zone Type AE is a special flood hazard area associated with rising waters from rivers, lakes, streams or other water bodies where the base flood elevation (BFE) has been established for the 1% annual-chance flooding (e.g. 100-year recurrence interval). A Type AE flood zone is located in the southeast corner of the Rogers Slough Upper Tributary Subbasin bordering Birch Point Road.
- Flood Zone Type VE is a special flood hazard area associated with coastal flooding (velocity hazard through wave action) where BFEs have been established for the 1% annual chance flood. Type VE flood zone is located along the shoreline from the north end of the Birch Point subwatershed to the inlet to the Birch Bay Village marina.
- Flood Zone Type V is a special flood hazard area associated with coastal flooding where BFEs have not been established for the 1% annual chance flood. Type V flood zone is located along the shoreline from the inlet to the Birch Bay Village marina to the east end of the Birch Point subwatershed.

Whatcom County regulates frequently flooded areas as critical areas under its Critical Areas Ordinance (Whatcom County Code 16.16).

Wetlands

Wetlands are areas inundated or saturated at a frequency and duration sufficient to support typical wetland vegetation. They are defined by the presence of wetland vegetation, standing water and hydric soils. Wetlands are common in Bellingham Drift deposits due to the imperviousness of soils of this type. Whatcom County regulates wetlands through its Critical Areas Ordinance, which requires protection of wetland areas and their buffers depending on classification. Whatcom County has categorized the following wetland types (ESA Adolfson, 2007):

- Depressional wetlands are formed in low areas where surface water from higher elevations pools through overland flow, precipitation or groundwater discharge.
- Riverine wetlands are in stream corridors and are saturated primarily during flood events.
- Slope wetlands are on sloping lands where groundwater or interflow discharges to the surface.

Wetlands are located in lowland areas of the subwatershed near Birch Point Road (see Figure 2-4) due to the flat topography, potentially high groundwater and relatively pervious surface soils. Table 2-1 summarizes the wetland area in each subbasin. Wetland locations were generated using approximate methods based on information from county sources; they may not represent actual wetland areas in the subwatershed.

Figure 2-4. Wetlands and FEMA Flood Zones within the Birch Point Subwatershed

TABLE 2-1.
WETLANDS IN THE BIRCH POINT SUBWATERSHED

Subwatershed	Wetland Area (acres)				Percent of Total Area
	Depressional	Riverine	Slope	Total	
Birch Point North	0	0	0	0	0%
Birch Point South	2	0	24.9	50.8	8%
Semiahmoo Uplands	50.6	0	0	50.6	11%
Rogers Slough Upper Tributary	1.5	8.8	0	10.3	3%
Rogers Slough Lower Tributary	0	0	0	0	0%
Birch Bay Marina	15.7	0	0	15.7	3%
Total	93.8	8.8	24.9	127.5	5%

Zoning and Land Use

Prior to European settlement, the Birch Bay watershed was covered with a mixture of coniferous and deciduous forest. The watershed was logged in the early 1900s, followed by development as a resort community near the bay and agricultural uses in the upland areas (ESA Adolfson, 2007).

Land use zoning guides future development and can be used as a predictor of how land use will change as the subwatershed becomes more fully developed. The Whatcom County Comprehensive Plan applies seven zoning designations:

- HII—Heavy Impact Industrial
- NC—Neighborhood Commercial
- R5A—Rural 1 Dwelling unit/5 acres
- R10A-Rural 1 Dwelling unit/10 acres
- RC—Resort Commercial
- UR4—Urban Residential 4/acre
- URM6—Urban Residential 6/acre

Approximately 16 percent the Birch Point Subwatershed lies within the City of Blaine, so regulation of development falls largely outside County jurisdiction. The urban growth boundary within unincorporated Whatcom County represents about 30 percent of the subwatershed. Urban growth boundaries and current zoning (2015) are shown on Figure 2-5. The subwatershed is zoned primarily as Rural 5 (1 lot per 5 acres). The exception is east of Selder Road where the zoning is UR4 (4 lots per acre). Current zoning (2015) in the Birch Point Subwatershed allows for an expansion of the medium density residential areas to the west and high density residential to the east.

Roadways, parking lots, sidewalks, rooftops and other hard surfaces that prevent rainfall from infiltrating into the ground are called impervious surfaces. The effects of impervious surface on stormwater runoff and water quality are well known. Increased impervious cover, if uncontrolled or untreated, affects receiving water bodies by increasing and extending the duration of peak flows and increasing the rate of pollutants washing off the landscape.

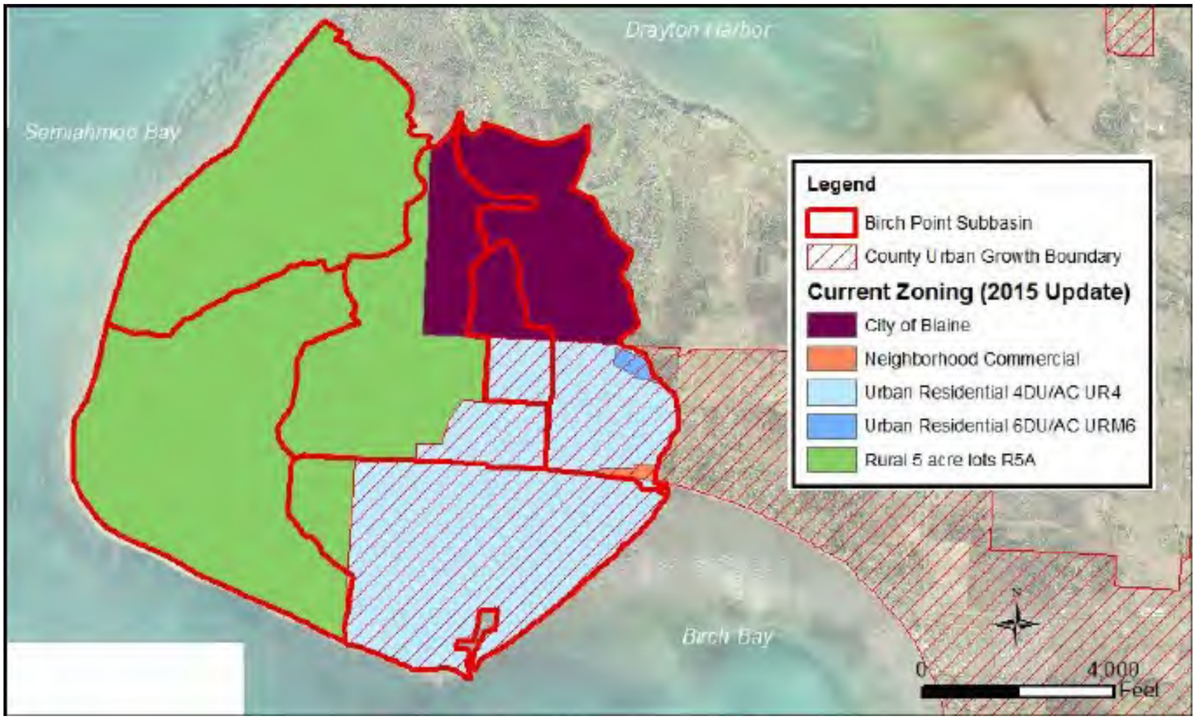

Figure 2-5. Current Zoning (2015) in the Birch Point Subwatershed

Existing impervious area was computed based on the delineation compiled for the watershed characterization study (ESA Adolfson, 2007). Impervious area for future conditions was estimated using a combination of representative impervious fractions typical for the region and maximum zoning allowances.

Impervious area for existing and future land-use conditions is summarized in Table 2-2. Impervious surfaces currently cover about 12 percent of the subwatershed. For future conditions, impervious area is expected to increase by 40% to 17 percent of the subwatershed area.

**TABLE 2-2.
ESTIMATED IMPERVIOUS AREA IN THE BIRCH POINT SUBWATERSHED**

		Current Land Use		Future Land Use	
Subbasin	Total Subbasin Area (acres)	Impervious Area (acres)	% of Total Area	Impervious Area (acres)	% of Total Area
Birch Point North	501	31	6	39	8
Birch Point South	613	23	4	30	5
Semiahmoo Uplands	457	24	5	47	10
Rogers Slough Upper Tributary	382	51	13	99	26
Rogers Slough Lower Tributary	87	17	19	19	22
Birch Bay Marina	522	189	36	189	36
Total	**2,561**	**335**	**13%**	**423**	**17%**

Stormwater System Inventory

The storm drain system in most of the Birch Point Subwatershed was inventoried by Whatcom County and Land Development Engineering and Surveying survey crews in the winter of 2015. Storm drainage facilities were excluded from the Birch Bay Marina Subbasin because all facilities are privately owned in this subbasin. Crews located drainage features in the field using GPS units and collected information on pipe diameter, material, and flow direction for all public storm drain facilities, including catch basins, manholes, storm drain pipes, driveway culverts, roadway culverts and roadside ditches. Survey elevation data were collected for catch basin rims, culvert inverts, and ditch bottoms, and compiled in a geo-database. Hand routines Manual procedures within ArcGIS were applied to the geo-database to connect the drainage features and create a drainage network. The storm drainage system inventory developed for this project is shown in Appendix A. Tables 2-3 and 2-4 summarize the drainage structure, ditch, and pipe data for the subwatershed.

TABLE 2-3.
DRAINAGE STRUCTURES IN THE BIRCH POINT SUBWATERSHED

Subbasin	Catch Basins	Outfalls	**Total**
Birch Point North	40	7	**47**
Birch Point South	8	2	**10**
Semiahmoo Uplands	11	0	**11**
Rogers Slough Upper Tributary	27	1	**28**
Rogers Slough Lower Tributary	9	0	**9**
Birch Bay Marina	NA[a]	NA[a]	NA[a]
Total	**95**	**10**	**105**

a. Not measured, no public stormwater inventory in Birch Bay Marina Subbasin.

TABLE 2-4.
DITCH, PIPE AND CULVERT INVENTORY IN THE BIRCH POINT SUBWATERSHED

	Drainage Element Length (feet)									
	Roadside	Storm Drain (by Diameter)				Culvert				
Subbasin	Ditch	≤8”	10”-12”	15”-18”	≥24”	≤8”	10”-12”	15”-18”	≥24”	**Total**
Birch Point North	12,209	0	2,665	1,112	0	19	1,008	468	194	**5,466**
Birch Point South	12,827	16	59	0	0	0	258	421	144	**898**
Semiahmoo Uplands	4,605	1,503	173	0	0	36	218	48	22	**2,001**
Rogers S. Upper Trib.	3,394	3,040	0	195	0	0	48	593	630	**4,506**
Rogers S Lower Trib.	15,301	1,481	405	391	0	495	4,058	230	64	**7,124**
Birch Bay Marina	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]
Total	**47,335**	**6,040**	**3,302**	**1,698**	**0**	**550**	**5,590**	**1,760**	**1,054**	**19,995**

a. Not measured, no public stormwater inventory in Birch Bay Marina Subbasin.

There are 98 drainage structures in the Birch Point Subwatershed, including catch basins and outfalls. There are 9 miles of ditch and 3.8 miles of pipeline (culvert and storm drain). Culverts and storm drain pipes range from 4-inch-diameter yard drains to 36-inch-diameter pipes conveying the main flow through a subbasin (trunk pipes or roadway culverts). Approximately 45 percent of the pipe is between 10 and 12 inches in diameter. Pipe materials include thermoplastic, concrete, and corrugated metal pipe (CMP). Generally, newer pipes are thermoplastic and older ones are concrete or CMP. CMP has a relatively short design life of about 30 years before it starts to rust, usually in the flow line of the pipe. CMP is also susceptible to bending and crushed pipe ends. Thermoplastic pipe may be susceptible to deformation if installed incorrectly.

A cursory condition assessment performed during the drainage inventory identified about three structures as being in poor condition. The condition assessment also found several locations where connection structures (catch basins or manholes) were absent, had inadequate surface access, or needed grout replaced. Missing or inadequate structures and damaged pipe ends are documented in Chapter 4.

TERRELL CREEK URBAN AREA SUBWATERSHED

Topography and Subbasins

The Terrell Creek Urban Area Subwatershed (Figure 2-6) extends from Birch Bay to about 2 miles east of the bay and from Helweg Road to about 1 north to 1 mile north to south. The subwatershed is generally bisected by Bay Road in the east-west direction and Jackson Road in the north-south direction. . It contains the Bay Crest and Beachwood Resort developments. The high point at the eastern edge of the subwatershed is 110 feet NAVD88; elevation drops to 40 to 60 feet to the west. The western edge of the subwatershed borders Terrell Creek, with a ridge that drops approximately 20 to 30 feet to sea level.

The *Birch Bay Watershed Characterization and Watershed Planning Study* (ESA Adolfson, 2007) divided each subwatershed area into subbasins. The names and locations were altered for this report, with boundaries re-delineated based on LiDAR mapping, flow paths from the storm drain inventory, and field investigation. The three subbasins in the Terrell Creek Urban Area Subwatershed total 474 acres:

- The Terrell Creek Upper Tributary 1 Subbasin covers 211 acres and is located in the area of Bay Road west of SR-548, extending to the western end of Helweg Road. The land use of the subbasin is mostly medium-density residential, which includes part of the Beachwood Resort and Bay Crest developments. Outside of these populated areas, land use is undeveloped pastureland.
- The Terrell Creek Estuarine Reach Subbasin covers 137 acres and skirts Birch Bay along Highland Drive to the northeast of Birch Bay State Park. The land use is low-density residential development along the northern shoreline. The remainder of the subbasin is medium-density residential, including about one third of the Beachwood Resort development.
- The Terrell Urban Area North Subbasin covers 126 acres to the northwest of the Bay Crest South development. The western half of the subbasin is characterized by medium-density residential development extending from the intersection of Jackson Road and Key Street to the Wooldridge neighborhood. Drainage from the Bay Crest North development is received from a detention pond to the east.

Surface Water Features

Eleven outfalls drain into Terrell Creek at various locations in the subwatershed. There are three detention ponds in the Bay Crest development.

Terrell Creek Upper Tributary 1 Subbasin

The Terrell Creek Upper Tributary 1 Subbasin drains most of the Bay Crest development along Bay Road and extends up Jackson Road to the intersection with Key Street. Runoff within the Bay Crest development is routed through a curb-and-gutter storm drain system and collected in two detention ponds near Bay Road.

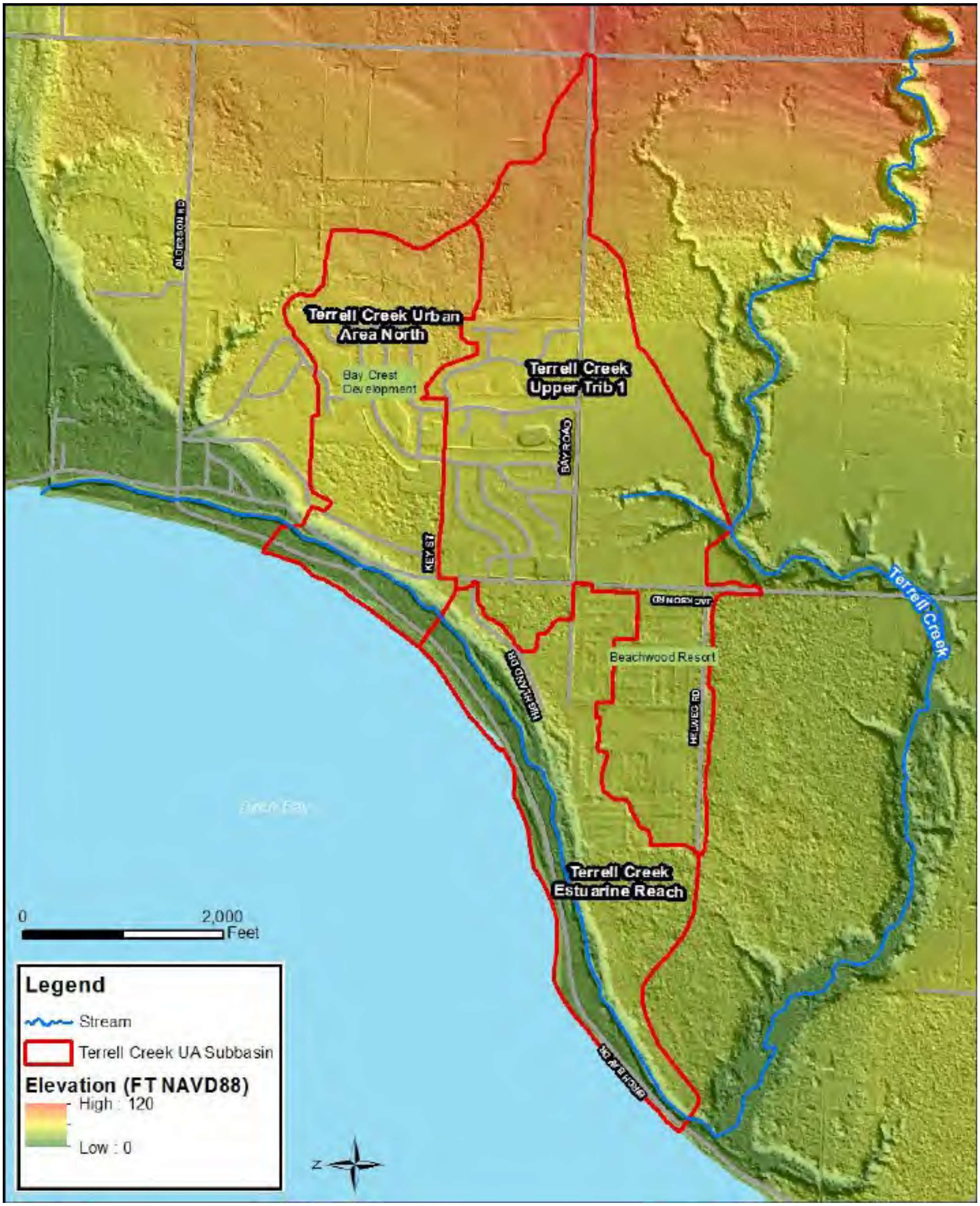

Figure 2-6. Topography of the Terrell Creek Urban Area Subwatershed

One pond is in the southwest corner of the development and the other is a few hundred yards to the east. The ponds provide active storage using an orifice and weir control structure. Water released from the detention ponds is routed through an open ditch-and-culvert system toward an 18-inch outfall that crosses under Bay Road and discharges into Terrell Creek.

Stormwater runoff is collected in roadside ditches along both sides of Jackson Road and is conveyed south to Bay Road. The roadside ditch along the west side of Jackson Road and is conveyed east under the intersection of Jackson Road and Bay Road through a 24-inch diameter storm pipe. At Bay Road, a roadside ditch conveys stormwater runoff east about 900 feet where it connects to a 24-inch diameter pipe that crosses under Bay Road and outfalls to Terrell Creek. Additionally, a small volume of water is received from Bay Road west of Jackson Road.

A second outfall is southeast of the intersection of Jackson Road and Helweg Road. This outfall receives stormwater runoff from the Beachwood Resort. Local runoff from Helweg Road and Jackson Road south of Bay Road is conveyed through an open ditch-and-culvert system and crosses under Helweg Road through a 24-inch diameter HDPE pipe. Runoff is discharged to Terrell Creek through a 24-inch HDPE outfall crossing under Jackson Road.

Terrell Creek Estuarine Reach Subbasin

Two outfalls discharge stormwater runoff to Terrell Creek from the Terrell Creek Estuarine Reach Subbasin: a 24-inch concrete pipe at the south end of the subbasin and a 12-inch concrete outfall at the north end. Both outfalls convey runoff over steep bluffs. The south outfall receives stormwater runoff from Highland Drive, Elaine Street, and the Beachwood Resort. The north outfall receives only a small volume of water from the north end of Highland Drive.

Terrell Creek Urban Area North

Runoff from the Terrell Creek Urban Area North Subbasin discharges into Terrell Creek through a 12-inch pipe west of Jackson Road. The outfall receives stormwater runoff from Key Street and Sunset Drive through a series of open ditches and driveway culverts. It also receives discharge from the Bay Crest North detention pond, providing active storage using an orifice structure for over 60 percent of the subbasin, including the majority of impervious area. Stormwater conveyed from the Bay Crest pond enters the east end of Key Street.

Geology and Soils

Geologic conditions of the Terrell Creek Urban Area Subwatershed are similar to the conditions described for the Birch Point Subwatershed. Hydrologic soil groups and surficial aquifers are shown in Figure 2-7. Soil types are described on page 10.

FEMA Flood Zone

A Type V flood zone is located along the shoreline through the entire length of the Terrell Creek Urban Area Subwatershed (Figure 2-8). Type AE flood zone is located along Terrell Creek. No other flood zones were identified within the subwatershed. Flood zones are described on page 12.

Wetlands

Wetlands within the Terrell Creek Urban Area Subwatershed are shown in Figure 2-8. They include depressional wetland located in upland areas and riverine wetlands located along Terrell Creek. Table 2-5 summarizes wetland area by subbasin. Wetland types are described on page 12.

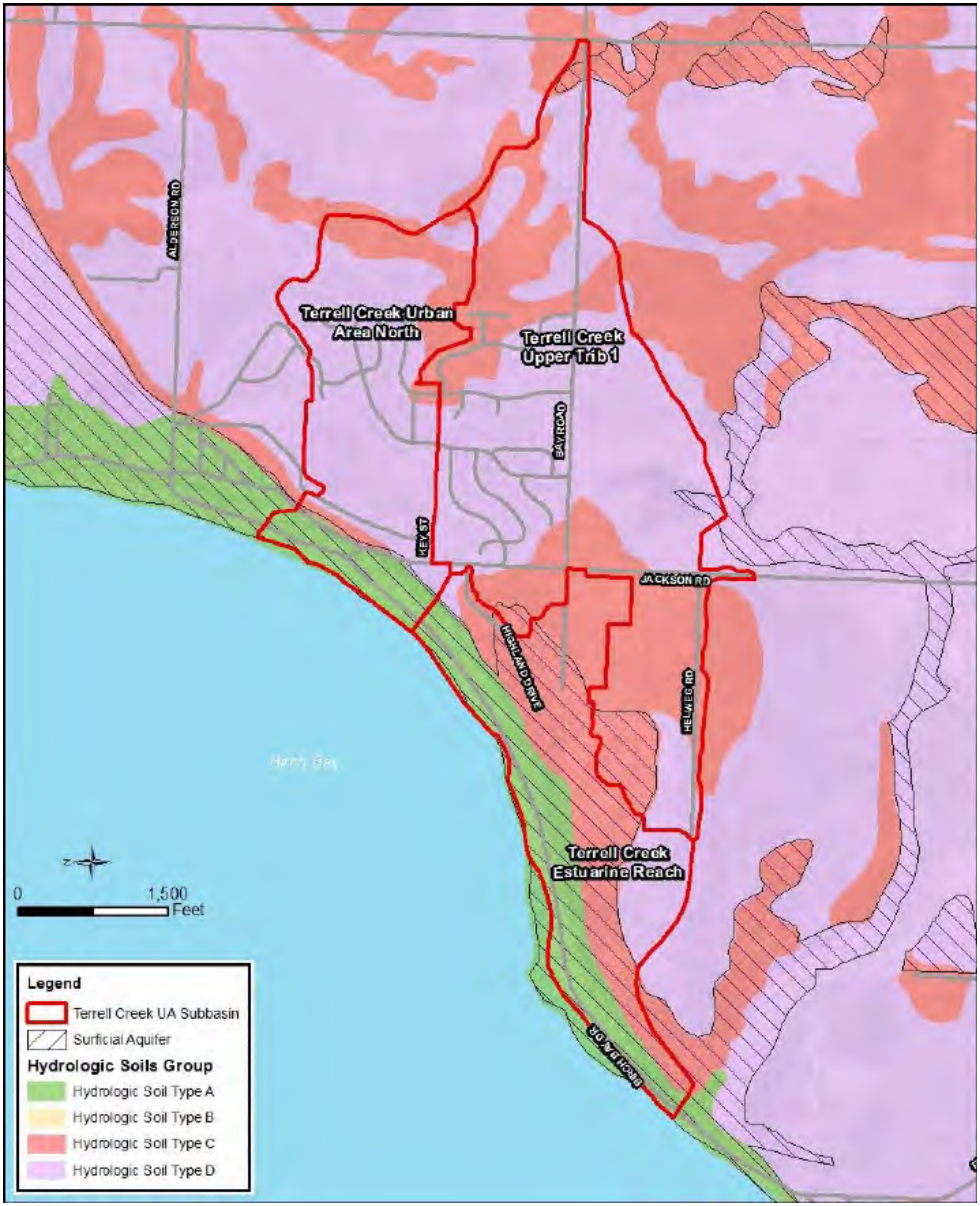

Figure 2-7. Hydrologic Soil Group and Surficial Aquifers in the Terrell Creek Urban Area Subwatershed

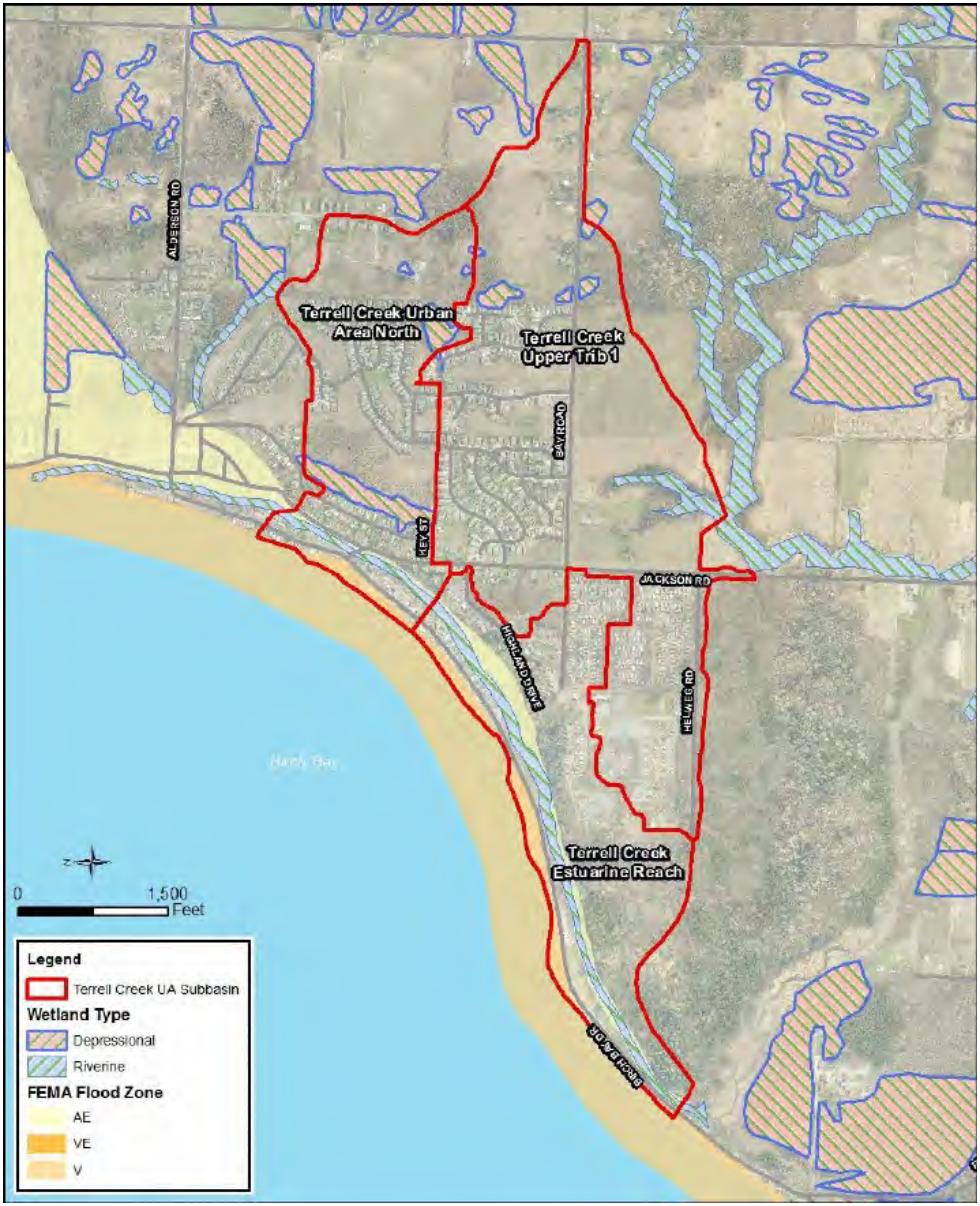

Figure 2-8. Wetlands and FEMA Flood Zones within the Terrell Creek Urban Area Subwatershed

TABLE 2-5.
WETLANDS IN THE TERRELL CREEK URBAN AREA SUBWATERSHED

Subwatershed	Wetland Area (acres)			Percent of Total Area
	Depressional	Riverine	**Total**	
Terrell Creek Upper Trib. 1	4.8	0	4.8	2%
Terrell Creek Estuarine Reach	0	11.1	11.1	18%
Terrell Creek Urban Area North	9.6	3.0	12.6	10%
Total	14.5	14.1	28.5	6%

Zoning Land Use

Approximately 80 percent of the Terrell Creek Urban Area is within the Birch Bay urban growth boundary, allowing for medium- and high-density development. Urban growth boundaries are shown in Figure 2-9. Current zoning (2015) is primarily high- and medium-density residential. This includes the Bay Crest development, Beachwood Resort, and the Wooldridge neighborhood. Zoning categories are described on page 14.

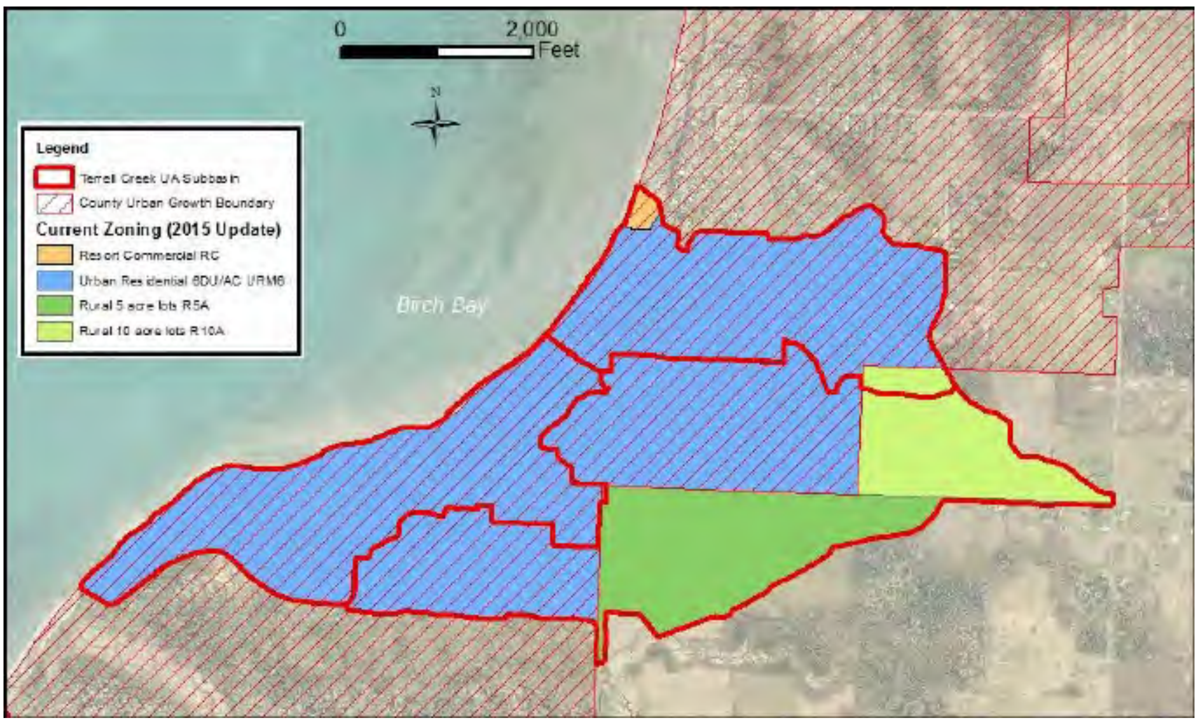

Figure 2-9. Current Zoning (2015) in the Terrell Creek Urban Area Subwatershed

Existing impervious area was computed based on the delineation compiled for the watershed characterization study (ESA Adolfson, 2007), as summarized in Table 2-6. Impervious surfaces currently cover approximately 10 percent of the Terrell Creek Urban Area. Future conditions were not examined for this subwatershed, because it is considered to be at full buildout. Any additional development is anticipated to have minimal impact on the subwatershed hydrology.

There are 233 drainage structures in the Terrell Creek Urban Area including catch basins, control structures, and outfalls. There are 4.3 miles of ditch and 5.4 miles of pipeline (culvert and storm drain). Culverts and storm drain pipes range from 4-inch-diameter yard drains to 36-inch-diameter pipe conveying the main flow through a subbasin (trunk pipes or roadway culverts). Approximately 40 percent of the pipe is between 10 and 12 inches in diameter. Pipes materials include thermoplastic, concrete, and CMP.

TABLE 2-6.
ESTIMATED IMPERVIOUS AREA IN THE TERRELL CREEK URBAN AREA SUBWATERSHED

		Current Land Use	
Subbasin	Total Subbasin Area (acres)	Impervious Area (acres)	% of Total Area
Terrell Creek Upper Trib. 1	270	30	11
Terrell Creek Estuarine Reach	137	35	25
Terrell Creek Urban Area North	126	63	50
Total	**533**	**128**	**24%**

Stormwater System Inventory

The storm drainage system inventory developed for this project is shown in Appendix A. Tables 2-7 and 2-8 summarize the drainage structure, ditch and pipe data for the Terrell Creek Urban Area Subwatershed.

TABLE 2-7.
DRAINAGE STRUCTURES IN THE TERRELL CREEK URBAN AREA SUBWATERSHED

Subbasin	Catch Basins	Outfalls to Birch Bay	Outfalls to Terrell Cr.	Total
Terrell Creek Upper Trib. 1	137	0	1	138
Terrell Creek Estuarine Reach	19	1	4	24
Terrell Creek Urban Area North	94	0	3	97
Total	**250**	**1**	**8**	**259**

TABLE 2-8.
DITCH, PIPE AND CULVERT INVENTORY IN THE TERRELL CREEK URBAN AREA SUBWATERSHED

	Drainage Facility Length (feet)									
	Roadside	Storm Drain (by Diameter)				Culvert				
Subbasin	Ditch	≤8”	10”-12”	15”-18”	≥24”	≤8”	10”-12”	15”-18”	≥24”	**Total**
Terrell Cr. Upper Trib. 1	19,051	3,425	3,701	4,806	2,802	89	1,284	175	435	**16,717**
Terrell Cr. Estuarine Reach	2,838	70	1,387	37	1,050	0	881	0	0	**3,425**
Terrell Cr. UA North	873	1,354	3,134	1,719	787	0	1,332	35	0	**8,361**
Total	**22,762**	**4,849**	**8,222**	**6,562**	**4,639**	**89**	**3,497**	**210**	**435**	**28,503**

A cursory condition assessment performed during the drainage inventory identified two structures as being in poor condition. The condition assessment also found several locations where connection structures (catch basins or manholes) were absent, had inadequate surface access, or needed grout replaced. Missing or inadequate structures and damaged pipe ends are documented in Chapter 4.

POINT WHITEHORN SUBWATERSHED

Topography and Subbasins

The Point Whitehorn Subwatershed (Figure 2-10) covers approximately 1.0 squares miles bordering the southern end of Birch Bay. Stormwater runoff discharges into either Terrell Creek or Birch Bay from three subbasins. A ridgeline runs east to west bisecting the subwatershed along Grandview Road with elevations dropping steeply toward Birch Bay to the north. The upland areas south and west of Grandview Road rise to 170 feet NAVD88. The elevation of the lowlands ranges from 10 to 50 feet NAVD88.

The *Birch Bay Watershed Characterization and Watershed Planning Study* (ESA Adolfson, 2007) divided each subwatershed area into subbasins. The names and locations were altered for this report, with boundaries re-delineated based on LiDAR mapping, flow paths from the storm drain inventory, and field investigation. The three subbasins in the Point Whitehorn Subwatershed total 660 acres:

- The Point Whitehorn Subbasin covers 107 acres along the northern shoreline of the subwatershed. The subbasin extends east from the western peninsula to Point Whitehorn Road. Land use is characterized by medium-density residential for the entire subbasin.
- The Point Whitehorn Uplands Subbasin covers 379 acres centered on the intersection of Grandview Road and Point Whitehorn Road. Land use in the subbasin is characterized by pastureland to the south, transitioning to forested land to the north around the Birch Bay Water and Sewer District treatment plant. Salish Breeze, a partially developed subdivision platted for medium-density development west of Point Whitehorn Road, contains the largest area of impervious surface.
- The Point Whitehorn South Subbasin covers 175 acres along the southern shoreline of the subwatershed. This subbasin actually drains to the Strait of Georgia rather than Birch Bay but was included in the Point Whitehorn Subwatershed because it is within the BBWARM administrative boundary. Koehn Road and Maple Way are drained by a series of roadside ditches and driveway culverts. Most of the subbasin is currently pastureland forest with a small area of low-density development along Maple Way.

Surface Water Features

Point Whitehorn Subbasin

Two outfalls discharge stormwater runoff from the Point Whitehorn Subbasin into Birch Bay and an additional discharge point near the intersection of Birch Bay Drive and Point Whitehorn Road.

The Holeman Avenue outfall is a 24-inch HDPE pipe that runs from Holeman Avenue to the toe of slope into Birch Bay. The outfall conveys stormwater from Holeman Avenue and Whitehorn Way. Drainage within these neighborhood is a combination of storm drain, culvert, and open ditches.

The Birch Bay Drive outfall is an 18-inch CMP outfall north of the intersection of Birch Bay Drive and Jill Street. Runoff is conveyed to the outfall through a series of storm pipes and catch basins from the southern half of Birch Bay Drive. Additional stormwater runoff is received from Petticote Lane to the south. High flows are currently able to bypass the Birch Bay Drive outfall and flow north toward the Point Whitehorn Road outfall.

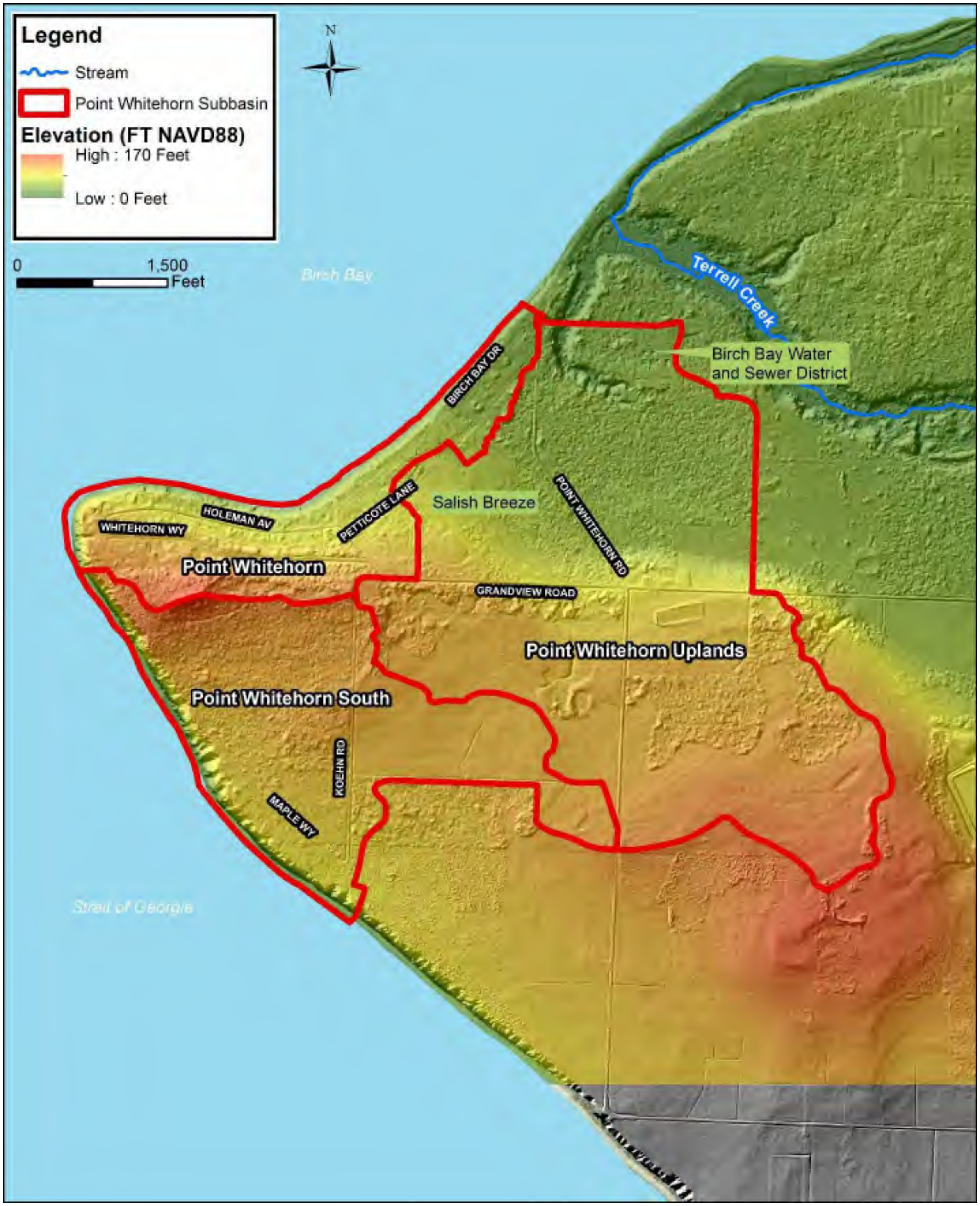

Figure 2-10. Topography of the Point Whitehorn Subwatershed

An additional discharge point is located to the northeast of the intersection of Birch Bay Drive and Point Whitehorn Road, an 18-inch HDPE pipe that discharges into a slough upstream of Terrell Creek. The 18-inch pipe receives runoff from a small area of Birch Bay Drive located to the west and to Helweg Lane located to the south.

Point Whitehorn Uplands Subbasin

Two discharge points drain the undeveloped upland areas of the Point Whitehorn Uplands Subbasin. The first discharge point is located near the intersection of Birch Bay Drive and Point Whitehorn Road, the 18-inch HDPE drains a large of amount of the Point Whitehorn Uplands Subbasin and is also connected to the Point Whitehorn subbasin as described above. Stormwater runoff is conveyed from undeveloped upland areas through a roadside ditch and culvert system along Grandview Road and the west side of Point Whitehorn Road. Stormwater runoff crosses under Point Whitehorn Road and discharges through an 18-inch driveway culvert into a slough upstream of Terrell Creek near the Water and Sewer District treatment plant. Additional stormwater runoff is received from Salish Breeze, a partially built-out neighborhood zoned for medium-density development. Stormwater runoff collected in the Salish Breeze development is discharged through a flow spreader and either infiltrates the ground or enters the Point Whitehorn Road roadside ditch.

The second drainage point drains the east side of Point Whitehorn Road. Runoff on the east side of Point Whitehorn Road is discharged routed through and roadside ditch into a slough upstream of Terrell Creek near the Water and Sewer District treatment plant. There is a connection that exists between the west side and east side of Point Whitehorn Road with a catch basin with control structure; however, the overflow elevation connecting the systems is unknown.

Point Whitehorn South Subbasin

The Point Whitehorn South outfall is at the southern end of the watershed, south of the intersection of Maple Way and Koehn Road. Runoff is conveyed as sheet flow through undeveloped upland areas before entering an open ditch system paralleling the roads. A series of 24-inch HDPE pipes and catch basins collects runoff at the roadway intersection and conveys the water down the bluff and into the Strait of Georgia.

Geology and Soils

Geologic conditions of the Point Whitehorn Subwatershed are similar to those described for the Birch Point Subwatershed. Hydrologic soil groups and surficial aquifers are shown in Figure 2-11. Soil types are described on page 10.

FEMA Flood Zone

A Type V flood zone is located along the shoreline through the entire length of the Point Whitehorn Subwatershed (Figure 2-12). No other flood zones were identified within the subwatershed. Flood zones are described on page 12.

Wetlands

Wetlands in the Point Whitehorn Subwatershed are shown in Figure 2-12 and cover approximately 20 percent of the subwatershed. The most extensive coverage is in the Point Whitehorn Uplands Subbasin, where wetlands cover 30 percent of the subbasin. Depressional wetland are found throughput the subwatershed and a slope wetland is located at the western edge. Table 2-9 summarizes wetland coverage in the Point Whitehorn Subwatershed. Wetland types are described on page 12.

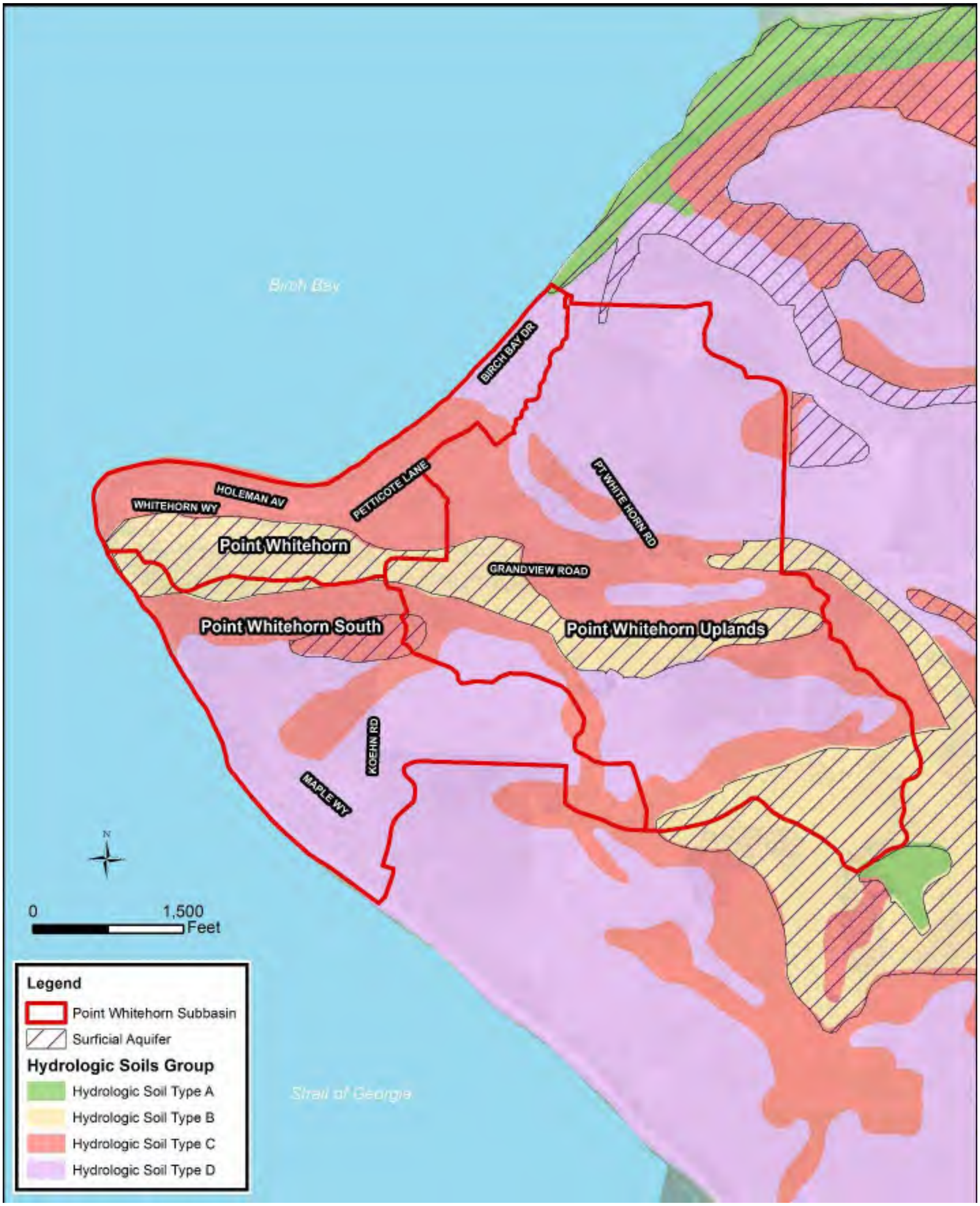

Figure 2-11. Hydrologic Soil Group and Surficial Aquifers in the Point Whitehorn Subwatershed

Figure 2-12. Wetlands and FEMA Flood Zones within the Point Whitehorn Subwatershed

**TABLE 2-9.
WETLANDS IN THE POINT WHITEHORN SUBWATERSHED**

Subwatershed	Wetland Area (acres) Depressional	Riverine	Slope	**Total**	Percent of Total Area
Point Whitehorn South	24.2	0	18.4	42.8	25%
Point Whitehorn Uplands	72.2	1.0	0	73.2	19%
Point Whitehorn	0	0	0	0	0%
Total	96.6	1.0	18.4	116.0	18%

Zoning and Land Use

Less than half of the Point Whitehorn Subwatershed is within the Birch Bay urban growth area, limiting the amount of medium- and high-density development. Current zoning (2015) is primarily low- and medium-density residential within the urban growth boundary (Figure 2-13).

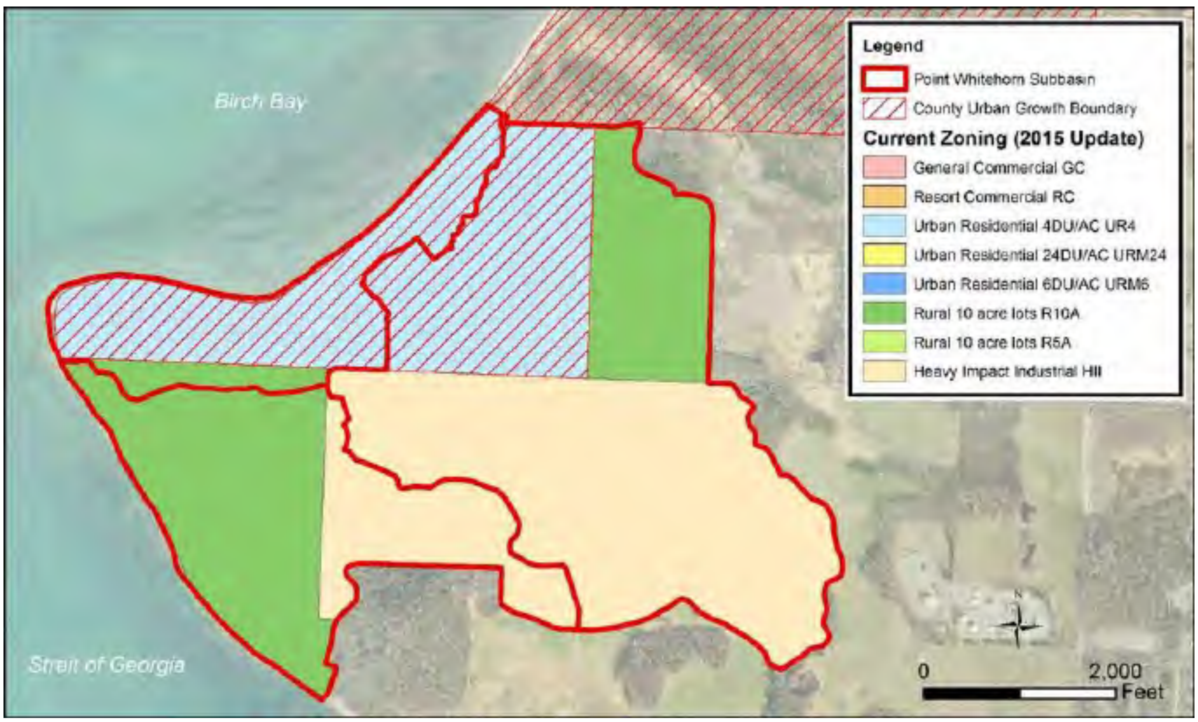

Figure 2-13. Current Zoning (2015) in the Point Whitehorn Subwatershed

Existing impervious area was computed based on the delineation compiled for the watershed characterization study (ESA Adolfson, 2007), as summarized in Table 2-10. Impervious surfaces currently cover about 8 percent of the Point Whitehorn Subwatershed. Future conditions were not examined for this subwatershed because no significant increase in impervious area is expected.

Stormwater System Inventory

The storm drainage system inventory developed for this project is shown in Appendix A. Tables 2-11 and 2-12 summarize the drainage structure, ditch and pipe data.

TABLE 2-10.
ESTIMATED IMPERVIOUS AREA IN THE POINT WHITEHORN SUBWATERSHED

Subbasin	Total Subbasin Area (acres)	Current Land Use: Impervious Area (acres)	Current Land Use: % of Total Area
Point Whitehorn			
Point Whitehorn South	175	7	4
Point Whitehorn Uplands	379	16	4
Point Whitehorn	107	28	26
Total	**661**	**51**	**7.7%**

TABLE 2-11.
DRAINAGE STRUCTURES IN THE POINT WHITEHORN SUBWATERSHED

Subbasin	Catch Basins	Outfalls to Birch Bay or Strait of Georgia	Outfalls to Terrell Cr.	Total
Point Whitehorn South	3	1	0	4
Point Whitehorn Uplands	70	0	0	70
Point Whitehorn	70	2	0	72
Total	**143**	**3**	**0**	**146**

TABLE 2-12.
DITCH, PIPE AND CULVERT INVENTORY IN THE POINT WHITEHORN SUBWATERSHED

	Drainage Facility Length (feet)									
	Roadside	Storm Drain (by Diameter)				Culvert				
Subbasin	Ditch	≤8”	10”-12”	15”-18”	≥24”	≤8”	10”-12”	15”-18”	≥24”	**Total**
Point Whitehorn	7,132	4,402	5,473	1,737	303	24	2,448	84	91	**14,562**
Point Whitehorn Uplands	17,775	3,161	3,031	1,699	324	0	531	299	38	**9,083**
Point Whitehorn South	0	0	0	0	0	0	0	0	184	**184**
Total	**24,907**	**7,563**	**8,504**	**3436**	**627**	**24**	**2,979**	**383**	**313**	**23,829**

There are 148 drainage structures in the Point Whitehorn Subwatershed, consisting of catch basins and outfalls to Birch Bay and Terrell Creek. There are 4.7 miles of ditch and 4.5 miles of pipeline (culvert and storm drain). Culverts and storm drain pipes range from 4-inch-diameter yard drains to 36-inch-diameter pipe conveying the main flow through a subbasin (trunk pipes or roadway culverts). Approximately 48 percent of the pipe is between 10 and 12 inches in diameter. Pipes materials include thermoplastic, concrete, and CMP

A cursory condition assessment performed during the drainage inventory identified five structures as being in poor condition. The condition assessment also found several locations where connection structures (catch basins or manholes) were absent, had inadequate surface access, or needed grout replaced. Missing or inadequate structures and damaged pipe ends are documented in Chapter 4.

CHAPTER 3.
HYDROLOGIC AND HYDRAULIC ANALYSIS

This chapter describes hydrologic and hydraulic modeling of the BP-TC-PW Subwatersheds to help quantify existing and future surface water conditions. The modeling was used to identify flooding-related problems and to evaluate potential solutions. The goals and objectives of the hydrologic and hydraulic modeling are as follows:

- Develop an understanding of the hydrologic regime in the BP-TC-PW Subwatersheds.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems.

In general, hydrologic models are used to determine the amount of stormwater runoff that will be generated from a drainage basin during a storm event or a series of storm events. The flow data generated by the hydrologic model are then input into a hydraulic model, which evaluates how the flow is routed through a conveyance system, such as a roadside ditch-and-culvert system, a stream channel or an enclosed storm drain system.

The storm drainage system was analyzed using the Hydrologic Simulation Program – Fortran (HSPF) model (U.S. EPA, 2005) and the Stormwater Management Model v5 (SWMM5) model (U.S. EPA, 2011). HSPF was used to simulate runoff. SWMM5 was used to analyze the hydraulics of natural and constructed surface water drainage systems in the BP=TC-PW Subwatersheds. A joint model was developed to encompass all subbasins, due to uncertainty in subbasin overflow. Model development is documented in Appendix B.

HYDROLOGIC ANALYSIS

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine long-term runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration and ground infiltration. Routing of runoff from discrete subwatersheds is modeled with rating tables that represent pipes, channels, lakes, and other flood storage areas. Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to the stream channel at a slower rate than direct runoff. Groundwater discharges to the stream channel where the stream intersects the saturated zone, contributing to long-term base flow in the system. Infiltrated flow can leave the surface watershed by entering deep groundwater.

Flow characteristics were computed for existing land use conditions in the BP-TC-PW Subwatersheds and used to compute peak runoff rates. Flood frequency was computed using the peak runoff rates to identify design events that correspond to the 2-, 25-, and 100-year peak runoff events. The design events were extracted from the hydrologic data set and routed through the hydraulic model.

In 2013, the Birch Bay urban growth area, which includes portions of the BP-TC-PW Subwatersheds, was added to Whatcom County's National Pollutant Discharge Elimination System Phase II permit coverage area. Coverage under this permit requires the County to implement minimum standards for maintenance of the existing stormwater system. Flow control and water quality treatment for new developments will be required to meet more stringent minimum technical requirements specified in the 2012 *Stormwater Manual for Western Washington* by December 31, 2016. Until that time, Whatcom County has specified the use of the 2005 manual (Ecology, 2005). Stormwater flow control requirements have the potential to significantly reduce stormwater runoff from developing areas. For this reason, future-condition flow rates would not provide useful information on drainage problems and were not analyzed for this plan for the Terrell Creek Urban Area and Point Whitehorn Subwatershed. However, these two subwatershed are nearing full buildout so the existing conditions is representative of future conditions. For the Birch Point Subwatershed, future conditions were analyzed because impervious area may an increase slightly where land use changes from forest and pasture to rural 5 acres lots. The undeveloped area in the Birch Point subwatershed is outside the Urban Growth Area (see Figure 2-5).

HYDRAULIC ANALYSIS

The variety of drainage elements in the BP-TC-PW Subwatershed storm drainage system (drain pipes, catch basins, roadside culverts and ditches, natural channels and flood storage areas) requires a sophisticated hydraulic model. The SWMM5 model is capable of representing the diverse character and hydraulic features of the drainage system, as well as tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as detention facilities. The model is well-suited to estimate flow and depth in the BP-TC-PW storm drainage system.

A SWMM5 model was developed to represent all drainages within the BP-TC-PW Subwatershed. Modeled runoff from HSPF subcatchments was input to the SWMM5 model at discrete nodes in the model schematic. SWMM5 models the routing of this runoff through a system of pipes, channels, storage and outfalls, tracking the flow of water in each pipe and channel. Birch Bay tidal data from the Cherry Point Station, adjusted for local conditions, were used as the downstream boundary at the pipe outfalls.

Flood Locations

Design analysis was performed using the SWMM5 model to identify locations where flooding is predicted for existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the defined overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause of flooding. The analysis showed that flooding is predicted at 22 nodes for the 25-year event and 34 nodes for the 100-year event. Flooding was grouped into 12 flood problem area locations.

The hydraulic analysis showed that the storm drain systems in the BP-TC-PW Subwatersheds have adequate capacity to convey the 2-year event. However, there are several locations with significant restrictions for the 25-year event, and flooding was predicted at several locations along major arterial streets:

- Semiahmoo Drive south of Oertel Drive (Birch Point South Subbasin)
- Normar Place near Semiahmoo Drive (Birch Point North Subbasin)
- Jackson Road at Bay Road (Terrell Creek Upper Tributary 1 Subbasin)
- Sunset Drive east of Jackson Road (Terrell Creek Urban North Subbasin)
- Holeman Avenue west of Birch Bay Drive (Point Whitehorn Subbasin).

Conveyance Capacity

Hydraulic modeling results were reviewed to assess the conveyance capacity of the primary conveyance route in each subbasin. Many of the problem areas in the subwatersheds are due to flows exceeding the capacity of the system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Capacity is exceeded when a drainage structure has less than 0.5 feet of freeboard during a storm event.

Table 3-1 summarizes the capacity analysis results at critical drainage elements within the BP-TC-PW Subwatersheds. Generally, the outfalls

TABLE 3-1.
EXISTING CONDITION PEAK FLOWS AND SYSTEM CAPACITY

Location	Pipe Diameter (inches)	Predicted Peak Flow (cfs) 2-Year	25-Year	100-Year	Maximum Flow Before Flooding
Point Whitehorn Subwatershed (Existing Condition)					
Holeman Avenue Outfall	24	2.7	8.6	11.9	> 100 Year
Inflow from Whitehorn Way	18	0.9	3.3	4.9	>100 Year
Birch Bay Drive Outfall	18	2.6	5.4	10.0	> 100 Year
Inflow from Petticote Lane	12	1.5	4.9	7.3	3.6 cfs
Point Whitehorn Road Outfall	18	6.0	12.5	14.2	> 100 Year
Koehn Road at Maple Way Outfall	24	0.9	10.4	15.5	> 100 Year
Terrell Creek Urban Area Subwatershed (Existing Condition)					
Highland Drive south of Elaine Street	24	13.4	32.0	38.7	> 100 Year
Highland Drive north of Elaine Street	12	1.0	2.5	3.2	> 100 Year
Bay Road east of Jackson Road	18	11.7	13.2	13.3	> 100 Year
Jackson Road at Key Street	12	9.0	14.4	16.2	6.0 cfs
Birch Point Subwatershed (Existing Condition / Future Condition)					
Hogan Street	12	1.7 / 2.7	2.4 / 4.7	3.2 / 6.7	> 100 Year
Normar Place (Upper)	12	2.4 / 3.5	3.3 / 5	4.4 / 6.1	> 100 Year
Semiahmoo Drive near Normar Place	12	2.7 / 2.8	6.7 / 8.3	9.4 / 12.1	3 cfs
Cary Lane near Charel Drive	12	3.5 / 6.1	7.2 / 10.6	9.3 / 13.9	> 100 Year
Semiahmoo Drive (DNR Outfall)	36	10.4 / 16.6	27.4 / 33.9	36.2 / 46.3	> 100 Year
Semiahmoo Drive at Birch Point Road	N/A	4.3 / 10.7	30.5 / 34.3	38.4 / 43.6	> 100 Year
Birch Point Road (Private Outfall)	36	7.3 / 16.8	21.2 / 24.4	24.4 / 28.1	< 2 Year[a]
Birch Point Road west of Bay Ridge Rd.	24	10.8 / 13.4	15.8 / 23.2	17 / 29.5	> 100 Year
Selder Road at Skyvue Road	18	8.9 / 15.3	30.4 / 34.7	39.7 / 44	11 cfs
Birch Point Road at Selder Road	18	1.7 / 2.7	2.4 / 4.7	3.2 / 7.7	> 100 Year

cfs = cubic feet per second

a. Flow in table represents functioning condition; however, flume has collapsed and is no longer able to convey flow.

CHAPTER 4.
SURFACE WATER PROBLEMS

COMMON SURFACE WATER PROBLEMS

Drainage conditions are considered to be problems when they negatively affect existing or proposed development. Although drainage problems may be caused by natural conditions such as steep slopes or underlying hardpan, they are exacerbated by development that increases impervious area, reduces vegetative cover, changes runoff routes, accelerates runoff rates, and affects water quality.

Rate and Volume of Stormwater Runoff Flows

The amount of runoff in a watershed is directly proportional to the amount of impervious area. Impervious area is the area covered by hard surfaces such as roofs, streets and sidewalks, which prevent rainfall from infiltrating into the soil. As development increases impervious area, the amount of stormwater runoff increases. Even in built-out areas, impervious area can increase through re-development. Increased impervious area can also decrease groundwater recharge and base flow in streams. With a larger percentage of precipitation flowing as runoff, less is available to replenish soil moisture and groundwater storage.

Development also can affect runoff by changing its natural flow pathways. Fill for driveways or homes often eliminates natural depressions. The flow of runoff from streets and roofs is faster than from treed and vegetated areas. The construction of artificial channels, such as storm sewers or ditches, also decreases the lag time between when rain falls and when it enters the flow of a receiving stream, thus increasing the peak runoff rate in the receiving stream; scouring streambeds and destabilizing slopes.

Vegetation loss that occurs with development can have several effects on stormwater runoff. Plants and trees not only improve soil permeability, they also provide a source of precipitation storage. With vegetation loss, rain that would have been evaporated from or absorbed by trees instead falls to the ground and contributes to standing water.

Several neighborhoods in the Birch Point Subwatershed may experience urban redevelopment in the future, potentially increasing the impervious area or decreasing the vegetation. Inclusion of drainage infrastructure would be beneficial in these instances.

Ponding

The following conditions can cause ponding of surface water runoff:

- Lack of drainage infrastructure
- Inadequate capacity in a drainage system
- Inadequate gradient for surface runoff to flow into the collection system
- Inadequate infiltration due to compaction from construction
- Inadequate infiltration due to low permeability or saturated soils
- Inadequate infiltration or surface ponding due to rising seasonal groundwater
- High tide blockage

Naturally occurring ponding in an undisturbed system is beneficial because it slows the rate of runoff, thus reducing the likelihood of conveyance and erosion problems downstream. However, if ponding poses a safety concern or property damage risk, then correction is required. Most ponding in the BP-TC-PW Subwatershed occurs due to low ground slopes and insufficient conveyance capacity.

Inadequate or Failing Drainage Structures

Drainage structures are considered inadequate when they are too small to accommodate stormwater flows, whether by original design or because land use changes increased flows to levels beyond the system's capacity. It is not economical to design systems with capacity for every possible storm, but systems that are inadequate for a reasonable design storm (see Figure 4-1) must be improved by performing a hydraulic analysis and designing improvements to meet local design criteria. Within the study area, many of the existing drainage structures were installed fairly recently and are of adequate size. Inadequate infrastructure also includes structures in poor condition and in need of replacement, as shown in Figure 4-2.

photo provided by Whatcom County

Figure 4-1. Roadside Ditches on Semiahmoo Drive, Undersized for Large Storms

photo by Whatcom County

Figure 4-2. Erosion-Undermined Storm Drain Outfall to Birch Bay

Water Quality

Urban stormwater quality is highly variable, depending on factors such as land use, the level of development, the age of the developed area, and the density of construction. The quality of stormwater runoff has historically been degraded by changes from natural to urbanized conditions.

The type and amount of pollutants depend on land uses in the drainage area, pollutant source controls, and drainage system maintenance programs. Primary contaminants in stormwater from developed areas are eroded sediment and debris from deteriorating roadways and buildings. Other pollutants associated with runoff are heavy metals, inorganic chemicals, nutrients (nitrogen and phosphorus), petroleum products, and fecal coliform bacteria (Figure 4-3). Older, poorly maintained urban neighborhoods generally have higher levels of pollutants than newer developments, due to higher levels of traffic, accumulation of debris, and deteriorating housing stock.

In rural or undeveloped areas, stormwater pollutant loadings are typically low. The stormwater quality of forested areas is often used as a base condition for comparison to developed areas. Stormwater runoff in agricultural areas is generally characterized by high nutrient or fecal coliform bacteria concentrations, virtually no petroleum products, and only naturally occurring metals.

Since the study area was mostly developed without water quality treatment measures, the urban runoff may be fairly low quality and the opportunity exists for improvements in treatment practices with redevelopment.

photo by Wilson Engineering

Figure 4-3. Catch Basin with Oil Sheen and Odors

Channel Erosion

Channel or stream bank erosion contributes to drainage problems in a number of ways. Water quality is affected due to the contribution of fine sediments, which can increase turbidity. Habitat is also affected when fine sediment deposition smothers spawning areas or shellfish harvesting areas. Transported sediments may be deposited in storm drain pipelines and other conveyances, requiring increased maintenance activity and possibly causing flooding due to flow obstruction. In some cases, stream bank erosion may lead to slope instability, which can threaten public facilities and private residences.

Operation and Maintenance

Drainage structures fill with sediment over time in the absence of regular cleaning (see Figure 4-4). When structures become blocked, stormwater may overflow during rainfall events, causing damage to surrounding public and private property. Drainage structures in the BP-TC-PW Subwatersheds are especially prone to siltation and blockage due to backwater in low-gradient systems, which allows sediment to settle into pipes and ditches. Sediments from developed areas have been shown to contain high levels of pollutants. Also, stormwater outfalls near sea level are susceptible to blockage due to tidal fluctuation that washes sand and mud into outfall pipes and offshore currents that float debris over the opening. Lack of access may also prevent adequate maintenance of the storm drain system. Proper storm drain design requires an access structure, usually a catch basin or manhole, at each point where a pipeline changes grade or alignment direction. Without this access, pipeline inspection and cleaning is difficult or impossible.

Figure 4-4. Catch Basin with Sediment and Debris Accumulation (photo by Wilson Engineering)

SPECIFIC PROBLEMS IDENTIFIED FOR THIS MASTER PLAN

Drainage and water quality problems specific to the BP-TC-PW Subwatersheds were identified from a number of sources:

- The Birch Bay Stormwater Comprehensive Plan (CH2M Hill, 2006)
- The Birch Bay Watershed Characterization and Watershed Planning Pilot study (ESA Adolfson, 2007)
- The Birch Bay Watershed Conceptual Design Memorandum (Osborne, 2010)
- The Whatcom County Stormwater Incident Database (Whatcom County, 2016)
- The Birch Bay/Terrell Creek Water Quality Monitoring Project
- Public input provided during BBWARM Advisory Committee meetings
- County staff input
- Stormwater inventory data collection
- Hydrologic and hydraulic analysis performed to support this report.

Each problem has been categorized based on the following:

- **Frequency** is a general indicator of the severity of the problem and has three types:
  - **Storm Event:** problems that only occur during storm events—usually with large volume or high-intensity rainfall. The frequency of the problem is quantified when known.
  - **Chronic:** problems that occur with or without direct rainfall. Groundwater seepage is an example of a chronic surface water problem.

- **Single-occurrence:** problems usually occur only once and do not return when resolved. An accumulation of pet waste washing fecal matter into a drainage path may be considered a single-event problem after cleanup.

- **Responsibility** refers to who is responsible for resolving a stormwater problem:
  - Stormwater problems generated on **public** property or with the public storm drain system are the responsibility of public entities, primarily Whatcom County and the BBWARM District. Undersized conveyance storm drains or damaged pipe outfalls in the public right-of-way are examples of surface water problems under the jurisdiction of the County.
  - Problems generated on **private** property are the responsibility of the property owners. County staff may offer advice on how to resolve private property issues but cannot provide capital for these solutions. A rooftop downspout that directs flow onto neighboring property is an example of a private property issue.
  - For some problems, responsibility is shared between **public and private**. Responsibility for these types of problems is sometimes hard to define and usually identified on a case-by-case basis. Public/private problems usually involve cases where the public storm drain conveyance systems cross private property where no easement has been granted.
- **Problem Types** are categorized as drainage, maintenance, or water quality as the root cause. Drainage problems are sub-categorized as inadequate conveyance or failing infrastructure.

Table 4-1 summarizes the 53 identified drainage and water quality problems specific to the BP-TC-PW Subwatersheds by subbasin and problem type.

TABLE 4-1.
SUMMARY OF DRAINAGE RELATED PROBLEMS IN THE BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHEDS

	Number of Problems				
	Drainage				
Subbasin	Inadequate Conveyance	Failing Infrastructure	Maintenance	Water Quality	Total
Birch Point					
Birch Point North	2	1	2	0	**5**
Birch Point South	2	0	1	0	**3**
Semiahmoo Uplands	3	2	0	0	**5**
Rogers Slough Upper Trib.	0	0	0	0	**0**
Rogers Slough Lower Trib.	2	5	1	0	**8**
Terrell Creek Urban Area					
Terrell Creek Upper Trib. 1	3	1	2	1	**7**
Terrell Creek Estuarine Reach	0	0	1	1	**2**
Terrell Creek Urban Area North	2	1	1	0	**4**
Point Whitehorn					
Point Whitehorn South	0	0	1	0	**1**
Point Whitehorn Uplands	0	0	0	0	**0**
Point Whitehorn	5	7	6	1	**19**
Total	**19**	**17**	**15**	**3**	**54**

The subbasins with the largest number of identified problems are Point Whitehorn, Rogers Slough Lower Tributary, and Terrell Creek Urban Area North. Drainage problems make up nearly 75 percent of the total problems, and of those, 75 percent are public responsibility and 25 percent are private facilities or split between public and private responsibility. A detailed summary of the problems evaluated for this plan is provided in the sections that follow.

Birch Point Subwatershed

Table 4-2 provides details on each problem identified within the Birch Point Subwatershed. Figures 4-5A through 4-5E show the problem locations.

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE BIRCH POINT SUBWATERSHED

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
BP-1	ACM	Hogan Drive	Storm Event	Public / Private	Drainage: Conveyance
Description: Outfall and upstream roadside drainage ditch are private property and not maintained by County. Property owner installed outfall pipe, however, the pipe does not adequately capture and convey receiving stormwater. High velocity may be scouring ditches and contributing to reduced conveyance capacity. A drainage easement at one property is required to fully resolve this problem.					
BP-2	ID 2014-07, CDM, HH Analysis, ACM	Semiahmoo Drive near Normar Place	Storm Event	Public / Private	Drainage: Conveyance
Description: Culvert crossing under Semiahmoo Drive is undersized and causing roadway flooding during the 2-year and larger storm event under existing and future conditions. A flume conveys stormwater from Semiahmoo Drive to Normar Place (private) and overflows during the 25-year and larger storm event for existing and future conditions. High flow velocity in the roadside ditches is causing scour, sediment is transported to the downstream catch basin and obstructs flow.					
BP-3	ID 2014-02	Oertel Drive	Storm Event	Private	Maintenance
Description: Drainage ditch on upstream private property is blocked with fill and causing erosion and flooding on Oertel Drive and flooding on adjacent private property. The property owner blocked the drainage ditch and agreed to remove blockage but has not done that yet.					
BP-4	County	Oertel Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: Missing grout around pipe ends in catch basin (2759). Catch basin sump is filled with sediment. Catch basin appears to be receding into ground.					
BP-5	ID 2010-22, HH Analysis	Semiahmoo Drive North of Pointe Road	Storm Event	Public	Drainage: Conveyance
Description: Driveway culverts and roadside ditches on the east side of Semiahmoo Drive have insufficient capacity and overflow during the 25-year and larger future conditions storm event.					
BP-6	CDM, HH Analysis	Semiahmoo Drive near Birch Point Road	Storm Event	Public	Drainage: Conveyance
Description: Ditches and driveway culverts on the east side of Semiahmoo Drive overflow during the 25-year and larger existing conditions storm event and the 2-year and larger future conditions storm event.					
BP-7	County	Birch Point Road near Semiahmoo Drive	Chronic	Public	Maintenance

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE BIRCH POINT SUBWATERSHED

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
Description: Ditch conveying stormwater to Birch Bay has not been maintained.					
BP-8	HH Analysis	Birch Point Road east of Paton Avenue	Storm Event	Public	Drainage: Conveyance
Description: Driveway culverts and roadside ditches along Birch Point Road are undersized and flooding for the 25-year and larger storm existing conditions storm event and 25-year and larger future conditions storm event.					
BP-9	Inventory	Birch Point Road east of Paton Avenue	Storm Event	Public / Private	Drainage: Conveyance
Description: High flow velocity is causing erosion at the outlet of both driveway culverts on the south side of Birch Point Road adjacent to the private driveway.					
BP-10	County	Private Drive Extended	Chronic	Public / Private	Drainage: Failing Infrastructure
Description: High flows in the CMP flume conveying stormwater from the roadside ditch to Birch Bay have overtopped the flume and scoured the bluff under the flume. The flume has collapsed due to the scouring and is no longer functioning.					
BP-11	County, HH Analysis	Birch Point Road west of Bay Ridge Road	Storm Event	Private	Drainage: Conveyance
Description: High flow velocity (greater than 10 feet per second) is causing channel erosion in the watercourse in Birch Bay Village downstream of Birch Point Road.					
BP-12	Inventory	Bayvue Road west of Selder Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Large cracks in catch basin (2723) allow sediment to fill structure.					
BP-13	Inventory	Sunrise Way near Hillvue Road	Chronic	Public	Drainage: Failing Infrastructure
Description: Crushed pipe end at culvert outlet.					
BP-14	Inventory	Hillvue Road at Watervue Way	Chronic	Public	Maintenance
Description: Missing grout around pipe ends in catch basin (2726). Catch basin sump is filled with sediment.					
BP-15	Inventory, HH Analysis	Selder Road at Skyvue Road	Storm Event	Public	Drainage: Conveyance
Description: Roadway flooding predicted at multiple of driveway culverts on the west side of Selder Road. Flooding predicted for the 25-year and larger existing conditions event and the 2-year and larger future conditions event. Scour caused by high flow velocity in the roadside ditches occurs at multiple locations.					

TABLE 4-2.
DRAINAGE RELATED PROBLEMS IN THE BIRCH POINT SUBWATERSHED

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
BP-16	County	4 Cul-de-sacs adjacent to Seavue Road	Storm Event	Public	Drainage: Failing Infrastructure
Description: Roadside ditch-and-culvert system in cul-de-sacs adjacent to Seavue Road has been partially filled and no longer able to collect stormwater runoff.					
BP-17	County	4 Cul-de-sacs adjacent to Hillvue Road	Storm Event	Public	Drainage: Failing Infrastructure
Description: Roadside ditch-and-culvert system in cul-de-sacs adjacent to Hillvue Road has been partially filled and no longer able to collect stormwater runoff.					
BP-18	County	4 Cul-de-sacs adjacent to Skyvue Road	Storm Event	Public	Drainage: Failing Infrastructure
Description: Roadside ditch-and-culvert system in cul-de-sacs adjacent to Skyvue Road has been partially filled and no longer able to collect stormwater runoff.					
BP-19	County	W. Shoreview near Birch Point Road	Storm Event	Private	Drainage: Conveyance
Description: Stormwater runoff from upland areas and a cutoff ditch discharges to the private storm drain system on W. Shoreview. The Shoreview storm drain system has insufficient capacity so ponding occurs at the intersection of Shoreview and Bay Ridge Drive.					
BP-20	WDFW	Birch Point Road west of Bay Ridge Road	Chronic	Public	Drainage: Failing Infrastructure
Description: The drop at the culvert outlet is greater than 1 foot, which impedes fish passage (WDFW, 2016).					
BP-21	County, ID 2013-05	East of Semiahmoo Drive near Charel	Chronic	Private	Maintenance
Description: Modifications to an upland stormwater pond has diverted flow from the Semiahmoo Drive drainage system through DNR property into Charel Terrace. The diversion may overwhelm the newly reconstructed Charel Drainage system.					

a. See Figures 4-5 for problem locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ACM = Advisory Committee Meeting, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, CDM = Conceptual Design Memorandum, HH Analysis = Hydrologic and Hydraulic Analysis, BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff, WDFW = Washington State Department of Fish and Wildlife (2016)

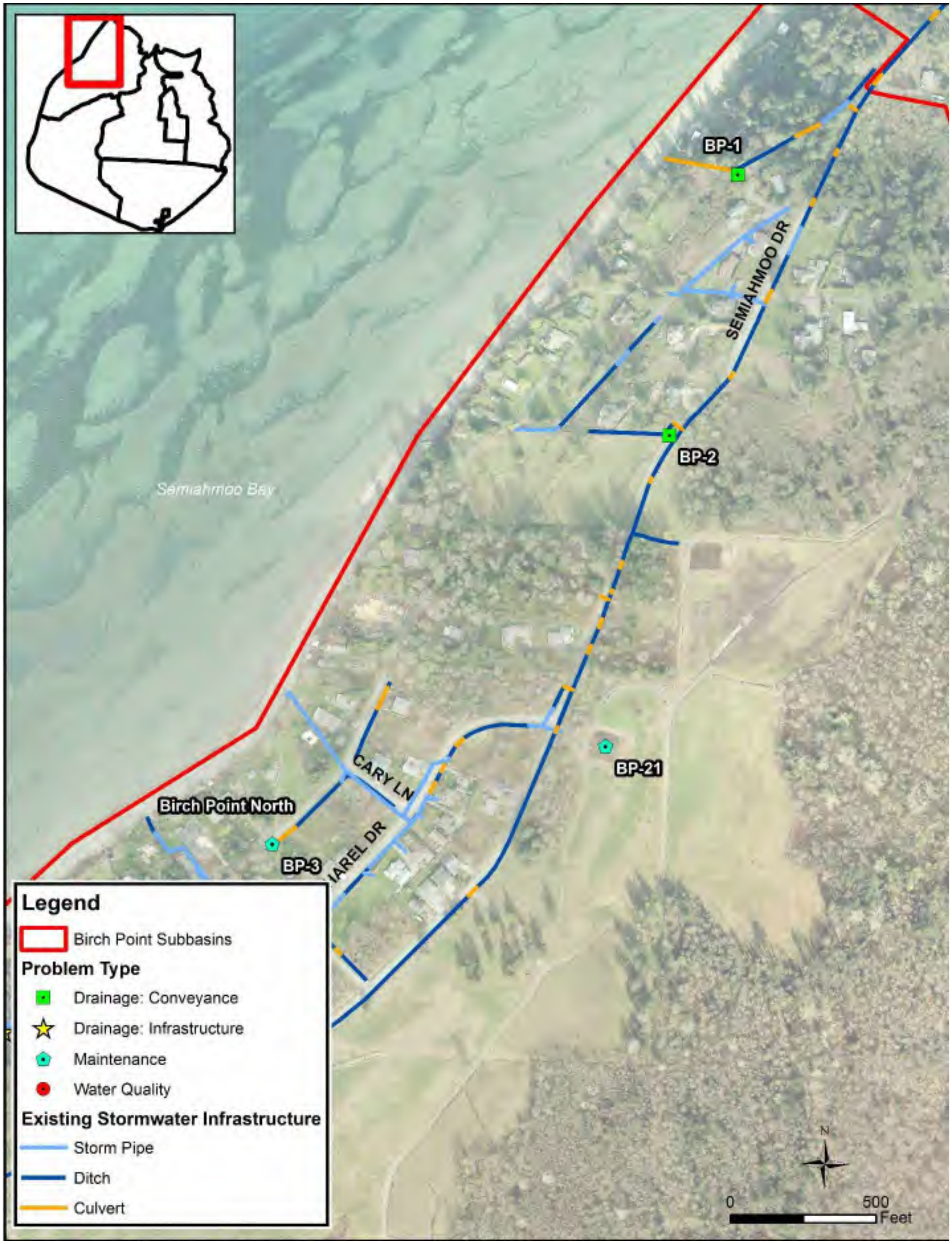

Figure 4-5A. Identified Problem Areas in the Birch Point Subwatershed

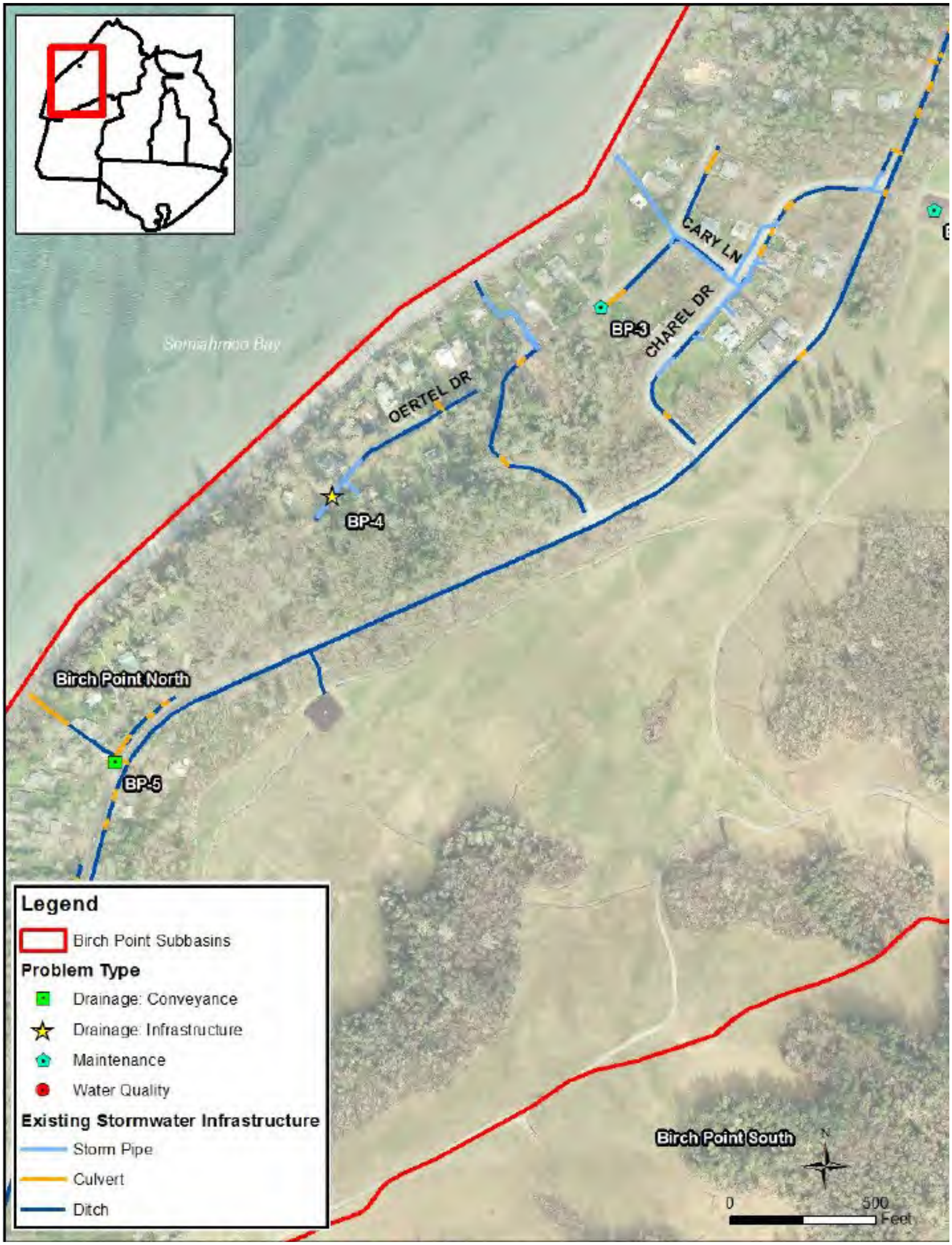

Figure 4-5B. Identified Problem Areas in the Birch Point Subwatershed

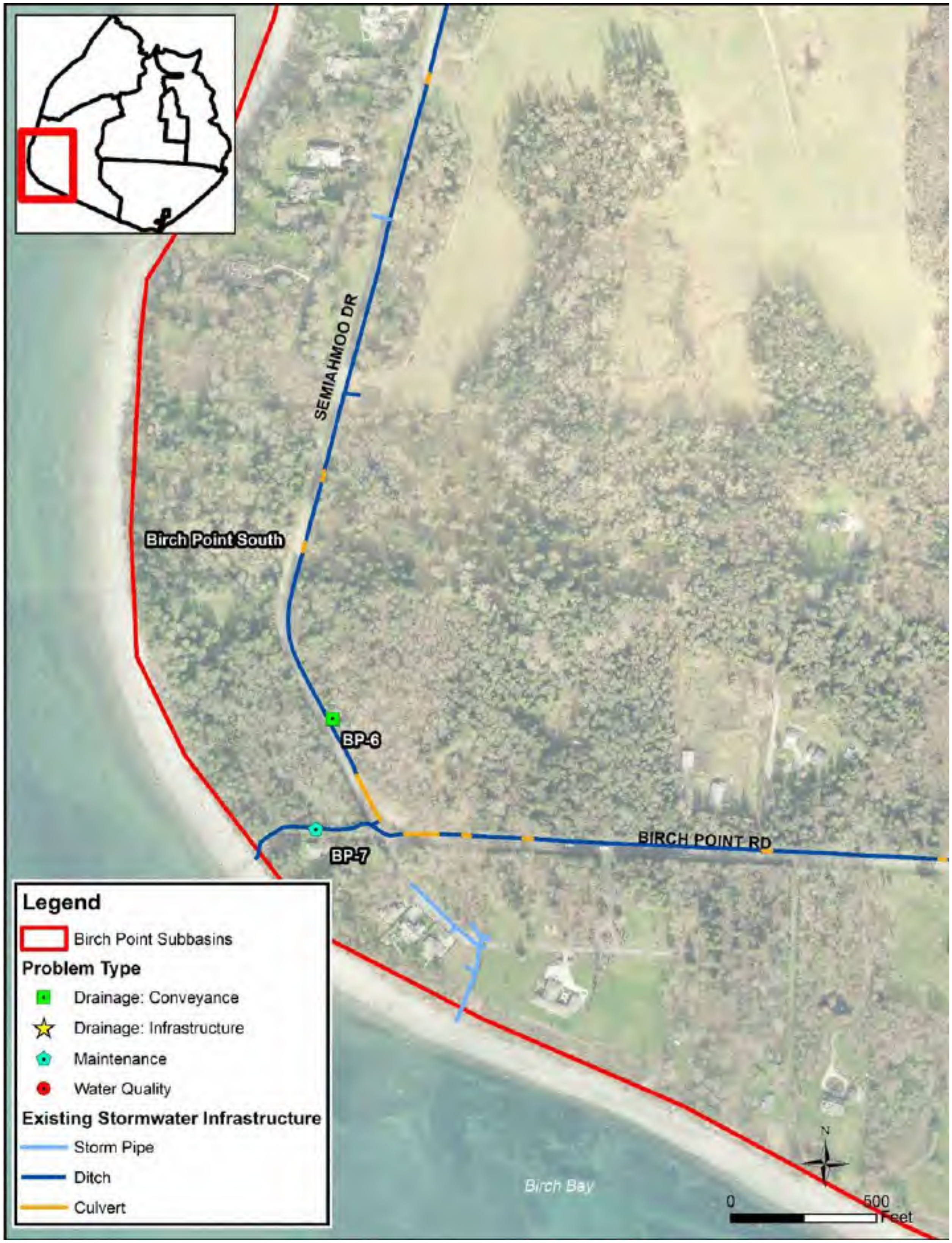

Figure 4-5C. Identified Problem Areas in the Birch Point Subwatershed

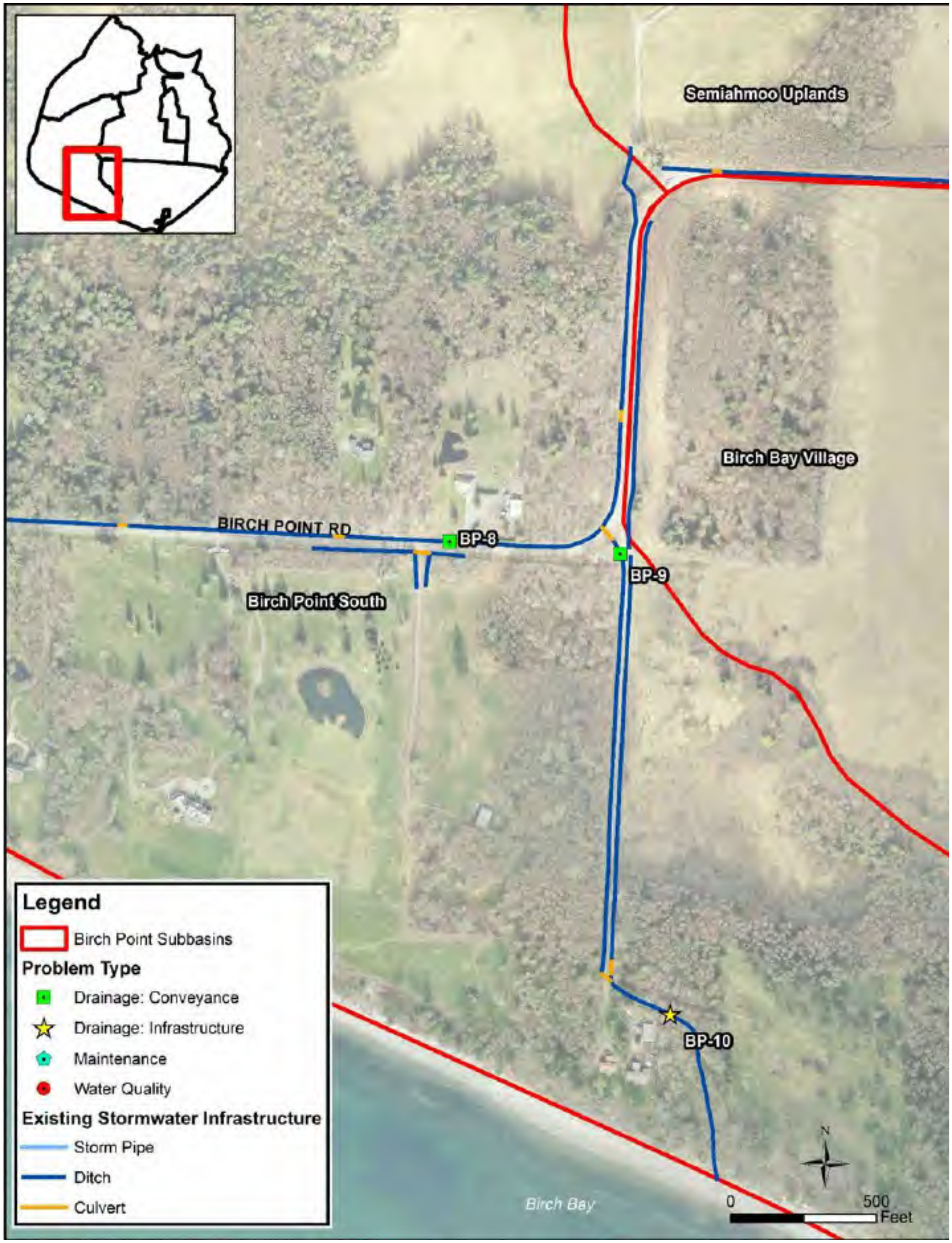

Figure 4-5D. Identified Problem Areas in the Birch Point Subwatershed

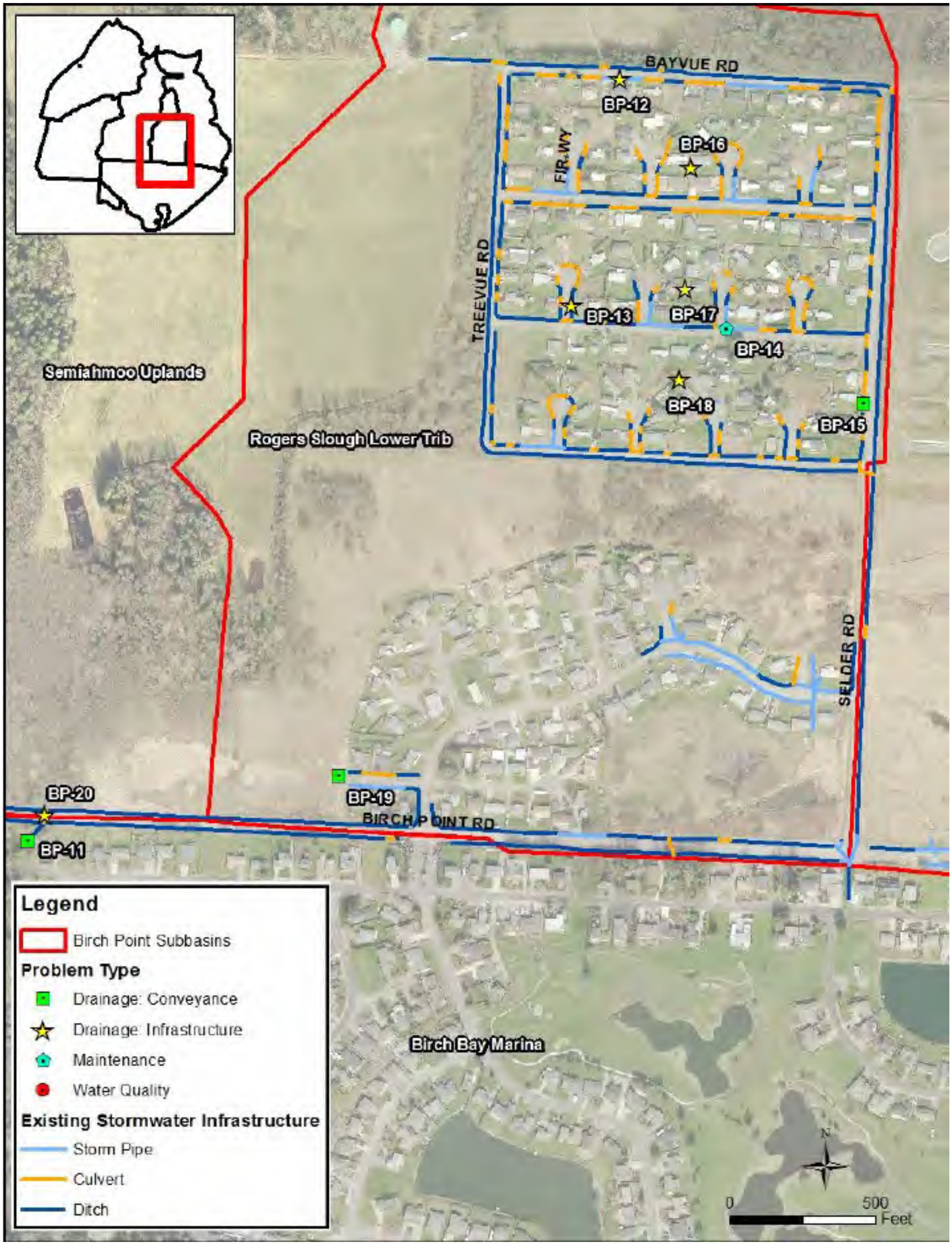

Figure 4-5E. Identified Problem Areas in the Birch Point Subwatershed

Terrell Creek Urban Area Subwatershed

Table 4-3 provides details on each problem identified within the Terrell Creek Urban Area Subwatershed. Figure 4-6 shows the problem locations.

TABLE 4-3.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK URBAN AREA SUBWATERSHED

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC-1	ID 2013-03, HH Analysis	Bay Road at Jackson Road	Storm Event / Chronic	Public	Drainage: Conveyance
Description: Hydraulic analysis predicted flooding during 25-year and larger storm events. High flow depth along Birch Bay Drive causes a backwater condition at the culvert outlet and contributes to reduced pipe capacity.					
TC-2	County	Highland Drive south of Elaine Street	Chronic	Public	Maintenance
Description: Catch basin (2547) interior walls missing grout around pipe connections. Catch basin sump is full of sediment.					
TC-3	County	7459 Sunset Drive	Chronic	Public / Private	Maintenance
Description: New driveway installation paved over catch basin (2671) preventing access.					
TC-4	HH Analysis, Retrofit Report	Sunset Drive and Key Street	Storm Event	Public	Drainage: Conveyance
Description: Hydraulic analysis predicted roadway flooding during 25-year and larger storm events starting at Key Street at Jackson Road and extending upstream along Sunset Drive.					
TC-5	Retrofit Report	Jackson Road north of Sunset Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: CMP outfall to Terrell Creek is broken and unsupported.					
TC-6	County	Bay Road east of Halibut Drive	Chronic	Public	Drainage: Failing Infrastructure
Description: Culvert is deteriorating. West end of culvert is damaged and ties into home-made catch basin.					
TC-7	CDM, Retrofit Report, BBCSP	Wooldridge Avenue north of Jackson Road	Chronic	Public	Drainage: Conveyance
Description: Street and private property flooding has been reported along Wooldridge Avenue during the 2-year and larger storm event. Roadside ditch system is undersized and not well defined. Operation of storm drain system also affected by high tide in Terrell Creek.					
TC-8	ID 2010-12	Terrell Creek below Highland Drive	Storm Event	Private	Water Quality
Description: Turbid water entering Terrell Creek from Highland Drive 18-inch diameter outfall. Source believed to be untreated surface runoff from upstream Beachwood Resort.					

**TABLE 4-3.
DRAINAGE RELATED PROBLEMS IN THE TERRELL CREEK URBAN AREA SUBWATERSHED**

ID[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
TC-9	County	Bay Crest Phase 1A Pond, Bay Road Near Jackson Road	Chronic	Private	Maintenance
Description: Bay Crest Phase 1A detention pond is not draining properly.					
TC-10	County	Bay Crest Phase 1A Pond, Bay Road Near Jackson Road	Chronic	Private	Maintenance
Description: Control structure catch basin lid misaligned with overflow structure.					
TC-11	BB/TC WQMP	Terrell Creek at Jackson Road	Chronic	Public	Water Quality
Description: Fecal coliform exceeds water quality standards for Birch Bay watershed at site TribTerBC1.					
TC-12	CDM, Retrofit Report	Jackson Road north of Key Street	Chronic	Public	Drainage: Conveyance
Description: Street and private property flooding has been reported along Jackson Road due to a non-functioning storm drain system. Roadside ditches have been filled.					
TC-13	CDM, Retrofit Report	Sunset Drive south of Broadway Drive	Chronic	Public	Drainage: Conveyance
Description: There are no storm drains on the west side of the street so stormwater runoff from properties on this side of the street is directed overland to Wooldridge Avenue.					

a. See Figure 4-6 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ACM = Advisory Committee Meeting, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, CDM = Conceptual Design Memorandum, HH Analysis = Hydrologic and Hydraulic Analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff, Retrofit Report = *Birch Bay Stormwater Retrofit Predesign, Part 4 – Wooldridge Avenue Predesign Report* (Tetra Tech, 2014)

Point Whitehorn Subwatershed

Table 4-4 provides details on each problem identified with the Point Whitehorn Subwatershed. Figure 4-7 shows the problem locations.

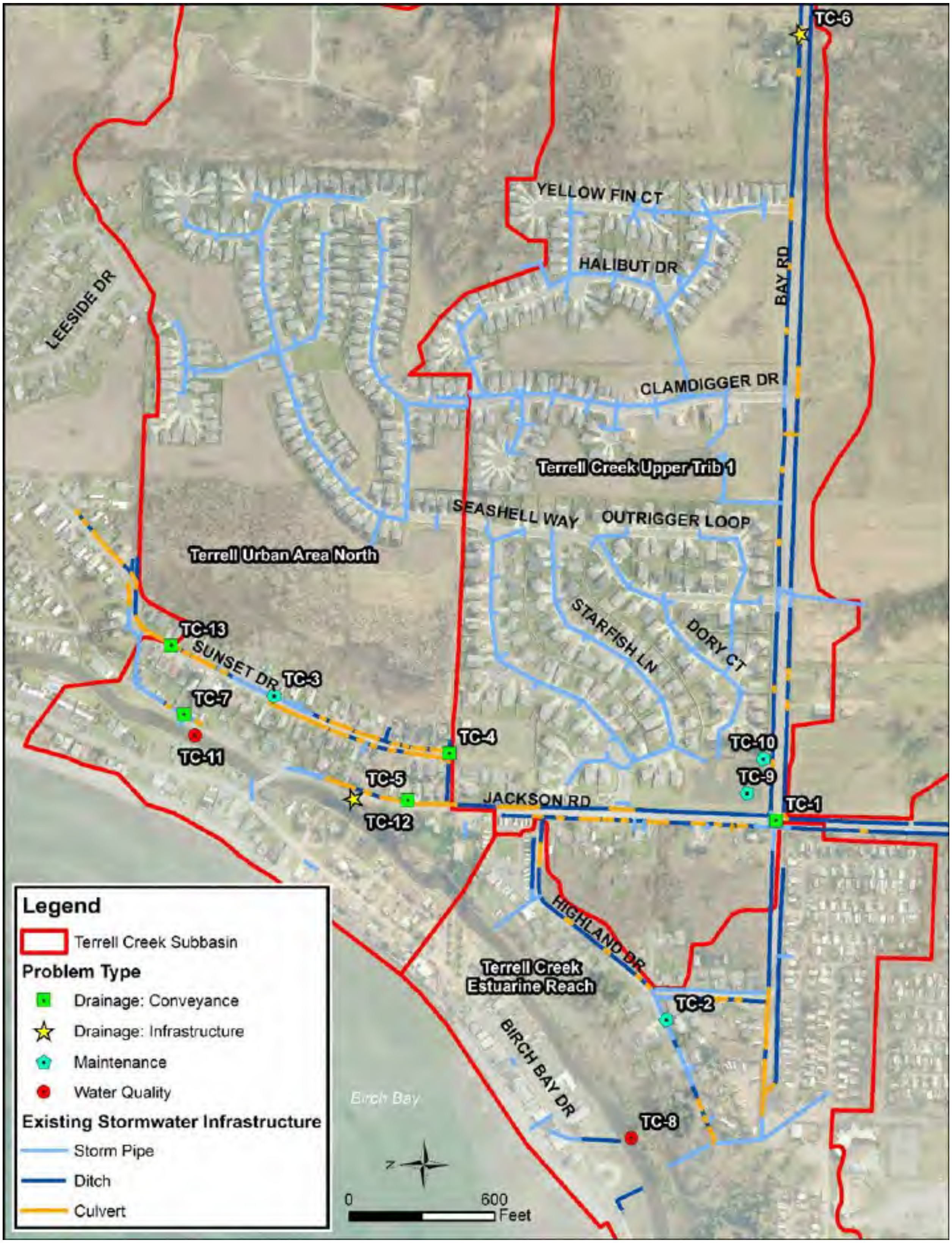

Figure 4-6. Identified Problem Areas in the Terrell Creek Urban Area Subwatershed

<table>
<tr><th colspan="6">TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE POINT WHITEHORN SUBWATERSHED</th></tr>
<tr><th>Id[a]</th><th>Source[b]</th><th>General Location</th><th>Frequency</th><th>Responsibility</th><th>Problem Type</th></tr>
<tr><td>PW-1</td><td>ID 2013-09, County</td><td>Holeman Ave. w of Birch Bay Dr.</td><td>Chronic</td><td>Public</td><td>Maintenance</td></tr>
<tr><td colspan="6">Description: Roadside ditches along Holeman Avenue are obstructed. Standing water in ditches overtops roads during storm events.</td></tr>
<tr><td>PW-2</td><td>County</td><td>6926 Holeman Avenue</td><td>Chronic</td><td>Public</td><td>Drainage: Failing Infrastructure</td></tr>
<tr><td colspan="6">Description: Ground has settled around catch basin (2716) so that rim is higher than ground and runoff is unable to enter the structure. Inlet pipe is at an adverse slope. Grout is missing at both the inlet and outlet connections. Catch basin sump is full of sediment.</td></tr>
<tr><td>PW-3</td><td>ID 2010-17</td><td>6933 Holeman Avenue</td><td>Chronic</td><td>Public</td><td>Drainage: Conveyance</td></tr>
<tr><td colspan="6">Description: Surface water isn’t draining properly into catch basin (2717). Requires road repair in addition to drainage improvements. Additional catch basin requested by adjacent property owner.</td></tr>
<tr><td>PW-4</td><td>ID 2013-09</td><td>Holeman Avenue</td><td>Single Occurrence</td><td>Public / Private</td><td>Water Quality</td></tr>
<tr><td colspan="6">Description: Swimming pool reported to have been drained to storm drain system.</td></tr>
<tr><td>PW-5</td><td>County</td><td>5620 Whitehorn Way</td><td>Chronic</td><td>Public</td><td>Maintenance</td></tr>
<tr><td colspan="6">Description: Catch basin (2705) missing grout at inlet and outlet connections. CB sump full of sediment.</td></tr>
<tr><td>PW-6</td><td>County</td><td>6976 Petticote Lane</td><td>Chronic</td><td>Public</td><td>Maintenance</td></tr>
<tr><td colspan="6">Description: Catch basin (2722) missing grout at all connections.</td></tr>
<tr><td>PW-7</td><td>County</td><td>Birch Bay Drive at Jill Street</td><td>Chronic</td><td>Public</td><td>Maintenance</td></tr>
<tr><td colspan="6">Description: Catch basin (2897) missing grout at outlet pipe connection. Frame and grate is not attached to catch basin structure. Catch basin sump is full of sediment.</td></tr>
<tr><td>PW-8</td><td>County</td><td>Birch Bay Drive at Point Whitehorn Way</td><td>Chronic</td><td>Public</td><td>Maintenance</td></tr>
<tr><td colspan="6">Description: Catch basin (2903) frame not attached to the structure. Catch basin sump is full of sediment.</td></tr>
<tr><td>PW-9</td><td>HH Analysis</td><td>6914 Holeman Avenue</td><td>Storm Event</td><td>Public</td><td>Drainage: Conveyance</td></tr>
<tr><td colspan="6">Description: Hydraulic analysis predicted roadway flooding during the 25-year and larger storm event.</td></tr>
<tr><td>PW-10</td><td>HH Analysis</td><td>6972 Petticote Lane near 6964 Petticote Lane</td><td>Storm Event</td><td>Public</td><td>Drainage: Conveyance</td></tr>
<tr><td colspan="6">Description: Hydraulic analysis predicted roadway flooding during the 25-year and larger storm event.</td></tr>
<tr><td>PW-11</td><td>HH Analysis</td><td>Birch Bay Drive between Holeman Avenue and Jill Street</td><td>Storm Event</td><td>Public</td><td>Drainage: Conveyance</td></tr>
<tr><td colspan="6">Description: Hydraulic analysis predicted roadway flooding during the 25-year and larger storm event.</td></tr>
<tr><td>PW-12</td><td>County, ID 2010-08, ID 2012-03</td><td>Birch Bay Drive near Jill Street</td><td>Chronic</td><td>Public</td><td>Drainage: Failing Infrastructure</td></tr>
<tr><td colspan="6">Description: Outfall is a metal pipe in poor condition and should be replaced before it fails. The bottom of the pipe is rusted out and he overflow is causing beach and bluff erosion..</td></tr>
</table>

TABLE 4-4.
DRAINAGE RELATED PROBLEMS IN THE POINT WHITEHORN SUBWATERSHED

Id[a]	Source[b]	General Location	Frequency	Responsibility	Problem Type
PW-13	County	Holeman Ave. s of Birch Bay Dr.	Chronic	Public	Maintenance
Description: Standing water observed at upstream catch basin (2718). County stormwater inventory suggests that pipe is likely in poor condition.					
PW-14	County	Helweg Lane s of Birch Bay Dr.	Chronic	Public	Drainage: Failing Infrastructure
Description: Culvert has crushed downstream pipe end and is 25% full of sediment.					
PW-15	HH Analysis	Birch Bay Drive between Jill Street and Point Whitehorn Road	Chronic	Public	Drainage: Conveyance
Description: Hydraulic analysis predicted roadway flooding during the 25-year storm event.					
PW-16	ID 2013-09, County	Whitehorn Way west of Birch Bay Drive	Chronic	Public	Maintenance
Description: Roadside ditches along Whitehorn Way are obstructed and need to be cleaned. Standing water in ditches overtops roads during large storm events.					
PW-17	ID 2013-09	Bluff North of Holeman Avenue	Storm Event	Public	Drainage: Failing Infrastructure
Description: Landslides and bluff erosion occurs due to high groundwater during large storm events.					
PW-18	County	Whitehorn Way Cul-de-sac (RD#22380)	Chronic	Public	Drainage: Failing Infrastructure
Description: Private storm drain systems appears to be connected to the perforated underdrain pipe system instead of the storm drain system. Roadway drainage system could not be located and may not have been installed when the road was constructed.					
PW-19	ID 2015-13	Birch Bay Drive near Holeman Avenue	Chronic	Private	Drainage: Failing Infrastructure
Description: Area on south property line along Birch Bay Drive is settling receding into ground possibly due to abandoned pipe in vicinity or slope movement.					
PW-20	County	Kohen Road near Maple Drive	Chronic	Public / Private	Maintenance
Description: Outfall is located on private property, but collects County runoff. Debris has collected on top of pipe and the tide is contributing to both erosion and debris obstruction and the base.					

a. See Figure 4-7 for locations.
b. Inventory = Whatcom County Stormwater Infrastructure Geodatabase, ACM= Advisory Committee Meeting, ID = Incident Database, BBCSP = Birch Bay Comprehensive Stormwater Plan, CDM = Conceptual Design Memorandum, HH Analysis = Hydrologic and Hydraulic Analysis), BB/TC WQMP = Birch Bay/Terrell Creek Water Quality Monitoring Project, County = County Staff

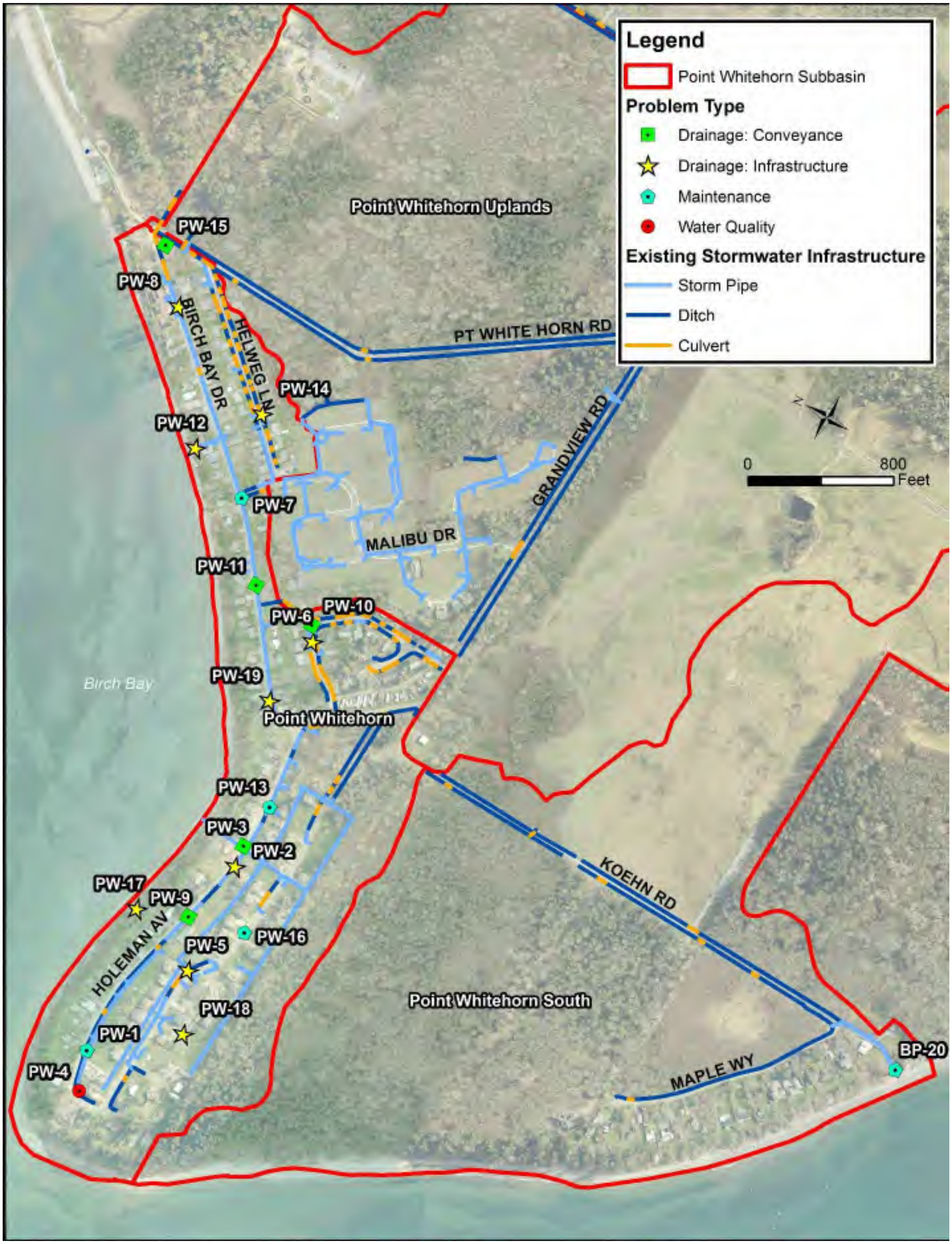

Figure 4-7. Identified Problem Areas in the Point Whitehorn Subwatershed

CHAPTER 5.
PROBLEM RESOLUTION

Each problem documented in Chapter 4 was evaluated and a determination was made about the manner in which each should be addressed:

- Some problems are not addressed in this plan because they have already been addressed or are outside the jurisdiction of BBWARM District and the County.
- Some problems are not addressed in this plan because their causes and solutions are beyond the scope of the subwatershed planning process but are proposed to be addressed by special studies subsequent to this master plan.
- Some problems are best addressed through operation and maintenance practices.
- Some problems are best addressed by a small works project.
- The remaining problems require a capital improvement project (CIP).

Problem disposition in each subwatershed is shown in Figures 5-1A through 5-1C. Details are provided in the following sections.

PROBLEMS NOT ADDRESSED IN THE PLAN

Eight problems were not addressed in the plan. The investigation found that some drainage problems were resolved with an earlier project or activity. Other problems are private issues, outside the jurisdiction of the County or the BBWARM District. Private property problems not addressed in the plan are usually due to flooding from adjacent properties or occur in privately-owned drainage systems. Table 5-1 lists the problems not addressed in the master plan.

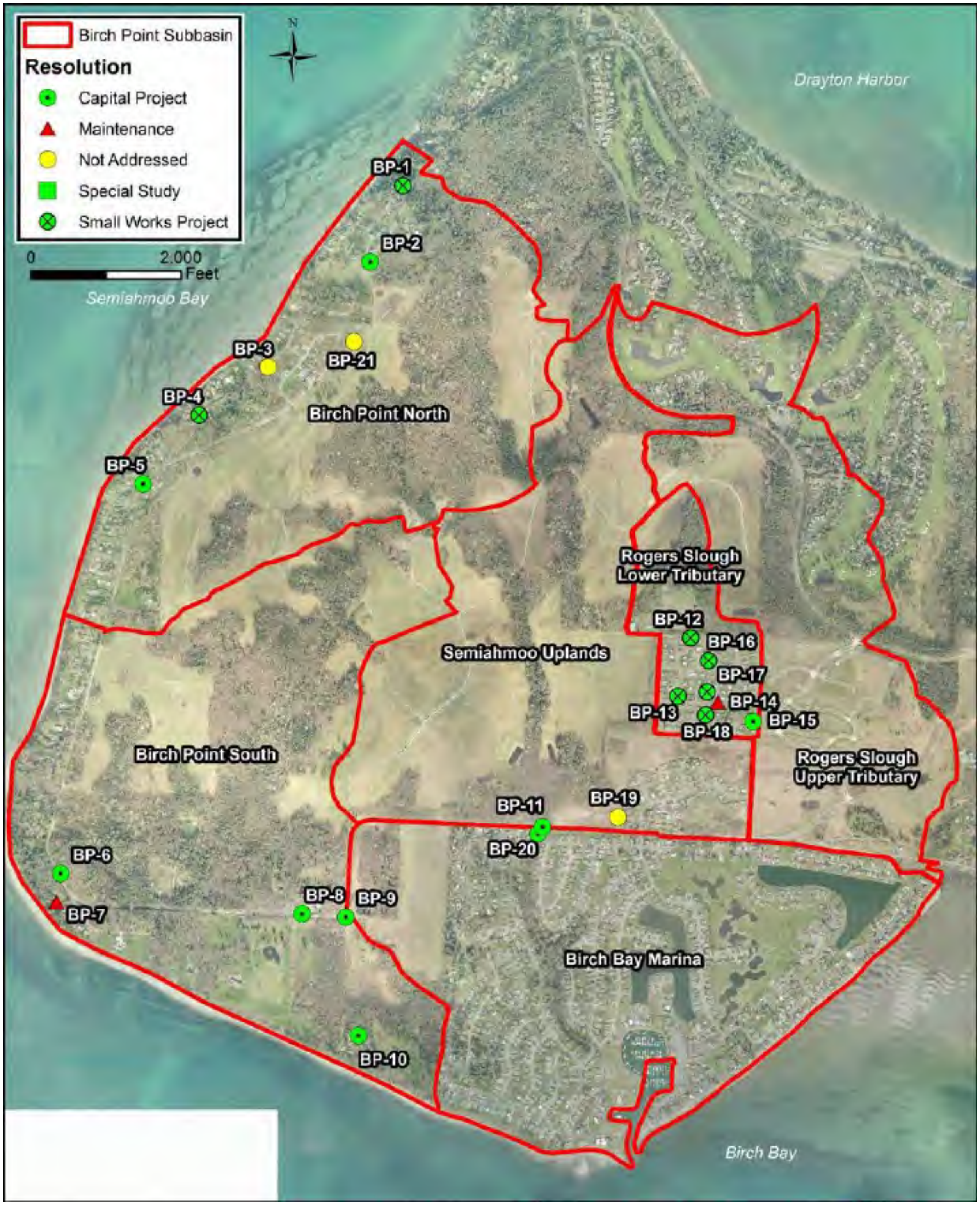

Figure 5-1A. Problem Disposition in the Birch Point Subwatershed

Figure 5-1B. Problem Disposition in the Terrell Creek Urban Subwatershed

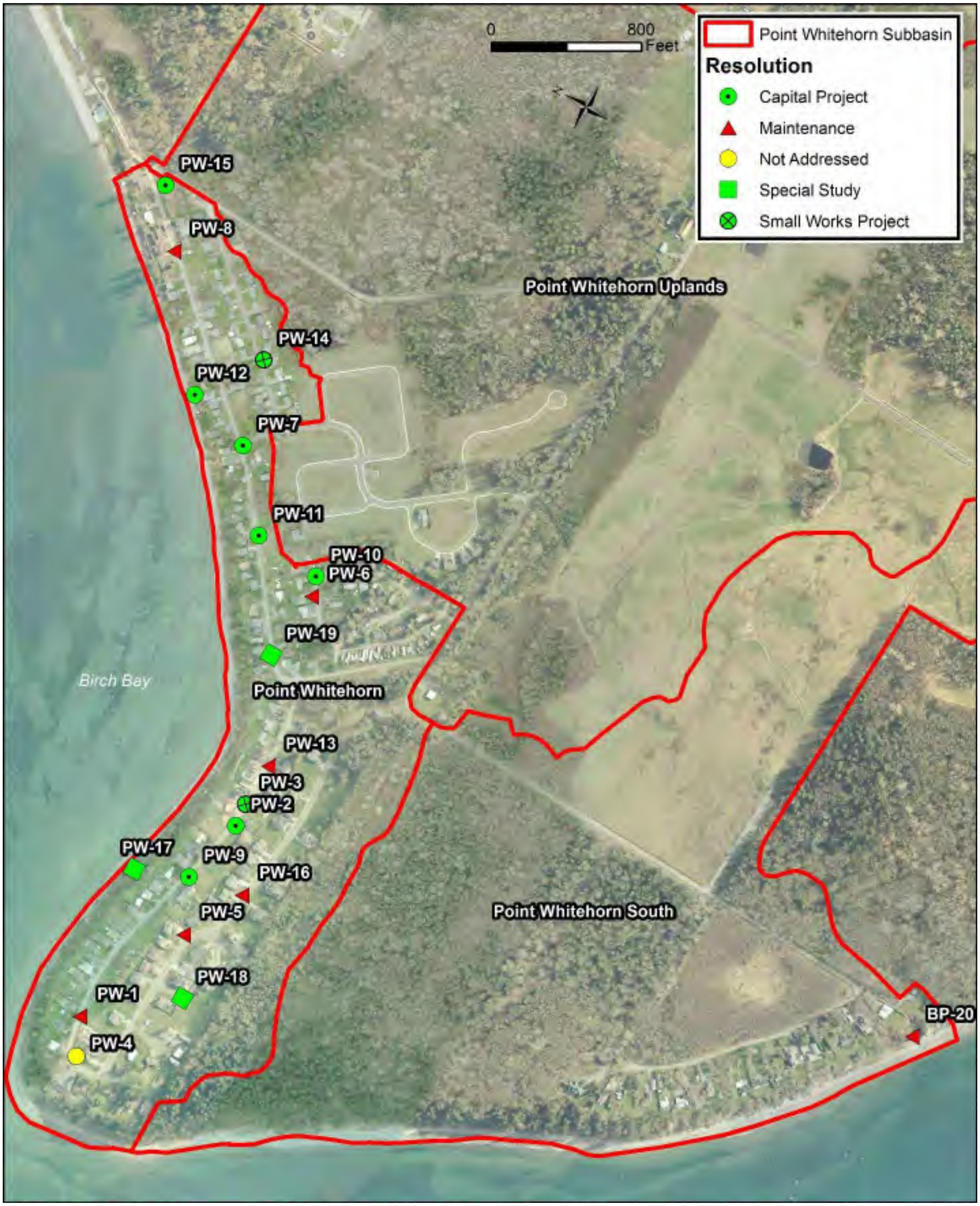

Figure 5-1C. Problem Disposition in the Point Whitehorn Subwatershed

TABLE 5-1.
PROBLEMS NOT ADDRESSED IN THE PLAN

Problem ID [a]	Problem Description	Problem Resolution
Birch Point Subwatershed		
BP-1	Privately installed outfall pipe is not collecting water and draining the ditch properly. High flow velocity is contributing to erosion in upstream roadside ditch.	Private property issue. County should work with property owner to resolve problem.
BP-3	Drainage ditch on upstream private property is blocked with fill and causing erosion and flooding on Oertel Drive and flooding on adjacent private property.	Private property issue. Contact property owner to remove blockage.
BP-11	High flow velocity is causing erosion in the roadside ditch at the driveway culvert on the south side of Birch Point Road adjacent to the private driveway.	Private property issue. County should work with upstream property owners and Birch Bay Village to resolve problem.
BP-19	The West Shoreview storm drain system has insufficient capacity so ponding occurs at the intersection of Shoreview and Bay Ridge Drive.	Private property issue. Install culvert at West Shoreview to direct inflow toward the drainage ditch parallel to Birch Point Road.
BP-21	Water has been diverted from the stormwater pond that outlets across Semiahmoo Drive into the Charel Terrace Subdivision. The diversion may overwhelm the newly reconstructed Charel Drainage system.	Remove diversion and restore original drainage pathway.
Terrell Creek Urban Area Subwatershed		
TC-9	Bay Crest Phase 1A pond is not draining properly.	Private property issue. Investigate pond performance compared to design condition.
TC-10	Control structure catch basin lid misaligned with overflow structure.	Private property issue. Align catch basin lid.
Point Whitehorn Subwatershed		
PW-4	Swimming pool drained to storm drain system.	One time occurrence. No action necessary.
PW-19	Area on south property line along Birch Bay Drive is receding into ground.	Investigate problem further and determine problem ownership and resolution.

a. See Figure 5-1.

SPECIAL STUDY AREAS

Special studies are recommended for problems whose solution requires resources beyond what is available in the master plan. These problems require targeted effort to more precisely determine the source of the problem and to identify potential solutions. The groundwater seepage and underdrain connections reported in the Holeman Avenue and Whitehorn Way area (PW-17 and PW-18) are examples of this type of problem. Studies underway by others, such as Whatcom County's Birch Bay/Terrell Creek Water Quality Monitoring Project, also fall into the category of a special study recommendation. Special studies are recommended to resolve five problems (Table 5-2).

TABLE 5-2.
SPECIAL STUDY RECOMMENDATIONS

Problem ID [a]	Problem Description	Problem Resolution
Terrell Creek Urban Area Subwatershed		
TC-8	Turbid water entering Terrell Creek from storm drain (GM3604).	Refer to NPDES Illicit Discharge and Elimination Program for further investigation.
TC-11	Fecal coliform exceeds water quality standards at water quality monitoring sites.	Whatcom County's Birch Bay / Terrell Creek Water Quality Monitoring project is currently providing a comprehensive water quality study for these outfalls.
Point Whitehorn Subwatershed		
PW-17;	Landslides and bluff erosion occurs due to high groundwater during large storm events.	Geotechnical study is needed to characterize the soil profile, groundwater flow patterns and the potential for infiltration. Underdrain and storm drain system should also be evaluated to determine if there is a surface connection to the underdrain system.
PW-18	Private storm drain systems appear to be connected to the perforated underdrain pipe instead of the storm drain system. Storm drain pipe may not have been installed.	
PW-19	Area on south property line along Birch Bay Drive is receding into ground.	

a. See Figure 5-1.

OPERATION AND MAINTENANCE

Nine problems were attributed to the need for increased maintenance. The recommendation for increased maintenance is extended to all Birch Bay outfalls. Other maintenance problems are related to sediment buildup in roadway culverts and pipelines, which interferes with conveyance. Table 5-3 documents maintenance needs.

SMALL WORKS PROJECTS

Small works projects are those that can be constructed at relatively low cost and can be quickly planned and designed. Small works projects have the following characteristics:

- Low or minimal complexity
- Low cost (less than $20,000)
- Easy to permit (e.g. only Whatcom County permits needed)
- Can be designed in-house by Whatcom County staff
- May be coordinated with other larger projects
- Are emergency actions needed to protect life and public safety

Eleven problems can be addressed as small works projects and are listed in Table 5-4. Groups of these projects can be aggregated into a single larger project to take advantage of economies of scale or each can be completed singly as County crews become available to implement the project. An annual budget of $50,000 is recommended to address small works projects.

TABLE 5-3.
MAINTENANCE NEEDS

Problem ID [a]	Problem Description	Problem Resolution
Birch Point Subwatershed		
BP-7	Ditch conveying stormwater to Birch Bay has not been maintained.	Investigate ditch condition, clean if necessary.
BP-14	Missing grout around pipe ends in catch basin (2726). Catch basin sump is filled with sediment.	Repair grout and remove sediment from structure.
Terrell Creek Urban Area Subwatershed		
TC-2	Catch basin (2547) interior walls missing grout around pipe connections. Catch basin sump is filled with sediment.	Repair grout and remove sediment from structure.
Point Whitehorn Subwatershed		
PW-1	Roadside ditches along Holeman Avenue are obstructed. Standing water in ditches overtops roads during storm events.	Investigate and remove sediment from ditches.
PW-5	Catch basin (2705) missing grout at both inlet and outlet connections. Catch basin sump is filled with sediment.	Repair grout and remove sediment from structure.
PW-6	Catch basin (2722) missing grout at all connections.	Repair grout and remove sediment from structure.
PW-8	Catch basin (2903) frame and grate not attached to the structure. Catch basin sump is filled with sediment.	Repair grout and remove sediment from structure.
PW-13	Standing water observed at upstream catch basin (2718). County stormwater inventory suggests that pipe is likely in poor condition.	Repair grout and remove sediment from structure.
PW-16	Roadside ditches along Whitehorn Way are obstructed with sediment.	Clean ditches to restore conveyance capacity.
BP-20	Outfall is located on private property, but collects County runoff. Debris has collected on top of pipe and the tide is contributing to both erosion and debris obstruction and the base.	Investigate condition and clean / repair as needed.

a. See Figure 5-1.

TABLE 5-4.
SMALL WORKS PROJECTS

Problem Id[a]	Problem Description	Problem Resolution	Cost
Birch Point Subwatershed			
BP-4	Missing grout around pipe ends in catch basin (2759). Catch basin sump is filled with sediment. Catch basin appears to be receding into ground.	Replace catch basin structure.	$7,000
BP-12	Large cracks in catch basin (2723) allow sediment to fill structure.	Replace catch basin structure.	$7,000
BP-16	Roadside ditch-and-culvert system in cul-de-sacs adjacent to Seavue Road has been partially filled and no longer able to collect stormwater runoff.	Clean roadside ditches and install driveway culverts as needed.	$20,000
BP-13; BP-17	Roadside ditch-and-culvert system in cul-de-sacs adjacent to Hillvue Road has been partially filled and no longer able to collect stormwater runoff.	Clean roadside ditches and install driveway culverts as needed.	$20,000
BP-18	Roadside ditch-and-culvert system in cul-de-sacs adjacent to Skyvue Road has been partially filled and no longer able to collect stormwater runoff.	Clean roadside ditches and install driveway culverts as needed.	$20,000
Terrell Creek Urban Area Subwatershed			
TC-3	Catch basin (2671) has been paved over by new driveway installation preventing access.	Remove and repair pavement surrounding CB 2761.	$2,000
TC-6	West end of culvert (C763) is damaged and ties into home-made catch basin.	Replace culvert C763.	$7,000
Point Whitehorn Subwatershed			
PW-3	Surface water isn't draining properly into catch basin (2717). Requires road repair in addition to drainage improvements. Additional catch basin requested by adjacent property owner.	Saw-cut and re-pave immediate area to restore access to structure. Install new structure.	$12,000
PW-14	Culvert has crushed downstream pipe end and is 25% full of sediment.	Clean culvert, repair pipe end.	$2,000
Total Cost of Small Works Projects			$97,000

a. See Figure 5-1.

STORMWATER CAPITAL PROJECTS

Project Types

Capital projects developed for this master plan consist primarily of conveyance improvements in the public right of way. A conveyance system is made up of large and small channels, culverts, and storm drain pipelines. Improvements include building overflow channels, increasing capacity, or increasing system efficiency. Specific structural solutions considered for the CIP are culvert and ditch improvements, storm drain pipelines, and outfall improvements.

Culverts are short lengths of pipe that convey stormwater under roadways or other embankments. New or replacement culverts in stream channels at road crossings can increase flow capacity and reduce the potential for upstream flooding. When culverts are too small to convey the stormwater flow, stormwater backs up behind the roadway. This is normally not acceptable if there is a danger of the road failing or if upstream structures are being damaged by floodwaters. Increasing the size or number of culverts reduces the possibility of upstream damage and road failure. A potential negative effect of increasing culvert capacity is the increased risk of additional flooding downstream of the culvert caused by the loss of storage upstream. However, flood storage behind an undersized culvert is usually very small. At some locations, peak flow increase is attenuated in deep roadside ditches downstream of the replaced culvert.

Underground storm drain lines are commonly installed to convey stormwater runoff from urban developments to a receiving body such as a lake, river or stream. Storm drain pipelines can reduce flooding and standing water during rainfall events but can increase peak flow rates to the receiving water. Small pipes are inexpensive to install, but may result in frequent flooding. This can be alleviated by installing pipelines of adequate size to convey larger flows. Installation of new pipelines in developed areas is always more expensive and disruptive than the installation of pipelines in an undeveloped area.

Storm drains work only where there is adequate gradient to maintain flow rates and keep the pipe from filling with sediment. Typically, these lines are installed in road right-of-ways, so there is little land acquisition cost, although some temporary easements may be required.

Capital projects may also include facilities designed to remove pollutants from stormwater flows and improve water quality. Common water treatment facilities include bio-infiltration swales and cartridge vaults. Where feasible, treatment facilities will be included in the proposed capital improvement projects included in this plan.

Project Assumptions

The configuration and size of stormwater capital projects was based on a detailed analysis of tributary area and land cover using the hydraulic models described in Chapter 3 and Appendix B. Pipe materials were assumed to be high-density polyethylene for pipes up to 24 inches in diameter and concrete for larger pipes. When an existing pipe is replaced with a larger diameter pipe, the cost assumes that existing catch basins can be reused. Some pipes were identified as outfalls or laterals. For cost estimating, outfall repair or replacement projects assume the installation of a tide valve.

Unit costs were generally derived from Washington State Department of Transportation bid tabs for recent local projects. Adjustments for planning level assumptions (such as trench excavation and pipe bedding material included in the price of culvert materials) were made using recent unit bid item costs from Whatcom County and other municipalities. Several unique lump sum items, such as water quality facilities, were priced based on engineer's judgment. Unit prices used for the estimates are shown in Appendix C.

Project Descriptions and Estimated Costs

Fifteen capital projects were developed to address 22 drainage problems, as listed in Table 5-5. Some projects address more than one problem. The proposed projects include about 6,700 feet of new or replaced storm drain pipeline, 10,000 feet of roadside ditch, 40 new or replaced catch basins, 9 water quality treatment facilities, and 8 new or replaced outfalls. Figure 5-2 shows the project locations. Detailed project descriptions are provided in Appendix C. Table 5-6 shows a breakdown of estimated project costs.

**TABLE 5-5.
PROPOSED CAPITAL IMPROVEMENT PROJECTS**

Project Number [a]	Problem ID [b]	Project Name [c]	Location	Cost
Birch Point Subwatershed				
BP-1	BP-2	Normar Place Storm Drain Improvements	Normar Place near Semiahmoo Drive	$191,000
BP-2	BP-5	Semiahmoo Drive Drainage Improvements (North)	Semiahmoo Drive	$93,000
BP-3	BP-8; BP-9	Birch Point Road Storm Drain Improvements	Birch Point Road east of Semiahmoo Drive	$95,000
BP-4	BP-15	Selder Road Storm Drain Improvements	Selder Road	$224,000
BP-5	BP-6	Semiahmoo Drive Drainage Improvements (South)	Semiahmoo Drive near Birch Point Road	$162,000
BP-6	BP-10	Birch Point Road Outfall Improvement	Birch Point Road	$326,000
BP-7	BP-20	Birch Point Road Culvert Improvements	Birch Point Road west of Bay Ridge Drive	$75,000
BP-8	N/A	Birch Point Water Quality Retrofits	Within the Birch Point Subwatershed	$489,000
Terrell Creek Urban Area Subwatershed				
TC-1	TC-1	Bay Road Storm Drain Improvements	Bay Road at Jackson Road	$53,000
TC-2	TC-4; TC-5; TC-7; TC-12; TC-13	Wooldridge Avenue Storm Drain Improvements	Wooldridge Avenue, Jackson Road, and Sunset Drive	$921,000
TC-3	N/A	Terrell Creek Urban Area Water Quality Retrofits	Within the Terrell Creek Urban Area Subwatershed	$379,000
Point Whitehorn Subwatershed				
PW-1	PW-2; PW-9; PW-10	Holeman Avenue Storm Drain Improvements	Holeman Avenue west of Birch Bay Drive	$108,000
PW-2	PW-7; PW-10; PW-11; PW-15	Birch Bay Drive and Petticote Lane Storm Drain Improvements	Birch Bay Drive and Petticote Lane	$293,000
PW-3	PW-12	Birch Bay Drive Outfall Improvements	Birch Bay Drive east of Jill Street	$150,000
PW-4	N/A	Point Whitehorn Water Quality Retrofits	Within the Point Whitehorn Subwatershed	$489,000

a. See Figures 5-2 for locations.
b. See Figures 4-5, 4-6, and 4-7 for locations.
c. All projects consist of installation of new/replaced storm drainage pipeline, connection to existing drainage infrastructure, and associated outfall and ditch improvements. See Appendix C for project descriptions.

TABLE 5-6.
BREAKDOWN OF PROJECT CAPITAL COSTS

Project ID	Construction Cost[a]	State Sales Tax[b]	Engineering/Legal/ Administration[c]	Construction Management[d]	Permitting[e]	**Total**
BP-1	$113,000	$10,000	$40,000	$11,000	$17,000	$191,000
BP-2	$ 55,000	$ 5,000	$ 22,000	$ 6,000	$ 6,000	$ 93,000
BP-3	$ 56,000	$ 5,000	$ 22,000	$ 6,000	$ 6,000	$ 95,000
BP-4	$137,000	$12,000	$48,000	$14,000	$14,000	$224,000
BP-5	$ 96,000	$ 8,000	$ 38,000	$ 10,000	$ 10,000	$ 162,000
BP-6	$193,000	$16,000	$68,000	$19,000	$29,000	$326,000
BP-7	$38,000	$3,000	$15,000	$4,000	$4,000	$75,000
BP-8	$322,000	$27,000	$97,000	$32,000	$11,000	$489,000
TC-1	$31,000	$3,000	$12,000	$3,000	$3,000	$53,000
TC-2	$ 620,000	$ 53,000	$ 155,000	$ 31,000	$ 62,000	$ 921,000
TC-3	$241,000	$20,000	$84,000	$24,000	$8,000	$379,000
PW-1	$64,000	$5,000	$26,000	$6,000	$6,000	$108,000
PW-2	$179,000	$15,000	$63,000	$18,000	$18,000	$293,000
PW-3	$86,000	$7,000	$34,000	$9,000	$13,000	$150,000
PW-4	$322,000	$27,000	$97,000	$32,000	$11,000	$489,000
				Total Project Capital Costs		**$ 4,048,000**

a. Includes 50 percent contingency
b. 8.5 percent of construction cost
c. 25 to 40 percent of construction cost
d. 10 percent of construction cost
e. 5 to 10 percent of construction cost based on need for local, state, or federal permits

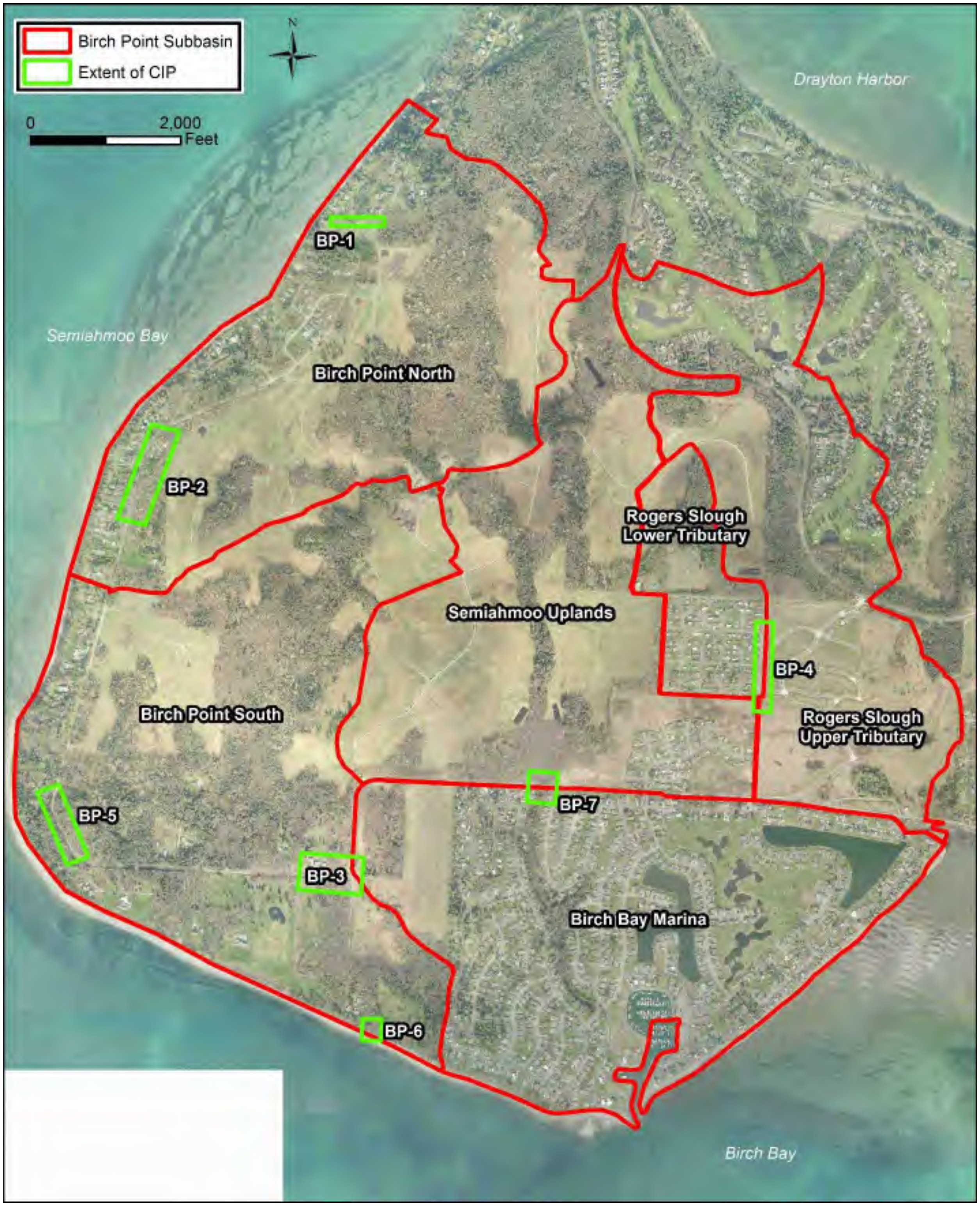

Figure 5-2A. Capital Projects within the Birch Point Subwatershed

Figure 5-2B. Capital Projects within the Terrell Creek Urban Area Subwatershed

Figure 5-2C. Capital Projects within the Point Whitehorn Subwatershed

CHAPTER 6.
IMPLEMENTATION PLAN

Stormwater plans typically include an implementation schedule for design and construction of capital projects. The projects are evaluated and scheduled over a six-year period based on capital funding levels. For larger projects, implementation is typically split into two phases: design and permitting occurs first, followed by construction in a subsequent year. Very large and/or complex projects may require a separate planning phase preceding the design and permit phase.

EVALUATION OF CAPITAL PROJECTS

The CIP prioritization process for this master plan used the evaluation-criteria method developed for the Central North Subwatershed Plan. This method rates projects and assigns a score that reflects the priorities set by the BBWARM Advisory Committee in 2010 (see Appendix D). Capital projects were prioritized using equally-weighted evaluation criteria in the following categories:

- The environmental benefit category includes a sediment reduction score in addition to the shellfish/fish habitat score. Higher scoring projects provide a greater improvement in habitat and greater sediment reduction. No points are awarded for projects that do not improve the current conditions.
- The community benefit category evaluates the reduction in flood frequency and magnitude, property damage (structure flooding), street flooding and public safety issues. No points are awarded for projects that only resolve nuisance property and road flooding.
- The implementation category considers project cost, permitting, property/easement acquisition, and coordination with other project and agencies. No points are assigned for projects that require a complex permitting process or where condemnation is necessary for property acquisition. Projects needed to meet regulatory requirements are scored significantly higher to ensure a high priority.
- Local support was given its own category in recognition of the need for strong support within the community to ensure project success.
- The predesign category considers the amount of work that has gone into the project design with the highest point values assigned to the project with the highest leve of engineering and design.

The project scoring and ranking are summarized in Table 6-1. Appendix D presents the full prioritization analysis.

IMPLEMENTATION SCHEDULE

A schedule for implementation of the capital projects outlined in this subwatershed should be incorporated into the annual BBWARM 6-year capital improvement program plan review. Implementation schedule for capital projects should consider funding, project priority and coordination with the Birch Bay Drive and Pedestrian Facility project. Generally, project implementation would be spread out over two years, with the engineering and permitting completed the first year and construction completed the following year.

TABLE 6-1.
PROJECT SCORING AND RANKING

Subwatershed Rank	Score	Project Name [a]
Birch Point Subwatershed		
1	35	BP-6: Birch Point Road Outfall Improvement
2	29	BP-2: Semiahmoo Drive Drainage Improvements (North)
3	28	BP-1: Normar Place Storm Drain Improvements
4	24	BP-8: Birch Point Water Quality Retrofits
5	24	BP-4: Selder Road Storm Drain Improvements
6	21	BP-3: Birch Point Road Storm Drain Improvements
7	20	BP-5: Semiahmoo Drive Drainage Improvements (South)
8	19	BP-7: Birch Point Road Culvert Improvement
Terrell Creek Urban Area Subwatershed		
1	34	TC-2: Wooldridge Avenue Storm Drain Improvements
2	24	TC-3: Terrell Creek Urban Area Water Quality Retrofits
3	20	TC-1: Bay Road Storm Drain Improvements
Point Whitehorn Subwatershed		
1	25	PW-3: Birch Bay Drive Outfall Improvement
2	24	PW-4: Point Whitehorn Water Quality Retrofits
3	22	PW-2: Birch Bay Dr. and Petticote Ln. Storm Drain Improvements
4	21	PW-1: Holeman Avenue Storm Drain Improvements

a. See Figure 5-2 for project location.

INCORPORATING THE MASTER PLAN INTO THE OVERALL STORMWATER PROGRAM

As part of its comprehensive planning effort, Whatcom County has adopted the Birch Bay Comprehensive Stormwater Plan (CH2M Hill, 2006). Approved subwatershed master plans are incorporated into the Stormwater Plan during plan updates or when added as an addendum. Priorities and timeframes from the comprehensive subwatershed plans must be integrated with other County needs to fit within the overall priorities and budget for the County.

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Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

APPENDIX A. STORMWATER INVENTORY

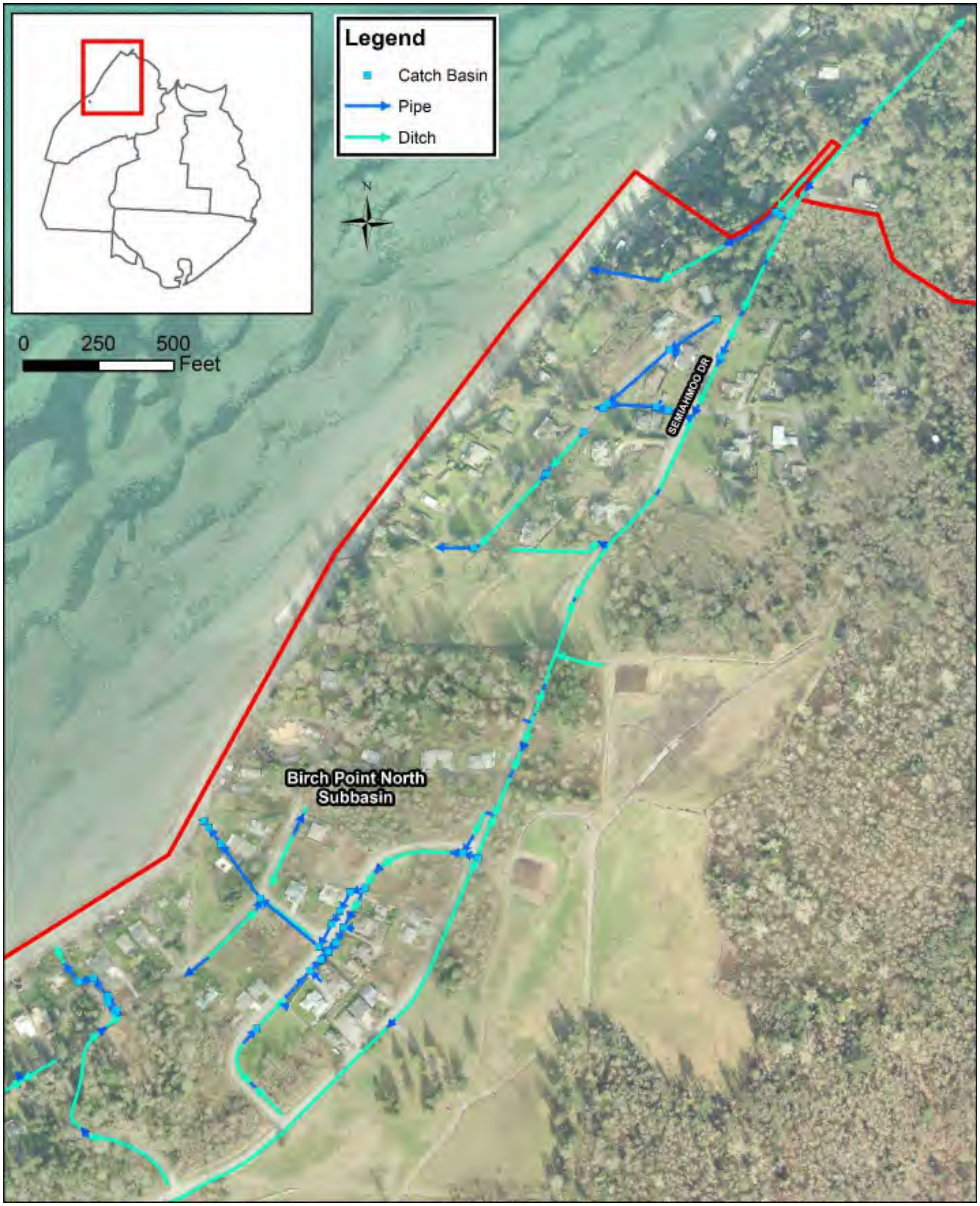

Figure A-1. Stormwater Inventory – Birch Point North Subbasin

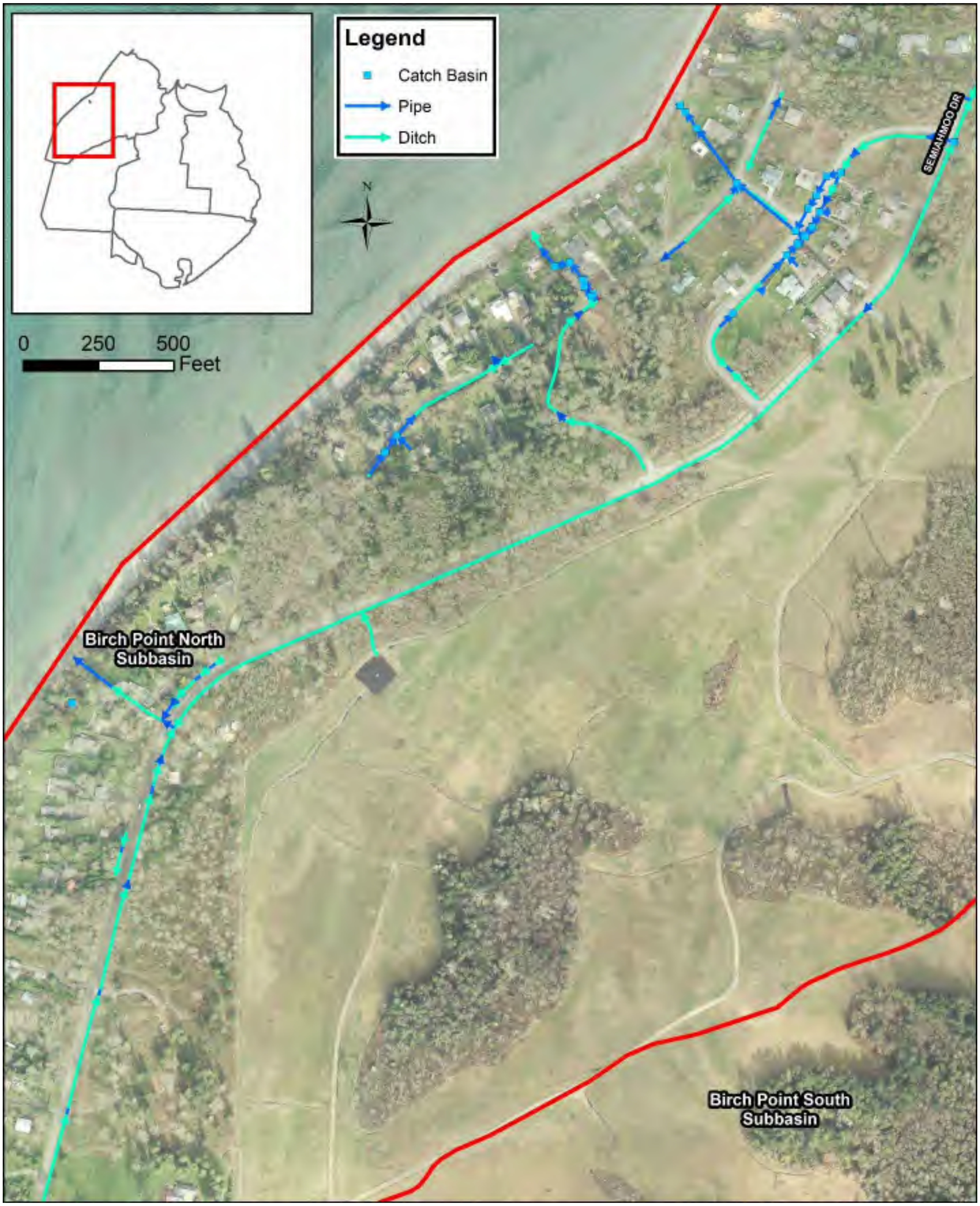

Figure A-2. Stormwater Inventory – Birch Point North Subbasin

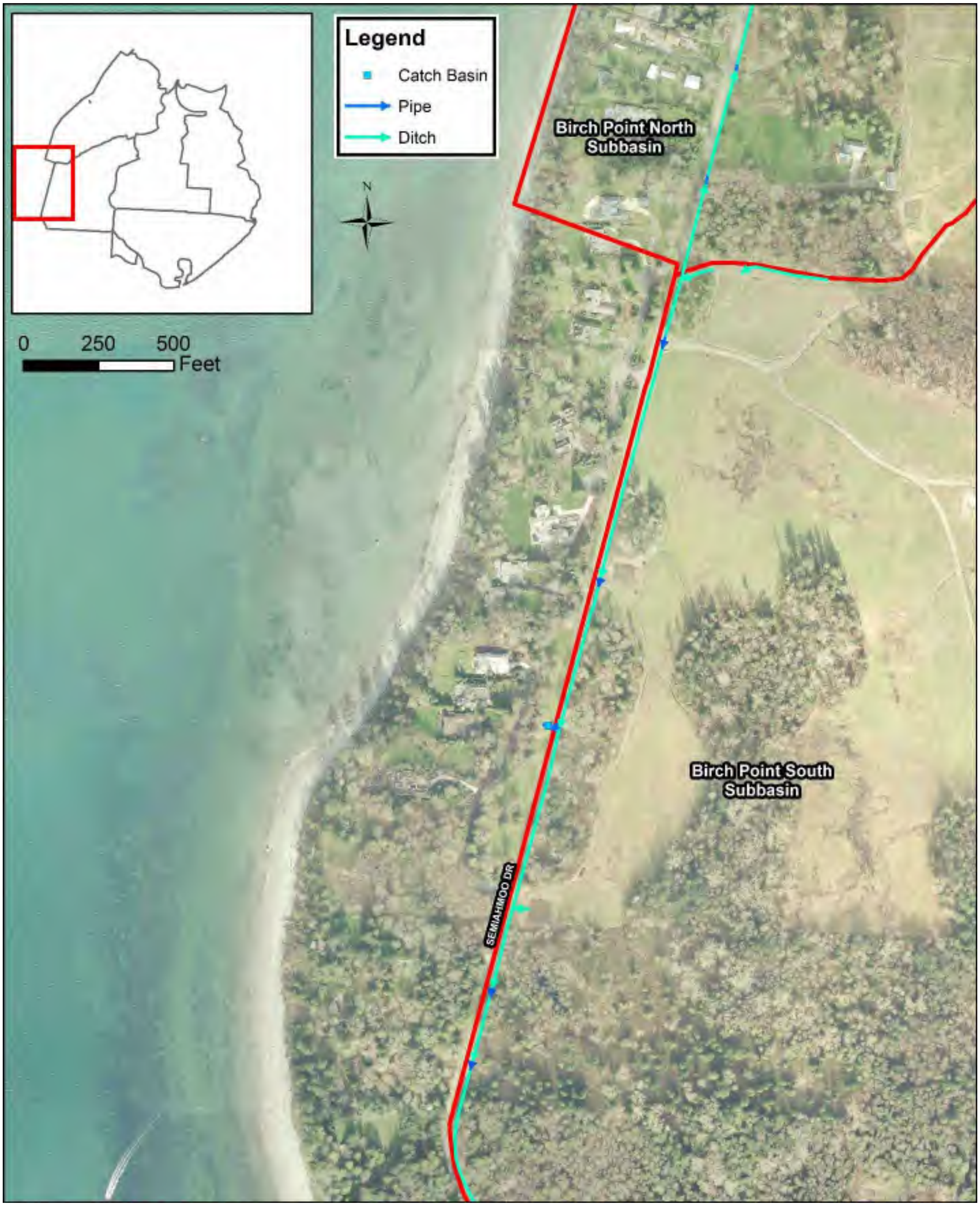

Figure A-3. Stormwater Inventory – Birch Point South Subbasin

Figure A-4. Stormwater Inventory – Birch Point South Subbasin

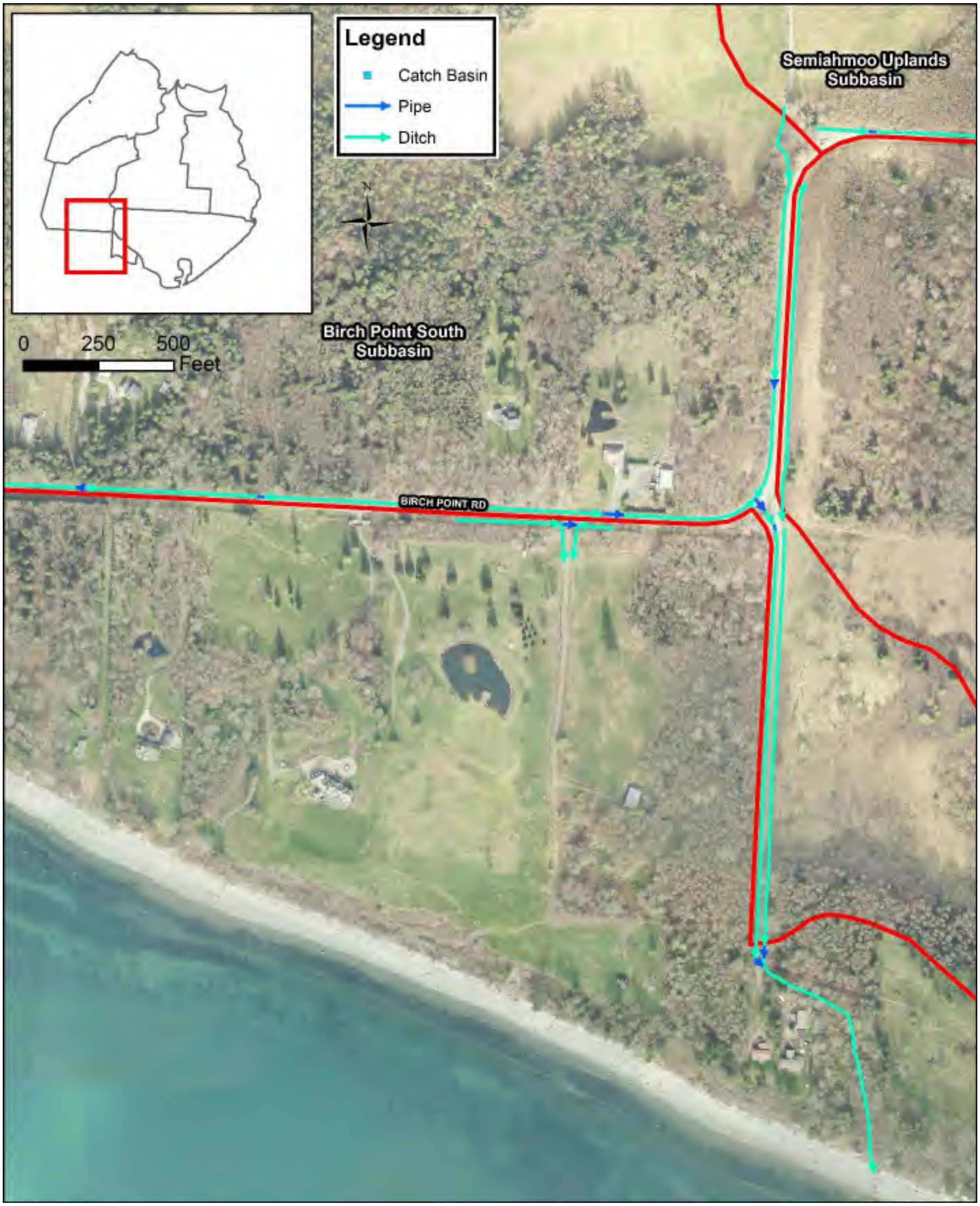

Figure A-5. Stormwater Inventory – Birch Point South Subbasin

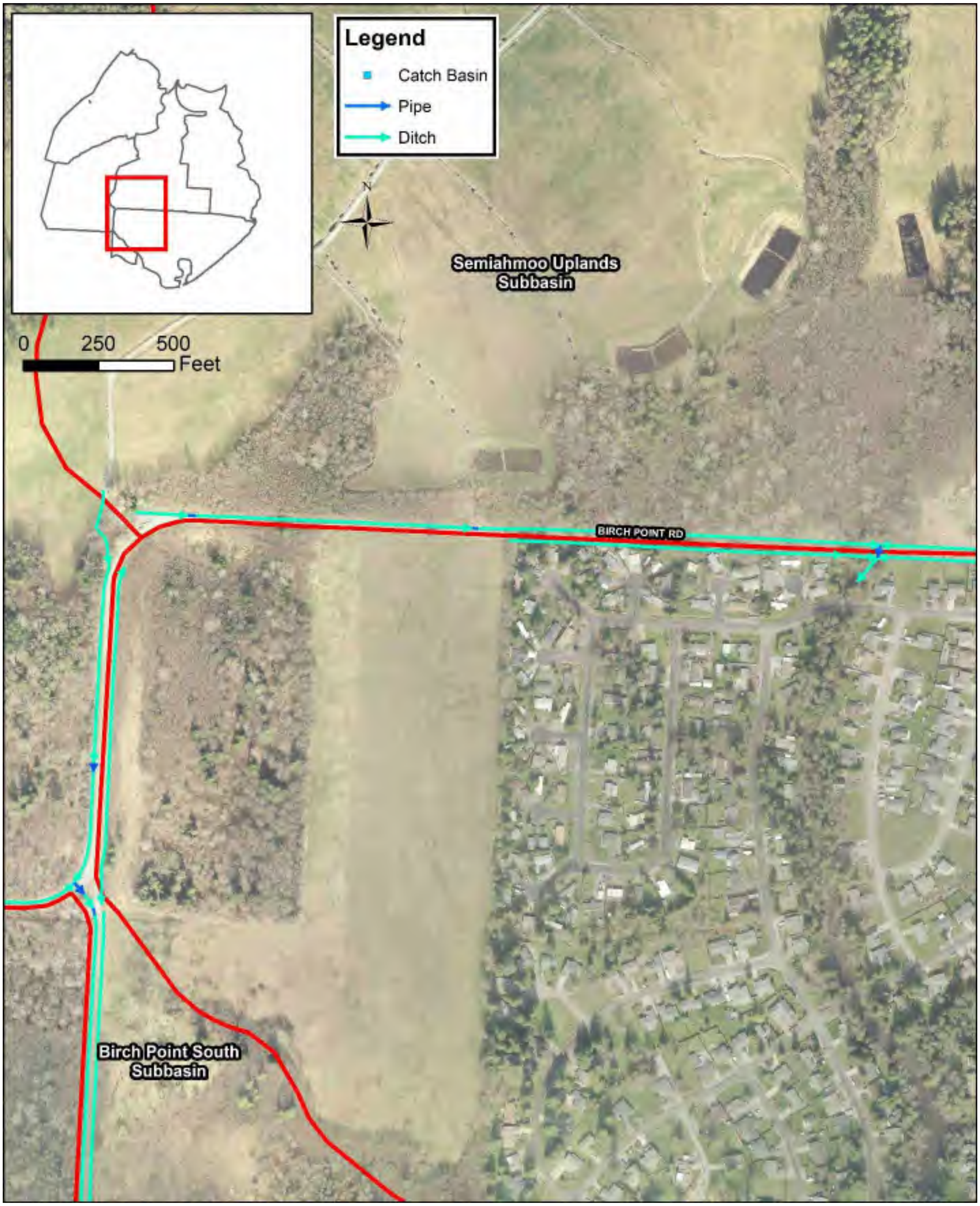

Figure A-6. Stormwater Inventory – Semiahmoo Uplands Subbasin

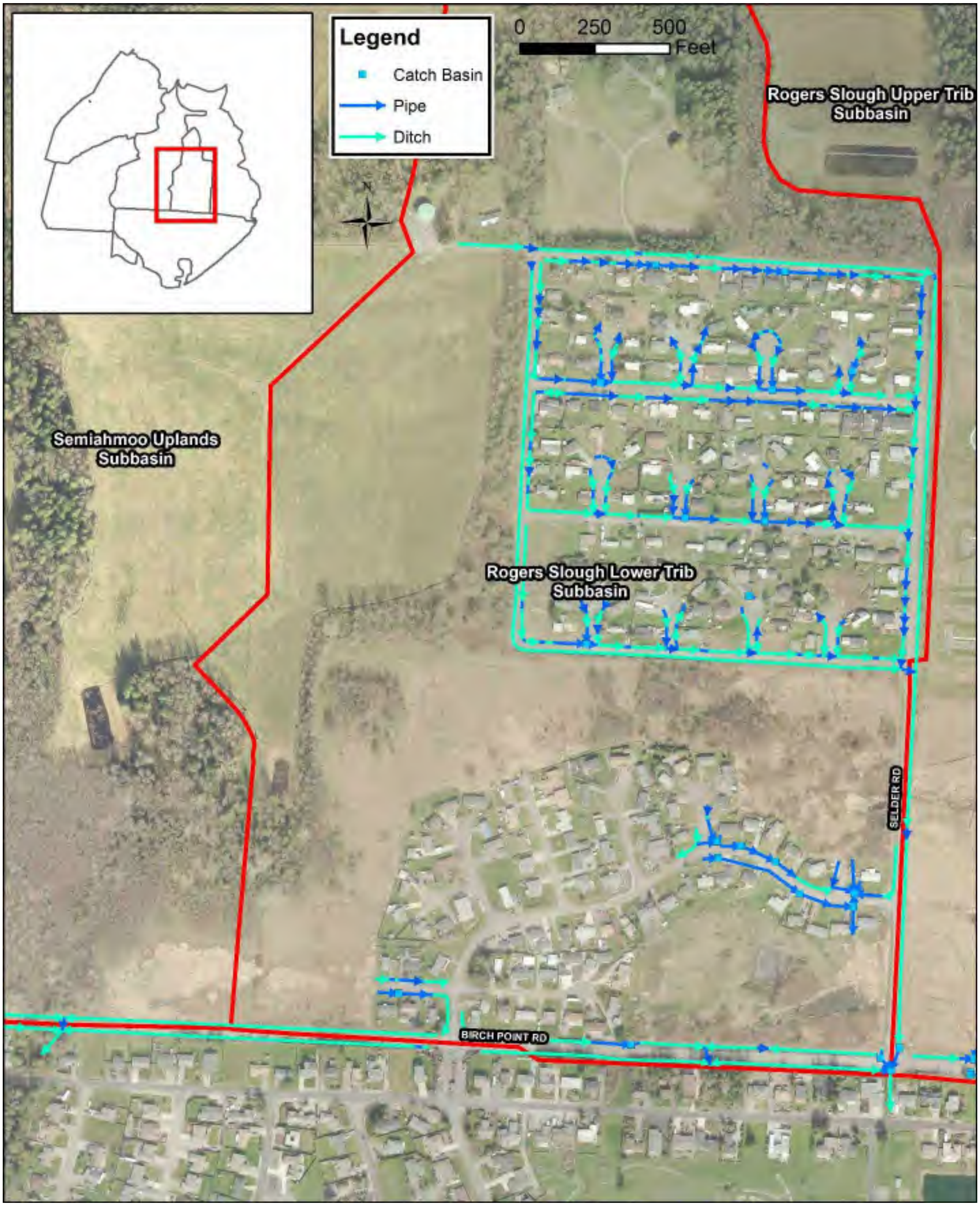

Figure A-7. Stormwater Inventory – Rogers Slough Lower Subbasin

Figure A-8. Stormwater Inventory – Rogers Upper Lower Subbasin

Figure A-8. Stormwater Inventory – Rogers Upper Tributary Subbasin

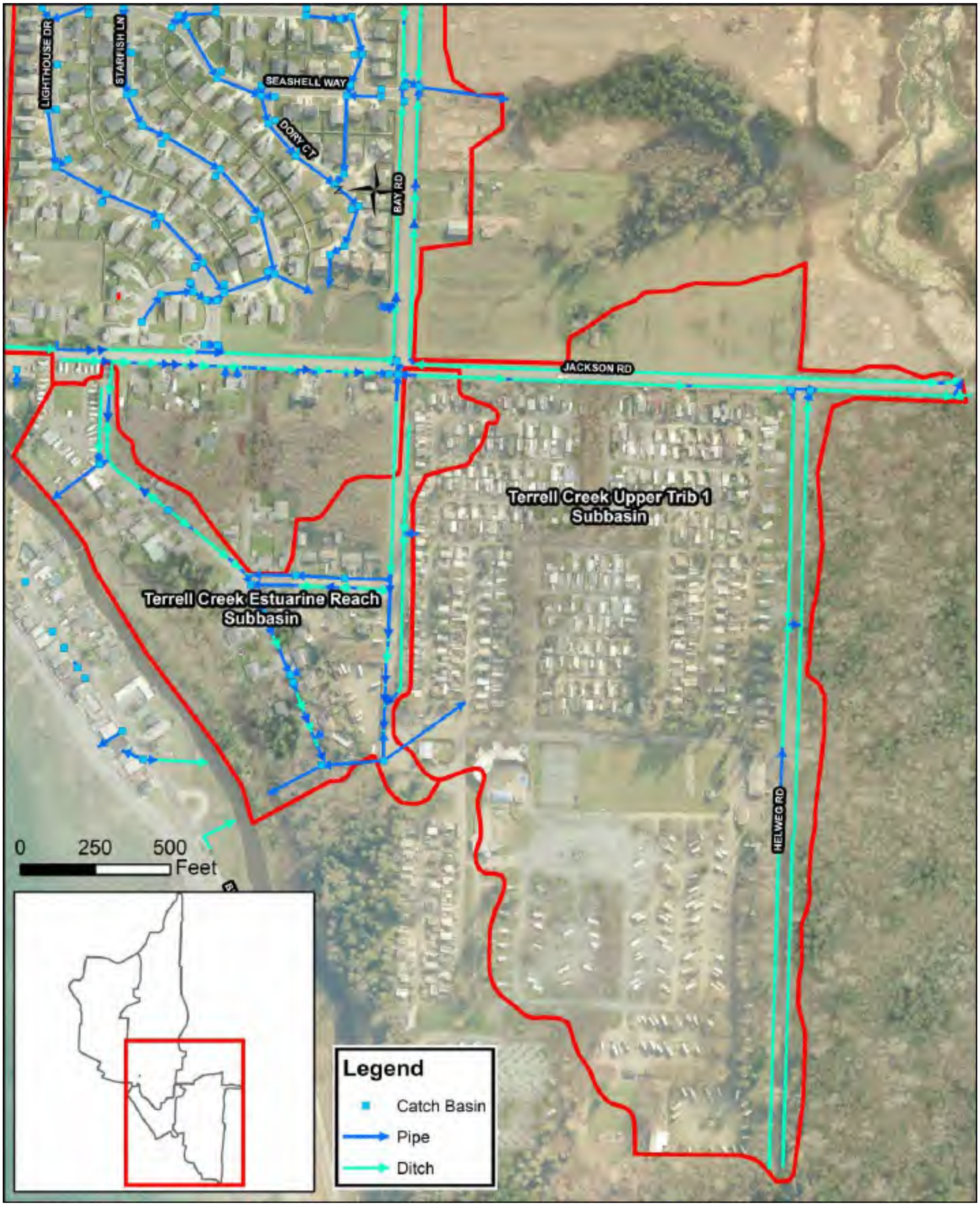

Figure A-9. Stormwater Inventory – Terrell Creek Upper Tributary 1 and Estuarine Reach Subbasins

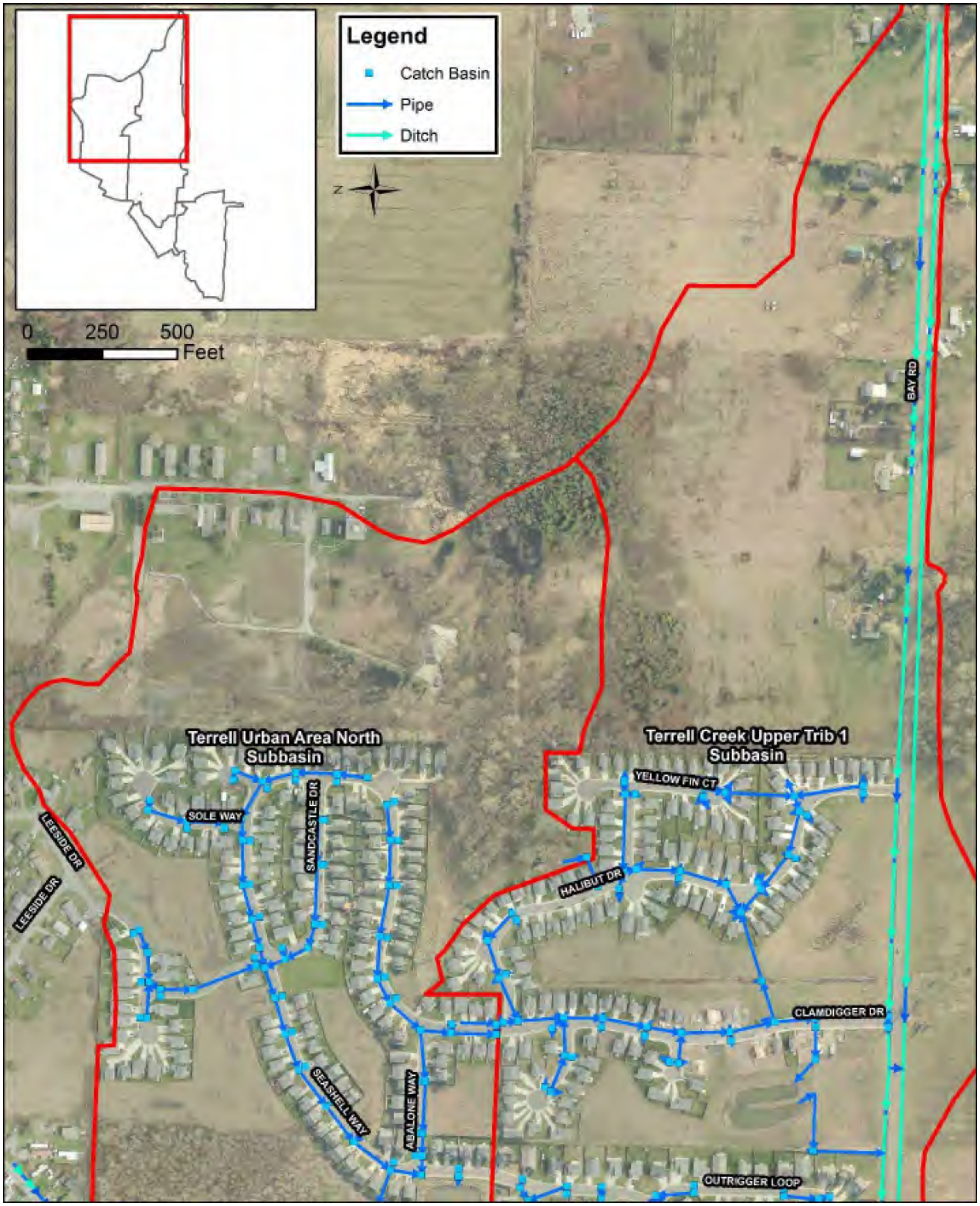

Figure A-10. Stormwater Inventory – Terrell Creek Upper Tributary 1 and Urban Area North Subbasins

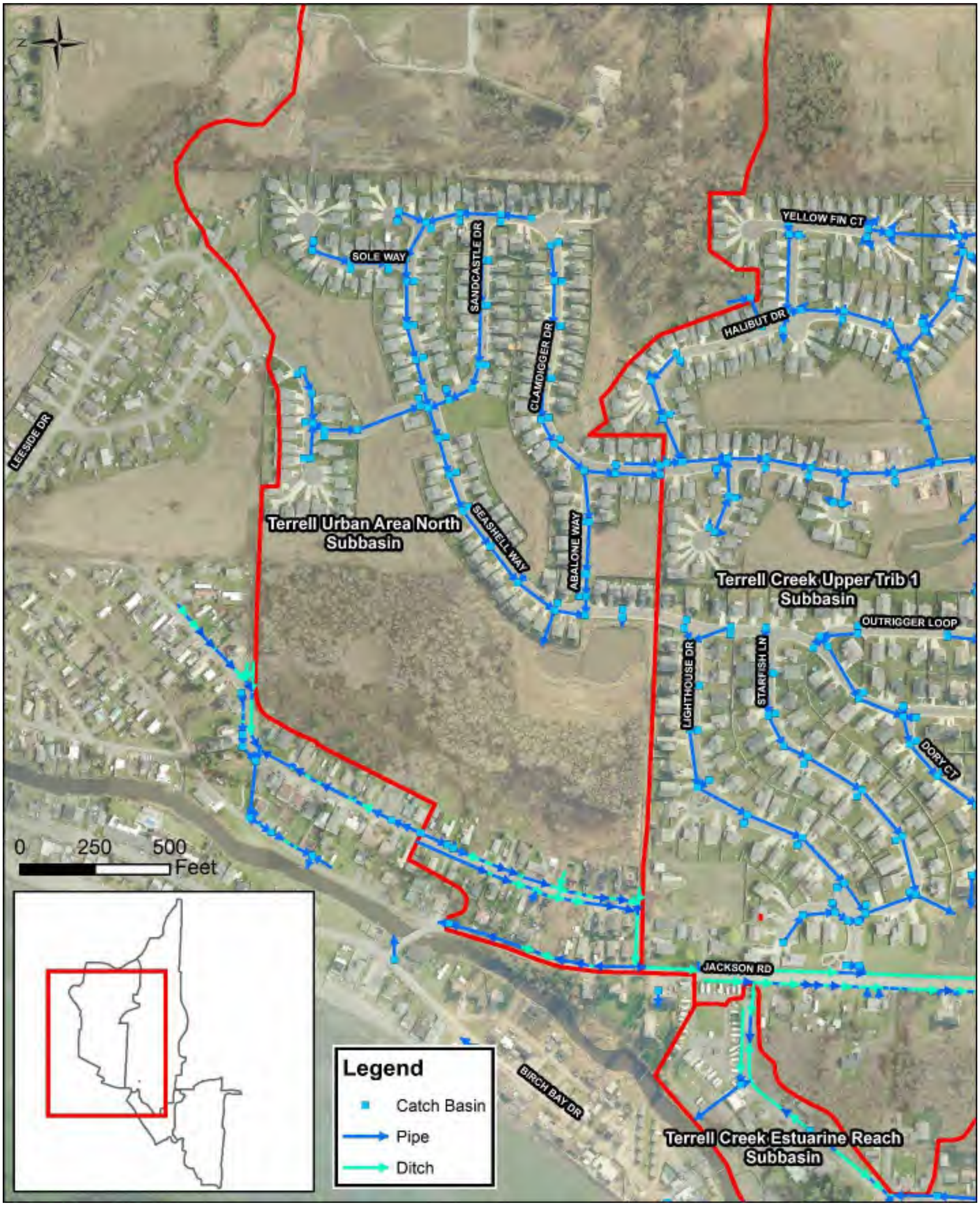

Figure A-11. Stormwater Inventory – Terrell Creek Urban Area North Subbasin

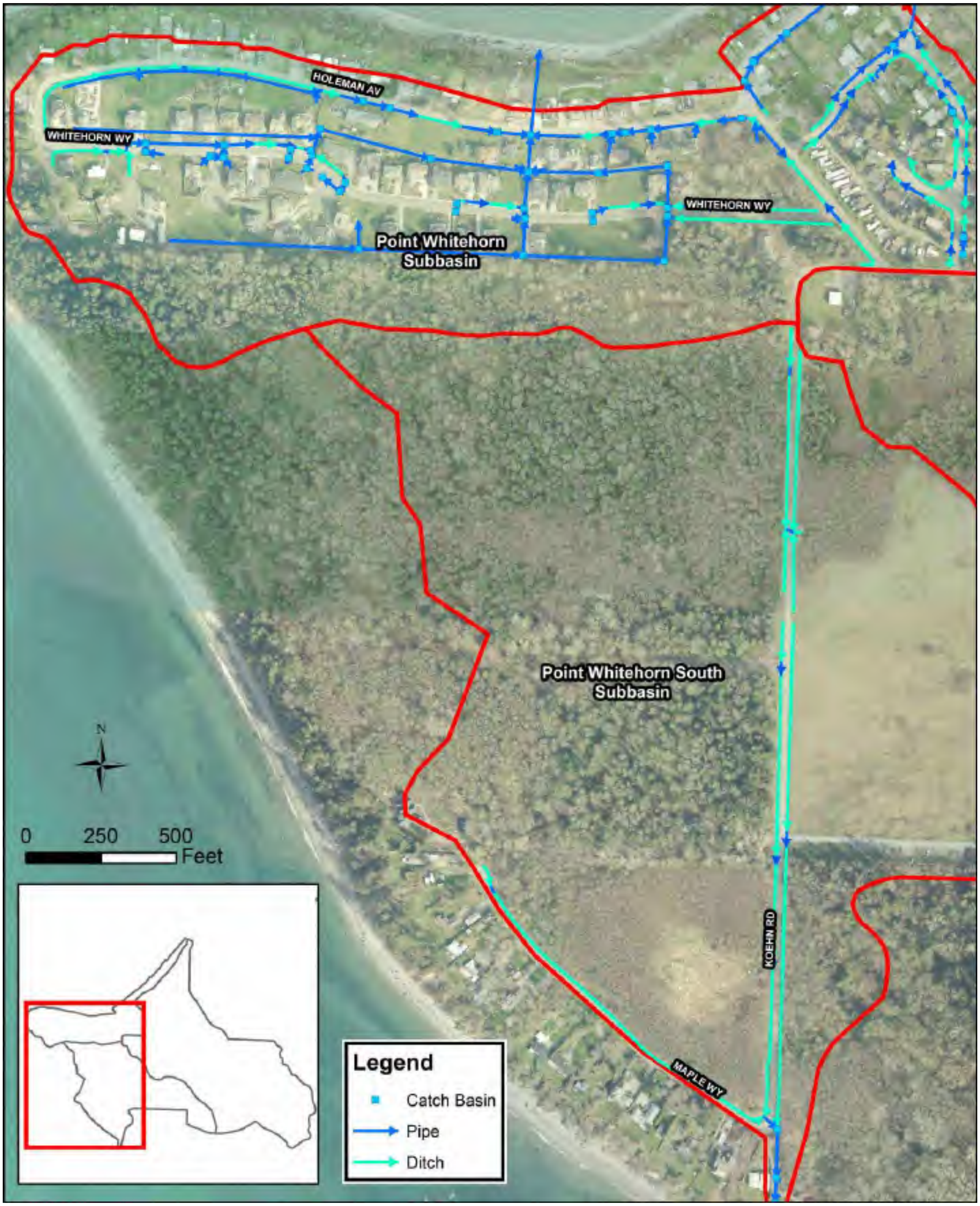

Figure A-12. Stormwater Inventory – Point Whitehorn and Point Whitehorn South Subbasins

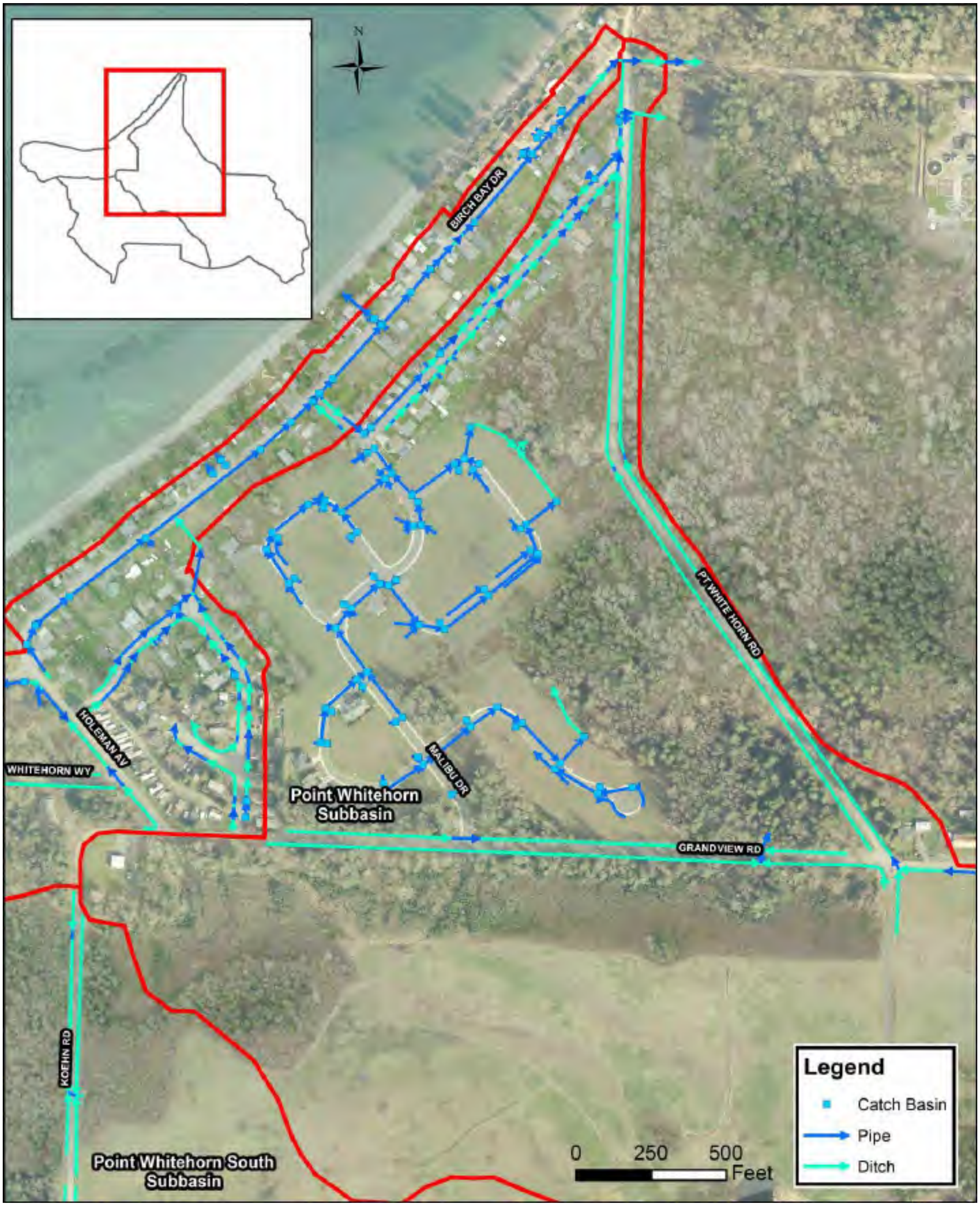

Figure A-13. Stormwater Inventory – Point Whitehorn and Point Whitehorn Uplands Subbasins

APPENDIX B.
HYDROLOGIC AND HYDRAULIC ANALYSIS

Whatcom County Public Works Stormwater Division
HYDROLOGIC AND HYDRAULIC ANALYSIS OF THE SURFACE WATER SYSTEM FOR THE BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED

November 2016

INTRODUCTION

Hydrologic and hydraulic analysis was performed for three subwatersheds that are included as part of the Birch Point, Terrell Creek Urban Area and Point Whitehorn (BP-TC-PW) subwatersheds. The purpose of this analysis was to support planning efforts for the subwatershed master plan. The objectives of the hydrologic and hydraulic modeling presented in this document are as follows:

- Develop an understanding of the hydrologic regime.
- Determine the capacity of the existing storm drainage system and identify capacity restrictions.
- Identify flooding problems in the subbasins.

The storm drainage system was analyzed using the HSPF model (USEPA, 2005) to simulate runoff from each subbasin and the SWMM5 model (USEPA, 2011) to analyze the hydraulics of natural and constructed surface water drainage systems. The models developed for this study are planning level models. Planning level models are typically developed at a coarser scale than design models and are useful for estimating system flow rates, identifying potential problem areas, sizing infrastructure improvements for cost estimating purposes, and analyzing relative impacts of land use changes. Detailed survey data was used for this analysis, which improves the model accuracy, but care should still be taken in interpreting the results. If the findings from this analysis are used for design, model development should be critically reviewed to be sure the assumptions used are applicable and that appropriate safety factors are incorporated into the design process. No calibration was performed for this analysis.

HYDROLOGIC MODEL DEVELOPMENT

HSPF is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration, and ground infiltration. Runoff from discrete subbasins is routed through rating tables used to represent pipes, channels, lakes, and other flood storage areas.

Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct surface runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to stream channels but at a slower rate than direct runoff. Groundwater also discharges to stream channels that intersect the saturated zone, contributing to long-term base flow in the system. Groundwater can also leave the surface watershed by entering deep groundwater or moving outside the watershed basin.

Subcatchment Delineation and Hydrologic Response Unit Assignment

The three subwatersheds included within the BP-TC-PW subwatersheds were previously delineated as eleven subbasins (ESA Adolfson, 2007); the subbasins evaluated in this technical memorandum are based on the original delineations within the subwatersheds and modified based on current topographic and drainage datasets. Subbasins are further refined into 53 subcatchments based on drainage direction. An overview of the Birch Point, Terrell Creek Urban Area, and Point Whitehorn subwatersheds and the resulting catchments are shown on Figures 1-A to 1-C.

The eleven subbasins are further divided into 60 categories of hydrologic response units, which are groupings of land cover types based on soils, land cover and topography. Hydrologic response units are categorized in HSPF as pervious or impervious. Impervious area estimates developed for the watershed characterization study (ESA Adolfson, 2007) were used as the impervious area input to the HSPF model. The measured impervious area was assumed to be directly connected, based on a comparison that showed the computed impervious fractions for representative land uses to be close to published values for the same land uses (Ecology, 2012). The HSPF model used regional input parameters appropriate for the Puget Sound area (Dinicola, 1990 and Clear Creek Solutions, 2016). Attachment A presents input parameters.

Land Use, Slope, and Soils

Flow characteristics were computed for existing land use conditions at the 53 subbasins in the SWMPIII. Existing conditions land use is based on 2013 aerial photography provided by Whatcom County. Existing condition land use and impervious area is shown in Figures 2-A to 2-C. Slope was computed from topographic LiDAR provided by Whatcom County and shown in Figures 3-A to 3-C. Soils mapping was obtained from the from the NRCS SSURGO National Cooperative Soils Survey (NRCS, 2015) and shown in Figures 4-A to 4-C. The Birch Point subwatershed is largely defined as a Type B soil condition and scrub land from available data and imagery. However, the subwatershed was modeled using a Type C soils condition and forested land cover to better represent observed flow conditions and previous studies.

Climate Data

Long-term precipitation data collected at Blaine from 1948 to 2012 was used to compute a continuous flow record. Long-term average precipitation values were compared to precipitation data collected by the Birch Bay Water and Sewer District and found to be about equal to the District data. Potential evaporation data was developed from pan evaporation data collected at the Washington State University Extension in Puyallup, Washington, adjusted by a factor 0.76 to account for regional differences in potential evapotranspiration.

Existing Conditions

Runoff time-series computed for existing conditions and were exported from the HSPF model for each subcatchments. The HSPF model does not include drainage elements so routed peak flow rates are not computed for HSPF subbasins.

Figure 1-A. Birch Point Subwatershed Subcatchments

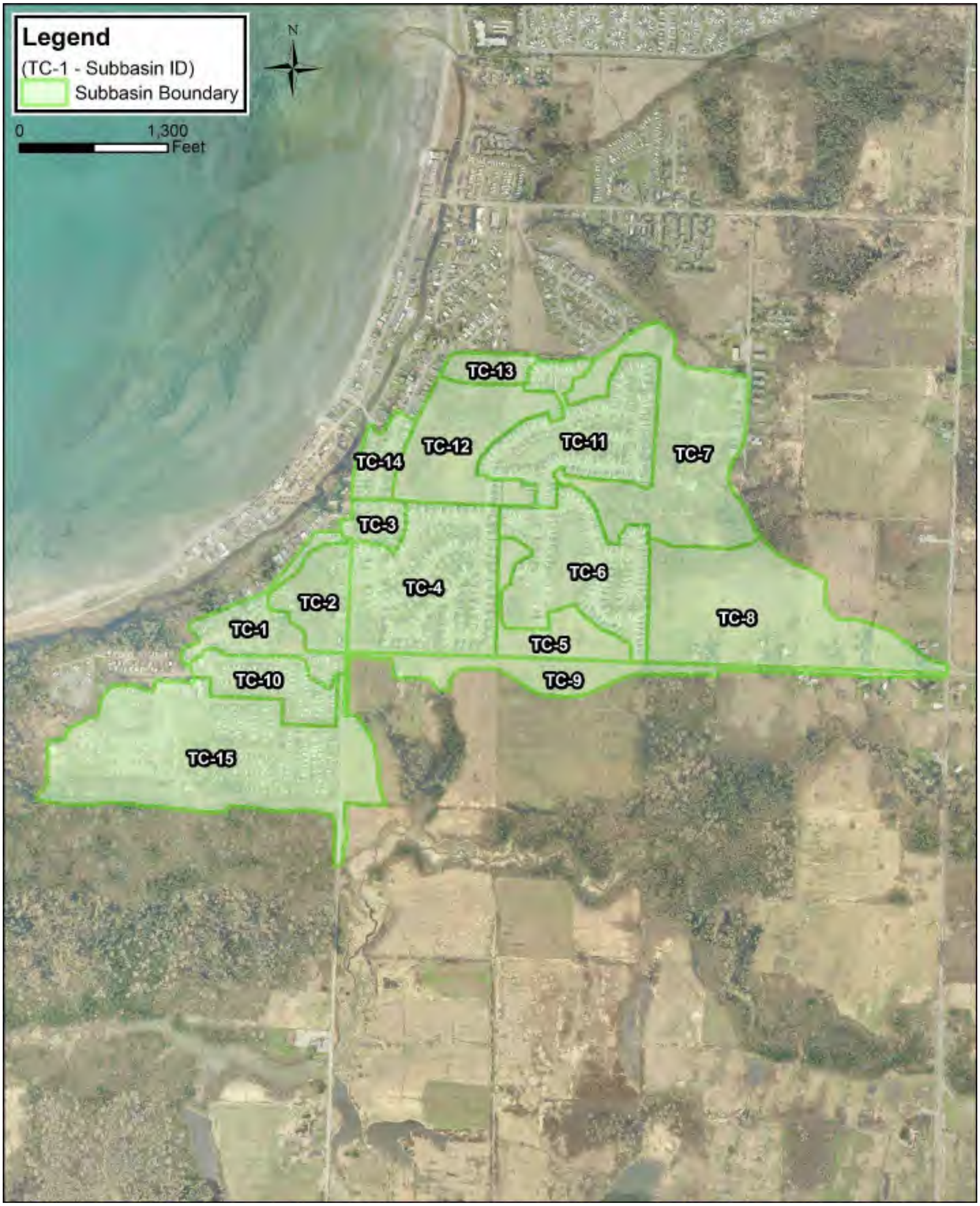

Figure 1-B. Terrell Creek Urban Area Subwatershed Subcatchments

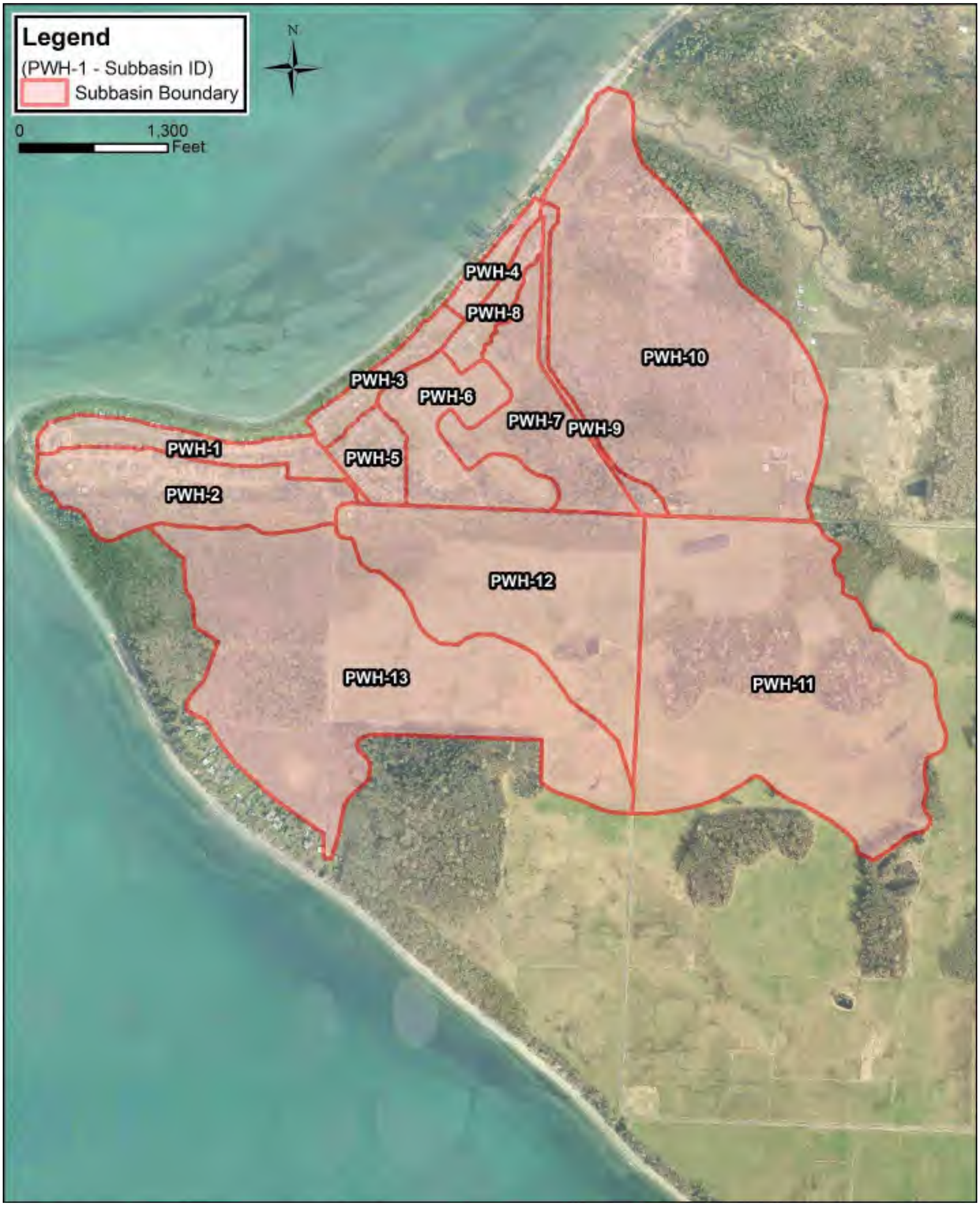

Figure 1-C. Point Whitehorn Subwatershed Subcatchments

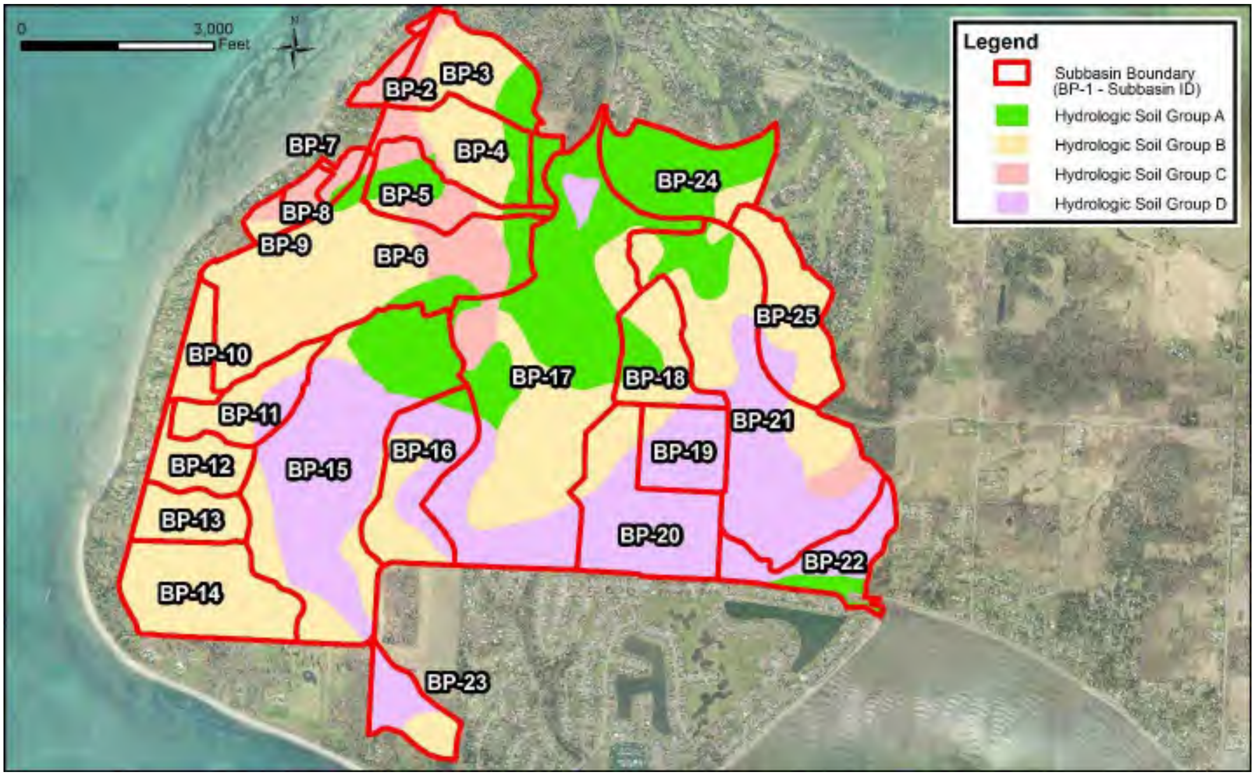

Figure 2-A. Soils within the Birch Point Subcatchments

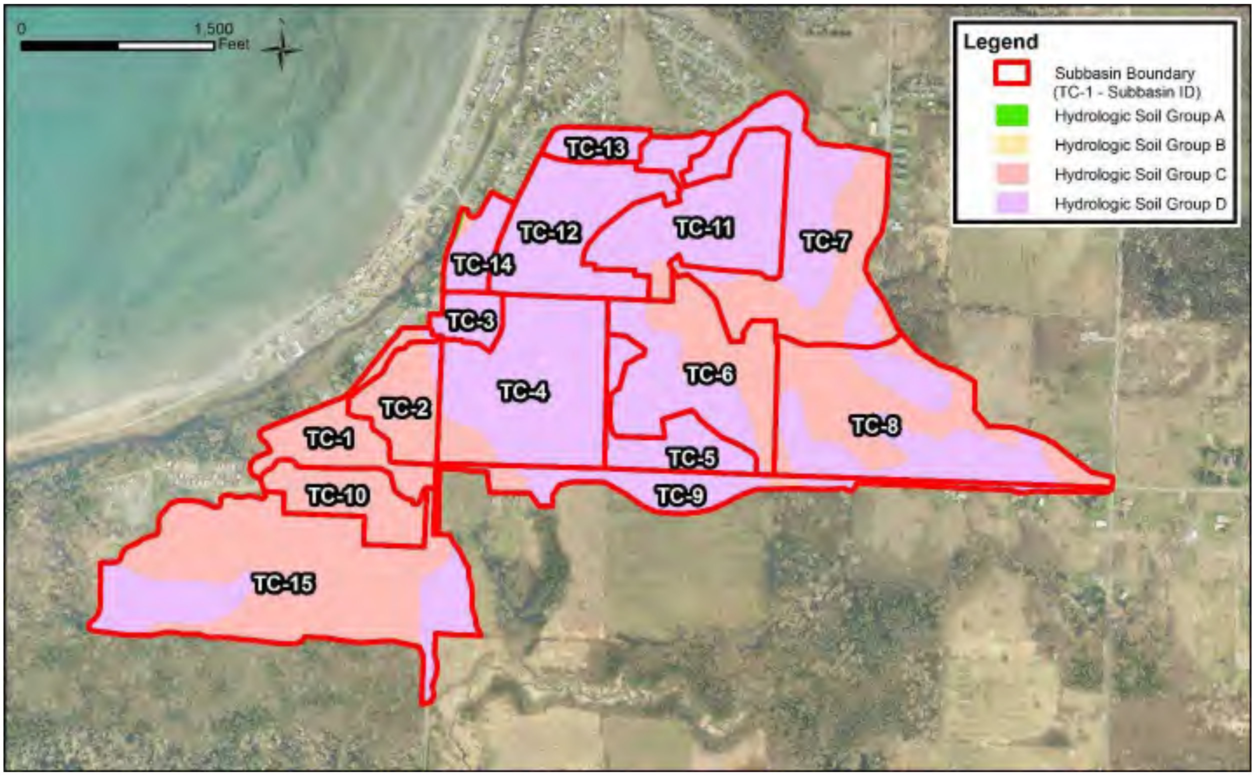

Figure 2-B. Soils within the Terrell Creek Urban Area Subcatchments

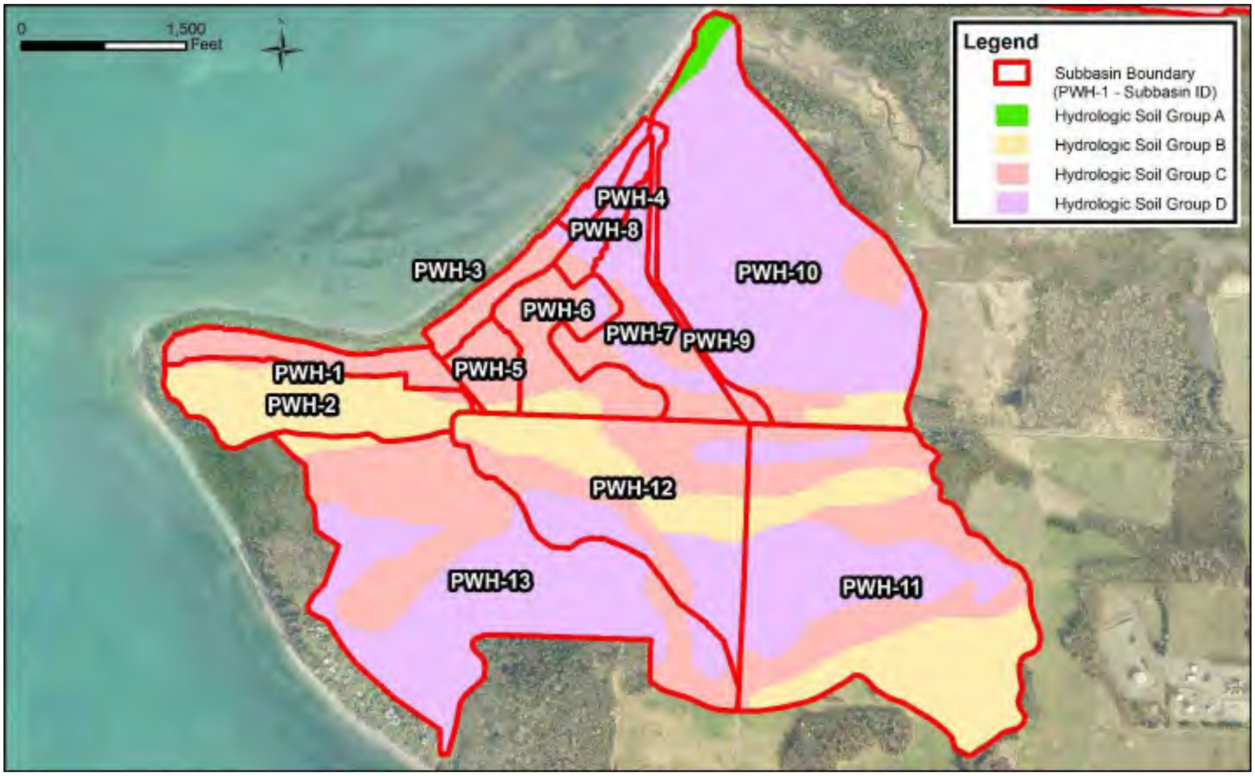

Figure 2-C. Soils within the Point Whitehorn Subcatchments

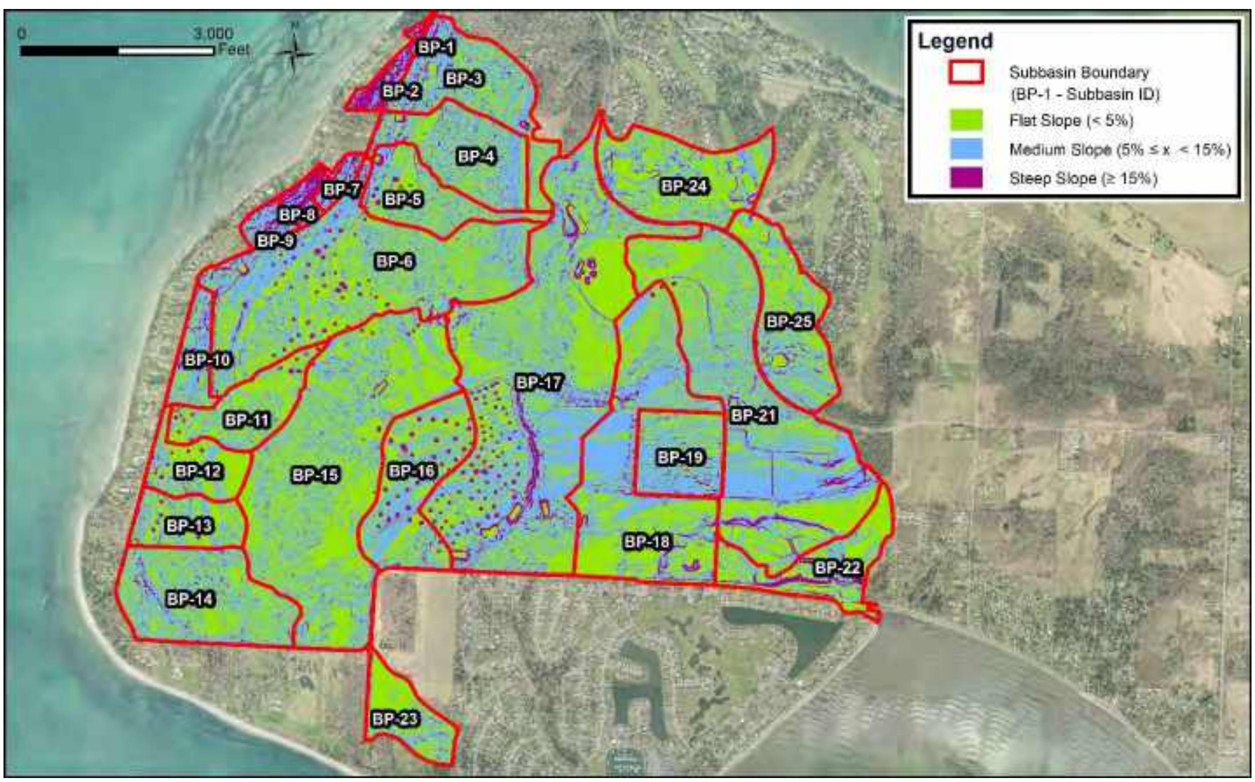

Figure 3-A. Land Surface Slope within the Birch Point Subcatchments

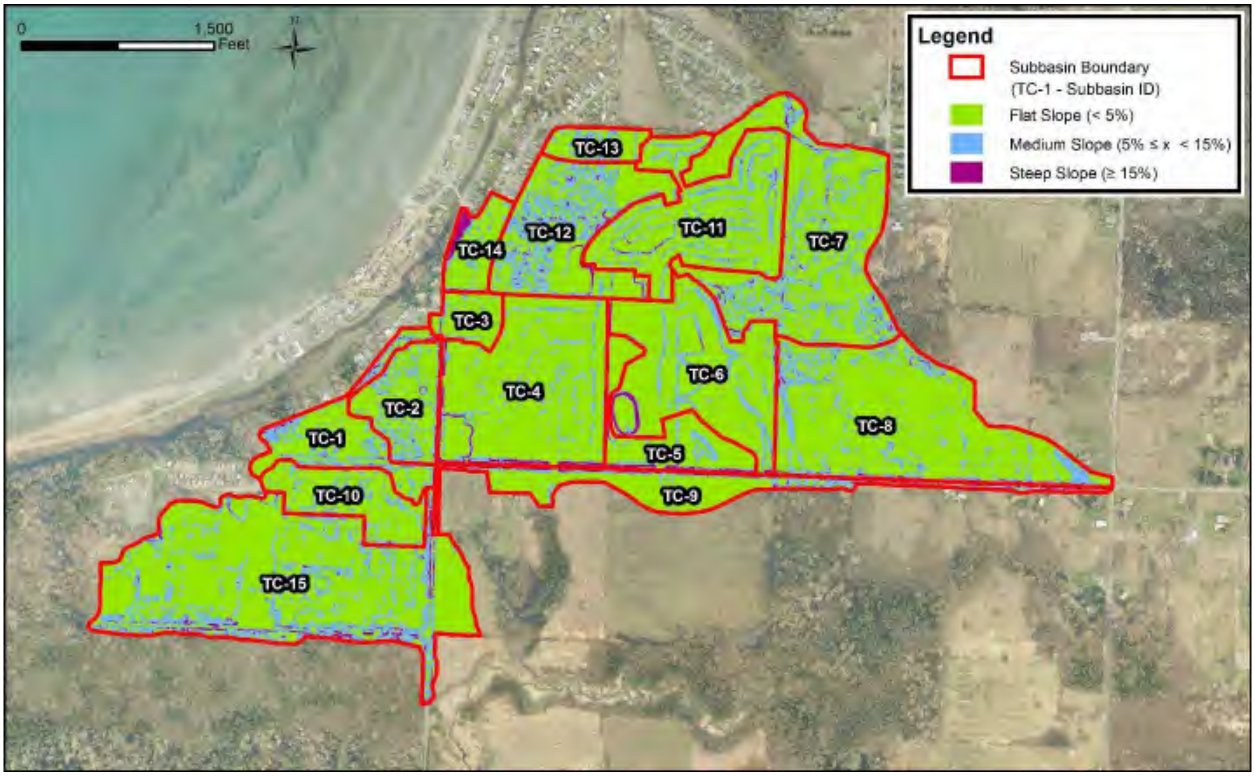

Figure 3-B. Land Surface Slope within the Point Whitehorn Subcatchments

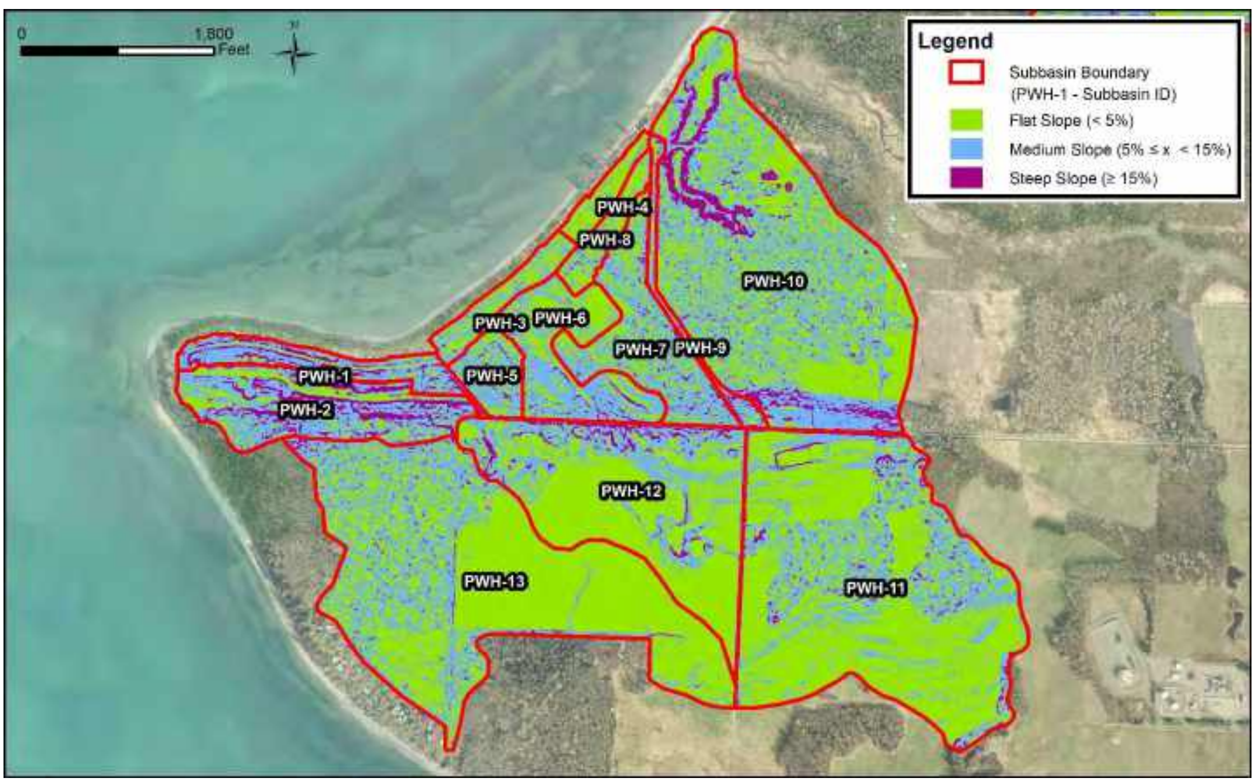

Figure 3-C. Land Surface Slope within the Terrell Creek Urban Area Subcatchments

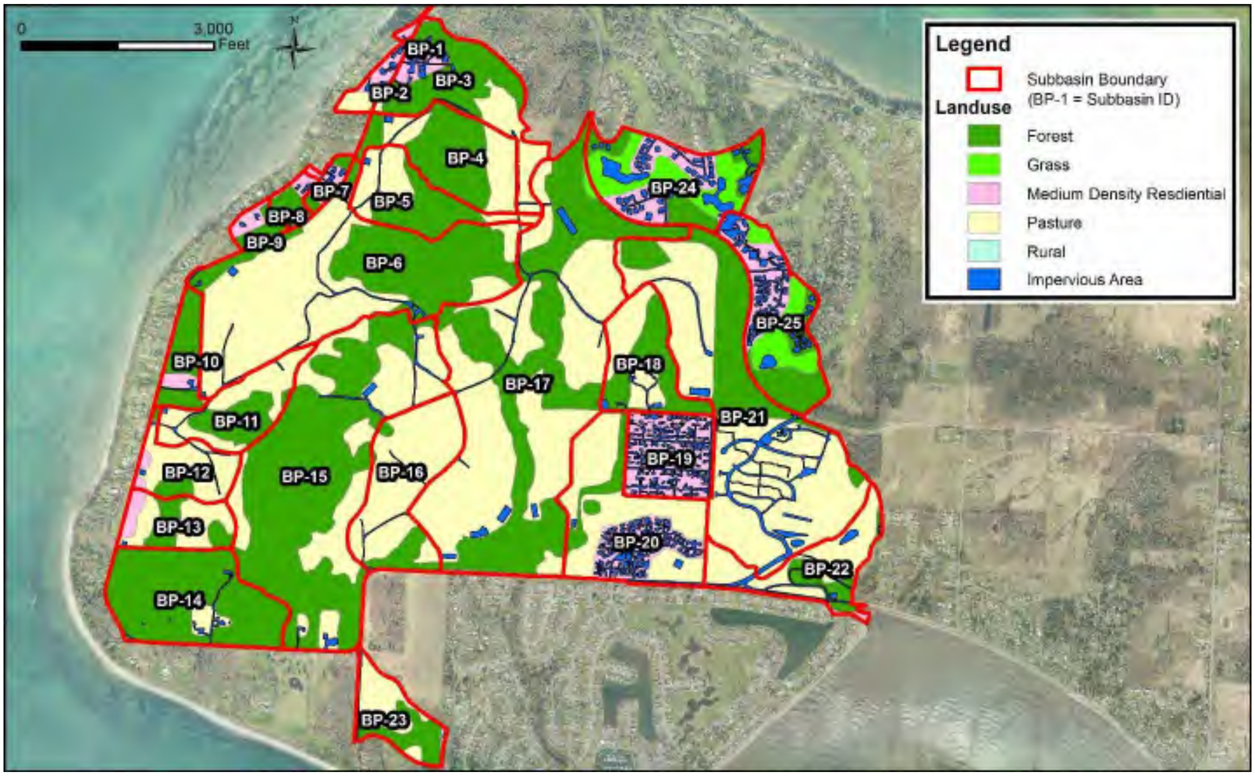

Figure 4-A. Land-use within the Birch Point Subcatchments

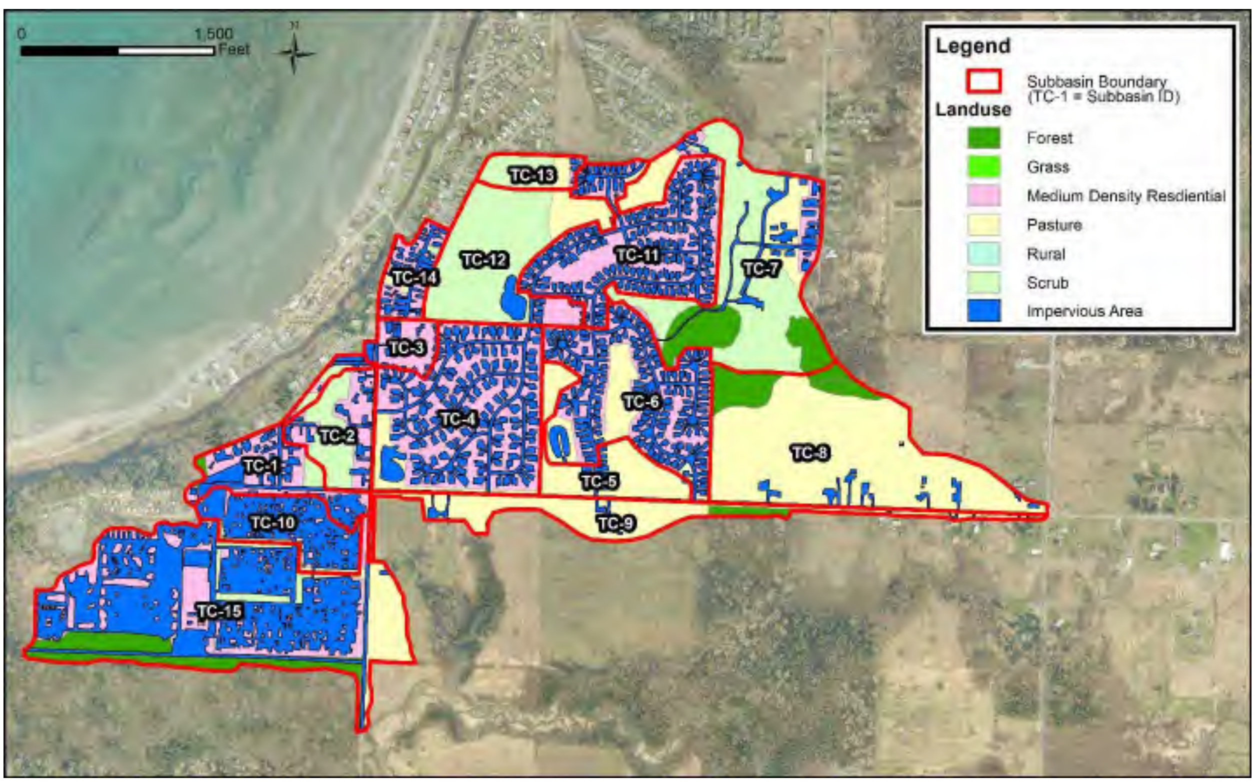

Figure 4-B. Land-use within the Terrell Creek Urban Area Subcatchments

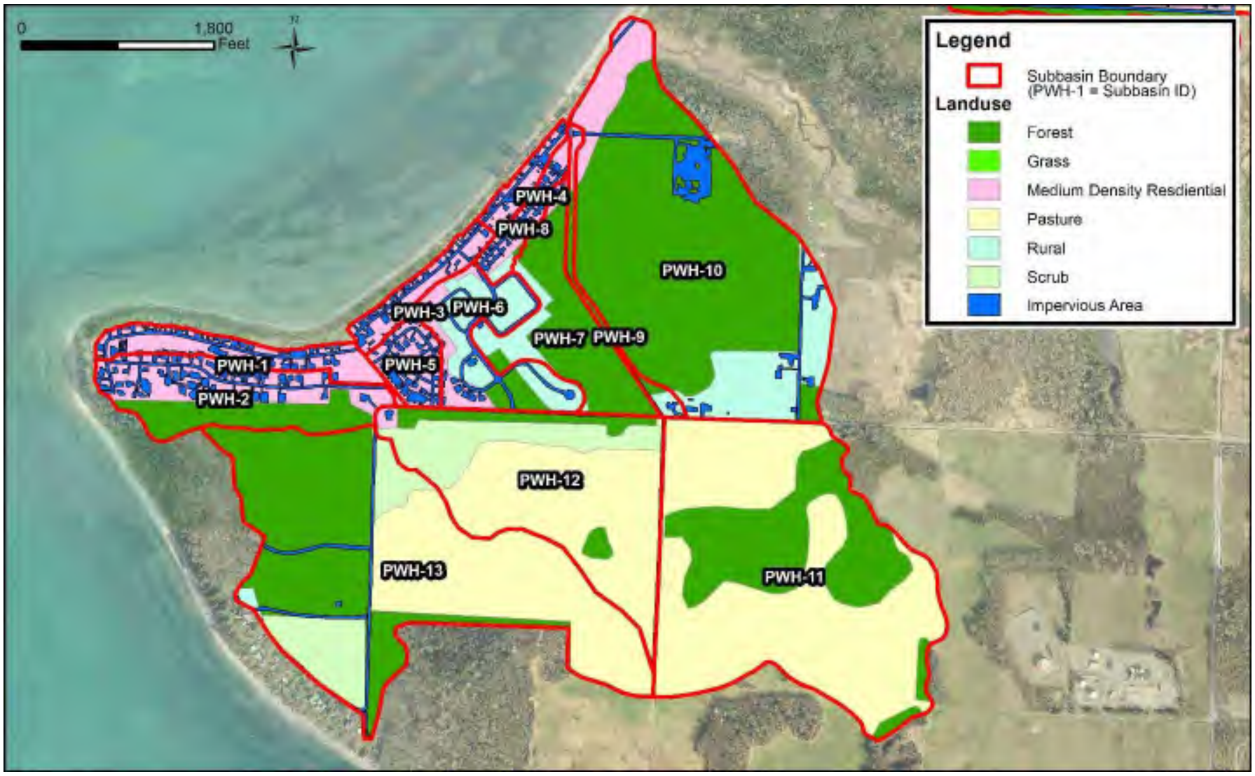

Figure 4-C. Land-use within the Point Whitehorn Subcatchments

Future Development

In 2013, the Birch Bay UGA, which includes portions of the BP-TC-PW subwatersheds, was added to Whatcom County's National Pollutant Discharge Elimination System (NPDES) Phase II permit coverage area. Coverage under this permit requires the County to implement minimum standards for maintenance of the existing stormwater system. Flow control and water quality treatment for new development will be required to meet more stringent minimum technical requirements specified in the 2012 *Stormwater Manual for Western Washington* by December 31, 2016. Until that time, Whatcom County has specified the use of the 2005 manual (Ecology, 2005). Stormwater flow control requirements have the potential to significantly reduce stormwater runoff from developing areas. For this reason, future conditions flow rates are not analyzed or included for the Terrell Creek Urban Area and Point Whitehorn subwatersheds. These subwatersheds are primarily within the county UGA. However, a significant portion and the Birch Point subwatershed is not within the UGA and could potentially develop without flow control. For these areas, an increase in peak stormwater runoff rates may occur with redevelopment so the future developed land use condition is included as part of this analysis.

HYDRAULIC MODEL DEVELOPMENT

The storm drainage system within the three BP-TC-PW subwatersheds is complex and requires a sophisticated hydraulic model such as the SWMM5 model (USEPA, 2011). SWMM5 can represent tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as natural and constructed detention facilities. It is well-suited for hydraulic analysis of the SWMPIII storm drainage system.

Runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. The routing portion of SWMM5 conveys this runoff through a system of pipes, channels, storage, and outfalls. SWMM5 tracks the flow rate and volume of water in each pipe and channel.

Model Extents

Three separate SWMM5 models were developed for the three subwatersheds included in the SWMPIII. Individual subbasins are assigned independent outfalls to measure water volume at the point of discharge. The SWMM5 models generally include all surveyed pipes and ditches, although very short conduits were eliminated to improve stability.

Conveyance System Data Inputs

The storm drainage inventory data collected for this project by Whatcom County and Land Development Engineering and Survey, Inc. (LDES) were used as the primary sources of data for the SWMM5 model network. This data consisted of pipe, culvert, ditches, manholes, catch basins, and drain points. Other data sources included a topographic grid surface derived from LiDAR mapping, as-constructed drawings, and observations made during field reconnaissance.

Storm drain and culvert pipe characteristics were obtained from the Whatcom County GIS geodatabase. Data elements included pipe size, upstream and downstream invert elevations, pipe material, and conduit length. Catch basin and manhole information was also obtained from the storm drainage inventory. Data elements included geographic coordinates (northing and easting), rim elevation and structure invert elevation. Manning's roughness coefficients for pipes were based on pipe material assuming fair condition. Smooth pipes (e.g., concrete, polyvinyl chloride, high density polyethylene) were assigned a roughness coefficient of 0.012 and rough pipes (e.g., corrugated metal) were assigned a coefficient of 0.024. An entrance loss coefficient of 0.5 was assigned to pipes where transitions from open-channel flow to closed conduit flow exist. An exit loss coefficient of 1.0 was assumed for pipes that discharge to open channels.

Open channel (roadside ditch and natural channel) characteristics were estimated from approximate field measurements for bottom width, side slope, and depth. Invert elevations were obtained from the topographic survey. Roadside ditches and natural channels were assumed to have a trapezoidal shape with varying width and depth. Channel dimensions were based primarily on a windshield survey, with measurements obtained at representative channel sections. Channels were assigned a roughness coefficient of 0.035, assuming an average maintained condition. The level of accuracy used to dimension most ditches channel sections is appropriate for this planning-level analysis because flow through the roadside ditch and culvert system in the three subwatersheds is controlled by culvert size and material rather than channel characteristics. However, certain ditches were measured in the field on a case-by-case basis when known problems had been reported or were observed in the hydraulic model.

Generally, overflow channels for roadway culverts were not included in the model unless preliminary model runs indicted surface flooding. For these cases, overflow conduits were added as approximate open channels with a 10-foot bottom width and 10:1 side slopes. A roughness coefficient of 0.024 was assigned to overflow channels.

Overtopping elevations for surveyed structures corresponded to the rim elevation of the catch basin or manhole. Overtopping for drain points associated with open channels was estimated from Lidar mapping, this elevation was measured from the Lidar. The Lidar derived data were adjusted at some locations where they were determined to be inaccurate due to vegetation or other obstructions. For these cases, the overtopping elevation was replaced with a value obtained from a nearby point in an unobstructed area. Topographic survey points collected at the top of ditches were also used supplemented for the Lidar when available.

Model nodes, representing catch basin and manholes are named using the facility identifier number assigned by county during their inventory (ex. 1500). An alphabetical prefix was used for gravity mains, culverts, and ditches, and other drainage pipes. Gravity main pipes are named with "GM", culverts begin with a "C", and open ditches begin with an "OD" prefix. For example, a ditch may be donated "OD1000". Overtopping conduits were assigned the suffix "-OF" and includes the two node names connecting the upstream and downstream ends (ex. 1500_LDES1600-OF). Weirs are assign a "-W" suffix and orifices are assigned a "-O" suffix. Nodes obtained from LDES were given a "LDES" prefix in front on each identification number (ex. LDES1600). Nodes created by Tetra Tech were assigned a "TT" prefix (ex. TT1600). Elevation data for Tetra Tech nodes was sampled using existing Lidar or interpolated between known elevation points.

Boundary Conditions

No boundary conditions were assigned to outfall nodes used to model the SWMPIII subwatersheds. Outfalls use a free discharge condition because the elevation at the point of discharge is sufficiently above the Mean Higher High Water (MHHW) datum set at 7.9 feet.

Inflow Nodes

Runoff time-series were exported from the HSPF model for each subcatchments shown in Figure 1. Runoff time-series were input to the SWMM5 model at discrete locations corresponding to the HSPF subcatchments. The SWMM5 model has a higher level of detail for the conveyance system than the HSPF model, so the runoff time series flows were split based on approximate tributary area.

Design Events

Design event hydrographs were extracted from the HSPF time-series data to represent the 2-, 25-, and 100-year peak flow conditions. Design events were created by performing a Log-Pearson III analysis on the annual maximum flows for each SWMPIII subwatershed. Peak flows calculated as part of the analysis were cross-referenced with the hourly maximum flow time-series in order to query the total number of events occurring for the period of record. The design event that was selected for analysis was chosen after reviewing candidate hydrographs for the 2-, 25-, and 100-year events; design events were selected with engineer's best judgment based on uniform shape and volume. Each subwatershed uses separate design events due to varying land-use. The event scaling factor adjusts the chosen hydrograph to match the calculated peak flow value.

HYDRAULIC MODELING RESULTS

Design event flow hydrographs described in Table 4 were routed through the SWMM5 hydraulic models to estimate peak flows and depths throughout the three subwatersheds. The chosen events from the hydrologic models were used as inputs to the hydraulic model to evaluate the performance of the stormwater conveyance system and identify flood problem areas in the subwatershed and capacity limitations in the storm drainage network.

System Performance

The hydraulic analysis showed that the storm drain system in the BP-TC-PW subwatersheds have adequate capacity to convey the 2-year event throughout the majority of the project area. However, there are several areas where flooding is predicted due to undersized storm drain pipelines or roadside ditches and culverts. Most flooding occurs from storms exceeding the 25-year event. Notable flood locations include the following:

- Holeman Ave. south of Birch Bay Drive (Point Whitehorn subwatershed)
- Birch Bay Drive north of Holeman Ave. (Point Whitehorn subwatershed)

- Sunset Drive near Jackson Road (Terrell Creek Urban Area subwatershed)
- Semiahmoo Drive near Normar Place (Birch Point subwatershed)
- Semiahmoo Drive south of Oertel Drive (Birch Point subwatershed)

TABLE 4
DESIGN EVENTS FOR HYDRAULIC INPUT

	Start Date	End Date	Duration	Scale Factor
Birch Point Subwatershed				
2 Year	11/13/1953 12:00	11/14/1953 12:00	24 Hours	1.0
25 Year	1/16/1996 21:00	1/17/1996 21:00	24 Hours	1.5
100 Year	1/16/1996 21:00	1/17/1996 21:00	24 Hours	2.0
Terrell Creek Urban Area Subwatershed				
2 Year	4/17/1969 00:00	4/18/1969 00:00	24 Hours	1.0
25 Year	8/15/1989 00:00	8/16/1989 00:00	24 Hours	1.0
100 Year	8/15/1989 00:00	8/16/1989 00:00	24 Hours	1.27
Point Whitehorn Subwatershed				
2 Year	1/28/1960 00:00	1/30/1960 00:00	48 Hours	1.0
25 Year	2/15/1986 00:00	2/16/1986 00:00	24 Hours	1.0
100 Year	2/15/1986 00:00	2/16/1986 00:00	24 Hours	1.5

Peak Flow Rates and System Capacity

Table shows the routed peak flow rated predicted by the SWMM model using the HSPF flow inputs at selected locations in the watershed.

Hydraulic modeling results were reviewed to assess the existing condition peak flow and conveyance capacity of the primary conveyance routes in each subbasin. Many of the problem areas in the subwatershed are due to flows exceeding the capacity of the system. Capacity was defined as the maximum flow that could be conveyed through the system with 0.5 feet of freeboard, per County design standards (Whatcom County, 2002). Capacity is exceeded when a drainage structure has less than 0.5 feet of freeboard during a storm event.

Future conditions flows were evaluated for the Birch Point subwatershed due to the expected increase impervious area stemming from future development. Table 5 summarizes the impact on future development on peak flows rates for the Birch Point subwatershed. Table 6 summarizes the existing conditions flows and system capacity in the Terrell Creek and Point Whitehorn subwatersheds. Reporting locations are shown in Figure 5-C.

TABLE 5
BIRCH POINT FLOWS AND SYSTEM CAPACITY

Reporting Location[a]	Location	Pipe Size (in)	2-Year			25-Year			100-Year			Max Flow Before Flooding (cfs)
			Ex	Fu	%	Ex	Fu	%	Ex	Fu	%	
1	Hogan Street	12	1.7	2.7	37	2.4	4.7	49	3.2	6.7	52	> 100 Year
2	Normar Place (Upper)	12	2.4	3.5	31	3.3	5.0	34	4.4	6.1	28	> 100 Year
3	Semiahmoo Dr. nr. Normar Pl.	12	2.7	2.8	4	6.7	8.3	19	9.4	12.1	22	3 cfs
4	Cary Lane near Charel Drive	12	3.5	6.1	43	7.2	10.6	32	9.3	13.9	33	> 100 Year
5	Semiahmoo Dr. (DNR Outfall)	18	10.4	16.6	37	27.4	33.9	19	36.2	46.3	22	> 100 Year
6	Semiahmoo Dr. at Birch Point Rd.	N/A	3.4	11.4	70	6.9	19.4	64	8.3	44.0	81	> 100 Year
7	Birch Point Rd. (Private Outfall)	36	4.3	10.7	60	30.5	34.3	11	38.4	43.6	12	< 2 Year[b]
8	Birch Point Rd. weet of Bay Ridge Rd.	24	7.3	16.8	57	21.2	24.4	13	24.4	28.1	13	> 100 Year
9	Selder Road at Skyvue Rd.	18	10.8	13.4	19	15.8	23.2	32	17.0	29.5	42	11 cfs
10	Birch Point Road at Selder Rd.	18	8.9	15.3	42	30.4	34.7	12	39.7	44.0	10	> 100 Year

cfs = cubic feet per second
a. See Figure 5-A.
b. Flow in table represents functioning condition however flume has collapsed and no longer able to convey flow.

TABLE 6
TERRELL CREEK AND POINT WHITEHORN FLOWS AND SYSTEM CAPACITY

Reporting Location[a]	Location	Pipe Size (in)	Existing Condition Predicted Peak Flow (cfs) 2-Year	25-Year	100-Year	Max Flow Before Flooding (cfs)
	Terrell Creek Urban Area Subwatershed					
1	Highland Dr. south of Elaine Street	24	13.4	32.0	38.7	> 100 Year
2	Highland Dr. north of Elaine Street	12	1.0	2.5	3.2	> 100 Year
3	Bay Road east of Jackson Road	18	11.7	13.2	13.3	> 100 Year
4	Jackson Road at Key Street	12	9.0	14.4	16.2	6.0 cfs
	Point Whitehorn Subwatershed					
1	Holeman Ave Outfall	24	2.7	8.6	11.9	> 100 Year
2	Inflow from Whitehorn Way	18	0.9	3.3	4.9	>100 Year
3	Birch Bay Drive Outfall	18	2.6	5.4	10.0	> 100 Year
4	Inflow from Petticote Lane	12	1.5	4.9	7.3	3.6 cfs
5	Point Whitehorn Road Outfall	18	5.9	12.5	14.2	> 100 Year
6	Koehn Road at Maple Way Outfall	24	4.6	10.4	15.5	> 100 Year

cfs = cubic feet per second
a. See Figures 5-B and 5-C.

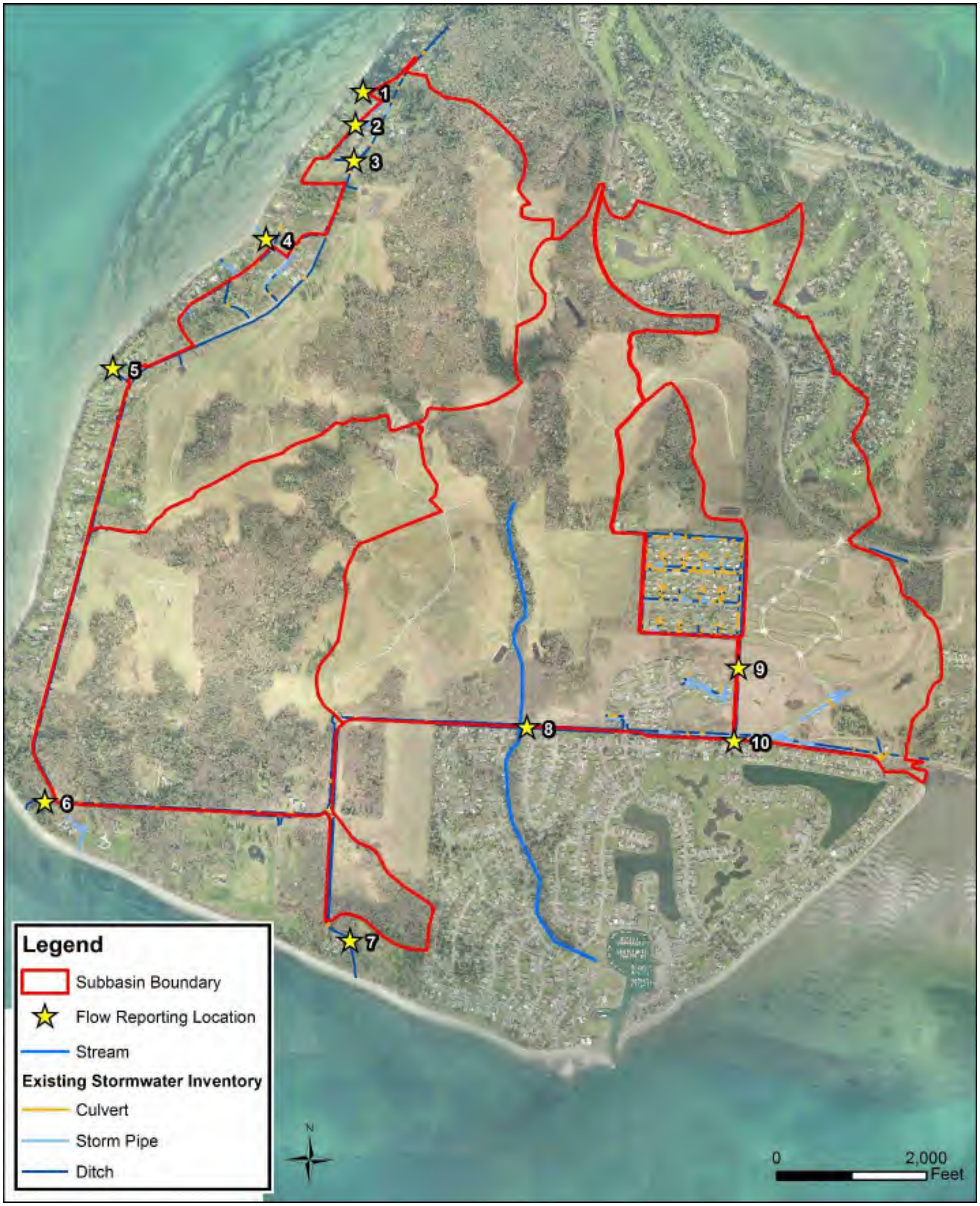

Figure 5-A. Peak flow reporting locations for Birch Point Subwatershed

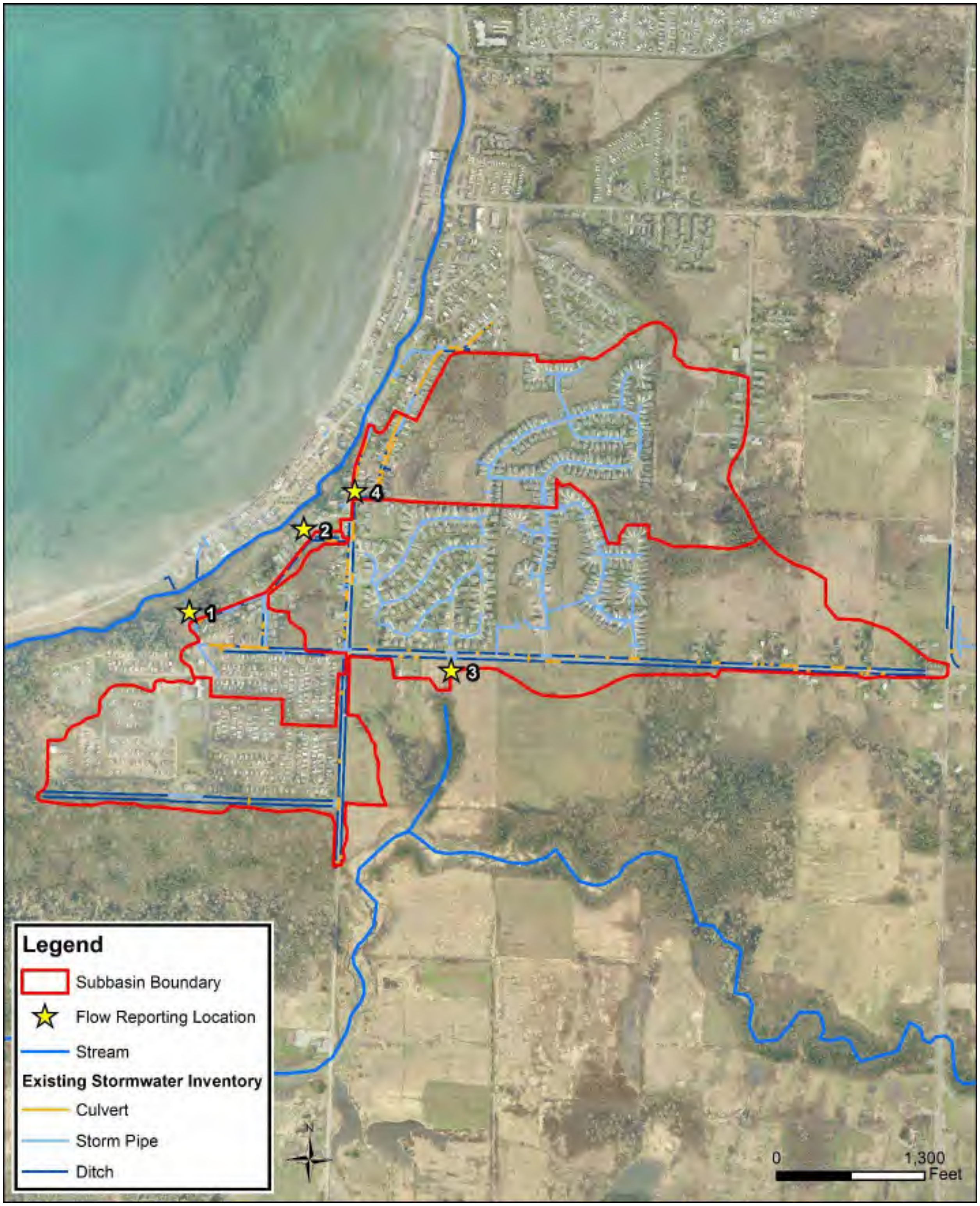

Figure 5-B. Peak flow reporting locations for Terrell Creek Urban Subwatershed

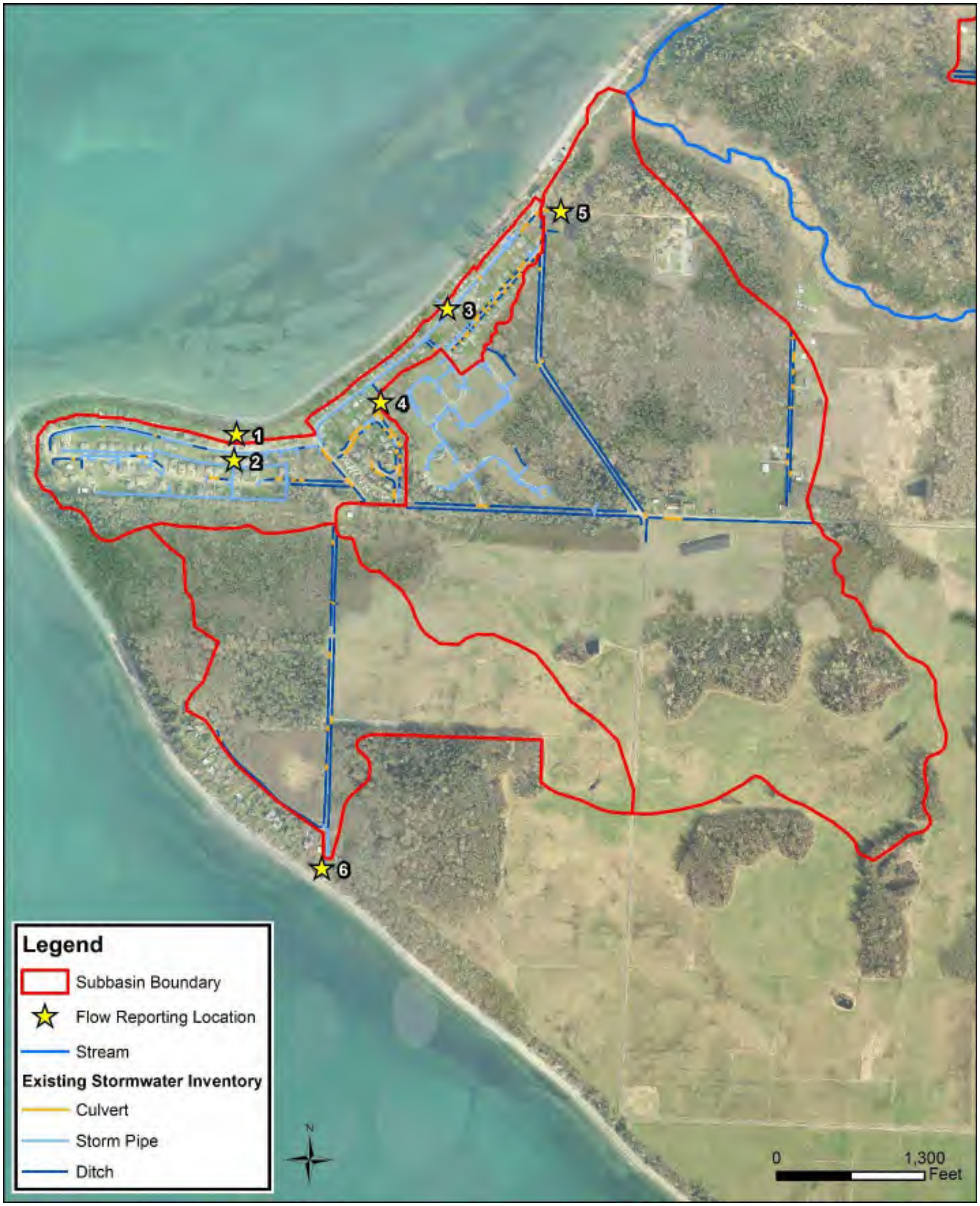

Figure 5-C. Peak flow reporting locations for Point Whitehorn Subwatershed

Flood Problem Areas

The hydraulic analysis was performed using the SWMM5 models to identify locations where flooding is predicted under existing and future conditions. Flooding was assumed when modeled peak depth at a model node exceeded the assumed overtopping elevation. Nodes with overtopping were grouped into problem areas based on the cause and location of flooding. The analysis showed that flooding is predicted at 11 locations in the BP-TC-PW subwatersheds. Six problem areas had been identified as areas were flooding occurred in the past as documented by incident reports or previous analysis on-file with the Birch Bay Public Works; flood problems had not previously been identified at the other five locations. Table 7 lists the flood problem areas by subbasin. Flood problem areas are also shown on Figures 6-A through Figure 6-C. Full model output is provided in Attachment B.

TABLE 7
DRAINAGE PROBLEMS IDENTIFIED FROM HYDRAULIC MODELING

ID[a]	Location	Extent	Triggering Event Existing	Triggering Event Future	Probable Cause
Birch Point Subwatershed					
BP-2	Semiahmoo Drive	Semiahmoo Dr. near Normar Pl.	25-Year	25-Year	Undersized 12-inch culvert crossing Semiahmoo Drive
BP-5	Semiahmoo Drive	8615 Semiahmoo Drive	N/A	25-Year	Undersized 18-inch culvert crossing Semiahmoo Drive
BP-6	Semiahmoo Drive	Semiahmoo Dr. north of Birch Point Rd.	25-Year	2-Year	Undersized 12-inch culvert crossing Birch Point Road
BP-8	Birch Point Road	Birch Point Rd. east of Paton Ave.	25-Year	25-Year	Multiple undersized culverts along Birch Point Road
BP-15	Selder Road	Selder Rd. at Skyvue Rd.	25-Year	2-Year	Multiple undersized culverts along Selder Road
Terrell Creek Urban Subwatershed					
TC-1	Bay Road	Bay Road at Jackson Road	25-year	N/A	Undersized culverts and high downstream flow depth
TC-7	Key Street	Key Street east of Jackson Road	2-Year	N/A	Multiple undersized culvert at various locations
Point Whitehorn Subbasin					
PW-9	Holeman Avenue	Holeman Ave. west of Birch Bay Dr.	25-Year	N/A	Undersized 12-inch culverts on Holeman Ave.
PW-10	Petticote Lane	Petticote Lane near Holeman Ave.	25-year	N/A	Undersized 12-inch culverts draining Petticote Lane
PW-11	Birch Bay Drive	Birch Bay Dr. between Holeman Ave and Jill Street	25-year	N/A	Undersized 12-inch storm drain along Birch Bay Road
PW-15	Birch Bay Drive	Birch Bay Dr. between Jill St. and Point Whitehorn Way	25-Year	N/A	Undersized 12-inch storm drain along Birch Bay Road

See Figure 6-A, 6-B, and 6-C

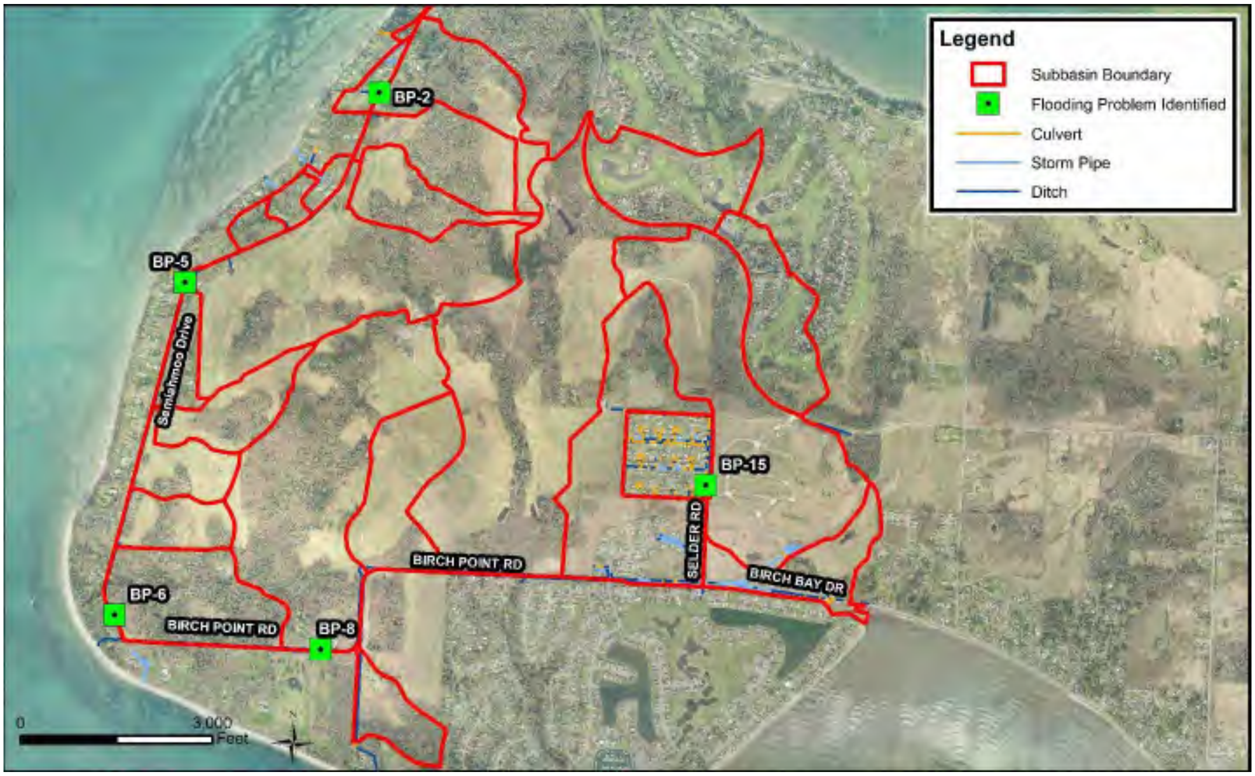

Figure 6-A. Flooding problems identified for the Birch Point subwatershed

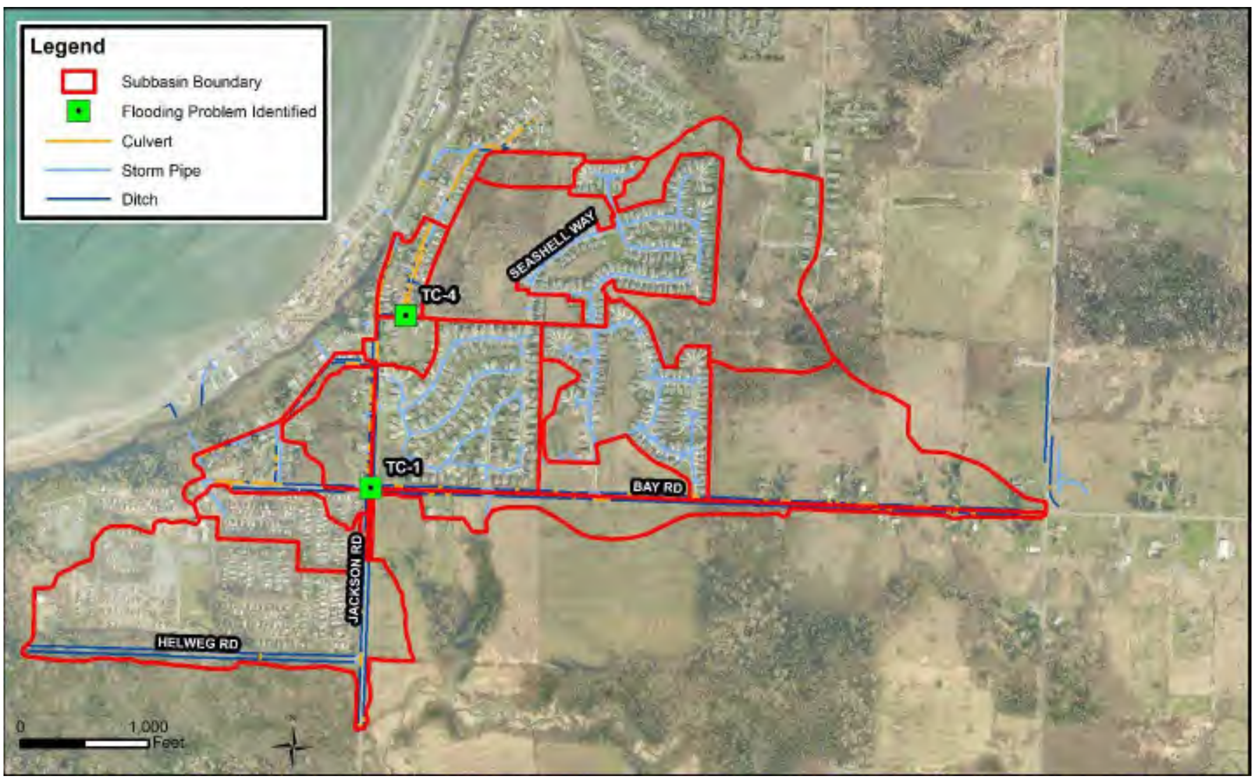

Figure 6-B. Flooding problems identified for the Terrell Creek Urban Area subwatershed

Figure 6-C. Flooding problems identified for the Point Whitehorn subwatershed

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Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

Hydrologic and Hydraulic Analysis of the Surface Water System in the Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

ATTACHMENT A. HSPF LAND CATEGORY ASSIGNMENTS

Table A-1

HSPF Land Category Assignments

	Subbasin	Birch Point North									
	PERLND	**BP-1**	**BP-2**	**BP-3**	**BP-4**	**BP-5**	**BP-6**	**BP-7**	**BP-8**	**BP-9**	**BP-10**
		1.48	6.52	26.55	83.75	28.95	196.29	5.82	7.89	8.37	20.07
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	C, Forest, Flat	0.00	0.00	5.06	17.50	5.05	37.08	0.10	0.29	0.51	4.05
32	C, Forest, Mod	0.00	0.00	11.64	26.06	6.13	42.53	1.28	2.72	2.87	11.01
33	C, Forest, Steep	0.01	0.00	2.58	2.37	0.34	4.43	0.82	2.77	1.48	2.15
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	C, Pasture, Flat	0.00	0.03	0.09	15.10	7.65	52.90	0.00	0.00	0.00	0.15
38	C, Pasture, Mod	0.00	0.52	0.34	21.06	8.07	52.17	0.00	0.00	0.00	0.05
39	C, Pasture, Steep	0.00	1.70	0.31	1.67	1.70	6.58	0.00	0.00	0.00	0.00
40	C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	C, Lawn, Flat	0.03	0.18	0.81	0.00	0.00	0.10	0.28	0.07	0.26	0.92
44	C, Lawn, Mod	0.31	1.19	4.24	0.00	0.00	0.33	1.90	0.38	2.14	1.65
45	C, Lawn, Steep	1.13	2.91	1.48	0.00	0.00	0.16	1.44	1.66	1.11	0.09
46	D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	D, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	D, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	D, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	D, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	0.19	1.90	3.60	2.59	0.79	5.72	2.18	1.18	0.65	1.22
	Total	1.66	8.43	30.14	86.33	29.74	202.01	8.00	9.07	9.02	21.29
	Pervious	1.48	6.52	26.55	83.75	28.95	196.29	5.82	7.89	8.37	20.07
	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	1.48	6.52	26.55	83.75	28.95	196.29	5.82	7.89	8.37	20.07
	D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Forest	0.01	0.00	19.27	45.93	11.53	84.04	2.19	5.78	4.86	17.21
	Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pasture	0.00	2.25	0.75	37.82	17.42	111.65	0.00	0.00	0.00	0.21
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	1.47	4.27	6.53	0.00	0.00	0.59	3.63	2.11	3.51	2.65
	Flat	0.03	0.20	5.95	32.59	12.70	90.08	0.38	0.36	0.77	5.12
	Mod	0.31	1.71	16.22	47.11	14.20	95.04	3.18	3.10	5.01	12.71
	Steep	1.13	4.61	4.37	4.04	2.04	11.18	2.26	4.43	2.59	2.25

Table A-1
HSPF Land Category Assignments

	Subbasin			Birch Point South				Semiahmoo Uplands		
	PERLND	BP-11	BP-12	BP-13	BP-14	BP-15	BP-23	BP-17	BP-16	BP-20
		40.85	29.40	31.21	79.06	214.50	32.05	286.90	67.03	80.23
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	C, Forest, Flat	4.51	1.98	4.67	32.64	20.93	3.34	31.34	2.24	0.40
32	C, Forest, Mod	4.02	2.85	5.57	39.59	24.08	4.47	51.01	3.55	1.49
33	C, Forest, Steep	0.10	0.22	0.29	2.66	1.60	0.29	9.19	0.55	0.32
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	C, Pasture, Flat	12.86	15.25	10.39	3.27	33.07	1.95	71.61	13.18	2.80
38	C, Pasture, Mod	6.95	6.55	5.86	0.89	10.99	0.55	58.51	12.92	13.86
39	C, Pasture, Steep	1.28	0.81	0.65	0.01	0.66	0.01	7.13	1.59	0.10
40	C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00
41	C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00
42	C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00
43	C, Lawn, Flat	0.00	0.42	1.19	0.00	0.00	2.34	0.00	0.00	0.00
44	C, Lawn, Mod	0.00	1.11	2.25	0.00	0.00	0.79	0.00	0.00	0.02
45	C, Lawn, Steep	0.00	0.21	0.33	0.00	0.00	0.03	0.00	0.00	0.00
46	D, Forest, Flat	4.07	0.00	0.00	0.00	52.48	1.99	12.39	1.03	3.16
47	D, Forest, Mod	3.55	0.00	0.00	0.00	46.80	2.48	16.84	1.74	5.14
48	D, Forest, Steep	0.14	0.00	0.00	0.00	1.61	0.15	2.23	0.15	0.67
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	D, Pasture, Flat	2.64	0.00	0.00	0.00	17.27	12.45	11.74	13.28	19.29
53	D, Pasture, Mod	0.75	0.00	0.00	0.00	4.66	1.17	10.08	14.02	14.92
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.34	0.03	2.69	2.79	2.03
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
56	D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	D, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	8.69
59	D, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	5.59
60	D, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	1.73
	Impervious	1.23	1.32	0.44	2.48	4.50	2.69	9.05	1.94	12.85
	Total	42.08	30.72	31.65	81.54	219.00	34.74	295.95	68.97	93.08
	Pervious	40.85	29.40	31.21	79.06	214.50	32.05	286.90	67.03	80.23
	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	29.71	29.40	31.21	79.06	91.33	13.78	229.90	34.03	19.00
	D	11.14	0.00	0.00	0.00	123.17	18.28	56.99	33.00	61.23
	Forest	16.38	5.05	10.54	74.89	147.50	12.72	122.99	9.25	11.19
	Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pasture	24.46	22.62	16.90	4.17	67.00	16.17	161.75	57.78	53.01
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00
	Lawn	0.00	1.73	3.78	0.00	0.00	3.16	1.01	0.00	16.03
	Flat	24.08	17.65	16.26	35.91	123.75	22.08	127.78	29.73	34.35
	Mod	15.26	10.51	13.69	40.48	86.54	9.46	137.37	32.23	41.02
	Steep	1.51	1.24	1.27	2.67	4.21	0.51	21.75	5.07	4.86

Table A-1

HSPF Land Category Assignments

	Subbasin	Rogers Slough Lower		Rogers Slough Uppper Tributary			
	PERLND	**BP-19**	**BP-18**	**BP-22**	**BP-21**	**BP-24**	**BP-25**
		26.71	44.10	42.12	182.90	55.74	50.80
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00
30	B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00
31	C, Forest, Flat	0.00	8.17	1.30	13.40	6.87	6.37
32	C, Forest, Mod	0.00	12.71	1.04	14.92	7.34	7.25
33	C, Forest, Steep	0.00	1.18	0.61	1.50	0.34	0.53
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
35	C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
36	C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
37	C, Pasture, Flat	0.00	9.09	1.33	30.88	0.00	0.00
38	C, Pasture, Mod	0.00	9.18	0.79	32.96	0.00	0.00
39	C, Pasture, Steep	0.00	0.28	0.63	2.75	0.00	0.00
40	C, Grass, Flat	0.00	0.00	0.00	0.00	10.52	7.21
41	C, Grass, Mod	0.00	0.00	0.00	0.00	11.93	8.03
42	C, Grass, Steep	0.00	0.00	0.00	0.00	1.95	0.58
43	C, Lawn, Flat	0.95	0.00	0.61	0.00	9.27	7.32
44	C, Lawn, Mod	1.73	0.00	0.61	0.00	6.95	6.68
45	C, Lawn, Steep	0.14	0.00	0.63	0.00	0.56	0.49
46	D, Forest, Flat	0.00	0.89	2.27	6.16	0.00	1.17
47	D, Forest, Mod	0.00	2.11	1.80	10.85	0.00	2.48
48	D, Forest, Steep	0.00	0.15	1.89	1.42	0.00	0.61
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
52	D, Pasture, Flat	0.09	0.11	16.69	31.80	0.00	0.00
53	D, Pasture, Mod	0.39	0.15	9.17	32.28	0.00	0.00
54	D, Pasture, Steep	0.12	0.01	2.12	3.96	0.00	0.00
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.41
56	D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.81
57	D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.42
58	D, Lawn, Flat	5.16	0.03	0.11	0.00	0.00	0.08
59	D, Lawn, Mod	16.33	0.03	0.28	0.00	0.00	0.23
60	D, Lawn, Steep	1.77	0.00	0.22	0.01	0.00	0.12
	Impervious	14.59	2.00	4.90	16.20	15.87	13.11
	Total	41.30	46.10	47.02	199.10	71.61	63.90
	Pervious	26.71	44.10	42.12	182.90	55.74	50.80
	A	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00
	C	2.83	40.61	7.57	96.42	55.74	44.46
	D	23.88	3.49	34.55	86.49	0.00	6.34
	Forest	0.00	25.21	8.92	48.25	14.56	18.41
	Shrub	0.00	0.00	0.00	0.00	0.00	0.00
	Pasture	0.60	18.82	30.73	134.64	0.00	0.00
	Grass	0.00	0.00	0.00	0.00	24.40	17.47
	Lawn	26.10	0.07	2.47	0.01	16.78	14.92
	Flat	6.21	18.28	22.32	82.24	26.67	22.56
	Mod	18.46	24.20	13.70	91.02	26.22	25.49
	Steep	2.04	1.62	6.11	9.64	2.85	2.74

Table A-1
HSPF Land Category Assignments (Future Conditions)

	PERLND	Birch Point North									
		BP-1	**BP-2**	**BP-3**	**BP-4**	**BP-5**	**BP-6**	**BP-7**	**BP-8**	**BP-9**	**BP-10**
		1.40	7.85	57.74	53.50	38.53	175.44	5.53	7.49	7.95	19.07
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	**0.00**	0.00	**11.04**	**13.26**	**9.29**	**30.73**	**0.09**	**0.27**	**0.48**	**3.84**
30	B, Lawn, Steep	**0.00**	0.00	**20.89**	**19.79**	**10.94**	**35.29**	**1.21**	**2.58**	**2.72**	**10.46**
31	C, Forest, Flat	**0.01**	0.00	**3.22**	**1.87**	**0.49**	**4.05**	**0.78**	**2.64**	**1.41**	**2.05**
32	C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	C, Shrub, Mod	0.00	**0.09**	**7.31**	**6.40**	**7.94**	**49.58**	0.00	0.00	0.00	**0.15**
36	C, Shrub, Steep	0.00	**1.00**	**8.71**	**11.17**	**8.04**	**49.20**	0.00	0.00	0.00	**0.05**
37	C, Pasture, Flat	0.00	**2.73**	**0.87**	**1.01**	**1.83**	**6.04**	0.00	0.00	0.00	**0.00**
38	C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	C, Grass, Mod	**0.03**	**0.17**	**0.74**	0.00	0.00	**0.10**	**0.27**	**0.07**	**0.24**	**0.87**
42	C, Grass, Steep	**0.30**	**1.14**	**3.72**	0.00	0.00	**0.32**	**1.81**	**0.36**	**2.04**	**1.57**
43	C, Lawn, Flat	**1.07**	**2.73**	**1.23**	0.00	0.00	**0.15**	**1.37**	**1.57**	**1.05**	**0.08**
44	C, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
46	D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
47	D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	D, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	D, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	D, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	D, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	0.26	2.18	7.76	3.99	2.98	14.79	2.47	1.58	1.07	2.22
	Total	1.66	10.04	65.50	57.49	41.51	190.24	8.00	9.07	9.02	21.29
	Pervious	1.40	7.85	57.74	53.50	38.53	175.44	5.53	7.49	7.95	19.07
	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	31.93	33.05	20.24	66.01	1.31	2.85	3.21	14.30
	C	1.40	7.85	25.81	20.45	18.29	109.43	4.22	4.64	4.74	4.77
	D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Forest	0.01	0.00	3.22	1.87	0.49	4.05	0.78	2.64	1.41	2.05
	Shrub	0.00	1.09	16.03	17.56	15.97	98.78	0.00	0.00	0.00	0.20
	Pasture	0.00	2.73	0.87	1.01	1.83	6.04	0.00	0.00	0.00	0.00
	Grass	0.32	1.31	4.46	0.00	0.00	0.41	2.08	0.43	2.28	2.44
	Lawn	1.07	2.73	33.17	33.05	20.24	66.17	2.67	4.43	4.26	14.38
	Flat	1.08	5.45	5.32	2.89	2.32	10.24	2.14	4.21	2.46	2.13
	Mod	0.03	0.26	19.09	19.65	17.23	80.40	0.36	0.34	0.73	4.86
	Steep	0.30	2.14	33.33	30.96	18.98	84.80	3.02	2.95	4.76	12.07

Table A-1

HSPF Land Category Assignments (Future Conditions)

	PERLND	Birch Point South						Semiahmoo Uplands		
		BP-11	**BP-12**	**BP-13**	**BP-14**	**BP-15**	**BP-23**	**BP-17**	**BP-16**	**BP-20**
		38.81	27.93	29.65	75.10	205.27	63.86	274.31	41.90	26.47
1	**A, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**A, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	**A, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**A, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**A, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	**A, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	**A, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	**A, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	**A, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	**A, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	**A, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	**A, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	**A, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	**A, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	**A, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	**B, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	**B, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	**B, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	**B, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	**B, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	**B, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	**B, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	**B, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	**B, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	**B, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	**B, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	**B, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	**B, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	**B, Lawn, Mod**	**4.29**	**1.88**	**4.44**	**31.01**	**19.90**	**2.19**	**13.27**	0.00	0.00
30	**B, Lawn, Steep**	**3.82**	**2.71**	**5.29**	**37.61**	**22.89**	**3.45**	**23.19**	0.00	0.00
31	**C, Forest, Flat**	**0.09**	**0.21**	**0.28**	**2.53**	**1.52**	**0.53**	**5.33**	0.00	0.00
32	**C, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	**C, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	**C, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	**C, Shrub, Mod**	**12.22**	**14.49**	**9.87**	**3.11**	**31.57**	**12.53**	**36.05**	0.00	0.00
36	**C, Shrub, Steep**	**6.60**	**6.22**	**5.57**	**0.84**	**10.46**	**12.28**	**49.81**	0.00	0.00
37	**C, Pasture, Flat**	**1.21**	**0.77**	**0.61**	**0.01**	**0.62**	**1.51**	**5.26**	0.00	0.00
38	**C, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	**C, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	**C, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	**C, Grass, Mod**	0.00	**0.40**	**1.13**	0.00	0.00	0.00	**49.18**	**16.39**	**0.95**
42	**C, Grass, Steep**	0.00	**1.05**	**2.14**	0.00	0.00	0.00	**31.53**	**20.80**	**1.73**
43	**C, Lawn, Flat**	0.00	**0.20**	**0.31**	0.00	0.00	0.00	**5.19**	**1.39**	**0.14**
44	**C, Lawn, Mod**	**3.87**	0.00	0.00	0.00	**50.42**	**0.99**	**9.06**	0.00	0.00
45	**C, Lawn, Steep**	**3.37**	0.00	0.00	0.00	**44.80**	**1.66**	**13.58**	0.00	0.00
46	**D, Forest, Flat**	**0.13**	0.00	0.00	0.00	**1.54**	**0.14**	**1.45**	0.00	0.00
47	**D, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48	**D, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	**D, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	**D, Shrub, Mod**	**2.50**	**0.00**	0.00	0.00	**16.73**	**12.62**	**8.81**	0.00	0.00
51	**D, Shrub, Steep**	**0.71**	0.00	0.00	0.00	**4.48**	**13.32**	**9.32**	0.00	0.00
52	**D, Pasture, Flat**	**0.00**	0.00	0.00	0.00	**0.32**	**2.65**	**2.54**	0.00	0.00
53	**D, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	**D, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	**D, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	**D, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	**5.79**	**0.98**	**5.22**
57	**D, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	**3.92**	**2.19**	**16.57**
58	**D, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	**1.02**	**0.15**	**1.85**
59	**D, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	**D, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	3.28	2.79	2.00	6.43	13.73	1.83	21.64	5.11	19.75
	Total	42.08	30.72	31.65	81.54	219.00	30.39	295.95	68.97	91.90
	Pervious	38.81	27.93	29.65	75.10	205.27	63.86	274.31	41.90	26.47
	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	8.10	4.59	9.73	68.62	42.79	5.64	36.45	0.00	0.00
	C	27.36	23.34	19.92	6.49	139.40	29.50	205.00	38.58	2.83
	D	3.34	0.00	0.00	0.00	23.08	28.73	32.86	3.31	23.63
	Forest	0.22	0.21	0.28	2.53	3.06	0.67	6.78	0.00	0.00
	Shrub	22.03	20.72	15.44	3.95	63.24	50.75	103.99	0.00	0.00
	Pasture	1.21	0.77	0.61	0.01	0.95	4.16	7.80	0.00	0.00
	Grass	0.00	1.45	3.28	0.00	0.00	0.00	90.42	40.36	24.47
	Lawn	15.34	4.78	10.04	68.62	138.02	8.28	65.31	1.54	1.99
	Flat	1.44	1.17	1.20	2.54	4.01	4.83	20.80	1.54	1.99
	Mod	22.88	16.77	15.44	34.11	118.62	28.33	122.16	17.37	6.17
	Steep	14.49	9.99	13.01	38.45	82.64	30.71	131.35	22.99	18.30

Table A-1

HSPF Land Category Assignments (Future Conditions)

	PERLND	Rogers Slough Lower		Rogers Slough Uppper Tributary			
		BP-19	BP-18	BP-22	BP-21	BP-24	BP-25
		72.16	150.88	28.56	28.56	54.00	49.06
1	A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00
2	A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
3	A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
4	A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
5	A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
6	A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
7	A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00
8	A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
9	A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
10	A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
11	A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00
12	A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00
13	A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00
14	A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00
15	A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00
16	B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00
17	B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
18	B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
19	B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
20	B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00
21	B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00
22	B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00
23	B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
24	B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
25	B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
26	B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00
27	B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00
28	B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00
29	B, Lawn, Mod	0.29	0.00	0.00	2.99	0.00	0.00
30	B, Lawn, Steep	0.98	0.00	0.00	4.15	0.00	0.00
31	C, Forest, Flat	0.20	0.00	0.00	0.28	0.00	0.00
32	C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
33	C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
34	C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
35	C, Shrub, Mod	2.60	0.00	0.00	1.90	0.00	0.00
36	C, Shrub, Steep	13.13	0.00	0.00	0.53	0.00	0.00
37	C, Pasture, Flat	0.09	0.00	0.00	0.01	0.00	0.00
38	C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
39	C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
40	C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
41	C, Grass, Mod	0.14	40.18	1.65	0.60	25.87	20.22
42	C, Grass, Steep	0.34	40.17	1.44	0.19	25.37	21.20
43	C, Lawn, Flat	0.08	3.36	1.25	0.01	2.76	1.54
44	C, Lawn, Mod	0.85	0.00	0.00	1.93	0.00	0.00
45	C, Lawn, Steep	2.66	0.00	0.00	2.40	0.00	0.00
46	D, Forest, Flat	0.44	0.00	0.00	0.14	0.00	0.00
47	D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00
48	D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00
49	D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00
50	D, Shrub, Mod	1.09	0.00	0.00	12.25	0.00	0.00
51	D, Shrub, Steep	1.91	0.00	0.00	1.14	0.00	0.00
52	D, Pasture, Flat	0.26	0.00	0.00	0.03	0.00	0.00
53	D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00
54	D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00
55	D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00
56	D, Grass, Mod	25.80	28.69	13.18	0.00	0.00	1.60
57	D, Grass, Steep	17.86	33.78	7.95	0.00	0.00	3.39
58	D, Lawn, Flat	3.45	4.69	3.09	0.00	0.00	1.11
59	D, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00
60	D, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00
	Impervious	14.83	4.20	18.46	48.23	17.61	14.85
	Total	41.30	46.10	47.02	199.10	71.61	63.90
	Pervious	72.16	150.88	28.56	28.56	54.00	49.06
	A	0.00	0.00	0.00	0.00	0.00	0.00
	B	1.27	0.00	0.00	7.14	0.00	0.00
	C	20.08	83.72	4.34	7.86	54.00	42.97
	D	50.81	67.16	24.22	13.56	0.00	6.09
	Forest	0.64	0.00	0.00	0.42	0.00	0.00
	Shrub	18.73	0.00	0.00	15.83	0.00	0.00
	Pasture	0.36	0.00	0.00	0.04	0.00	0.00
	Grass	44.13	142.83	24.22	0.79	51.24	46.41
	Lawn	8.30	8.05	4.34	11.49	2.76	2.65
	Flat	4.52	8.05	4.34	0.47	2.76	2.65
	Mod	30.76	68.87	14.84	19.67	25.87	21.82
	Steep	36.88	73.95	9.39	8.42	25.37	24.59

Table A-1

HSPF Land Category Assignments

	Subbasin	Estuarine Area		Terrell Creek Upper Tributary 1							
	PERLND	**TC-1**	**TC-10**	**TC-3**	**TC-4**	**TC-5**	**TC-6**	**TC-2**	**TC-8**	**TC-9**	**TC-15**
		7.20	2.42	3.24	20.50	9.18	17.09	8.90	41.50	13.42	28.24
1	**A, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**A, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	**A, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	**A, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	**A, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	**A, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	**A, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	**A, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	**A, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	**A, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	**A, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	**A, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	**A, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	**A, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	**A, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	**B, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	**B, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	**B, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	**B, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	**B, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	**B, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	**B, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	**B, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	**B, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	**B, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26	**B, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	**B, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	**B, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	**B, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	**B, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	**C, Forest, Flat**	**0.10**	0.00	0.00	0.00	0.00	**0.02**	0.00	**2.30**	**0.13**	**1.20**
32	**C, Forest, Mod**	**0.18**	0.00	0.00	0.00	0.00	**0.03**	0.00	**2.11**	**0.26**	**2.29**
33	**C, Forest, Steep**	**0.02**	0.00	0.00	0.00	0.00	**0.00**	0.00	**0.10**	**0.03**	**0.59**
34	**C, Shrub, Flat**	**0.68**	**0.55**	0.00	0.00	0.00	**0.02**	**2.98**	0.00	0.00	**1.16**
35	**C, Shrub, Mod**	**0.72**	**0.49**	0.00	0.00	0.00	**0.01**	**1.96**	0.00	0.00	**1.30**
36	**C, Shrub, Steep**	**0.05**	**0.03**	0.00	0.00	0.00	0.00	**0.03**	0.00	0.00	**0.04**
37	**C, Pasture, Flat**	0.00	0.00	0.00	**0.46**	0.00	**1.29**	0.00	**15.10**	**1.13**	**0.56**
38	**C, Pasture, Mod**	0.00	0.00	0.00	**0.37**	0.00	**0.31**	0.00	**2.90**	**0.57**	**0.10**
39	**C, Pasture, Steep**	0.00	0.00	0.00	**0.31**	0.00	**0.04**	0.00	**0.11**	**0.27**	**0.05**
40	**C, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41	**C, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42	**C, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43	**C, Lawn, Flat**	**3.44**	**0.96**	0.00	**0.35**	0.00	**4.75**	**2.66**	**0.01**	0.00	**6.46**
44	**C, Lawn, Mod**	**1.85**	**0.39**	0.00	**0.13**	0.00	**1.52**	**0.86**	**0.00**	0.00	**3.43**
45	**C, Lawn, Steep**	**0.10**	**0.00**	0.00	**0.05**	0.00	**0.07**	**0.07**	**0.00**	0.00	**0.26**
46	**D, Forest, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.42**	**0.21**	**1.73**
47	**D, Forest, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.25**	**0.41**	**1.95**
48	**D, Forest, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	**0.03**	**0.12**
49	**D, Shrub, Flat**	0.00	0.00	**0.02**	**0.10**	0.00	0.00	0.00	0.00	0.00	0.00
50	**D, Shrub, Mod**	0.00	0.00	**0.00**	**0.02**	0.00	0.00	0.00	0.00	0.00	0.00
51	**D, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	**D, Pasture, Flat**	0.00	0.00	0.00	**0.49**	**6.98**	**2.13**	0.00	**15.16**	**7.84**	**4.20**
53	**D, Pasture, Mod**	0.00	0.00	0.00	**0.14**	**1.46**	**0.88**	0.00	**2.82**	**1.71**	**0.54**
54	**D, Pasture, Steep**	0.00	0.00	0.00	**0.47**	**0.54**	**0.45**	0.00	**0.19**	**0.82**	**0.10**
55	**D, Grass, Flat**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	**D, Grass, Mod**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	**D, Grass, Steep**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	**D, Lawn, Flat**	**0.03**	0.00	**2.78**	**14.88**	**0.13**	**4.78**	**0.23**	0.00	0.00	**1.19**
59	**D, Lawn, Mod**	**0.02**	0.00	**0.41**	**2.48**	**0.07**	**0.68**	**0.09**	0.00	0.00	**0.95**
60	**D, Lawn, Steep**	**0.01**	0.00	**0.02**	**0.26**	**0.01**	**0.11**	**0.03**	0.00	0.00	**0.02**
	Impervious	5.77	9.08	1.33	15.16	1.22	12.21	2.02	2.33	2.00	33.31
	Pervious	7.20	2.42	3.24	20.50	9.18	17.09	8.90	41.50	13.42	28.24
	Total	12.96	11.50	4.57	35.66	10.40	29.30	10.92	43.83	15.43	61.55
	A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	C	7.14	2.42	0.00	1.66	0.00	8.06	8.56	22.65	2.39	17.44
	D	0.06	0.00	3.24	18.84	9.18	9.03	0.34	18.85	11.03	10.80
	Forest	0.30	0.00	0.00	0.00	0.00	0.06	0.00	5.19	1.08	7.89
	Shrub	1.45	1.06	0.03	0.12	0.00	0.02	4.98	0.00	0.00	2.50
	Pasture	0.00	0.00	0.00	2.24	8.97	5.10	0.00	36.29	12.35	5.55
	Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Lawn	5.44	1.35	3.21	18.14	0.21	11.90	3.92	0.02	0.00	12.30
	Flat	4.24	1.50	2.80	16.27	7.11	13.00	5.87	33.00	9.32	16.50
	Mod	2.77	0.88	0.41	3.14	1.53	3.43	2.91	8.09	2.95	10.57
	Steep	0.19	0.03	0.02	1.09	0.54	0.66	0.12	0.42	1.15	1.17

Table A-1

HSPF Land Category Assignments

Subbasin		Terrell Creek Urban Area North				
PERLND		**TC-11**	**TC-12**	**TC-13**	**TC-14**	**TC-7**
		15.73	21.71	4.34	3.30	35.24
1	**A, Forest, Flat**	0.00	0.00	0.00	0.00	0.00
2	**A, Forest, Mod**	0.00	0.00	0.00	0.00	0.00
3	**A, Forest, Steep**	0.00	0.00	0.00	0.00	0.00
4	**A, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00
5	**A, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00
6	**A, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00
7	**A, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00
8	**A, Pasture, Mod**	0.00	0.00	0.00	**0.00**	0.00
9	**A, Pasture, Steep**	0.00	0.00	0.00	**0.00**	0.00
10	**A, Grass, Flat**	0.00	0.00	0.00	0.00	0.00
11	**A, Grass, Mod**	0.00	0.00	0.00	0.00	0.00
12	**A, Grass, Steep**	0.00	0.00	0.00	0.00	0.00
13	**A, Lawn, Flat**	0.00	0.00	0.00	**0.00**	0.00
14	**A, Lawn, Mod**	0.00	0.00	0.00	**0.01**	0.00
15	**A, Lawn, Steep**	0.00	0.00	0.00	**0.09**	0.00
16	**B, Forest, Flat**	0.00	0.00	0.00	0.00	0.00
17	**B, Forest, Mod**	0.00	0.00	0.00	0.00	0.00
18	**B, Forest, Steep**	0.00	0.00	0.00	0.00	0.00
19	**B, Shrub, Flat**	0.00	0.00	0.00	0.00	0.00
20	**B, Shrub, Mod**	0.00	0.00	0.00	0.00	0.00
21	**B, Shrub, Steep**	0.00	0.00	0.00	0.00	0.00
22	**B, Pasture, Flat**	0.00	0.00	0.00	0.00	0.00
23	**B, Pasture, Mod**	0.00	0.00	0.00	0.00	0.00
24	**B, Pasture, Steep**	0.00	0.00	0.00	0.00	0.00
25	**B, Grass, Flat**	0.00	0.00	0.00	0.00	0.00
26	**B, Grass, Mod**	0.00	0.00	0.00	0.00	0.00
27	**B, Grass, Steep**	0.00	0.00	0.00	0.00	0.00
28	**B, Lawn, Flat**	0.00	0.00	0.00	0.00	0.00
29	**B, Lawn, Mod**	0.00	0.00	0.00	0.00	0.00
30	**B, Lawn, Steep**	0.00	0.00	0.00	0.00	0.00
31	**C, Forest, Flat**	**0.00**	0.00	0.00	0.00	**2.41**
32	**C, Forest, Mod**	**0.00**	0.00	0.00	0.00	**1.94**
33	**C, Forest, Steep**	0.00	0.00	0.00	0.00	**0.11**
34	**C, Shrub, Flat**	**0.03**	0.00	0.00	0.00	**5.11**
35	**C, Shrub, Mod**	**0.01**	0.00	0.00	0.00	**1.99**
36	**C, Shrub, Steep**	0.00	0.00	0.00	0.00	**0.08**
37	**C, Pasture, Flat**	0.00	0.00	0.00	0.00	**1.89**
38	**C, Pasture, Mod**	0.00	0.00	0.00	0.00	**0.61**
39	**C, Pasture, Steep**	0.00	0.00	0.00	0.00	**0.00**
40	**C, Grass, Flat**	0.00	0.00	0.00	0.00	0.00
41	**C, Grass, Mod**	0.00	0.00	0.00	0.00	0.00
42	**C, Grass, Steep**	0.00	0.00	0.00	0.00	0.00
43	**C, Lawn, Flat**	**0.48**	**0.01**	0.00	**0.01**	**1.41**
44	**C, Lawn, Mod**	**0.12**	**0.00**	0.00	**0.06**	**0.38**
45	**C, Lawn, Steep**	0.00	0.00	0.00	**0.16**	**0.02**
46	**D, Forest, Flat**	**0.00**	0.00	0.00	0.00	**1.12**
47	**D, Forest, Mod**	**0.00**	0.00	0.00	0.00	**0.81**
48	**D, Forest, Steep**	0.00	0.00	0.00	0.00	**0.03**
49	**D, Shrub, Flat**	**0.43**	**8.61**	**1.84**	**0.18**	**9.67**
50	**D, Shrub, Mod**	**0.17**	**7.74**	**1.46**	**0.03**	**3.38**
51	**D, Shrub, Steep**	**0.04**	**0.63**	**0.04**	0.00	**0.22**
52	**D, Pasture, Flat**	**0.15**	**2.41**	**0.72**	**0.25**	**3.21**
53	**D, Pasture, Mod**	**0.27**	**0.43**	**0.05**	**0.12**	**0.33**
54	**D, Pasture, Steep**	**0.02**	**0.06**	0.00	**0.06**	**0.00**
55	**D, Grass, Flat**	0.00	0.00	0.00	0.00	0.00
56	**D, Grass, Mod**	0.00	0.00	0.00	0.00	0.00
57	**D, Grass, Steep**	0.00	0.00	0.00	0.00	0.00
58	**D, Lawn, Flat**	**9.86**	**1.29**	**0.15**	**1.78**	**0.43**
59	**D, Lawn, Mod**	**3.99**	**0.39**	**0.08**	**0.50**	**0.08**
60	**D, Lawn, Steep**	**0.15**	**0.12**	0.00	**0.06**	0.00
	Impervious	12.76	1.71	0.20	2.62	4.16
	Pervious	15.73	21.71	4.34	3.30	35.24
	Total	28.49	23.42	4.54	5.92	39.40
	A	0.00	0.00	0.00	0.10	0.00
	B	0.00	0.00	0.00	0.00	0.00
	C	0.65	0.01	0.00	0.23	15.94
	D	15.09	21.69	4.34	2.97	19.30
	Forest	0.01	0.00	0.00	0.00	6.42
	Shrub	0.68	16.98	3.34	0.21	20.46
	Pasture	0.45	2.90	0.76	0.43	6.04
	Grass	0.00	0.00	0.00	0.00	0.00
	Lawn	14.60	1.82	0.23	2.66	2.32
	Flat	10.94	12.33	2.71	2.21	25.24
	Mod	4.58	8.56	1.59	0.72	9.53
	Steep	0.21	0.81	0.04	0.37	0.47

Table A-1

HSPF Land Category Assignments

Subbasin			Point Whitehorn			Point Whitehorn Uplands							South
PERLND	PWH-1	PWH-2	PWH-3	PWH-4	PWH-5	PWH-6	PWH-7	PWH-8	PWH-9	PWH-10	PWH-11	PWH-12	PWH-13
	10.05	27.88	5.83	3.34	5.10	21.22	28.24	5.20	4.49	121.79	134.06	72.16	124.74
1 A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00
2 A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00
3 A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
4 A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6 A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7 A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
8 A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
9 A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11 A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12 A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13 A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	0.00	0.00	0.00
14 A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00	0.00
15 A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00
16 B, Forest, Flat	0.00	2.78	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.16	2.06	0.69	0.85
17 B, Forest, Mod	0.00	8.31	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.69	3.24	1.65	2.01
18 B, Forest, Steep	0.00	3.01	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.43	0.52	0.51	0.36
19 B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.84	0.00
20 B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.72	0.00
21 B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00
22 B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	36.38	11.12	0.00
23 B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	2.79	5.61	2.33	0.00
24 B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.21	0.17	0.00
25 B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26 B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27 B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28 B, Lawn, Flat	0.05	2.24	0.00	0.00	0.07	0.31	0.00	0.00	0.00	0.00	0.00	0.47	0.00
29 B, Lawn, Mod	0.15	5.88	0.00	0.00	0.17	0.98	0.00	0.00	0.00	0.00	0.00	0.24	0.00
30 B, Lawn, Steep	0.07	3.68	0.00	0.00	0.07	0.13	0.00	0.00	0.00	0.00	0.00	0.02	0.00
31 C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.17	2.69	0.00	0.05	2.33	4.84	0.49	13.26
32 C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	1.61	6.54	0.00	0.26	3.05	7.63	1.71	16.13
33 C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.26	0.61	0.00	0.16	0.68	0.80	0.92	0.66
34 C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.26	2.39
35 C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	2.63
36 C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.16
37 C, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	5.58	2.18	0.43	0.17	1.10	22.01	10.80	12.12
38 C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	5.93	2.43	0.17	0.61	2.30	8.93	3.84	1.41
39 C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.31	0.07	0.00	0.18	0.69	0.94	0.05	0.07
40 C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
41 C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42 C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
43 C, Lawn, Flat	1.02	0.39	2.70	0.00	1.15	1.12	0.00	0.28	0.00	0.00	0.00	0.00	0.00
44 C, Lawn, Mod	6.34	0.87	2.50	0.00	3.34	1.98	0.00	0.24	0.00	0.00	0.00	0.00	0.00
45 C, Lawn, Steep	2.41	0.73	0.08	0.00	0.30	0.09	0.00	0.02	0.00	0.00	0.00	0.00	0.00
46 D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	4.54	0.14	0.80	36.73	9.71	0.31	10.98
47 D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	6.87	0.18	1.20	43.21	12.30	0.48	10.98
48 D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.01	0.13	6.66	0.90	0.20	0.47
49 D, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	8.05
50 D, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	3.33
51 D, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.10
52 D, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	1.40	0.45	0.12	0.00	8.88	13.44	17.56	37.32
53 D, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.12	0.50	0.04	0.00	1.96	3.72	1.19	1.37
54 D, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.15	0.61	0.14	0.09
55 D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56 D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57 D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58 D, Lawn, Flat	0.00	0.00	0.27	2.64	0.00	0.00	0.36	2.18	0.29	2.70	0.00	0.00	0.00
59 D, Lawn, Mod	0.00	0.00	0.29	0.68	0.00	0.00	0.34	1.28	0.52	2.17	0.00	0.00	0.00
60 D, Lawn, Steep	0.00	0.00	0.01	0.02	0.00	0.00	0.02	0.09	0.11	1.22	0.00	0.00	0.00
Impervious	5.45	7.55	3.35	2.19	4.22	5.12	0.90	2.40	1.38	7.67	0.66	2.35	3.71
Pervious	10.05	27.88	5.83	3.34	5.10	21.22	28.24	5.20	4.49	121.79	134.06	72.16	124.74
Total	15.50	35.43	9.19	5.53	9.32	26.34	29.13	7.60	5.87	129.46	134.73	74.52	128.45
A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.13	0.21	0.00	0.00
B	0.27	25.90	0.00	0.00	0.31	2.66	0.00	0.00	0.00	4.84	48.02	23.29	3.24
C	9.77	1.98	5.27	0.00	4.79	17.04	14.53	1.15	1.44	10.15	45.15	27.21	48.83
D	0.00	0.00	0.56	3.34	0.00	1.52	13.71	4.05	3.05	103.68	40.69	21.67	72.68
Forest	0.00	14.10	0.00	0.00	0.00	3.19	21.87	0.33	2.60	93.94	42.19	6.96	55.70
Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.27	16.65
Pasture	0.00	0.00	0.00	0.00	0.00	13.42	5.65	0.77	0.97	18.63	91.87	47.20	52.39
Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lawn	10.05	13.78	5.83	3.34	5.10	4.61	0.72	4.09	0.92	9.22	0.00	0.73	0.01
Flat	1.07	5.40	2.96	2.64	1.22	8.69	10.22	3.16	1.32	53.48	88.51	48.47	84.98
Mod	6.49	15.06	2.78	0.68	3.51	11.61	16.68	1.91	2.59	57.69	41.57	20.04	37.86
Steep	2.48	7.42	0.09	0.02	0.37	0.92	1.34	0.13	0.58	10.62	3.99	3.66	1.90

Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Hydrologic and Hydraulic Analysis of the Surface Water System in the Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

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ATTACHMENT B.
SUBBASIN FLOODING MODELING RESULTS

Table B-1

Birch Point Subwatershed Flooding

		Existing Conditions						Future Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
LDES2061	158.2	157.5	158.0	158.0	-0.7	-0.2	-0.2	157.5	157.9	158.0	-0.7	-0.3	-0.2		
LDES2062	158.1	157.2	157.3	157.3	-0.9	-0.8	-0.8	157.2	157.3	157.3	-0.9	-0.8	-0.8		
LDES2069	156.6	154.7	154.9	154.9	-1.9	-1.7	-1.7	154.7	154.8	154.9	-1.9	-1.8	-1.7		
LDES2079	157.1	155.7	155.7	155.7	-1.4	-1.4	-1.4	155.7	155.7	155.7	-1.4	-1.4	-1.4		
LDES2081	157.3	155.5	155.5	155.5	-1.8	-1.8	-1.8	155.5	155.5	155.5	-1.8	-1.8	-1.8		
LDES2084	154.0	153.5	153.6	153.6	-0.5	-0.4	-0.4	153.5	153.6	153.6	-0.5	-0.4	-0.4		
LDES2090	154.1	152.1	152.1	152.1	-2.0	-2.0	-2.0	152.1	152.1	152.1	-2.0	-2.0	-2.0		
LDES2091	157.3	155.5	155.6	155.7	-1.8	-1.7	-1.7	155.6	155.7	155.8	-1.7	-1.6	-1.5		
LDES2093	157.8	156.1	156.1	156.1	-1.7	-1.7	-1.7	156.1	156.1	156.1	-1.7	-1.7	-1.7		
LDES2100	156.8	155.6	155.7	155.8	-1.2	-1.1	-1.0	155.6	155.8	155.8	-1.2	-1.0	-1.0		
LDES2104	135.9	134.5	134.5	134.5	-1.4	-1.4	-1.4	134.5	134.5	134.5	-1.4	-1.4	-1.4		
LDES2111	132.9	131.4	131.4	131.4	-1.5	-1.5	-1.5	131.4	131.4	131.4	-1.5	-1.5	-1.5		
LDES2112	121.2	120.2	120.2	120.3	-1.0	-1.0	-1.0	120.2	120.3	120.3	-1.0	-0.9	-0.9		
LDES2119	120.8	119.5	119.5	119.6	-1.3	-1.3	-1.22	119.6	119.6	119.7	-1.2	-1.2	-1.14		
LDES2121	120.4	119.3	119.3	119.3	-1.1	-1.1	-1.1	119.3	119.4	119.4	-1.1	-1.0	-1.0		
LDES2127	65.7	63.5	63.5	63.5	-2.2	-2.2	-2.2	63.5	63.5	63.9	-2.2	-2.2	-1.8		
LDES2134	64.4	62.8	63.0	63.0	-1.6	-1.4	-1.4	63.2	63.4	63.9	-1.2	-1.1	-0.5		
LDES2135	60.2	57.5	57.7	57.7	-2.7	-2.6	-2.49	57.5	57.6	57.6	-2.7	-2.6	-2.61		
LDES2144	60.4	59.4	59.4	59.5	-1.0	-1.0	-0.9	59.4	59.4	59.4	-1.0	-1.0	-1.0		
LDES2152	60.7	59.4	59.4	59.5	-1.3	-1.3	-1.3	59.4	59.4	59.4	-1.3	-1.3	-1.3		
LDES2156	61.6	61.3	61.3	61.3	-0.3	-0.3	-0.3	61.3	61.3	61.5	-0.3	-0.3	-0.1		
LDES2160	61.7	60.2	60.3	60.4	-1.5	-1.4	-1.3	60.5	60.9	61.5	-1.2	-0.8	-0.2		
LDES2164	67.3	66.3	66.4	66.4	-1.0	-0.9	-0.9	66.5	66.7	66.8	-0.8	-0.6	-0.5		
LDES2177	102.0	99.7	99.7	99.7	-2.3	-2.3	-2.3	99.7	99.7	99.7	-2.3	-2.3	-2.3		
LDES2178	96.1	93.6	93.6	93.6	-2.5	-2.5	-2.5	93.6	93.6	93.6	-2.5	-2.5	-2.5		
LDES2188	99.6	97.4	97.4	97.4	-2.2	-2.2	-2.2	97.4	97.4	97.4	-2.2	-2.2	-2.2		
LDES2195	98.1	96.2	96.2	96.2	-1.9	-1.9	-1.9	96.2	96.2	96.2	-1.9	-1.9	-1.9		
LDES2196	101.2	98.3	98.3	98.3	-2.9	-2.9	-2.9	98.3	98.3	98.3	-2.9	-2.9	-2.9		
LDES2203	100.6	97.8	97.8	97.8	-2.8	-2.8	-2.8	97.8	97.8	97.8	-2.8	-2.8	-2.8		
LDES2204	97.3	95.1	95.1	95.1	-2.2	-2.2	-2.2	95.1	95.1	95.1	-2.2	-2.2	-2.2		
LDES2211	96.1	94.7	94.7	94.7	-1.4	-1.4	-1.4	94.7	94.7	94.7	-1.4	-1.4	-1.4		
LDES2212	96.3	94.6	94.6	94.6	-1.7	-1.7	-1.7	94.6	94.6	94.6	-1.7	-1.7	-1.7		
LDES2217	92.0	84.5	84.9	85.1	-7.4	-7.0	-6.9	84.7	85.1	85.3	-7.3	-6.9	-6.7		
LDES2223	97.6	93.8	94.2	94.3	-3.8	-3.4	-3.3	93.9	94.3	94.6	-3.7	-3.3	-3.0		
LDES2223D	97.6	85.8	86.6	86.9	-11.8	-11.0	-10.7	86.1	86.8	87.3	-11.5	-10.8	-10.3		
LDES2227	97.6	95.0	95.1	95.2	-2.6	-2.5	-2.4	95.0	95.6	95.8	-2.6	-2.0	-1.8		
LDES2228	97.5	95.2	95.6	95.9	-2.3	-1.9	-1.7	95.3	97.6	97.7	-2.2	0.1	0.2	Near 8621 Semiahmoo Drive	BP-2
LDES2235	98.2	95.5	95.7	95.9	-2.7	-2.5	-2.3	95.5	97.6	97.8	-2.7	-0.6	-0.4		
LDES2236	98.2	95.6	95.9	96.1	-2.6	-2.3	-2.1	95.7	98.2	98.5	-2.5	0.0	0.3	Near 8621 Semiahmoo Drive	BP-2
LDES2251	100.2	98.6	98.7	98.8	-1.6	-1.5	-1.4	98.6	99.2	99.4	-1.6	-1.0	-0.8		
LDES2252	100.7	99.3	100.1	100.7	-1.4	-0.7	0.0	99.4	101.0	101.0	-1.3	0.3	0.3	Near 8621 Semiahmoo Drive	BP-2
LDES2259	102.3	100.7	100.9	101.0	-1.6	-1.4	-1.30	100.8	101.5	101.7	-1.6	-0.8	-0.62		
LDES2260	102.4	101.1	101.5	101.9	-1.3	-0.9	-0.5	101.2	102.7	102.9	-1.2	0.3	0.4	Near 8621 Semiahmoo Drive	BP-2
LDES2267	103.3	102.1	102.3	102.4	-1.2	-1.0	-0.86	102.2	103.0	103.2	-1.1	-0.3	-0.07		
LDES2268	103.0	102.3	102.6	102.8	-0.7	-0.4	-0.2	102.4	103.3	103.4	-0.6	0.3	0.4	Near 8621 Semiahmoo Drive	BP-2
LDES2275	106.3	104.8	104.9	105.0	-1.6	-1.4	-1.3	104.8	105.5	105.7	-1.5	-0.8	-0.6		
LDES2276	106.5	105.1	105.3	105.5	-1.4	-1.2	-1.0	105.2	106.7	106.9	-1.3	0.2	0.3	Near 8621 Semiahmoo Drive	BP-2
LDES2280	112.8	110.4	110.6	110.6	-2.4	-2.2	-2.17	110.5	111.1	111.3	-2.3	-1.7	-1.53		
LDES2284	110.7	109.2	109.4	109.4	-1.5	-1.4	-1.3	109.3	109.9	110.1	-1.4	-0.8	-0.6		
LDES2290	113.5	111.2	111.3	111.3	-2.3	-2.2	-2.2	111.5	111.6	111.7	-2.0	-1.9	-1.8		
LDES2291	113.4	111.2	111.3	111.3	-2.2	-2.1	-2.1	111.5	111.7	111.8	-1.9	-1.7	-1.6		
LDES2298	109.1	107.0	107.4	107.7	-2.1	-1.7	-1.4	109.1	109.6	109.8	0.0	0.5	0.7	Semiahmoo Drive near Birch Point Road	BP-6
LDES2299	108.9	106.9	107.1	107.3	-2.0	-1.8	-1.6	107.6	107.6	108.3	-1.3	-1.3	-0.6		
LDES2306	104.1	102.5	102.8	102.8	-1.6	-1.3	-1.3	103.0	103.1	103.8	-1.1	-1.0	-0.3		
LDES2313	97.0	94.4	95.0	95.5	-2.6	-2.0	-1.5	96.2	96.8	97.4	-0.8	-0.2	0.4	Semiahmoo Drive near Birch Point Road	BP-6
LDES2314	96.1	93.7	94.0	94.3	-2.4	-2.1	-1.8	94.1	94.2	95.6	-2.0	-1.9	-0.5		
LDES2321	94.2	91.6	93.7	94.3	-2.6	-0.5	0.06	93.5	93.6	94.6	-0.7	-0.6	0.41	Semiahmoo Drive near Birch Point Road	BP-6
LDES2322	93.0	90.9	91.2	91.3	-2.1	-1.8	-1.70	91.4	91.6	93.1	-1.6	-1.4	0.07	Semiahmoo Drive near Birch Point Road	BP-6
LDES2326	89.1	87.0	88.4	89.2	-2.1	-0.7	0.1	88.1	88.2	89.7	-1.1	-0.9	0.6	Semiahmoo Drive near Birch Point Road	BP-6
LDES2330	91.2	86.3	86.4	86.5	-4.9	-4.8	-4.7	86.7	87.1	87.7	-4.5	-4.2	-3.5		
LDES2333	92.5	87.9	88.2	88.2	-4.6	-4.3	-4.3	88.0	88.2	88.3	-4.5	-4.3	-4.2		
LDES2337	92.3	90.7	90.9	91.0	-1.6	-1.4	-1.3	90.8	91.1	91.2	-1.5	-1.2	-1.1		
LDES2344	93.9	92.0	92.2	92.3	-1.9	-1.7	-1.6	92.1	92.3	92.4	-1.8	-1.6	-1.5		
LDES2345	94.2	92.5	92.9	93.0	-1.7	-1.3	-1.2	92.7	93.1	93.3	-1.5	-1.1	-0.9		
LDES2352	98.3	96.2	96.4	96.4	-2.1	-1.9	-1.9	96.3	96.5	96.5	-2.0	-1.8	-1.8		
LDES2353	98.2	96.3	96.8	97.0	-1.9	-1.4	-1.3	96.6	97.0	97.3	-1.6	-1.2	-0.9		
LDES2368	108.9	107.1	107.3	107.4	-1.8	-1.6	-1.5	107.2	107.4	107.5	-1.7	-1.5	-1.4		
LDES2369	109.3	107.5	107.8	107.9	-1.8	-1.5	-1.4	107.7	108.0	108.1	-1.6	-1.3	-1.2		
LDES2376	117.2	115.6	115.7	115.7	-1.7	-1.5	-1.5	115.6	115.7	115.8	-1.6	-1.5	-1.4		
LDES2377	117.7	115.6	115.9	116.0	-2.1	-1.9	-1.7	115.7	116.0	116.2	-2.0	-1.7	-1.5		
LDES2384	118.8	117.1	117.1	117.1	-1.7	-1.7	-1.7	117.1	117.1	117.1	-1.7	-1.7	-1.7		
LDES2385	118.3	116.8	116.8	116.8	-1.5	-1.5	-1.5	116.8	116.8	116.8	-1.5	-1.5	-1.5		
LDES2400	116.8	114.3	116.1	117.1	-2.5	-0.7	0.3	114.8	116.8	117.1	-2.0	0.0	0.3	Birch Point Road	BP-3
LDES2401	115.5	113.9	114.5	114.7	-1.6	-1.0	-0.8	114.0	114.3	114.7	-1.5	-1.2	-0.8		
LDES2408	108.0	104.5	106.3	106.9	-3.5	-1.8	-1.1	104.9	105.6	107.3	-3.1	-2.4	-0.7		
LDES2414	107.3	104.3	106.1	106.6	-3.1	-1.3	-0.7	104.7	105.5	106.9	-2.6	-1.8	-0.4		
LDES2415	106.1	104.0	104.9	105.1	-2.1	-1.2	-0.96	104.3	104.6	105.3	-1.8	-1.5	-0.84		
LDES2420	109.0	104.6	106.9	107.9	-4.4	-2.1	-1.1	105.1	106.1	108.6	-3.9	-2.9	-0.4		
LDES2421	100.4	97.5	99.2	99.7	-3.0	-1.2	-0.7	98.0	98.6	100.1	-2.4	-1.8	-0.3		
LDES2428	100.7	97.3	97.9	98.0	-3.4	-2.8	-2.7	97.5	97.7	98.1	-3.2	-3.0	-2.6		
LDES2429	99.8	97.4	97.9	98.0	-2.4	-1.9	-1.8	97.5	97.7	98.1	-2.3	-2.1	-1.7		
LDES2430	100.7	97.7	97.9	98.0	-3.0	-2.8	-2.7	97.7	97.7	98.1	-3.0	-3.0	-2.6		
LDES2440	109.1	107.8	108.5	108.8	-1.3	-0.6	-0.3	108.0	108.6	109.3	-1.1	-0.5	0.2	Birch Point Road	BP-3
LDES2441	110.8	107.8	109.5	110.2	-3.0	-1.3	-0.6	108.2	109.8	110.9	-2.6	-1.0	0.1	Birch Point Road	BP-3
LDES2448	112.1	109.9	110.2	110.8	-2.2	-1.9	-1.3	109.9	110.3	110.5	-2.2	-1.8	-1.6		
LDES2449	111.2	109.5	109.7	110.2	-1.7	-1.5	-1.0	109.6	109.7	109.8	-1.6	-1.5	-1.4		
LDES2456	80.0	76.2	77.6	78.4	-3.8	-2.4	-1.7	76.4	78.0	79.0	-3.6	-2.0	-1.0		
LDES2457	77.6	75.4	76.1	76.2	-2.2	-1.5	-1.4	75.9	76.2	76.4	-1.7	-1.4	-1.2		
LDES2463	50.3	48.2	48.2	48.2	-2.1	-2.1	-2.10	48.2	48.2	48.2	-2.1	-2.1	-2.10		
LDES2464	51.1	44.2	44.6	44.6	-6.9	-6.5	-6.5	44.5	44.6	44.7	-6.6	-6.5	-6.4		
LDES2470	51.1	45.7	46.8	47.4	-5.4	-4.3	-3.7	46.4	47.1	48.2	-4.7	-4.0	-2.9		
LDES2476	52.1	51.0	51.0	51.0	-1.1	-1.1	-1.1	51.0	51.0	51.0	-1.1	-1.1	-1.1		
LDES2478	52.7	51.7	51.7	51.7	-1.0	-1.0	-1.0	51.7	51.7	51.7	-1.0	-1.0	-1.0		

Table B-1
Birch Point Subwatershed Flooding

		Existing Conditions						Future Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
LDES2482	46.3	44.3	44.6	44.7	-2.0	-1.7	-1.6	44.4	44.7	44.9	-1.9	-1.6	-1.5		
LDES2490	52.2	51.1	51.1	51.1	-1.1	-1.1	-1.1	51.1	51.1	51.1	-1.1	-1.1	-1.1		
LDES2491	52.2	50.8	50.8	50.8	-1.4	-1.4	-1.4	50.8	50.8	50.8	-1.4	-1.4	-1.4		
LDES2498	36.0	34.2	34.5	34.6	-1.8	-1.5	-1.4	34.3	34.6	34.7	-1.7	-1.4	-1.3		
LDES2502	28.7	26.4	27.6	28.4	-2.3	-1.1	-0.3	26.8	28.2	29.0	-1.9	-0.5	0.3	Birch Point Road near Selder Road	N/A
LDES2503	28.0	26.2	26.7	27.1	-1.8	-1.3	-0.9	26.4	26.9	27.9	-1.6	-1.1	-0.1		
LDES2508	30.0	26.3	27.6	28.3	-3.8	-2.4	-1.7	26.7	28.1	28.9	-3.3	-1.9	-1.1		
LDES2509	27.8	26.2	27.0	27.1	-1.6	-0.9	-0.7	26.5	27.1	27.4	-1.3	-0.7	-0.4		
LDES2516	27.8	24.5	25.8	26.8	-3.3	-2.1	-1.0	24.7	26.3	27.2	-3.1	-1.5	-0.6		
LDES2521	27.8	25.2	26.1	26.9	-2.6	-1.7	-0.9	25.4	26.6	27.7	-2.5	-1.2	-0.1		
LDES2552	30.0	25.1	25.7	27.1	-4.9	-4.3	-2.9	25.1	26.0	27.5	-4.9	-4.0	-2.5		
LDES2569	42.9	39.7	40.3	40.6	-3.2	-2.6	-2.3	39.7	40.4	40.6	-3.2	-2.6	-2.3		
LDES2570	44.0	40.6	41.9	44.6	-3.4	-2.1	0.6	40.6	41.9	45.0	-3.4	-2.1	1.0	Selder Road	BP-4
LDES2578	66.1	63.5	63.6	63.6	-2.6	-2.5	-2.5	63.6	63.8	63.9	-2.5	-2.3	-2.2		
LDES2586	64.7	64.6	65.1	65.2	-0.1	0.4	0.5	64.6	65.1	65.2	-0.1	0.4	0.5	Selder Road	BP-4
LDES2587	67.5	66.1	67.6	67.6	-1.4	0.1	0.1	66.1	67.6	67.7	-1.4	0.1	0.2	Selder Road	
LDES2594	74.5	72.7	72.9	73.0	-1.8	-1.6	-1.5	72.7	72.9	73.0	-1.8	-1.6	-1.5		
LDES2595	79.6	79.6	79.8	79.8	0.0	0.2	0.2	79.6	79.8	79.8	0.0	0.2	0.2	Selder Road	BP-4
LDES2602	81.7	80.8	81.0	81.1	-0.9	-0.7	-0.6	80.8	81.0	81.1	-0.9	-0.7	-0.6		
LDES2603	85.8	85.6	85.9	86.0	-0.2	0.1	0.2	85.7	85.9	86.0	-0.1	0.1	0.2	Selder Road	BP-4
LDES2610	86.8	86.3	86.4	86.5	-0.5	-0.4	-0.3	86.3	86.4	86.5	-0.5	-0.4	-0.3		
LDES2611	93.0	92.8	93.1	93.2	-0.2	0.1	0.2	92.9	93.1	93.2	-0.1	0.1	0.2	Selder Road	BP-4
LDES2618	99.9	97.9	98.1	98.2	-2.0	-1.8	-1.7	97.9	98.1	98.2	-2.0	-1.8	-1.7		
LDES2619	102.5	101.0	101.7	102.6	-1.5	-0.8	0.0	101.0	101.8	102.6	-1.5	-0.8	0.0	Selder Road	BP-4
LDES2626	111.0	108.8	109.0	109.1	-2.2	-2.0	-1.9	108.8	109.0	109.1	-2.2	-2.0	-1.9		
LDES2627	112.4	110.7	112.5	112.5	-1.7	0.0	0.1	110.7	112.5	112.5	-1.7	0.0	0.1	Selder Road	BP-4
LDES2634	116.8	115.6	115.8	115.9	-1.2	-1.0	-0.9	115.6	115.8	115.9	-1.2	-1.0	-0.9		
LDES2635	118.9	118.1	119.0	119.1	-0.8	0.1	0.1	118.1	119.0	119.1	-0.8	0.1	0.1	Selder Road	BP-4
LDES2639	126.3	124.2	124.5	124.7	-2.1	-1.8	-1.6	124.2	124.5	124.7	-2.1	-1.8	-1.6		
LDES2646	124.0	122.1	122.3	122.3	-1.9	-1.8	-1.7	122.1	122.3	122.3	-1.9	-1.8	-1.7		
LDES2674	144.3	141.1	141.3	141.3	-3.2	-3.0	-3.0	141.4	141.6	141.7	-2.9	-2.7	-2.6		
LDES2675	144.7	142.0	142.9	143.6	-2.7	-1.8	-1.1	144.2	144.9	145.0	-0.5	0.2	0.3	Bayvue Road	N/A
LDES4214	160.7	160.3	160.8	160.9	-0.4	0.1	0.2	160.9	161.0	161.0	0.2	0.3	0.3	Bayvue Road	N/A
LDES4215	160.1	159.2	159.4	159.5	-0.9	-0.7	-0.6	159.6	159.7	159.8	-0.5	-0.4	-0.3		
LDES4222	155.6	153.3	154.6	155.6	-2.3	-1.0	0.02	155.7	155.7	155.8	0.1	0.1	0.19	Bayvue Road	N/A
LDES4223	154.8	152.9	153.1	153.2	-1.9	-1.7	-1.6	153.4	153.5	153.7	-1.5	-1.3	-1.1		
LDES4278	170.5	169.6	170.7	170.8	-0.9	0.2	0.3	170.9	171.0	171.1	0.4	0.4	0.6	Bayvue Road	N/A
LDES4279	174.2	173.3	173.5	173.6	-0.9	-0.7	-0.6	173.7	173.9	174.0	-0.5	-0.3	-0.2		
LDES6347	139.5	137.7	137.7	137.7	-1.8	-1.8	-1.8	137.7	137.7	137.7	-1.8	-1.8	-1.8		
LDES6547	151.5	150.2	151.6	151.7	-1.3	0.1	0.2	151.4	151.7	151.7	-0.1	0.2	0.2	Semiahmoo Drive near Normar Place	BP-1
LDES6551	94.1	93.5	93.5	93.5	-0.7	-0.6	-0.61	93.5	93.5	93.5	-0.6	-0.6	-0.60		
LDES6558	88.6	86.0	86.1	86.1	-2.5	-2.5	-2.44	86.1	86.1	86.1	-2.5	-2.5	-2.42		
LDES6560	85.0	83.7	83.7	83.7	-1.3	-1.3	-1.3	83.7	83.7	83.7	-1.3	-1.3	-1.3		
LDES2586	64.7	64.6	65.1	65.2	-0.1	0.4	0.5	64.6	65.1	65.2	-0.1	0.4	0.5	Selder Road	BP-4
LDES6567	66.3	64.8	65.2	65.7	-1.5	-1.1	-0.5	64.8	65.7	65.8	-1.5	-0.6	-0.5		
TT1000	68.0	65.1	65.1	65.1	-2.9	-2.9	-2.9	65.1	65.1	65.1	-2.9	-2.9	-2.9		
TT-1000	151.0	149.9	151.1	151.1	-1.2	0.1	0.1	151.0	151.1	151.1	0.0	0.1	0.1	Semiahmoo Drive near Normar Place	BP-1
TT-1001	88.0	86.2	86.4	86.4	-1.8	-1.6	-1.6	86.5	86.6	87.0	-1.5	-1.4	-1.1		
TT1002	123.7	123.2	123.4	123.5	-0.6	-0.3	-0.24	123.3	123.5	123.7	-0.4	-0.2	-0.03		
TT1003	123.0	122.5	122.7	122.7	-0.5	-0.3	-0.3	122.6	122.8	122.9	-0.4	-0.2	-0.1		
TT1004	154.8	154.1	154.2	154.3	-0.7	-0.6	-0.55	154.1	154.2	154.2	-0.7	-0.6	-0.57		
TT1005	61.7	60.0	60.0	60.0	-1.7	-1.7	-1.70	60.0	60.0	60.0	-1.7	-1.7	-1.69		
TT1006	87.0	77.0	77.3	77.4	-10.0	-9.7	-9.63	77.1	77.4	77.5	-9.9	-9.7	-9.51		
TT1007	170.7	169.0	169.2	169.3	-1.7	-1.5	-1.38	169.4	169.5	169.7	-1.3	-1.2	-1.03		
TT1008	118.9	114.1	114.1	114.1	-4.9	-4.9	-4.9	114.1	114.1	114.1	-4.9	-4.9	-4.9		
TT1009	80.0	77.2	77.2	77.2	-2.8	-2.8	-2.8	77.2	77.2	77.2	-2.8	-2.8	-2.8		
TT1010	120.9	119.0	119.1	119.1	-1.9	-1.9	-1.8	119.1	119.1	119.1	-1.8	-1.8	-1.8		
TT1011	147.1	145.1	145.1	145.1	-2.0	-2.0	-2.0	145.1	145.1	145.1	-2.0	-2.0	-2.0		
TT1012	101.7	99.7	99.7	99.7	-2.0	-2.0	-2.0	99.7	99.7	99.7	-2.0	-2.0	-2.0		
TT1013	122.0	118.5	118.9	119.0	-3.5	-3.1	-3.0	118.7	119.0	119.1	-3.3	-3.0	-2.9		
TT1014	107.0	105.8	106.3	106.4	-1.3	-0.8	-0.6	106.0	106.4	106.6	-1.0	-0.6	-0.4		
TT1015	106.1	104.0	104.0	104.0	-2.1	-2.1	-2.1	104.0	104.0	104.0	-2.1	-2.1	-2.1		
TT1016	100.3	99.7	99.7	99.7	-0.6	-0.6	-0.6	99.7	99.7	99.7	-0.6	-0.6	-0.6		
TT1017	118.0	116.0	116.0	116.0	-2.0	-2.0	-2.0	116.0	116.0	116.0	-2.0	-2.0	-2.0		
TT1018	117.0	115.1	115.3	115.4	-1.9	-1.7	-1.6	115.2	115.4	115.4	-1.8	-1.7	-1.6		
TT1019	72.0	68.0	68.0	68.0	-4.0	-4.0	-4.0	68.0	68.0	68.0	-4.0	-4.0	-4.0		
TT1020	53.9	51.0	51.0	51.0	-2.9	-2.9	-2.9	51.0	51.0	51.0	-2.9	-2.9	-2.9		
TT1021	52.2	51.6	51.6	51.6	-0.6	-0.6	-0.6	51.6	51.6	51.6	-0.6	-0.6	-0.6		
TT1022	53.4	52.0	52.3	52.4	-1.5	-1.1	-1.0	52.1	52.4	52.5	-1.3	-1.0	-0.9		
TT1023	28.0	26.1	26.5	27.1	-1.9	-1.5	-0.9	26.3	26.8	27.8	-1.7	-1.2	-0.2		
TT1024	98.3	96.7	97.0	97.1	-1.6	-1.3	-1.2	97.2	97.3	98.5	-1.1	-1.0	0.2	Semiahmoo Drive near Birch Point Road	BP-6
TT1025	148.0	147.3	147.4	147.5	-0.7	-0.6	-0.5	147.4	147.5	147.6	-0.6	-0.5	-0.4		

Table B-1
Terrell Creek Subwatershed Flooding

		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
2546	39.9	37.1	37.5	37.7	-2.8	-2.4	-2.22		
2547	39.2	37.4	37.7	37.9	-1.8	-1.5	-1.32		
3005	39.5	36.2	37.2	37.4	-3.3	-2.3	-2.12		
3649	45.0	41.0	40.9	41.0	-4.0	-4.1	-4.01		
3650	45.1	41.4	41.3	41.3	-3.8	-3.8	-3.76		
6302	40.3	36.8	37.5	37.7	-3.5	-2.8	-2.64		
6303	39.9	36.7	38.1	38.2	-3.2	-1.8	-1.75		
6304	37.1	34.8	35.2	35.5	-2.3	-1.9	-1.65		
6305	36.5	33.0	33.3	33.4	-3.5	-3.2	-3.13		
6306	31.4	23.3	23.7	23.8	-8.1	-7.7	-7.58		
6307	38.9	36.3	36.5	36.6	-2.7	-2.4	-2.28		
6308	39.2	36.6	36.8	36.9	-2.7	-2.4	-2.3		
6309	39.3	37.5	38.0	38.1	-1.8	-1.3	-1.2		
6310	40.9	39.2	39.3	39.3	-1.8	-1.6	-1.60		
6311	40.9	39.3	39.5	39.5	-1.6	-1.4	-1.4		
6312	40.3	37.4	37.5	37.5	-2.9	-2.8	-2.8		
6708	30.1	26.1	27.1	29.2	-4.0	-3.1	-0.9		
LDES1260	31.4	30.4	30.8	31.0	-1.0	-0.6	-0.4		
LDES1264	31.9	30.8	31.3	31.6	-1.1	-0.6	-0.3		
LDES1271	32.2	31.0	31.3	31.6	-1.2	-0.9	-0.6		
LDES1272	32.4	31.4	31.9	32.3	-1.0	-0.5	-0.1		
LDES1279	33.4	31.7	31.9	32.1	-1.7	-1.5	-1.3		
LDES1280	34.6	33.3	33.5	33.6	-1.3	-1.1	-1.1		
LDES1284	37.6	35.9	36.0	36.0	-1.8	-1.6	-1.6		
LDES1290	38.6	36.9	37.3	37.6	-1.7	-1.3	-1.0		
LDES1294	39.2	37.3	37.4	37.7	-1.9	-1.8	-1.6		
LDES1300	40.5	39.3	39.4	39.4	-1.2	-1.1	-1.1		
LDES1307	41.1	40.1	40.3	40.4	-1.0	-0.8	-0.8		
LDES1308	40.5	40.1	40.3	40.4	-0.4	-0.2	-0.1		
LDES1315	40.7	40.1	40.3	40.3	-0.6	-0.4	-0.4		
LDES1316	40.7	40.1	40.2	40.3	-0.6	-0.5	-0.5		
LDES1333	39.3	38.0	38.0	38.1	-1.3	-1.3	-1.2		
LDES1341	39.2	37.5	38.0	38.1	-1.7	-1.2	-1.1		
LDES1342	39.2	37.4	37.8	38.2	-1.8	-1.4	-1.1		
LDES1343	38.8	37.5	37.8	38.1	-1.3	-1.0	-0.7		
LDES1353	39.4	37.9	38.3	38.4	-1.5	-1.1	-1.0		
LDES1354	39.4	38.0	38.3	38.4	-1.4	-1.1	-1.0		
LDES1355	40.2	38.6	38.9	39.0	-1.6	-1.3	-1.2		
LDES1360	40.3	38.5	38.7	38.7	-1.8	-1.6	-1.6		
LDES1365	39.9	38.2	38.4	38.5	-1.7	-1.5	-1.4		
LDES1369	39.7	38.2	38.2	38.2	-1.5	-1.5	-1.5		
LDES1376	39.8	38.6	38.8	38.9	-1.2	-1.0	-0.9		
LDES1385	40.0	38.6	38.8	38.9	-1.4	-1.2	-1.1		
LDES1389	40.9	39.8	39.8	39.8	-1.1	-1.1	-1.1		
LDES1395	40.4	38.4	38.9	38.9	-2.0	-1.5	-1.5		
LDES1396	41.3	40.6	41.7	41.9	-0.8	0.4	0.6	Jackson Road	TC-1
LDES1403	41.6	40.6	41.8	42.0	-1.0	0.2	0.4	Jackson Road	TC-1
LDES1413	40.6	39.7	39.7	39.7	-0.9	-0.9	-0.9		
LDES1419	41.0	39	39	38.9	-2.3	-2.3	-2.2		
LDES1420	41.1	38.0	38.5	38.9	-3.1	-2.6	-2.3		
LDES1424	40.6	38.6	38.8	38.9	-2.0	-1.8	-1.7		
LDES1428	39.7	37.9	38.5	38.9	-1.8	-1.2	-0.9		
LDES1429	39.8	37.9	38.5	38.9	-1.9	-1.3	-0.9		
LDES1436	39.6	37.9	38.5	38.9	-1.7	-1.1	-0.8		
LDES1437	40.2	37.8	38.4	38.8	-2.4	-1.8	-1.4		
LDES1444	40.1	37.8	38.4	38.8	-2.3	-1.7	-1.3		
LDES1445	40.2	37.7	38.4	38.8	-2.5	-1.8	-1.4		
LDES1449	40.0	37.7	38.4	38.8	-2.3	-1.6	-1.2		
LDES1456	39.0	37.7	38.4	38.8	-1.3	-0.6	-0.2		
LDES1457	39.6	37.7	38.4	38.8	-1.9	-1.2	-0.84		
LDES1464	39.8	37.7	38.4	38.7	-2.2	-1.5	-1.1		
LDES1465	40.6	37.7	38.4	38.7	-3.0	-2.3	-1.9		
LDES1472	40.6	37.6	38.3	38.6	-3.0	-2.3	-2.0		
LDES1473	39.0	37.6	38.3	38.6	-1.4	-0.7	-0.4		

Table B-1 Terrell Creek Subwatershed Flooding									
		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	Problem ID
LDES1480	39.3	37.6	38.3	38.6	-1.7	-1.0	-0.7		
LDES1481	39.0	37.6	38.3	38.6	-1.4	-0.7	-0.4		
LDES1488	38.9	37.5	38.0	38.2	-1.4	-0.9	-0.7		
LDES1489	38.3	37.5	38.0	38.2	-0.8	-0.3	-0.1		
LDES1496	38.4	37.4	37.8	37.9	-1.0	-0.6	-0.5		
LDES1497	38.3	37.4	37.7	37.9	-0.9	-0.6	-0.4		
LDES1504	38.3	37.2	37.5	37.7	-1.1	-0.8	-0.6		
LDES1505	39.9	37.2	37.5	37.7	-2.7	-2.4	-2.2		
LDES1515	40.3	37.4	37.7	37.7	-2.9	-2.6	-2.6		
LDES1519	40.8	38.0	38.8	38.9	-2.8	-2.0	-1.9		
LDES1526	36.4	35.2	35.8	36.3	-1.2	-0.6	-0.1		
LDES1533	37.0	34.9	35.8	36.3	-2.2	-1.2	-0.7		
LDES1548	35.1	32.0	32.0	32.0	-3.1	-3.1	-3.1		
LDES1557	37.0	33.7	33.8	33.9	-3.4	-3.2	-3.1		
LDES1563	35.6	32.8	33.0	33.1	-2.8	-2.6	-2.5		
LDES1566	31.7	25.7	26.1	26.2	-6.0	-5.6	-5.47		
LDES1575	34.3	33.7	33.8	33.9	-0.6	-0.5	-0.4		
LDES1594	32.6	29.8	30.9	32.6	-2.8	-1.7	0.0	Jackson Road	
LDES1598	37.0	34.3	34.6	34.7	-2.7	-2.4	-2.3		
LDES1605	36.6	34.5	35.6	35.8	-2.1	-1.0	-0.82		
LDES1606	37.3	34.9	35.6	35.8	-2.4	-1.7	-1.5		
LDES1613	38.9	38.4	38.7	38.7	-0.5	-0.2	-0.2		
LDES1616	39.8	38.2	38.2	38.2	-1.6	-1.6	-1.6		
LDES1625	39.7	36.0	37.2	37.3	-3.7	-2.5	-2.4		
LDES1626	39.0	36.5	37.2	37.3	-2.5	-1.8	-1.7		
LDES1633	38.6	36.2	37.2	37.4	-2.4	-1.4	-1.2		
LDES1639	38.7	36.8	37.5	37.6	-1.9	-1.2	-1.1		
LDES1641	38.2	36.3	37.4	37.6	-1.9	-0.8	-0.6		
LDES1646	39.2	36.4	37.4	37.6	-2.9	-1.8	-1.6		
LDES1651	39.2	36.4	37.5	37.6	-2.8	-1.7	-1.6		
LDES1656	38.3	36.4	37.5	37.6	-1.9	-0.8	-0.7		
LDES1658	39.5	36.4	37.5	37.7	-3.1	-2.0	-1.9		
LDES1660	39.5	36.4	37.5	37.7	-3.1	-2.0	-1.9		
LDES1664	39.3	36.5	37.5	37.7	-2.8	-1.8	-1.6		
LDES1668	38.6	36.3	37.2	37.4	-2.4	-1.4	-1.2		
LDES1675	38.0	36.3	37.2	37.4	-1.8	-0.8	-0.6		
LDES1676	37.7	36.2	37.2	37.4	-1.5	-0.5	-0.3		
LDES1683	37.8	36.2	37.2	37.4	-1.6	-0.6	-0.4		
LDES1684	37.6	36.2	37.2	37.4	-1.4	-0.4	-0.2		
LDES1691	38.8	36.2	37.2	37.4	-2.6	-1.6	-1.4		
LDES1692	38.7	36.2	37.2	37.4	-2.5	-1.5	-1.3		
LDES1704	39.9	36.3	37.4	37.6	-3.6	-2.5	-2.3		
LDES1710	39.9	36.6	37.6	37.8	-3.3	-2.3	-2.1		
LDES1711	39.8	37.3	38.1	38.4	-2.5	-1.7	-1.38		
LDES1715	41.3	38.6	38.6	38.9	-2.7	-2.7	-2.5		
LDES1723	41.5	38.8	38.7	38.9	-2.8	-2.8	-2.61		
LDES1724	41.8	39.0	38.8	39.0	-2.8	-3.0	-2.8		
LDES1726	43.6	39.2	39.1	39.2	-4.4	-4.5	-4.4		
LDES1732	45.1	40.7	40.6	40.7	-4.4	-4.5	-4.4		
LDES1735	45.9	42.0	41.9	42.0	-3.9	-4.0	-3.92		
LDES1742	44.0	42.6	42.6	42.7	-1.4	-1.4	-1.3		
LDES1743	42.7	40.3	40.3	40.3	-2.4	-2.4	-2.4		
LDES1753	55.7	53.4	53.4	53.4	-2.3	-2.3	-2.3		
LDES1757	52.1	49.5	49.4	49.5	-2.6	-2.7	-2.6		
LDES1758	51.6	49.0	48.9	49.0	-2.6	-2.7	-2.6		
LDES1769	47.2	45.1	44.9	45.0	-2.1	-2.3	-2.2		
LDES1770	47.1	44.4	44.4	44.4	-2.7	-2.8	-2.7		
LDES1771	46.4	43.6	43.6	43.7	-2.8	-2.8	-2.8		
LDES1793	75.5	73.9	73.9	73.9	-1.6	-1.6	-1.56		
LDES1794	72.8	72.0	71.6	71.9	-0.8	-1.2	-0.92		
LDES1808	70.5	68.6	68.5	68.6	-1.9	-2.0	-1.9		
LDES1816	58.5	54.2	54.0	54.1	-4.3	-4.5	-4.4		
LDES1823	91.3	89.8	89.8	89.8	-1.5	-1.5	-1.5		
LDES1824	90.6	89.3	89.3	89.3	-1.3	-1.3	-1.3		

Table B-1 Terrell Creek Subwatershed Flooding									
		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	Problem ID
LDES1831	88.9	87.7	87.7	87.8	-1.2	-1.2	-1.1		
LDES1832	88.3	87.2	87.2	87.3	-1.1	-1.1	-1.0		
LDES1833	87.8	86.3	86.3	86.3	-1.5	-1.5	-1.5		
LDES1834	87.1	86.2	86.2	86.3	-0.9	-0.9	-0.8		
LDES1850	82.1	81.2	81.2	81.2	-0.9	-0.9	-0.9		
LDES1851	82.4	81.1	81.1	81.1	-1.3	-1.3	-1.3		
LDES1852	80.9	79.6	79.6	79.7	-1.3	-1.3	-1.2		
LDES1853	80.8	79.6	79.6	79.6	-1.3	-1.3	-1.2		
LDES1860	76.3	74.4	74.3	74.4	-1.9	-2.0	-1.9		
LDES1867	77.2	75.0	75.0	75.0	-2.2	-2.2	-2.2		
LDES1868	77.1	75.2	75.1	75.2	-1.9	-2.0	-1.9		
LDES1875	77.5	76.2	76.1	76.1	-1.3	-1.4	-1.4		
LDES1876	77.7	76.8	76.7	76.7	-1.0	-1.0	-1.0		
LDES1883	79.3	78.0	78.0	78.0	-1.3	-1.3	-1.3		
LDES1884	82.0	80.0	79.9	80.0	-2.0	-2.1	-2.05		
LDES1891	84.0	82.8	82.7	82.8	-1.3	-1.3	-1.3		
LDES1892	85.5	84.6	84.6	84.6	-0.9	-0.9	-0.9		
LDES1902	89.0	87.9	87.8	87.9	-1.2	-1.2	-1.2		
LDES1903	89.3	88.2	88.1	88.2	-1.1	-1.2	-1.1		
LDES6473	40.1	38.9	39.2	39.4	-1.2	-0.9	-0.7		
LDES6474	39.5	38.9	39.1	39.2	-0.6	-0.4	-0.3		
LDES6475	39.8	38.9	39.1	39.2	-0.9	-0.8	-0.6		
LDES6476	39.7	38.8	39.0	39.1	-0.9	-0.7	-0.6		
LDES6489	39.6	38.4	38.8	39.1	-1.2	-0.8	-0.5		
LDES6490	39.5	38.3	38.7	39.0	-1.2	-0.8	-0.5		
LDES6491	39.7	38.3	38.7	39.0	-1.4	-1.0	-0.7		
LDES6507	39.5	38.3	38.7	38.9	-1.2	-0.8	-0.60		
LDES6509	39.7	38.3	38.7	38.9	-1.4	-1.0	-0.8		
LDES6510	39.2	37.8	38.0	38.1	-1.4	-1.2	-1.1		
LDES6511	39.2	37.7	37.9	38.0	-1.5	-1.3	-1.2		
LDES6519	39.6	38.3	38.7	39.0	-1.3	-0.9	-0.6		
LDES6523	40.2	39.1	39.3	39.4	-1.2	-0.9	-0.9		
LDES6530	40.0	39.1	39.3	39.4	-0.9	-0.7	-0.6		
OD1931	38.3	37.8	38.4	38.4	-0.5	0.1	0.1	Bay Road	TC-2
TT-1001	56.0	54.6	54.7	54.8	-1.4	-1.3	-1.2		
TT-1002	41.1	37.9	38.5	38.8	-3.2	-2.7	-2.3		
TT-1003	82.1	78.8	78.8	78.8	-3.3	-3.3	-3.3		
TT-1004	35.1	33.2	33.5	33.6	-2.0	-1.6	-1.5		
TT-1005	40.4	38.6	38.8	38.9	-1.8	-1.6	-1.6		
TT-1006	40.3	38.6	38.8	38.8	-1.7	-1.5	-1.5		
TT-1007	40.4	38.6	38.8	38.9	-1.8	-1.6	-1.5		
TT-1009	72.0	71.3	71.1	71.3	-0.7	-0.9	-0.8		
TT-1010	39.9	38.8	39.1	39.3	-1.1	-0.8	-0.6		
TT-1011	72.0	70.6	70.6	70.6	-1.4	-1.4	-1.4		
TT-1012	43.0	36.7	37.1	37.2	-6.3	-5.9	-5.8		
TT-1013	41.9	39.4	41.7	41.8	-2.5	-0.3	-0.1		
TT-1014	36.3	34.8	35.8	36.3	-1.5	-0.5	0.0	Helweg Road	
TT-1015	70.7	69.5	69.3	69.5	-1.2	-1.4	-1.2		
TT-1016	39.3	36.4	37.5	37.7	-2.9	-1.8	-1.6		
TT-1017	39.5	36.4	37.5	37.7	-3.1	-2.0	-1.9		
TT-1018	44.9	41.4	43.8	43.8	-3.5	-1.1	-1.1		
TT-1019	44.5	40.5	42.0	41.9	-4.0	-2.5	-2.6		
TT-1020	42.3	42.3	42.6	42.7	0.0	0.3	0.4	Sunset Drive	TC-1
TT-1021	42.3	42.3	42.6	42.7	0.0	0.3	0.3	Sunset Drive	TC-1
TT-1022	42.6	42.3	42.6	42.7	-0.3	0.0	0.1	Sunset Drive	TC-1
TT-1023	42.5	42.3	42.6	42.7	-0.3	0.0	0.1	Sunset Drive	TC-1
TT-1024	42.8	42.3	42.6	42.7	-0.5	-0.2	-0.1		
TT-1025	42.6	42.3	42.6	42.7	-0.3	0.0	0.0	Sunset Drive	TC-1
TT-1026	42.7	42.3	42.6	42.7	-0.4	-0.1	0.0	Sunset Drive	TC-1
TT-1027	42.4	42.3	42.6	42.7	-0.2	0.1	0.2	Sunset Drive	TC-1
TT-1028	43.0	42.3	42.6	42.7	-0.7	-0.3	-0.2		
TT-1029	43.1	42.3	42.6	42.7	-0.8	-0.5	-0.4		
TT-1030	41.7	41.8	41.9	42.0	0.1	0.3	0.3	Sunset Drive	TC-1
TT-1031	44.1	42.8	43.0	43.0	-1.2	-1.1	-1.07		

Table B-1
Terrell Creek Subwatershed Flooding

Junction	Flood Elev	Existing Conditions						Location	Problem ID
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				
		2 Year	25 Year	100 Year	2 Year	25 Year	100 Year		
TT-1032	43.5	42.3	42.6	42.7	-1.2	-0.8	-0.7		
TT-1033	43.4	42.3	42.7	42.9	-1.1	-0.7	-0.5		
TT-1034	42.9	42.3	42.6	42.7	-0.6	-0.3	-0.2		
TT-1035	46.2	44.5	44.6	44.7	-1.7	-1.6	-1.5		
TT-1036	44.9	43.6	43.7	43.7	-1.3	-1.3	-1.2		
TT-1037	29.4	28.4	28.6	29.3	-0.9	-0.8	-0.07		
TT-1038	33.2	33.3	33.3	33.4	0.1	0.2	0.21	Jackson Road	TC-1
TT-1039	32.0	30.9	31.0	31.1	-1.1	-1.0	-1.0		
TT-1040	40.0	39.3	40.1	40.1	-0.7	0.0	0.1	Jackson Road	TC-1
TT-1041	35.4	34.3	34.4	34.5	-1.1	-1.0	-0.9		
TT-1042	42.2	42.0	42.4	42.5	-0.2	0.1	0.3	Key Street	TC-1
TT-1043	40.2	39.4	40.1	40.1	-0.9	-0.1	-0.1		
TT-1044	45.4	44.7	45.0	45.0	-0.8	-0.4	-0.4		
TT-1045	42.2	42.3	42.6	42.7	0.1	0.4	0.45	Key Street	TC-1
TT-1046	42.1	42.3	42.6	42.7	0.1	0.4	0.5	Sunset Drive	TC-1
TT-1047	42.3	42.3	42.6	42.7	0.1	0.3	0.40	Sunset Drive	TC-1
TT-1048	42.0	42.3	42.6	42.7	0.3	0.6	0.65	Sunset Drive	TC-1
POND83	38.8	36.43	37.49	37.66	-2.37	-1.31	-1.14		
BCSPOND1	44.4	41.55	44.01	43.99	-2.85	-0.39	-0.41		
BCNPOND1	48.4	45.46	45.96	46.03	-2.94	-2.44	-2.37		

Table B-1

Point Whitehorn Subwatershed Flooding

		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
2714	73.5	72.0	73.2	73.7	-1.5	-0.3	0.15	Holeman Avenue	PWH-1
2715	73.1	71.8	73.0	73.5	-1.3	-0.1	0.42	Holeman Avenue	PWH-1
2716	73.0	71.2	71.5	72.2	-1.8	-1.5	-0.80		
2717	72.5	68.3	68.4	68.5	-4.2	-4.1	-4.05		
2718	73.1	71.8	72.1	72.2	-1.3	-1.0	-0.87		
2719	73.4	71.9	72.2	72.4	-1.5	-1.2	-1.01		
2722	72.5	70.8	72.5	72.6	-1.8	0.0	0.10	Petticote Lane	PWH-2
2891	71.5	69.4	69.4	69.4	-2.2	-2.2	-2.15		
2892	68.8	67.0	67.0	67.0	-1.8	-1.8	-1.76		
2893	65.4	63.9	64.1	64.2	-1.5	-1.3	-1.24		
2894	62.9	61.4	61.9	62.1	-1.6	-1.0	-0.79		
2895	57.9	56.2	56.4	56.5	-1.7	-1.5	-1.4		
2896	55.7	54.4	55.7	55.9	-1.3	0.0	0.2	Birch Bay Road	PWH-2
2897	53.1	51.7	52.1	52.1	-1.4	-1.0	-0.98		
2898	52.2	50.6	51.0	51.0	-1.6	-1.2	-1.2		
2899	50.0	48.5	50.0	50.2	-1.6	0.0	0.2	Birch Bay Road	PWH-2
2900	42.3	39.6	40.4	42.5	-2.7	-1.9	0.2	Birch Bay Road	PWH-2
2901	40.7	39.2	40.0	40.8	-1.5	-0.7	0.1	Birch Bay Road	PWH-2
2902	40.1	38.6	39.6	40.2	-1.5	-0.5	0.1	Birch Bay Road	PWH-2
2903	33.9	31.5	31.8	33.5	-2.4	-2.1	-0.4		
2904	31.5	29.4	30.5	31.6	-2.2	-1.0	0.1	Birch Bay Road	PWH-2
2977	42.0	39.5	40.4	42.2	-2.5	-1.6	0.2	Birch Bay Road	PWH-2
6133	77.6	74.6	74.9	75.1	-3.0	-2.7	-2.5		
6134	31.3	27.9	28.4	29.4	-3.4	-2.9	-1.9		
6322	37.7	36.0	36.3	37.3	-1.7	-1.4	-0.4		
6326	87.8	82.4	82.5	82.6	-5.4	-5.3	-5.2		
6332	74.2	72.1	72.4	72.6	-2.1	-1.8	-1.6		
6333	76.5	74.6	74.6	74.6	-1.9	-1.9	-1.9		
6334	88.8	85.4	85.8	86.0	-3.4	-3.0	-2.8		
6335	86.9	83.7	83.9	84.1	-3.2	-3.0	-2.8		
6336	84.6	80.2	80.3	80.4	-4.4	-4.3	-4.2		
LDES1001	104.8	101.2	101.2	101.2	-3.6	-3.6	-3.6		
LDES1005	83.2	81.3	81.5	81.6	-1.9	-1.7	-1.6		
LDES1006	82.8	80.6	80.7	80.8	-2.2	-2.1	-2.0		
LDES1007	74.8	73.0	74.1	75.0	-1.8	-0.8	0.2	Holeman Avenue	PWH-1
LDES1008	74.7	72.7	73.9	74.9	-2.0	-0.8	0.2	Holeman Avenue	PWH-1
LDES1009	74.8	72.7	73.9	74.9	-2.1	-0.9	0.1	Holeman Avenue	PWH-1
LDES1012	73.4	71.6	72.4	73.2	-1.8	-1.0	-0.2		
LDES1013	73.0	71.6	72.4	73.2	-1.4	-0.6	0.2	Holeman Avenue	PWH-1
LDES1016	73.8	70.4	70.7	71.1	-3.4	-3.1	-2.7		
LDES1017	73.7	71.5	71.6	71.7	-2.3	-2.1	-2.1		
LDES1023	75.4	73.0	73.2	73.4	-2.4	-2.2	-2.1		
LDES1024	76.2	73.7	73.9	73.9	-2.5	-2.4	-2.3		
LDES1026	77.5	74.7	74.7	74.7	-2.8	-2.8	-2.8		
LDES1027	79.0	75.4	75.4	75.4	-3.6	-3.6	-3.6		
LDES1028	77.6	74.0	74.0	74.0	-3.6	-3.6	-3.6		
LDES1033	61.7	60.5	61.9	62.0	-1.2	0.2	0.3	Birch Bay Road	PWH-2
LDES1034	60.8	59.3	60.9	61.0	-1.5	0.1	0.2	Birch Bay Road	PWH-2
LDES1055	39.0	37.5	38.4	39.2	-1.5	-0.6	0.2	Birch Bay Road	PWH-2
LDES1056	38.5	37.5	38.4	39.2	-1.0	-0.1	0.7	Birch Bay Road	PWH-2
LDES1057	39.2	37.4	37.9	39.2	-1.8	-1.3	0.0	Birch Bay Road	PWH-2
LDES1058	39.2	37.4	37.9	39.2	-1.8	-1.3	0.0	Birch Bay Road	PWH-2
LDES1067	29.9	26.7	29.3	29.5	-3.2	-0.6	-0.4		
LDES1068	29.2	26.5	29.3	29.4	-2.7	0.1	0.2	Birch Bay Road	PWH-2
LDES1069	30.0	26.4	28.3	29.0	-3.6	-1.7	-1.0		
LDES1070	30.1	26.4	28.3	29.0	-3.7	-1.8	-1.1		
LDES1071	28.0	25.2	25.5	25.5	-2.8	-2.6	-2.5		
LDES1072	25.0	22.4	22.8	23.0	-2.6	-2.2	-2.1		
LDES1091	99.8	98.0	98.0	98.0	-1.8	-1.8	-1.8		
LDES1094	103.5	101.7	101.7	101.7	-1.8	-1.8	-1.8		
LDES1109	79.2	75.5	76.0	76.4	-3.7	-3.2	-2.8		
LDES1127	77.2	75.1	75.1	75.1	-2.1	-2.1	-2.1		
LDES1175	122.9	122.2	122.2	122.2	-0.7	-0.7	-0.7		
LDES1178	120.6	120.0	120.0	120.0	-0.6	-0.6	-0.6		

Table B-1 Point Whitehorn Subwatershed Flooding									
		Existing Conditions							
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (feet)				Problem
Junction	Flood Elev	2 Year	25 Year	100 Year	2 Year	25 Year	100 Year	Location	ID
LDES118	115.1	113.5	113.5	113.5	-1.6	-1.6	-1.6		
LDES1181	119.9	118.4	118.6	118.7	-1.5	-1.4	-1.3		
LDES1186	118.7	118.4	118.6	118.7	-0.3	-0.2	0.0		
LDES1205	107.0	105.0	106.6	106.7	-2.0	-0.4	-0.3		
LDES1208	107.0	105.9	106.6	106.7	-1.1	-0.4	-0.3		
LDES1211	106.3	104.8	104.8	104.8	-1.5	-1.5	-1.5		
LDES1214	106.6	105.5	105.5	105.5	-1.1	-1.1	-1.1		
LDES1220	120.3	119.3	119.3	119.3	-1.0	-1.0	-1.0		
LDES1223	122.2	121.0	121.0	121.0	-1.2	-1.2	-1.2		
LDES1235	88.7	85.6	85.9	86.2	-3.2	-2.8	-2.5		
LDES1241	100.1	98.6	98.6	98.6	-1.5	-1.5	-1.5		
LDES1244	100.6	99.2	99.2	99.2	-1.4	-1.4	-1.4		
LDES1253	87.9	85.9	86.2	86.4	-2.0	-1.7	-1.5		
LDES6382	72.8	71.2	72.5	72.6	-1.6	-0.3	-0.2		
LDES6389	73.5	72.6	72.9	73.5	-0.9	-0.7	0.0	Petticote Lane	PWH-2
LDES6400	71.6	70.1	71.2	71.3	-1.6	-0.4	-0.3		
LDES6401	71.1	70.0	71.2	71.2	-1.1	0.1	0.1	Petticote Lane	PWH-2
LDES6402	67.0	66.2	66.4	66.6	-0.8	-0.6	-0.5		
LDES6406	28.7	27.9	28.4	28.9	-0.8	-0.3	0.2	Whitehorn Way	N/A
LDES6413	31.1	27.8	28.4	29.1	-3.3	-2.7	-2.1		
LDES6417	31.3	28.0	28.5	29.3	-3.3	-2.8	-2.0		
LDES6424	31.7	28.2	28.5	29.3	-3.6	-3.2	-2.4		
LDES6425	30.4	28.5	29.2	30.0	-1.9	-1.2	-0.4		
LDES6433	32.2	29.9	30.4	31.2	-2.3	-1.8	-1.0		
LDES6443	33.6	31.8	32.3	32.6	-1.9	-1.3	-1.0		
LDES6450	41.2	39.5	39.8	40.0	-1.7	-1.4	-1.2		
LDES6451	41.5	39.8	40.5	40.9	-1.7	-1.1	-0.6		
LDES6458	40.4	39.4	40.5	40.7	-1.0	0.1	0.3	Whitehorn Way	
LDES6461	40.1	38.6	39.0	39.3	-1.5	-1.1	-0.8		
LDES6462	33.5	31.0	31.4	31.5	-2.5	-2.1	-2.0		
LDES6463	32.6	29.2	29.5	30.0	-3.4	-3.1	-2.6		
LDES6465	52.7	50.5	50.8	51.0	-2.2	-1.9	-1.7		
TT-1000	30.8	28.2	30.1	30.9	-2.6	-0.7	0.1	Birch Bay Road	PWH-2
TT-1001	42.0	38.6	38.7	38.9	-3.4	-3.3	-3.1		
TT-1002	77.5	76.6	77.0	77.2	-0.9	-0.5	-0.3		
TT-1003	78.0	77.5	78.3	78.5	-0.5	0.3	0.5	Whitehorn Way and Grandview Drive	N/A
TT-1004	78.6	76.0	76.0	76.0	-2.6	-2.6	-2.6		
TT-1005	116.0	114.6	114.6	114.7	-1.4	-1.4	-1.3		
TT-1006	82.8	81.4	81.5	81.5	-1.4	-1.3	-1.3		
TT-1007	129.5	128.0	128.0	128.0	-1.5	-1.5	-1.5		
TT-1008	128.1	126.6	126.6	126.6	-1.5	-1.5	-1.5		
TT-1009	122.4	120.8	120.8	120.8	-1.6	-1.6	-1.6		
TT-1010	124.2	123.1	123.2	123.3	-1.1	-1.0	-0.9		
TT-1011	125.1	124.1	124.1	124.1	-1.0	-1.0	-1.0		
TT-1012	124.6	122.8	122.8	122.8	-1.8	-1.8	-1.8		
TT-1013	129.5	128.2	128.3	128.4	-1.3	-1.2	-1.1		
TT-1014	78.5	77.0	77.0	77.0	-1.5	-1.5	-1.5		
TT-1015	28.7	27.8	28.3	28.7	-0.9	-0.4	0.0	Whitehorn Way	N/A
TT-1016	39.6	38.0	39.4	39.7	-1.7	-0.3	0.1	Birch Bay Road	PWH-2
TT-1017	70.5	69.7	69.8	69.8	-0.9	-0.8	-0.7		
TT-1018	98.3	95.3	95.4	93.2	-3.0	-2.9	-5.1		

Whatcom County Public Works Department—Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District

Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

APPENDIX C. CAPITAL IMPROVEMENT PROJECT DESCRIPTION

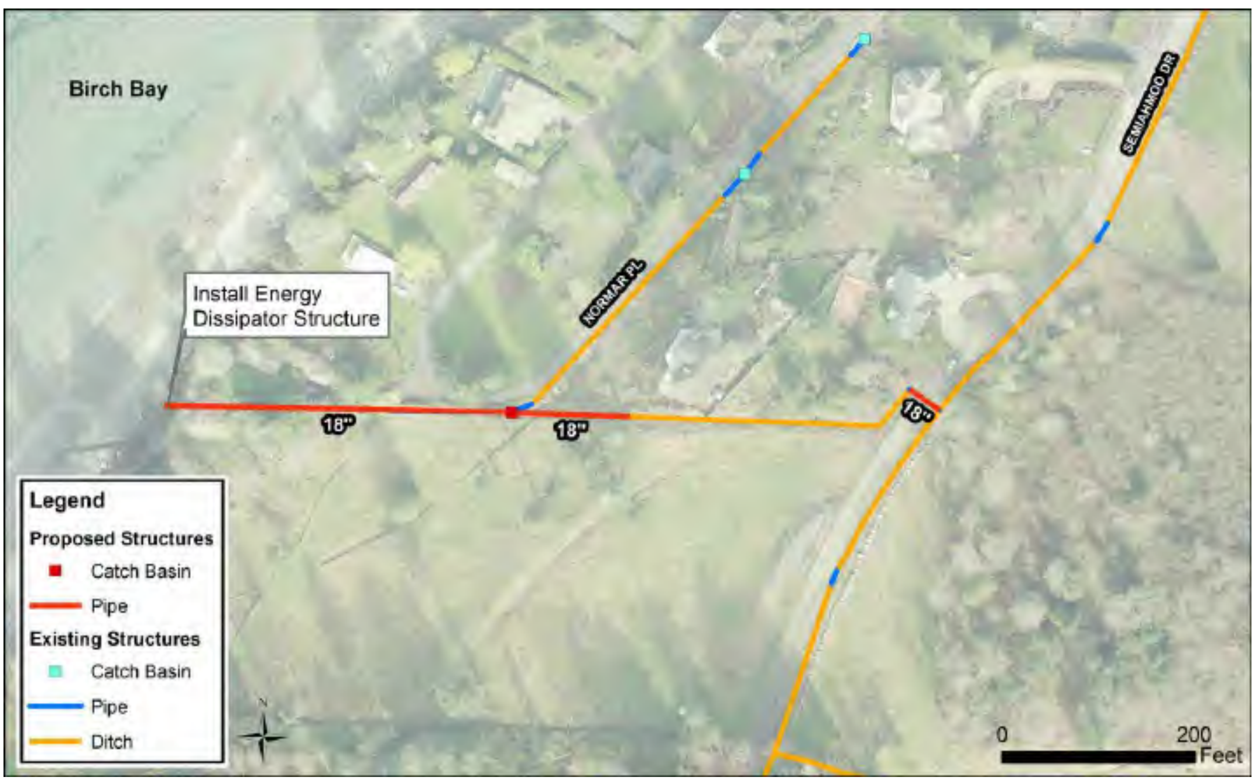
Birch Point North Subbasin

Project BP-1: Normar Place Storm Drain Improvements

Problem ID:	BP-2
Location:	Normar Place near Semiahmoo Drive
Description:	Culvert crossing under Semiahmoo Drive is undersized and causing roadway flooding during the 2-year and larger storm event under existing and future conditions. A flume conveys stormwater from Semiahmoo Drive to Normar Place (private) and overflows during the 25-year and larger storm event for existing and future conditions. High flow velocity in the roadside ditches is causing scour, sediment is transported to the downstream catch basin and obstructs flow.
Cost Estimate:	$191,000
Score:	28
Related Projects:	N/A

Project Description:

- Replace 415 lineal feet of 12-inch diameter pipe with 18-inch diameter CPE.
- Replace 30 lineal feet of 12-inch diameter concrete culvert with 18-inch CPE.
- Replace 1 CB Type 1 structure with 1 CB Type 2 structure.
- Install energy dissipater at pipe outfall.



BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-1 **BY:** GW
DESCRIPTION: Normar Place Storm Drain Improvements **CHECKED BY:** GMS
SUBBASIN: Birch Point North **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	13	SY	$ 40	$ 500
REMOVE PIPE	445	LF	$ 5	$ 2,225
CONNECT EXISTING PIPE	1	EA	$ 500	$ 500
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	445	LF	$ 55	$ 24,475
CATCH BASIN TYPE 2, 48-IN DIAM	1	EA	$ 2,400	$ 2,400
ASPHALT CONCRETE PAVEMENT PATCHING	2	TN	$ 100	$ 200
CRUSHED SURFACING BASE COURSE	3	TN	$ 15	$ 45
CRUSHED SURFACING TOP COURSE	2	TN	$ 35	$ 70
ENERGY DISSIPATER STRUCTURE	1	EA	$ 20,000	$ 20,000
			Material Subtotal	$ 55,415
CONTINGENCY	50%			$ 27,710
			Material Subtotal with Contingency	$ 83,125
DEWATERING	5%			$ 4,160
ARCHEOLOGICAL MONITORING	5%			$ 4,160
EROSION & SEDIMENTATION CONTROL	10%			$ 8,320
TRAFFIC CONTROL	5%			$ 4,160
SITE RESTORATION	5%			$ 4,160
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 5,410
			Construction Subtotal (Rounded)	$ 113,000
STATE SALES TAX	8.5%			$ 9,610
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 39,550
CONSTRUCTION MANAGEMENT	10%			$ 11,300
PERMITTING - WITH OUTFALL TO BAY	15%			$ 16,950
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 191,000**

Notes:

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2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Birch Point North Subbasin

Project BP-2: Semiahmoo Drive Drainage Improvements (North)

Problem ID:	BP-5
Location:	Semiahmoo Drive
Description:	Driveway culverts and roadside ditches on the east side of Semiahmoo Drive have insufficient capacity and overflow during the 25-year and larger future conditions storm event.
Cost Estimate:	$93,000
Score:	29
Related Projects:	N/A

Project Description:

- Replace 165-lineal feet of 15-, 18-, & 24- inch diameter pipe with 30-inch & 24-inch diameter CPE pipe.
- Re-establish 2,090 lineal feet of roadside ditch.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-2 **BY:** GW
DESCRIPTION: Semiahmoo Drive Drainage Improvements (North) **CHECKED BY:** GMS
SUBBASIN: Birch Point North **DATE:** 11/1/2016

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
REMOVE PIPE	165	LF	$ 5	$ 825
CONNECT EXISTING PIPE	1	EA	$ 500	$ 500
REESTABLISH DITCH	2,090	LF	$ 5	$ 10,450
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	130	LF	$ 60	$ 7,800
CORRUGATED POLYETHYLENE STORM SEWER PIPE 30 IN. DIAM.	35	LF	$ 70	$ 2,450
			Material Subtotal	$ 27,025
CONTINGENCY	50%			$ 13,520
			Material Subtotal with Contingency	$ 40,545
DEWATERING	5%			$ 2,030
ARCHEOLOGICAL MONITORING	5%			$ 2,030
EROSION & SEDIMENTATION CONTROL	10%			$ 4,060
TRAFFIC CONTROL	3%			$ 1,220
SITE RESTORATION	5%			$ 2,030
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 2,600
			Construction Subtotal (Rounded)	$ 55,000
STATE SALES TAX	8.5%			$ 4,680
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 22,000
CONSTRUCTION MANAGEMENT	10%			$ 5,500
PERMITTING	10%			$ 5,500
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 93,000**

Notes:

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2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

Birch Point South Subbasin

Project BP-3: Birch Point Road Storm Drain Improvements

Problem ID:	BP-8, BP-9
Location:	Birch Point Road east of Semiahmoo Drive
Description:	Driveway culverts and roadside ditches along Birch Point Road are undersized and flooding for the 25-year and larger storm existing conditions storm event and 25-year and larger future conditions storm event. High flow velocity is causing erosion at the outlet of both driveway culverts on the south side of Birch Point Road adjacent to the private driveway.
Cost Estimate:	$95,000
Score:	21
Related Projects:	BP-7

Project Description:

- Replace 70 lineal feet of 18-inch diameter PE culvert with 36-inch CPE.
- Replace 30 lineal feet of 24-inch diameter PE culvert with 36-inch CPE.
- Re-establish 2,000 lineal feet of roadside ditch.
- Place 12-inch quarry spall at culvert outlets adjacent to private driveway.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-3 **BY:** GW
DESCRIPTION: Birch Point Road Storm Drain Improvement **CHECKED BY:** GMS
SUBBASIN: Birch Point South **DATE:** 11/1/2016

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	58	SY	$ 40	$ 2,333
REMOVE PIPE	100	LF	$ 5	$ 500
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	100	LF	$ 80	$ 8,000
12" QUARRY SPALL	2	TON	$ 300	$ 600
REESTABLISH DITCH	2,000	LF	$ 5	$ 10,000
ASPHALT CONCRETE PAVEMENT PATCHING	5	TN	$ 100	$ 500
CRUSHED SURFACING BASE COURSE	16	TN	$ 15	$ 240
CRUSHED SURFACING TOP COURSE	8	TN	$ 35	$ 280
			Material Subtotal	$ 27,453
CONTINGENCY	50%			$ 13,730
			Material Subtotal with Contingency	$ 41,183
DEWATERING	5%			$ 2,060
ARCHEOLOGICAL MONITORING	5%			$ 2,060
EROSION & SEDIMENTATION CONTROL	10%			$ 4,120
TRAFFIC CONTROL	5%			$ 2,060
SITE RESTORATION	5%			$ 2,060
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 2,680
			Construction Subtotal (Rounded)	$ 56,000
STATE SALES TAX	8.5%			$ 4,760
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 22,400
CONSTRUCTION MANAGEMENT	10%			$ 5,600
PERMITTING	10%			$ 5,600
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 95,000**

Notes:

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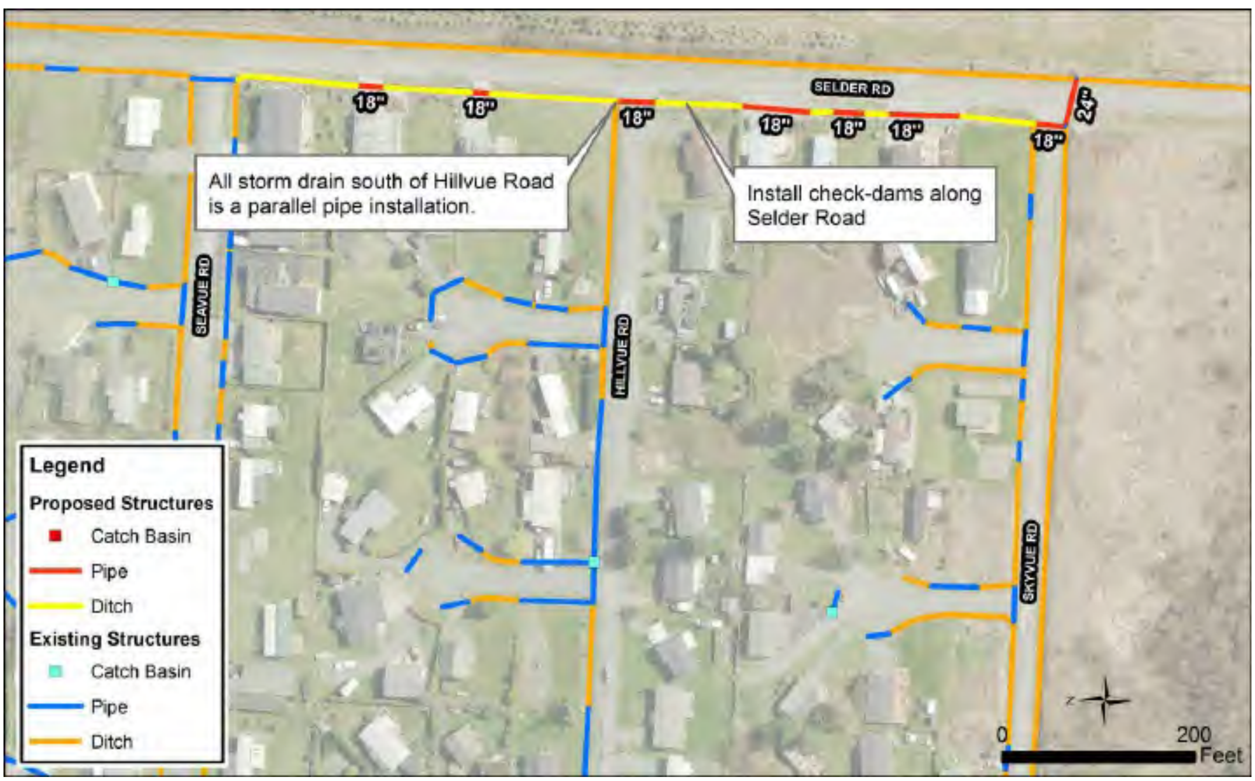
Semiahmoo Uplands Subbasin

Project BP-4: Selder Road Storm Drain Improvements

Problem ID:	BP-15
Location:	Selder Road north of Birch Point Road
Description:	Roadway flooding predicted at multiple driveway culverts along the west side of Selder Road for the 25-year and larger existing conditions storm event and the 2-year and larger future conditions storm event. Scour caused by high flow velocity in the roadside ditches occurs at multiple locations.
Cost Estimate:	$224,000
Score:	24
Related Projects:	N/A

Project Description:

- Replace 50 feet of 18-inch diameter pipe with twin 24-inch diameter CPE pipes.
- Replace 30 feet of 18-inch diameter pipe with twin 18-inch diameter CPE pipes.
- Replace 265 feet of 12-inch diameter pipe with twin 18-inch diameter CPE pipes.
- Replace 50 feet of 12-inch diameter pipe with 18-inch diameter CPE.
- Re-establish 550 lineal feet of roadside ditch.
- Install check dams in roadside ditches along both sides of Selder Road.



BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-4 | **BY:** GW
DESCRIPTION: Selder Road Storm Drain Improvements | **CHECKED BY:** GMS
SUBBASIN: Rogers Slough Lower Tributary | **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	183	SY	$ 40	$ 7,300
REMOVE PIPE	365	LF	$ 5	$ 1,825
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	580	LF	$ 55	$ 31,900
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	100	LF	$ 60	$ 6,000
REESTABLISH DITCH	550	LF	$ 5	$ 2,750
12" QUARRY SPALL	33	TON	$ 300	$ 9,800
ASPHALT CONCRETE PAVEMENT PATCHING	17	TN	$ 100	$ 1,700
CRUSHED SURFACING BASE COURSE	49	TN	$ 15	$ 735
CRUSHED SURFACING TOP COURSE	25	TN	$ 35	$ 875
			Material Subtotal	$ 67,885
CONTINGENCY	50%			$ 33,950
			Material Subtotal with Contingency	$ 101,835
DEWATERING	5%			$ 5,100
ARCHEOLOGICAL MONITORING	5%			$ 5,100
EROSION & SEDIMENTATION CONTROL	10%			$ 10,190
TRAFFIC CONTROL	3%			$ 3,060
SITE RESTORATION	5%			$ 5,100
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 6,520
			Construction Subtotal (Rounded)	$ 137,000
STATE SALES TAX	8.5%			$ 11,650
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 47,950
CONSTRUCTION MANAGEMENT	10%			$ 13,700
PERMITTING	10%			$ 13,700
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 224,000**

Notes:

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Birch Point South Subbasin

Project BP-5: Semiahmoo Drive Drainage Improvements (South)

Problem ID:	BP-6
Location:	Semiahmoo Drive near Birch Point Road
Description:	Ditches and driveway culverts on the east side of Semiahmoo Drive overflow during the 25-year and larger existing conditions storm event and the 2-year and larger future conditions storm event.
Cost Estimate:	$162,000
Score:	20
Related Projects:	N/A

Project Description:

- Replace 265 lineal feet of 12-inch diameter concrete pipe with 30-inch CPE.
- Deepen 3,260 feet of existing ditches

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-5 **BY:** GW
DESCRIPTION: Semiahmoo Drive Drainage Improvements (South) **CHECKED BY:** GMS
SUBBASIN: Birch Point South **DATE:** 11/1/2016

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	102	SY	$ 40	$ 4,083
REMOVE PIPE	265	LF	$ 5	$ 1,325
CORRUGATED POLYETHYLENE STORM SEWER PIPE 30 IN. DIAM.	265	LF	$ 70	$ 18,550
REESTABLISH DITCH	3,260	LF	$ 5	$ 16,300
ASPHALT CONCRETE PAVEMENT PATCHING	9	TN	$ 100	$ 900
CRUSHED SURFACING BASE COURSE	28	TN	$ 15	$ 420
CRUSHED SURFACING TOP COURSE	14	TN	$ 35	$ 490
			Material Subtotal	$ 47,068
CONTINGENCY	50%			$ 23,540
			Material Subtotal with Contingency	$ 70,608
DEWATERING	5%			$ 3,540
ARCHEOLOGICAL MONITORING	5%			$ 3,540
EROSION & SEDIMENTATION CONTROL	10%			$ 7,070
TRAFFIC CONTROL	5%			$ 3,540
SITE RESTORATION	5%			$ 3,540
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 4,600
			Construction Subtotal (Rounded)	$ 96,000
STATE SALES TAX	8.5%			$ 8,160
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 38,400
CONSTRUCTION MANAGEMENT	10%			$ 9,600
PERMITTING	10%			$ 9,600
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 162,000**

Notes:

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Birch Point South Subbasin

Project BP-6: Birch Point Road Outfall Improvement

Problem ID:	BP-10
Location:	Birch Point Road
Description:	Outfall located west of Birch Point Village and south of Birch Point Road has collapsed due to undermining.
Cost Estimate:	$326,000
Score:	30
Related Projects:	BP-3

Project Description:

- Replace approximately 100 lineal feet of 48” diameter CMP half-pipe with 48-inch diameter HDPE tightline and anchor.
- Inspect and repair ditch connecting outfall and upstream storm drain system.
- Install energy dissipater.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-6 | **BY:** GW
DESCRIPTION: Birch Point Road Outfall Improvement | **CHECKED BY:** GMS
SUBBASIN: Birch Point South | **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
REMOVE PIPE	150	LF	$ 5	$ 750
STRUCTURE EXCAVATION CLASS B, INCLUDING BACKFILL	500	CY	$ 30	$ 15,000
48-INCH DIAM HDPE	150	LF	$ 120	$ 18,000
REESTABLISH DITCH	1,700	LF	$ 5	$ 8,500
PIPE SUPPORTS / ANCHORING	5	EA	$ 5,000	$ 25,000
ENERGY DISSIPATER STRUCTURE	1	EA	$ 20,000	$ 20,000
			Material Subtotal	$ 92,250
CONTINGENCY	50%			$ 46,130
			Material Subtotal with Contingency	$ 138,380
DEWATERING	5%			$ 6,920
ARCHEOLOGICAL MONITORING	5%			$ 6,920
EROSION & SEDIMENTATION CONTROL	10%			$ 13,840
TRAFFIC CONTROL	3%			$ 4,160
SITE RESTORATION	10%			$ 13,840
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 9,210
			Construction Subtotal (Rounded)	$ 193,000
STATE SALES TAX	8.5%			$ 16,410
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 67,550
CONSTRUCTION MANAGEMENT	10%			$ 19,300
PERMITTING - WITH OUTFALL TO BAY	15%			$ 28,950
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 326,000**

Notes:

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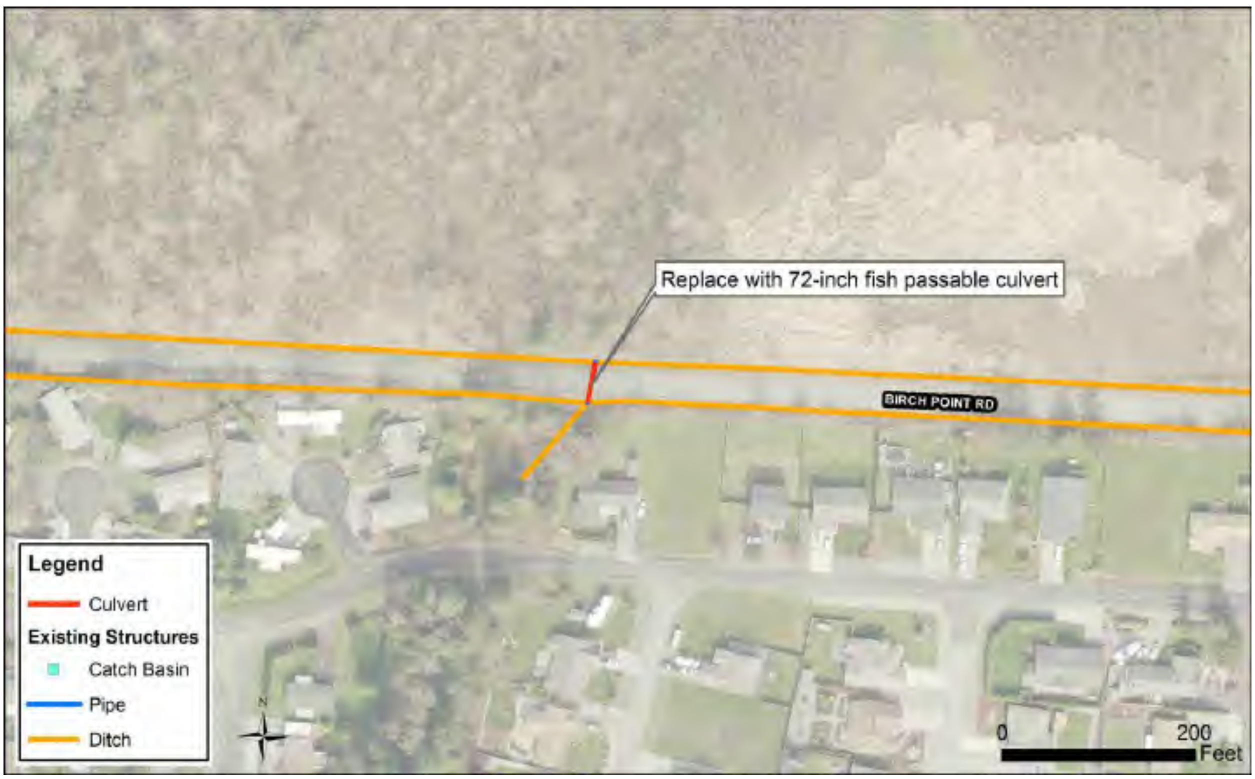
Semiahmoo Uplands Subbasin

Project BP-7: Birch Point Road Culvert Improvement

Problem ID:	BP-20
Location:	Birch Point Road west of Bay Ridge Road
Description:	Culvert crossing Birch Point Road has greater than a 1-foot drop which impedes fish passage (WDFW, 2016).
Cost Estimate:	$75,000
Score:	19
Related Projects:	N/A

Project Description:

- Replace existing 24-inch diameter concrete culvert with 72-inch diameter fish passage culvert structure (50 lineal feet).



BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: BP-7 **BY:** GW
DESCRIPTION: Birch Point Road Culvert Improvement **CHECKED BY:** GMS
SUBBASIN: Semiahmoo Uplands **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	58	SY	$ 40	$ 2,333
REMOVE PIPE	50	LF	$ 5	$ 250
CORRUGATED POLYETHYLENE STORM SEWER PIPE 72 IN. DIAM.	50	LF	$ 200	$ 10,000
STREAMBED GRAVEL	65	TN	$ 52	$ 3,367
ASPHALT CONCRETE PAVEMENT PATCHING	5	TN	$ 100	$ 500
CRUSHED SURFACING BASE COURSE	16	TN	$ 15	$ 240
CRUSHED SURFACING TOP COURSE	8	TN	$ 35	$ 280
			Material Subtotal	$ 21,970
CONTINGENCY	50%			$ 10,990
			Material Subtotal with Contingency	$ 32,960
DEWATERING	5%			$ 1,650
ARCHEOLOGICAL MONITORING	5%			$ 1,650
EROSION & SEDIMENTATION CONTROL	10%			$ 3,300
TRAFFIC CONTROL	3%			$ 990
SITE RESTORATION	5%			$ 1,650
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 2,120
			Construction Subtotal (Rounded)	$ 44,000
STATE SALES TAX	8.5%			$ 3,740
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 17,600
CONSTRUCTION MANAGEMENT	10%			$ 4,400
PERMITTING	10%			$ 4,400
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 75,000**

Notes:

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Birch Point South Subbasin

Project BP-8: Birch Point Water Quality Retrofits

Problem ID:	N/A
Location:	Various locations in the Birch Point subwatershed.
Description:	Several water quality monitoring locations have been identified to exceed fecal coliform standards as part of the Birch Bay / Terrell Creek Water Quality Monitoring Project
Cost Estimate:	$489,000
Score:	24
Related Projects:	N/A

Project Description:

- 4 locations have been identified for water quality facility installations. Facility types will be evaluated and selected based on individual opportunity and may include water quality filter vaults and swales

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**BP-8**	**BY:**	**GW**
DESCRIPTION:	**Subwatershed Water Quality Retrofit**	**CHECKED BY:**	**GMS**
Subwatershed	**Birch Point Subwatershed**	**DATE:**	**8/11/2106**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
WATER QUALITY FACILITY	4	EA	$ 40,000	$ 160,000
			Material Subtotal	$ 160,000
CONTINGENCY	50%			$ 80,000
			Material Subtotal with Contingency	$ 240,000
DEWATERING	5%			$ 12,000
ARCHEOLOGICAL MONITORING	5%			$ 12,000
EROSION & SEDIMENTATION CONTROL	10%			$ 24,000
TRAFFIC CONTROL	3%			$ 7,200
SITE RESTORATION	5%			$ 12,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 14,760
			Construction Subtotal (Rounded)	$ 322,000
STATE SALES TAX	8.5%			$ 27,370
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 96,600
CONSTRUCTION MANAGEMENT	10%			$ 32,200
PERMITTING - NO OUTFALL	5%			$ 10,760
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 489,000**

Notes:

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Terrell Creek Upper Tributary 1 Subbasin

Project TC-1: Bay Road Storm Drain Improvements

Problem ID:	TC-1
Location:	Bay Road at Jackson Road
Description:	Roadside storm drainage at the intersection of Bay Road and Jackson road is undersized and causing roadway flooding for the 25-year and larger storm event. High flow depth along Birch Bay Road causes a backwater condition at the culvert outlet and contributes to reduced pipe capacity.
Cost Estimate:	$53,000
Score:	20
Related Projects:	N/A

Project Description:

- Replace 90 lineal feet of 8-inch diameter pipe with 12-inch CPE.
- Replace 25 lineal feet of 24-inch diameter pipe with 36-inch CPE.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC-1 — **BY:** GW
DESCRIPTION: Bay Road Storm Drain Improvments — **CHECKED BY:** GMS
SUBBASIN: Terrell Creek Upper Tribtuary 1 — **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	60	SY	$ 40	$ 2,400
REMOVE PIPE	115	LF	$ 5	$ 575
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	90	LF	$ 40	$ 3,600
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	25	LF	$ 80	$ 2,000
ASPHALT CONCRETE PAVEMENT PATCHING	6	TN	$ 100	$ 600
CRUSHED SURFACING BASE COURSE	16	TN	$ 15	$ 240
CRUSHED SURFACING TOP COURSE	8	TN	$ 35	$ 280
			Material Subtotal	$ 14,695
CONTINGENCY	50%			$ 7,350
			Material Subtotal with Contingency	$ 22,045
DEWATERING	5%			$ 1,110
ARCHEOLOGICAL MONITORING	5%			$ 1,110
EROSION & SEDIMENTATION CONTROL	10%			$ 2,210
TRAFFIC CONTROL	10%			$ 2,210
SITE RESTORATION	5%			$ 1,110
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 1,490
			Construction Subtotal (Rounded)	$ 31,000
STATE SALES TAX	8.5%			$ 2,640
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 12,400
CONSTRUCTION MANAGEMENT	10%			$ 3,100
PERMITTING	10%			$ 3,100
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 53,000**

Notes:

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Terrell Creek Urban Area North Subbasin

Project TC-2: Wooldridge Avenue Storm Drain Improvements

Problem ID:	TC-4; TC-5; TC-7; TC-12; TC-13
Location:	Wooldridge Avenue, Jackson Road, and Sunset Drive
Description:	Storm drain system is undersized causing roadway flooding along Wooldridge Avenue, Jackson Road, and Sunrise Drive for the 2-year and larger storm event. Outfall to Terrell Creek is in poor condition and requires replacement. Water quality monitoring in Birch Bay has shown that state water quality standards for fecal coliform is frequently exceeded at the Terrell Creek outfalls.
Cost Estimate:	$921,000 See *Wooldridge Avenue Predesign Report*, (Tetra Tech 2014).
Score:	34
Related Projects:	N/A

Project Description:

- Replace roadside diteches and culvert and install 1,750 lineal feet of 12-inch diameter CPE.
- Replace roadside diteches and culvert and install 865 lineal feet of 12-inch diameter CPE.
- Install 25 Type 1 CB structures and 9 Type 2 CB structures.
- Install 72-inch water quality filter vault.
- Install 100 lineal feet of water quality treatment swale.
- Remove 1,300 lineal feet of existing storm pipe.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	TC-2	**BY:**	GW
DESCRIPTION:	Wooldridge Avenue Stormwater Improvements	**CHECKED BY:**	GMS
SUBBASIN:	Terrell Creek Urban Area North	**DATE:**	11/1/2016

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
Clearing and Grubbing	1	LS	$ 5,000	$ 5,000
Structure Excavation Class B Including Haul	2,050	CY	$ 15	$ 30,750
Ditch Excavation, Including Haul	210	CY	$ 30	$ 6,300
Gravel Base	830	TON	$ 10	$ 8,300
Crushed Surfacing Top Course	400	TON	$ 25	$ 10,000
Commercial HMA CL. 1/2 in. PG 64-22	230	TON	$ 90	$ 20,700
Gravel Borrow Including Haul	1,200	CY	$ 22	$ 26,400
Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	1,750	LF	$ 40	$ 70,000
Corrugated Polyethylene Storm Sewer Pipe 24 In. Diam.	865	LF	$ 65	$ 56,225
Catch Basin Type 1	25	EA	$ 1,000	$ 25,000
Catch Basin Type 2 48 In. Diam.	9	EA	$ 2,200	$ 19,800
Pipe End Debris Rack, 12" Diam.	2	EA	$ 475	$ 950
Pipe End Debris Rack, 24" Diam.	2	EA	$ 650	$ 1,300
Connect to Existing 12" Concrete Storm Sewer	6	EA	$ 360	$ 2,160
Remove Pipe	1,300	LF	$ 5	$ 6,500
Bioinfiltration Soil	93	TON	$ 60	$ 5,600
Swale Seeding	320	SY	$ 8	$ 2,560
Seeded Lawn Installation	667	SY	$ 2	$ 1,333
Landscape Restoration	1	EST	$ 12,000	$ 12,000
Repair Existing Public and Private Facilities	1	EST	$ 20,000	$ 20,000
Stormfilter CB (72")	1	EA	$ 24,000	$ 24,000
			Material Subtotal	$ 354,878
CONTINGENCY	30%			$ 106,470
			Material Subtotal with Contingency	$ 461,348
DEWATERING	5%			$ 23,070
ARCHEOLOGICAL MONITORING	5%			$ 23,070
EROSION & SEDIMENTATION CONTROL	10%			$ 46,140
TRAFFIC CONTROL	3%			$ 13,850
SITE RESTORATION	5%			$ 23,070
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 29,530
			Construction Subtotal (Rounded)	$ 620,000
STATE SALES TAX	8.5%			$ 52,700
ENGRG/LEGAL/ADMIN > $250K CONST	25%			$ 155,000
CONSTRUCTION MANAGEMENT	5%			$ 31,000
PERMITTING	10%			$ 62,000
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 921,000**

Notes:

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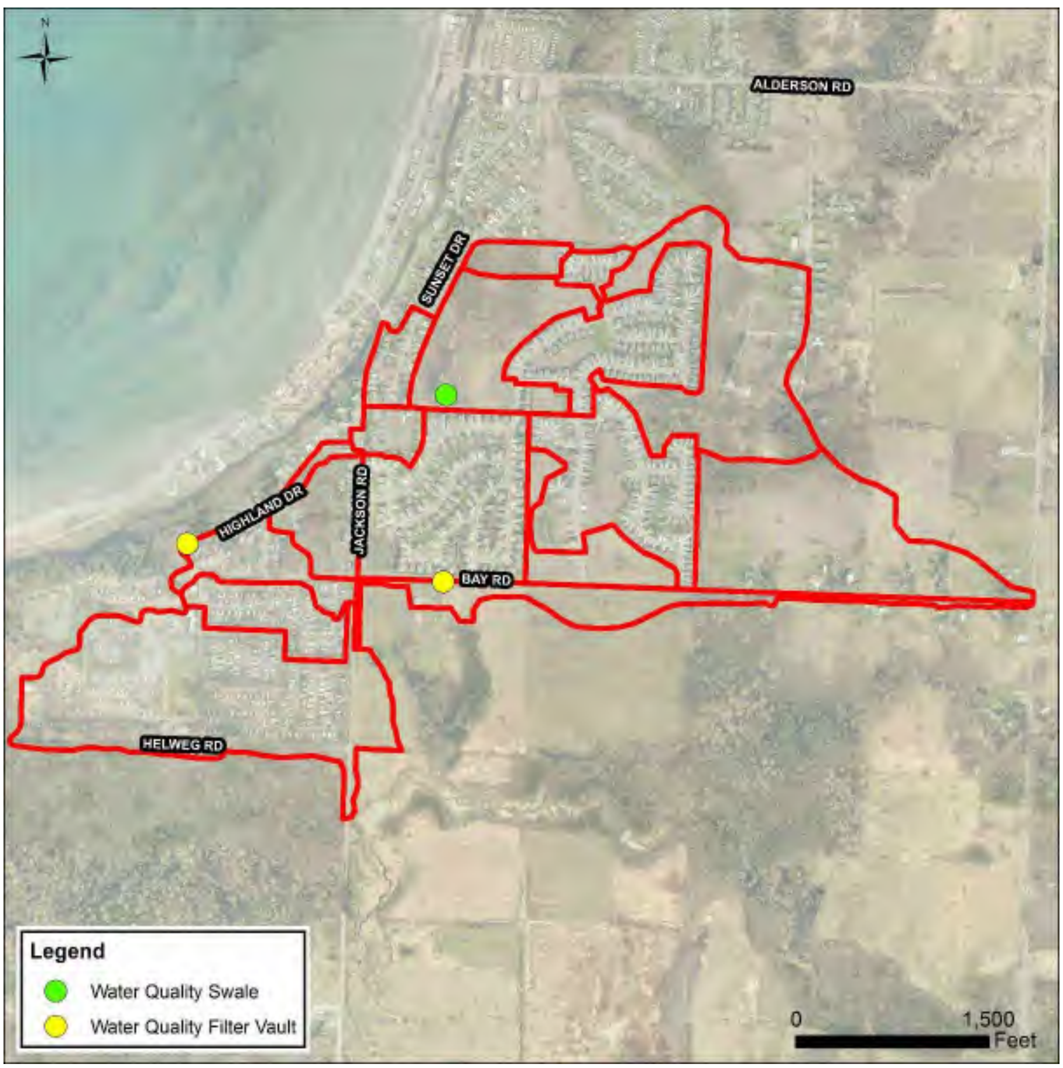
Terrell Creek Urban Area Subwatershed

Project TC-3: Terrell Creek Urban Area Water Quality Retrofits

Problem ID:	N/A
Location:	Various locations in the Terrell Creek Urban Area subwatershed.
Description:	Several water quality monitoring locations have been identified to exceed fecal coliform standards as part of the Birch Bay / Terrell Creek Water Quality Monitoring Project
Cost Estimate:	$379,000
Score:	24
Related Projects:	N/A

Project Description:

- 3 locations have been identified for water quality facility installations. Facility types will be evaluated and selected based on individual opportunity and may include water quality filter vaults and swales



BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: TC-3 — **BY:** GW
DESCRIPTION: Subwatershed Water Quality Retrofit — **CHECKED BY:** GMS
Subwatershed Terrell Creek Urban Area — **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
WATER QUALITY FACILITY	3	EA	$ 40,000	$ 120,000
			Material Subtotal	$ 120,000
CONTINGENCY	50%			$ 60,000
			Material Subtotal with Contingency	$ 180,000
DEWATERING	5%			$ 9,000
ARCHEOLOGICAL MONITORING	5%			$ 9,000
EROSION & SEDIMENTATION CONTROL	10%			$ 18,000
TRAFFIC CONTROL	3%			$ 5,400
SITE RESTORATION	5%			$ 9,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 11,070
			Construction Subtotal (Rounded)	$ 241,000
STATE SALES TAX	8.5%			$ 20,490
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 84,350
CONSTRUCTION MANAGEMENT	10%			$ 24,100
PERMITTING - NO OUTFALL	5%			$ 8,070
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 379,000**

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Point Whitehorn Subbasin

Project PW-1: Holeman Avenue Storm Drain Improvements

Problem ID:	PW-2, PW-9
Location:	Holeman Avenue near Birch Bay Drive
Description:	Storm drain on Holeman Avenue is undersized causing roadway flooding to the west of the Holeman Avenue outfall for the 25-year and larger storm event.
Cost Estimate:	$108,000
Score:	21
Related Projects:	N/A

Project Description:

- Replace 235 lineal feet of 12-inch diameter pipe with 18-inch CPE.
- Replace 100 lineal feet of 12-inch diameter pipe with 12-inch CPE.
- Replace 1 CB Type 1 structure.
- Replace 1 CB Type 1 structure with 1 CB Type 2 structure.
- Re-establish 160 lineal feet of existing ditch to match pipe invert elevations.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: PW-1 | **BY:** GW
DESCRIPTION: Holeman Avenue Storm Drain Improvements | **CHECKED BY:** GMS
SUBBASIN: Point Whitehorn | **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	42	SY	$ 40	$ 1,667
REMOVE PIPE	335	LF	$ 5	$ 1,675
CONNECT EXISTING PIPE	2	EA	$ 500	$ 1,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 12 IN. DIAM.	100	LF	$ 40	$ 4,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	235	LF	$ 55	$ 12,925
REESTABLISH DITCH	160	LF	$ 5	$ 800
CATCH BASIN TYPE 1	1	EA	$ 1,100	$ 1,100
CATCH BASIN TYPE 2, 48-IN DIAM	1	EA	$ 2,400	$ 2,400
ASPHALT CONCRETE PAVEMENT PATCHING	4	TN	$ 100	$ 400
CRUSHED SURFACING BASE COURSE	11	TN	$ 15	$ 165
CRUSHED SURFACING TOP COURSE	6	TN	$ 35	$ 210
			Material Subtotal	$ 31,342
CONTINGENCY	50%			$ 15,680
			Material Subtotal with Contingency	$ 47,022
DEWATERING	5%			$ 2,360
ARCHEOLOGICAL MONITORING	5%			$ 2,360
EROSION & SEDIMENTATION CONTROL	10%			$ 4,710
TRAFFIC CONTROL	5%			$ 2,360
SITE RESTORATION	5%			$ 2,360
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 3,060
			Construction Subtotal (Rounded)	$ 64,000
STATE SALES TAX	8.5%			$ 5,440
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 25,600
CONSTRUCTION MANAGEMENT	10%			$ 6,400
PERMITTING	10%			$ 6,400
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 108,000**

Notes:

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Point Whitehorn Subbasin

Project PW-2: Birch Bay Drive and Petticote Lane Storm Drain Improvements

Problem ID:	PW-7, PW-10, PW-11, PW-15
Location:	Birch Bay Drive and Petticote Lane near Holeman Avenue
Description:	Storm drain on Birch Bay Drive and Petticote Lane is undersized and causing roadway flooding for the 25-year and larger storm event. Sediment disposition is reducing conveyance of ditches and culverts along Petticote Lane. Roadway flooding between Jill Street and Point Whitehorn Way occurs for the 25-year and larger storm event.
Cost Estimate:	$293,000
Score:	22
Related Projects:	PW-3

Project Description:

- Replace 950 lineal feet of 12-inch diameter pipe with 18-inch CPE along Birch Bay Road.
- Replace 8 Type 1 CB structures with 8 CB Type 2 structures.
- Disconnect existing 12-inch diameter storm drain on Birch Bay Road.
- Replace 110 lineal feet of 12-inch diameter CMP culvert with 18-inch CPE at Petticote Lane.
- Clean roadside ditches and culverts within Petticote Lane.
- Re-establish 190 lineal feet of ditch connecting Petticote Lane and Birch Bay Road.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: PW-2 | **BY:** GW
DESCRIPTION: Birch Bay Drive and Petticote Lane Storm Drain Improvements | **CHECKED BY:** GMS
SUBBASIN: Point Whitehorn | **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
SAWCUT & REMOVE PAVEMENT	63	SY	$ 40	$ 2,500
REMOVE PIPE	960	LF	$ 5	$ 4,800
CONNECT EXISTING PIPE	4	EA	$ 500	$ 2,000
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	960	LF	$ 55	$ 52,800
PLUGGING EXISTING PIPE	1	EA	$ 200	$ 200
REESTABLISH DITCH	190	LF	$ 5	$ 950
CATCH BASIN TYPE 2, 48-IN DIAM	8	EA	$ 2,400	$ 19,200
ASPHALT CONCRETE PAVEMENT PATCHING	6	TN	$ 100	$ 600
CRUSHED SURFACING BASE COURSE	17	TN	$ 15	$ 255
CRUSHED SURFACING TOP COURSE	8	TN	$ 35	$ 280
			Material Subtotal	$ 88,585
CONTINGENCY	50%			$ 44,300
			Material Subtotal with Contingency	$ 132,885
DEWATERING	5%			$ 6,650
ARCHEOLOGICAL MONITORING	5%			$ 6,650
EROSION & SEDIMENTATION CONTROL	10%			$ 13,290
TRAFFIC CONTROL	3%			$ 3,990
SITE RESTORATION	5%			$ 6,650
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 8,510
			Construction Subtotal (Rounded)	$ 179,000
STATE SALES TAX	8.5%			$ 15,220
ENGRG/LEGAL/ADMIN $100-250K CONST	35%			$ 62,650
CONSTRUCTION MANAGEMENT	10%			$ 17,900
PERMITTING	10%			$ 17,900
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 293,000**

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Point Whitehorn Subbasin

Project PW-3: Birch Bay Drive Outfall Improvement

Problem ID:	PW-12
Location:	Birch Bay Drive east of Jill Street
Description:	Outfall at Birch Bay Drive has deteriorated to the point of failure.
Cost Estimate:	$150,000
Score:	25
Related Projects:	PW-2

Project Description:

- Replace 1 Type 2 CB structure and install 1 Type 2 CB structure.
- Replace 18-inch diameter outfall with 18-inch diameter HDPE pipe (80 lineal feet).
- Replace 35 feet of 18-inch diameter concrete pipe with 18-inch CPE.
- Replace 55 feet of 12-inch diameter concrete pipe with 18-inch CPE.
- Install energy dissipater.

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: PW-3 **BY:** GW
DESCRIPTION: Birch Bay Drive Outfall Improvement **CHECKED BY:** GMS
SUBBASIN: Point Whitehorn **DATE:** 8/11/2106

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
CLEAR AND GRUB	1	LS	$ 5,000	$ 5,000
REMOVE PIPE	170	LF	$ 5	$ 850
SAWCUT & REMOVE PAVEMENT	19	SY	$ 40	$ 750
CATCH BASIN TYPE 2, 48-IN DIAM	2	EA	$ 2,400	$ 4,800
CORRUGATED POLYETHYLENE STORM SEWER PIPE 18 IN. DIAM.	170	LF	$ 55	$ 9,350
ASPHALT CONCRETE PAVEMENT PATCHING	16	TN	$ 100	$ 1,600
CRUSHED SURFACING BASE COURSE	5	TN	$ 15	$ 75
CRUSHED SURFACING TOP COURSE	3	TN	$ 35	$ 105
ENERGY DISSIPATOR STRUCTURE	1	EA	$ 20,000	$ 20,000
			Material Subtotal	$ 42,530
CONTINGENCY	50%			$ 21,270
			Material Subtotal with Contingency	$ 63,800
DEWATERING	5%			$ 3,190
ARCHEOLOGICAL MONITORING	5%			$ 3,190
EROSION & SEDIMENTATION CONTROL	10%			$ 6,380
TRAFFIC CONTROL	3%			$ 1,920
SITE RESTORATION	5%			$ 3,190
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 4,090
			Construction Subtotal (Rounded)	$ 86,000
STATE SALES TAX	8.5%			$ 7,310
ENGRG/LEGAL/ADMIN < $100K CONST	40%			$ 34,400
CONSTRUCTION MANAGEMENT	10%			$ 8,600
PERMITTING - WITH OUTFALL TO BAY	15%			$ 12,900
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 150,000**

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Point Whitehorn Subwatershed

Project PW-4: Point Whitehorn Water Quality Retrofits

Problem ID:	N/A
Location:	Various locations in the Point Whitehorn subwatershed.
Description:	Several water quality monitoring locations have been identified to exceed fecal coliform standards as part of the Birch Bay / Terrell Creek Water Quality Monitoring Project
Cost Estimate:	$489,000
Score:	24
Related Projects:	N/A

Project Description:

- 4 locations have been identified for water quality facility installations. Facility types will be evaluated and selected based on individual opportunity and may include water quality filter vaults and swales

BIRCH BAY BIRCH POINT, TERRELL CREEK URBAN AREA, AND POINT WHITEHORN SUBWATERSHED MASTER PLAN
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**PW-4**	**BY:**	**GW**
DESCRIPTION:	**Subwatershed Water Quality Retrofit**	**CHECKED BY:**	**GMS**
Subwatershed	**Point Whitehorn**	**DATE:**	**8/11/2106**

BID ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**
WATER QUALITY FACILITY	4	EA	$ 40,000	$ 160,000
			Material Subtotal	$ 160,000
CONTINGENCY	50%			$ 80,000
			Material Subtotal with Contingency	$ 240,000
DEWATERING	5%			$ 12,000
ARCHEOLOGICAL MONITORING	5%			$ 12,000
EROSION & SEDIMENTATION CONTROL	10%			$ 24,000
TRAFFIC CONTROL	3%			$ 7,200
SITE RESTORATION	5%			$ 12,000
MOBILIZATION (GENERAL REQUIREMENT)	5%			$ 14,760
			Construction Subtotal (Rounded)	$ 322,000
STATE SALES TAX	8.5%			$ 27,370
ENGRG/LEGAL/ADMIN > $250K CONST	30%			$ 96,600
CONSTRUCTION MANAGEMENT	10%			$ 32,200
PERMITTING - NO OUTFALL	5%			$ 10,760
2016 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 489,000**

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Whatcom County Public Works Department Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Bay Birch Point, Terrell Creek Urban Area, and Point Whitehorn Subwatershed Master Plan

APPENDIX D. CAPITAL IMPROVEMENT PROJECT PRIORITY EVALUATION

	Project BP-1		Project BP-2		Project BP-3		Project BP-4	
Evaluation Criteria	Project BP-1: Normar Place Storm Drain Improvements		Project BP-2: Semiahmoo Drive Drainage Improvements		Project BP-3: Birch Point Road Storm Drain Improvements		Project BP-4: Selder Road Storm Drain Improvements	
Category	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit								
Shellfish Habitat (WQ)	Indirect improvement - single outfall to bay	4	Indirect improvement - single outfall to bay	4	No Improvement	0	No Improvement	0
Sediment source removal	Removes a significant sediment source	6	Removes a significant sediment source	6	No Improvement	0	Removes a minor sediment source	4
	Subtotal	10	Subtotal	10	Subtotal	0	Subtotal	4
	Weighted Score	10.0	Weighted Score	10.0	Weighted Score	0.0	Weighted Score	4.0
Community Benefit								
Frequency of Flooding	10- or 25-year recurrence interval	3	10- or 25-year recurrence interval	3	2-year recurrence interval	4	2-year recurrence interval	4
Property Damage	Nuisance yard flooding	0	1 to 2 homes flooded	1	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Street flooding less than 6 inches	1	Street flooding less than 6 inches	1	Street flooding less than 6 inches	1	Street flooding less than 6 inches	1
	Subtotal	4	Subtotal	5	Subtotal	5	Subtotal	5
	Weighted Score	4.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
Implementation								
Anticipated Cost of Project	$100,000 to $250,000	3	$0 to $100,000	4	$100,000 to $250,000	3	$100,000 to $250,000	3
Permit Complexity	Local and state permits required	1	Local, state, and federal permits required	0	Local permits required	2	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	No project link	0	No project link	0	Non-critical project link	1	No project link	0
	Subtotal	9	Subtotal	9	Subtotal	11	Subtotal	10
	Weighted Score	9.0	Weighted Score	9.0	Weighted Score	11.0	Weighted Score	10.0
Local support								
	Medium	5	Medium	5	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
Predesign								
	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
	Total Score	28.0	Total Score	29.0	Total Score	21.0	Total Score	24.0
	Rank	3	Rank	2	Rank	6	Rank	5
Notes and comments								

Birch Point Subwatershed Plan Project Prioritization Worksheet

	Project BP-5		Project BP-6		Project BP-7		Project BP-8	
Evaluation Criteria	Project BP-5: Semiahmoo Drive Drainage Improvements (South)		Project BP-6: Birch Point Road Outfall Improvement		Project BP-7: Birch Point Road Culvert Improvement		Project BP-8: Birch Point Water Quality Retrofits	
Category	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit								
Shellfish Habitat (WQ)	No Improvement	0	Indirect improvement - single outfall to bay	4	No Improvement	0	Indirect improvement - multiple outfalls to bay	6
Sediment source removal	No Improvement	0	Removes a significant sediment source	6	No Improvement	0	Removes a minor sediment source	4
	Subtotal	0	Subtotal	10	Subtotal	0	Subtotal	10
	Weighted Score	0.0	Weighted Score	10.0	Weighted Score	0.0	Weighted Score	10.0
Community Benefit								
Frequency of Flooding	10- or 25-year recurrence interval	3	Less than 2-year recurrence interval	5	Less than 2-year recurrence interval	5	No flooding	0
Property Damage	Nuisance yard flooding	0	Nuisance yard flooding	0	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Street flooding less than 6 inches	1	No street flooding	0	No street flooding	0	No street flooding	0
	Subtotal	4	Subtotal	5	Subtotal	5	Subtotal	0
	Weighted Score	4.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	0.0
Implementation								
Anticipated Cost of Project	$0 to $100,000	4	$250,000 to $500,000	2	$0 to $100,000	4	$250,000 to $500,000	2
Permit Complexity	Local permits required	2	Local, state, and federal permits required	0	Local, state, and federal permits required	0	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	No project link	0	Critical project link	3	No project link	0	No project link	0
	Subtotal	11	Subtotal	10	Subtotal	9	Subtotal	9
	Weighted Score	11.0	Weighted Score	10.0	Weighted Score	9.0	Weighted Score	9.0
Local support			0					
	Medium	5	High	10	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	10.0	Weighted Score	5.0	Weighted Score	5.0
Predesign								
	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
	Total Score	20.0	Total Score	35.0	Total Score	19.0	Total Score	24.0
	Rank	7	Rank	1	Rank	8	Rank	4
Notes and comments								

Terrell Creek Urban Area Project Prioritization Worksheet

	Project	TC-1	Project	TC-2	Project	TC-3
Evaluation Criteria	Project TC-1: Bay Road Storm Drain Improvements		Project TC-2: Wooldridge Avenue Storm Drain Improvements		Project TC-3: Terrell Creek Urban Area Water Quality Retrofits	
Category	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit						
Shellfish Habitat (WQ)	No Improvement	0	Indirect improvement - multiple outfalls to bay	6	Indirect improvement - multiple outfalls to bay	6
Sediment source removal	No Improvement	0	Removes a minor sediment source	4	Removes a minor sediment source	4
	Subtotal	0	Subtotal	10	Subtotal	10
	Weighted Score	0.0	Weighted Score	10.0	Weighted Score	10.0
Community Benefit						
Frequency of Flooding	10- or 25-year recurrence interval	3	Less than 2-year recurrence interval	5	No flooding	0
Property Damage	Nuisance yard flooding	0	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Street flooding less than 6 inches	1	Street flooding greater than 6 inches	3	No street flooding	0
	Subtotal	4	Subtotal	8	Subtotal	0
	Weighted Score	4.0	Weighted Score	8.0	Weighted Score	0.0
Implementation						
Anticipated Cost of Project	$0 to $100,000	4	$500,000 +	1	$250,000 to $500,000	2
Permit Complexity	Local permits required	2	Local, state, and federal permits required	0	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	No project link	0	No project link	0	No project link	0
	Subtotal	11	Subtotal	6	Subtotal	9
	Weighted Score	11.0	Weighted Score	6.0	Weighted Score	9.0
Local support			0			
	Medium	5	High	10	Medium	5
	Weighted Score	5.0	Weighted Score	10.0	Weighted Score	5.0
Predesign						
	Identified in a subwatershed master plan	5	Engineering feasibility evaluation with survey	10	Identified in a subwatershed master plan	5
	Weighted Score	5.0	Weighted Score	10.0	Weighted Score	5.0
	Total Score	20.0	Total Score	34.0	Total Score	24.0
	Rank	3	Rank	1	Rank	2
Notes and comments						

Point Whitehorn Subwatershed Prioritization Worksheet

	Project PW-1		Project PW-2		Project PW-3		Project PW-4	
Evaluation Criteria	Project PW-1: Holeman Avenue Storm Drain Improvements		Project PW-2: Birch Bay Dr. and Petticote Ln. Storm Drain Improvements		Project PW-3: Birch Bay Drive Outfall Improvement		Project PW-4: Point Whitehorn Water Quality Retrofits	
Category	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Benefit								
Shellfish Habitat (WQ)	No Improvement	0	No Improvement	0	Indirect improvement - single outfall to bay	4	Indirect improvement - multiple outfalls to bay	6
Sediment source removal	No Improvement	0	No Improvement	0	No Improvement	0	Removes a minor sediment source	4
	Subtotal	0	Subtotal	0	Subtotal	4	Subtotal	10
	Weighted Score	0.0	Weighted Score	0.0	Weighted Score	4.0	Weighted Score	10.0
Community Benefit								
Frequency of Flooding	10- or 25-year recurrence interval	3	10- or 25-year recurrence interval	3	Less than 2-year recurrence interval	5	Nuisance yard flooding	0
Property Damage	Nuisance yard flooding	0	1 to 2 homes flooded	1	Nuisance yard flooding	0	Nuisance yard flooding	0
Public Infrastructure	Street flooding greater than 6 inches	3	Street flooding greater than 6 inches	3	No street flooding	0	No street flooding	0
	Subtotal	6	Subtotal	7	Subtotal	5	Subtotal	0
	Weighted Score	6.0	Weighted Score	7.0	Weighted Score	5.0	Weighted Score	0.0
Implementation								
Anticipated Cost of Project	$100,000 to $250,000	3	$250,000 to $500,000	2	$100,000 to $250,000	3	$250,000 to $500,000	2
Permit Complexity	Local permits required	2	Local permits required	2	Local, state, and federal permits required	0	Local permits required	2
Property/Easement Acquisition	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5	No cost property/easement acquisition	5
Coordination with other projects/agencies	No project link	0	Non-critical project link	1	Critical project link	3	No project link	0
	Subtotal	10	Subtotal	10	Subtotal	11	Subtotal	9
	Weighted Score	10.0	Weighted Score	10.0	Weighted Score	11.0	Weighted Score	9.0
Local support								
	Medium	5	Medium	5	Medium	5	Medium	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
Predesign					0			
	Identified in a subwatershed master	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master plan	5	Identified in a subwatershed master	5
	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0	Weighted Score	5.0
	Total Score	21.0	Total Score	22.0	Total Score	25.0	Total Score	24.0
	Rank	4	Rank	3	Rank	1	Rank	2
Notes and comments								

BP-TC-PW Subwatershed Plan
Draft Prioritization Scoring

	Category	Criteria	Score	Comments
Environmental Benefit		Weighting	1	
	Shellfish Habitat (WQ)	No Improvement	0	
		Indirect Improvement - immediate vicinity (< 100 feet)	2	
		Indirect improvement - single outfall to bay	4	
		Indirect improvement - multiple outfalls to bay	6	
		Direct improvement to shellfish habitat	10	
	Sediment source removal	No Improvement	0	
		Nuisance removal	2	Removes sediment from stormwater runoff
		Removes a minor sediment source	4	Sediment deposition in downstream system restricts flow but does not completely obstruct conveyance
		Removes a significant sediment source	6	Sediment deposition in downstream system completely obstructs conveyance
Community Benefit		Weighting	1	
	Frequency of Flooding	No flooding	0	
		100-year recurrence interval	1	Based on hydraulic model
		10- or 25-year recurrence interval	3	Based on hydraulic model
		2-year recurrence interval	4	Based on hydraulic model
		Less than 2-year recurrence interval	5	Generally applies to areas with no storm drain system
	Property Damage	Nuisance yard flooding	0	
		1 to 2 homes flooded	1	The relative number of homes flooded has been reduced 0 - 5 OCI compared to the pervious prioritization
		3 to 4 homes flooded	2	5 -20 OCI
		5 to 10 homes flooded	3	20+ OCI
		10 + homes flooded	5	
	Public Infrastructure	No street flooding	0	
		Street flooding less than 6 inches	1	
		Street flooding greater than 6 inches	3	Flooding greater than 6 inches becomes dangerous to drive through
		Access to homes blocked	4	
		Emergency access blocked	8	Generally reserved for locations with only one emergency access route
		Critical public safety issue / critical public facility flooded	10	Swirling hole of death and high landslide risk are examples of the critical public safety issues
Implementation		Weighting	1	
	Anticipated Cost of Project	$500,000 +	1	
		$250,000 to $500,000	2	
		$100,000 to $250,000	3	
		$0 to $100,000	4	
	Permit Complexity	Local, state, and federal permits required	0	
		Local and state permits required	1	
		Local permits required	2	
		Programmatic permit action	3	
		No permits required	5	
	Property/Easement Acquisition	Condemnation necessary to obtain property/easements	0	
		High cost property acquisition/easements	1	> 10 % of construction cost
		Easement Acquisition only	2	
		Low cost property/easement acquisition	3	< 10 % of construction cost
		No cost property/easement acquisition	5	
	Coordination with other projects/agencies	No project link	0	
		Non-critical project link	1	Project is associated with other projects but not a critical or required element
		Critical project link	3	Associated project can not be built until this project is constructed
		50 percent funding by non-BBWARM fees	5	Recognizes funding sources other than BBWARM
		100 percent funding by non-BBWARM fees	8	Project to be built by others
		Regulatory Requirement	10	
Local Support		Weighting	1	
	Local Support	None	0	
		Low	2	One or two advocates
		Medium	5	Enthusiastic community support
		High	10	Identifeid by Advisory Committee as a prority project
Predesign			1	
	Predesign	No engineering evaluation	1	e.g., staff investigation of incident reports; no cost estimate
		Concept level engineering evaluation	3	e.g., top 10 conceptual designs (Osborn); minimal field work
		Identified in a subwatershed master plan	5	modeling, cost estimates
		Engineering feasibility evaluation with survey	10	analyze options, field work, cost estimates

Addendum 4

Birch Point Subwatershed Drainage Study Report

Prepared for:

Whatcom County
Public Works
Stormwater Division

Birch Bay Watershed
and Aquatic
Resources
Management District

Prepared by:

TETRA TECH

(Tt Project Number T42523)

September 2023

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Whatcom County and Tetra Tech would like to thank the Birch Bay Village Community Club and residents, Bay Ridge Estates HOA, Cantrell and Associates, and Cascade Engineering for their valuable assistance in preparing the Birch Point Subwatershed Drainage Study.

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1.0 INTRODUCTION

1.1 PROJECT OVERVIEW AND BACKGROUND

This study provides updates to the hydrologic and hydraulic analyses for the Birch Point and Shintaffer subwatersheds. The original models were developed for the Birch Point Subwatershed Master Plan (Tetra Tech, 2016b), and for the Central North Subwatershed Master Plan (Tetra Tech, 2013), respectively. This report will provide hydrologic and hydraulic analysis and preliminary sizing for conceptual design options to mitigate flooding in residential areas impacted by drainage from upland areas to where it enters Birch Bay.

The findings, conclusions, and project recommendations presented in this report are intended to help guide selection of a preferred solution to reduce flood hazards in the study area. The information provided should be considered planning level only and is based on limited ground survey and incomplete information on site conditions. Additional effort will be needed to optimize performance, investigate potential adverse impacts, and develop the design configuration of the options presented in this report prior to construction.

1.2 PREVIOUS STUDIES

The Central North Subwatershed Master Plan (Tetra Tech, 2013) was developed as a systematic approach to solving stormwater problems in the Central North subwatershed, improving drainage, and reducing flooding. The Shintaffer subbasin was included in the 2013 Master Plan hydrologic and hydraulic analysis. Stormwater drainage issues identified in the Shintaffer subbasin include inadequate conveyance, failing infrastructure, and inadequate maintenance.

The 2016 Tetra Tech Hydrologic and Hydraulic technical memorandum prepared for the Birch Point Subwatershed Master Plan previously summarized the hydrology and hydraulics of the study area (Tetra Tech, 2016a). The purpose of the 2016 technical memorandum was to develop an understanding of the hydrologic regime, determine the capacity of the existing storm drainage system and identify capacity restrictions, and identify flooding problems in the Birch Point, Terrell Creek Urban Area, and Point Whitehorn subwatersheds. The hydrologic and hydraulic model development, as well as updates to the models, are discussed below as part of this report. The Birch Bay Village development was outside the scope of the 2016 study so was not included in that report.

1.3 STUDY AREA

The study area (see Figure 1) is approximately 1,600 acres in size and is located north of Birch Bay and bounded by Shintaffer Road on the east. The northern boundary is defined by a line from Shintaffer Road 2,000 feet north of Lincoln Road extending in a northwesterly direction to Semiahmoo Parkway. The western boundary extends from Birch Bay to Birch Point Road about one mile west of Selder Road then in a northeasterly direction to Semiahmoo Parkway.

The study area includes the following subbasins identified in the 2016 Birch Point Subwatershed Master Plan: Semiahmoo Uplands, Birch Bay Marina, Rogers Slough Lower Trib, Rogers Slough Upper Trib and the Shintaffer subbasin from the Central North subwatershed plan (Tetra Tech, 2013). For this report, the subbasins have been reorganized into subareas for convenience in reporting and to reflect a better understanding of drainage patterns developed with this detailed study. The study area vicinity map with subarea delineation is shown on Figure 1 and subareas are described in greater detail in Section 2.0. The subbasins used as planning units for the 2013 and 2016 subwatershed master planning are also shown on this figure for reference.

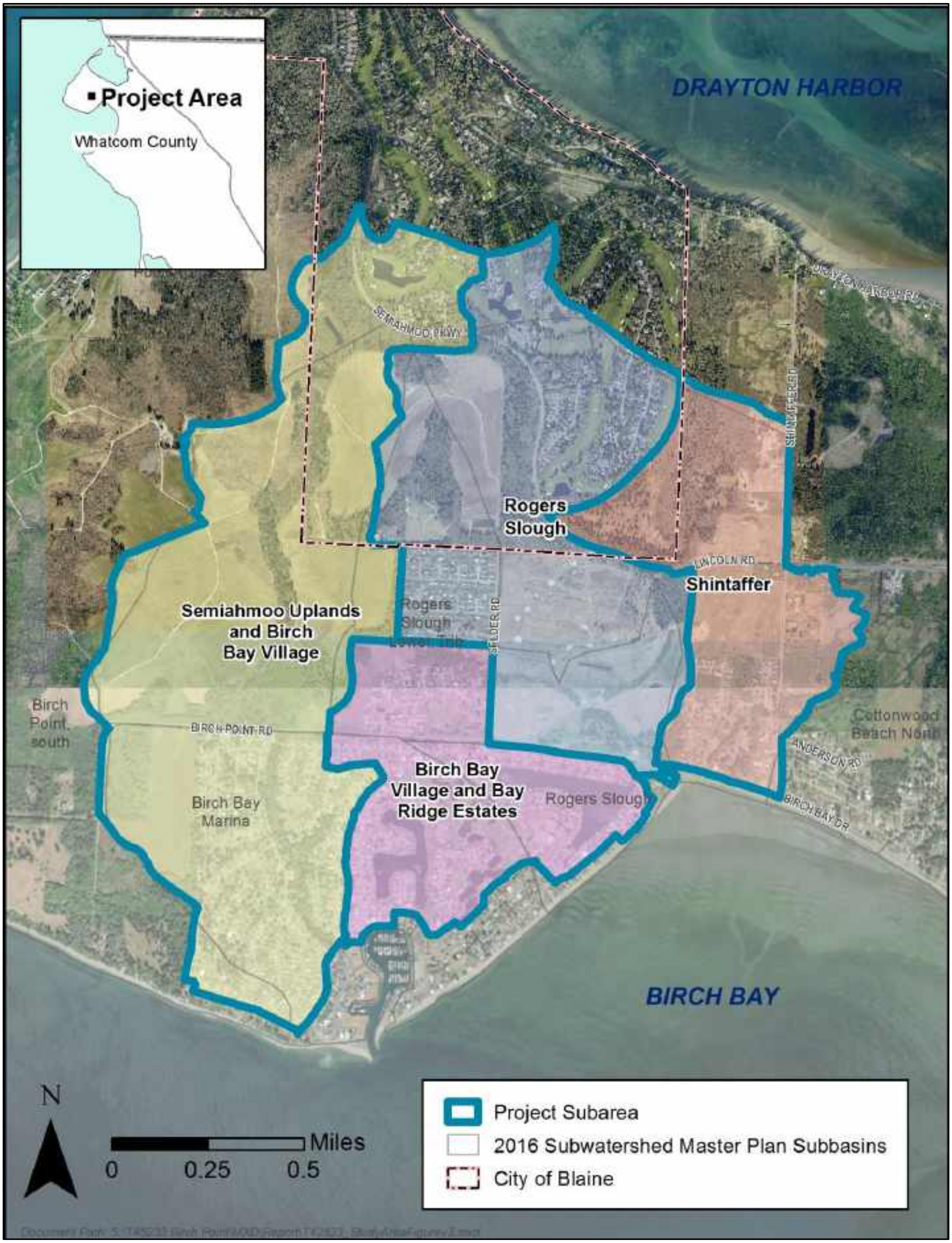


Figure 1. Birch Point Subwatershed Vicinity Map and Project Area

2.0 SUBAREA DESCRIPTIONS

The Birch Point Study Area is subdivided into four planning subareas aligned with primary drainage paths through the tributary basins:

- Semiahmoo Uplands and Birch Bay Village
- Birch Bay Village and Bay Ridge Estates
- Rogers Slough
- Shintaffer

2.1 SEMIAHMOO UPLANDS AND BIRCH BAY VILLAGE SUBAREA

The Semiahmoo Uplands and Birch Bay Village subarea covers the western third of the study area (see Figure 2). This subarea covers 705 acres between the residential neighborhood north of Semiahmoo Parkway to Birch Bay. Semiahmoo Parkway runs near the northern portion and Birch Bay is along the southern boundary. The subarea is bisected by Birch Point Road. Land use northwest of Semiahmoo Parkway is residential and recreational (golf course). Between Semiahmoo Parkway and Birch Point Road land use is undeveloped agricultural, with a forested riparian area surrounding an ephemeral stream that carries stormwater runoff. This stream originates in the subarea uplands and flows south under Birch Point Road through a 24-inch culvert. The west side of the Birch Bay Village neighborhood is located south (downstream) of Birch Point Road. Future land use assumes the undeveloped land in unincorporated Whatcom County between Semiahmoo Parkway and Birch Point Road will convert based on zoning as rural residential with five and ten acre lots. Zoning for the area in the City of Blaine is Residential Planned Recreation. The residential area north of Semiahmoo Parkway and Birch Bay Village are assumed to be fully built out and are representative of future land use.

The drainage system for this subarea starts in the residential golf course neighborhood north of Semiahmoo Parkway where stormwater runoff is collected in a golf course pond and routed south under Semiahmoo Parkway. The drainageway flows in a natural channel to an inline impoundment downstream of the parkway then continues in a natural channel to the Beaver Creek Wetland north of Birch Point Road. Stormwater runoff from five upland areas is routed through detention facilities located on the perimeter of the wetland and discharge to the wetland area. The hydraulic analysis (see Section 4.2) showed that during large runoff events, surface water flows overland to the Bay Ridge Estates area located to the east of Beaver Creek Wetland area. The wetland discharges through a 24-inch diameter culvert to Beaver Creek and into the west side of the Birch Bay Village neighborhood. Beaver Creek flows south through an open channel and two road culverts then into a pond controlled by a 42-inch diameter pipeline to the Birch Bay Marina.

2.2 BIRCH BAY VILLAGE AND BAY RIDGE ESTATES SUBAREA

The Birch Bay Village and Bay Ridge Estates Subarea covers 246 acres and generally includes the Bay Ridge Estates neighborhood and is bounded by Skyvue Road on the north, Chehalis Road on the west side, and Selder Road and Birch Bay to the south and east (see Figure 3). The subarea is mostly medium-density residential in Birch Bay Village and Bay Ridge Estates neighborhoods. The remaining area is undeveloped vacant land (north of Bay Ridge Estates) and open space/golf course in Birch Bay Village.

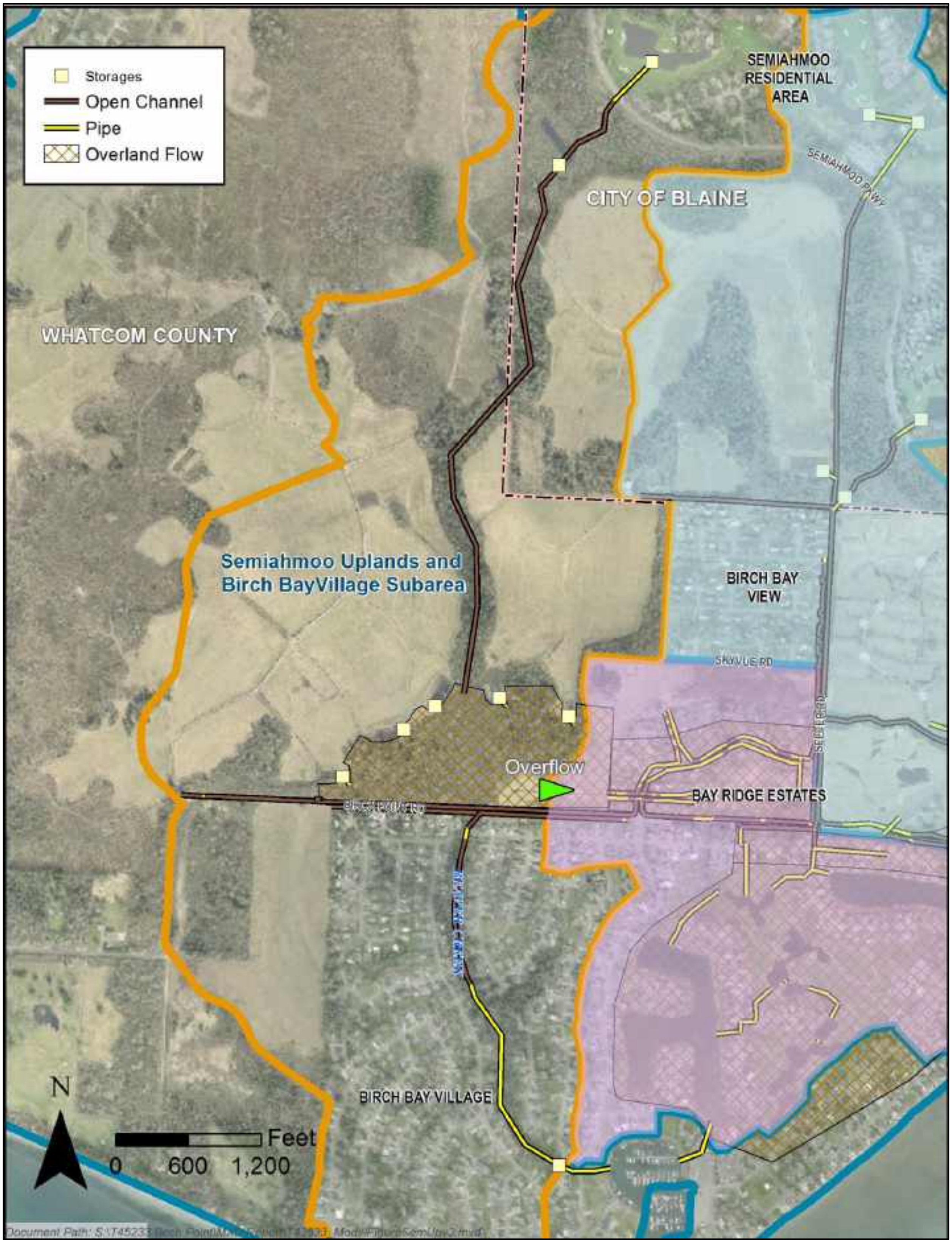


Figure 2. Semiahmoo Uplands and Birch Bay Village Subarea

Figure 3. Birch Bay Village and Bay Ridge Estates Subarea

Bay Ridge Estates is served by a piped storm drain system within the development and discharges to a pond at the northwest corner of Selder Road and Birch Point Road. The Bay Ridge Estates system combines with the Birch Point Road and Selder Road drainage system and crosses under Birch Point Road at two locations: at the entrance to Birch Bay Village and at Selder Road. From this point, the drainageway enters the Birch Bay Village drainage system and is combined with the golf course ponds and is conveyed to Thunderbird Lake and then to the Birch Bay Marina.

The hydraulic analysis showed that stormwater runoff from adjacent subareas overflows to the Birch Bay Village and Bay Ridge Estates subarea at three locations during large storm events (see green arrows in Figure 3):

- From the Semiahmoo Uplands and Birch Bay Village subarea (see Section 4.2) to the west end of Bay Ridge Estates.
- From the Rogers Slough subarea from the culvert under Selder Road at Skyvue Road (see Section 4.3).
- From the Rogers Slough subarea at Birch Bay Drive near Birch Point Loop to Nootka Loop and Salish Road in Birch Bay Village (see Section 4.5).

2.3 ROGERS SLOUGH SUBAREA

The Rogers Slough Subarea covers 444 acres along the eastern edge of the subwatershed (see Figure 4). The subbasin extends from the north side of Semiahmoo Parkway to Birch Point Road. Land use is medium-density residential north of Semiahmoo Parkway and undeveloped agricultural land south of the parkway to the north end of Selder Road. The undeveloped land is in the City of Blaine and is zoned Residential Planned Recreation. The Birch Bay View residential neighborhood is located west of Selder Road. The area east of Selder Road is vacant land but actively developing as the Horizon at Semiahmoo neighborhood. The area south of Horizon Drive and Birch Bay Drive is vacant land or low density residential and is zoned as Rural Residential.

The subbasin drains through roadside ditches and culverts, eventually combining flow with drainage from the north end of Selder Road near the Horizons development north of Birch Point Road and east of Selder Road. The combined runoff forms a defined stream along the east side of Selder Road and north of Bay Ridge Drive. The stream flows east of Birch Point Road then south to Birch Bay Drive where it discharges under the road through 18- and 30-inch concrete culverts into Rogers Slough. A tide gate that was installed immediately downstream of the road crossing was removed in November 2022. However this gate was present during the large storm event that occurred in November 2021.

2.4 SHINTAFFER SUBAREA

The Shintaffer subarea is 256 acres on the west side of the Central North subwatershed (see Figure 5). The subbasin is west of Shintaffer Road except for a moderately sized area immediately south of Lincoln Road. The Shintaffer subbasin is bisected by Lincoln Road. Land use in the subbasin is primarily agricultural north of Richmond Park and residential to the south. An undeveloped area is located north of Semiahmoo Parkway and west of Shintaffer Road. The subarea crosses into the City of Blaine in the northwest corner. The area north of Richmond Park is zoned Urban Residential, Neighborhood Commercial, and Rural Residential.

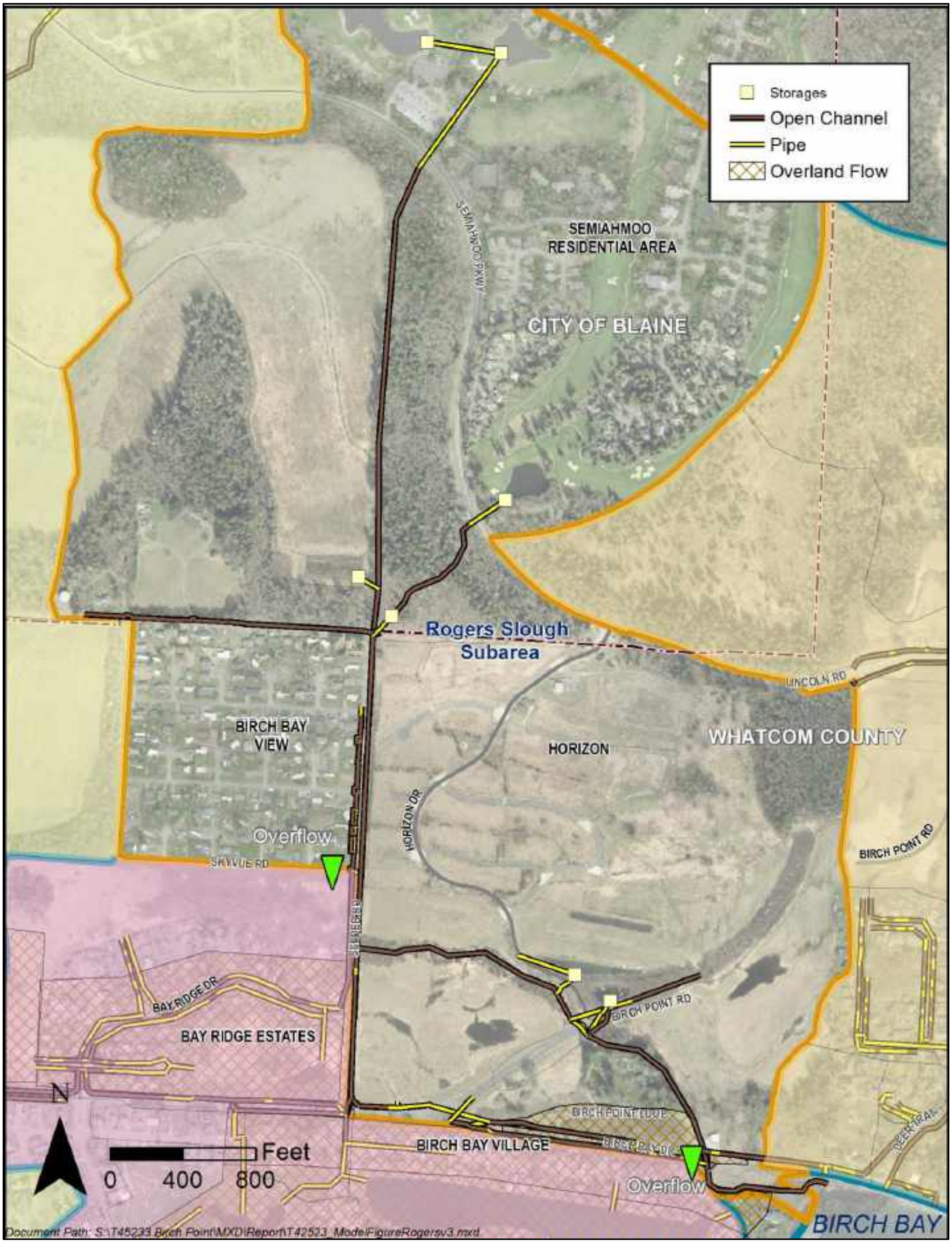


Figure 4. Rogers Slough Subarea

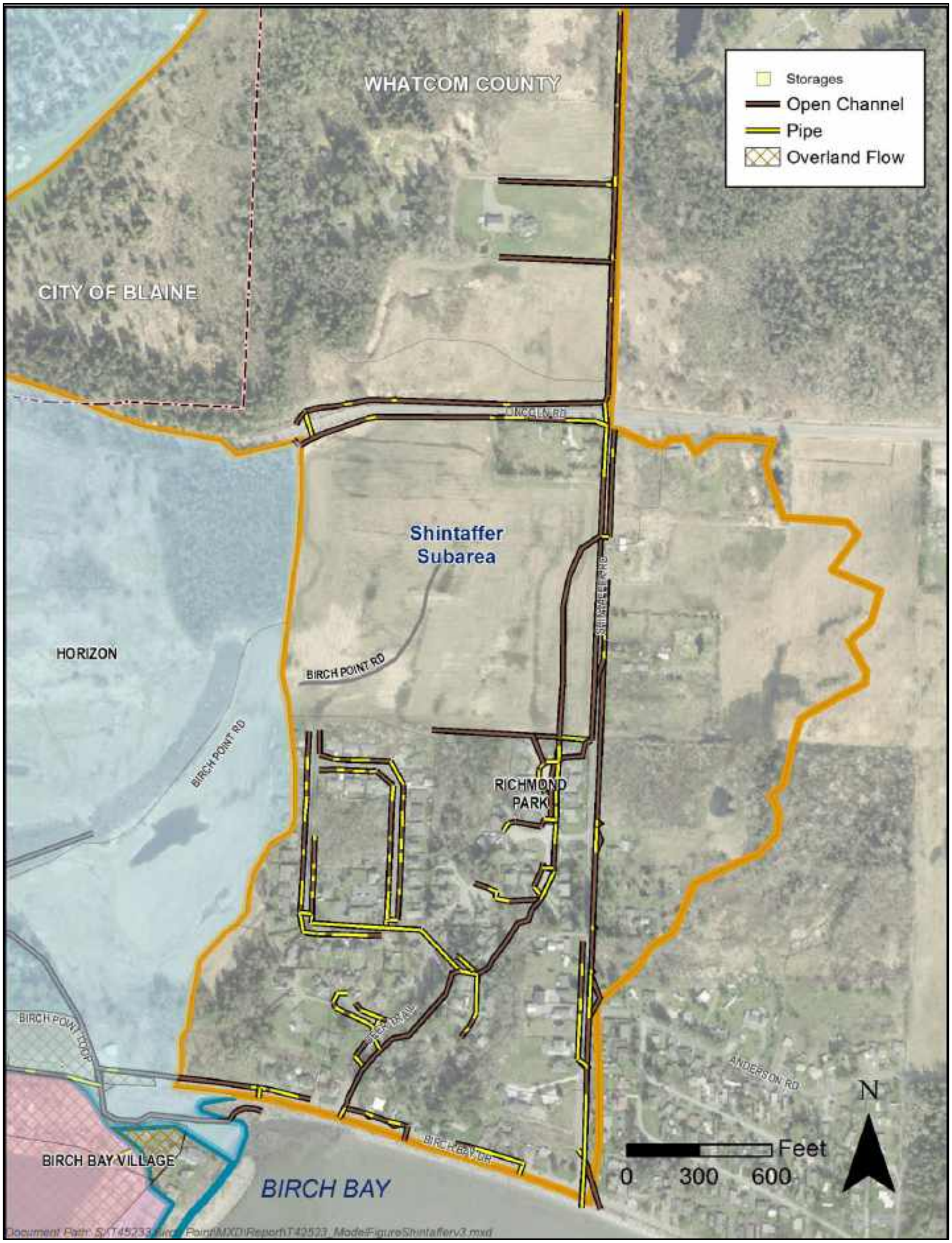


Figure 5. Shintaffer Subarea

Surface water in the Shintaffer subarea flows south to Birch Bay from headwaters north of Semiahmoo Parkway and west of Shintaffer Road. Drainage from the Semiahmoo residential area discharges to a wetland area east of Shintaffer Road and north of Lincoln Road. A network of field ditches drains the wetland area to roadside ditches along the north side of Lincoln Road and the west side of Shintaffer Road. The main conveyance pathway continues south along Shintaffer Road where it becomes a storm drain pipeline at Richmond Park Road. This 24-inch concrete pipe conveys flow through the Richmond Park subdivision and outfalls to a steep ravine. Ultimately, stormwater is discharged to Birch Bay through an ungated outfall near Deer Trail. A small local system along the north side of Birch Bay Drive is also served by the outfall.

A system of ditches, culverts, and storm drains collects runoff from the area east of Shintaffer Road and conveys it to a pipeline south of Anderson Road. This pipeline discharges to Birch Bay through an ungated outfall at Shintaffer Road.

Two local storm drain systems with separate outfalls to Birch Bay collect runoff from along Birch Bay Drive. One system discharges to Birch Bay west of Deer Trail and the other discharges to Birch Bay west of Shintaffer Road.

3.0 UPDATES TO HYDROLOGIC MODEL

The Hydrologic Simulation Program-Fortran (HSPF) (USEPA, 2005) is a continuous simulation hydrology model that uses long-term climate data (rainfall and evapotranspiration data) and land use parameter inputs to determine runoff characteristics for a watershed. HSPF simulates all phases of the hydrologic cycle, including rainfall, direct surface runoff, evapotranspiration, and ground infiltration. Runoff from discrete subbasins is routed through rating tables used to represent pipes, channels, lakes, and other flood storage areas.

Generally, rainfall that falls on the land surface and is not removed through evapotranspiration either soaks into the ground or discharges to a stream channel or other body of water as direct surface runoff. Water that infiltrates into the ground moves laterally through the unsaturated zone as interflow or percolates into the saturated zone as groundwater. Interflow discharges to stream channels but at a slower rate than direct runoff. Groundwater also discharges to stream channels that intersect the saturated zone, contributing to long-term base flow in the system. Groundwater can also leave the surface watershed by entering deep groundwater or moving outside the watershed basin.

3.1 SUBCATCHMENT DELINEATION

The Birch Point subwatershed was previously delineated into 25 subcatchments (Tetra Tech, 2016a).The existing subcatchment delineation was re-evaluated for this report and modified into 40 subcatchments based on 2017 LiDAR data (Quantum Spatial, 2017), as-builts drawings, and aerial photography (see Appendix A). Specifically, Shintaffer (Tetra Tech, 2013), and Birch Bay Village subbasins were included in the study area, and resolution was added to the Semiahmoo Uplands and Birch Bay Village subarea and the Roger Slough subarea.

3.2 LAND USE AND IMPERVIOUS AREA

Flow characteristics were computed for existing land use conditions at the 40 subcatchments in the study area. Existing land use conditions were updated based on 2019 aerial photography provided by Whatcom County. Existing land use conditions and impervious area are shown in Figure 6. Impervious area estimates developed for the watershed characterization study (ESA Adolfson, 2007) were used as the impervious area input to the HSPF model. The ESA Adolfson study represents the most complete representation of impervious area in the Birch Bay watershed The measured impervious area was assumed to be directly connected to the storm drain system. Table 1 shows the existing and future impervious area in the Birch Point study area.

Table 1. Impervious Area in the Birch Point Study Area

Return Period	Semiahmoo Uplands and Birch Bay Village Subarea	Birch Bay Village and Bay Ridge Estates Subarea	Rogers Slough Subarea	Shintaffer Subarea	Birch Point Study Area
Total Area (acres)	705	246	444	256	**1,652**
Existing Conditions					
Impervious Area (acres)	97	100	60	21	**277**
Impervious Area (%)	14%	41%	14%	8%	17%
Future Conditions					
Impervious Area (acres)	150	105	166	64	**485**
Impervious Area (%)	21%	42%	37%	25%	29%
Change from Existing					
Impervious Area (acres)	54	4	106	44	**208**
Percent Change (%)	56%	5%	176%	209%	75%

Currently, impervious area in the Birch Point study area is found mostly in unincorporated Whatcom County with a small amount in the City of Blaine, primarily in the residential neighborhoods east of Semiahmoo Parkway. Figure 7 illustrates the distribution of impervious area in the study area.

3.1 FUTURE LAND USE

In 2013, the Birch Bay Urban Growth Area (UGA), which includes portions of the Birch Point study area, was added to Whatcom County's National Pollutant Discharge Elimination System (NPDES) Phase II permit coverage area. Coverage under this permit requires the County to implement minimum standards for maintenance of the existing stormwater system. Flow control and water quality treatment for new development will be required to meet more stringent minimum technical requirements specified in the Stormwater Manual for Western Washington. However, a significant portion of the Birch Point subwatershed is outside the NPDES boundary and could potentially develop without flow control. For these areas, an increase in peak stormwater runoff rates may occur with redevelopment so the future developed land use condition is included as part of this analysis.

Flow estimates for future land use runoff are not intended to establish detention based runoff rates and would represent the worst case scenario for sizing estimates. The performance of future stormwater management facilities due to design deficiencies and the potential for poor maintenance result in uncertain estimates of peak flow rates. Using uncontrolled flow rates would allow the Birch Bay Watershed & Aquatic Resources Management (BBWARM) district, a stormwater utility provider, to provide resiliency in solutions to resolve flooding and conveyance issues.

Figure 6. Existing Land Use Condition

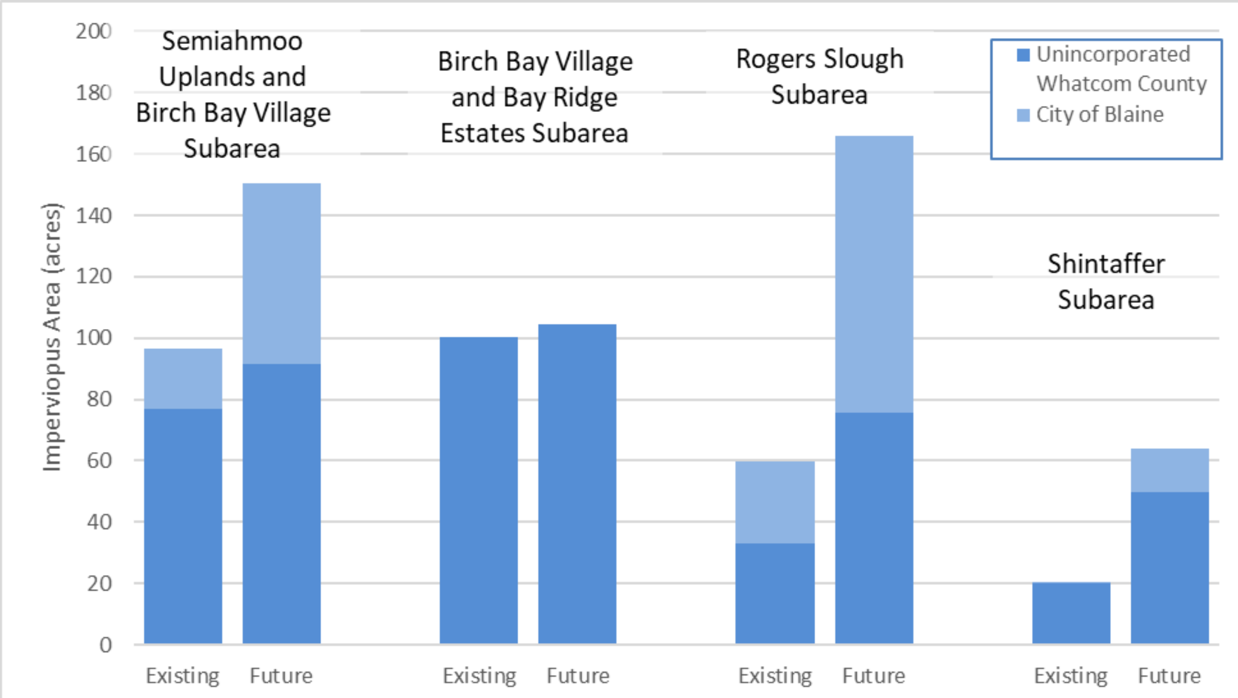


Figure 7. Impervious Area Distribution by Jurisdiction

Runoff for future conditions was evaluated based on land cover defined by Whatcom County and the City of Blaine zoning. Land use conversion is assumed to occur only for vacant areas currently undeveloped. Areas currently developed as single-family residential areas were assumed to be fully built-out and would remain at the current housing density into the future. This includes the Semiahmoo residential area, Birch Bay Village, Bay Ridge Estates, Richmond Park, and the residential area along Shintaffer Road, Deer Trail, Pheasant and Grouse Crescent and Birch Bay Drive near Shintaffer Road. Wetland and riparian corridors along with associated buffers and other critical areas were also retained and land use in these areas was not converted to a higher density land use. Impervious area is computed by applying the directly connected impervious fraction by zoning classification listed in Table 2 for the undeveloped areas. Directly connected impervious area is the portion of the land cover that is directly connected to the storm drainage system. Land use conversion in non-critical areas was assumed to occur over the entire zoned area regardless of parcel size. Figure 8 shows the zoning used to define future land use.

Table 2. Impervious Area Assignments for Zoning Classifications

Zoning[a]	Density	Directly Connected Impervious Area
Rural Residential	5 to 10 acre lots	5%
Residential Planned Recreation (Blaine)	3 lots per acres	40%
Urban Residential	4 lots per acre	40%
Urban Residential Medium Density	6 lots per acres	50%
General Commercial		80%
Neighborhood Commercial		85%
Open Water		100%

a. Whatcom County zoning except as noted, See Figure 8

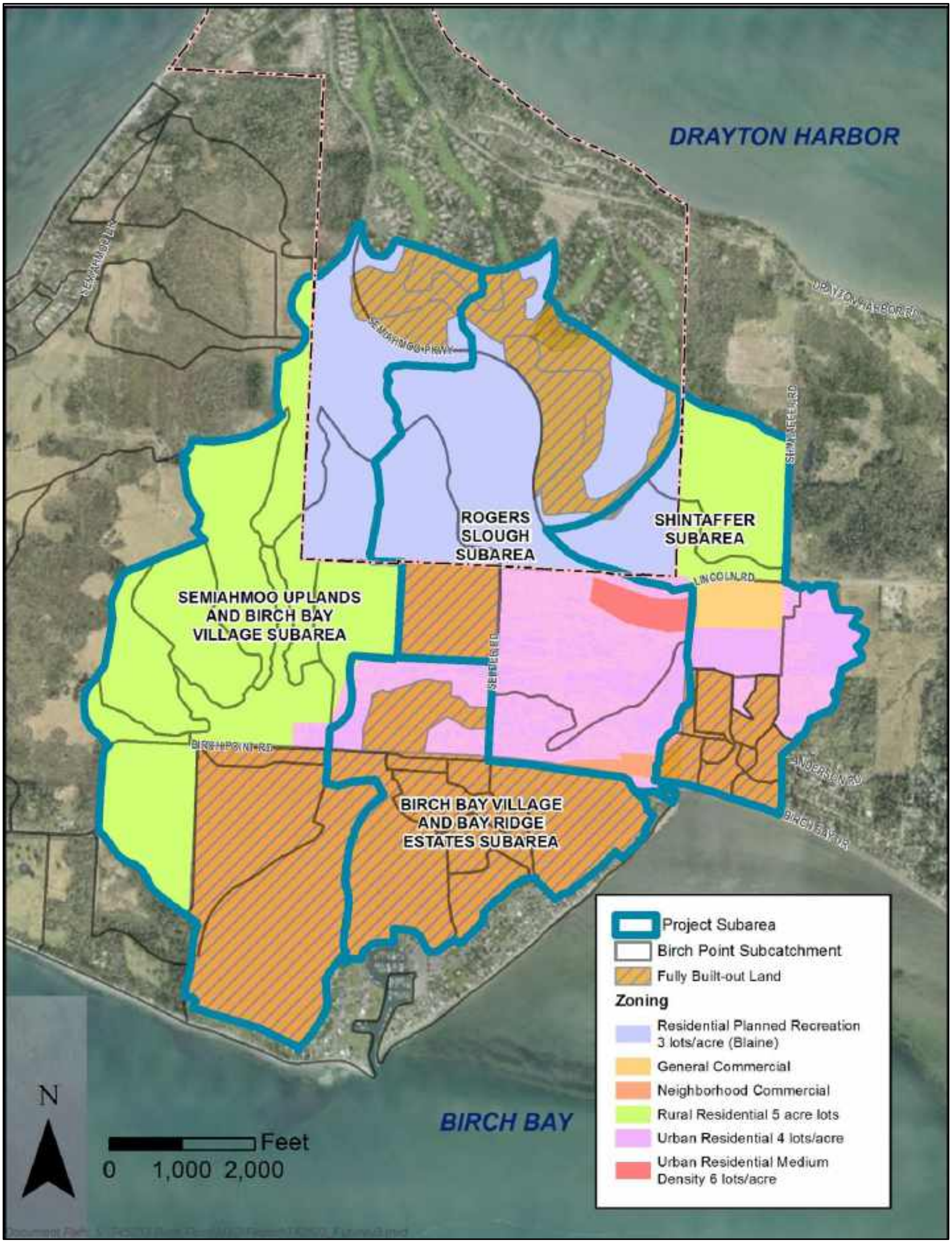


Figure 8. Future Land Use Condition

Table 1 shows that total impervious area under future conditions is expected to increase by over 200 acres, or a 75% increase in impervious area in the study area. Figure 7 shows that the impervious area will increase disproportionality in the City of Blaine for the Semiahmoo Uplands and Birch Bay Village subarea and the Rogers Slough subarea. The increase in impervious area in the Shintaffer subarea will occur mostly in Whatcom County but is also expected to increase in the City of Blaine where currently there is very little impervious surface in the study area.

The increase in impervious area with future development will also increase stormwater runoff volume (see Section 4.1) and peak flow rates. The City and County will need to coordinate future stormwater management efforts in the study area to ensure effective stormwater controls are implemented to control peak flows and sufficient conveyance is provided with storm drain infrastructure improvements.

3.2 CLIMATE DATA

Long-term precipitation data collected at Blaine from 1948 to 2009 was previously used to compute a continuous flow record (Agweathernet, 2022). This report further incorporates data collected at Blaine in November 2021 that corresponded to a large rainfall event. Long-term average precipitation values recorded at Blaine were compared to precipitation data collected by the Birch Bay Water and Sewer District (BBWSD) and found to be equivalent. Potential evaporation data was developed from pan evaporation data collected at the Washington State University Extension in Puyallup, Washington (WSU, 2022) adjusted by a factor 0.76 to account for regional differences in potential evapotranspiration (NOAA, 1982).

3.3 UPDATES TO HYDRAULIC MODEL

The storm drainage system within the Birch Point subwatershed is complex and requires a sophisticated hydraulic model such as the PCSWMM model (CHI, 2023) which uses the United States Environmental Protection Agency's (USEPA's) Stormwater Management Model (SWMM5) (USEPA, 2011) as it's computational engine. SWMM5 can represent tidal fluctuation, surcharging and flooding of pipes and open channels, split flows, and hydraulic features such as natural and constructed detention facilities. The two-dimensional (2-D) flow module in PCSWMM can represent overland flow conditions in areas with flat topography and indistinct flow patterns where routing elements (e.g. channels and pipe) are unsuitable for representing the hydraulic conditions. PCSWMM with SWMM5 is well-suited for hydraulic analysis of the storm drainage system.

Runoff from HSPF subcatchments is input to the SWMM5 model at discrete nodes in the model schematic. The routing portion of SWMM5 conveys this runoff through a system of pipes, channels, storage, and outfalls. SWMM5 tracks the flow rate and volume of water in each pipe and channel.

3.4 CONVEYANCE SYSTEM DATA INPUTS

The storm drainage inventory data previously collected by Whatcom County, Land Development Engineering and Survey, Inc. (LDES), and Wilson Engineering were used as the primary sources of data for the SWMM5 model network. The Bay Ridge Estates system was surveyed by Whatcom County in 2022. The survey data consisted of pipe, culvert, ditches, manholes, catch basins, and drain points. Other data sources included a topographic grid surface derived from LiDAR mapping, as-built drawings, and observations made during field reconnaissance.

Storm drain and culvert pipe characteristics were obtained from the Whatcom County Geographic Information System (GIS) geodatabase. Data elements included pipe size, pipe material, and conduit length. Upstream and downstream pipe invert elevations were obtained from field survey completed to support the watershed master plan. Pipe size is assumed to be one foot in diameter where GIS data is not available. Catch basin and manhole information was also obtained from the storm drainage inventory. Data elements included geographic coordinates (northing and easting), rim elevation and structure invert elevation. Rim elevations are measured based on LiDAR where GIS data was not available. Manning's roughness coefficients for pipes were based on accepted engineering values for pipe material assuming fair condition. Smooth pipes (e.g., concrete, polyvinyl chloride, high density polyethylene) were assigned a roughness coefficient of 0.012 and rough pipes (e.g., corrugated metal) were assigned a coefficient of 0.024. An entrance loss coefficient of 0.5 to 0.8 was assigned to pipes where transitions from open-channel flow to closed conduit flow exist. An exit loss coefficient of 1.0 was assumed for pipes that discharge to open channels.

Open channel (roadside ditch and natural channel) characteristics were estimated from approximate field measurements for bottom width, side slope, and depth. Invert elevations were obtained from the topographic survey. Roadside ditches and natural channels were previously assumed to have a trapezoidal shape with varying width and depth. As part of this study, roadside ditch cross-section dimensions were extracted from LiDAR at critical locations. Channels were assigned a roughness coefficient of 0.035, assuming an average maintained condition. The level of accuracy used to dimension most ditches channel sections is appropriate for this planning-level analysis because flow through the roadside ditch and culvert system in the four subareas is controlled by culvert size and material rather than channel characteristics. However, certain ditches were measured in the field on a case-by-case basis when known problems had been reported or were observed in the hydraulic model.

Generally, overflow channels for roadway culverts were not included in the model unless preliminary model runs indicted surface flooding. For these cases, overflow conduits were added as trapezoidal open channels with dimensions measured from LiDAR. A roughness coefficient of 0.024 was assigned to overflow channels.

Overtopping elevations for surveyed structures corresponded to the rim elevation of the catch basin or manhole. Overtopping elevations for drain points associated with open channels, non-surveyed structures, and ponds were estimated from LiDAR mapping. The LiDAR-derived data were adjusted at some locations where they were determined to be inaccurate due to vegetation or other obstructions. For these cases, the overtopping elevation was replaced with a value obtained from a nearby point in an unobstructed area. Topographic survey points collected at the top of ditches were also supplemented for the LiDAR when available.

Flat areas with indistinct flow patterns were modeled using the 2-D overland flow routing model in PCSWMM. The interconnections between the storm drainage system and the overland flow pathways are relatively complex and not intuitively obvious from a review of the topography. To address this uncertainty, a 2-D hydraulic model was developed to simulate the overland flow paths between networks. A flow mesh of the ground surface was created from the LiDAR using the pre-processing capabilities of the PCSWMM software and merged with the storm drain system network.

Model nodes, representing catch basin and manholes are named using the facility identifier number assigned by the county during their inventory (e.g. 1500). An alphabetical prefix was used for gravity mains, culverts, ditches, and other drainage pipes. Gravity main pipes are preceded with "GM", culverts begin with a "C", and open ditches begin with an "OD" prefix. For example, a ditch may be denoted "OD1000". Overtopping conduits were assigned the suffix "-OF" and includes the two node names connecting the upstream and downstream ends (e.g. 1500_1600-OF). Weirs are assigned a "-W" suffix and orifices are assigned a "-O" suffix. Nodes obtained from LDES were given a "LDES" prefix in front on each identification number (e.g. LDES1600). Nodes created by Tetra Tech were assigned a "TT" prefix (e.g. TT1600). Elevation data for Tetra Tech nodes was sampled using existing LiDAR or interpolated between known elevation points. Names with the prefix "BBV-" indicate the structure is located in Birch Bay Village.

As part of this study, several details were added to the hydraulic model, including:

- Details and stormwater facilities were added at the private developments of Birch Bay Village and Bay Ridge Estates based on LiDAR and Whatcom County GIS geodatabase data.
- Modified routing from upland areas to study area based on LiDAR.
- Golf course ponds and outflow details were added for ponds east of Semiahmoo Parkway, near the Semiahmoo Golf and Country Club, based on site drawings (Raper and Associates, 1985)
- Detail added at the new Horizon at Semiahmoo development based on as-builts drawings (David Evans and Associates, 2007).
- Added storm drain network in Bay Ridge Estates based on survey provided by Whatcom County.
- Details were added at Birch Point Road and Birch Bay Drive based on record drawings (David Evans and Associates, 2008).
- Modified storm drain and tide gate at Birch Bay Drive and Nootka Loop based on record drawings (Tetra Tech, 2020) and concept plans (Osbourn Consultants, 2011).
- Kwan Lake and Thunderbird Lake bathymetry information was added to the model based on survey data provided by William Reilly from Birch Bay Village.

3.5 DESIGN EVENTS

Peak flows were computed by routing a hydrograph extracted from the long-term continuous simulation hydrologic model output (see Section 3.0) through the hydraulic model. The extracted hydrograph with scaling factors represents the 25- and 100-year flood events, November 2021 peak rainfall event, and a climate change scenario. The largest simulated event in the combined runoff time series is the December 1983 event which is equivalent to the 25-year so the hydrograph for this event is used as the design hydrograph and adjusted by a scaling factor to represent the other design events. The scaling factor is computed as a ratio of the rainfall for the design event to the 25-year rainfall. Rainfall events are described in Table 3.

In November 2021, the Birch Point subwatershed experienced a rainfall event in excess of the 100-year return period that caused extensive flooding throughout the Birch Bay watershed area. Approximately 6.1 inches of rain was recorded over a 36-hour period at the Blaine weather station operated by Washington Conservation District (Agweathernet, 2022) located approximately 5 miles northwest of the Birch Point study area.

This study also evaluates a climate change scenario. This evaluation assumes a 22% increase in the 100-year design event (Whatcom, 2020), which results in a 48% increase in the 25-year event.

Table 3. Application of the Design Event for Hydrologic Input

Return Period	Rainfall Amount[a] (in)	Scale Factor[b]
25-Year	4.5	1.0
100-Year	5.2	1.21
November 2021	6.1	1.33
Climate Change	6.67	1.48

a. After scaling factor applied.

b. The scale factor is in reference to the 25-year event.

3.6 MODEL VALIDATION

The November 2021 event listed in Table 3 was also used to verify flood elevations observed in the model against flooding observed in Birch Bay Village. William Reilly of Birch Bay Village provided a high water mark measure after the November 2021 event of 9.5 feet (in the North American Vertical Datum of 1988; NAVD88). Mr. Reilly also provided photos of flooding on Nootka Loop and Salish Road north of Kwann Lake. These photos show extensive flooding on the roadway.

The initial run of the hydraulic model showed it was unable to replicate flood level and inundation extents using the hydrograph computed by HSPF for this event. The inability of the model to replicate flood conditions for this event is likely due to the use of an uncalibrated HSPF model to simulate runoff during early wet season events. To rectify the deficiency, the December 1983 design hydrograph was adjusted by a scaling factor derived from rainfall comparison at the BBWSD shops (see Scale Factor in Table 3). With this approach, the hydraulic model was able to predict peak stage at Thunderbird Lake within 0.7 feet and also more closely simulate the flood extent on Salish Road.

4.0 MODEL RESULTS AND FLOOD PROBLEM AREAS

Design event flow hydrographs representing existing and future land use conditions were routed through the SWMM5 hydraulic models to estimate peak flows and depths throughout the four subareas. The chosen events from the hydrologic models were used as inputs to the hydraulic model to evaluate the performance of the stormwater conveyance system and identify flood problem areas in the subwatershed and capacity limitations in the storm drainage network. Output flow data was analyzed at four subareas described in Section 2.0:

- Semiahmoo Uplands and Birch Bay Village Subarea
- Birch Bay Village and Bay Ridge Estates Subarea
- Rogers Slough Subarea
- Shintaffer Subarea

Stage (depth in feet NAVD88) is reported at selected locations represented by green circles in Figure 9 and flow (cubic feet per second [cfs]) output locations are represented with orange bars to show where conveyance capacity may be restricted in the storm drain system resulting in surface flooding in residential areas and on public and private roads.

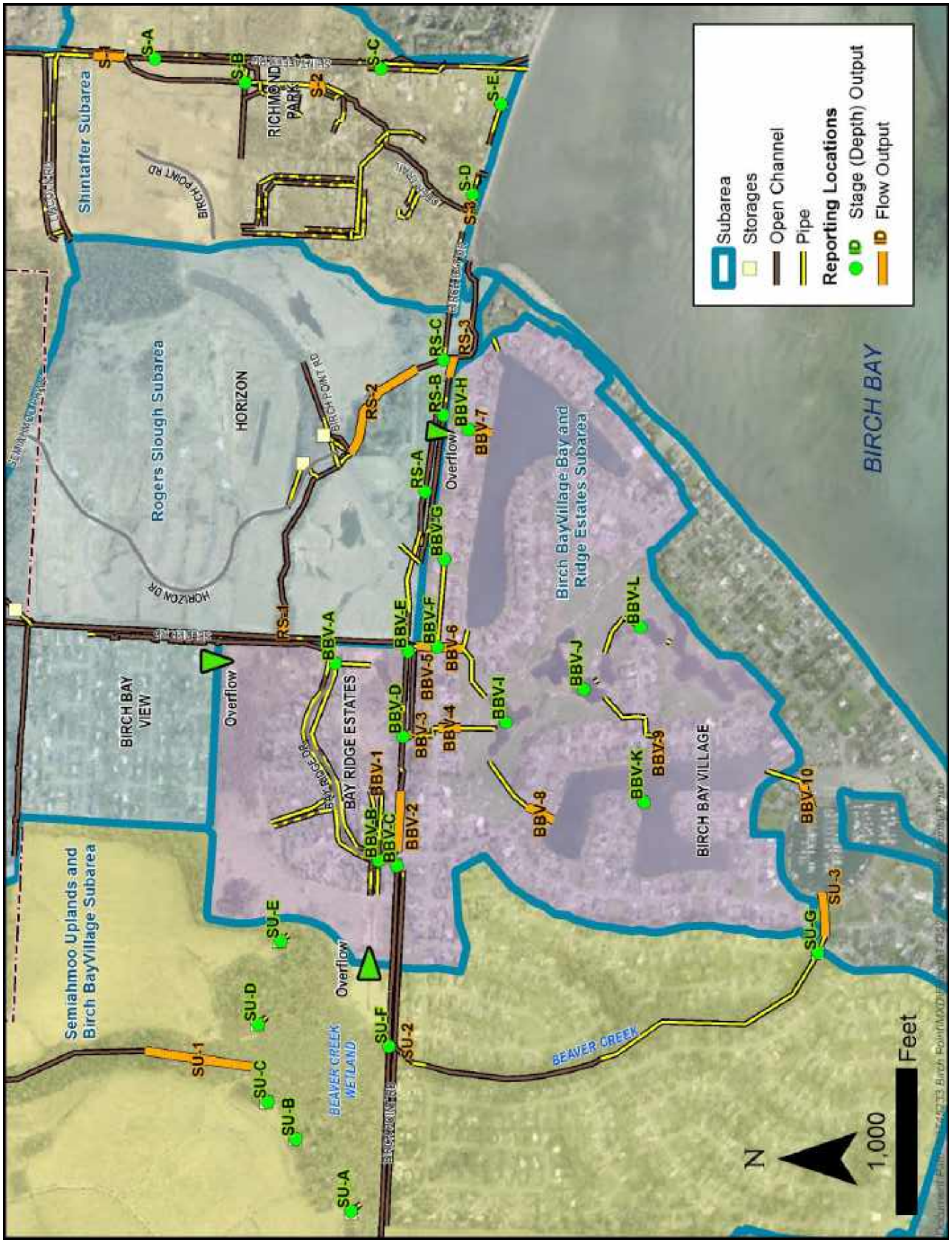
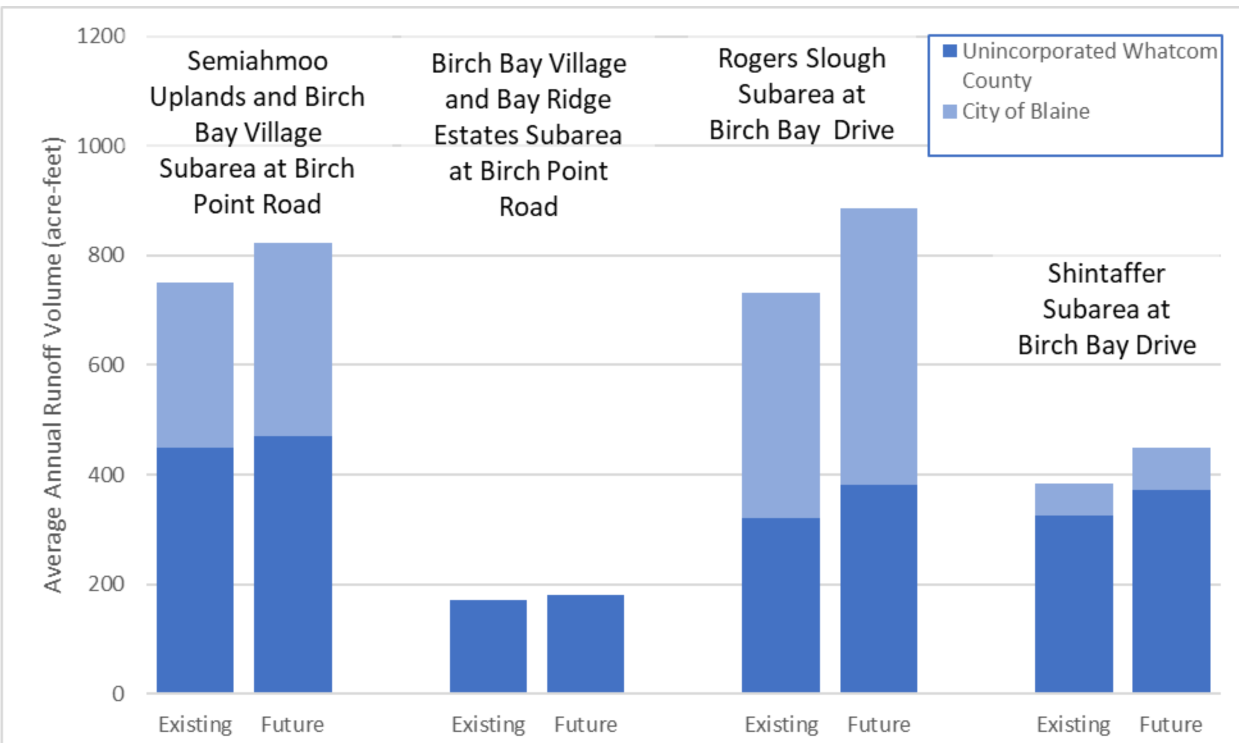


Figure 9. Model Output Locations

4.1 STORMWATER RUNOFF CONTRIBUTION

For three of the four subareas a significant portion of stormwater runoff is generated in the City of Blaine and flows downhill to unincorporated Whatcom County. Figure 10 shows the average annual volume of stormwater runoff contribution from the City of Blaine and Whatcom County. This figure shows that approximately 40 percent of stormwater runoff is generated in the City of Blaine for the Semiahmoo Uplands and Birch Bay Village subarea (measured at Birch Point Road) and over 50 percent of stormwater runoff comes from the City in the Rogers Slough subarea. Only about 15 percent of stormwater runoff is generated in the City of Blaine in the Shintaffer subarea. Stormwater runoff in the Birch Bay Village and Bay Ridge Estates subarea is generated entirely in the County however the evaluation of runoff volume does not consider the overflows from adjacent subareas described later in this section.

Stormwater runoff volume will increase with future development which will result in an increase in peak flow rates if stormwater controls are not properly implemented. The City and County will need to coordinate future stormwater management efforts in the Birch Point watershed to ensure effective stormwater controls are implemented to control peak flows and sufficient conveyance is provided in storm drain infrastructure.



One acre-foot = 1 foot of flooding over 1 acre of land (43,560 cubic feet or 326,000 gallons)

Figure 10.Existing Conditions Runoff Contribution from City of Blaine and Unincorporated Whatcom County

4.2 SEMIAHMOO UPLANDS AND BIRCH BAY VILLAGE

4.2.1 Existing Conditions

Table 4 and Table 5 show predicted peak stage and flow at selected locations in the Semiahmoo Uplands and Birch Bay Village subarea. The hydraulic analysis showed that for existing conditions, two of the detention ponds (SU-B, SU-E) along the perimeter of the wetland overflow starting at the 25-year event and at thee additional facilities (SU-A, SU-C, SU-D) at the 100-year event indicating the facilities may be undersized for stormwater control. However, natural storage in the wetland area north of Birch Point Road and west of Bay Ridge Estates partially mitigates overflow from these ponds although overland flow to Bay Ridge Estates likely contributes to flooding in that neighborhood. The travel lane on Birch Point Road at the Beaver Creek crossing (SU-F) was predicted to flood during the November 2021 event but floodwater did not get high enough to overtop the roadway. No other flooding problems are identified in this subarea.

4.2.2 Future Conditions

The future conditions hydraulic analysis showed that peak stage is predicted to increase in all of the detention facilities (SU-A, SU-B, SU-C, SU-D, SU-E). Future conditions peak flows entering the wetland from upland areas (S-1) will be higher than existing conditions if flow control is not provided with future development. This increase is transferred to Birch Point Road (SU-2) and flooding is predicted to occur at this location (SU-F) for all events analyzed.

Table 4. Peak Stage in the Semiahmoo Uplands and Birch Bay Village Subarea

ID[a]	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)				Height above Flood Stage[c] (feet)			
		25-Year	100-Year	Nov. 2021	Climate Change	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions									
SU-A	80.6	80.6	81.1	81.1	81.3	0.0	0.5	0.5	0.7
SU-B	81.8	82.6	82.7	82.7	82.8	0.8	0.9	0.9	1.0
SU-C	90.3	90.0	90.4	90.5	90.6	-0.3	0.1	0.2	0.3
SU-D	75.5	75.5	75.7	75.9	76.0	0.0	0.2	0.3	0.5
SU-E	74.0	74.8	75.0	75.0	75.1	0.8	1.0	1.0	1.1
SU-F	51.1	48.4	50.2	51.9	52.5	-2.7	-0.9	0.8	1.4
SU-G	26.3	24.8	25.0	25.1	25.3	-1.5	-1.3	-1.2	-1.0
Future Conditions									
SU-A	80.6	81.0	81.1	81.3	81.4	0.4	0.5	0.6	0.8
SU-B	81.8	82.6	82.7	82.8	82.8	0.8	0.9	1.0	1.0
SU-C	90.3	90.4	90.6	90.7	90.7	0.1	0.3	0.4	0.4
SU-D	75.5	76.2	76.3	76.3	76.4	0.7	0.8	0.8	0.9
SU-E	74.0	74.9	75.1	75.1	75.2	0.9	1.1	1.1	1.2
SU-F	51.1	51.2	52.4	52.6	52.6	0.1	1.3	1.5	1.5
SU-G	26.3	24.9	25.1	25.2	25.4	-1.4	-1.2	-1.1	-0.9

a. See Figure 9.

b. Flood stage is the elevation where surface flooding is assumed to occur.

c. Red highlighted values indicate predicted peak stage above flood stage.

Table 5. Peak Flow in the Semiahmoo Uplands and Birch Bay Village Subarea

ID[a]	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions Flow (cfs)				
SU-1	12.9	15.4	16.9	18.7
SU-2	29.0	36.5	42.7	47.3
SU-3	94.7	115.9	127.8	135.3
Future Conditions Flow (cfs)				
SU-1	20.5	24.7	27.0	29.9
SU-2	40.6	47.2	47.3	47.5
SU-3	102.6	125.9	133.4	138.8
Future Change from Existing (%)				
SU-1	59.3%	59.7%	60.0%	60.1%
SU-2	40.3%	29.4%	10.8%	0.4%
SU-3	8.4%	8.6%	4.4%	2.7%

a. See Figure 9.

4.3 BIRCH BAY VILLAGE AND BAY RIDGE ESTATES SUBAREA

4.3.1 Existing Conditions

The existing conditions hydraulic analysis predicted flooding at four locations in the Birch Bay Village and Bay Ridge Estates subarea. Table 6 and Table 7 show predicted peak stage and flow at selected locations in this subarea. Figure 11 and Figure 12 show flood inundation in the subarea.

- Bay Ridge Drive at Selder Road (BBV-A) – High storm flows exceed the capacity of the cross culvert under Selder Road at Skyvue Road and overflow into the ditch located on the west side of Selder Road. Flow then continues south along the road to accumulate at the intersection with Bay Ridge Drive. Figure 11 shows the inundation extent of flooding in this area for the 100-year event.
- East and West Shoreview (BBV-C, BBV-D) – Flooding is partly due to the undersized storm drain system along East and West Shoreview but is exacerbated by overflow through the roadside ditch from the adjacent subarea to the west and accumulates in the low area at Bay Ridge Drive on East Shoreview. Figure 11 shows the inundation extent of flooding in this area for the 100-year event.
- Birch Bay Village Golf Course Ponds – High flow from upland areas (BBV-3, BBV-5) cause flooding in the Birch Bay Village golf course ponds (BBV-I BBV-J, BBV-K, BBV-L). For the 100-year event and larger, stormwater flow exceeds the capacity of a control structure located on the south side of Birch Point Road (BBV-D). Stormwater also overflows Birch Point Road at Selder Road into Birch Bay Village (BBV-F) and overflows the ditch that conveys drainage from the Birch Point Road system into the Birch Bay Village system.
- Salish Road and Nootka Loop (BBV-G, BBV-H) – Flooding at this location is due to the undersized culvert at Birch Point Road (RS-C, see Table 8) that causes water to eventually spill over Birch Bay Drive towards Salish Road. Removing the Rogers Slough tide gate reduced flooding at this location but did not eliminate it entirely. The cause of flooding at this location is discussed in greater detail in Section 4.5.

4.3.2 Future Conditions

Under future conditions, flood risk increases slightly with 0.1 to 0.2 foot increase expected at most locations in the Birch Bay Village and Bay Ridge Estates subarea. However, the overflow from the Rogers Slough subarea will increase flood depth on Salish Road (BBV-H) by almost a foot for all events analyzed and worsening the existing flood conditions at that location. Additional flooding will also occur on Selder Road at Birch Point Road (BBV-E) under future conditions.

Table 6. Peak Stage in the Birch Bay Village and Bay Ridge Estates Subarea

Junction ID[a]	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)				Height above Flood Stage[c] (feet)			
		25-Year	100-Year	Nov. 2021	Climate Change	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions (Rogers Slough Tide Gate Removed)									
BBV-A	34.2	34.5	34.6	34.6	34.6	0.3	0.4	0.4	0.4
BBV-B	52.4	52.3	52.4	52.5	52.5	0.1	0.2	0.3	0.3
BBV-C	52.1	52.3	52.4	52.4	52.5	0.2	0.3	0.3	0.4
BBV-D	28.7	28.1	29.3	29.4	29.5	-0.6	0.6	0.7	0.8
BBV-E	28.1	26.8	27.9	28.1	28.1	-1.3	-0.2	0.0	0.0
BBV-F	12.6	11.7	12.1	14.2	14.2	-0.9	-0.5	1.6	1.7
BBV-G	12.6	11.7	12.1	12.9	12.9	-0.9	-0.5	0.3	0.3
BBV-H	10.4	8.2	10.5	10.8	11.0	-2.2	0.1	0.4	0.6
BBV-I	8.4	8.7	8.7	8.8	8.8	0.3	0.3	0.4	0.4
BBV-J	8.4	8.0	8.5	8.6	8.8	-0.4	0.1	0.2	0.4
BBV-K	11.5	7.7	7.9	8.0	8.1	-3.8	-3.6	-3.5	-3.4
BBV-L	8.4	7.7	8.1	8.4	8.6	-0.7	-0.3	0.0	0.2
Future Conditions									
BBV-A	34.2	34.5	34.6	34.6	34.6	0.3	0.4	0.4	0.4
BBV-B	52.4	52.5	52.6	52.7	52.7	0.3	0.4	0.5	0.5
BBV-C	52.1	52.5	52.5	52.5	52.6	0.4	0.4	0.4	0.4
BBV-D	28.7	29.4	29.5	29.5	29.6	0.7	0.8	0.8	0.9
BBV-E	28.1	28.1	28.2	28.2	28.2	0.0	0.1	0.1	0.1
BBV-F	12.6	13.7	14.3	14.3	14.4	1.2	1.7	1.7	1.8
BBV-G	12.6	12.9	12.9	12.9	12.9	0.3	0.3	0.3	0.3
BBV-H	10.4	11.0	11.4	11.6	11.7	0.6	1.0	1.2	1.3
BBV-I	8.4	8.7	8.8	8.9	9.0	0.3	0.4	0.5	0.6
BBV-J	8.4	8.5	8.7	8.9	9.0	0.1	0.3	0.5	0.6
BBV-K	11.5	7.8	8.0	8.1	8.2	-3.7	-3.5	-3.4	-3.3
BBV-L	8.4	7.9	8.4	8.5	8.8	-0.5	0.0	0.1	0.4

a. See Figure 9.

b. Flood stage is the elevation where surface flooding is assumed to occur.

c. Red highlighted values indicate predicted peak stage above flood stage.

Peak flow will increase at all locations with the largest increase occurring for smaller events. For instance, Table 7 shows that future conditions peak flow in the Birch Bay Village storm drain system at Selder Road

(BBV-5) will be 15 percent higher than existing conditions for the 25-year event but less than 5 percent higher for larger events due to limited pipe capacity of the culvert under Birch Point Road.

Table 7. Peak Flow in the Birch Bay Village and Bay Ridge Estates Subarea

Conduit ID[a]	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions Flow (cfs) (Rogers Slough Tide Gate Removed)				
BBV-1	13.2	14.3	15.4	18.9
BBV-2	9.5	12.8	14.6	16.5
BBV-3	24.5	27.2	27.3	28.2
BBV-4	20.9	22.1	22.5	22.7
BBV-5	18.4	20.6	21.2	21.6
BBV-6	18.9	24.9	30.7	31.3
BBV-7	0.3	4.1	4.2	4.3
BBV-8	26.6	26.6	26.6	26.6
BBV-9	11.2	13.4	13.5	13.6
BBV-10	15.2	18.3	19.8	21.6
Future Conditions Flow (cfs)				
BBV-1	19.0	19.2	19.2	19.3
BBV-2	16.6	17.7	18.4	19.1
BBV-3	28.5	28.9	29.1	29.5
BBV-4	22.1	22.6	22.7	22.7
BBV-5	21.2	21.7	21.9	22.2
BBV-6	29.7	31.6	31.7	31.8
BBV-7	4.5	4.6	4.7	4.6
BBV-8	26.6	26.6	26.6	26.6
BBV-9	13.9	14.1	14.3	14.3
BBV-10	16.6	19.6	21.1	22.8
Future Change from Existing (%)				
BBV-1	43.9%	34.5%	24.9%	1.9%
BBV-2	74.8%	38.1%	26.4%	15.5%
BBV-3	16.0%	6.4%	6.5%	4.6%
BBV-4	5.8%	2.0%	0.9%	0.0%
BBV-5	14.9%	5.2%	3.3%	2.6%
BBV-6	57.0%	26.8%	3.3%	1.4%
BBV-7	--[b]	13.6%	11.5%	9.2%
BBV-8	0.0%	0.0%	0.0%	0.0%
BBV-9	24.4%	5.8%	5.5%	5.5%
BBV-10	9.2%	7.0%	6.5%	5.6%

a. See Figure 9.

b. Not computed: existing conditions flow too low to provide a meaningful value.

Land use in this subarea is not expected to change significantly with future development. The increase in peak flow will be due to the increase in the volume of overflow from the Beaver Creek wetlands in the

Semiahmoo Uplands and Birch Bay Village subarea rather than an increase in impervious area (less than 5%, see Table 1 and Figure 7). Increased overflow also occurs from the Rogers Slough subarea to the Birch Bay View neighborhood and the drainageway adjacent to Birch Point Loop at Nootka Loop.

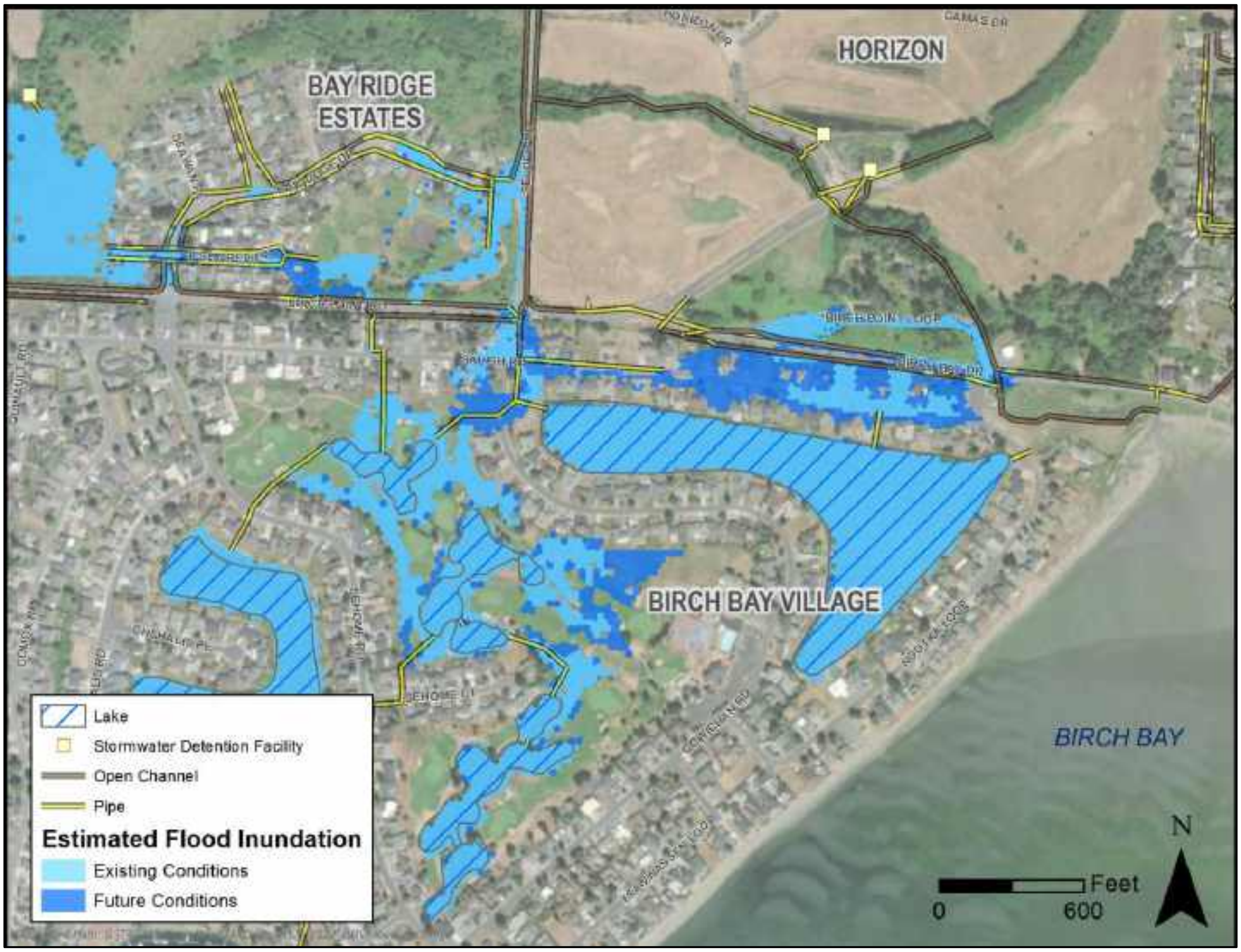


Figure 11. Simulated Flooding in Birch Bay Village and Bay Ridge Estates Subarea - Existing and Future Conditions, 100-year Event

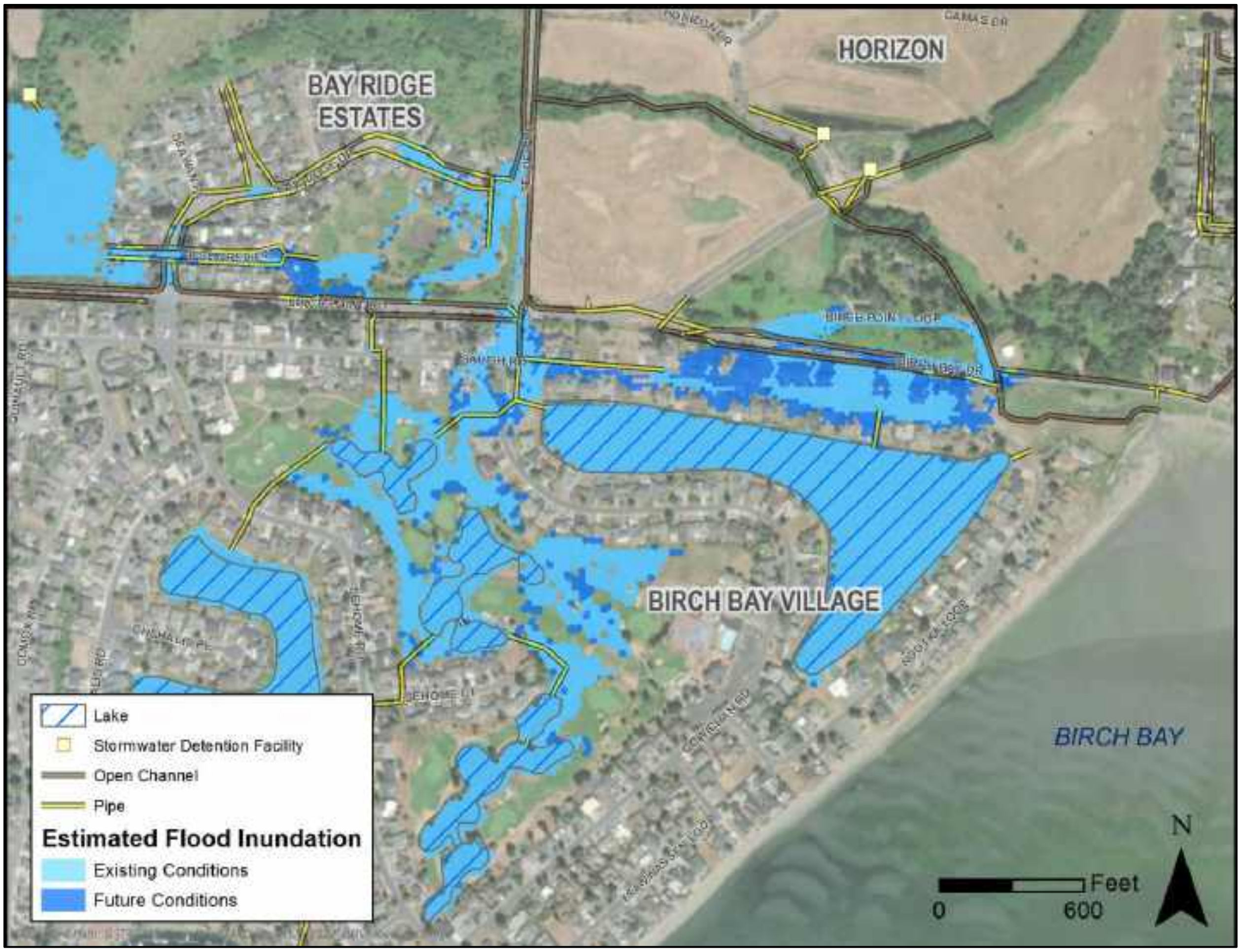


Figure 12. Simulated Flooding in Bay Village and Bay Ridge Estates Subarea - Existing and Future Conditions, November 2021 Event

4.4 ROGERS SLOUGH TIDE GATE REMOVAL

The impact of removing the Rogers Slough tide gate at Birch Bay Drive and Nootka Loop was evaluated with the hydraulic model. This gate was removed in November 2022 at the beginning of the study and was used as the baseline condition for subsequent analysis. Table 8, Figure 13, and Figure 14 show the change in existing condition flows pre- and post-tide gate removal in the vicinity of Rogers Slough. The post-tide gate removal condition is considered the existing condition (baseline) for comparison purposes for this study.

The hydraulic analysis showed that removing the Rogers Slough tide gate reduced flood inundation in the vicinity of the Birch Bay Drive (RS-B) and Birch Point Loop (RS-C). Flooding is also eliminated on Salish Road (BBV-H) for the 25-year event and reduced by 0.4 feet for all other events analyzed. Flood levels were unchanged in the golf course ponds (BBV-J).

Table 8. Peak Stage with Rogers Slough Tide Gate Removal

ID[a]	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)				Height above Flood Stage[c] (feet)			
		25-Year	100-Year	Nov. 2021	Climate Change	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions (Rogers Slough Tide Gate In Place)									
BBV-G	12.6	11.8	12.9	12.9	12.9	-0.9	0.3	0.3	0.3
BBV-H	10.4	10.7	11.1	11.2	11.4	0.3	0.7	0.8	1.0
BBV-J	8.4	8.7	8.7	8.8	8.8	0.3	0.3	0.4	0.4
RS-A	9.9	12.1	12.2	12.3	12.3	2.1	2.3	2.3	2.4
RS-B	9.2	11.4	11.7	11.9	12.1	2.2	2.5	2.7	2.9
RS-C	11.2	12.1	12.2	12.2	12.3	0.9	1.0	1.0	1.1
Existing Conditions (Rogers Slough Tide Gate Removed)									
BBV-G	12.6	11.8	12.7	12.9	12.9	-0.9	0.1	0.3	0.3
BBV-H	10.4	7.7	10.5	10.8	11.0	-2.7	0.1	0.4	0.6
BBV-J	8.4	8.7	8.7	8.8	8.8	0.3	0.3	0.4	0.4
RS-A	9.9	11.5	12.0	12.1	12.2	1.6	2.1	2.2	2.3
RS-B	9.2	10.8	11.1	11.4	11.6	1.6	1.9	2.2	2.4
RS-C	11.2	11.9	12.0	12.1	12.2	0.7	0.8	0.9	1.0

a. See Figure 9.
b. Flood stage is the elevation where surface flooding is assumed to occur.
c. Red highlighted values indicate predicted peak stage above flood stage.

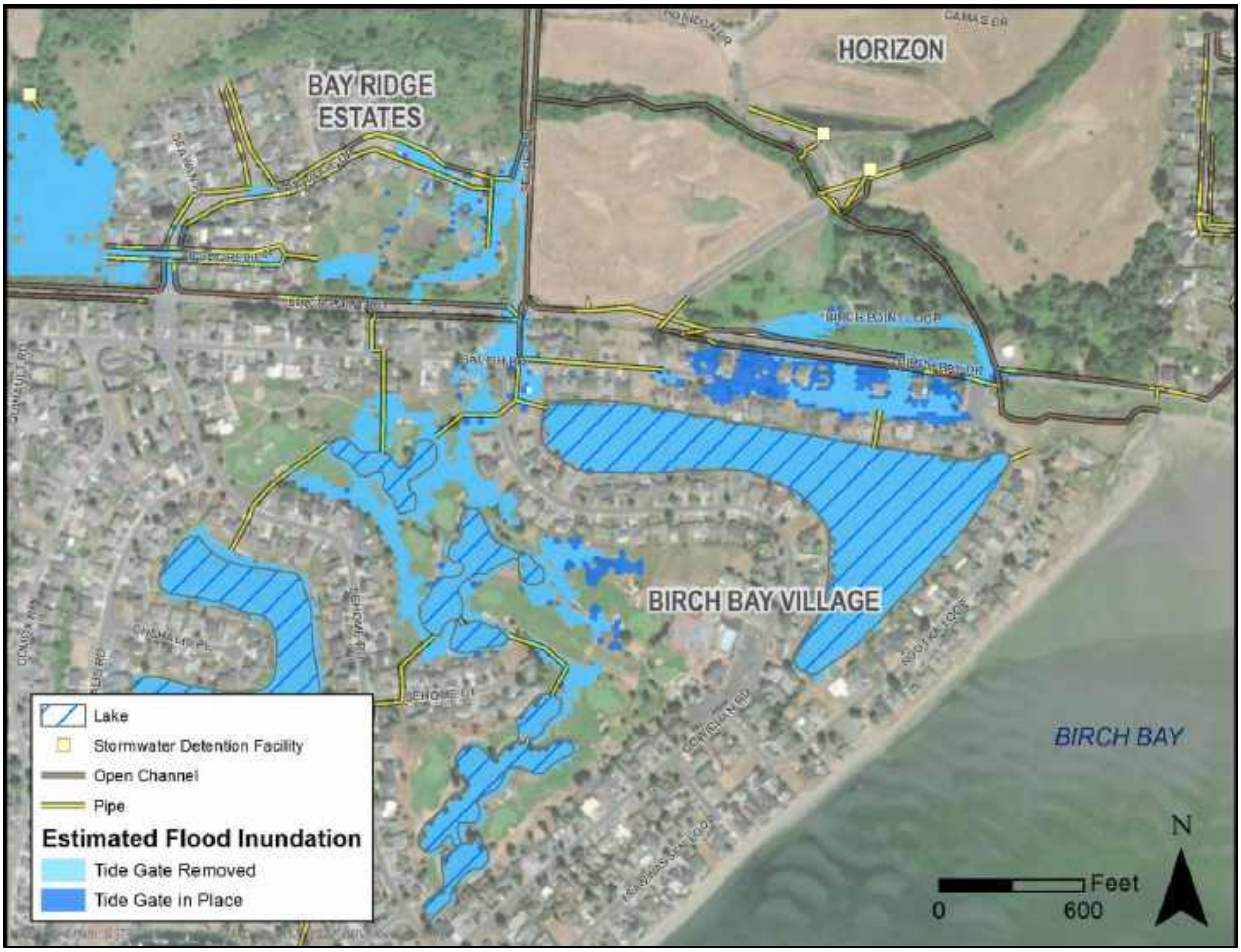


Figure 13. Effect of Tide Gate Removal, Existing Conditions 100-year Event

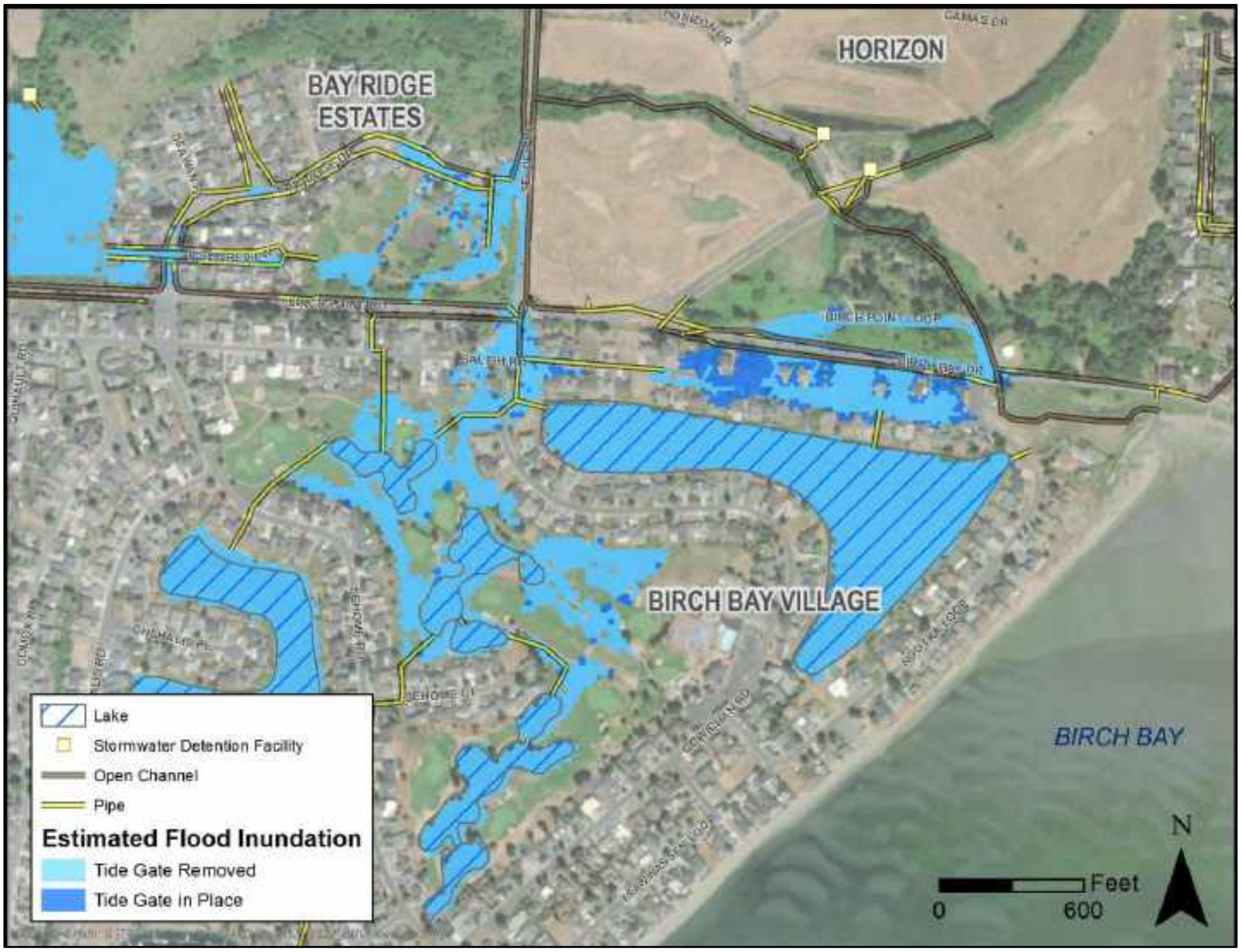


Figure 14. Effect of Tide Gate Removal, Existing Conditions November 2021 Event

4.5 ROGERS SLOUGH SUBAREA

4.5.1 Existing Conditions

The hydraulic analysis predicted flooding at one location at Birch Loop Road at Birch Bay Drive (RS-A, RS-B, RS-C). However, flooding at this location is widespread for all events analyzed and also overflows into adjacent subareas. Table 9 and Table 10 show predicted peak stage and flow at selected locations in this subarea. Figure 11 and Figure 12 show flood inundation in this subarea.

Flooding at this location is due to the undersized culverts under Birch Bay Drive (RS-C) that back up flood water into the shallow ditch on the east side of Birch Point Loop. Backwater in this ditch overtops the bank and spills onto Birch Point Loop, then flows over the road into the drainage system along Birch Bay Drive (RS-A). The overflow is conveyed under Birch Bay Drive in a cross culvert located west of the east intersection with Birch Point Loop (RS-B) and into the roadside ditch on the south side of Birch Bay Drive. Increased flow in this ditch exceeds the capacity of the cross culvert under Nootka Loop, backs up in the ditch adjacent to Birch Point Road (RS-B), and spills over the bank towards Salish Road. Flood waters also overtop Birch Bay Drive and flow towards Nootka Loop which exacerbates flooding at this location.

Flooding at this location is exacerbated with king tide events in Birch Bay that increase the submergence of the outlet of the culvert under Birch Bay Drive thus reducing the ability of this pipeline to convey flow to the slough. Natural shore current in combination with king tide events in Birch Bay also push large wood and sediment north along the shore where both accumulate at the mouth of Rogers Slough and obstruct flow from the slough during high flow events.

4.5.2 Future Conditions

Table 10 shows that future conditions peak flows will be higher than existing conditions at all locations reported for all events in the Rogers Slough Subarea. Future conditions peak runoff from the watershed is likely higher than the peak flow reported because the additional upstream flooding would store stormwater runoff and mitigate the increase in peak flow.

Table 9. Peak Stage in the Rogers Slough Subarea

ID[a]	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)				Height above Flood Stage[c] (feet)			
		25-Year	100-Year	Nov. 2021	Climate Change	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions (Rogers Slough Tide Gate Removed)									
RS-A	9.9	11.5	12.0	12.1	12.2	1.6	2.1	2.2	2.3
RS-B	9.2	10.8	11.1	11.4	11.6	1.6	1.9	2.2	2.4
RS-C	11.2	11.9	12.0	12.1	12.2	0.7	0.8	0.9	1.0
Future Conditions									
RS-A	9.9	12.3	12.4	12.4	12.5	2.4	2.5	2.5	2.6
RS-B	9.2	11.8	12.1	12.3	12.5	2.5	2.9	3.1	3.3
RS-C	11.2	12.2	12.3	12.3	12.5	1.0	1.1	1.1	1.3

a. See Figure 9.
b. Flood stage is the elevation where surface flooding is assumed to occur.
c. Red highlighted values indicate predicted peak stage above flood stage.

Table 10. Peak Flow in the Rogers Slough Subarea

ID[a]	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions Flow (cfs)				
RS-1	60.9	71.6	77.5	89.9
RS-2	79.1	97.0	105.3	116.4
RS-3	11.5	12.2	12.8	13.2
Future Conditions Flow (cfs)				
RS-1	110.4	142.7	156.2	170.7
RS-2	126.3	140.4	148.4	158.8
RS-3	13.4	14.1	14.4	14.4
Future Change from Existing (%)				
RS-1	81.3%	99.3%	101.7%	90.0%
RS-2	59.7%	44.6%	40.9%	36.4%
RS-3	16.8%	15.4%	12.9%	9.2%

a. See Figure 9.

4.6 SHINTAFFER SUBAREA

4.6.1 Existing Conditions

The hydraulic analysis predicted flooding at three locations under existing conditions in the Shintaffer subarea. Table 11 and Table 12 show predicted peak stage and flow at selected locations in this sub area. Figure 15 and Figure 16 show the estimated flood inundation extents for the 100-year and November 2021 events.

- Richmond Park Area (S-B) – Floodwaters accumulate in the farm field located north of Richmond Park and spill into the neighborhood. Drainage from this area is conveyed south through Richmond Park in the primary drainage system comprised of a series of open ditches and culverts. When the capacity of the primary drainage system through the park is exceeded, extensive flooding occurs in Richmond Park (S-B) for all events analyzed. Minor flooding also occurs on the west side of Shintaffer Road between Lincoln Road and Richmond Park.
- Shintaffer Road at Anderson Road (S-C) – Flooding occurs on the west side of Shintaffer Road at Anderson Road due to an undersized and shallow conveyance system.
- Birch Bay Drive (S-D, S-E) – Flooding occurs for all events analyzed along the north side of Birch Bay Drive at Deer Trail due to an obstructed outfall to Birch Bay. Flooding occurs near Shintaffer starting with the 100-year event.

Table 11. Peak Stage in the Shintaffer Subarea

ID[a]	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)				Height above Flood Stage[c] (feet)			
		25-Year	100-Year	Nov. 2021	Climate Change	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions									
S-A	54.4	52.7	52.8	53.0	53.1	-1.8	-1.6	-1.5	-1.3
S-B	52.4	52.6	52.8	52.9	53.0	0.2	0.4	0.5	0.6
S-C	51.7	51.3	52.1	52.5	53.0	-0.4	0.4	0.8	1.3
S-D	13.0	13.8	13.8	13.8	13.8	0.6	0.8	0.8	0.8
S-E	13.2	10.1	10.2	10.2	10.3	-3.1	-3.0	-3.0	-3.0
Future Conditions									
S-A	54.4	53.1	53.4	53.5	53.7	-1.3	-1.0	-0.9	-0.8
S-B	52.4	53.0	53.2	53.4	53.6	0.6	0.9	1.0	1.2
S-C	51.7	51.4	52.2	52.6	53.2	-0.3	0.5	0.9	1.5
S-D	13.0	13.8	13.9	13.9	13.9	0.7	0.8	0.9	0.9
S-E	13.2	10.4	10.5	10.5	10.6	-2.8	-2.8	-2.7	-2.7

a. See Figure 9.

b. Flood stage is the elevation where surface flooding is assumed to occur.

c. Red highlighted values indicate predicted peak stage above flood stage.

Table 12. Peak Flow in the Shintaffer Subarea

ID[a]	25-Year	100-Year	Nov. 2021	Climate Change
Existing Conditions Flow (cfs)				
S-1	21.4	24.0	25.4	27.6
S-2	14.0	16.2	17.6	18.1
S-3	20.3	21.2	21.3	21.4
Future Conditions Flow (cfs)				
S-1	30.5	33.7	35.2	35.0
S-2	18.2	18.9	19.2	20.2
S-3	21.1	21.5	21.6	21.7
Future Change from Existing (%)				
S-1	42.9%	40.6%	38.5%	27.0%
S-2	29.5%	16.5%	9.3%	11.3%
S-3	3.8%	2.9%	3.4%	1.3%

a. See Figure 9.

4.6.2 Future Conditions

The hydraulic analysis of future conditions showed that flood depth will increase up to 0.5 feet in the Richmond Park area (S-B) if flow control is not provided with upstream development. Peak flow rates would increase for all events along Shintaffer Road, but the increase would be mitigated with the depression storage on the farm field north of Richmond Park. The peak flow attenuation of this storage is demonstrated by the peak flow reduction that occurs between the farm field (S-1) and Richmond Park (S-2) for all events analyzed. For example, Table 12 shows peak flow for the 100-year event is about 34 cfs in the roadside ditch west of Shintaffer Road (S-1) but is reduced to about 18 cfs downstream of Richmond Park (S-2).

Figure 15. Simulated Flooding in Shintaffer Sub Area - Existing and Future Conditions, 100-year Event

Figure 16. Simulated Flooding in Shintaffer Sub Area - Existing and Future Conditions, November 2021 Event

5.0 CONCEPT DESIGN AND ANALYSIS

5.1 DESIGN OPTIONS

Conceptual design options were evaluated using SWMM5 for five capital projects to resolve flooding problems in the Birch Point study area (see Figure 17). Capital project are sized to convey the existing conditions 100-year peak flow and eliminate flooding at the problem areas. A second variation of the concept is sized to convey the future conditions 100-year peak flow for systems where the future conditions flows are predicted to increase over the existing conditions. A project designed to convey future conditions assumes stormwater controls are not provided with land use conversion and excess stormwater is conveyed directly to Birch Bay in a larger pipeline. The performance for each concept is summarized in Table 13 which shows predicted stage for the simulated November 2021 event and the climate change scenario.

The design options considered single improvements or a combination of improvements to provide a range of performance and conceptual costs for evaluation toward further development. The design options are summarized in Appendix B project sheets which provide the quantities, conceptual cost, and maps that detail the location and extent. The capital projects are generally described below and in Table 14.

Beaver Creek Drainage Improvements – The Beaver Creek Drainage Improvements project is located on Beaver Creek where it flows through the west side of Birch Bay Village. The cross culvert carrying Beaver Creek under Birch Point Road would be replaced with a larger fish passable structure. The proposed culvert would be seven feet wide and four feet high. Bankfull width was not measured for this study so the size would need to be confirmed during design. This project diverts floodwaters from the wetland area upstream of Birch Point Road to larger roadside ditches and excavated floodplain connections to eliminate the overflow to the Bay Ridge Estates. Eliminating the overflow to Bay Ridge Estates also reduces the volume of water flowing into the Birch Bay Village in the storm drains under Birch Point Road near Selder Road. The existing conditions 100-year peak flow would increase in Beaver Creek by 13 cfs which also increases stage at Chehalis Road. However, the increase in stage is limited to 0.1 feet and would not cause flooding in this area because the stage is still well below the overflow elevation.

Bay Ridge Estates Stormwater Improvements – The Bay Ridge Estates Stormwater Improvements project is located in the vicinity of Birch Point Road and Selder Road. A roadside culvert would be installed under Bay Ridge Drive at Birch Point Road at to divert floodwaters from Bay Ridge Estates through a new larger diameter culvert on the north side of Birch Point Road to replace the existing undersized pipe. A new storm drain connection would also be provided at Selder Road and Birch Point Road to collect road drainage that accumulates in this area. The cross culvert under Selder Road at Skyvue Road would be increased to improve conveyance capacity and eliminate the ditch overtopping that occurs on the west side of Selder Road. Table 13 shows that flooding is eliminated at critical locations (BBV-B and BBV-C) in the Bay Ridge Estates neighborhood for the simulated November 2021 flood and the climate change scenario for existing and future conditions. The flow diversion to Beaver Creek would reduce flow though the storm drains that pass through Birch Bay Village at Selder Road (BBV-5) and west of Selder Road (BBV-3).

Roger’s Slough Drainage Improvements – The two existing culverts under Birch Bay Drive at Birch Point Loop would be replaced with a seven-foot-wide by four-foot-high fish-passable box culvert. The cross culvert under Birch Bay Drive west of Birch Point Loop would be abandoned and replaced with a cross culvert under the eastern Birch Point Loop entrance and connect to the ditch on the east side of Birch Point Loop. This ditch would also be widened and deepened to keep flow in the channel. Table 13 shows that flooding is eliminated at critical locations on Birch Point Loop (RS-B) and in Birch Bay Village (BBV-I) for the simulated November 2021 flood and the climate change scenario for existing and future conditions. A new outfall pipe to Birch Bay would be installed to bypass high flows around log jams that may occur at the mouth of Rogers Slough.

To convey future conditions flows, a larger culvert (8 feet wide and 5 feet high) would need to be installed under Birch Bay Drive at Birch Point Loop.

Birch Bay Village Stormwater Improvements – This project is located on the east side of Birch Bay Village in the vicinity of the Kwann Lake and Salish Road. New drainage pipe lateral connections would be added to the Salish Road storm drain system to connect Birch Bay Drive and Kwann Lake to divert storm runoff from the road to the pond. Outflow conveyance capacity from the lake would be increased with a second new pipe connection to Rogers Slough at the east end of the pond and the existing inlet/outlet pipe at the west end of the lake would be replaced with larger diameter pipes. This pipe would be connected to a new outfall pipe to Birch Bay installed to convey high flows around any log jams that may occur at the mouth of Rogers Slough. Table 13 shows that flooding is eliminated at critical locations (BBV-G and BBV-I) in Birch Bay Village for the simulated November 2021 flood and the climate change scenario for existing conditions, but flooding would still occur in the golf course pond (BBV-I) for the climate change scenario for future conditions.

Richmond Park Stormwater Improvements – The Richmond Park stormwater improvements are located in the Shintaffer subarea along Shintaffer Road from Richmond Park to Birch Bay Drive. This project would construct a new pipeline on the west side of Shintaffer Road to convey flows directly to Birch Bay.

This project would also move the location of the Deer Trail outfall or lengthen the pipe to reduce the potential for obstruction. Table 13 shows that flooding is eliminated at critical locations in Richmond Park (S-B) and Deer Trail (S-C) for the simulated November 2021 event, but flooding would still occur in Richmond Park for the climate change scenario for existing conditions.

For future conditions, a larger diameter pipeline would need to be constructed adjacent to Shintaffer Road. The culvert under Birch Bay Drive at Deer Trail would also need to be replaced with a larger diameter pipe. These improvements would eliminate flooding for all events including the November 2021 and climate change scenario.

Table 13. Peak Stage at Critical Flooding Locations

ID[a]	Location	Flood Stage[b] (feet NAVD88)	Peak Stage (feet NAVD88)		Height above Flood Stage[c] (feet)	
			Nov. 2021	Climate Change	Nov. 2021	Climate Change
Existing Conditions						
BBV-A	*Bay Ridge Estates Stormwater Improvements* Selder Road at Bay Ridge Drive	34.2	32.6	32.7	-1.6	-1.5
BBV-B	*Bay Ridge Estates Stormwater Improvements* Birch Point Road and Bay Ridge Drive	53.9	50.6	50.7	-1.7	-1.5
BBV-F	*Birch Bay Village Stormwater Improvements* Salish Road at Cowichan Road	12.6	11.4	11.4	-1.2	-1.2
BBV-H	*Birch Bay Village Stormwater Improvements* Salish Road	10.0	8.4	9.1	-1.6	-0.9
RS-B	*Roger's Slough Drainage Improvements* Birch Bay Drive at Birch Point Loop	9.2	8.5	8.7	-0.8	-0.6
S-B	*Richmond Park Stormwater Improvements* Richmond Park	52.4	52.3	52.5	-0.1	0.1
S-D	*Richmond Park Stormwater Improvements* Birch Bay Drive at Deer Trail	13.0	12.4	12.7	-0.6	-0.4
Future Conditions						
BBV-A	*Bay Ridge Estates Stormwater Improvements* Selder Road at Bay Ridge Drive	34.2	32.8	32.9	-1.4	-1.3
BBV-B	*Bay Ridge Estates Stormwater Improvements* Birch Point Road and Bay Ridge Drive	53.9	51.0	51.2	-1.2	-1.0
BBV-F	*Birch Bay Village Stormwater Improvements* Salish Road at Cowichan Road	12.6	11.6	11.8	-1.0	-0.8
BBV-H	*Birch Bay Village Stormwater Improvements* Salish Road	10.0	8.0	10.1	-2.0	0.1
RS-B	*Roger's Slough Drainage Improvements* Birch Bay Drive at Birch Point Loop	9.2	8.8	8.9	-0.4	-0.3
S-B	*Richmond Park Stormwater Improvements* Richmond Park	52.4	52.2	52.3	-0.2	-0.1
S-D	*Richmond Park Stormwater Improvements* Birch Bay Drive at Deer Trail	13.0	12.1	12.1	-0.9	-0.9

a. See Figure 17.

b. Flood stage is the elevation where surface flooding is assumed to occur.

c. Red highlighted values indicate predicted peak stage above flood stage.

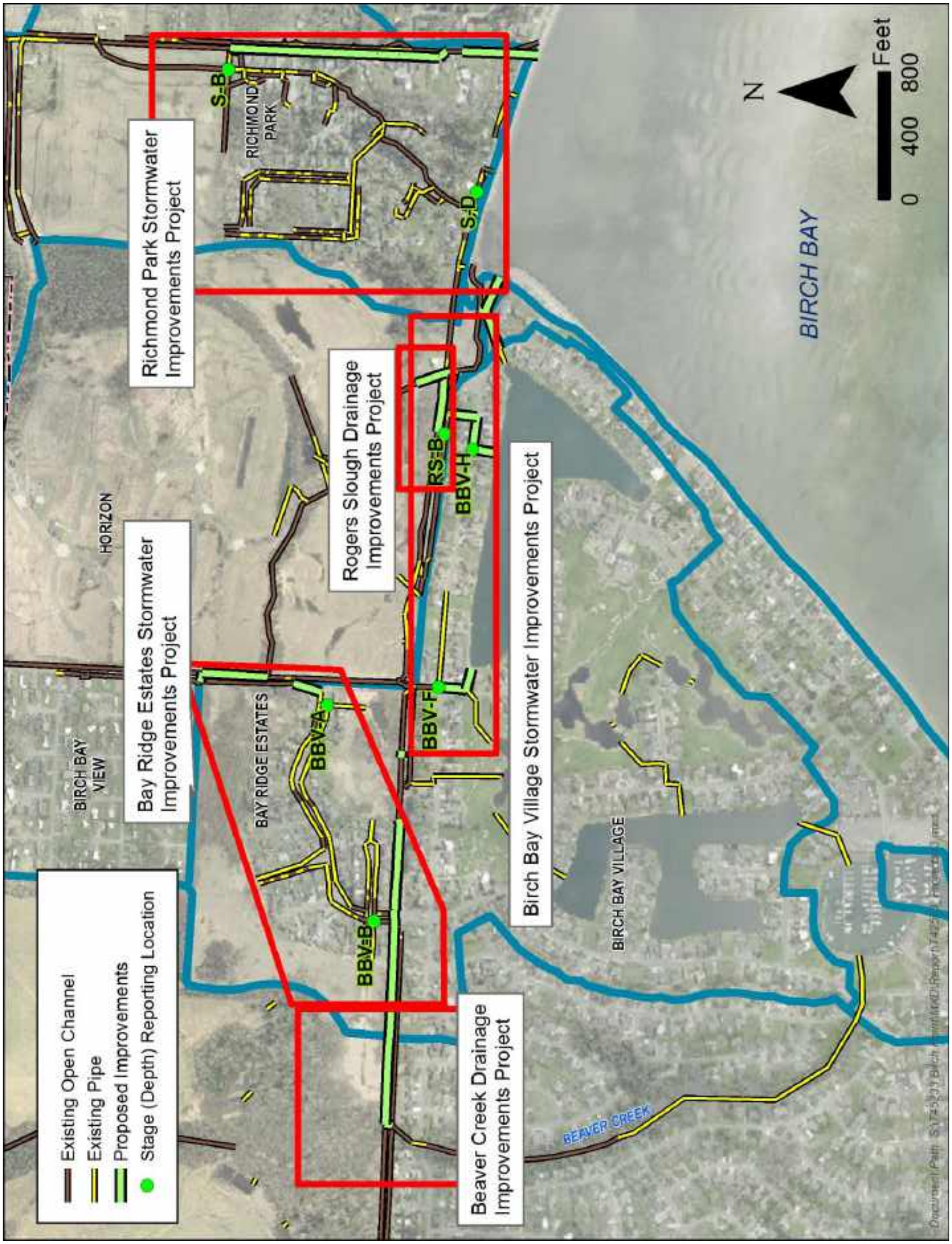


Figure 17. Concept Project Locations

5.2 COST OPINION

Planning level project costs were estimated for each concept described above, as summarized in Table 14. This cost estimate includes engineering, permitting and construction. The construction cost estimate is based on Washington State Department of Transportation (WSDOT) unit cost factors, experience with local projects, and a 50% contingency**.** Engineering and administration, permitting, and construction management costs are included in the estimate. Typical engineering cost range from 15% to 40% of total construction cost depending on size and complexity of the project. Permitting costs range from 5% to 10% of total construction costs depending on the degree of environmental impacts. Construction management ranges from 5% to 10% depending on the size and complexity of the project. The total cost breakdown is included in Table 15.

Table 14 shows two entries for the planning level cost for projects that would be configured differently depending on the land use conditions assumed. Project costs for future land use conditions would be higher than existing due to the need to have larger pipes to convey the higher flow rates estimated for future conditions. Projects with a single cost entry would be able to convey both existing and future land use condition flows without changing the size of the facility.

Table 14. Capital Project Summary

Concept Name	Description	Planning Level Cost	Priority[a]
Beaver Creek Drainage Improvements Project	Install fish passable culvert under Birch Point Road, deepen roadside ditches along Birch Point Road.	$1,250,000[b]	5
Bay Ridge Estates Stormwater Improvements Project	Install new cross culverts on Birch Point Road at Bay Ridge Drive and Selder Road at Bay Ridge Drive.	$770,000[b]	4
Roger's Slough Drainage Improvements Project	Install fish passable culvert under Birch Bay Drive at Birch Point Loop and construct local improvements to the drainage system.	$2,444,000 (Ex.)[c] $2,850,000 (Fu.)[c]	2
Birch Bay Village Stormwater Improvements Project	Improve stormwater conveyance on Salish Road and increase outfall capacity from Kwann Lake.	$1,260,000[b,c]	3
Richmond Park Stormwater Improvements Project	Construct diversion pipeline along Shintaffer Road to convey high flows directly to Birch Bay.	$1,770,000 (Ex.) $2,605,000 (Fu.)	1

a. Priority may change in the future based on available funding.

b. Planning level costs are identical for future and existing conditions.

c. Roger's Slough Drainage Improvements Project and the Birch Bay Village Stormwater Improvements Project both include a bypass at Roger's Slough. The cost of this facility is included in both projects for this report but only the first project constructed would actually include this cost.

Table 15. Total Project Cost Summary

Concept Name	Const. Cost[a]	Eng. - Survey	Permitting	Const. Mgmt.	Total Project Cost
Beaver Creek Drainage Improvements Project	$844,000	$279,000	$64,000	$64,000	$1,250,000
Bay Ridge Estates Stormwater Improvements Project	$519,000	$171,000	$39,000	$39,000	$770,000
Roger's Slough Drainage Improvements Project *(Existing Conditions)*	$1,651,000	$545,000	$124,000	$124,000	$2,440,000
Roger's Slough Drainage Improvements Project *(Future Conditions)*	$1,927,000	$636,000	$145,000	$145,000	$2,850,000
Birch Bay Village Stormwater Improvements Project	$848,000	$280,000	$64,000	$64,000	$1,260,000
Richmond Park Stormwater Improvements Project *(Existing Conditions)*	$1,196,000	$395,000	$90,000	$90,000	$1,770,000
Richmond Park Stormwater Improvements Project *(Future Conditions)*	$1,760,000	$581,000	$132,000	$132,000	$2,605,000

a. Includes Contingency and Sales Tax.

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APPENDIX A. HYDROLOGIC AND HYDRAULIC MODEL DOCUMENTATION

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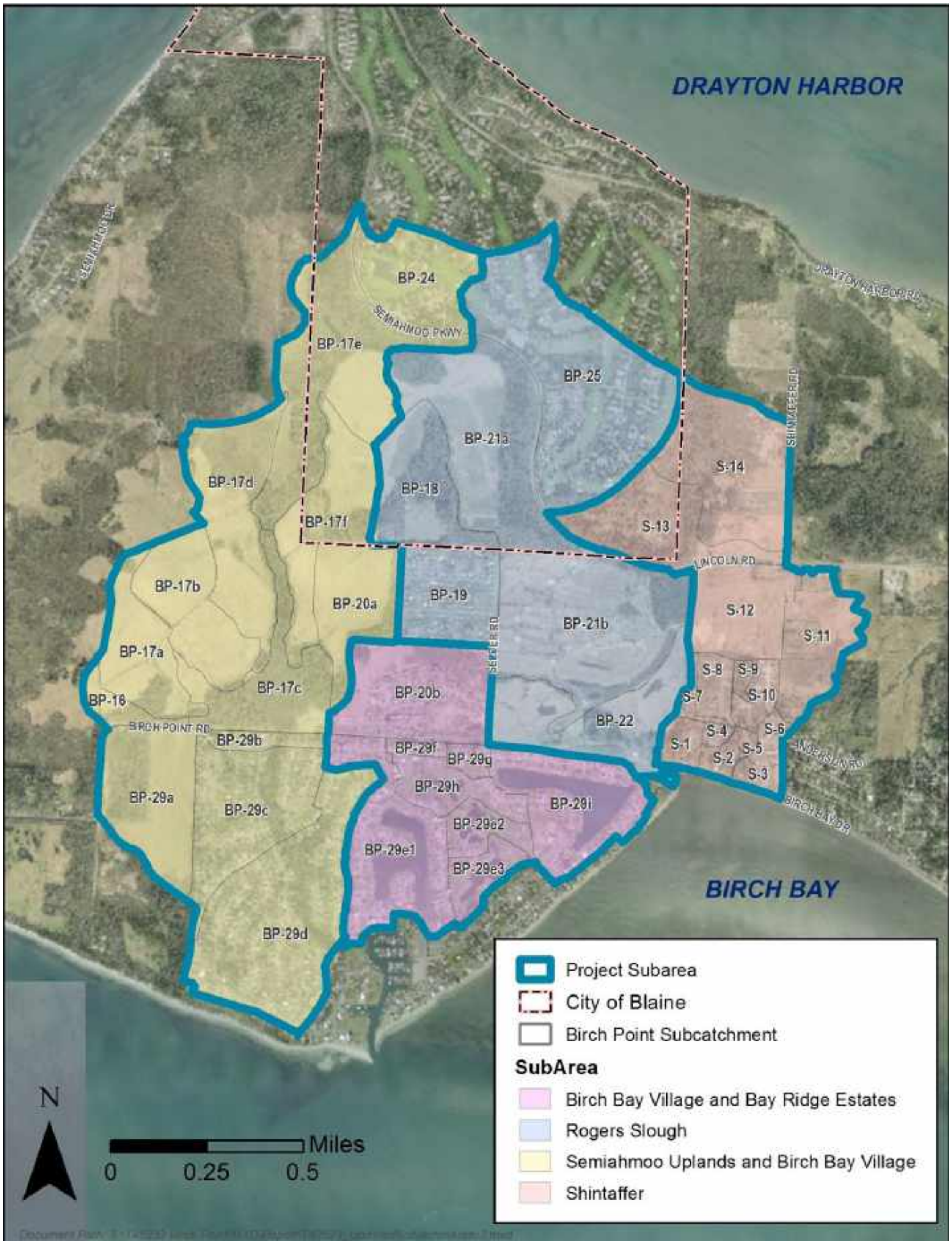

Figure A-1. Subcatchments

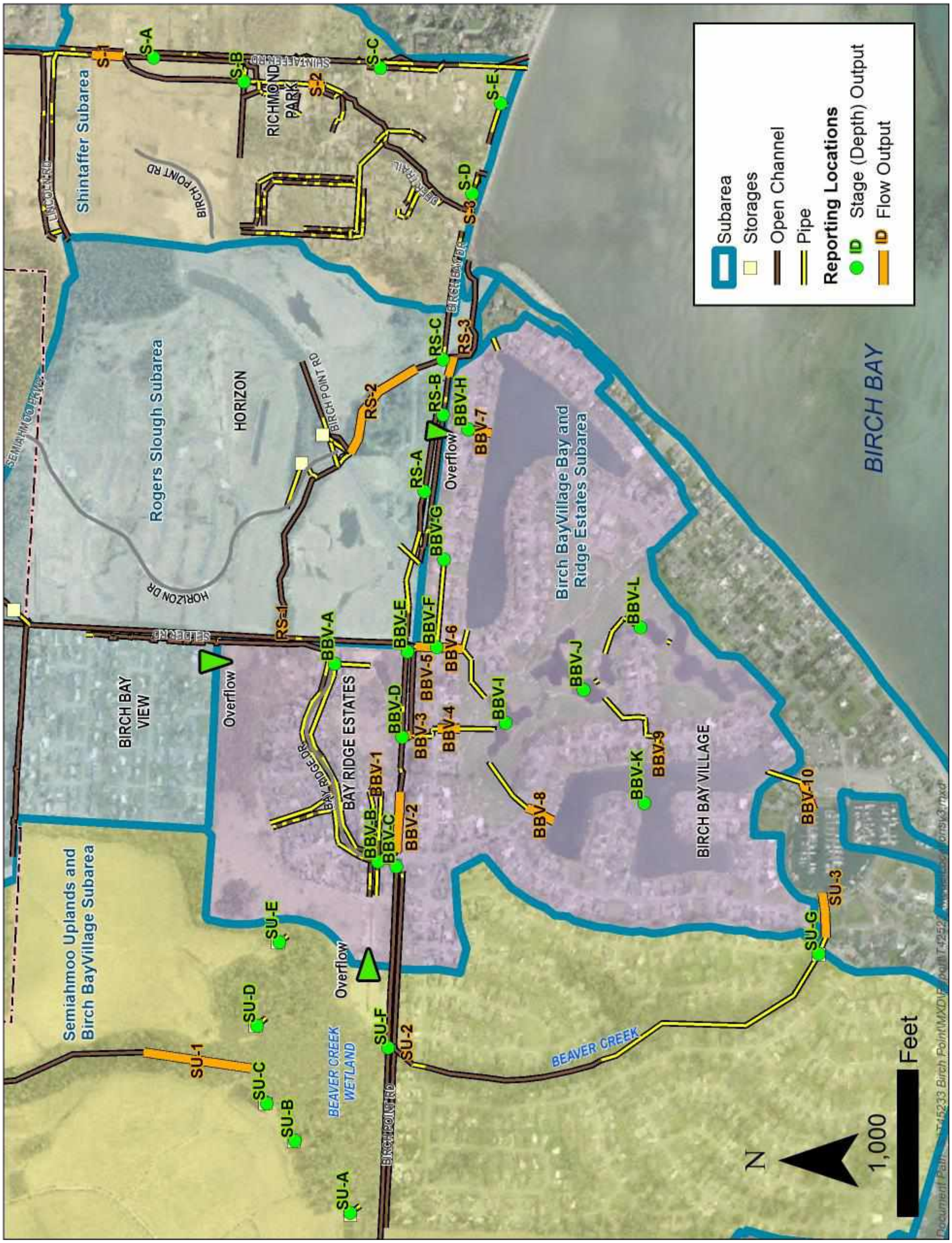

Figure A-2. Model Reporting Locations

Table A-1
HSPF Input Paramters - Existing Land Use

PERLND Area (Acres)	BP-16	BP-17a	BP-17b	BP-17c	BP-17d	BP-17e	BP-17f	BP-18	BP-19	BP-20a	BP-20b	BP-20b1	BP-20b2	BP-20b3	BP-21a	BP-21b	BP-22	BP-24	BP-25
Pervious Area	9.88	36.66	45.13	46.44	61.24	93.77	49.29	44.14	26.71	40.49	50.05	20.70	15.95	13.40	89.67	92.21	52.96	55.74	78.92
A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00
C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.87	0.00	0.00	0.00
C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00
C, Shrub, Flat	1.33	0.90	0.00	1.68	6.32	19.76	3.57	8.17	0.00	0.37	0.00	0.00	0.00	0.00	12.81	0.70	1.31	6.87	14.00
C, Shrub, Mod	2.12	1.42	0.01	5.84	9.21	27.51	8.38	12.71	0.00	1.44	0.00	0.00	0.00	0.00	13.73	1.52	1.04	7.34	11.83
C, Shrub, Steep	0.37	0.18	0.00	3.68	0.91	3.12	1.47	1.19	0.00	0.31	0.00	0.00	0.00	0.00	1.05	0.71	0.64	0.34	1.28
C, Pasture, Flat	2.42	7.50	6.56	0.11	20.68	24.96	20.21	9.08	0.00	5.16	0.00	0.00	0.00	0.00	25.53	5.36	1.33	0.00	0.00
C, Pasture, Mod	3.26	6.21	9.91	0.74	17.43	9.70	15.00	9.19	0.00	22.93	0.00	0.00	0.00	0.00	17.08	16.23	0.79	0.00	0.02
C, Pasture, Steep	0.02	1.06	1.97	0.43	2.76	1.80	0.67	0.28	0.00	0.13	0.00	0.00	0.00	0.00	0.50	2.51	0.67	0.00	0.01
C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.52	17.49
C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.93	11.96
C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.84
C, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	9.27	8.73
C, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.62	6.95	7.63
C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.56	0.54
D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00
D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00
D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
D, Shrub, Flat	0.17	0.87	0.03	9.94	0.00	2.44	0.00	0.90	0.00	1.57	0.89	0.54	0.00	0.35	6.18	0.01	2.25	0.00	0.69
D, Shrub, Mod	0.14	1.61	0.04	14.25	0.00	2.61	0.00	2.13	0.00	4.11	0.59	0.36	0.00	0.23	10.66	0.11	1.80	0.00	1.47
D, Shrub, Steep	0.03	0.12	0.02	1.51	0.00	0.72	0.00	0.15	0.00	0.67	0.00	0.00	0.00	0.00	1.34	0.02	1.87	0.00	0.38
D, Pasture, Flat	0.01	6.76	11.71	4.69	1.83	0.00	0.00	0.11	0.09	1.16	18.15	11.02	0.00	7.14	0.36	24.19	24.26	0.00	0.00
D, Pasture, Mod	0.01	8.11	12.39	2.04	1.58	0.00	0.00	0.15	0.39	2.20	12.78	7.76	0.00	5.02	0.40	28.85	12.26	0.00	0.00
D, Pasture, Steep	0.01	1.91	2.49	0.52	0.53	0.00	0.00	0.01	0.12	0.35	1.68	1.02	0.00	0.66	0.04	3.79	2.25	0.00	0.00
D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81
D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
D, Lawn, Flat	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.03	5.18	0.01	8.68	0.00	8.68	0.00	0.00	0.00	0.14	0.00	0.08
D, Lawn, Mod	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.03	16.36	0.05	5.54	0.00	5.54	0.00	0.00	0.00	0.29	0.00	0.23
D, Lawn, Steep	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	1.78	0.00	1.73	0.00	1.73	0.00	0.00	0.01	0.21	0.00	0.12
Impervious	0.7	1.4	1.3	0.5	2.2	4.0	0.9	2.1	14.6	0.5	12.3	0.0	12.0	0.3	3.2	13.5	4.9	15.9	21.5
Total	10.6	38.1	46.4	46.9	63.4	97.8	50.2	46.2	41.3	41.0	62.4	20.7	28.0	13.7	92.9	105.7	57.9	71.6	100.4

Table A-1
HSPF Input Paramters - Existing Land Use

PERLND Area (Acres)	BP-29a	BP-29b	BP-29c	BP-29d	BP-29e1	BP-29e2	BP-29e3	BP-29f	BP-29g	BP-29h	BP-29i	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14
Pervious Area	55.41	5.54	41.31	67.61	28.85	9.71	9.51	2.06	3.53	15.02	22.10	8.39	4.06	4.28	1.94	1.06	5.01	3.31	6.60	3.06	6.16	35.63	38.83	48.60	68.43
A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81
A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.92
A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.00	0.00	11.51	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.02	0.00	3.45	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	1.18	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Flat	9.58	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.31	0.00
B, Shrub, Mod	5.72	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.80	0.00
B, Shrub, Steep	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22	0.00
B, Pasture, Flat	5.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Mod	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00
B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00
B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
B, Lawn, Flat	0.09	0.00	1.02	8.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Mod	0.09	0.00	0.72	6.51	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Steep	0.00	0.00	0.05	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.68	0.00	0.00	0.01	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.51	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.28	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00
C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.10	0.00
C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.50	0.00
C, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.90	0.00	0.14	11.95
C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.23	7.47
C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.17	8.31
C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
C, Lawn, Flat	0.00	0.00	0.64	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.61	3.25	0.00	0.00	0.00	2.91	0.00	0.00	0.00	0.00
C, Lawn, Mod	0.00	0.00	2.89	4.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.37	1.04	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00
C, Lawn, Steep	0.00	0.00	0.24	4.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.14	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00
D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.02	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.01	0.00	0.00
D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.26	0.00	0.00	0.00	0.00	0.00	1.37	0.01	0.00	0.01	0.00	0.00
D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.08	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
D, Shrub, Flat	2.46	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00
D, Shrub, Mod	2.56	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	0.00
D, Shrub, Steep	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00
D, Pasture, Flat	21.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.01	28.52	35.84	4.20	22.21
D, Pasture, Mod	6.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.01	5.37	2.67	2.04	10.80
D, Pasture, Steep	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.30	0.79	1.91
D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Lawn, Flat	0.29	3.30	18.00	19.31	14.69	6.87	6.06	0.94	1.95	9.50	4.47	2.18	0.00	0.00	1.64	0.00	0.46	1.84	4.12	0.00	0.73	0.00	0.01	0.00	0.00
D, Lawn, Mod	0.30	1.62	12.47	14.77	7.46	2.46	2.72	0.83	1.40	4.14	0.99	1.32	0.00	0.00	0.26	0.00	0.09	0.85	2.32	0.00	0.22	0.00	0.00	0.00	0.00
D, Lawn, Steep	0.04	0.61	5.18	7.12	6.69	0.27	0.66	0.29	0.14	1.38	0.51	1.26	0.00	0.00	0.00	0.00	0.02	0.03	0.15	0.00	0.02	0.00	0.00	0.00	0.00
Impervious	0.7	3.5	22.2	43.1	37.2	3.5	4.7	1.6	2.0	6.0	32.7	1.6	1.8	1.5	0.8	0.6	1.6	1.1	3.4	0.0	3.4	1.6	0.8	1.3	1.0
Total	56.1	9.0	63.5	110.7	66.5	14.2	15.7	3.7	5.6	21.6	56.9	10.0	5.9	5.8	2.7	1.7	6.6	4.5	10.0	3.1	9.6	37.2	39.6	49.9	69.5

Table A-2
HSPF Input Paramters - Future Land Use

PERLND Area (acres)	BP-16	BP-17a	BP-17b	BP-17c	BP-17d	BP-17e	BP-17f	BP-18	BP-19	BP-20a	BP-20b	BP-20b1	BP-20b2	BP-20b3	BP-21a	BP-21b	BP-22	BP-24	BP-25
Total Pervious	9.60	34.99	42.88	45.77	58.19	71.93	35.80	26.51	26.47	37.33	45.64	16.87	15.95	13.40	55.72	64.40	38.24	49.92	67.17
A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00
C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.87	0.00	0.00	0.00
C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	0.00	0.00
C, Shrub, Flat	1.33	0.87	0.00	1.63	6.00	7.56	0.24	0.00	0.00	0.27	0.00	0.00	0.00	0.00	2.81	0.02	0.68	0.00	0.00
C, Shrub, Mod	2.11	1.38	0.01	5.67	8.75	10.91	0.88	0.00	0.00	0.96	0.00	0.00	0.00	0.00	1.42	0.16	0.48	0.00	0.00
C, Shrub, Steep	0.36	0.17	0.00	3.65	0.86	1.48	0.16	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.03	0.22	0.21	0.00	0.00
C, Pasture, Flat	2.31	7.18	6.23	0.11	19.64	6.69	4.42	0.00	0.00	4.72	0.00	0.00	0.00	0.00	0.11	0.46	0.06	0.00	0.00
C, Pasture, Mod	3.11	5.92	9.43	0.73	16.56	7.33	10.57	0.00	0.00	21.74	0.00	0.00	0.00	0.00	0.04	2.11	0.11	0.00	0.00
C, Pasture, Steep	0.02	1.01	1.87	0.42	2.63	0.28	0.61	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.56	0.02	0.00	0.00
C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.03
C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.23	0.13
C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.04
C, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	18.17	11.32	10.35	0.94	0.17	0.00	0.00	0.00	0.00	21.25	3.12	0.91	22.53	34.59
C, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	11.17	6.80	13.14	1.71	0.31	0.00	0.00	0.00	0.00	17.61	8.84	0.84	21.05	26.57
C, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	2.02	0.80	0.88	0.14	0.07	0.00	0.00	0.00	0.00	0.91	1.44	1.07	2.18	2.13
D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.00	0.00	0.00
D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
D, Shrub, Flat	0.16	0.83	0.03	9.87	0.00	2.43	0.00	0.00	0.00	0.91	0.09	0.09	0.00	0.35	0.01	0.01	1.16	0.00	0.15
D, Shrub, Mod	0.14	1.53	0.04	14.13	0.00	2.61	0.00	0.00	0.00	2.70	0.04	0.04	0.00	0.23	0.13	0.09	1.04	0.00	0.14
D, Shrub, Steep	0.03	0.12	0.02	1.51	0.00	0.72	0.00	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.04	0.02	1.15	0.00	0.00
D, Pasture, Flat	0.00	6.44	11.12	4.59	1.74	0.00	0.00	0.00	0.00	1.05	13.14	6.01	0.00	7.14	0.06	3.77	8.56	0.00	0.00
D, Pasture, Mod	0.01	7.71	11.76	1.96	1.50	0.00	0.00	0.00	0.00	1.89	8.50	3.48	0.00	5.02	0.10	7.59	4.14	0.00	0.00
D, Pasture, Steep	0.01	1.83	2.37	0.51	0.51	0.00	0.00	0.00	0.00	0.27	1.35	0.69	0.00	0.66	0.03	2.20	0.53	0.00	0.00
D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
D, Lawn, Flat	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.64	5.23	0.42	12.16	3.48	8.68	0.00	3.88	12.31	10.21	0.00	0.70
D, Lawn, Mod	0.00	0.00	0.00	0.65	0.00	0.00	0.00	1.41	16.60	0.94	8.43	2.90	5.54	0.00	6.50	13.03	5.55	0.00	1.53
D, Lawn, Steep	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.10	1.85	0.16	1.92	0.20	1.73	0.00	0.78	0.98	1.54	0.00	0.52
Impervious	1.0	3.1	3.5	1.1	5.2	25.9	14.4	19.7	14.8	3.6	16.7	4.7	12.0	0.3	37.2	41.3	19.6	21.7	33.3
Total	10.6	38.1	46.4	46.9	63.4	97.8	50.2	46.2	41.3	41.0	62.4	21.6	28.0	13.7	92.9	105.7	57.9	71.6	100.4

Table A-2
HSPF Input Paramters - Future Land Use

PERLND Area (acres)	BP-29a	BP-29b	BP-29c	BP-29d	BP-29e1	BP-29e2	BP-29e3	BP-29f	BP-29g	BP-29h	BP-29i	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14
Total Pervious	53.89	5.54	41.30	67.57	28.83	9.71	9.52	2.06	3.53	15.02	22.10	7.59	3.11	2.53	1.94	1.06	5.00	3.09	6.60	2.49	6.15	30.62	20.08	36.05	65.49
A, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
A, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63
A, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35
A, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A, Lawn, Flat	0.00	0.00	0.00	0.00	0.00	0.07	0.04	0.00	0.00	0.00	11.52	0.88	0.08	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
A, Lawn, Mod	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.02	0.00	3.45	0.83	0.13	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
A, Lawn, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.18	0.82	0.40	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27
B, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Flat	9.41	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Mod	5.63	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Shrub, Steep	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Flat	5.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Mod	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B, Lawn, Flat	0.10	0.00	1.02	8.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35	0.00
B, Lawn, Mod	0.09	0.00	0.73	6.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.56	0.00
B, Lawn, Steep	0.00	0.00	0.05	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00
C, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
C, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
C, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
C, Shrub, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00
C, Shrub, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.38	0.00
C, Shrub, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	0.00
C, Pasture, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	0.00	0.14	11.73
C, Pasture, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.23	6.38
C, Pasture, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.17	4.64
C, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C, Lawn, Flat	0.00	0.00	0.64	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.41	0.03	0.62	3.25	0.00	0.00	0.12	2.91	0.46	0.00	0.35	0.02
C, Lawn, Mod	0.00	0.00	2.89	4.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.30	0.01	0.37	1.04	0.00	0.00	0.09	1.53	0.19	0.00	3.44	0.63
C, Lawn, Steep	0.00	0.00	0.24	4.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17	0.00	0.07	0.14	0.00	0.00	0.01	0.71	0.01	0.00	3.08	2.18
D, Forest, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.01	0.00	0.00
D, Forest, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.01	0.00	0.00
D, Forest, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
D, Shrub, Flat	2.37	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.00
D, Shrub, Mod	2.46	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
D, Shrub, Steep	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00
D, Pasture, Flat	20.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	19.04	11.51	3.99	21.87
D, Pasture, Mod	5.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	3.52	0.65	1.88	10.75
D, Pasture, Steep	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.10	0.75	1.90
D, Grass, Flat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Grass, Mod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Grass, Steep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D, Lawn, Flat	0.31	3.30	18.00	19.33	14.69	6.87	6.06	0.94	1.95	9.50	4.47	2.41	0.13	0.01	1.64	0.00	0.46	2.06	4.12	0.30	0.73	5.69	7.10	0.30	0.00
D, Lawn, Mod	0.32	1.63	12.48	14.77	7.46	2.47	2.73	0.83	1.40	4.13	0.99	1.38	0.08	0.15	0.26	0.00	0.10	0.96	2.32	0.34	0.22	1.11	0.62	0.61	0.00
D, Lawn, Steep	0.04	0.61	5.18	7.12	6.69	0.27	0.66	0.29	0.14	1.38	0.51	1.26	0.06	0.04	0.00	0.00	0.02	0.03	0.15	0.01	0.02	0.05	0.10	0.14	0.00
Impervious	2.2	3.5	22.2	43.1	37.2	3.5	4.7	1.6	2.0	6.0	32.7	2.4	2.7	3.3	0.8	0.6	1.6	1.4	3.4	0.6	3.5	6.6	19.5	13.8	4.0
Total	56.1	9.0	63.5	110.7	66.5	14.2	15.7	3.7	5.6	21.6	56.9	10.0	5.9	5.8	2.7	1.7	6.6	4.5	10.0	3.1	9.6	37.2	39.6	49.9	69.5

Table A-3
Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	mate Char	25 Year	100 Year	Nov-21	imate Chang	Location
LDES2448	112.1	110.3	110.4	110.4	110.5	-1.8	-1.72	-1.66	-1.58	110.3	110.4	110.4	110.5	-1.8	-1.72	-1.66	-1.58	110.3	110.4	110.5	110.6	-1.8	-1.69	-1.6	-1.5	Birch Point Road West of Selder
LDES2449	111.2	109.7	109.7	109.8	109.8	-1.5	-1.47	-1.45	-1.43	109.7	109.7	109.8	109.8	-1.5	-1.47	-1.45	-1.43	109.7	109.7	109.8	109.8	-1.5	-1.46	-1.4	-1.4	Birch Point Road West of Selder
LDES2456	80.0	76.3	76.4	76.4	76.5	-3.7	-3.61	-3.56	-3.51	76.3	76.4	76.4	76.5	-3.7	-3.61	-3.56	-3.51	76.3	76.4	76.5	76.5	-3.7	-3.58	-3.5	-3.5	Birch Point Road West of Selder
LDES2457	77.6	75.0	75.0	75.0	75.1	-2.6	-2.58	-2.57	-2.55	75.0	75.0	75.0	75.1	-2.6	-2.58	-2.57	-2.55	75.0	75.0	75.0	75.1	-2.6	-2.57	-2.6	-2.6	Birch Point Road West of Selder
LDES2463	50.3	48.2	48.2	48.2	48.2	-2.1	-2.10	-2.10	-2.10	48.2	48.2	48.2	48.2	-2.1	-2.10	-2.10	-2.10	48.2	48.2	48.6	50.3	-2.1	-2.10	-1.7	0.0	Birch Point Road West of Selder
LDES2464	51.1	44.7	44.9	45.0	46.7	-6.4	-6.23	-6.14	-4.40	44.7	44.9	45.0	46.7	-6.4	-6.24	-6.14	-4.40	44.9	46.6	48.6	50.3	-6.2	-4.49	-2.5	-0.8	Birch Point Road West of Selder
LDES2470	51.1	48.4	50.2	51.9	52.5	-2.7	-0.90	0.76	1.36	48.4	50.2	51.9	52.5	-2.7	-0.94	0.76	1.36	51.2	52.4	52.6	52.6	0.1	1.34	1.5	1.5	Birch Point Road West of Selder
Od1010_3	55.3	51.7	51.7	51.9	52.5	-3.6	-3.58	-3.40	-2.80	51.7	51.8	51.9	52.5	-3.6	-3.52	-3.40	-2.80	51.8	52.5	52.6	52.7	-3.6	-2.84	-2.7	-2.6	Birch Point Road West of Selder
OD1010-1	62.3	61.9	61.9	61.9	62.0	-0.4	-0.38	-0.36	-0.34	61.9	61.9	61.9	62.0	-0.4	-0.38	-0.36	-0.34	61.9	61.9	62.0	62.0	-0.4	-0.37	-0.3	-0.3	Birch Point Road West of Selder
OD1010-2	59.4	56.8	56.9	57.0	57.1	-2.6	-2.54	-2.44	-2.34	56.9	56.9	57.0	57.1	-2.5	-2.48	-2.44	-2.34	56.9	57.0	57.1	57.1	-2.5	-2.45	-2.4	-2.3	Birch Point Road West of Selder
TT1018	117.0	115.3	115.4	115.4	115.4	-1.7	-1.64	-1.62	-1.60	115.3	115.4	115.4	115.4	-1.7	-1.64	-1.62	-1.60	115.3	115.4	115.4	115.4	-1.7	-1.63	-1.6	-1.6	Birch Point Road West of Selder
TT1019	72.0	68.0	68.0	68.0	68.0	-4.0	-4.0	-4.00	-4.00	68.0	68.0	68.0	68.0	-4.0	-4.0	-4.00	-4.00	68.0	68.0	68.0	68.0	-4.0	-4.0	-4.0	-4.0	Birch Point Road West of Selder
2886	28.1	27.2	28.0	28.1	28.1	-1.0	-0.1	0.00	0.03	26.8	27.9	28.1	28.1	-1.3	-0.2	0.00	0.03	28.1	28.2	28.2	28.2	0.0	0.1	0.1	0.1	Birch Point Road West of Selder
2887	39.1	36.4	36.5	36.5	36.6	-2.7	-2.64	-2.60	-2.54	36.5	36.6	36.5	36.6	-2.6	-2.52	-2.60	-2.54	36.8	36.8	36.8	36.8	-2.3	-2.31	-2.3	-2.3	Birch Point Road West of Selder
2888	29.4	26.1	26.5	26.6	26.6	-3.3	-2.9	-2.85	-2.80	25.8	26.4	26.6	26.6	-3.6	-3.0	-2.85	-2.80	26.5	26.6	26.7	26.7	-2.9	-2.8	-2.7	-2.7	Birch Point Road West of Selder
LDES2482	46.3	44.5	44.6	44.7	44.7	-1.8	-1.7	-1.63	-1.57	45.9	46.5	44.7	44.7	-0.4	0.2	-1.63	-1.57	46.7	46.7	46.8	46.8	0.4	0.4	0.5	0.5	Birch Point Road West of Selder
LDES2490	52.2	51.1	51.1	51.1	51.1	-1.1	-1.1	-1.10	-1.10	51.1	51.1	51.1	51.1	-1.1	-1.1	-1.10	-1.10	51.1	51.1	51.1	51.1	-1.1	-1.1	-1.1	-1.1	Birch Point Road West of Selder
LDES2491	52.2	50.8	50.8	50.8	50.8	-1.4	-1.4	-1.40	-1.40	50.8	50.8	50.8	50.8	-1.4	-1.4	-1.40	-1.40	50.8	50.8	50.8	50.8	-1.4	-1.4	-1.4	-1.4	Birch Point Road West of Selder
LDES2498	36.0	34.5	34.6	34.7	34.7	-1.5	-1.4	-1.34	-1.29	34.5	34.6	34.7	34.7	-1.5	-1.4	-1.34	-1.29	34.7	34.8	34.8	34.8	-1.3	-1.2	-1.2	-1.2	Birch Point Road West of Selder
LDES2502	28.7	28.6	29.4	29.4	29.5	-0.1	0.7	0.71	0.76	28.1	29.3	29.4	29.5	-0.6	0.6	0.71	0.76	29.4	29.5	29.5	29.6	0.7	0.78	0.8	0.9	Birch Point Road West of Selder
LDES2503	28.0	26.5	27.0	27.1	27.2	-1.5	-1.0	-0.89	-0.78	26.1	27.0	27.1	27.2	-1.9	-1.1	-0.89	-0.78	27.0	27.2	27.3	27.3	-1.0	-0.8	-0.7	-0.7	Birch Point Road West of Selder
LDES2508	30.0	28.6	29.4	29.4	29.5	-1.4	-0.6	-0.59	-0.55	28.1	29.3	29.4	29.5	-1.9	-0.7	-0.59	-0.55	29.4	29.5	29.5	29.6	-0.6	-0.5	-0.5	-0.4	Birch Point Road West of Selder
LDES2509	27.8	27.6	28.6	28.6	28.7	-0.2	0.8	0.84	0.91	27.2	28.5	28.6	28.7	-0.6	0.6	0.84	0.91	28.6	28.7	28.8	28.9	0.8	0.9	1.0	1.1	Birch Point Road West of Selder
LDES2516	27.8	27.5	28.5	28.6	28.6	-0.3	0.7	0.79	0.83	27.1	28.4	28.6	28.6	-0.7	0.6	0.79	0.83	28.6	28.6	28.7	28.7	0.8	0.8	0.9	0.9	Birch Point Road West of Selder
LDES2521	27.8	26.1	26.5	26.6	26.6	-1.7	-1.3	-1.25	-1.19	25.9	26.4	26.6	26.6	-2.0	-1.4	-1.25	-1.19	26.5	26.6	26.7	26.7	-1.3	-1.2	-1.1	-1.1	Birch Point Road West of Selder
OD1020-1	53.4	53.0	53.1	53.2	53.3	-0.4	-0.3	-0.21	-0.11	53.0	53.1	53.2	53.3	-0.4	-0.3	-0.21	-0.11	53.3	53.4	53.4	53.5	-0.1	0.0	0.0	0.1	Birch Point Road West of Selder
OD1020-2	53.4	52.7	52.9	53.0	53.1	-0.7	-0.5	-0.42	-0.29	52.7	52.9	53.0	53.1	-0.7	-0.5	-0.42	-0.29	53.1	53.2	53.2	53.3	-0.3	-0.2	-0.2	-0.1	Birch Point Road West of Selder
OD1020-3	53.3	52.5	52.6	52.7	52.8	-0.8	-0.7	-0.60	-0.48	52.5	52.6	52.7	52.8	-0.8	-0.7	-0.60	-0.48	52.8	52.9	52.9	53.0	-0.5	-0.4	-0.4	-0.3	Birch Point Road West of Selder
OF-TT6	29.4	23.7	23.7	23.7	23.8	-5.7	-5.7	-5.66	-5.65	23.7	23.7	23.7	23.8	-5.7	-5.7	-5.66	-5.65	23.7	23.8	23.8	23.8	-5.7	-5.7	-5.7	-5.7	Birch Point Road West of Selder
TT1020	52.2	52.4	52.4	52.5	52.5	0.1	0.2	0.26	0.33	52.3	52.4	52.5	52.5	0.1	0.2	0.26	0.33	52.5	52.6	52.7	52.7	0.3	0.4	0.5	0.5	Birch Point Road West of Selder
TT1021	52.2	51.6	51.6	51.6	51.6	-0.6	-0.6	-0.60	-0.60	51.6	51.6	51.6	51.6	-0.6	-0.6	-0.60	-0.60	51.6	51.6	51.6	51.6	-0.6	-0.6	-0.6	-0.6	Birch Point Road West of Selder
TT1022	52.2	52.2	52.3	52.3	52.4	0.0	0.1	0.12	0.16	52.1	52.2	52.3	52.4	-0.1	0.0	0.12	0.16	52.3	52.4	52.4	52.4	0.1	0.2	0.2	0.2	Birch Point Road West of Selder
TT1023	28.0	26.5	27.0	27.1	27.2	-1.6	-1.0	-0.90	-0.79	26.1	26.9	27.1	27.2	-1.9	-1.1	-0.90	-0.79	27.0	27.2	27.3	27.3	-1.0	-0.8	-0.8	-0.7	Birch Point Road West of Selder
35701	53.4	53.3	53.3	53.3	53.3	-0.1	-0.1	-0.09	-0.06	53.3	53.3	53.3	53.3	-0.1	-0.1	-0.09	-0.06	53.3	53.4	53.4	53.4	-0.1	0.0	0.0	0.0	Bay Ridge Estates - West Shoreview Road
35702	53.3	53.3	53.3	53.3	53.3	0.0	0.0	0.00	0.03	53.3	53.3	53.3	53.3	0.0	0.0	0.00	0.03	53.3	53.4	53.4	53.4	0.0	0.1	0.1	0.1	Bay Ridge Estates - West Shoreview Road
35711	53.3	53.3	53.3	53.3	53.3	0.0	0.0	0.00	0.03	53.3	53.3	53.3	53.3	0.0	0.0	0.00	0.03	53.3	53.4	53.4	53.4	0.0	0.1	0.1	0.1	Bay Ridge Estates - West Shoreview Road
35712	52.8	52.4	52.5	52.5	52.6	-0.4	-0.3	-0.30	-0.25	52.4	52.4	52.5	52.6	-0.4	-0.4	-0.30	-0.25	52.6	52.6	52.6	52.6	-0.3	-0.2	-0.2	-0.2	Bay Ridge Estates - West Shoreview Road
35721	52.2	52.4	52.4	52.4	52.5	0.1	0.2	0.24	0.29	52.4	52.4	52.4	52.5	0.1	0.2	0.24	0.29	52.5	52.5	52.5	52.6	0.3	0.3	0.3	0.3	Bay Ridge Estates - West Shoreview Road
10001	53.8	53.6	53.6	53.6	53.6	-0.2	-0.2	-0.18	-0.17	53.6	53.6	53.6	53.6	-0.2	-0.2	-0.18	-0.17	53.6	53.6	53.6	53.6	-0.2	-0.2	-0.1	-0.1	Bay Ridge Estates - West Shoreview Road
35861	52.1	52.4	52.4	52.4	52.5	0.3	0.3	0.34	0.39	52.3	52.4	52.4	52.5	0.2	0.3	0.34	0.39	52.5	52.5	52.5	52.6	0.4	0.4	0.4	0.4	Bay Ridge Estates - West Shoreview Road
6365	52.8	53.0	53.1	53.1	53.2	0.2	0.3	0.33	0.43	53.0	53.1	53.1	53.2	0.2	0.3	0.33	0.43	53.2	53.3	53.3	53.3	0.4	0.5	0.5	0.5	Bay Ridge Estates - West Shoreview Road
LDES2476	52.1	52.5	52.6	52.6	52.6	0.4	0.5	0.49	0.52	52.5	52.6	52.6	52.6	0.4	0.5	0.49	0.52	52.6	52.6	52.7	52.7	0.5	0.5	0.5	0.6	Bay Ridge Estates - West Shoreview Road
LDES2478	52.7	53.5	53.5	53.5	53.5	0.8	0.77	0.79	0.81	53.5	53.5	53.5	53.5	0.8	0.77	0.79	0.81	53.5	53.5	53.5	53.5	0.8	0.82	0.8	0.8	Bay Ridge Estates - West Shoreview Road
35722	52.4	51.4	51.4	51.4	51.4	-1.0	-1.0	-0.99	-0.98	51.4	51.4	51.4	51.4	-1.0	-1.0	-0.99	-0.98	51.5	51.5	51.5	51.5	-0.9	-0.9	-0.9	-0.9	Bay Ridge Estates - East Shoreview Road
35751	51.5	51.4	51.4	51.4	51.4	-0.1	-0.1	-0.10	-0.09	51.4	51.4	51.4	51.4	-0.1	-0.1	-0.10	-0.09	51.4	51.4	51.4	51.5	-0.1	-0.1	-0.1	0.0	Bay Ridge Estates - East Shoreview Road
35752	52.5	50.9	50.9	50.9	51.0	-1.6	-1.6	-1.57	-1.47	50.9	50.9	50.9	51.0	-1.6	-1.6	-1.57	-1.47	51.0	51.1	51.1	51.2	-1.5	-1.4	-1.4	-1.3	Bay Ridge Estates - East Shoreview Road
35862	51.9	51.2	51.2	51.3	51.6	-0.7	-0.7	-0.58	-0.35	51.2	51.2	51.3	51.6	-0.7	-0.7	-0.58	-0.35	51.5	51.7	51.7	51.8	-0.4	-0.3	-0.2	-0.1	Bay Ridge Estates - East Shoreview Road
6399	50.1	50.0	50.1	50.1	50.8	-0.1	0.0	-0.01	0.68	50.0	50.1	50.1	50.8	-0.1	-0.1	-0.01	0.68	50.7	50.9	50.9	51.0	0.6	0.8	0.8	0.8	Bay Ridge Estates - East Shoreview Road
6501	49.8	50.5	50.5	50.5	50.6	0.7	0.7	0.73	0.84	50.5	50.5	50.5	50.6	0.7	0.7	0.73	0.84	50.6	50.7	50.8	50.8	0.8	0.9	1.0	1.0	Bay Ridge Estates - East Shoreview Road
6502	49.5	48.6	48.6	48.6	50.4	-0.9	-0.89	-0.83	0.91	48.6	48.6	48.6	50.4	-0.9	-0.90	-0.83	0.91	50.2	50.4	50.4	50.4	0.8	0.96	1.0	1.0	Bay Ridge Estates - East Shoreview Road
6503	49.0	49.9	49.9	49.9	50.1	0.9	0.9	0.89	1.10	49.9	49.9	49.9	50.1	0.9	0.9	0.89	1.10	50.0	50.2	50.3	50.3	1.0	1.2	1.2	1.3	Bay Ridge Estates - East Shoreview Road
6504	49.6	49.8	49.7	49.8	50.1	0.1	0.1	0.14	0.49	49.8	49.8	49.8	50.1	0.1	0.1	0.14	0.49	50.0	50.2	50.3	50.3	0.3	0.6	0.6	0.6	Bay Ridge Estates - East Shoreview Road
6505	48.8	47.6	47.7	47.8	50.1	-1.1	-1.1	-0.95	1.37	47.6	47.6	47.8	50.1	-1.2	-1.1	-0.95	1.37	50.0	50.2	50.3	50.3	1.2	1.5	1.5	1.5	Bay Ridge Estates - East Shoreview Road
6506	50.3	47.8	48.0	48.1	50.2	-2.5	-2.36	-2.23	-0.11	47.8	47.9	48.1	50.2	-2.5	-2.45	-2.23	-0.11	50.1	50.3	50.3	50.3	-0.3	-0.02	0.0	0.0	Bay Ridge Estates - East Shoreview Road
7801	50.4	50.9	50.9	50.9	51.0	0.5	0.5	0.53	0.63	50.9	50.9	50.9	51.0	0.5	0.5	0.53	0.63	51.0	51.1	51.1	51.2	0.6	0.7	0.7	0.8	Bay Ridge Estates - East Shoreview Road
7881	50.6	51.1	51.1	51.1	51.2	0.5	0.5	0.53	0.60	51.1	51.1	51.1	51.2	0.5	0.5	0.53	0.60	51.2	51.3	51.3	51.3	0.6	0.6	0.7	0.7	Bay Ridge Estates - East Shoreview Road
35441	52.7	52.7	52.7	52.7	52.7	0.0	0.0	0.04	0.04	52.7	52.7	52.7	52.7	0.0	0.0	0.04	0.04	52.7	52.7	52.7	52.7	0.0	0.0	0.0	0.0	Bay Ridge Estates - Bay Ridge Drive South
35442	52.7	52.4	52.4	52.5	52.5	-0.3	-0.3	-0.27	-0.23	52.4	52.4	52.5	52.5	-0.3	-0.3	-0.27	-0.23	52.5	52.5	52.5	52.6	-0.2	-0.2	-0.2	-0.2	Bay Ridge Estates - Bay Ridge Drive South
35962	51.8	52.3	52.4	52.4	52.5	0.5	0.6	0.61	0.66	52.2	52.3	52.4	52.5	0.4	0.5	0.61	0.66	52.5	52.5	52.5	52.5	0.7	0.7	0.7	0.7	Bay Ridge Estates - Bay Ridge Drive South
6370	34.2	31.7	31.7	31.8	31.8	-2.5	-2.42	-2.40	-2.38	31.7	31.7	31.8	31.8	-2.5	-2.44	-2.40	-2.38	31.7	31.7	31.8	31.8	-2.5	-2.42	-2.4	-2.4	Bay Ridge Estates - Bay Ridge Drive South
6387	52.5	51.4	51.5	51.6	51.7	-1.1	-1.0	-0.93	-0.84	51.4	51.5	51.6	51.7	-1.1	-1.0	-0.93	-0.84	51.4	51.5	51.6	51.7	-1.1	-1.0	-0.9	-0.8	Bay Ridge Estates - Bay Ridge Drive South
6388	52.9	53.4	53.4	53.4	53.4	0.5	0.5	0.50	0.52	53.4	53.4	53.4	53.4	0.4	0.5	0.50	0.52	53.4	53.4	53.4	53.4	0.5	0.5	0.5	0.5	Bay Ridge Estates - Bay Ridge Drive South
6389	52.5	51.4	51.5	51.6	51.6	-1.1	-1.0	-0.97	-0.89	51.4	51.5	51.6	51.6	-1.1	-1.1	-0.97	-0.89	51.4	51.5	51.6	51.7	-1.1	-1.0	-1.0	-0.8	Bay Ridge Estates - Bay Ridge Drive South
6390	53.2	53.3	53.2	53.2	53.3	0.0	0.0	-0.01	0.01	53.1	53.2	53.2	53.3	-0.1	-0.1	-0.01	0.01	53.2	53.2	53.2	53.2	-0.1	0.0	0.0	0.0	Bay Ridge Estates - Bay Ridge Drive South
6398	53.1	53.1	53.1	53.1	53.1	0.0	0.0	0.01	0.04	53.0	53.1	53.1	53.1	-0.1	0.0	0.01	0.04	53.1	53.1	53.1	53.1	0.0	0.0	0.0	0.0	Bay Ridge Estates - Bay Ridge Drive South
7552	52.8	52.8	52.8	52.8	52.8	0.0	0.0	-0.02	-0.02	52.8	52.8	52.8	52.8	0.0	0.0	-0.02	-0.02	52.8	52.8	52.8	52.8	0.0	0.0	0.0	0.0	Bay Ridge Estates - Bay Ridge Drive South
6386	52.8	53.5	53.5	53.5	53.5	0.7	0.7	0.68	0.68	53.5	53.5	53.5	53.5	0.6	0.7	0.68	0.68	53.5	53.5	53.5	53.5	0.7	0.7	0.7	0.7	Bay Ridge Estates - Bay Ridge Drive South
757753	52.8	51.4	51.5	51.6	51.7	-1.4	-1.3	-1.23	-1.13	51.4	51.5	51.6	51.7	-1.4	-1.3	-1.23	-1.13	51.4	51.5	51.6	51.8	-1.4	-1.3	-1.2	-1.1	Bay Ridge Estates - Bay Ridge Drive South
7612	52.8	51.4	51.4	51.4	51.4	-1.4	-1.4	-1.39	-1.38	51.4	51.4	51.4	51.4	-1.4	-1.4	-1.39	-1.38	51.5	51.5	51.5	51.5	-1.3	-1.3	-1.3	-1.3	Bay Ridge Estates - Bay Ridge Drive South
33461	60.6	56.1	56.1	56.1	56.2	-4.6	-4.5	-4.48	-4.45	56.0	56.1	56.1	56.2	-4.6	-4.6	-4.48	-4.45	56.1	56.1	56.2	56.2	-4.5	-4.5	-4.5	-4.4	Bay Ridge Estates - Seawan Place
33571	61.5	60.0	60.1	60.2	60.4	-1.5	-1.4	-1.35	-1.06	59.9	60.0	60.2	60.4	-1.6	-1.5	-1.35	-1.06	60.0	60.1	60.2	60.6	-1.5	-1.4	-1.3	-0.9	Bay Ridge Estates - Seawan Place
33572	61.0	59.4	59.6	59.8	60.2	-1.6	-1.4	-1.21	-0.82	59.4	59.4	59.8	60.2	-1.6	-1.6	-1.21	-0.82	59.5	59.7	59.9	60.3	-1.5	-1.4	-1.1	-0.7	Bay Ridge Estates - Seawan Place
33771	60.8	59.4	59.6	59.8	60.2	-1.4	-1.2	-1.01	-0.62	59.4	59.4	59.8	60.2	-1.4	-1.4	-1.01	-0.62	59.5	59.6	59.9	60.3	-1.3	-1.2	-0.9	-0.5	Bay Ridge Estates - Seawan Place
33772	60.5	58.9	59.3	59.5	59.8	-1.6	-1.2	-1.01	-0.69	58.8	58.9	59.5	59.8	-1.7	-1.6	-1.01	-0.69	59.0	59.3	59.6	59.9	-1.5	-1.2	-0.9	-0.6	Bay Ridge Estates - Seawan Place
33991	60.0	58.9	59.3	59.5	59.8	-1.1	-0.8	-0.51	-0.19	58.8	58.9	59.5	59.8	-1.2	-1.1	-0.51	-0.19	59.0	59.3	59.6	59.9	-1.0	-0.7	-0.4	-0.1	Bay Ridge Estates - Seawan Place
33992	59.2	57.3	57.4	57.4	57.4	-1.9	-1.9	-1.84	-1.83	57.3	57.3	57.4	57.4	-1.9	-1.9	-1.84	-1.83	57.3	57.4	57.4	58.2	-1.9	-1.8	-1.8	-1.1	Bay Ridge Estates - Seawan Place
34341	57.5	56.4	56.8	57.0	57.3	-1.1	-0.7	-0.47	-0.16	56.3	56.5	57.0	57.3	-1.2	-1.1	-0.47	-0.16	56.5	56.9	57.1	58.1	-1.0	-0.6	-0.4	0.6	Bay Ridge Estates - Seawan Place
34342	55.6	55.0	55.0	55.0	55.0	-0.6	-0.5	-0.54	-0.53	55.0	55.0	55.0	55.0	-0.6	-0.6	-0.54	-0.53	55.0	55.0	55.0	55.6	-0.6	-0.5	-0.5	0.1	Bay Ridge Estates - Seawan Place
6385	57.0	54.4	54.4	54.4	54.4	-2.6	-2.6	-2.58	-2.56	54.3	54.4	54.4	54.4	-2.7	-2.6	-2.58	-2.59	54.4	54.4	54.5	54.5	-2.6	-2.6	-2.6	-2.5	Bay Ridge Estates - Seawan Place
7141	56.1	54.7	54.8	54.8	54.9	-1.5	-1.4	-1.30	-1.23	54.6	54.7	54.8	54.8	-1.5	-1.4	-1.30	-1.34	54.7	54.8	54.8	55.6	-1.4	-1.4	-1.3	-0.5	Bay Ridge Estates - Seawan Place
6380	49.8	48.6	48.6	48.7	48.7	-1.2	-1.1	-1.10	-1.06	48.5	48.6	48.7	48.7	-1.2	-1.2	-1.10	-1.10	48.6	48.6	48.7	48.7	-1.2	-1.1	-1.1	-1.1	Bay Ridge Estates - Bay Ridge Drive Middle
6381	51.2	50.2	50.7	51.0	51.2	-1.0	-0.5	-0.23	-0.02	49.8	50.3	51.0	50.9	-1.4	-0.9	-0.23	-0.37	50.3	50.7	51.0	51.2	-1.0	-0.5	-0.3	0.0	Bay Ridge Estates - Bay Ridge Drive Middle

Table A-3
Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	nate Char	25 Year	100 Year	Nov-21	limate Chang	Location
6383	51.1	50.4	51.0	51.3	51.5	-0.7	-0.1	0.19	0.42	49.9	50.5	51.3	51.1	-1.2	-0.6	0.19	0.03	50.4	50.9	51.3	51.5	-0.7	-0.1	0.2	0.4	Bay Ridge Estates - Bay Ridge Drive Middle
6384	52.5	51.1	51.2	51.3	51.4	-1.4	-1.3	-1.26	-1.13	51.1	51.1	51.3	51.2	-1.5	-1.4	-1.26	-1.28	51.1	51.2	51.3	51.5	-1.4	-1.3	-1.3	-1.1	Bay Ridge Estates - Bay Ridge Drive Middle
6951	50.1	48.3	48.7	48.9	49.1	-1.8	-1.4	-1.22	-0.99	48.0	48.4	48.9	48.8	-2.1	-1.7	-1.22	-1.27	48.2	48.6	48.8	49.0	-1.8	-1.5	-1.3	-1.1	Bay Ridge Estates - Bay Ridge Drive Middle
7042	52.3	51.1	51.3	51.6	51.8	-1.2	-1.0	-0.68	-0.46	51.1	51.1	51.6	51.4	-1.2	-1.2	-0.68	-0.87	51.1	51.3	51.6	51.8	-1.2	-1.1	-0.7	-0.5	Bay Ridge Estates - Bay Ridge Drive Middle
7052	50.8	48.5	48.7	48.9	49.1	-2.3	-2.1	-1.93	-1.70	48.4	48.5	48.9	48.8	-2.4	-2.3	-1.93	-1.98	48.5	48.6	48.8	49.0	-2.3	-2.2	-2.0	-1.8	Bay Ridge Estates - Bay Ridge Drive Middle
7102	51.0	48.8	48.9	48.9	49.0	-2.3	-2.1	-2.06	-1.97	48.7	48.8	48.9	48.9	-2.3	-2.2	-2.06	-2.07	48.7	48.9	48.9	49.1	-2.3	-2.2	-2.1	-1.9	Bay Ridge Estates - Bay Ridge Drive Middle
7201	52.1	48.8	48.9	48.9	49.0	-3.3	-3.2	-3.16	-3.06	48.8	48.8	48.9	48.9	-3.3	-3.3	-3.16	-3.17	48.8	48.9	48.9	49.1	-3.3	-3.2	-3.2	-3.0	Bay Ridge Estates - Bay Ridge Drive Middle
72011	51.6	50.4	50.5	50.5	50.6	-1.2	-1.1	-1.07	-0.99	50.3	50.4	50.5	50.5	-1.3	-1.2	-1.07	-1.08	50.4	50.5	50.5	50.6	-1.2	-1.1	-1.1	-1.0	Bay Ridge Estates - Bay Ridge Drive Middle
7242	51.8	50.7	51.2	51.6	51.8	-1.1	-0.6	-0.19	0.03	50.6	50.7	51.6	51.4	-1.2	-1.1	-0.19	-0.38	50.7	51.2	51.6	51.8	-1.1	-0.6	-0.2	0.0	Bay Ridge Estates - Bay Ridge Drive Middle
6371	34.1	31.1	31.2	31.2	31.2	-3.0	-3.0	-2.93	-2.90	31.1	31.1	31.2	31.2	-3.0	-3.0	-2.93	-2.92	31.1	31.2	31.2	31.2	-3.0	-3.0	-2.9	-2.9	Bay Ridge Estates - Bay Ridge Drive West
6372	35.2	35.0	36.4	36.4	36.4	-0.1	1.3	1.27	1.28	34.3	35.5	36.4	36.4	-0.8	0.4	1.27	1.27	34.8	36.2	36.4	36.4	-0.4	1.0	1.3	1.3	Bay Ridge Estates - Bay Ridge Drive West
6373	39.6	38.2	38.2	38.2	38.2	-1.4	-1.4	-1.42	-1.42	38.2	38.2	38.2	38.2	-1.4	-1.4	-1.42	-1.42	38.2	38.2	38.2	38.2	-1.4	-1.4	-1.4	-1.4	Bay Ridge Estates - Bay Ridge Drive West
6374	46.5	47.3	47.3	47.3	47.3	0.8	0.9	0.85	0.85	47.3	47.3	47.3	47.3	0.8	0.8	0.85	0.85	47.3	47.3	47.3	47.3	0.8	0.8	0.9	0.9	Bay Ridge Estates - Bay Ridge Drive West
6972	43.8	43.6	43.6	43.6	43.7	-0.2	-0.2	-0.16	-0.15	43.5	43.6	43.6	43.6	-0.3	-0.2	-0.16	-0.16	43.6	43.6	43.6	43.6	-0.2	-0.2	-0.2	-0.2	Bay Ridge Estates - Bay Ridge Drive West
7271	35.5	33.1	33.1	33.1	33.1	-2.4	-2.4	-2.40	-2.38	33.1	33.1	33.1	33.1	-2.5	-2.4	-2.40	-2.40	33.1	33.1	33.1	33.1	-2.4	-2.4	-2.4	-2.4	Bay Ridge Estates - Bay Ridge Drive West
7311	34.2	34.5	34.6	34.6	34.6	0.3	0.4	0.38	0.40	34.5	34.6	34.6	34.6	0.3	0.4	0.38	0.40	34.5	34.6	34.6	34.6	0.3	0.4	0.4	0.4	Bay Ridge Estates - Bay Ridge Drive West
734738	34.4	32.3	32.4	32.4	32.4	-2.1	-2.0	-1.99	-1.98	32.3	32.3	32.4	32.4	-2.2	-2.1	-1.99	-1.99	32.3	32.4	32.4	32.4	-2.1	-2.0	-2.0	-2.0	Bay Ridge Estates - Bay Ridge Drive West
9581	36.6	35.4	35.4	35.4	35.4	-1.2	-1.2	-1.21	-1.20	35.4	35.4	35.4	35.4	-1.2	-1.2	-1.21	-1.21	35.4	35.4	35.4	35.4	-1.2	-1.2	-1.2	-1.2	Bay Ridge Estates - Bay Ridge Drive West
6375	49.1	47.9	48.1	48.2	48.4	-1.2	-1.0	-0.83	-0.69	47.7	48.0	48.2	48.2	-1.3	-1.1	-0.83	-0.86	47.9	48.1	48.2	48.3	-1.2	-1.0	-0.9	-0.7	Bay Ridge Estates - Bay Ridge Drive West
6376	48.9	46.5	46.6	46.6	46.6	-2.4	-2.3	-2.27	-2.24	46.5	46.5	46.6	46.6	-2.4	-2.3	-2.27	-2.28	46.5	46.5	46.6	46.6	-2.4	-2.3	-2.3	-2.3	Bay Ridge Estates - Bay Ridge Drive West
9391	43.1	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.09	-0.07	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.09	-0.08	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.1	-0.1	Bay Ridge Estates
BayRidgePond	30.5	29.4	29.5	29.6	29.6	-1.1	-1.0	-0.93	-0.89	29.4	29.5	29.6	29.6	-1.1	-1.0	-0.93	-0.90	29.5	29.6	29.6	29.7	-1.0	-0.9	-0.9	-0.8	Bay Ridge Estates
9391	43.1	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.09	-0.07	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.09	-0.08	43.0	43.0	43.0	43.0	-0.1	-0.1	-0.1	-0.1	Bay Ridge Estates
BBV-0009	8.7	7.8	8.0	8.1	8.2	-0.9	-0.66	-0.56	-0.45	8.2	8.4	8.1	8.7	-0.5	-0.28	-0.56	0.01	8.3	8.6	8.8	9.0	-0.4	-0.08	0.1	0.3	Birch Bay Village
BBVJ-005	12.6	11.8	13.4	14.2	14.2	-0.8	0.9	1.61	1.67	11.7	12.1	14.2	14.2	-0.9	-0.5	1.61	1.66	13.7	14.3	14.3	14.4	1.2	1.7	1.7	1.8	Birch Bay Village
BBVJ-007	45.0	39.4	39.5	39.5	39.6	-5.6	-5.5	-5.48	-5.42	39.4	39.5	39.5	39.6	-5.6	-5.5	-5.48	-5.42	39.5	39.6	39.6	39.7	-5.5	-5.4	-5.4	-5.3	Birch Bay Village
BBVJ-008	35.0	27.9	28.1	28.3	28.7	-7.2	-6.9	-6.73	-6.35	27.9	28.1	28.3	28.6	-7.2	-6.9	-6.73	-6.36	28.0	28.4	28.9	29.8	-7.0	-6.7	-6.1	-5.2	Birch Bay Village
BBVJ-009	7.8	7.5	7.8	7.9	8.2	-0.2	0.04	0.15	0.40	7.7	8.1	8.4	8.6	0.0	0.36	0.63	0.80	7.9	8.4	8.5	8.8	0.1	0.63	0.8	1.0	Birch Bay Village
BBVJ-009a	7.6	7.7	8.0	8.0	8.2	0.1	0.4	0.39	0.52	7.8	8.1	8.4	8.6	0.2	0.5	0.75	0.92	8.0	8.4	8.5	8.8	0.4	0.8	0.9	1.2	Birch Bay Village
BBVJ-20	10.8	12.4	12.4	12.4	12.4	1.6	1.6	1.59	1.59	12.4	12.4	12.4	12.4	1.6	1.6	1.59	1.59	12.4	12.4	12.4	12.4	1.6	1.6	1.6	1.6	Birch Bay Village
BBVJ-21	17.6	18.1	18.2	18.2	18.9	0.5	0.6	0.63	1.28	18.0	18.1	18.2	18.8	0.5	0.6	0.61	1.24	18.1	18.2	18.8	18.9	0.6	0.6	1.2	1.3	Birch Bay Village
BBVJ-22	22.2	21.8	22.2	22.3	22.7	-0.5	0.0	0.07	0.48	21.6	22.1	22.3	22.7	-0.6	-0.1	0.02	0.41	22.1	22.3	22.6	22.8	-0.1	0.1	0.4	0.6	Birch Bay Village
BBVJ-23	28.0	26.3	26.8	26.9	27.0	-1.7	-1.2	-1.09	-0.97	26.0	26.8	26.9	27.0	-2.1	-1.3	-1.13	-0.99	26.8	27.0	27.1	27.1	-1.2	-1.0	-0.9	-0.9	Birch Bay Village
BBVJ-24	18.8	19.7	20.0	20.0	20.6	1.0	1.2	1.26	1.78	19.7	19.9	20.0	20.5	0.9	1.1	1.22	1.73	19.9	20.0	20.5	20.6	1.1	1.2	1.7	1.9	Birch Bay Village
BBVJ-26	9.0	9.0	9.4	9.6	9.7	0.0	0.4	0.66	0.76	9.0	9.2	9.5	9.7	0.0	0.2	0.56	0.74	9.5	9.7	9.8	9.8	0.5	0.8	0.8	0.8	Birch Bay Village
BBVJ-27	9.9	9.2	9.7	10.1	10.3	-0.7	-0.2	0.16	0.42	9.2	9.5	9.9	10.3	-0.7	-0.4	-0.03	0.36	9.8	10.4	10.5	10.5	-0.1	0.4	0.6	0.6	Birch Bay Village
BBVJ-28	11.5	9.4	9.9	10.3	10.7	-2.1	-1.61	-1.21	-0.86	9.3	9.6	10.1	10.6	-2.2	-1.90	-1.45	-0.95	10.0	10.7	11.0	11.3	-1.5	-0.81	-0.5	-0.2	Birch Bay Village
BBVJ-29	10.9	8.8	8.6	7.9	8.4	-2.2	-2.33	-2.99	-2.49	7.8	7.9	8.0	8.1	-3.1	-3.04	-2.94	-2.82	10.2	9.2	8.1	8.2	-0.7	-1.70	-2.9	-2.8	Birch Bay Village
BBVJ-30	7.9	7.3	7.5	7.5	7.7	-0.6	-0.4	-0.33	-0.22	7.7	7.9	8.0	8.1	-0.2	0.0	0.12	0.24	7.8	8.0	8.1	8.2	-0.1	0.1	0.2	0.3	Birch Bay Village
BBVJ-31	9.7	7.7	8.0	8.1	8.3	-2.0	-1.6	-1.55	-1.40	7.8	8.2	8.3	8.4	-1.9	-1.5	-1.41	-1.25	8.0	8.3	8.4	8.6	-1.7	-1.4	-1.3	-1.1	Birch Bay Village
BBVJ-32	8.6	7.7	8.0	8.1	8.3	-0.9	-0.6	-0.50	-0.35	7.8	8.1	8.3	8.4	-0.8	-0.5	-0.35	-0.19	8.0	8.3	8.4	8.6	-0.6	-0.3	-0.2	0.0	Birch Bay Village
BBVJ-33	8.6	7.6	7.9	8.0	8.1	-1.0	-0.7	-0.60	-0.46	7.7	8.1	8.2	8.3	-0.9	-0.5	-0.42	-0.26	7.9	8.2	8.3	8.5	-0.7	-0.4	-0.3	-0.1	Birch Bay Village
BBVJ-34	8.6	7.5	7.8	7.9	8.1	-1.1	-0.8	-0.67	-0.53	7.7	8.0	8.2	8.3	-0.9	-0.6	-0.45	-0.29	7.9	8.1	8.3	8.4	-0.7	-0.5	-0.3	-0.2	Birch Bay Village
BBVJ-35	7.3	7.5	7.8	7.9	8.0	0.2	0.5	0.61	0.75	7.7	8.0	8.1	8.3	0.4	0.7	0.85	1.00	7.9	8.1	8.3	8.4	0.6	0.8	1.0	1.1	Birch Bay Village
BBVJ-36	23.7	19.3	19.9	21.7	21.8	-4.4	-3.8	-2.04	-1.85	19.3	19.9	21.6	21.8	-4.4	-3.8	-2.05	-1.94	19.5	21.2	21.8	21.9	-4.2	-2.5	-1.9	-1.8	Birch Bay Village
BBVJ-37	10.4	10.7	11.1	11.2	11.4	0.3	0.7	0.82	1.02	8.2	10.5	10.8	11.0	-2.2	0.1	0.39	0.61	11.1	11.4	11.6	11.7	0.7	1.0	1.2	1.3	Birch Bay Village
BBVJ-39	12.6	11.8	12.9	12.9	12.9	-0.9	0.3	0.31	0.32	11.7	12.1	12.9	12.9	-0.9	-0.5	0.30	0.31	12.9	12.9	12.9	12.9	0.3	0.3	0.3	0.3	Birch Bay Village
BBVS_Pond1	8.4	8.7	8.7	8.8	8.8	0.3	0.3	0.37	0.42	8.7	8.7	8.8	8.8	0.3	0.3	0.35	0.40	8.7	8.8	8.9	9.0	0.3	0.4	0.5	0.6	Birch Bay Village
BBVS_Pond2	8.4	8.0	8.5	8.6	8.8	-0.4	0.1	0.24	0.40	8.0	8.5	8.6	8.8	-0.4	0.1	0.21	0.37	8.5	8.7	8.9	9.0	0.1	0.3	0.5	0.6	Birch Bay Village
BBVS_Pond3	8.4	7.4	7.7	7.9	8.2	-1.0	-0.7	-0.50	-0.25	7.7	8.1	8.4	8.6	-0.7	-0.3	-0.02	0.15	7.9	8.4	8.5	8.8	-0.5	0.0	0.1	0.4	Birch Bay Village
Kwan_Pond	12.0	7.8	8.0	8.1	8.2	-4.2	-4.0	-3.87	-3.76	8.2	8.4	8.5	8.7	-3.8	-3.6	-3.46	-3.30	8.3	8.6	8.8	9.0	-3.7	-3.4	-3.2	-3.1	Birch Bay Village
hunderbird_Pon	11.5	7.3	7.4	7.5	7.6	-4.2	-4.1	-3.97	-3.87	7.7	7.9	8.0	8.1	-3.8	-3.6	-3.52	-3.40	7.8	8.0	8.1	8.2	-3.7	-3.5	-3.4	-3.3	Birch Bay Village
Kwan_Pond	12.0	7.8	8.0	8.1	8.2	-4.2	-4.0	-3.87	-3.76	8.2	8.4	8.5	8.7	-3.8	-3.6	-3.46	-3.30	8.3	8.6	8.8	9.0	-3.7	-3.4	-3.2	-3.1	Birch Bay Village
BV_BeaverCreel	26.3	24.8	25.0	25.1	25.3	-1.5	-1.3	-1.19	-1.04	24.8	25.0	25.1	25.3	-1.5	-1.3	-1.20	-1.04	24.9	25.1	25.2	25.4	-1.4	-1.2	-1.1	-0.9	Birch Bay Village
LDES2569	42.9	39.7	39.7	39.7	39.7	-3.2	-3.2	-3.20	-3.20	39.7	39.7	39.7	39.7	-3.2	-3.2	-3.20	-3.20	39.7	39.7	39.7	39.7	-3.2	-3.2	-3.2	-3.2	Selder Road
LDES2570	44.0	40.6	40.6	40.6	40.6	-3.4	-3.4	-3.40	-3.40	40.6	40.6	40.6	40.6	-3.4	-3.4	-3.40	-3.40	40.6	40.6	40.6	40.6	-3.4	-3.4	-3.4	-3.4	Selder Road
LDES2578	66.1	64.1	64.2	64.3	64.3	-2.0	-1.9	-1.85	-1.80	64.1	64.2	64.3	64.3	-2.0	-1.9	-1.85	-1.80	64.4	64.5	64.5	64.6	-1.7	-1.6	-1.6	-1.5	Selder Road
LDES2586	66.0	65.1	65.1	65.2	65.2	-0.9	-0.9	-0.84	-0.81	65.1	65.1	65.2	65.2	-0.9	-0.9	-0.84	-0.81	65.1	65.1	65.2	65.2	-0.9	-0.9	-0.8	-0.8	Selder Road
LDES2587	67.5	67.6	67.6	67.7	67.7	0.1	0.11	0.15	0.18	67.6	67.6	67.7	67.7	0.1	0.11	0.15	0.18	67.6	67.6	67.7	67.7	0.1	0.11	0.2	0.2	Selder Road
LDES2594	74.5	73.0	73.0	73.1	73.1	-1.5	-1.5	-1.44	-1.40	73.0	73.0	73.1	73.1	-1.5	-1.5	-1.44	-1.40	73.0	73.0	73.1	73.1	-1.5	-1.5	-1.4	-1.4	Selder Road
LDES2595	79.6	79.7	79.8	79.8	79.8	0.1	0.2	0.21	0.23	79.7	79.8	79.8	79.8	0.1	0.2	0.21	0.23	79.7	79.8	79.8	79.8	0.1	0.2	0.2	0.2	Selder Road
LDES2602	81.7	81.0	81.0	81.1	81.1	-0.7	-0.7	-0.65	-0.61	81.0	81.0	81.1	81.1	-0.7	-0.7	-0.65	-0.61	81.0	81.0	81.1	81.1	-0.7	-0.7	-0.6	-0.6	Selder Road
LDES2603	85.8	85.9	86.0	86.0	86.0	0.1	0.2	0.18	0.20	85.9	86.0	86.0	86.0	0.1	0.2	0.18	0.20	85.9	86.0	86.0	86.0	0.1	0.2	0.2	0.2	Selder Road
LDES2610	86.8	86.4	86.5	86.5	86.6	-0.4	-0.3	-0.28	-0.24	86.4	86.5	86.5	86.6	-0.4	-0.3	-0.28	-0.24	86.4	86.5	86.5	86.6	-0.4	-0.3	-0.3	-0.2	Selder Road
LDES2611	93.0	93.1	93.2	93.2	93.2	0.1	0.2	0.18	0.21	93.1	93.2	93.2	93.2	0.1	0.2	0.18	0.21	93.1	93.2	93.2	93.2	0.1	0.2	0.2	0.2	Selder Road
LDES2618	99.9	98.1	98.1	98.2	98.2	-1.8	-1.8	-1.72	-1.69	98.1	98.1	98.2	98.2	-1.8	-1.8	-1.72	-1.69	98.1	98.1	98.2	98.2	-1.8	-1.8	-1.7	-1.7	Selder Road
LDES2619	102.5	101.5	102.4	102.6	102.6	-1.0	-0.1	0.05	0.07	101.5	102.4	102.6	102.6	-1.0	-0.1	0.05	0.07	101.5	102.5	102.6	102.6	-1.0	0.0	0.0	0.1	Selder Road
LDES2626	111.0	108.9	109.0	109.0	109.0	-2.1	-2.0	-2.02	-1.99	108.9	109.0	109.0	109.0	-2.1	-2.0	-2.02	-1.99	108.9	109.0	109.0	109.0	-2.1	-2.0	-2.0	-2.0	Selder Road
LDES2627	112.4	112.3	112.5	112.5	112.5	-0.1	0.1	0.08	0.10	112.3	112.5	112.5	112.5	-0.1	0.1	0.08	0.10	112.4	112.5	112.5	112.5	-0.1	0.1	0.1	0.1	Selder Road
LDES2634	116.8	115.8	115.9	115.9	115.9	-1.0	-0.9	-0.91	-0.89	115.8	115.9	115.9	115.9	-1.0	-0.9	-0.91	-0.89	115.8	115.9	115.9	115.9	-1.0	-0.9	-0.9	-0.9	Selder Road
LDES2635	118.9	119.0	119.0	119.0	119.0	0.1	0.11	0.13	0.14	119.0	119.0	119.0	119.0	0.1	0.11	0.13	0.14	119.0	119.0	119.0	119.0	0.1	0.11	0.1	0.1	Selder Road
LDES2639	126.3	124.5	124.6	124.7	124.8	-1.8	-1.7	-1.64	-1.55	124.5	124.6	124.7	124.8	-1.8	-1.7	-1.64	-1.55	124.5	124.6	124.7	124.8	-1.8	-1.7	-1.6	-1.6	Selder Road
LDES2646	124.0	122.2	122.2	122.2	122.2	-1.8	-1.8	-1.79	-1.76	122.2	122.2	122.2	122.2	-1.8	-1.8	-1.79	-1.76	122.2	122.2	122.2	122.2	-1.8	-1.8	-1.8	-1.8	Selder Road
TT1009	80.0	76.9	76.9	76.9	76.9	-3.1	-3.1	-3.10	-3.10	76.9	76.9	76.9	76.9	-3.1	-3.1	-3.10	-3.10	76.9	76.9	76.9	76.9	-3.1	-3.1	-3.1	-3.1	Selder Road
TT9	47.0	43.1	43.1	43.2	43.2	-3.9	-3.9	-3.82	-3.78	43.1	43.1	43.2	43.2	-3.9	-3.9	-3.82	-3.78	43.3	43.4	43.4	43.5	-3.7	-3.6	-3.6	-3.5	Selder Road
LDES2674	144.3	141.8	141.9	142.0	142.0	-2.5	-2.4	-2.35	-2.31	141.8	141.9	142.0	142.0	-2.5	-2.4	-2.35	-2.31	142.1	142.2	142.2	142.3	-2.3	-2.2	-2.1	-2.0	Selder Road
LDES2675	144.7	144.6	144.8	144.9	144.9	-0.1	0.1	0.15	0.20	144.6	144.8	144.9	144.9	-0.1	0.1	0.15	0.20	145.0	145.1	145.1	145.1	0.3	0.4	0.4	0.4	Selder Road
LDES4214	160.7	160.9	160.9	160.9	161.0	0.2	0.2	0.24	0.26	160.9	160.9	160.9	161.0	0.2	0.2	0.24	0.26	161.1	161.1	161.2	161.2	0.4	0.4	0.5	0.5	Selder Road
LDES4215	160.1	159.6	159.6	159.7	159.7	-0.5	-0.5	-0.44	-0.40	159.6	159.6	159.7	159.7	-0.5	-0.5	-0.44	-0.40	159.9	160.0	160.1	160.1	-0.2	-0.1	0.0	0.0	Selder Road
LDES4222	155.6	155.7	155.7	155.7	155.7	0.1	0.1	0.13	0.14	155.7	155.7	155.7	155.7	0.1	0.1	0.13	0.14	155.8	155.9	155.9	155.9	0.2	0.3	0.3	0.3	Selder Road
LDES4223	154.8	153.3	153.4	153.5	153.5	-1.5	-1.4	-1.34	-1.29	153.3	153.4	153.5	153.5	-1.5	-1.4	-1.34	-1.29	153.8	153.9	154.0	154.0	-1.0	-0.9	-0.9	-0.8	Selder Road
LDES4278	170.5	170.8	170.9	170.9	170.9	0.3	0.4	0.40	0.43	170.8	170.9	170.9	170.9	0.3	0.4	0.40	0.43	171.2	171.4	171.5	171.6	0.7	0.9	1.0	1.1	Selder Road
LDES4279	174.2	173.7	173.8	173.8	173.9	-0.5	-0.4	-0.39	-0.34	173.7	173.8	173.8	173.9	-0.5	-0.4	-0.39	-0.34	174.1	174.2	174.3	174.4	-0.1	0.0	0.1	0.2	Selder Road
TT1007	170.7	169.4	169.5	169.5	169.6	-1.3	-1.2	-1.20	-1.15	169.4	169.5	169.5	169.6	-1.3	-1.2	-1.20	-1.15	169.8	169.9	169.9	170.0	-0.9	-0.8	-0.8	-0.7	Selder Road

Table A-3
Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	mate Char	25 Year	100 Year	Nov-21	limate Chang	Location
2728	29.7	26.1	26.5	26.6	26.6	-3.6	-3.2	-3.14	-3.10	25.8	26.4	26.5	26.6	-3.9	-3.3	-3.18	-3.11	26.5	26.6	26.7	26.7	-3.2	-3.1	-3.0	-3.0	Birch Point Road East of Selder
3897	28.0	24.5	24.6	24.7	25.5	-3.5	-3.4	-3.29	-2.50	24.5	24.6	24.7	25.5	-3.5	-3.4	-3.29	-2.50	24.8	26.8	28.0	28.0	-3.2	-1.2	0.0	0.0	Birch Point Road East of Selder
5382	29.2	23.9	24.1	24.2	24.9	-5.3	-5.2	-5.05	-4.28	23.9	24.1	24.2	24.9	-5.3	-5.2	-5.05	-4.28	24.2	26.2	27.4	27.6	-5.0	-3.1	-1.8	-1.6	Birch Point Road East of Selder
LDES2552	30.0	26.1	26.5	26.6	26.6	-3.9	-3.5	-3.45	-3.40	25.8	26.4	26.5	26.6	-4.2	-3.6	-3.48	-3.41	26.5	26.6	26.7	26.7	-3.5	-3.4	-3.3	-3.3	Birch Point Road East of Selder
OD1038_In	29.7	27.8	27.8	27.8	27.8	-1.9	-1.9	-1.90	-1.90	27.8	27.8	27.8	27.8	-1.9	-1.9	-1.90	-1.90	27.8	27.8	28.1	28.1	-1.9	-1.9	-1.7	-1.6	Birch Point Road East of Selder
SM800_In	28.0	25.6	25.6	25.7	25.9	-2.5	-2.4	-2.33	-2.13	25.6	25.6	25.7	25.9	-2.5	-2.4	-2.33	-2.13	25.7	27.1	28.4	28.5	-2.3	-0.9	0.4	0.5	Birch Point Road East of Selder
SM802_In	29.2	25.3	25.4	25.4	25.6	-3.9	-3.8	-3.76	-3.65	25.3	25.4	25.4	25.6	-3.9	-3.8	-3.76	-3.65	25.5	26.4	27.7	27.9	-3.7	-2.9	-1.5	-1.3	Birch Point Road East of Selder
TR19	28.0	24.5	24.6	24.7	25.5	-3.5	-3.4	-3.29	-2.50	24.5	24.6	24.7	25.5	-3.5	-3.4	-3.29	-2.50	24.8	26.8	28.0	28.1	-3.2	-1.2	0.0	0.1	Birch Point Road East of Selder
1	12.0	11.4	11.7	11.9	12.1	-0.6	-0.3	-0.07	0.13	10.8	11.1	11.4	11.6	-1.2	-0.9	-0.60	-0.36	11.8	12.1	12.3	12.5	-0.3	0.1	0.3	0.5	Birch Bay Drive at Birch Loop
5380	36.5	34.5	34.5	34.6	34.7	-2.0	-2.0	-1.92	-1.85	34.5	34.5	34.6	34.7	-2.0	-2.0	-1.92	-1.85	34.6	36.5	36.5	36.5	-1.9	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
7851	9.8	11.4	11.7	11.9	12.1	1.6	1.9	2.08	2.29	10.7	11.0	11.3	11.5	0.9	1.2	1.48	1.71	11.6	12.0	12.2	12.3	1.8	2.2	2.4	2.5	Birch Bay Drive at Birch Loop
CS52	25.9	22.7	22.7	22.8	22.8	-3.2	-3.2	-3.13	-3.09	22.7	22.7	22.8	22.8	-3.2	-3.2	-3.13	-3.09	22.8	22.9	22.9	22.9	-3.1	-3.1	-3.0	-3.0	Birch Bay Drive at Birch Loop
CS52-D	25.9	22.9	22.9	22.9	22.9	-3.1	-3.0	-3.00	-2.98	22.9	22.9	22.9	22.9	-3.1	-3.0	-3.00	-2.98	22.9	22.9	23.0	23.0	-3.0	-3.0	-3.0	-2.9	Birch Bay Drive at Birch Loop
CV2738-1	12.0	12.1	12.2	12.2	12.3	0.1	0.2	0.23	0.27	11.9	12.0	12.1	12.2	-0.1	0.0	0.12	0.20	12.2	12.3	12.3	12.5	0.2	0.3	0.3	0.5	Birch Bay Drive at Birch Loop
CV3690-1	19.0	15.3	15.4	15.4	15.4	-3.7	-3.6	-3.61	-3.58	15.3	15.4	15.4	15.4	-3.7	-3.6	-3.61	-3.58	15.4	15.5	15.5	15.5	-3.6	-3.5	-3.5	-3.5	Birch Bay Drive at Birch Loop
CV3690-2	11.2	11.4	11.7	11.9	12.1	0.2	0.5	0.73	0.93	10.8	11.1	11.4	11.6	-0.4	-0.1	0.21	0.44	11.8	12.1	12.3	12.5	0.6	0.9	1.1	1.3	Birch Bay Drive at Birch Loop
CV3714-1	12.1	12.0	12.2	12.2	12.3	-0.1	0.1	0.11	0.16	11.5	12.0	12.1	12.2	-0.6	-0.1	0.01	0.09	12.2	12.3	12.3	12.5	0.1	0.2	0.2	0.4	Birch Bay Drive at Birch Loop
CV3714-2	9.2	11.4	11.7	11.9	12.1	2.2	2.5	2.72	2.92	10.8	11.1	11.4	11.6	1.6	1.9	2.20	2.43	11.8	12.1	12.3	12.5	2.5	2.9	3.1	3.3	Birch Bay Drive at Birch Loop
CV3723-1	12.0	12.0	12.2	12.2	12.3	0.0	0.2	0.21	0.26	11.9	12.0	12.1	12.2	-0.1	0.0	0.11	0.19	12.2	12.3	12.3	12.5	0.2	0.3	0.3	0.5	Birch Bay Drive at Birch Loop
CV3723-2	12.0	12.0	12.2	12.2	12.3	0.0	0.2	0.21	0.26	11.9	12.0	12.1	12.2	-0.1	0.0	0.11	0.19	12.2	12.3	12.3	12.5	0.2	0.3	0.3	0.5	Birch Bay Drive at Birch Loop
CV3732-1	11.2	12.1	12.2	12.2	12.3	0.9	1.0	1.03	1.07	11.9	12.0	12.1	12.2	0.7	0.8	0.92	1.00	12.2	12.3	12.3	12.5	1.0	1.1	1.1	1.3	Birch Bay Drive at Birch Loop
CV3732-2	12.2	10.4	10.5	10.5	10.5	-1.8	-1.8	-1.73	-1.69	8.9	8.9	8.9	8.9	-3.3	-3.3	-3.26	-3.26	9.0	9.0	9.0	9.0	-3.3	-3.3	-3.3	-3.3	Birch Bay Drive at Birch Loop
CV3738-2	11.9	12.1	12.2	12.2	12.3	0.2	0.3	0.33	0.37	11.9	12.0	12.1	12.2	0.0	0.1	0.22	0.30	12.2	12.3	12.3	12.5	0.3	0.4	0.4	0.6	Birch Bay Drive at Birch Loop
CV3740-1	9.2	11.4	11.7	11.9	12.1	2.2	2.5	2.72	2.92	10.8	11.1	11.4	11.6	1.6	1.9	2.19	2.43	11.8	12.1	12.3	12.5	2.5	2.9	3.1	3.3	Birch Bay Drive at Birch Loop
CV3740-2	9.8	11.4	11.7	11.9	12.1	1.6	1.9	2.13	2.33	10.8	11.1	11.4	11.6	1.0	1.3	1.60	1.84	11.8	12.1	12.3	12.5	1.9	2.3	2.5	2.7	Birch Bay Drive at Birch Loop
DP-77	19.3	17.3	17.3	17.4	17.4	-2.0	-1.96	-1.95	-1.94	17.3	17.3	17.4	17.4	-2.0	-1.96	-1.95	-1.94	17.4	17.4	17.4	17.4	-1.9	-1.93	-1.9	-1.9	Birch Bay Drive at Birch Loop
DP-78	15.0	14.9	15.1	15.1	15.2	-0.1	0.1	0.14	0.19	14.6	15.1	15.1	15.2	-0.4	0.1	0.12	0.18	15.2	15.2	15.2	15.2	0.2	0.2	0.2	0.2	Birch Bay Drive at Birch Loop
OD1058-1	11.2	12.1	12.2	12.2	12.3	0.9	1.0	1.03	1.08	11.9	12.0	12.1	12.2	0.7	0.8	0.93	1.01	12.3	12.3	12.3	12.5	1.1	1.1	1.1	1.3	Birch Bay Drive at Birch Loop
OD1058-2	11.8	12.2	12.3	12.3	12.4	0.4	0.5	0.54	0.59	12.1	12.2	12.3	12.3	0.3	0.4	0.48	0.54	12.4	12.4	12.5	12.5	0.6	0.6	0.6	0.7	Birch Bay Drive at Birch Loop
OD1058-3	13.0	13.3	13.4	13.4	13.5	0.3	0.4	0.47	0.52	13.3	13.4	13.4	13.5	0.3	0.4	0.46	0.51	13.5	13.6	13.6	13.6	0.5	0.6	0.6	0.7	Birch Bay Drive at Birch Loop
OD1071_2	12.2	12.0	12.2	12.2	12.3	-0.2	0.0	0.03	0.09	11.5	12.0	12.1	12.2	-0.7	-0.2	-0.08	0.01	12.2	12.3	12.4	12.5	0.0	0.1	0.2	0.3	Birch Bay Drive at Birch Loop
OD1071_3	12.2	12.0	12.2	12.2	12.3	-0.2	-0.03	0.02	0.08	11.5	12.0	12.1	12.2	-0.7	-0.18	-0.08	0.00	12.2	12.3	12.3	12.5	0.0	0.11	0.1	0.3	Birch Bay Drive at Birch Loop
OD1073-up	23.6	19.7	19.8	19.8	19.8	-3.9	-3.85	-3.83	-3.81	19.7	19.8	19.8	19.8	-3.9	-3.85	-3.83	-3.81	19.8	19.8	19.8	19.9	-3.8	-3.78	-3.8	-3.8	Birch Bay Drive at Birch Loop
OD1075-1	11.1	11.4	11.7	11.9	12.1	0.3	0.6	0.83	1.03	10.8	11.1	11.4	11.6	-0.3	0.0	0.31	0.54	11.8	12.1	12.3	12.5	0.7	1.0	1.2	1.4	Birch Bay Drive at Birch Loop
OD1075-2	11.0	11.4	11.7	11.9	12.1	0.4	0.7	0.93	1.13	10.8	11.1	11.4	11.6	-0.2	0.1	0.41	0.64	11.8	12.1	12.3	12.5	0.8	1.1	1.3	1.5	Birch Bay Drive at Birch Loop
OD1075-3	11.1	11.4	11.7	11.9	12.1	0.3	0.6	0.83	1.03	10.8	11.1	11.4	11.6	-0.3	0.0	0.31	0.54	11.8	12.1	12.3	12.5	0.7	1.0	1.2	1.4	Birch Bay Drive at Birch Loop
OD1075-4	11.4	11.4	11.7	11.9	12.1	0.0	0.3	0.53	0.73	10.8	11.1	11.4	11.6	-0.6	-0.3	0.01	0.24	11.8	12.1	12.3	12.5	0.4	0.7	0.9	1.1	Birch Bay Drive at Birch Loop
OD1075-5	10.6	11.4	11.7	11.9	12.1	0.8	1.1	1.33	1.53	10.8	11.1	11.4	11.6	0.2	0.5	0.81	1.04	11.8	12.1	12.3	12.5	1.2	1.5	1.7	1.9	Birch Bay Drive at Birch Loop
OD1075-6	11.1	11.4	11.7	11.9	12.1	0.3	0.6	0.83	1.03	10.8	11.1	11.4	11.6	-0.3	0.0	0.31	0.54	11.8	12.1	12.3	12.5	0.7	1.0	1.2	1.4	Birch Bay Drive at Birch Loop
PD46_In	28.0	23.1	23.1	23.1	23.2	-4.9	-4.88	-4.87	-4.85	23.1	23.1	23.1	23.2	-4.9	-4.88	-4.87	-4.85	23.1	23.2	23.2	23.2	-4.9	-4.83	-4.8	-4.8	Birch Bay Drive at Birch Loop
PD46_Out	28.0	23.1	23.1	23.1	23.2	-4.9	-4.9	-4.87	-4.85	23.1	23.1	23.1	23.2	-4.9	-4.9	-4.87	-4.85	23.1	23.2	23.2	23.2	-4.9	-4.8	-4.8	-4.8	Birch Bay Drive at Birch Loop
SM840-2	12.3	12.1	12.2	12.3	12.3	-0.3	-0.11	-0.05	0.02	11.5	12.0	12.1	12.2	-0.8	-0.26	-0.16	-0.07	12.3	12.4	12.4	12.5	0.0	0.06	0.1	0.2	Birch Bay Drive at Birch Loop
SM9799	9.8	11.4	11.7	11.9	12.1	1.6	1.94	2.13	2.33	10.8	11.1	11.4	11.6	1.0	1.32	1.60	1.84	11.8	12.1	12.3	12.5	2.0	2.34	2.5	2.7	Birch Bay Drive at Birch Loop
TG-1	12.0	10.4	10.5	10.5	10.5	-1.6	-1.55	-1.53	-1.49	8.9	8.9	8.9	8.9	-3.1	-3.06	-3.06	-3.06	8.9	8.9	8.9	9.0	-3.1	-3.06	-3.1	-3.1	Birch Bay Drive at Birch Loop
TG-2	9.8	8.9	8.9	8.9	8.9	-0.9	-0.86	-0.86	-0.86																	Birch Bay Drive at Birch Loop
1366	52.5	50.4	50.8	50.9	51.1	-2.1	-1.7	-1.56	-1.38	50.4	50.8	50.9	51.1	-2.1	-1.7	-1.56	-1.38	50.4	50.7	50.9	51.1	-2.1	-1.7	-1.6	-1.4	Pheasant - Grouse Cress
1367	52.3	50.4	50.8	50.9	51.1	-1.9	-1.5	-1.36	-1.17	50.4	50.8	50.9	51.1	-1.9	-1.5	-1.36	-1.17	50.4	50.7	50.9	51.1	-1.9	-1.5	-1.4	-1.2	Pheasant - Grouse Cress
1368	53.1	50.9	51.4	51.6	51.9	-2.1	-1.6	-1.42	-1.17	50.9	51.4	51.6	51.9	-2.1	-1.6	-1.42	-1.17	50.9	51.4	51.6	51.9	-2.1	-1.6	-1.4	-1.2	Pheasant - Grouse Cress
1372	53.0	45.2	45.3	45.5	45.7	-7.8	-7.6	-7.50	-7.26	45.2	45.3	45.5	45.7	-7.8	-7.6	-7.50	-7.26	45.2	45.4	45.6	45.9	-7.7	-7.5	-7.3	-7.0	Pheasant - Grouse Cress
1373	52.7	50.7	51.2	51.4	51.6	-1.9	-1.5	-1.27	-1.03	50.7	51.2	51.4	51.6	-1.9	-1.5	-1.27	-1.03	50.7	51.2	51.4	51.6	-2.0	-1.4	-1.3	-1.0	Pheasant - Grouse Cress
1374	53.3	51.0	51.5	51.7	52.0	-2.4	-1.8	-1.62	-1.35	51.0	51.5	51.7	52.0	-2.4	-1.8	-1.62	-1.35	50.9	51.5	51.7	52.0	-2.4	-1.8	-1.6	-1.4	Pheasant - Grouse Cress
1375	52.5	50.9	51.4	51.6	51.9	-1.5	-1.0	-0.84	-0.59	50.9	51.4	51.6	51.9	-1.5	-1.0	-0.84	-0.59	50.9	51.4	51.6	51.9	-1.5	-1.1	-0.8	-0.6	Pheasant - Grouse Cress
1376	52.7	51.1	51.7	51.9	52.2	-1.6	-1.0	-0.80	-0.53	51.1	51.7	51.9	52.2	-1.6	-1.0	-0.80	-0.53	51.1	51.7	51.9	52.2	-1.6	-1.1	-0.8	-0.5	Pheasant - Grouse Cress
1377	53.3	51.0	51.5	51.7	52.0	-2.3	-1.8	-1.58	-1.31	51.0	51.5	51.7	52.0	-2.3	-1.8	-1.58	-1.31	51.0	51.5	51.7	52.0	-2.3	-1.8	-1.6	-1.3	Pheasant - Grouse Cress
1378	52.8	51.4	51.8	52.0	52.3	-1.5	-1.0	-0.81	-0.52	51.4	51.8	52.0	52.3	-1.5	-1.0	-0.81	-0.52	51.4	51.8	52.0	52.3	-1.5	-1.1	-0.8	-0.5	Pheasant - Grouse Cress
1379	53.7	51.1	51.7	51.9	52.2	-2.6	-2.0	-1.79	-1.53	51.1	51.7	51.9	52.2	-2.6	-2.0	-1.79	-1.53	51.1	51.7	51.9	52.2	-2.6	-2.0	-1.8	-1.5	Pheasant - Grouse Cress
1380	53.6	51.4	52.0	52.2	52.5	-2.2	-1.7	-1.39	-1.09	51.4	52.0	52.2	52.5	-2.2	-1.7	-1.39	-1.09	51.4	51.9	52.2	52.5	-2.3	-1.7	-1.4	-1.1	Pheasant - Grouse Cress
1381	53.3	51.4	51.8	52.0	52.3	-1.9	-1.5	-1.26	-0.97	51.4	51.8	52.0	52.3	-1.9	-1.5	-1.26	-0.97	51.4	51.8	52.0	52.3	-1.9	-1.5	-1.3	-1.0	Pheasant - Grouse Cress
1382	54.4	51.9	52.1	52.4	52.7	-2.5	-2.3	-2.02	-1.69	51.9	52.1	52.4	52.7	-2.5	-2.3	-2.02	-1.69	51.9	52.1	52.4	52.7	-2.5	-2.3	-2.0	-1.7	Pheasant - Grouse Cress
1383	53.8	51.4	52.0	52.2	52.5	-2.5	-1.9	-1.61	-1.31	51.4	52.0	52.2	52.5	-2.5	-1.9	-1.61	-1.31	51.4	51.9	52.2	52.5	-2.5	-1.9	-1.6	-1.3	Pheasant - Grouse Cress
1384	53.9	51.6	52.3	52.6	52.9	-2.2	-1.6	-1.31	-0.98	51.6	52.3	52.6	52.9	-2.2	-1.6	-1.31	-0.98	51.6	52.2	52.5	52.9	-2.3	-1.6	-1.3	-1.0	Pheasant - Grouse Cress
1385	54.2	51.9	52.1	52.4	52.7	-2.3	-2.0	-1.80	-1.47	51.9	52.1	52.4	52.7	-2.3	-2.0	-1.80	-1.47	51.9	52.1	52.4	52.7	-2.3	-2.1	-1.8	-1.5	Pheasant - Grouse Cress
1386	54.9	52.1	52.4	52.7	53.0	-2.8	-2.5	-2.25	-1.89	52.1	52.4	52.7	53.0	-2.8	-2.5	-2.25	-1.89	52.1	52.4	52.7	53.0	-2.8	-2.5	-2.3	-1.9	Pheasant - Grouse Cress
1387	53.7	51.6	52.3	52.6	52.9	-2.0	-1.4	-1.11	-0.78	51.6	52.3	52.6	52.9	-2.0	-1.4	-1.11	-0.78	51.6	52.2	52.5	52.9	-2.0	-1.4	-1.1	-0.8	Pheasant - Grouse Cress
1388	53.5	52.0	52.6	53.0	53.4	-1.6	-0.9	-0.53	-0.15	52.0	52.6	53.0	53.4	-1.6	-0.9	-0.53	-0.15	52.0	52.6	53.0	53.4	-1.6	-0.9	-0.5	-0.2	Pheasant - Grouse Cress
1389	54.2	52.0	52.6	53.0	53.4	-2.2	-1.6	-1.20	-0.81	52.0	52.6	53.0	53.4	-2.2	-1.6	-1.20	-0.81	52.0	52.6	53.0	53.4	-2.2	-1.6	-1.2	-0.8	Pheasant - Grouse Cress
1390	53.6	52.7	53.1	53.5	54.0	-1.0	-0.5	-0.12	0.33	52.7	53.1	53.5	54.0	-1.0	-0.5	-0.12	0.33	52.7	53.1	53.5	54.0	-1.0	-0.6	-0.1	0.3	Pheasant - Grouse Cress
1391	53.7	52.1	52.4	52.7	53.0	-1.6	-1.3	-1.07	-0.70	52.1	52.4	52.7	53.0	-1.6	-1.3	-1.07	-0.70	52.1	52.4	52.7	53.0	-1.6	-1.3	-1.1	-0.7	Pheasant - Grouse Cress
1392	53.5	52.1	52.4	52.7	53.0	-1.4	-1.1	-0.82	-0.46	52.1	52.4	52.7	53.0	-1.4	-1.1	-0.82	-0.46	52.1	52.4	52.7	53.0	-1.4	-1.1	-0.8	-0.5	Pheasant - Grouse Cress
1393	54.1	52.7	53.1	53.5	54.0	-1.5	-1.0	-0.63	-0.18	52.7	53.1	53.5	54.0	-1.5	-1.0	-0.63	-0.18	52.7	53.1	53.5	54.0	-1.5	-1.1	-0.6	-0.2	Pheasant - Grouse Cress
1394	54.5	52.7	53.1	53.5	54.0	-1.8	-1.4	-0.93	-0.47	52.7	53.1	53.5	54.0	-1.8	-1.4	-0.93	-0.47	52.7	53.1	53.5	54.0	-1.8	-1.4	-1.0	-0.5	Pheasant - Grouse Cress
1395	55.6	52.1	52.4	52.7	53.0	-3.5	-3.2	-2.95	-2.59	52.1	52.4	52.7	53.0	-3.5	-3.2	-2.95	-2.59	52.1	52.4	52.7	53.0	-3.5	-3.2	-3.0	-2.6	Pheasant - Grouse Cress
1396	55.5	52.1	52.4	52.7	53.0	-3.4	-3.1	-2.84	-2.48	52.1	52.4	52.7	53.0	-3.4	-3.1	-2.84	-2.48	52.1	52.4	52.7	53.0	-3.4	-3.1	-2.9	-2.5	Pheasant - Grouse Cress
1397	55.6	52.1	52.4	52.7	53.0	-3.5	-3.2	-2.87	-2.51	52.1	52.4	52.7	53.0	-3.5	-3.2	-2.87	-2.51	52.1	52.4	52.7	53.0	-3.5	-3.2	-2.9	-2.5	Pheasant - Grouse Cress
1398	55.9	52.2	52.4	52.7	53.0	-3.7	-3.5	-3.27	-2.91	52.2	52.4	52.7	53.0	-3.7	-3.5	-3.27	-2.91	52.2	52.4	52.7	53.0	-3.7	-3.6	-3.3	-2.9	Pheasant - Grouse Cress
1399	54.8	52.7	53.1	53.5	54.0	-2.1	-1.7	-1.29	-0.83	52.7	53.1	53.5	54.0	-2.1	-1.7	-1.29	-0.83	52.7	53.1	53.5	54.0	-2.2	-1.7	-1.3	-0.8	Pheasant - Grouse Cress
1400	55.8	53.0	53.1	53.5	54.0	-2.9	-2.7	-2.33	-1.87	53.0	53.1	53.5	54.0	-2.9	-2.7	-2.33	-1.87	53.0	53.1	53.5	54.0	-2.9	-2.8	-2.3	-1.9	Pheasant - Grouse Cress
1401	56.2	53.7	53.7	53.7	54.0	-2.6	-2.6	-2.56	-2.24	53.7	53.7	53.7	54.0	-2.6	-2.6	-2.56	-2.24	53.7	53.7	53.7	54.0	-2.6	-2.6	-2.6	-2.3	Pheasant - Grouse Cress
1402	56.3	53.4	53.4	53.4	54.0	-2.9	-2.9	-2.85	-2.30	53.4	53.4	53.4	54.0	-2.9	-2.9	-2.85	-2.30	53.4	53.4	53.4	54.0	-2.9	-2.9	-2.9	-2.3	Pheasant - Grouse Cress
1403	55.7	53.3	53.3	53.3	53.3	-2.4	-2.4	-2.39	-2.39	53.3	53.3	53.3	53.3	-2.4	-2.4	-2.39	-2.39	53.3	53.3	53.3	53.3	-2.4	-2.4	-2.4	-2.4	Pheasant - Grouse Cress
1404	55.5	53.4	53.4	53.4	53.4	-2.1	-2.1	-2.06	-2.06	53.4	53.4	53.4	53.4	-2.1	-2.1	-2.06	-2.06	53.4	53.4	53.4	53.4	-2.1	-2.1	-2.1	-2.1	Pheasant - Grouse Cress
1405	55.0	53.7	53.7	53.7	53.7	-1.4	-1.4	-1.35	-1.35	53.7	53.7	53.7	53.7	-1.4	-1.4	-1.35	-1.35	53.7	53.7	53.7	53.7	-1.4	-1.4	-1.4	-1.4	Pheasant - Grouse Cress
1406	55.9	54.2	54.2	54.2	54.2	-1.8	-1.8	-1.76	-1.76	54.2	54.2	54.2	54.2	-1.8	-1.8	-1.76	-1.76	54.2	54.2	54.2	54.2	-1.8	-1.8	-1.8	-1.8	Pheasant - Grouse Cress
1407	57.1	55.6	55.6	55.6	55.6	-1.5	-1.5	-1.52	-1.52	55.6	55.6	55.6	55.6	-1.5	-1.5	-1.52	-1.52	55.6	55.6	55.6	55.6	-1.5	-1.5	-1.5	-1.5	Pheasant - Grouse Cress

Table A-3
Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	mate Char	25 Year	100 Year	Nov-21	imate Chang	Location
1408	58.4	57.2	57.2	57.2	57.2	-1.2	-1.2	-1.17	-1.17	57.2	57.2	57.2	57.2	-1.2	-1.2	-1.17	-1.17	57.2	57.2	57.2	57.2	-1.2	-1.2	-1.2	-1.2	Pheasant - Grouse Cress
1409	57.9	55.1	55.1	55.1	55.1	-2.8	-2.8	-2.79	-2.79	55.1	55.1	55.1	55.1	-2.8	-2.8	-2.79	-2.79	55.1	55.1	55.1	55.1	-2.8	-2.8	-2.8	-2.8	Pheasant - Grouse Cress
1410	57.7	54.7	54.7	54.7	54.7	-3.0	-3.0	-3.02	-3.02	54.7	54.7	54.7	54.7	-3.0	-3.0	-3.02	-3.02	54.7	54.7	54.7	54.7	-3.0	-3.0	-3.0	-3.0	Pheasant - Grouse Cress
1411	57.5	54.8	54.8	54.8	54.8	-2.7	-2.7	-2.75	-2.75	54.8	54.8	54.8	54.8	-2.7	-2.7	-2.75	-2.75	54.8	54.8	54.8	54.8	-2.7	-2.7	-2.7	-2.7	Pheasant - Grouse Cress
1412	57.1	54.4	54.4	54.4	54.4	-2.7	-2.7	-2.69	-2.67	54.4	54.4	54.4	54.4	-2.7	-2.7	-2.69	-2.67	54.4	54.4	54.4	54.4	-2.7	-2.7	-2.7	-2.7	Pheasant - Grouse Cress
1413	57.1	54.3	54.4	54.4	54.4	-2.8	-2.8	-2.76	-2.75	54.3	54.4	54.4	54.4	-2.8	-2.8	-2.76	-2.75	54.4	54.4	54.4	54.4	-2.8	-2.8	-2.7	-2.7	Pheasant - Grouse Cress
1414	56.9	54.3	54.4	54.4	54.4	-2.6	-2.6	-2.57	-2.56	54.3	54.4	54.4	54.4	-2.6	-2.6	-2.57	-2.56	54.3	54.4	54.4	54.4	-2.6	-2.6	-2.5	-2.5	Pheasant - Grouse Cress
1415	56.7	53.5	53.5	53.6	53.6	-3.2	-3.1	-3.10	-3.06	53.5	53.5	53.6	53.6	-3.2	-3.1	-3.10	-3.06	53.5	53.6	53.6	53.7	-3.1	-3.1	-3.1	-3.0	Pheasant - Grouse Cress
1416	56.0	53.5	53.5	53.6	53.6	-2.6	-2.5	-2.47	-2.43	53.5	53.5	53.6	53.6	-2.6	-2.5	-2.47	-2.43	53.5	53.6	53.6	53.7	-2.5	-2.4	-2.4	-2.4	Pheasant - Grouse Cress
1417	56.1	53.2	53.2	53.2	53.2	-3.0	-3.0	-2.96	-2.94	53.2	53.2	53.2	53.2	-3.0	-3.0	-2.96	-2.94	53.2	53.2	53.2	53.2	-3.0	-2.9	-2.9	-2.9	Pheasant - Grouse Cress
1418	56.6	52.5	52.5	52.5	52.5	-4.1	-4.1	-4.08	-4.08	52.5	52.5	52.5	52.5	-4.1	-4.1	-4.08	-4.08	52.5	52.5	52.5	52.5	-4.1	-4.1	-4.1	-4.1	Pheasant - Grouse Cress
1419	54.6	52.9	53.0	53.0	53.1	-1.6	-1.6	-1.52	-1.48	52.9	53.0	53.0	53.1	-1.6	-1.6	-1.52	-1.48	53.0	53.1	53.1	53.1	-1.6	-1.5	-1.5	-1.4	Pheasant - Grouse Cress
1420	54.9	52.6	52.6	52.6	52.6	-2.4	-2.4	-2.36	-2.35	52.6	52.6	52.6	52.6	-2.4	-2.4	-2.36	-2.35	52.6	52.6	52.6	52.6	-2.4	-2.4	-2.3	-2.3	Pheasant - Grouse Cress
1421	56.7	52.4	52.4	52.4	52.4	-4.3	-4.3	-4.29	-4.29	52.4	52.4	52.4	52.4	-4.3	-4.3	-4.29	-4.29	52.4	52.4	52.4	52.4	-4.3	-4.3	-4.3	-4.3	Pheasant - Grouse Cress
1422	54.9	52.5	52.5	52.5	52.5	-2.4	-2.4	-2.40	-2.40	52.5	52.5	52.5	52.5	-2.4	-2.4	-2.40	-2.40	52.5	52.5	52.5	52.5	-2.4	-2.4	-2.4	-2.4	Pheasant - Grouse Cress
1423	54.5	52.5	52.5	52.5	52.5	-2.0	-2.0	-2.00	-2.00	52.5	52.5	52.5	52.5	-2.0	-2.0	-2.00	-2.00	52.5	52.5	52.5	52.5	-2.0	-2.0	-2.0	-2.0	Pheasant - Grouse Cress
1424	54.4	51.8	51.8	51.8	51.8	-2.6	-2.6	-2.60	-2.60	51.8	51.8	51.8	51.8	-2.6	-2.6	-2.60	-2.60	51.8	51.8	51.8	51.8	-2.6	-2.6	-2.6	-2.6	Pheasant - Grouse Cress
1425	54.7	51.8	51.8	51.8	51.8	-2.9	-2.9	-2.94	-2.94	51.8	51.8	51.8	51.8	-2.9	-2.9	-2.94	-2.94	51.8	51.8	51.8	51.8	-2.9	-2.9	-2.9	-2.9	Pheasant - Grouse Cress
1426	54.5	51.8	51.8	51.8	51.8	-2.7	-2.7	-2.64	-2.61	51.8	51.8	51.8	51.8	-2.7	-2.7	-2.64	-2.61	51.8	51.8	51.8	51.9	-2.7	-2.6	-2.6	-2.6	Pheasant - Grouse Cress
1427	53.3	49.6	49.6	49.6	49.6	-3.8	-3.8	-3.76	-3.76	49.6	49.6	49.6	49.6	-3.8	-3.8	-3.76	-3.76	49.6	49.6	49.6	49.6	-3.8	-3.8	-3.8	-3.8	Pheasant - Grouse Cress
1428	51.4	48.2	48.2	48.2	48.2	-3.3	-3.3	-3.26	-3.26	48.2	48.2	48.2	48.2	-3.3	-3.3	-3.26	-3.26	48.2	48.2	48.2	48.2	-3.3	-3.3	-3.3	-3.3	Pheasant - Grouse Cress
1429	51.9	49.0	49.0	49.0	49.0	-2.9	-2.9	-2.91	-2.90	49.0	49.0	49.0	49.0	-2.9	-2.9	-2.91	-2.90	49.0	49.0	49.0	49.0	-2.9	-2.9	-2.9	-2.9	Pheasant - Grouse Cress
1430	49.6	47.3	47.5	47.6	47.8	-2.3	-2.2	-1.99	-1.81	47.3	47.5	47.6	47.8	-2.3	-2.2	-1.99	-1.81	47.4	47.7	47.9	48.1	-2.2	-1.9	-1.7	-1.5	Pheasant - Grouse Cress
1431	49.2	46.5	46.5	46.5	46.6	-2.8	-2.7	-2.69	-2.65	46.5	46.5	46.5	46.6	-2.8	-2.7	-2.69	-2.65	46.5	46.6	46.6	46.7	-2.7	-2.7	-2.6	-2.5	Pheasant - Grouse Cress
1434	50.2	45.9	46.0	46.0	46.2	-4.2	-4.2	-4.12	-3.99	45.9	46.0	46.0	46.2	-4.2	-4.2	-4.12	-3.99	46.0	46.1	46.2	46.5	-4.2	-4.1	-4.0	-3.7	Pheasant - Grouse Cress
1436	49.4	48.1	48.2	48.2	48.2	-1.2	-1.2	-1.21	-1.20	48.1	48.2	48.2	48.2	-1.2	-1.2	-1.21	-1.20	48.2	48.2	48.2	48.2	-1.2	-1.2	-1.2	-1.2	Pheasant - Grouse Cress
1437	50.8	48.3	48.3	48.3	48.3	-2.6	-2.6	-2.53	-2.50	48.3	48.3	48.3	48.3	-2.6	-2.6	-2.53	-2.50	48.3	48.3	48.4	48.4	-2.6	-2.5	-2.5	-2.5	Pheasant - Grouse Cress
1438	52.2	49.6	49.6	49.6	49.6	-2.7	-2.6	-2.61	-2.59	49.6	49.6	49.6	49.6	-2.7	-2.6	-2.61	-2.59	49.6	49.6	49.7	49.7	-2.6	-2.6	-2.6	-2.6	Pheasant - Grouse Cress
1439	52.1	49.7	49.8	49.8	49.8	-2.4	-2.4	-2.34	-2.32	49.7	49.8	49.8	49.8	-2.4	-2.4	-2.34	-2.32	49.8	49.8	49.8	49.8	-2.4	-2.3	-2.3	-2.3	Pheasant - Grouse Cress
1440	51.8	50.1	50.2	50.2	50.2	-1.7	-1.6	-1.61	-1.57	50.1	50.2	50.2	50.2	-1.7	-1.6	-1.61	-1.57	50.2	50.2	50.3	50.3	-1.6	-1.6	-1.6	-1.5	Pheasant - Grouse Cress
1441	50.4	47.3	47.5	47.6	47.8	-3.1	-2.9	-2.78	-2.60	47.3	47.5	47.6	47.8	-3.1	-2.9	-2.78	-2.60	47.4	47.7	47.9	48.1	-3.0	-2.7	-2.5	-2.3	Pheasant - Grouse Cress
1442	48.9	46.5	46.5	46.6	46.6	-2.4	-2.4	-2.36	-2.32	46.5	46.5	46.6	46.6	-2.4	-2.4	-2.36	-2.32	46.5	46.6	46.6	46.7	-2.4	-2.3	-2.3	-2.2	Pheasant - Grouse Cress
1443	52.3	50.3	50.3	50.3	50.4	-2.0	-2.0	-1.96	-1.93	50.3	50.3	50.3	50.4	-2.0	-2.0	-1.96	-1.93	50.3	50.4	50.4	50.4	-2.0	-1.9	-1.9	-1.9	Pheasant - Grouse Cress
1446	51.3	50.4	50.4	50.5	50.5	-1.0	-0.9	-0.84	-0.79	50.4	50.4	50.5	50.5	-1.0	-0.9	-0.84	-0.79	50.4	50.5	50.6	50.6	-0.9	-0.8	-0.8	-0.7	Pheasant - Grouse Cress
1447	52.5	50.4	50.4	50.5	50.5	-2.1	-2.1	-2.03	-1.97	50.4	50.4	50.5	50.5	-2.1	-2.1	-2.03	-1.97	50.4	50.5	50.6	50.6	-2.1	-2.0	-1.9	-1.9	Pheasant - Grouse Cress
1448	53.1	51.4	51.4	51.4	51.4	-1.8	-1.8	-1.78	-1.78	51.4	51.4	51.4	51.4	-1.8	-1.8	-1.78	-1.78	51.4	51.4	51.4	51.4	-1.8	-1.8	-1.8	-1.8	Pheasant - Grouse Cress
1449	49.6	47.3	47.5	47.6	47.8	-2.3	-2.2	-1.99	-1.81	47.3	47.5	47.6	47.8	-2.3	-2.2	-1.99	-1.81	47.4	47.7	47.9	48.1	-2.2	-1.9	-1.7	-1.5	Pheasant - Grouse Cress
1450	48.6	46.5	46.5	46.5	46.6	-2.2	-2.1	-2.09	-2.05	46.5	46.5	46.5	46.6	-2.2	-2.1	-2.09	-2.05	46.5	46.6	46.6	46.7	-2.1	-2.1	-2.0	-1.9	Pheasant - Grouse Cress
1460	53.4	43.5	43.6	43.7	43.7	-9.8	-9.7	-9.70	-9.65	43.5	43.6	43.7	43.7	-9.8	-9.7	-9.70	-9.65	43.6	43.7	43.7	43.8	-9.8	-9.7	-9.7	-9.6	Pheasant - Grouse Cress
1239	52.4	50.9	50.9	50.9	50.9	-1.5	-1.5	-1.54	-1.54	50.9	50.9	50.9	50.9	-1.5	-1.5	-1.54	-1.54	50.9	50.9	50.9	50.9	-1.5	-1.5	-1.5	-1.5	Deer Trail Area
1240	52.4	50.6	50.6	50.6	50.6	-1.8	-1.8	-1.80	-1.80	50.6	50.6	50.6	50.6	-1.8	-1.8	-1.80	-1.80	50.6	50.6	50.6	50.6	-1.8	-1.8	-1.8	-1.8	Deer Trail Area
1241	52.1	50.6	50.6	50.6	50.6	-1.5	-1.5	-1.54	-1.54	50.6	50.6	50.6	50.6	-1.5	-1.5	-1.54	-1.54	50.6	50.6	50.6	50.6	-1.5	-1.5	-1.5	-1.5	Deer Trail Area
1242	52.0	49.8	49.8	49.8	49.8	-2.1	-2.1	-2.13	-2.13	49.8	49.8	49.8	49.8	-2.1	-2.1	-2.13	-2.13	49.8	49.8	49.8	49.8	-2.1	-2.1	-2.1	-2.1	Deer Trail Area
1243	50.6	50.0	50.0	50.0	50.0	-0.6	-0.6	-0.58	-0.57	50.0	50.0	50.0	50.0	-0.6	-0.6	-0.58	-0.57	50.0	50.0	50.0	50.0	-0.6	-0.6	-0.6	-0.6	Deer Trail Area
1451	42.7	36.9	37.2	37.3	37.5	-5.8	-5.5	-5.40	-5.22	36.9	37.2	37.3	37.5	-5.8	-5.5	-5.40	-5.22	37.2	37.8	38.1	38.3	-5.5	-4.9	-4.6	-4.4	Deer Trail Area
1452	46.2	45.0	45.0	45.0	45.0	-1.1	-1.1	-1.15	-1.15	45.0	45.0	45.0	45.0	-1.1	-1.1	-1.15	-1.15	45.0	45.0	45.0	45.0	-1.1	-1.1	-1.1	-1.1	Deer Trail Area
1453	49.1	46.3	46.3	46.3	46.3	-2.8	-2.8	-2.75	-2.75	46.3	46.3	46.3	46.3	-2.8	-2.8	-2.75	-2.75	46.3	46.3	46.3	46.3	-2.8	-2.8	-2.8	-2.8	Deer Trail Area
1454	49.3	47.0	47.0	47.0	47.0	-2.3	-2.3	-2.28	-2.28	47.0	47.0	47.0	47.0	-2.3	-2.3	-2.28	-2.28	47.0	47.0	47.0	47.0	-2.3	-2.3	-2.3	-2.3	Deer Trail Area
1457	47.9	35.9	36.0	36.0	36.1	-12.1	-12.0	-11.94	-11.89	35.9	36.0	36.0	36.1	-12.1	-12.0	-11.94	-11.89	35.9	36.1	36.2	36.2	-12.0	-11.8	-11.8	-11.7	Deer Trail Area
1463	51.8	50.4	50.4	50.5	50.5	-1.3	-1.3	-1.31	-1.30	50.4	50.4	50.5	50.5	-1.3	-1.3	-1.31	-1.30	50.4	50.4	50.5	50.5	-1.3	-1.3	-1.3	-1.3	Deer Trail Area
1464	52.0	50.0	50.0	50.0	50.0	-2.0	-2.0	-2.00	-1.98	50.0	50.0	50.0	50.0	-2.0	-2.0	-2.00	-1.98	50.0	50.0	50.0	50.0	-2.0	-2.0	-2.0	-2.0	Deer Trail Area
1467	51.1	49.6	49.7	49.7	49.7	-1.5	-1.4	-1.39	-1.36	49.6	49.6	49.7	49.7	-1.5	-1.5	-1.44	-1.41	49.6	49.6	49.7	49.7	-1.5	-1.5	-1.4	-1.4	Deer Trail Area
1468	52.3	50.7	50.7	50.7	50.7	-1.6	-1.6	-1.63	-1.62	50.7	50.7	50.7	50.7	-1.6	-1.6	-1.63	-1.62	50.7	50.7	50.7	50.7	-1.6	-1.6	-1.6	-1.6	Deer Trail Area
1469	52.5	51.0	51.0	51.0	51.0	-1.5	-1.5	-1.46	-1.45	51.0	51.0	51.1	51.0	-1.5	-1.4	-1.42	-1.44	51.0	51.0	51.0	51.0	-1.5	-1.5	-1.5	-1.5	Deer Trail Area
1472	50.4	51.0	51.0	51.0	51.0	0.6	0.6	0.63	0.63	51.0	51.0	51.0	51.1	0.6	0.6	0.63	0.65	51.0	51.0	51.0	51.0	0.6	0.6	0.6	0.6	Deer Trail Area
1473	51.4	51.0	51.0	51.0	51.0	-0.5	-0.5	-0.45	-0.43	51.0	51.0	51.0	51.0	-0.5	-0.5	-0.45	-0.43	51.0	51.0	51.0	51.0	-0.5	-0.5	-0.5	-0.4	Deer Trail Area
1474	51.7	51.0	51.0	51.0	51.0	-0.8	-0.7	-0.73	-0.71	51.0	51.0	51.0	51.0	-0.8	-0.7	-0.73	-0.71	51.0	51.0	51.0	51.0	-0.8	-0.7	-0.7	-0.7	Deer Trail Area
1475	52.6	50.9	51.0	51.0	51.0	-1.6	-1.6	-1.60	-1.59	50.9	51.0	51.0	51.0	-1.6	-1.6	-1.60	-1.59	50.9	51.0	51.0	51.0	-1.6	-1.6	-1.6	-1.6	Deer Trail Area
1476	52.5	50.9	50.9	51.0	51.0	-1.5	-1.5	-1.51	-1.50	50.9	50.9	51.0	51.0	-1.5	-1.5	-1.51	-1.50	50.9	50.9	51.0	51.0	-1.5	-1.5	-1.5	-1.5	Deer Trail Area
1477	52.8	50.7	50.7	50.7	50.7	-2.2	-2.2	-2.13	-2.12	50.7	50.7	50.7	50.7	-2.2	-2.1	-2.13	-2.12	50.7	50.7	50.7	50.7	-2.2	-2.1	-2.1	-2.1	Deer Trail Area
1478	52.7	50.5	50.5	50.6	50.6	-2.2	-2.1	-2.13	-2.12	50.5	50.5	50.5	50.6	-2.2	-2.2	-2.14	-2.12	50.5	50.5	50.5	50.6	-2.2	-2.2	-2.1	-2.1	Deer Trail Area
1479	52.7	50.0	50.0	50.0	50.0	-2.7	-2.7	-2.68	-2.68	50.0	50.0	50.0	50.0	-2.7	-2.7	-2.67	-2.66	50.0	50.0	50.0	50.0	-2.7	-2.7	-2.7	-2.7	Deer Trail Area
1481	50.1	47.6	47.7	47.7	47.7	-2.5	-2.5	-2.47	-2.46	47.4	47.5	47.5	47.5	-2.7	-2.7	-2.70	-2.69	47.4	47.5	47.5	47.5	-2.7	-2.7	-2.7	-2.7	Deer Trail Area
1348	12.8	13.6	13.7	13.7	13.7	0.8	0.9	0.94	0.97	13.6	13.7	13.7	13.8	0.8	0.9	0.96	0.99	13.7	13.8	13.8	13.8	0.9	1.0	1.0	1.0	Birch Bay Drive East at Deer Trail
1349	12.9	13.6	13.7	13.7	13.7	0.7	0.8	0.81	0.84	13.6	13.7	13.7	13.8	0.7	0.8	0.83	0.86	13.7	13.8	13.8	13.8	0.8	0.9	0.9	0.9	Birch Bay Drive East at Deer Trail
1350	13.2	13.6	13.7	13.8	13.8	0.4	0.6	0.60	0.64	13.7	13.8	13.8	13.8	0.5	0.6	0.63	0.67	13.8	13.9	13.9	13.9	0.6	0.7	0.7	0.8	Birch Bay Drive East at Deer Trail
1351	13.0	13.6	13.7	13.8	13.8	0.6	0.7	0.75	0.79	13.7	13.8	13.8	13.8	0.6	0.8	0.79	0.82	13.8	13.9	13.9	13.9	0.7	0.8	0.9	0.9	Birch Bay Drive East at Deer Trail
1352	13.9	13.7	14.1	14.2	14.3	-0.2	0.2	0.32	0.37	13.9	14.2	14.3	14.3	0.0	0.3	0.37	0.41	14.2	14.3	14.4	14.4	0.3	0.4	0.5	0.5	Birch Bay Drive East at Deer Trail
1353	12.9	13.7	14.1	14.2	14.3	0.8	1.2	1.30	1.35	13.9	14.2	14.3	14.3	1.0	1.3	1.35	1.39	14.2	14.3	14.4	14.4	1.3	1.4	1.5	1.5	Birch Bay Drive East at Deer Trail
1483	18.0	13.7	14.1	14.2	14.3	-4.3	-3.9	-3.78	-3.73	13.9	14.2	14.3	14.3	-4.1	-3.8	-3.73	-3.68	14.2	14.3	14.4	14.4	-3.8	-3.7	-3.6	-3.6	Birch Bay Drive East at Deer Trail
1355	15.4	13.7	14.1	14.2	14.3	-1.6	-1.2	-1.13	-1.08	13.9	14.2	14.3	14.3	-1.4	-1.1	-1.08	-1.04	14.2	14.3	14.4	14.4	-1.2	-1.0	-1.0	-0.9	Birch Bay Drive East at Deer Trail
1339	13.2	10.1	10.2	10.2	10.3	-3.1	-3.0	-3.00	-2.97	10.1	10.2	10.2	10.3	-3.1	-3.0	-3.00	-2.97	10.4	10.5	10.5	10.6	-2.8	-2.8	-2.7	-2.7	Birch Bay Drive East at Deer Trail
1340	12.6	11.1	11.2	11.3	11.3	-1.5	-1.4	-1.36	-1.29	11.1	11.2	11.3	11.3	-1.5	-1.4	-1.36	-1.29	12.0	12.6	12.9	13.3	-0.6	0.0	0.3	0.7	Birch Bay Drive East at Deer Trail
1346	12.9	12.0	12.0	12.0	12.0	-0.9	-0.9	-0.95	-0.95	12.0	12.0	12.0	12.0	-0.9	-0.9	-0.95	-0.95	12.0	12.6	12.9	13.3	-0.9	-0.4	0.0	0.4	Birch Bay Drive East at Deer Trail
1347	12.6	10.8	10.9	10.9	11.0	-1.8	-1.7	-1.65	-1.59	10.8	10.9	10.9	11.0	-1.8	-1.7	-1.65	-1.59	12.1	12.6	12.1	12.6	-0.5	0.0	-0.5	0.0	Birch Bay Drive East at Deer Trail
1356	14.0	12.8	13.0	13.6	14.3	-1.2	-1.0	-0.44	0.27	12.7	12.7	12.7	12.7	-1.3	-1.3	-1.28	-1.26	12.7	12.7	12.8	12.9	-1.3	-1.3	-1.2	-1.1	Birch Bay Drive West at Deer Trail
1357	12.4	12.1	13.0	13.6	14.3	-0.4	0.6	1.13	1.84	11.1	11.4	11.7	12.1	-1.4	-1.1	-0.75	-0.38	11.4	12.0	12.4	12.9	-1.1	-0.5	-0.1	0.4	Birch Bay Drive West at Deer Trail
1358	12.3	11.3	11.9	12.3	12.8	-1.0	-0.4	-0.05	0.41	10.7	11.0	11.2	11.5	-1.6	-1.3	-1.15	-0.88	11.0	11.4	11.7	12.1	-1.4	-0.9	-0.7	-0.3	Birch Bay Drive West at Deer Trail
1359	12.2	11.3	11.9	12.3	12.8	-0.9	-0.3	0.06	0.52	10.7	11.0	11.2	11.5	-1.5	-1.2	-1.04	-0.77	11.0	11.4	11.7	12.1	-1.3	-0.8	-0.6	-0.2	Birch Bay Drive West at Deer Trail
1360	11.8	11.0	11.4	11.7	12.1	-0.9	-0.4	-0.10	0.24	10.5	10.8	11.0	11.2	-1.3	-1.0	-0.86	-0.63	10.8	11.2	11.4	11.7	-1.0	-0.7	-0.4	-0.1	Birch Bay Drive West at Deer Trail
1361	11.6	11.0	11.4	11.7	12.1	-0.7	-0.2	0.12	0.46	10.5	10.8	11.0	11.2	-1.1	-0.8	-0.64	-0.41	10.8	11.2	11.4	11.7	-0.8	-0.5	-0.2	0.1	Birch Bay Drive West at Deer Trail
1362	11.4	11.0	11.4	11.7	12.1	-0.4	0.1	0.36	0.70	10.5	10.8	11.0	11.2	-0.9	-0.6	-0.40	-0.17	10.8	11.2	11.4	11.7	-0.6	-0.2	0.0	0.3	Birch Bay Drive West at Deer Trail
1363	11.9	11.1	11.6	11.9	12.3	-0.8	-0.3	0.01	0.39	10.7	11.0	11.2	11.5	-1.2	-0.9	-0.71	-0.45	11.0	11.4	11.7	12.1	-0.9	-0.5	-0.2	0.2	Birch Bay Drive West at Deer Trail
1364	11.9	11.1	11.6	11.9	12.3	-0.8	-0.3	0.05	0.42	10.9	11.1	11.2	11.5	-0.9	-0.8	-0.64	-0.40	11.1	11.4	11.7	12.1	-0.8	-0.4	-0.2	0.2	Birch Bay Drive West at Deer Trail

Table A-3
Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	limate Chang	25 Year	100 Year	Nov-21	mate Char	25 Year	100 Year	Nov-21	limate Chang	Location
1171	52.0	50.6	50.6	50.6	50.7	-1.4	-1.4	-1.35	-1.33	50.6	50.6	50.6	50.7	-1.4	-1.4	-1.35	-1.33	50.6	50.7	50.7	50.7	-1.4	-1.3	-1.3	-1.3	Richmond Park - Richmond Park Road South
1172	51.5	49.9	49.9	49.9	50.0	-1.7	-1.6	-1.63	-1.59	49.9	49.9	49.9	50.0	-1.7	-1.6	-1.63	-1.59	49.9	50.0	50.0	50.2	-1.6	-1.6	-1.5	-1.4	Richmond Park - Richmond Park Road South
1173	50.7	48.8	48.9	49.0	49.3	-1.9	-1.8	-1.74	-1.47	48.8	48.9	49.0	49.3	-1.9	-1.8	-1.74	-1.47	48.9	49.2	49.5	49.8	-1.8	-1.5	-1.3	-1.0	Richmond Park - Richmond Park Road South
1180	50.6	47.9	47.9	47.9	48.0	-2.7	-2.7	-2.63	-2.61	47.9	47.9	47.9	48.0	-2.7	-2.7	-2.63	-2.61	47.9	47.9	48.0	48.0	-2.7	-2.6	-2.6	-2.6	Richmond Park - Richmond Park Road South
1181	50.7	48.6	48.7	48.8	49.0	-2.0	-1.9	-1.84	-1.62	48.6	48.7	48.8	49.0	-2.0	-1.9	-1.84	-1.62	48.7	49.0	49.2	49.4	-1.9	-1.6	-1.5	-1.2	Richmond Park - Richmond Park Road South
1182	49.3	47.5	47.5	47.5	47.5	-1.8	-1.8	-1.81	-1.80	47.5	47.5	47.5	47.5	-1.8	-1.8	-1.81	-1.80	47.5	47.5	47.5	47.5	-1.8	-1.8	-1.8	-1.8	Richmond Park - Richmond Park Road South
1184	51.7	44.2	44.3	44.3	44.3	-7.5	-7.4	-7.42	-7.40	44.2	44.3	44.3	44.3	-7.5	-7.4	-7.42	-7.40	44.3	44.3	44.3	44.4	-7.4	-7.4	-7.3	-7.3	Richmond Park - Richmond Park Road South
1188	49.2	47.2	47.3	47.3	47.3	-2.0	-2.0	-1.97	-1.96	47.2	47.3	47.3	47.3	-2.0	-2.0	-1.97	-1.96	47.2	47.3	47.4	47.5	-2.0	-1.9	-1.8	-1.8	Richmond Park - Richmond Park Road South
1189	50.1	47.0	47.1	47.2	47.2	-3.1	-3.0	-2.92	-2.88	47.0	47.1	47.2	47.2	-3.1	-3.0	-2.92	-2.88	47.2	47.3	47.4	47.5	-2.9	-2.8	-2.7	-2.7	Richmond Park - Richmond Park Road South
1190	50.5	46.9	47.0	47.1	47.2	-3.6	-3.5	-3.39	-3.34	46.9	47.0	47.1	47.2	-3.6	-3.5	-3.39	-3.34	47.2	47.2	47.3	47.4	-3.3	-3.3	-3.2	-3.1	Richmond Park - Richmond Park Road South
1191	50.2	47.0	47.1	47.2	47.2	-3.2	-3.1	-3.00	-2.97	47.0	47.1	47.2	47.2	-3.2	-3.1	-3.00	-2.97	47.2	47.3	47.3	47.4	-3.0	-2.9	-2.8	-2.8	Richmond Park - Richmond Park Road South
1192	50.7	47.0	47.1	47.2	47.2	-3.7	-3.6	-3.50	-3.46	47.0	47.1	47.2	47.2	-3.7	-3.6	-3.50	-3.46	47.2	47.3	47.4	47.5	-3.5	-3.4	-3.3	-3.2	Richmond Park - Richmond Park Road South
1193	50.7	48.3	48.3	48.3	48.3	-2.5	-2.5	-2.46	-2.46	48.3	48.3	48.3	48.3	-2.5	-2.5	-2.46	-2.46	48.3	48.3	48.3	48.3	-2.5	-2.5	-2.5	-2.5	Richmond Park - Richmond Park Road South
1194	51.1	48.1	48.2	48.2	48.2	-3.0	-2.9	-2.85	-2.83	48.1	48.2	48.2	48.2	-3.0	-2.9	-2.85	-2.83	48.2	48.2	48.3	48.3	-2.8	-2.8	-2.8	-2.8	Richmond Park - Richmond Park Road North
1195	50.9	49.4	49.7	49.9	50.0	-1.5	-1.3	-1.05	-0.95	49.4	49.7	49.9	50.0	-1.5	-1.3	-1.05	-0.95	50.0	50.1	50.2	50.4	-0.9	-0.8	-0.7	-0.5	Richmond Park - Richmond Park Road North
1196	51.9	49.4	49.7	49.9	50.0	-2.5	-2.2	-1.99	-1.87	49.4	49.7	49.9	50.0	-2.5	-2.2	-1.99	-1.87	50.0	50.1	50.2	50.4	-1.9	-1.7	-1.7	-1.5	Richmond Park - Richmond Park Road North
1197	51.2	50.2	50.7	51.0	51.2	-1.0	-0.5	-0.17	0.02	50.2	50.7	51.0	51.2	-1.0	-0.5	-0.17	0.02	51.2	51.5	51.6	51.7	0.0	0.3	0.4	0.5	Richmond Park - Richmond Park Road North
1198	51.1	50.2	50.7	51.1	51.2	-0.8	-0.4	-0.02	0.16	50.2	50.7	51.1	51.2	-0.8	-0.4	-0.02	0.16	51.2	51.5	51.6	51.8	0.2	0.4	0.5	0.7	Richmond Park - Richmond Park Road North
1199	52.0	50.7	51.3	51.7	51.9	-1.2	-0.7	-0.27	-0.05	50.7	51.3	51.7	51.9	-1.2	-0.7	-0.27	-0.04	52.0	52.3	52.3	52.4	0.0	0.3	0.3	0.4	Richmond Park - Richmond Park Road North
1200	51.6	50.7	51.3	51.7	51.9	-0.9	-0.4	0.05	0.29	50.7	51.3	51.7	51.9	-0.9	-0.4	0.04	0.28	52.0	52.2	52.3	52.3	0.3	0.6	0.6	0.7	Richmond Park - Richmond Park Road North
1201	52.5	51.4	52.1	52.6	52.9	-1.1	-0.4	0.11	0.42	51.4	52.1	52.6	52.9	-1.1	-0.4	0.10	0.42	52.9	53.3	53.4	53.6	0.5	0.8	0.9	1.1	Richmond Park - Richmond Park Road North
1202	52.3	51.9	52.4	52.7	53.0	-0.4	0.1	0.45	0.70	51.9	52.4	52.7	53.0	-0.3	0.1	0.47	0.72	53.0	53.3	53.4	53.6	0.7	1.1	1.2	1.3	Richmond Park - Richmond Park Road North
1203	52.4	52.6	52.8	52.9	53.0	0.2	0.4	0.49	0.61	52.6	52.8	52.9	53.0	0.2	0.4	0.48	0.61	53.0	53.3	53.4	53.6	0.6	0.9	1.0	1.2	Richmond Park - Richmond Park Road North
1204	52.4	52.6	52.8	52.9	53.0	0.2	0.4	0.50	0.62	52.6	52.8	52.9	53.0	0.2	0.4	0.50	0.62	53.0	53.3	53.4	53.6	0.6	0.9	1.0	1.2	Richmond Park - Richmond Park Road North
1204B	52.0	52.6	52.8	52.8	53.0	0.6	0.8	0.80	0.95	52.6	52.8	52.8	53.0	0.6	0.8	0.80	0.95	53.0	53.3	53.4	53.5	1.0	1.3	1.4	1.5	Richmond Park - Richmond Park Road North
1205	52.2	51.4	52.1	52.6	52.9	-0.8	-0.1	0.37	0.68	51.4	52.1	52.6	52.9	-0.8	-0.1	0.36	0.68	53.0	53.3	53.4	53.6	0.7	1.1	1.2	1.3	Richmond Park - Richmond Park Road North
1206	53.2	51.3	52.1	52.8	53.0	-1.9	-1.0	-0.35	-0.22	51.3	52.1	52.8	53.0	-1.9	-1.1	-0.37	-0.22	53.0	53.3	53.4	53.5	-0.2	0.1	0.2	0.4	Richmond Park - Richmond Park Road North
1207	53.1	51.3	52.1	52.8	52.9	-1.8	-1.0	-0.27	-0.12	51.3	52.1	52.8	52.9	-1.8	-1.0	-0.27	-0.12	53.0	53.3	53.4	53.5	-0.1	0.2	0.3	0.5	Richmond Park - Richmond Park Road North
1208	52.6	51.2	51.7	52.1	52.2	-1.4	-0.9	-0.51	-0.41	51.2	51.7	52.1	52.2	-1.4	-0.9	-0.50	-0.40	52.2	52.5	52.6	52.9	-0.4	-0.1	0.0	0.3	Richmond Park - Richmond Park Road North
1209	52.6	51.2	51.7	52.1	52.2	-1.4	-1.0	-0.58	-0.46	51.2	51.7	52.1	52.2	-1.4	-1.0	-0.58	-0.46	52.2	52.5	52.6	52.8	-0.4	-0.2	-0.1	0.2	Richmond Park - Richmond Park Road North
1210	52.8	51.1	51.2	51.2	51.3	-1.7	-1.6	-1.58	-1.51	51.1	51.2	51.2	51.3	-1.7	-1.6	-1.58	-1.51	51.3	51.5	51.6	51.7	-1.5	-1.3	-1.2	-1.0	Richmond Park - Richmond Park Road North
1211	51.8	51.1	51.2	51.2	51.3	-0.7	-0.7	-0.63	-0.56	51.1	51.2	51.2	51.3	-0.7	-0.7	-0.63	-0.56	51.3	51.5	51.6	51.7	-0.5	-0.3	-0.2	-0.1	Richmond Park - Richmond Park Road North
1220	51.9	49.5	49.7	49.9	50.0	-2.5	-2.3	-2.02	-1.91	49.5	49.7	49.9	50.0	-2.5	-2.3	-2.02	-1.91	50.0	50.2	50.2	50.4	-1.9	-1.8	-1.7	-1.5	Richmond Park - Richmond Park Road North
1221	51.0	49.4	49.7	49.9	50.0	-1.5	-1.3	-1.07	-0.96	49.4	49.7	49.9	50.0	-1.5	-1.3	-1.07	-0.96	50.0	50.1	50.2	50.4	-0.9	-0.8	-0.7	-0.6	Richmond Park - Richmond Park Road North
1222	51.4	50.0	50.1	50.1	50.1	-1.4	-1.4	-1.34	-1.33	50.0	50.1	50.1	50.1	-1.4	-1.4	-1.34	-1.33	50.0	50.2	50.2	50.4	-1.4	-1.3	-1.2	-1.0	Richmond Park - Richmond Park Road North
1227	52.1	51.0	51.0	51.1	51.1	-1.1	-1.0	-1.03	-1.01	51.0	51.0	51.1	51.1	-1.1	-1.0	-1.03	-1.01	51.0	51.0	51.1	51.1	-1.1	-1.0	-1.0	-1.0	Richmond Park - Richmond Crescent
1228	53.5	51.0	51.0	51.1	51.1	-2.5	-2.5	-2.44	-2.42	51.0	51.0	51.1	51.1	-2.5	-2.5	-2.44	-2.42	51.0	51.0	51.1	51.1	-2.5	-2.5	-2.4	-2.4	Richmond Park - Richmond Crescent
1229	52.4	51.0	51.0	51.0	51.1	-1.4	-1.4	-1.36	-1.35	51.0	51.0	51.0	51.1	-1.4	-1.4	-1.36	-1.35	51.0	51.0	51.0	51.1	-1.4	-1.4	-1.4	-1.3	Richmond Park - Richmond Crescent
1230	51.8	51.0	51.0	51.0	51.0	-0.9	-0.8	-0.81	-0.80	51.0	51.0	51.0	51.0	-0.9	-0.8	-0.81	-0.80	51.0	51.0	51.0	51.0	-0.8	-0.8	-0.8	-0.8	Richmond Park - Richmond Crescent
1272	61.1	59.7	59.7	59.7	59.8	-1.5	-1.4	-1.37	-1.35	59.7	59.7	59.7	59.8	-1.5	-1.4	-1.37	-1.35	59.7	59.7	59.8	59.8	-1.4	-1.4	-1.4	-1.3	Shintaffer north of Semiahmoo Parkway
1273	60.3	59.7	59.7	59.7	59.8	-0.6	-0.6	-0.55	-0.53	59.7	59.7	59.7	59.8	-0.6	-0.6	-0.56	-0.53	59.7	59.7	59.8	59.8	-0.6	-0.6	-0.5	-0.5	Shintaffer north of Semiahmoo Parkway
1274	63.2	61.2	61.2	61.2	61.2	-2.0	-2.0	-2.02	-2.01	61.2	61.2	61.2	61.2	-2.0	-2.0	-2.02	-2.01	61.2	61.2	61.2	61.2	-2.0	-2.0	-2.0	-2.0	Shintaffer north of Semiahmoo Parkway
1275	59.7	59.6	59.7	59.7	59.7	-0.1	0.0	0.01	0.04	59.6	59.7	59.7	59.7	-0.1	0.0	0.01	0.04	59.6	59.7	59.7	59.7	0.0	0.0	0.0	0.1	Shintaffer north of Semiahmoo Parkway
1276	59.3	57.8	57.9	57.9	58.0	-1.5	-1.4	-1.39	-1.35	57.8	57.9	57.9	58.0	-1.5	-1.4	-1.39	-1.35	57.8	57.9	57.9	57.9	-1.5	-1.5	-1.4	-1.4	Shintaffer north of Semiahmoo Parkway
1277	64.1	63.0	63.4	63.6	63.8	-1.1	-0.7	-0.55	-0.31	63.0	63.4	63.6	63.8	-1.1	-0.7	-0.55	-0.31	63.2	63.5	63.8	64.0	-0.9	-0.6	-0.3	-0.1	Shintaffer north of Semiahmoo Parkway
1278	64.3	61.7	61.8	61.8	61.8	-2.5	-2.5	-2.47	-2.45	61.7	61.8	61.8	61.8	-2.5	-2.5	-2.47	-2.45	61.7	61.8	61.8	61.8	-2.5	-2.5	-2.5	-2.4	Shintaffer north of Semiahmoo Parkway
1280	63.7	61.6	61.7	61.7	61.7	-2.1	-2.0	-2.00	-1.98	61.6	61.7	61.7	61.7	-2.1	-2.0	-2.00	-1.98	61.6	61.7	61.7	61.7	-2.0	-2.0	-2.0	-2.0	Shintaffer north of Semiahmoo Parkway
1281	64.8	63.2	63.4	63.5	63.6	-1.6	-1.4	-1.29	-1.20	63.2	63.4	63.5	63.6	-1.6	-1.4	-1.29	-1.20	63.3	63.5	63.6	63.7	-1.5	-1.3	-1.2	-1.1	Shintaffer north of Semiahmoo Parkway
1284	58.2	54.2	54.7	55.0	55.6	-3.9	-3.5	-3.20	-2.56	54.1	54.6	54.9	55.3	-4.0	-3.6	-3.30	-2.86	56.2	56.7	57.3	57.3	-2.0	-1.4	-0.9	-0.9	Shintaffer north of Semiahmoo Parkway
1298	56.9	54.8	54.9	55.0	55.6	-2.1	-2.1	-1.94	-1.33	54.8	54.9	54.9	55.3	-2.1	-2.1	-2.02	-1.63	55.9	56.7	57.3	57.3	-1.1	-0.2	0.3	0.3	Shintaffer north of Semiahmoo Parkway
1308	65.7	63.2	63.4	63.5	63.6	-2.4	-2.2	-2.14	-2.05	63.2	63.4	63.5	63.6	-2.4	-2.2	-2.14	-2.05	63.3	63.5	63.6	63.7	-2.3	-2.2	-2.1	-2.0	Shintaffer north of Semiahmoo Parkway
1309	64.7	63.3	63.4	63.5	63.6	-1.4	-1.3	-1.19	-1.09	63.3	63.4	63.5	63.6	-1.4	-1.3	-1.19	-1.09	63.3	63.5	63.6	63.7	-1.4	-1.2	-1.1	-1.0	Shintaffer north of Semiahmoo Parkway
1310	65.5	63.3	63.4	63.5	63.6	-2.3	-2.1	-2.04	-1.94	63.3	63.4	63.5	63.6	-2.3	-2.1	-2.04	-1.94	63.3	63.5	63.6	63.7	-2.2	-2.0	-1.9	-1.8	Shintaffer north of Semiahmoo Parkway
1311	66.3	63.8	63.8	63.8	63.9	-2.5	-2.5	-2.45	-2.43	63.8	63.8	63.8	63.9	-2.5	-2.5	-2.45	-2.43	63.8	63.8	63.9	63.9	-2.5	-2.4	-2.4	-2.4	Shintaffer north of Semiahmoo Parkway
1316	67.0	64.4	64.5	64.5	64.5	-2.6	-2.6	-2.54	-2.51	64.4	64.5	64.5	64.5	-2.6	-2.6	-2.54	-2.51	64.5	64.5	64.5	64.6	-2.6	-2.5	-2.5	-2.5	Shintaffer north of Semiahmoo Parkway
1317	65.5	64.4	64.4	64.4	64.4	-1.1	-1.1	-1.09	-1.07	64.4	64.4	64.4	64.4	-1.1	-1.1	-1.09	-1.07	64.4	64.4	64.4	64.4	-1.1	-1.1	-1.1	-1.1	Shintaffer north of Semiahmoo Parkway
1253	78.6	77.2	77.2	77.2	77.2	-1.5	-1.5	-1.47	-1.47	77.2	77.2	77.2	77.2	-1.5	-1.5	-1.47	-1.47	77.2	77.2	77.2	77.2	-1.5	-1.5	-1.5	-1.5	Semiahmoo Parkway
1254	82.3	80.4	80.4	80.4	80.4	-1.9	-1.9	-1.86	-1.86	80.4	80.4	80.4	80.4	-1.9	-1.9	-1.86	-1.86	80.4	80.4	80.4	80.4	-1.9	-1.9	-1.9	-1.9	Semiahmoo Parkway
1256	66.6	63.3	63.3	63.3	63.3	-3.3	-3.3	-3.35	-3.35	65.5	65.7	65.7	65.8	-1.1	-1.0	-0.90	-0.82	66.0	66.2	66.3	66.4	-0.6	-0.4	-0.3	-0.2	Semiahmoo Parkway
1257	67.0	64.1	64.1	64.1	64.1	-2.9	-2.9	-2.92	-2.92	65.4	65.5	65.6	65.6	-1.7	-1.6	-1.50	-1.42	65.8	66.0	66.1	66.3	-1.2	-1.0	-0.9	-0.8	Semiahmoo Parkway
1258	80.8	77.5	77.5	77.5	77.5	-3.4	-3.4	-3.36	-3.36	77.5	77.5	77.5	77.5	-3.4	-3.4	-3.36	-3.36	77.5	77.5	77.5	77.5	-3.4	-3.4	-3.4	-3.4	Semiahmoo Parkway
1259	67.0	62.8	62.8	62.8	62.8	-4.2	-4.2	-4.22	-4.22	63.8	63.9	64.1	64.2	-3.3	-3.1	-2.97	-2.85	64.5	65.1	65.4	65.9	-2.5	-2.0	-1.6	-1.1	Semiahmoo Parkway
1260	68.6	62.6	62.6	62.6	62.6	-6.0	-6.0	-6.05	-6.05	62.9	63.0	63.0	63.0	-5.7	-5.7	-5.64	-5.61	63.1	63.2	63.2	63.2	-5.5	-5.5	-5.4	-5.4	Semiahmoo Parkway
1261	64.7	62.7	62.7	62.8	62.8	-1.9	-1.9	-1.91	-1.91	63.4	63.5	63.5	63.5	-1.2	-1.2	-1.19	-1.18	63.6	63.6	63.6	63.6	-1.1	-1.1	-1.0	-1.0	Semiahmoo Parkway
1262	64.0	62.4	62.4	62.4	62.4	-1.6	-1.6	-1.63	-1.63	62.7	62.8	62.8	62.8	-1.3	-1.3	-1.28	-1.28	62.8	62.8	62.8	62.8	-1.2	-1.2	-1.2	-1.2	Semiahmoo Parkway
1263	64.9	61.9	61.9	61.9	62.0	-3.0	-3.0	-2.96	-2.93	61.8	61.8	61.9	61.9	-3.2	-3.1	-3.05	-3.02	62.0	62.0	62.0	62.1	-3.0	-2.9	-2.9	-2.8	Semiahmoo Parkway
1264	65.8	61.5	61.6	61.6	61.6	-4.3	-4.2	-4.20	-4.17	61.4	61.4	61.5	61.5	-4.4	-4.4	-4.33	-4.29	61.6	61.7	61.7	61.8	-4.2	-4.1	-4.1	-4.0	Semiahmoo Parkway
1265	64.5	61.5	61.6	61.6	61.6	-2.9	-2.9	-2.87	-2.84	61.4	61.4	61.5	61.5	-3.1	-3.0	-3.00	-2.95	61.6	61.7	61.7	61.8	-2.8	-2.8	-2.7	-2.7	Semiahmoo Parkway
1266	60.0	57.9	58.1	58.2	58.3	-2.1	-1.9	-1.85	-1.76	57.6	57.7	57.8	57.9	-2.4	-2.3	-2.20	-2.09	58.2	58.4	58.6	58.7	-1.8	-1.6	-1.5	-1.3	Semiahmoo Parkway
1267	60.1	57.1	57.2	57.2	57.2	-3.1	-3.0	-2.97	-2.93	56.9	57.0	57.1	57.1	-3.2	-3.1	-3.10	-3.05	57.2	57.3	57.6	57.7	-2.9	-2.8	-2.5	-2.5	Semiahmoo Parkway
1268	59.8	57.3	57.3	57.3	57.3	-2.5	-2.5	-2.45	-2.45	58.2	58.2	58.2	58.2	-1.6	-1.6	-1.59	-1.58	58.3	58.4	58.4	58.4	-1.5	-1.4	-1.4	-1.4	Semiahmoo Parkway
1269	60.2	57.2	57.2	57.2	57.2	-3.1	-3.0	-3.03	-3.03	58.0	58.0	58.0	58.0	-2.3	-2.2	-2.24	-2.23	58.1	58.1	58.1	58.1	-2.1	-2.1	-2.1	-2.1	Semiahmoo Parkway
1270	60.2	57.2	57.2	57.2	57.2	-3.1	-3.0	-3.02	-3.02	58.0	58.0	58.0	58.0	-2.3	-2.2	-2.24	-2.23	58.1	58.1	58.1	58.1	-2.1	-2.1	-2.1	-2.1	Semiahmoo Parkway
1271	60.0	56.9	56.9	56.9	56.9	-3.1	-3.1	-3.09	-3.09	57.5	57.5	57.5	57.5	-2.5	-2.5	-2.53	-2.52	57.6	57.6	57.6	57.6	-2.4	-2.4	-2.4	-2.4	Semiahmoo Parkway
1286	56.8	55.4	55.4	55.4	55.4	-1.4	-1.4	-1.35	-1.35	55.8	55.8	55.8	55.8	-1.0	-1.0	-0.96	-0.95	55.9	56.2	56.5	56.5	-0.9	-0.6	-0.3	-0.3	Semiahmoo Parkway
1297	56.4	53.8	54.2	54.4	54.9	-2.5	-2.1	-1.95	-1.47	53.9	54.3	54.5	54.8	-2.5	-2.1	-1.89	-1.54	55.7	56.1	56.4	56.4	-0.7	-0.3	0.0	0.0	Semiahmoo Parkway
1327	67.8	63.6	63.6	63.6	63.6	-4.2	-4.2	-4.21	-4.21	64.4	64.5	64.5	64.6	-3.4	-3.3	-3.23	-3.16	64.8	65.1	65.5	65.9	-3.0	-2.6	-2.3	-1.8	Semiahmoo Parkway
1328	67.7	63.9	63.9	63.9	63.9	-3.8	-3.8	-3.81	-3.81	64.9	65.1	65.1	65.2	-2.8	-2.6	-2.58	-2.52	65.4	65.6	65.7	66.0	-2.3	-2.1	-2.0	-1.7	Semiahmoo Parkway
1329	66.7	64.0	64.0	64.0	64.0	-2.7	-2.7	-2.74	-2.74	65.2	65.3	65.4	65.5	-1.6	-1.4	-1.36	-1.29	65.6	65.8	66.0	66.2	-1.1	-0.9	-0.8	-0.6	Semiahmoo Parkway
1330	67.5	64.4	64.4	64.4	64.4	-3.1	-3.1	-3.06	-3.06	65.5	65.6	65.7	65.8	-2.0	-1.9	-1.78	-1.70	66.0	66.1	66.2	66.4	-1.5	-1.3	-1.2	-1.1	Semiahmoo Parkway
1331	64.5	62.7	62.7	62.8	62.8	-1.8	-1.8	-1.77	-1.77	63.6	63.6	63.6	63.6	-0.9	-0.9	-0.92	-0.91	63.7	63.7	63.8	63.8	-0.8	-0.8	-0.8	-0.7	Semiahmoo Parkway
1332	65.5	64.1	64.1	64.1	64.1	-1.4	-1.4	-1.42	-1.42	64.1	64.1	64.1	64.1	-1.4	-1.4	-1.42	-1.42	64.1	64.1	64.1	64.1	-1.4	-1.4	-1.4	-1.4	Semiahmoo Parkway
1333	64.8	62.7	62.7	62.8	62.8	-2.0	-2.0	-2.01	-2.01	63.6	63.6	63.6	63.6	-1.2	-1.2	-1.15	-1.14	63.7	63.8	63.8	63.8	-1.0	-1.0	-1.0	-1.0	Semiahmoo Parkway
1291	55.0	52.9	53.0	53.1	53.2	-2.1	-2.0	-1.89	-1.76	53.0	53.1	53.1	53.2	-2.1	-2.0	-1.88	-1.76	53.3	53.6	53.7	53.8	-1.7	-1.4	-1.3	-1.2	Shintaffer North of Richmond Park - West Side

Table A-3

Birch Point Drainage Study - Peak Stage Summary

		Existing Land Use								Existing Land Use with Rogers Slough Structure Removed								Future Land Use								
		Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				Peak HGL (feet NAVD 88)				Height Above Flood Depth (feet)				
Junction	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	mate Char	25 Year	100 Year	Nov-21	imate Chang	Location
1296	56.3	53.8	54.2	54.4	54.9	-2.5	-2.1	-1.87	-1.39	53.9	54.3	54.5	54.8	-2.5	-2.0	-1.83	-1.48	55.6	56.0	56.3	56.3	-0.7	-0.3	0.0	0.0	Shintaffer North of Richmond Park - West Side
1318	54.3	52.9	53.0	53.1	53.2	-1.4	-1.3	-1.19	-1.10	52.9	53.0	53.1	53.2	-1.4	-1.3	-1.19	-1.10	53.3	53.6	53.7	53.8	-1.0	-0.7	-0.6	-0.5	Shintaffer North of Richmond Park - West Side
1326	55.2	52.7	52.9	53.0	53.1	-2.5	-2.3	-2.21	-2.08	52.7	52.9	53.0	53.1	-2.5	-2.3	-2.21	-2.08	53.2	53.5	53.7	53.8	-2.0	-1.7	-1.5	-1.4	Shintaffer North of Richmond Park - West Side
1326A	54.4	52.7	52.8	53.0	53.1	-1.8	-1.6	-1.45	-1.32	52.7	52.8	53.0	53.1	-1.8	-1.6	-1.45	-1.32	53.1	53.4	53.5	53.7	-1.3	-1.0	-0.9	-0.8	Shintaffer North of Richmond Park - West Side
1326B	53.1	52.6	52.8	52.9	53.0	-0.4	-0.2	-0.13	-0.01	52.6	52.8	52.9	53.0	-0.4	-0.2	-0.13	-0.01	53.1	53.3	53.4	53.6	0.0	0.3	0.4	0.5	Shintaffer North of Richmond Park - West Side
1326C	52.8	52.6	52.8	52.9	53.0	-0.2	0.0	0.15	0.28	52.6	52.8	52.9	53.0	-0.2	0.0	0.15	0.28	53.1	53.3	53.4	53.6	0.3	0.6	0.7	0.8	Shintaffer North of Richmond Park - West Side
1319	54.2	52.1	52.3	52.5	52.7	-2.1	-1.9	-1.68	-1.46	52.1	52.3	52.5	52.7	-2.1	-1.9	-1.68	-1.46	52.4	52.8	53.2	53.8	-1.8	-1.4	-1.0	-0.4	Middle Shintaffer
1320	53.0	52.1	52.3	52.5	52.7	-0.9	-0.7	-0.49	-0.27	52.1	52.3	52.5	52.7	-0.9	-0.7	-0.49	-0.27	52.4	52.8	53.2	55.4	-0.6	-0.2	0.2	2.4	Middle Shintaffer
1321	53.2	52.1	52.3	52.5	52.7	-1.2	-0.9	-0.72	-0.51	52.1	52.3	52.5	52.7	-1.2	-0.9	-0.72	-0.51	52.4	52.8	53.3	54.1	-0.9	-0.4	0.0	0.9	Middle Shintaffer
1322	52.4	52.1	52.3	52.5	52.7	-0.4	-0.1	0.07	0.28	52.1	52.3	52.5	52.7	-0.4	-0.1	0.07	0.28	52.4	52.8	53.3	54.1	-0.1	0.4	0.8	1.6	Middle Shintaffer
1323	52.7	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.46	-0.30	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.46	-0.30	52.1	52.8	53.2	53.6	-0.6	0.1	0.5	0.9	Middle Shintaffer
1323	52.7	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.46	-0.30	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.46	-0.30	52.1	52.8	53.2	53.6	-0.6	0.1	0.5	0.9	Middle Shintaffer
1323A	52.7	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.48	-0.32	51.9	52.1	52.2	52.4	-0.8	-0.6	-0.48	-0.32	52.1	52.8	54.6	54.6	-0.6	0.1	1.9	1.9	Middle Shintaffer
1324	52.4	52.6	52.8	52.9	53.0	0.2	0.4	0.50	0.62	52.6	52.8	52.9	53.0	0.2	0.4	0.50	0.62	53.0	53.3	53.4	53.6	0.6	0.9	1.0	1.2	Middle Shintaffer
1235	53.2	51.7	51.9	52.0	52.2	-1.5	-1.3	-1.20	-1.05	51.7	51.9	52.0	52.2	-1.5	-1.3	-1.20	-1.05	51.9	52.3	52.7	53.2	-1.3	-0.9	-0.5	0.0	Middle Shintaffer
1236	53.6	51.7	51.9	52.0	52.2	-1.9	-1.7	-1.57	-1.42	51.7	51.9	52.0	52.2	-1.9	-1.7	-1.57	-1.42	51.9	52.3	52.7	53.2	-1.7	-1.3	-0.9	-0.4	Middle Shintaffer
1237	52.9	51.9	52.1	52.2	52.4	-1.0	-0.8	-0.63	-0.47	51.9	52.1	52.2	52.4	-1.0	-0.8	-0.63	-0.47	52.1	52.8	53.2	53.6	-0.8	-0.1	0.3	0.7	Middle Shintaffer
1238	53.9	51.7	51.9	52.0	52.2	-2.2	-2.0	-1.86	-1.71	51.7	51.9	52.0	52.2	-2.2	-2.0	-1.86	-1.71	51.9	52.3	52.7	53.2	-2.0	-1.6	-1.2	-0.7	Middle Shintaffer
1292	54.6	52.7	52.9	53.0	53.1	-1.9	-1.7	-1.61	-1.48	52.7	52.9	53.0	53.1	-1.9	-1.7	-1.61	-1.48	53.2	53.5	53.7	53.8	-1.4	-1.1	-0.9	-0.8	Middle Shintaffer
1293	55.4	52.7	52.9	53.0	53.1	-2.7	-2.5	-2.37	-2.24	52.7	52.9	53.0	53.1	-2.7	-2.5	-2.37	-2.24	53.2	53.5	53.7	53.8	-2.2	-1.9	-1.7	-1.6	Middle Shintaffer
1294	54.9	53.4	53.5	53.5	53.5	-1.5	-1.5	-1.47	-1.46	53.4	53.5	53.5	53.5	-1.5	-1.5	-1.47	-1.46	53.5	53.5	53.7	53.8	-1.4	-1.4	-1.3	-1.1	Middle Shintaffer
1295	55.9	53.9	53.9	54.0	54.0	-2.0	-1.9	-1.90	-1.88	53.9	53.9	54.0	54.0	-2.0	-1.9	-1.90	-1.88	54.0	54.1	54.1	54.1	-1.8	-1.8	-1.8	-1.7	Middle Shintaffer
1300	54.9	54.0	54.0	54.0	54.0	-1.0	-1.0	-0.97	-0.95	54.0	54.0	54.0	54.0	-1.0	-1.0	-0.97	-0.95	54.0	54.1	54.1	54.1	-0.9	-0.9	-0.8	-0.8	Middle Shintaffer
1325	54.8	52.7	52.9	53.0	53.1	-2.1	-1.9	-1.81	-1.68	52.7	52.9	53.0	53.1	-2.1	-1.9	-1.81	-1.68	53.2	53.5	53.7	53.8	-1.6	-1.3	-1.1	-1.0	Middle Shintaffer
501	26.5	23.0	23.0	23.0	23.0	-3.6	-3.5	-3.53	-3.51	23.0	23.0	23.0	23.0	-3.6	-3.5	-3.53	-3.51	23.0	23.0	23.0	23.0	-3.6	-3.5	-3.5	-3.5	Lower Shintaffer
505	30.0	27.1	27.1	27.1	27.1	-2.9	-2.9	-2.92	-2.92	27.1	27.1	27.1	27.1	-2.9	-2.9	-2.92	-2.92	27.1	27.1	27.1	27.1	-2.9	-2.9	-2.9	-2.9	Lower Shintaffer
507	48.9	45.1	45.1	45.1	45.1	-3.9	-3.8	-3.82	-3.80	45.1	45.1	45.1	45.1	-3.9	-3.8	-3.82	-3.80	45.1	45.1	45.1	45.1	-3.8	-3.8	-3.8	-3.8	Lower Shintaffer
508	51.7	47.8	47.8	47.8	47.9	-3.9	-3.8	-3.83	-3.82	47.8	47.8	47.8	47.9	-3.9	-3.8	-3.83	-3.82	47.8	47.8	47.9	47.9	-3.9	-3.8	-3.8	-3.8	Lower Shintaffer
509	52.5	50.1	50.3	50.4	50.6	-2.5	-2.2	-2.12	-1.98	50.1	50.3	50.4	50.6	-2.5	-2.2	-2.12	-1.98	50.1	50.4	50.5	50.7	-2.4	-2.2	-2.0	-1.9	Lower Shintaffer
510	51.3	47.7	47.7	47.8	47.8	-3.5	-3.5	-3.51	-3.49	47.7	47.7	47.8	47.8	-3.5	-3.5	-3.51	-3.49	47.7	47.8	47.8	47.8	-3.5	-3.5	-3.5	-3.5	Lower Shintaffer
511	52.5	50.4	50.8	51.0	51.3	-2.1	-1.7	-1.53	-1.27	50.4	50.8	51.0	51.3	-2.1	-1.7	-1.53	-1.27	50.5	50.9	51.1	51.4	-2.0	-1.6	-1.4	-1.1	Lower Shintaffer
514	52.4	50.9	51.4	51.7	52.1	-1.5	-1.0	-0.67	-0.27	50.9	51.4	51.7	52.1	-1.5	-1.0	-0.67	-0.27	51.0	51.5	51.9	52.3	-1.4	-0.9	-0.5	-0.1	Lower Shintaffer
518	52.2	51.3	52.0	52.5	53.0	-0.9	-0.1	0.28	0.82	51.3	52.0	52.5	53.0	-0.9	-0.1	0.28	0.82	51.4	52.2	52.6	53.2	-0.8	0.0	0.4	1.0	Lower Shintaffer
519	52.2	51.3	52.0	52.5	53.0	-0.9	-0.1	0.30	0.84	51.3	52.0	52.5	53.0	-0.9	-0.1	0.30	0.84	51.4	52.2	52.6	53.2	-0.8	0.0	0.4	1.0	Lower Shintaffer
520	51.9	51.3	52.0	52.5	53.0	-0.6	0.2	0.60	1.14	51.3	52.0	52.5	53.0	-0.6	0.2	0.60	1.14	51.4	52.2	52.6	53.2	-0.5	0.3	0.7	1.3	Lower Shintaffer
521	52.4	51.3	52.0	52.5	53.0	-1.1	-0.4	0.03	0.57	51.3	52.0	52.5	53.0	-1.1	-0.4	0.03	0.57	51.4	52.2	52.6	53.2	-1.0	-0.3	0.2	0.7	Lower Shintaffer
522	51.7	51.3	52.1	52.5	53.0	-0.4	0.4	0.81	1.35	51.3	52.1	52.5	53.0	-0.4	0.4	0.81	1.35	51.4	52.2	52.6	53.2	-0.3	0.5	0.9	1.5	Lower Shintaffer
523	52.9	51.4	51.6	51.7	51.8	-1.6	-1.3	-1.22	-1.08	51.4	51.6	51.7	51.8	-1.6	-1.3	-1.22	-1.08	51.6	51.8	52.1	52.5	-1.4	-1.1	-0.8	-0.4	Lower Shintaffer
524	52.4	51.1	51.3	51.4	51.5	-1.3	-1.1	-1.02	-0.89	51.1	51.3	51.4	51.5	-1.3	-1.1	-1.02	-0.89	51.2	51.5	51.6	51.9	-1.2	-0.9	-0.8	-0.5	Lower Shintaffer
525	51.8	51.1	51.3	51.4	51.5	-0.8	-0.5	-0.44	-0.31	51.1	51.3	51.4	51.5	-0.8	-0.5	-0.44	-0.31	51.2	51.5	51.6	51.9	-0.6	-0.3	-0.2	0.1	Lower Shintaffer
527	51.5	50.1	50.3	50.4	50.6	-1.4	-1.2	-1.09	-0.95	50.1	50.3	50.4	50.6	-1.4	-1.2	-1.09	-0.95	50.1	50.4	50.5	50.7	-1.4	-1.1	-1.0	-0.8	Lower Shintaffer
1244	51.8	51.3	52.1	52.5	53.0	-0.5	0.3	0.68	1.22	51.3	52.1	52.5	53.0	-0.5	0.3	0.68	1.22	51.4	52.2	52.6	53.2	-0.4	0.4	0.8	1.4	Lower Shintaffer
1245	52.9	51.4	51.6	51.7	51.8	-1.6	-1.4	-1.26	-1.12	51.4	51.6	51.7	51.8	-1.6	-1.4	-1.26	-1.12	51.6	51.8	52.1	52.5	-1.4	-1.1	-0.9	-0.4	Lower Shintaffer
1246	53.3	51.7	51.9	52.0	52.2	-1.7	-1.4	-1.32	-1.17	51.7	51.9	52.0	52.2	-1.7	-1.4	-1.32	-1.17	51.9	52.3	52.7	53.2	-1.4	-1.1	-0.7	-0.2	Lower Shintaffer
BP21aPond	164.2	160.2	160.5	160.7	161.0	-4.0	-3.7	-3.48	-3.22	160.2	160.5	160.7	161.0	-4.0	-3.7	-3.48	-3.22	162.3	163.3	163.9	164.4	-1.9	-0.9	-0.3	0.2	Semiahmoo Uplands
FieldPond1	152.7	147.5	147.7	147.8	147.9	-5.2	-5.0	-4.91	-4.78	147.5	147.7	147.8	147.9	-5.2	-5.0	-4.91	-4.78	147.9	148.1	148.3	148.5	-4.8	-4.6	-4.4	-4.2	Semiahmoo Uplands
G1-1	81.8	82.6	82.7	82.7	82.8	0.8	0.9	0.92	0.98	82.6	82.7	82.7	82.8	0.8	0.9	0.92	0.98	82.6	82.7	82.8	82.8	0.8	0.9	1.0	1.0	Semiahmoo Uplands
G1-2	90.3	90.0	90.3	90.5	90.6	-0.3	0.0	0.18	0.32	90.3	90.4	90.5	90.6	0.0	0.1	0.17	0.32	90.4	90.6	90.7	90.7	0.1	0.3	0.4	0.4	Semiahmoo Uplands
G2-1	75.5	75.5	75.7	75.9	76.0	0.0	0.2	0.35	0.45	75.6	75.7	75.9	76.0	0.1	0.2	0.35	0.45	76.2	76.3	76.3	76.4	0.7	0.8	0.8	0.9	Semiahmoo Uplands
G2-2	74.0	74.8	75.0	75.0	75.1	0.8	1.0	1.02	1.11	74.8	75.0	75.0	75.1	0.8	1.0	1.02	1.11	74.9	75.1	75.1	75.2	0.9	1.1	1.1	1.2	Semiahmoo Uplands
SU-1b	229.0	226.3	226.6	226.8	227.0	-2.8	-2.4	-2.24	-2.02	226.8	227.3	227.6	227.9	-2.2	-1.7	-1.42	-1.06	227.3	227.9	228.2	228.6	-1.8	-1.2	-0.8	-0.4	Semiahmoo Uplands
TF-1	80.6	80.6	80.9	81.1	81.3	0.0	0.3	0.46	0.65	81.0	81.1	81.1	81.3	0.4	0.4	0.46	0.65	81.0	81.1	81.3	81.4	0.4	0.5	0.6	0.8	Semiahmoo Uplands
HorizonPond	32.4	32.7	33.2	33.3	33.6	0.3	0.7	0.92	1.15	32.7	33.2	33.3	33.6	0.3	0.7	0.92	1.15	33.9	34.3	34.6	34.9	1.5	1.9	2.2	2.5	Horizon Pond
PD63	33.7	31.3	32.0	32.5	33.1	-2.4	-1.6	-1.18	-0.59	31.3	32.1	32.6	33.1	-2.4	-1.6	-1.11	-0.60	31.7	32.5	33.0	33.6	-2.0	-1.1	-0.6	-0.1	Horizon Pond
Lake6	181.0	179.7	179.8	179.8	179.9	-1.3	-1.3	-1.20	-1.14	179.7	179.8	179.8	179.9	-1.3	-1.3	-1.20	-1.14	179.8	179.9	180.0	180.0	-1.2	-1.1	-1.0	-1.0	Semiahmoo Golf Course
Lake9	235.0	231.7	231.8	231.8	231.8	-3.3	-3.3	-3.22	-3.18	231.7	231.8	231.8	231.8	-3.3	-3.3	-3.22	-3.18	231.8	231.9	231.9	231.9	-3.2	-3.2	-3.1	-3.1	Semiahmoo Golf Course
Lake12	229.2	226.3	226.6	226.8	227.0	-2.9	-2.6	-2.44	-2.22	226.8	227.3	227.6	227.9	-2.4	-1.9	-1.62	-1.26	227.3	227.9	228.2	228.6	-1.9	-1.3	-1.0	-0.6	Semiahmoo Golf Course
Lake18	235.0	233.0	233.1	233.2	233.3	-2.0	-1.9	-1.80	-1.70	233.0	233.1	233.2	233.3	-2.0	-1.9	-1.80	-1.70	233.2	233.3	233.4	233.5	-1.8	-1.7	-1.6	-1.5	Semiahmoo Golf Course
Pond3Dn_In	8.4	7.4	7.7	7.9	8.2	-1.0	-0.7	-0.50	-0.25	7.7	8.1	8.4	8.6	-0.7	-0.3	-0.02	0.15	7.9	8.4	8.5	8.8	-0.5	0.0	0.1	0.4	Birch Bay Village

Table A-5
Birch Point Drainage Study - Peak Flow Summary

		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	Location
C1006	1.9	2.4	2.9	3.2	3.6	2.4	2.9	3.2	3.6	2.6	3.1	3.4	3.7	Birch Point Road West of Selder
OD1752	1.7	2.4	2.9	3.2	3.5	2.4	2.9	3.2	3.5	2.5	3.0	3.3	3.7	Birch Point Road West of Selder
C1007	1.7	2.3	2.8	3.1	3.4	2.3	2.8	3.1	3.4	2.5	2.9	3.2	3.6	Birch Point Road West of Selder
OF-C1007	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1010_1	1.7	2.3	2.8	3.1	3.4	2.3	2.8	3.1	3.4	2.5	2.9	3.2	3.6	Birch Point Road West of Selder
OD1756	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	8.1	Birch Point Road West of Selder
OD1757	2.8	29.0	36.7	42.9	56.7	28.9	36.5	42.7	56.8	40.5	55.6	64.4	72.6	Birch Point Road West of Selder
C1008	2.9	29.0	36.7	42.9	47.3	28.9	36.5	42.7	47.3	40.6	47.2	47.3	47.5	Birch Point Road West of Selder
C1008-OF	0.0	0.0	0.0	0.0	19.8	0.0	0.0	0.0	19.3	0.0	17.5	36.1	56.0	Birch Point Road West of Selder
OD1010_4	1.6	2.5	2.9	4.3	6.6	3.1	3.7	4.2	6.6	3.4	4.8	6.4	8.2	Birch Point Road West of Selder
OD1010_2	1.6	2.3	2.8	3.0	3.4	2.3	2.8	3.0	3.4	2.4	2.9	3.2	3.5	Birch Point Road West of Selder
OD1010_3	1.6	2.5	3.0	4.3	6.7	3.1	3.7	4.3	6.6	3.4	4.4	6.4	8.2	Birch Point Road West of Selder
OD1753	1.9	2.4	3.0	3.2	3.6	2.4	3.0	3.2	3.6	2.6	3.1	3.4	3.8	Birch Point Road West of Selder
OD1755	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
GM3875	2.1	15.7	19.1	19.2	19.2	15.1	18.9	19.2	19.2	19.2	19.3	19.4	19.4	Birch Point Road West of Selder
GM3873	0.3	10.3	13.4	14.5	16.4	9.2	11.5	11.8	12.0	12.0	12.1	12.2	12.2	Birch Point Road West of Selder
GM3878	2.1	19.5	20.9	21.2	21.4	18.4	20.6	21.1	21.3	21.0	21.4	21.6	21.7	Birch Point Road West of Selder
GM3872	0.3	10.3	13.4	14.5	16.4	9.2	11.5	11.8	12.0	12.0	12.1	12.2	12.2	Birch Point Road West of Selder
C1009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1759	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1031	0.3	10.3	13.4	14.5	16.5	9.2	12.7	14.7	16.7	16.7	19.0	20.1	21.5	Birch Point Road West of Selder
C1025	4.9	25.9	27.7	28.3	29.1	24.5	27.2	27.3	28.2	28.5	28.9	29.1	29.5	Birch Point Road West of Selder
C1025-OF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
BBVC18	4.8	20.4	21.0	21.0	20.7	20.1	21.0	21.0	20.6	21.1	21.2	20.7	21.0	Birch Point Road West of Selder
C1026	0.7	10.0	11.5	11.8	12.2	9.4	11.0	11.0	11.5	12.4	12.3	12.4	12.6	Birch Point Road West of Selder
OD1032	1.5	6.8	7.1	8.3	11.1	6.7	7.6	8.8	10.1	9.5	18.0	24.2	31.4	Birch Point Road West of Selder
OD1034	2.1	17.1	28.5	35.6	43.4	16.8	21.8	32.0	41.8	31.0	46.3	55.2	66.7	Birch Point Road West of Selder
GM3874	2.1	15.7	19.1	19.2	19.2	15.1	18.9	19.2	19.2	19.2	19.3	19.4	19.4	Birch Point Road West of Selder
GM3877	0.1	4.0	4.4	4.4	4.5	3.5	4.3	4.3	4.5	4.5	4.4	4.5	4.7	Birch Point Road West of Selder
OD1020_1	0.0	1.8	3.0	4.6	7.3	1.7	2.9	4.5	7.1	7.2	10.7	13.2	16.0	Birch Point Road West of Selder
OD1020_2	0.0	1.8	3.0	4.3	6.1	1.7	2.8	4.2	6.0	6.1	7.6	8.3	9.2	Birch Point Road West of Selder
OD1020_3	0.0	1.7	2.9	4.1	5.9	1.6	2.8	4.0	5.8	6.0	7.2	8.0	8.8	Birch Point Road West of Selder
OD1020_4	0.0	1.7	2.9	4.1	5.9	1.6	2.8	4.0	5.7	6.0	7.2	8.0	8.8	Birch Point Road West of Selder
BBVC1	2.1	19.5	21.1	21.4	21.7	18.4	20.6	21.2	21.6	21.2	21.7	21.9	22.2	Birch Point Road West of Selder
OD1761	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1778	53.3	10.0	13.1	14.4	16.2	9.5	12.8	14.6	16.5	16.6	17.7	18.4	19.1	Birch Point Road West of Selder
OD1782	0.1	5.1	6.1	6.4	7.1	4.2	5.9	6.0	6.5	6.6	6.8	7.0	7.4	Birch Point Road West of Selder
OD1784	0.1	4.1	5.5	5.5	5.7	3.6	5.4	5.5	5.8	5.5	5.5	5.8	5.8	Birch Point Road West of Selder
CV3570	0.0	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	Bay Ridge Estates - West Shoreview Road
OD1001	0.2	4.6	5.6	6.6	8.3	4.5	5.4	6.4	8.1	8.1	9.8	10.9	11.7	Bay Ridge Estates - West Shoreview Road
CV3571	0.2	3.1	3.1	3.1	3.1	3.1	3.2	3.1	3.1	3.1	3.1	3.2	3.5	Bay Ridge Estates - West Shoreview Road
OD1002	0.3	6.8	6.8	6.9	6.9	6.8	7.2	7.3	7.0	7.0	7.1	7.1	7.2	Bay Ridge Estates - West Shoreview Road
CV3572	2.2	3.3	3.3	3.4	3.4	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	Bay Ridge Estates - West Shoreview Road
OD1000	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	Bay Ridge Estates - West Shoreview Road
CV3586	1.0	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	Bay Ridge Estates - West Shoreview Road
OD1762_2	0.2	2.1	3.3	4.8	7.5	2.3	3.8	4.6	7.3	7.4	10.9	13.5	16.3	Bay Ridge Estates - West Shoreview Road
GM3867	0.5	2.5	2.4	2.4	2.6	2.5	2.4	2.4	2.5	2.5	2.7	2.7	2.7	Bay Ridge Estates - West Shoreview Road
OD1762_1	0.9	7.4	7.4	7.5	7.4	7.4	7.5	7.5	7.5	7.5	7.5	7.5	7.7	Bay Ridge Estates - West Shoreview Road
GM3866	0.5	2.4	2.3	2.3	2.3	2.4	2.3	2.3	2.3	2.3	2.4	2.4	2.4	Bay Ridge Estates - West Shoreview Road
OD0985lower	2.4	4.0	4.5	4.8	5.5	3.8	4.2	4.4	8.9	8.9	8.9	9.1	9.1	Bay Ridge Estates - East Shoreview Road
CV3575	1.9	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2	Bay Ridge Estates - East Shoreview Road
OD1004	1.9	2.2	2.2	2.2	3.2	2.2	2.2	2.2	3.2	3.2	3.2	3.7	4.3	Bay Ridge Estates - East Shoreview Road
CV3592.1	0.1	2.9	3.0	3.1	3.1	2.9	3.0	3.1	3.1	3.1	3.1	3.1	3.1	Bay Ridge Estates - East Shoreview Road
OD1009	1.3	7.0	7.5	9.0	12.2	6.9	7.1	8.3	11.9	12.0	13.0	13.4	13.8	Bay Ridge Estates - East Shoreview Road
SM781	2.0	2.3	2.3	2.3	2.4	2.3	2.3	2.3	2.4	2.3	2.4	2.4	2.4	Bay Ridge Estates - East Shoreview Road
SM789	1.7	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.4	Bay Ridge Estates - East Shoreview Road
SM778	2.1	2.6	2.7	2.7	2.8	2.5	2.6	2.7	2.7	2.6	2.8	2.8	2.8	Bay Ridge Estates - East Shoreview Road
SM790	1.9	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	Bay Ridge Estates - East Shoreview Road
SM782	2.1	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	Bay Ridge Estates - East Shoreview Road
SM783	4.6	13.7	15.1	16.9	19.1	13.2	14.3	15.4	18.9	19.0	19.2	19.2	19.3	Bay Ridge Estates - East Shoreview Road
SM777	2.3	2.8	3.0	3.1	3.2	2.8	2.9	3.0	3.1	3.0	3.1	3.1	3.2	Bay Ridge Estates - East Shoreview Road
SM780	2.0	2.1	2.1	2.1	2.1	2.1	2.2	2.1	2.1	2.1	2.1	2.2	2.2	Bay Ridge Estates - East Shoreview Road
SM788	1.5	3.4	3.3	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	3.4	3.3	Bay Ridge Estates - East Shoreview Road
CV3544	1.9	2.6	2.2	2.3	2.4	2.3	2.3	2.2	2.2	2.4	2.3	2.4	2.3	Bay Ridge Estates - Bay Ridge Drive South
OD994	2.1	24.5	21.7	21.8	23.3	22.5	22.1	21.8	21.8	23.0	23.2	22.9	22.8	Bay Ridge Estates - Bay Ridge Drive South
OD1015	0.1	9.8	12.8	14.2	15.9	9.3	12.6	14.4	16.3	16.4	17.5	18.2	18.8	Bay Ridge Estates - Bay Ridge Drive South
SM732	4.1	9.7	10.0	10.2	10.4	9.6	9.9	10.0	10.2	9.7	9.9	10.1	10.3	Bay Ridge Estates - Bay Ridge Drive South
SM757	0.1	0.5	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	Bay Ridge Estates - Bay Ridge Drive South
SM758	0.3	0.5	0.5	0.6	0.8	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.9	Bay Ridge Estates - Bay Ridge Drive South
SM748	1.5	2.1	1.9	1.8	1.7	2.1	2.0	1.8	1.7	1.8	1.8	1.7	1.9	Bay Ridge Estates - Bay Ridge Drive South
SM761	0.5	0.6	0.8	1.0	1.2	0.5	0.6	0.7	0.9	0.6	0.8	0.9	1.2	Bay Ridge Estates - Bay Ridge Drive South
SM749	1.7	2.4	2.2	2.0	1.9	2.3	2.2	2.1	1.9	1.9	1.9	1.9	2.1	Bay Ridge Estates - Bay Ridge Drive South
SM755	1.9	2.6	2.4	2.3	2.4	2.6	2.4	2.3	2.3	2.2	2.2	2.3	2.3	Bay Ridge Estates - Bay Ridge Drive South
OD984	2.0	8.2	6.5	7.4	7.8	7.4	6.7	6.6	7.6	8.0	8.1	7.4	7.4	Bay Ridge Estates - Bay Ridge Drive South
SM743	1.3	1.9	1.7	1.6	1.6	1.9	1.8	1.6	1.5	1.6	1.6	1.6	1.8	Bay Ridge Estates - Bay Ridge Drive South
SM753	0.2	1.4	1.8	1.9	2.2	1.2	1.5	1.7	1.9	1.4	1.8	1.9	2.3	Bay Ridge Estates - Bay Ridge Drive South
OD985Upper	0.6	0.9	1.2	1.3	1.6	0.6	0.9	1.1	5.8	5.8	6.5	8.4	7.1	Bay Ridge Estates - Bay Ridge Drive South
CV3346	0.3	1.0	1.3	1.4	1.5	0.8	1.0	1.1	1.2	1.1	1.4	1.5	1.7	Bay Ridge Estates - Seawan Place
CV3357	0.5	1.5	1.9	2.0	2.3	1.2	1.5	1.6	1.8	1.7	2.0	2.2	2.5	Bay Ridge Estates - Seawan Place
OD907	0.5	1.5	1.9	2.0	2.3	1.2	1.5	1.6	1.8	1.7	2.0	2.1	2.6	Bay Ridge Estates - Seawan Place
CV3377	0.7	1.8	2.1	2.3	2.6	1.4	1.7	1.9	2.1	1.9	2.3	2.4	3.2	Bay Ridge Estates - Seawan Place
OD918	0.7	1.8	2.1	2.3	2.6	1.4	1.8	1.9	2.1	1.9	2.2	2.4	3.6	Bay Ridge Estates - Seawan Place
CV3399	0.9	2.0	2.4	2.6	2.9	1.7	2.0	2.2	2.4	2.1	2.5	2.7	4.4	Bay Ridge Estates - Seawan Place
OD935	0.9	2.0	2.4	2.6	2.9	1.7	2.0	2.2	2.4	2.1	2.5	2.7	5.0	Bay Ridge Estates - Seawan Place
CV3434	1.1	2.3	2.7	2.9	3.2	1.9	2.3	2.5	2.8	2.4	2.7	3.0	5.3	Bay Ridge Estates - Seawan Place
OD950	1.1	2.3	2.7	2.9	3.2	1.9	2.3	2.5	2.8	2.4	2.7	3.0	5.3	Bay Ridge Estates - Seawan Place
SM704	0.6	1.3	1.5	1.7	1.9	1.1	1.3	1.4	1.6	1.4	1.7	1.9	2.0	Bay Ridge Estates - Seawan Place
SM714	1.3	2.6	3.0	3.3	3.6	2.2	2.6	2.8	3.1	2.6	3.0	3.3	4.5	Bay Ridge Estates - Seawan Place
SM702	0.8	2.2	2.7	3.0	3.3	1.9	2.4	2.6	2.9	2.2	2.6	2.9	3.4	Bay Ridge Estates - Bay Ridge Drive Middle
SM705	1.2	2.1	2.5	2.7	2.9	1.8	2.2	2.4	2.6	2.2	2.5	2.7	2.9	Bay Ridge Estates - Bay Ridge Drive Middle
SM715	1.0	1.9	2.3	2.4	2.6	1.6	2.1	2.2	2.3	2.0	2.3	2.4	2.6	Bay Ridge Estates - Bay Ridge Drive Middle
SM7201	0.4	1.7	2.1	2.3	2.6	1.5	1.8	2.0	2.3	1.7	2.1	2.3	2.6	Bay Ridge Estates - Bay Ridge Drive Middle
SM695	1.6	2.6	3.1	3.4	3.6	2.3	2.8	3.0	3.3	2.6	3.1	3.3	3.5	Bay Ridge Estates - Bay Ridge Drive Middle
OD967	0.6	1.3	1.6	1.8	2.1	1.1	1.5	1.5	1.7	1.5	1.8	1.9	2.2	Bay Ridge Estates - Bay Ridge Drive Middle
OD938	1.4	2.4	2.8	3.0	3.3	2.1	2.5	2.7	3.0	2.4	2.8	3.0	3.2	Bay Ridge Estates - Bay Ridge Drive Middle
SM710	0.6	1.9	2.4	2.6	3.0	1.7	2.1	2.3	2.6	1.9	2.3	2.6	3.1	Bay Ridge Estates - Bay Ridge Drive Middle
OD954	0.6	2.0	2.4	2.6	3.0	1.7	2.1	2.3	2.6	1.9	2.3	2.6	3.2	Bay Ridge Estates - Bay Ridge Drive Middle
SM720	0.4	1.7	2.1	2.3	2.6	1.5	1.8	2.0	2.3	1.7	2.1	2.3	2.6	Bay Ridge Estates - Bay Ridge Drive Middle
SM724	0.8	1.7	2.1	2.2	2.3	1.3	2.0	2.0	2.1	1.9	2.1	2.2	2.3	Bay Ridge Estates - Bay Ridge Drive Middle

Table A-5
Birch Point Drainage Study - Peak Flow Summary

		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	Location
SM740	5.4	13.4	14.9	15.4	16.0	12.8	14.1	14.9	15.7	13.3	14.7	15.4	16.0	Bay Ridge Estates - Bay Ridge Drive West
SM734	1.2	2.8	3.5	3.5	3.5	2.4	3.1	3.4	3.5	2.7	3.4	3.5	3.5	Bay Ridge Estates - Bay Ridge Drive West
SM707	2.2	3.0	3.0	3.1	3.1	2.9	3.0	3.0	3.1	2.9	3.0	3.1	3.1	Bay Ridge Estates - Bay Ridge Drive West
SM697	2.0	2.7	2.7	2.7	2.7	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	Bay Ridge Estates - Bay Ridge Drive West
SM701	2.2	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	Bay Ridge Estates - Bay Ridge Drive West
SM727	2.4	3.3	3.5	3.6	3.7	3.1	3.3	3.4	3.6	3.2	3.4	3.5	3.6	Bay Ridge Estates - Bay Ridge Drive West
SM731	2.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	Bay Ridge Estates - Bay Ridge Drive West
SM738	1.4	3.1	3.8	3.9	4.0	2.7	3.4	3.7	3.9	2.9	3.7	3.9	3.9	Bay Ridge Estates - Bay Ridge Drive West
OD958	2.4	3.3	3.5	3.5	3.7	3.1	3.3	3.4	3.5	3.2	3.4	3.5	3.6	Bay Ridge Estates - Bay Ridge Drive West
SM694	1.8	2.9	3.4	3.7	3.9	2.5	3.1	3.3	3.6	2.9	3.3	3.6	3.8	Bay Ridge Estates - Bay Ridge Drive West
SM703	1.0	2.5	3.0	3.3	3.7	2.2	2.7	2.9	3.3	2.4	2.9	3.2	3.7	Bay Ridge Estates - Bay Ridge Drive West
C1156-OF_2	2.1	10.6	14.9	18.5	22.2	10.3	14.5	18.0	21.7	12.1	16.6	20.4	24.3	
OD939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Bay Ridge Estates
BBVC27	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	Birch Bay Village
BBVC22	2.3	20.0	29.0	31.1	31.4	18.9	24.9	30.7	31.3	29.7	31.6	31.7	31.8	Birch Bay Village
BBVC29	0.0	0.1	1.1	1.6	1.7	0.1	0.1	1.6	1.7	1.3	1.7	1.7	1.7	Birch Bay Village
3	3.1	32.7	38.5	44.4	56.8	32.5	38.3	44.2	56.6	42.0	56.4	64.2	70.8	
BBV_Canal_chnl	6.2	40.7	49.1	54.5	64.7	40.6	49.0	54.4	64.4	50.5	63.2	72.4	81.9	Birch Bay Drive at Birch Loop
BBV_CHNL_POND9	25.5	64.9	77.6	85.3	93.4	64.8	77.5	85.2	93.2	73.7	88.5	96.5	109.6	Birch Bay Village
BBVC4_1	0.8	4.3	6.2	5.2	5.2	5.7	6.3	6.6	5.1	6.3	6.6	5.2	5.1	Birch Bay Village
BBVC4_2	0.8	4.3	5.5	5.8	6.4	4.1	5.4	5.7	6.2	5.5	6.1	6.6	6.7	Birch Bay Village
BBVC16	5.2	12.9	12.7	12.3	12.3	12.9	12.8	12.4	12.3	12.6	12.3	12.3	12.3	Birch Bay Village
BBVC15	5.2	21.3	22.3	22.6	22.7	20.9	22.1	22.5	22.7	22.1	22.6	22.7	22.7	Birch Bay Village
BBVC13	5.2	21.3	22.3	22.6	22.7	20.9	22.1	22.5	22.7	22.1	22.6	22.7	22.7	Birch Bay Village
BBVC17	4.8	20.4	21.0	21.0	20.7	20.1	21.0	21.0	20.6	21.1	21.2	20.7	21.0	Birch Bay Village
BBVC14	5.2	21.3	22.3	22.6	22.7	20.9	22.1	22.5	22.7	22.1	22.6	22.7	22.7	Birch Bay Village
BBVC20	1.9	17.5	27.5	33.0	34.9	16.4	22.0	30.5	34.6	29.2	35.3	36.0	36.4	Birch Bay Village
BBVC21	1.9	17.5	27.5	36.9	44.7	16.4	22.0	30.9	43.1	29.2	45.6	48.5	50.1	Birch Bay Village
BBVC23	1.7	16.8	26.9	35.6	43.1	15.8	21.4	30.2	41.5	28.7	44.2	51.2	60.0	Birch Bay Village
BBVC24	0.7	3.2	3.7	4.1	4.4	3.2	3.5	3.9	4.4	3.7	4.3	4.6	4.9	Birch Bay Village
BBVC26	1.5	10.9	13.8	13.9	15.0	15.2	18.3	19.8	21.6	16.6	19.6	21.1	22.8	Birch Bay Village
BBVC28	0.0	4.3	4.4	4.4	4.5	0.3	4.1	4.2	4.3	4.5	4.6	4.7	4.6	Birch Bay Village
Thunderbird_Pond	0.7	10.9	13.8	13.8	15.0	15.2	18.3	19.8	21.6	16.6	19.6	21.1	22.8	
BBVC_1_1	5.6	6.3	6.3	6.2	6.1	6.3	6.2	6.2	6.0	6.4	6.2	6.2	6.4	
BBVC1_2	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	Birch Bay Village
BBVC2	2.5	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	
BBVC2_3	2.5	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	Birch Bay Village
BBVC2_2	2.6	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	Birch Bay Village
BBVC2_4	2.6	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	Birch Bay Village
BBVC2_1	2.7	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	Birch Bay Village
BBVC2_5	2.6	11.7	13.6	13.7	13.7	11.2	13.4	13.5	13.6	13.9	14.1	14.3	14.3	Birch Bay Village
BBVC11	22.4	94.7	116.0	127.8	135.3	94.7	115.9	127.8	135.3	102.6	125.9	133.4	138.8	Birch Bay Village
BBVC12	22.4	94.7	116.6	127.8	135.3	94.7	116.8	127.8	135.3	102.6	125.3	133.4	138.8	
BBVC6	0.8	4.1	4.4	4.3	4.0	3.9	4.4	6.7	4.1	4.9	6.8	6.6	3.6	Birch Bay Village
OD1904_1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
C1157	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
OD1793_3	41.4	60.7	71.7	77.9	85.0	60.7	71.7	77.9	85.0	94.0	112.5	123.6	137.3	Selder Road
C1156	10.2	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.4	9.3	9.2	9.1	Selder Road
C1156-OF_1	1.9	8.9	12.8	16.4	19.8	8.9	12.8	16.4	19.8	10.3	14.3	18.1	21.6	Selder Road
C1125	11.5	16.2	16.2	16.2	16.3	16.2	16.2	16.2	16.3	16.1	16.2	16.2	16.3	Selder Road
C1125-OF	0.0	2.0	5.8	9.7	13.1	2.0	5.8	9.7	13.1	2.2	5.9	9.9	13.3	Selder Road
OD1873	8.0	12.0	14.6	17.3	19.6	12.0	14.6	17.3	19.6	12.1	14.7	17.4	19.7	Selder Road
C1123	6.6	6.8	6.9	6.9	7.0	6.8	6.9	6.9	7.0	6.8	6.9	6.9	7.0	Selder Road
F-LDES2595_LDES25	1.4	5.2	7.7	10.4	12.6	5.2	7.7	10.4	12.6	5.3	7.8	10.5	12.7	Selder Road
OD1872	8.0	12.0	14.6	17.4	19.6	12.0	14.6	17.4	19.6	12.1	14.7	17.5	19.7	Selder Road
C1122	7.1	7.6	7.8	8.0	8.1	7.6	7.8	8.0	8.1	7.6	7.8	8.0	8.1	Selder Road
F-LDES2603_LDES26	0.9	4.4	6.8	9.4	11.5	4.4	6.8	9.4	11.5	4.5	6.8	9.5	11.5	Selder Road
OD1871	8.1	12.0	14.6	17.4	19.6	12.0	14.6	17.4	19.6	12.1	14.7	17.5	19.7	Selder Road
C1121	7.1	7.5	7.7	7.8	7.9	7.5	7.7	7.8	7.9	7.5	7.7	7.8	7.9	Selder Road
F-LDES2611_LDES26	1.0	4.6	6.9	9.6	11.6	4.6	6.9	9.6	11.6	4.6	7.0	9.7	11.7	Selder Road
OD1870	8.7	12.0	14.6	17.4	19.6	12.0	14.6	17.4	19.6	12.1	14.7	17.5	19.7	Selder Road
C1120	8.7	12.0	14.6	15.2	15.5	12.0	14.6	15.2	15.5	12.1	14.7	15.2	15.5	Selder Road
C1120-OF	0.0	0.0	0.0	2.2	4.1	0.0	0.0	2.2	4.1	0.0	0.0	2.3	4.2	Selder Road
OD1869	4.1	5.9	8.0	8.8	9.8	5.9	8.0	8.8	9.8	6.0	8.1	8.9	9.9	Selder Road
C1119	4.1	5.9	6.4	6.5	6.6	5.9	6.4	6.5	6.6	6.0	6.4	6.5	6.6	Selder Road
C1119-OF	0.0	0.0	1.7	2.4	3.2	0.0	1.7	2.4	3.2	0.0	1.7	2.4	3.3	Selder Road
OD1868	4.1	6.6	8.0	8.8	9.9	6.6	8.0	8.8	9.9	6.6	8.1	8.9	9.9	Selder Road
C1118	4.1	4.9	5.0	5.1	5.1	4.9	5.0	5.1	5.1	4.9	5.0	5.1	5.1	Selder Road
F-LDES2635_LDES26	0.0	1.6	3.0	3.8	4.8	1.6	3.0	3.8	4.8	1.7	3.1	3.8	4.8	Selder Road
C1038	4.9	6.7	8.1	8.9	9.9	6.7	8.1	8.9	9.9	6.7	8.2	9.0	10.0	Selder Road
OD1836	4.9	6.7	8.1	8.9	9.9	6.7	8.1	8.9	9.9	6.7	8.1	8.9	9.9	Selder Road
C1124	6.6	6.8	6.9	6.9	7.0	6.8	6.9	6.9	7.0	6.8	6.9	6.9	7.0	Selder Road
OD630	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
RS_Creek_4	41.4	60.7	71.7	77.9	85.0	60.7	71.7	77.9	85.0	94.0	112.5	123.6	137.3	Selder Road
10_2	5.8	13.3	15.2	16.2	17.5	13.3	15.2	16.2	17.4	19.3	24.6	28.1	33.8	
OD1793_1	32.8	51.9	63.3	69.5	76.7	51.9	63.3	69.5	76.7	86.5	105.3	116.6	130.6	Selder Road
C1032	5.0	7.3	7.4	7.4	7.4	7.3	7.4	7.4	7.4	7.7	7.7	7.7	7.7	Selder Road
C1032-OF	0.0	0.0	2.5	4.1	6.2	0.0	2.5	4.1	6.2	15.6	20.6	23.5	27.0	Selder Road
C1017	4.2	4.4	4.5	4.6	4.6	4.4	4.5	4.6	4.6	4.7	4.7	4.7	4.7	Selder Road
C1017-OF	3.0	5.5	7.5	8.7	10.1	5.5	7.5	8.7	10.1	18.7	23.9	26.8	30.4	Selder Road
OD1774	7.2	9.9	12.0	13.2	14.7	9.9	12.0	13.2	14.7	23.3	28.4	31.2	34.8	Selder Road
C1022	6.2	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.5	7.5	7.5	7.5	Selder Road
C1022-OF	0.0	2.6	4.8	6.1	7.6	2.6	4.8	6.1	7.6	16.5	21.8	24.7	28.3	Selder Road
OD1776	6.1	9.7	11.9	13.0	14.5	9.7	11.9	13.0	14.5	23.2	28.2	31.0	34.5	Selder Road
C1012	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.9	Selder Road
C1012-OF	2.7	5.4	7.6	8.8	10.3	5.4	7.6	8.8	10.3	18.9	23.9	26.6	30.0	Selder Road
OD1767	7.4	10.0	12.1	13.3	14.8	10.0	12.1	13.3	14.8	23.6	28.5	31.3	34.9	Selder Road
OD1768	7.2	9.9	12.0	13.2	14.7	9.9	12.0	13.2	14.7	23.3	28.4	31.3	34.8	Selder Road
GM3879	0.0	0.4	0.6	0.6	0.9	0.2	0.5	0.6	0.6	0.6	1.0	1.2	1.3	Birch Point Road East of Selder
SM806	2.3	4.4	5.3	5.8	6.7	4.4	5.3	5.8	6.7	6.1	7.6	8.5	8.7	Birch Point Road East of Selder
SM807	4.6	8.8	10.6	11.6	12.6	8.8	10.6	11.6	12.6	12.3	13.4	14.4	14.5	Birch Point Road East of Selder
GM3880	0.0	0.4	0.6	0.6	0.9	0.2	0.5	0.6	0.6	0.6	1.0	1.2	1.3	Birch Point Road East of Selder
OD1904_2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
OF-LDES2552_2728	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road East of Selder
OF-LDES2552_2888	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road East of Selder
OD1038	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.6	Birch Point Road East of Selder
SM800	2.4	4.4	5.4	5.9	6.6	4.4	5.4	5.9	6.6	6.2	7.5	8.3	9.2	Birch Point Road East of Selder
SM802	2.4	4.4	5.4	5.9	6.6	4.4	5.4	5.9	6.6	6.2	7.5	8.3	9.2	Birch Point Road East of Selder
SM815	0.1	0.2	0.3	0.3	1.5	0.2	0.3	0.3	1.5	0.3	3.0	4.6	4.7	Birch Point Road East of Selder
OD1093_2	3.3	13.4	37.0	48.2	59.6	11.5	12.1	20.7	37.2	45.8	58.9	62.1	64.1	Birch Bay Drive at Birch Loop

Table A-5
Birch Point Drainage Study - Peak Flow Summary

		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	Location
SM822	0.9	1.8	2.1	2.3	2.6	1.8	2.1	2.3	2.6	2.5	2.8	2.8	2.8	Birch Bay Drive at Birch Loop
CV3751	3.4	8.7	9.2	9.2	9.2	11.5	12.2	12.8	13.2	13.4	14.1	14.4	14.4	Birch Bay Drive at Birch Loop
11	0.7	3.0	3.1	3.1	3.1	3.0	3.1	3.1	3.1	3.1	3.1	3.2	3.2	Birch Bay Drive at Birch Loop
92608	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
CV3738	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
13	0.0	1.3	2.2	2.7	3.4	1.3	2.2	2.7	3.4	3.0	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_1	0.0	1.3	2.3	2.7	3.3	1.3	2.3	2.7	3.4	3.0	4.1	4.6	5.0	Birch Bay Drive at Birch Loop
5CV3714	5.1	16.2	16.5	16.6	16.6	15.9	17.0	17.1	17.2	17.3	17.4	17.4	17.4	Birch Bay Drive at Birch Loop
OD1075-L	3.0	13.0	36.4	46.8	57.1	11.7	12.0	20.3	37.3	46.6	60.3	63.8	65.7	Birch Bay Drive at Birch Loop
CV3723	0.0	8.9	6.8	4.2	5.9	3.2	2.6	3.7	1.5	1.8	2.3	1.6	1.4	Birch Bay Drive at Birch Loop
3732	30.3	33.0	33.8	34.1	34.2	42.6	43.4	44.0	44.5	44.7	45.2	45.8	47.5	Birch Bay Drive at Birch Loop
3734	9.7	10.5	10.8	10.9	10.9	15.8	16.1	16.2	16.4	16.5	16.5	16.5	16.6	Birch Bay Drive at Birch Loop
CV3732_OF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
Rogers_Slough_1	39.9	49.9	52.0	52.9	54.9	69.6	71.6	72.7	73.9	74.7	77.9	83.1	105.5	Birch Bay Drive at Birch Loop
OD1086	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	Birch Bay Drive at Birch Loop
CV3740	3.1	5.8	5.3	5.7	5.9	9.4	9.5	9.7	9.9	9.8	10.1	9.9	9.5	Birch Bay Drive at Birch Loop
OD1093_1	3.2	13.3	36.8	48.2	60.5	11.6	12.1	20.5	37.0	45.8	60.6	64.6	67.3	Birch Bay Drive at Birch Loop
5	4.6	11.8	13.7	14.7	15.7	11.8	13.7	14.7	15.7	15.4	16.6	17.5	17.7	Birch Bay Drive at Birch Loop
SM840	4.6	10.4	10.5	10.5	10.5	11.1	11.2	11.4	11.4	11.3	11.2	11.0	10.9	Birch Bay Drive at Birch Loop
SM840-OF	0.0	0.6	3.5	4.8	6.1	0.0	2.9	4.2	5.9	5.0	7.2	8.1	8.3	Birch Bay Drive at Birch Loop
OD1058_1	40.1	46.6	50.6	52.7	54.4	55.2	57.6	58.9	61.1	63.3	64.5	64.1	64.6	Birch Bay Drive at Birch Loop
OD1058_2	42.0	48.4	47.9	47.7	48.6	54.3	54.7	55.0	55.4	55.1	54.7	55.0	55.1	Birch Bay Drive at Birch Loop
7	0.0	3.6	3.8	4.0	4.1	3.6	3.9	4.0	4.1	3.8	4.0	4.1	4.3	
SM722	5.7	6.9	7.1	6.8	7.0	6.9	6.9	7.1	6.9	6.7	6.7	6.7	6.7	
OD1058_3	42.1	60.7	65.6	67.5	69.8	60.7	66.8	68.8	71.2	73.8	75.8	77.6	79.9	Birch Bay Drive at Birch Loop
RS_Creek_5	39.2	60.9	71.6	77.5	89.9	60.9	71.6	77.5	89.9	110.4	142.7	156.2	170.7	
RS_Creek_1	44.1	79.1	97.0	105.3	116.4	79.1	97.0	105.3	116.4	126.3	140.4	148.4	158.8	
OD1071_2	6.9	12.8	15.5	19.4	26.4	14.1	15.4	17.5	21.9	23.1	32.0	35.2	37.7	Birch Bay Drive at Birch Loop
OD1071_3	5.9	12.9	16.3	19.3	26.2	12.7	16.7	18.4	24.3	26.4	31.1	33.6	35.1	Birch Bay Drive at Birch Loop
OD1073	0.0	1.3	2.2	2.7	3.4	1.3	2.2	2.7	3.4	3.0	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_2	0.0	1.2	9.3	11.6	11.8	1.3	2.2	2.7	7.9	11.4	12.6	11.7	11.3	Birch Bay Drive at Birch Loop
OD1075-U_3	0.2	1.8	12.2	15.6	16.9	1.9	2.0	2.2	10.1	15.2	17.7	17.4	17.3	Birch Bay Drive at Birch Loop
OD1075-U_4	0.5	6.8	17.2	21.6	24.1	2.5	3.4	6.3	14.3	21.0	25.0	25.4	25.8	Birch Bay Drive at Birch Loop
OD1075-U_5	1.1	7.2	20.2	26.6	30.8	2.9	5.2	6.7	16.1	25.6	32.0	32.9	33.6	Birch Bay Drive at Birch Loop
OD1075-U_6	1.8	9.0	16.0	17.8	19.6	3.6	6.8	10.0	16.6	18.9	21.4	21.9	22.1	Birch Bay Drive at Birch Loop
OD1075-U_7	2.8	9.3	16.6	18.9	22.0	4.5	8.4	10.4	17.3	19.7	23.3	24.3	24.8	Birch Bay Drive at Birch Loop
PD46	1.2	4.3	5.3	5.8	6.5	4.3	5.3	5.8	6.5	6.2	7.3	7.8	8.3	Birch Bay Drive at Birch Loop
92971	0.0	1.3	2.2	2.7	3.4	1.3	2.2	2.7	3.4	3.0	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
SM838	0.0	1.8	1.8	1.8	1.9	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	Birch Bay Drive at Birch Loop
SM839	0.7	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	Birch Bay Drive at Birch Loop
OD1071_1	6.8	14.4	15.1	15.5	15.3	15.4	16.4	16.7	18.1	16.8	18.7	18.7	15.9	Birch Bay Drive at Birch Loop
SM9799	3.4	8.7	9.2	9.3	9.2	11.5	12.2	12.8	13.2	13.4	14.1	14.4	14.4	Birch Bay Drive at Birch Loop
Rogers_Slough_2	39.9	49.9	52.0	52.9	54.9	69.6	71.6	72.7	73.9	74.7	77.9	83.1	105.5	Birch Bay Drive at Birch Loop
P-1366-1372	2.7	3.8	4.3	4.5	4.7	3.8	4.3	4.5	4.7	3.8	4.3	4.4	4.6	Pheasant - Grouse Cress
D-1367-1366	2.7	3.8	4.3	4.5	4.7	3.8	4.3	4.5	4.7	3.8	4.3	4.4	4.6	Pheasant - Grouse Cress
P-1368-1367	1.3	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1372-1460	3.8	5.3	6.1	6.4	6.8	5.3	6.1	6.4	6.8	5.6	6.3	6.7	7.1	Pheasant - Grouse Cress
P-1373-1367	1.3	2.0	2.2	2.3	2.5	2.0	2.2	2.3	2.5	2.0	2.2	2.3	2.4	Pheasant - Grouse Cress
P-1374-1373	1.3	2.0	2.2	2.3	2.5	2.0	2.2	2.3	2.5	2.0	2.2	2.3	2.4	Pheasant - Grouse Cress
D-1375-1368	1.4	1.9	2.1	2.2	2.3	1.9	2.1	2.2	2.3	1.9	2.1	2.2	2.3	Pheasant - Grouse Cress
P-1376-1375	1.4	1.9	2.1	2.2	2.3	1.9	2.1	2.2	2.3	1.9	2.1	2.2	2.3	Pheasant - Grouse Cress
D-1377-1374	1.3	2.0	2.3	2.3	2.5	2.0	2.3	2.3	2.5	2.0	2.2	2.3	2.5	Pheasant - Grouse Cress
P-1378-1377	1.3	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	2.0	2.3	2.3	2.5	Pheasant - Grouse Cress
D-1379-1376	1.5	2.0	2.2	2.3	2.4	2.0	2.2	2.3	2.4	2.0	2.2	2.3	2.4	Pheasant - Grouse Cress
P-1380-1379	1.5	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1381-1378	1.3	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1382-1381	1.4	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	2.0	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1383-1380	1.5	2.1	2.3	2.4	2.5	2.1	2.3	2.4	2.5	2.0	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1384-1383	1.5	2.1	2.3	2.4	2.5	2.1	2.3	2.4	2.5	2.1	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1385-1382	1.4	2.0	2.3	2.4	2.6	2.0	2.3	2.4	2.6	2.0	2.3	2.4	2.6	Pheasant - Grouse Cress
P-1386-1385	1.4	2.0	2.3	2.5	2.6	2.0	2.3	2.5	2.6	2.0	2.3	2.4	2.6	Pheasant - Grouse Cress
D-1387-1384	1.5	2.1	2.4	2.5	2.6	2.1	2.4	2.5	2.6	2.1	2.4	2.5	2.6	Pheasant - Grouse Cress
P-1388-1387	1.5	2.1	2.4	2.5	2.6	2.1	2.4	2.5	2.6	2.1	2.4	2.5	2.6	Pheasant - Grouse Cress
D-1389-1388	1.5	2.1	2.4	2.6	2.7	2.1	2.4	2.6	2.7	2.1	2.4	2.6	2.7	Pheasant - Grouse Cress
P-1390-1389	1.5	2.1	2.5	2.6	2.7	2.1	2.5	2.6	2.7	2.1	2.5	2.6	2.7	Pheasant - Grouse Cress
D-1391-1386	1.4	2.0	2.4	2.5	2.7	2.0	2.4	2.5	2.7	2.0	2.4	2.5	2.7	Pheasant - Grouse Cress
P-1392-1391	0.2	0.2	0.3	0.3	0.4	0.2	0.3	0.3	0.4	0.2	0.3	0.3	0.4	Pheasant - Grouse Cress
D-1393-1390	0.1	0.1	0.4	0.5	0.6	0.1	0.4	0.5	0.6	0.2	0.4	0.5	0.6	Pheasant - Grouse Cress
P-1394-1393	0.1	0.1	0.3	0.4	0.5	0.1	0.3	0.4	0.5	0.1	0.3	0.4	0.5	Pheasant - Grouse Cress
D-1395-1392	0.0	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.2	Pheasant - Grouse Cress
P-1396-1395	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	Pheasant - Grouse Cress
D-1397-1396	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	Pheasant - Grouse Cress
P-1398-1397	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1399-1394	0.0	0.0	0.1	0.2	0.3	0.0	0.1	0.2	0.3	0.0	0.1	0.2	0.3	Pheasant - Grouse Cress
P-1400-1399	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.2	Pheasant - Grouse Cress
D-1401-1400	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	Pheasant - Grouse Cress
P-1402-1401	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	Pheasant - Grouse Cress
D-1403-1398	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1404-1403	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1405-1404	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1406-1402	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1407-1406	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1408-1409	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1409-1410	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1410-1411	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1411-1412	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1412-1413	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1413-1414	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1414-1415	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1415-1416	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1416-1417	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1417-1419	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1418-1421	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1419-1420	0.5	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1420-1426	0.5	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1421-1422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1422-1423	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1423-1424	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1424-1425	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1425-1427	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress

Table A-5
Birch Point Drainage Study - Peak Flow Summary

		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	Location
P-1426-1429	0.5	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1427-1428	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1428-1450	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1429-1449	0.5	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1430-1441	0.7	0.9	1.0	1.0	1.1	0.9	1.0	1.0	1.1	1.0	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1431-1434	1.2	1.6	1.8	2.0	2.2	1.6	1.8	2.0	2.2	1.8	2.1	2.3	2.6	Pheasant - Grouse Cress
P-1434-1372	1.2	1.6	1.8	2.0	2.2	1.6	1.8	2.0	2.2	1.8	2.1	2.3	2.5	Pheasant - Grouse Cress
P-1436-1430	0.7	0.9	1.1	1.2	1.3	0.9	1.1	1.2	1.3	1.0	1.2	1.3	1.4	Pheasant - Grouse Cress
P-1437-1436	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1438-1437	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1439-1438	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1440-1439	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1441-1442	1.2	1.6	1.9	2.0	2.2	1.6	1.9	2.0	2.2	1.8	2.1	2.3	2.6	Pheasant - Grouse Cress
D-1442-1450	1.2	1.6	1.9	2.0	2.2	1.6	1.9	2.0	2.2	1.8	2.1	2.3	2.6	Pheasant - Grouse Cress
D-1443-1440	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1446-1443	0.5	0.8	0.9	1.0	1.2	0.8	0.9	1.0	1.2	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1447-1446	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1448-1447	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1449-1441	0.5	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.9	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1450-1431	1.2	1.6	1.8	2.0	2.2	1.6	1.8	2.0	2.2	1.8	2.1	2.3	2.6	Pheasant - Grouse Cress
P-1460-1457	3.8	5.3	6.1	6.4	6.8	5.3	6.1	6.4	6.8	5.5	6.3	6.7	7.1	Pheasant - Grouse Cress
D-1239-1240	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1240-1241	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1241-1242	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1242-1243	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1243-1451	0.7	0.8	1.0	1.1	1.2	0.8	1.0	1.1	1.2	0.8	1.0	1.1	1.2	Deer Trail Area
P-1451-1457	9.2	16.7	18.2	18.9	19.8	16.7	18.2	18.9	19.8	18.9	21.6	22.7	23.9	Deer Trail Area
D-1452-1451	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1453-1452	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1454-1453	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1457-1483	10.6	22.0	24.2	25.3	26.6	22.4	24.8	26.0	27.3	24.4	28.5	30.1	31.7	Deer Trail Area
D-1463-1464	0.3	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	Deer Trail Area
P-1464-1467	0.3	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	Deer Trail Area
P-1467-1481	0.6	0.9	1.0	1.1	1.3	0.9	1.0	1.1	1.3	0.8	1.0	1.1	1.3	Deer Trail Area
D-1468-1477	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1469-1472	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Deer Trail Area
P-1472-1473	0.2	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
D-1473-1474	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
P-1474-1475	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
D-1475-1476	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
P-1476-1478	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
P-1477-1467	0.3	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.6	Deer Trail Area
P-1478-1479	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
P-1479-1481	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Deer Trail Area
D-1481-1356	0.7	1.1	1.3	1.4	1.6	0.6	0.7	0.7	0.8	0.5	0.7	0.7	0.8	Deer Trail Area
D-1348-1349	0.0	1.7	4.1	5.6	7.1	2.6	5.7	7.1	8.6	5.5	9.7	11.7	13.7	Birch Bay Drive East at Deer Trail
OF-1348-1354A	0.0	1.7	4.1	5.6	7.1	2.6	5.7	7.1	8.6	5.5	9.7	11.7	13.7	Birch Bay Drive East at Deer Trail
OF-1349-1350	0.0	1.1	3.2	4.6	6.1	1.8	4.7	6.0	7.5	4.5	8.6	10.5	12.5	Birch Bay Drive East at Deer Trail
P-1349-1350	0.1	0.7	0.9	1.0	1.1	0.8	1.0	1.1	1.1	1.0	1.2	1.2	1.3	Birch Bay Drive East at Deer Trail
D-1350-1351	1.1	1.3	3.4	4.6	5.9	2.1	4.7	5.9	7.3	4.4	8.3	10.0	11.7	Birch Bay Drive East at Deer Trail
OF-1351-1352	0.0	0.0	0.8	1.9	3.2	0.0	2.0	3.2	4.5	1.7	5.5	7.2	8.9	Birch Bay Drive East at Deer Trail
P-1351-1352	1.1	1.4	2.6	2.7	2.7	2.1	2.7	2.7	2.8	2.7	2.8	2.8	2.8	Birch Bay Drive East at Deer Trail
D-1352-1353	1.1	2.0	3.7	4.7	5.9	2.9	4.8	5.9	7.3	4.4	8.3	10.0	11.7	Birch Bay Drive East at Deer Trail
P-1353-1354_1	10.5	19.8	20.9	21.1	21.3	20.3	21.2	21.3	21.4	21.1	21.5	21.6	21.7	Birch Bay Drive East at Deer Trail
D-1483-1355	10.7	22.2	24.6	25.9	27.2	23.4	26.0	27.2	28.7	25.5	29.8	31.6	33.4	Birch Bay Drive East at Deer Trail
D-1355-1353	10.6	22.1	24.5	25.8	27.2	23.3	26.0	27.2	28.7	25.5	29.8	31.6	33.4	Birch Bay Drive East at Deer Trail
P-1339-1335	1.3	1.4	1.7	1.9	2.1	1.4	1.7	1.9	2.1	2.9	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
P-1340-1347	1.3	1.4	1.7	1.9	2.1	1.4	1.7	1.9	2.1	2.9	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
D-1346-1340	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	Birch Bay Drive East at Deer Trail
P-1347-1339	1.3	1.4	1.7	1.9	2.1	1.4	1.7	1.9	2.1	2.9	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
D-1356-1357	1.7	2.6	3.2	3.5	3.8	1.6	2.0	2.2	2.4	2.0	2.4	2.6	2.9	Birch Bay Drive West at Deer Trail
P-1357-1358	1.7	2.6	3.0	3.3	3.6	1.6	1.9	2.1	2.3	1.9	2.3	2.5	2.7	Birch Bay Drive West at Deer Trail
D-1358-1359	1.7	2.5	3.0	3.3	3.6	1.6	1.9	2.1	2.3	1.9	2.2	2.4	2.7	Birch Bay Drive West at Deer Trail
P-1359-1360	1.7	2.5	3.0	3.3	3.6	1.6	1.9	2.1	2.3	1.9	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
D-1360-1361	1.7	2.5	3.0	3.3	3.6	1.6	1.9	2.0	2.2	1.9	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
P-1361-1365	2.6	4.0	4.7	5.1	5.6	3.2	3.7	4.0	4.4	3.7	4.3	4.6	5.1	Birch Bay Drive West at Deer Trail
D-1362-1361	1.0	1.5	1.8	1.9	2.1	1.6	1.9	2.0	2.2	1.8	2.1	2.3	2.6	Birch Bay Drive West at Deer Trail
P-1363-1362	1.0	1.5	1.7	1.9	2.0	1.6	1.9	2.0	2.2	1.8	2.1	2.3	2.5	Birch Bay Drive West at Deer Trail
D-1364-1363	1.0	1.5	1.8	2.0	2.2	1.6	1.9	2.1	2.2	1.9	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
D-1171-1172	0.4	1.0	1.2	1.3	1.4	1.0	1.2	1.3	1.4	1.2	1.5	1.6	1.8	Richmond Park - Richmond Park Road South
P-1172-1173	0.5	1.1	1.3	1.4	1.6	1.1	1.3	1.4	1.6	1.4	1.6	1.8	2.0	Richmond Park - Richmond Park Road South
P-1173-1181	0.7	1.2	1.5	1.6	1.8	1.2	1.5	1.6	1.8	1.5	1.8	2.0	2.2	Richmond Park - Richmond Park Road South
D-1180-1184	0.9	1.5	1.8	1.9	2.2	1.5	1.8	1.9	2.2	1.7	2.1	2.3	2.5	Richmond Park - Richmond Park Road South
P-1181-1180	0.8	1.3	1.6	1.8	2.0	1.3	1.6	1.8	2.0	1.6	1.9	2.1	2.3	Richmond Park - Richmond Park Road South
P-1182-1188	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	Richmond Park - Richmond Park Road South
D-1184-1451	9.1	16.3	17.7	18.4	19.2	16.3	17.6	18.3	19.2	18.7	21.3	22.3	23.3	Richmond Park - Richmond Park Road South
P-1188-1189	0.2	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	Richmond Park - Richmond Park Road South
D-1189-1192	0.3	0.4	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.5	Richmond Park - Richmond Park Road South
P-1190-1184	9.0	14.8	16.3	17.7	18.2	14.7	16.3	17.7	18.2	18.3	19.3	20.0	20.7	Richmond Park - Richmond Park Road South
D-1191-1190	9.0	14.7	16.3	17.7	18.2	14.6	16.3	17.7	18.2	18.3	19.2	19.8	20.5	Richmond Park - Richmond Park Road South
P-1192-1191	0.5	0.6	0.7	0.8	0.9	0.6	0.7	0.8	0.9	0.6	0.7	0.8	0.9	Richmond Park - Richmond Park Road South
D-1193-1192	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	Richmond Park - Richmond Park Road South
D-1194-1191	8.9	14.0	16.2	17.6	18.1	14.0	16.2	17.6	18.1	18.2	18.9	19.2	20.2	Richmond Park - Richmond Park Road North
P-1195-1194	8.9	13.9	16.2	17.5	18.1	13.9	16.2	17.5	18.1	18.2	18.9	19.2	20.1	Richmond Park - Richmond Park Road North
P-1196-1221	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	Richmond Park - Richmond Park Road North
O-1197-1221	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Richmond Park - Richmond Park Road North
P-1197-1196	8.7	13.6	16.0	17.4	18.0	13.6	16.0	17.4	18.0	18.0	18.7	19.0	19.3	Richmond Park - Richmond Park Road North
D-1198-1197	8.7	12.3	13.6	14.0	14.6	12.3	13.5	14.0	14.6	14.7	15.3	15.2	15.2	Richmond Park - Richmond Park Road North
P-1199-1198	8.7	12.2	13.3	13.9	14.4	12.2	13.3	13.9	14.4	14.6	15.2	15.1	15.0	Richmond Park - Richmond Park Road North
D-1200-1199	8.7	12.5	13.4	13.9	14.5	12.6	13.3	13.9	14.5	14.6	15.2	15.1	14.9	Richmond Park - Richmond Park Road North
P-1201-1200	8.7	12.2	13.3	13.8	14.4	12.2	13.2	13.8	14.4	14.5	15.1	15.4	16.0	Richmond Park - Richmond Park Road North
P-1202-1205	8.6	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	Richmond Park - Richmond Park Road North
O-1203-1205	0.0	0.1	2.4	5.2	8.1	0.1	2.4	5.2	8.1	8.4	10.0	9.8	12.5	Richmond Park - Richmond Park Road North
P-1203-1202	8.6	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	Richmond Park - Richmond Park Road North
D-1204-1203	8.6	13.4	13.9	13.9	13.7	13.4	13.9	13.9	13.7	13.8	13.6	13.6	13.8	Richmond Park - Richmond Park Road North
D-1204A-1204B	0.7	2.6	2.9	3.2	3.5	2.6	3.0	3.2	3.6	4.4	5.0	4.9	26.6	
D-1204B-1204A	0.7	2.1	2.3	4.2	4.6	2.1	2.3	4.2	4.6	4.9	4.3	4.4	5.6	Richmond Park - Richmond Park Road North
OF-1204B-1207	0.0	0.0	3.0	5.0	5.0	0.0	3.0	5.0	5.0	5.1	5.3	5.3	8.0	Richmond Park - Richmond Park Road North
D-1205-1201	8.7	12.2	13.2	13.8	14.4	12.2	13.2	13.8	14.4	14.5	15.1	15.4	19.2	Richmond Park - Richmond Park Road North
P-1206-1205	0.5	1.2	1.4	1.6	1.7	1.2	1.4	1.6	1.7	1.8	1.9	1.9	2.0	Richmond Park - Richmond Park Road North

Table A-5 Birch Point Drainage Study - Peak Flow Summary														
		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	Location
D-1207-1206	0.4	1.9	1.8	1.7	1.8	1.9	1.8	1.7	1.8	1.8	1.8	1.9	2.0	Richmond Park - Richmond Park Road North
P-1208-1207	0.3	1.3	2.6	3.4	3.5	1.3	2.6	3.4	3.5	3.5	3.7	3.7	3.6	Richmond Park - Richmond Park Road North
D-1209-1208	0.3	1.3	2.9	3.6	3.7	1.3	2.7	3.5	3.7	3.7	3.8	3.8	3.7	Richmond Park - Richmond Park Road North
P-1210-1209	0.3	1.3	2.7	3.5	3.6	1.3	2.7	3.5	3.6	3.6	3.7	3.7	3.8	Richmond Park - Richmond Park Road North
D-1211-1210	0.2	1.3	2.7	3.5	3.6	1.3	2.7	3.5	3.6	3.6	3.7	4.5	6.2	Richmond Park - Richmond Park Road North
P-1220-1221	0.6	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	0.8	0.9	1.0	1.1	Richmond Park - Richmond Park Road North
D-1221-1195	8.9	13.9	16.2	17.5	18.1	13.8	16.2	17.5	18.1	18.1	18.8	19.2	19.7	Richmond Park - Richmond Park Road North
D-1222-1220	0.5	0.6	0.8	0.8	0.9	0.6	0.8	0.8	0.9	0.6	0.8	0.8	0.9	Richmond Park - Richmond Park Road North
P-1227-1228	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	Richmond Park - Richmond Crescent
P-1228-1229	0.2	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	Richmond Park - Richmond Crescent
D-1229-1230	0.3	0.4	0.5	0.5	0.6	0.4	0.5	0.5	0.6	0.4	0.5	0.5	0.6	Richmond Park - Richmond Crescent
D-1230-1222	0.4	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.8	Richmond Park - Richmond Crescent
D-1272-1275	5.3	12.0	13.5	14.3	15.2	12.0	13.5	14.3	15.2	12.7	14.2	15.0	15.9	Shintaffer north of Semiahmoo Parkway
D-1272A-1272	1.0	2.0	2.4	2.7	3.0	2.0	2.4	2.7	3.0	2.2	2.7	3.0	3.3	
D-1273-1272	4.8	10.1	11.3	11.9	12.5	10.1	11.3	11.9	12.5	10.7	11.8	12.4	13.0	Shintaffer north of Semiahmoo Parkway
O-1274-1273	0.0	4.0	5.0	5.5	6.1	4.0	5.0	5.5	6.1	4.5	5.5	6.0	6.5	Shintaffer north of Semiahmoo Parkway
P-1274-1273	4.6	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	Shintaffer north of Semiahmoo Parkway
O-1275-1276	0.0	6.0	7.6	8.4	9.3	6.0	7.6	8.4	9.3	6.7	8.3	9.1	10.0	Shintaffer north of Semiahmoo Parkway
P-1275-1276	5.1	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.1	6.1	6.0	Shintaffer north of Semiahmoo Parkway
D-1276-1298	5.5	13.3	15.1	16.0	17.5	13.3	15.1	16.0	17.2	14.5	16.0	17.0	18.1	Shintaffer north of Semiahmoo Parkway
D-1277A-1277	3.2	5.9	7.2	7.9	8.8	5.9	7.2	7.9	8.8	6.5	7.9	8.7	9.6	
O-1277-1278	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Shintaffer north of Semiahmoo Parkway
P-1277-1278	2.2	4.9	5.7	6.0	6.4	4.9	5.7	6.0	6.4	5.3	6.0	6.3	6.7	Shintaffer north of Semiahmoo Parkway
D-1278-1279	2.2	4.9	5.7	6.0	6.4	4.9	5.7	6.0	6.4	5.3	6.0	6.3	6.7	Shintaffer north of Semiahmoo Parkway
D-1279-1274	5.0	9.4	10.4	10.9	11.4	9.4	10.4	10.9	11.4	9.9	10.8	11.3	11.8	Shintaffer north of Semiahmoo Parkway
O-1281-1280	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Shintaffer north of Semiahmoo Parkway
P-1281-1280	2.8	4.5	4.8	4.9	5.0	4.5	4.8	4.9	5.0	4.6	4.9	5.0	5.1	Shintaffer north of Semiahmoo Parkway
P-1284-1296	11.1	20.6	23.1	24.4	27.7	17.0	19.5	20.8	23.0	25.2	28.5	33.2	33.2	Shintaffer north of Semiahmoo Parkway
D-1298-1284	5.5	13.3	15.1	16.0	16.9	13.3	15.1	16.0	16.8	20.4	22.3	22.9	22.7	Shintaffer north of Semiahmoo Parkway
D-1308-1281	2.8	5.1	5.9	6.4	7.0	5.1	5.9	6.4	7.0	5.5	6.4	6.9	7.5	Shintaffer north of Semiahmoo Parkway
O-1309-1308	0.0	2.9	4.2	4.9	5.7	2.9	4.2	4.9	5.7	3.5	4.8	5.6	6.3	Shintaffer north of Semiahmoo Parkway
P-1309-1308	2.8	4.5	4.7	4.8	4.8	4.5	4.7	4.8	4.8	4.6	4.8	4.8	4.9	Shintaffer north of Semiahmoo Parkway
D-1310-1309	0.4	0.6	0.7	0.7	0.8	0.6	0.7	0.7	0.8	0.7	0.7	0.8	0.9	Shintaffer north of Semiahmoo Parkway
P-1311-1310	0.4	0.8	0.9	1.1	1.2	0.8	0.9	1.1	1.2	0.9	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
P-1316-1317	0.4	0.8	1.0	1.1	1.2	0.8	1.0	1.1	1.2	0.9	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
D-1317-1311	0.4	0.8	0.9	1.1	1.2	0.8	0.9	1.1	1.2	0.9	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
D-1253-1332	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
D-1254-1258	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
D-1256-1330	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.3	17.3	19.6	Semiahmoo Parkway
D-1257-1329	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.3	17.2	19.5	Semiahmoo Parkway
D-1258-1256	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
P-1259-1260	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.2	17.0	19.2	Semiahmoo Parkway
D-1260-1263	0.0	0.0	0.0	0.0	0.0	4.6	6.2	7.2	8.4	11.9	15.2	17.0	19.2	Semiahmoo Parkway
P-1261-1262	0.0	0.0	0.1	0.1	0.1	3.9	4.0	4.1	4.2	5.1	5.3	5.4	5.5	Semiahmoo Parkway
D-1262-1268	0.0	0.0	0.1	0.1	0.1	3.9	4.0	4.1	4.2	5.1	5.3	5.4	5.5	Semiahmoo Parkway
D-1263-1264	5.7	8.4	10.3	11.3	12.5	4.5	6.2	7.1	8.4	11.8	15.1	16.9	19.1	Semiahmoo Parkway
O-1264-1265	5.4	8.1	9.8	10.8	12.0	4.3	5.8	6.7	7.9	11.3	14.5	16.3	18.5	Semiahmoo Parkway
P-1264-1265	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	Semiahmoo Parkway
D-1265-1266	5.5	8.2	10.0	11.0	12.2	4.4	6.0	6.9	8.1	11.6	14.8	16.6	18.9	Semiahmoo Parkway
P-1266-1267	5.2	8.0	9.7	10.6	11.7	4.2	5.7	6.6	7.8	11.1	13.7	15.2	16.9	Semiahmoo Parkway
D-1267-1284	6.3	9.9	12.0	13.1	14.5	6.1	8.0	9.1	10.5	14.9	18.2	20.0	22.2	Semiahmoo Parkway
P-1268-1269	0.0	0.0	0.1	0.1	0.1	3.8	3.9	4.0	4.1	5.0	5.2	5.3	5.4	Semiahmoo Parkway
D-1269-1270	0.0	0.0	0.1	0.1	0.1	3.8	3.9	4.0	4.1	5.0	5.2	5.3	5.4	Semiahmoo Parkway
P-1270-1271	0.0	0.0	0.1	0.1	0.1	3.8	3.9	4.0	4.1	5.0	5.2	5.3	5.4	Semiahmoo Parkway
D-1271-1286	0.0	0.0	0.1	0.1	0.1	3.8	3.9	4.0	4.1	5.0	5.2	5.3	5.5	Semiahmoo Parkway
P-1286-1297	0.0	0.0	0.1	0.1	0.1	3.8	3.9	4.0	4.1	5.0	5.1	5.3	5.4	Semiahmoo Parkway
P-1297-1296	0.0	0.1	0.1	0.1	0.1	3.8	3.9	4.0	4.0	5.0	5.1	5.3	5.4	Semiahmoo Parkway
D-1327-1259	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.2	17.0	19.2	Semiahmoo Parkway
D-1328-1327	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.2	17.1	19.2	Semiahmoo Parkway
D-1329-1328	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.3	17.2	19.4	Semiahmoo Parkway
D-1330-1257	0.0	0.0	0.0	0.0	0.0	4.6	6.3	7.2	8.4	11.9	15.3	17.2	19.6	Semiahmoo Parkway
D-1331-1261	0.0	0.0	0.0	0.0	0.0	3.9	4.0	4.1	4.1	5.0	5.2	5.3	5.4	Semiahmoo Parkway
D-1332-1333	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
D-1333-1331	0.0	0.0	0.0	0.0	0.0	3.9	4.0	4.1	4.1	5.0	5.2	5.3	5.4	Semiahmoo Parkway
D-1291-1318	10.9	21.4	23.9	25.3	28.8	21.5	24.1	25.6	37.9	33.0	35.0	36.7	36.8	Shintaffer North of Richmond Park - West Side
P-1296-1291	11.1	20.6	23.1	24.5	27.8	20.8	23.3	24.7	27.1	30.1	33.6	35.2	35.2	Shintaffer North of Richmond Park - West Side
D-1318-1326	10.9	21.2	23.7	25.1	28.4	21.4	24.0	25.4	27.6	30.5	33.7	35.2	35.0	Shintaffer North of Richmond Park - West Side
D-1326-1324_1	10.9	21.2	23.8	24.9	27.4	21.4	24.0	25.2	26.8	29.6	32.1	33.2	33.5	Shintaffer North of Richmond Park - West Side
Rich_Field_1	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	Shintaffer North of Richmond Park - West Side
D-1326-1324_2	10.3	21.0	23.3	24.3	26.7	21.2	23.5	24.6	26.1	29.0	31.4	32.3	32.7	Shintaffer North of Richmond Park - West Side
D-1326-1324_3	9.2	21.0	23.0	23.9	26.0	21.1	23.3	24.2	25.5	26.6	26.7	24.2	23.2	Shintaffer North of Richmond Park - West Side
D-1326-1324_4	7.8	12.2	12.5	12.6	12.8	12.2	12.5	12.7	12.9	12.3	11.9	12.0	12.0	Shintaffer North of Richmond Park - West Side
D-1319-1320	0.0	0.2	0.4	0.5	0.7	0.2	0.4	0.5	0.7	0.3	0.6	0.9	6.2	Middle Shintaffer
P-1320-1321	0.0	0.6	0.8	1.0	1.6	0.6	0.8	1.0	1.6	0.8	1.4	1.7	2.0	Middle Shintaffer
D-1321-1322	0.8	1.9	2.1	7.0	13.7	1.9	2.1	2.2	13.6	2.1	2.3	2.4	6.2	Middle Shintaffer
P-1322-1323	0.8	1.6	1.8	1.9	2.2	1.6	1.8	1.9	2.2	1.8	2.2	2.3	2.4	Middle Shintaffer
D-1323-1237_1	0.6	1.2	1.8	2.0	2.3	1.2	1.8	2.0	2.3	1.5	3.1	128.4	96.4	Middle Shintaffer
D-1323-1326C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	11.1	17.0	Middle Shintaffer
D-1323-1237_2	0.6	4.3	5.7	6.3	7.1	4.3	5.7	6.3	7.1	5.1	6.5	20.0	13.9	Middle Shintaffer
D-1324-1204	7.4	10.2	10.2	10.3	10.4	10.3	10.3	10.3	10.4	9.7	9.6	9.5	9.4	Middle Shintaffer
OF-1324-1205	0.0	0.0	0.0	0.3	1.5	0.0	0.0	0.2	1.5	1.8	4.1	4.6	6.7	Middle Shintaffer
O-1235-1238	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	Middle Shintaffer
P-1235-1238	1.5	2.4	2.5	2.5	2.6	2.4	2.5	2.5	2.6	2.5	2.9	3.1	3.4	Middle Shintaffer
D-1236-1235	1.5	2.4	2.5	2.5	2.6	2.4	2.5	2.5	2.6	2.5	2.9	3.1	3.5	Middle Shintaffer
O-1237-1236	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	Middle Shintaffer
P-1237-1236	1.5	2.4	2.5	2.5	2.6	2.4	2.5	2.5	2.6	2.5	2.9	3.1	3.3	Middle Shintaffer
D-1238-1246	1.4	2.5	2.6	2.6	2.7	2.5	2.6	2.6	2.7	2.6	2.9	3.0	3.0	Middle Shintaffer
P-1292-1293	0.1	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.2	Middle Shintaffer
D-1293-1326	0.2	0.5	0.6	0.7	0.7	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.2	Middle Shintaffer
D-1294-1325	0.1	0.6	0.7	0.8	0.9	0.6	0.7	0.8	0.9	0.9	1.1	1.2	1.4	Middle Shintaffer
P-1295-1294	0.2	0.6	0.7	0.8	0.9	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	Middle Shintaffer
D-1300-1295	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
D-1325-1292	0.1	0.5	0.7	0.7	0.7	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.2	Middle Shintaffer
O-507-500A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-501-500	2.7	4.4	4.8	5.0	5.2	4.4	4.8	5.0	5.2	4.6	4.9	5.2	5.4	Lower Shintaffer
P-505-501	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-507-501	2.7	4.4	4.8	5.0	5.2	4.4	4.8	5.0	5.2	4.6	4.9	5.2	5.4	Lower Shintaffer
D-508-510	2.7	4.4	4.8	5.0	5.2	4.4	4.8	5.0	5.2	4.6	4.9	5.2	5.4	Lower Shintaffer
O-509-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-509-508	2.7	4.4	4.8	5.0	5.2	4.4	4.8	5.0	5.2	4.6	4.9	5.2	5.4	Lower Shintaffer

Table A-5
Birch Point Drainage Study - Peak Flow Summary

		Existing Conditions				ing Conditions with Rogers Slough Structure Rem				Future Conditions				
		Peak Flow (cfs)				Peak Flow (cfs)				Peak Flow (cfs)				
Conduit	Flood Elev	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	imate Chang	25 Year	100 Year	Nov-21	limate Chang	Location
D-510-507	2.7	4.4	4.8	5.0	5.2	4.4	4.8	5.0	5.2	4.6	4.9	5.2	5.4	Lower Shintaffer
O-511-508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-511-509	1.6	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	Lower Shintaffer
P-514-511	1.6	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	Lower Shintaffer
P-518-514	1.6	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	2.3	2.7	2.9	3.2	Lower Shintaffer
D-519-518	0.6	0.9	1.1	1.3	1.5	0.9	1.1	1.3	1.5	0.9	1.1	1.3	1.5	Lower Shintaffer
P-520-519	0.6	0.8	1.1	1.2	1.4	0.8	1.1	1.2	1.4	0.8	1.1	1.2	1.4	Lower Shintaffer
D-521-520	0.5	0.6	0.8	0.9	1.1	0.6	0.8	0.9	1.1	0.6	0.8	0.9	1.1	Lower Shintaffer
P-522-521	0.3	0.4	0.5	0.6	0.7	0.4	0.5	0.6	0.7	0.4	0.5	0.6	0.7	Lower Shintaffer
O-525-524	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-523-524	1.8	2.9	3.0	3.0	3.1	2.9	3.0	3.0	3.1	3.0	3.2	3.3	3.5	Lower Shintaffer
D-524-525	1.8	2.9	3.0	3.0	3.1	2.9	3.0	3.0	3.1	3.0	3.2	3.3	3.5	Lower Shintaffer
O-525-527	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-525-526	1.8	2.9	3.0	3.0	3.1	2.9	3.0	3.0	3.1	3.0	3.2	3.3	3.5	Lower Shintaffer
D-527-509	1.8	2.9	3.0	3.1	3.1	2.9	3.0	3.1	3.1	3.0	3.2	3.3	3.5	Lower Shintaffer
D-1244-522	0.1	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	Lower Shintaffer
D-1245-523	1.8	2.8	2.9	3.0	3.0	2.8	2.9	3.0	3.0	2.9	3.2	3.3	3.5	Lower Shintaffer
O-1246-1245	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-1246-1245	1.8	2.8	2.9	2.9	2.9	2.8	2.9	2.9	2.9	2.9	3.2	3.3	3.5	Lower Shintaffer
BP21aPond_Out	3.0	5.2	5.5	5.6	5.8	5.2	5.5	5.6	5.8	6.6	7.3	7.7	8.1	Semiahmoo Uplands
6	23.5	29.9	36.0	39.5	43.8	29.9	36.0	39.5	43.8	39.1	47.2	51.9	57.8	
FieldPond1Out	22.8	33.1	39.8	43.7	48.4	33.1	39.8	43.7	48.4	46.7	56.1	61.5	68.0	Semiahmoo Uplands
SU-1_3	0.8	2.1	2.9	3.4	4.0	2.1	2.9	3.4	4.0	7.7	9.7	10.7	12.0	
SU-1b-Oit	0.7	3.1	3.4	3.5	3.7	3.5	3.9	4.0	4.2	3.9	4.3	4.5	4.7	Semiahmoo Uplands
92603	19.4	19.4	19.6	17.2	20.0	18.9	14.6	20.3	20.0	23.8	27.7	29.9	32.4	Horizon Pond
92604	14.5	14.5	14.8	17.2	20.0	14.2	14.6	17.2	20.0	23.8	27.7	29.9	32.4	
92606	8.0	8.1	9.9	10.9	12.1	8.1	9.9	10.9	12.1	25.1	30.4	33.4	37.2	
PD63_OF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Horizon Pond
SM723	0.0	3.6	3.9	4.0	4.1	3.6	3.9	4.0	4.1	3.8	4.0	4.1	4.3	Horizon Pond
Lake6_Out	23.1	29.9	36.0	39.5	43.9	29.9	36.0	39.5	43.9	39.2	47.3	51.9	57.8	Semiahmoo Golf Course
Lake9_Out	2.6	5.7	6.7	7.3	7.9	5.7	6.7	7.3	7.9	7.2	8.4	9.1	9.9	Semiahmoo Golf Course
Lake12_Out	0.3	1.8	2.4	2.8	3.3	1.8	2.4	2.8	3.3	7.0	8.8	9.6	10.8	Semiahmoo Golf Course
Lake18_Out	0.3	3.0	3.5	3.8	4.1	3.0	3.5	3.8	4.1	3.6	4.1	4.3	4.5	Semiahmoo Golf Course
SU-2_1	5.1	12.9	15.5	16.9	18.7	12.9	15.4	16.9	18.7	20.5	24.7	27.0	29.9	Bay Ridge Estates

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
LDES2448	112.1	110.38	110.44	110.52	-1.7	-1.66	-1.58	110.41	110.48	110.56	-1.7	-1.62	-1.54	Birch Point Road West of Selder
LDES2449	111.2	109.73	109.75	109.77	-1.5	-1.45	-1.43	109.74	109.76	109.78	-1.5	-1.44	-1.42	Birch Point Road West of Selder
LDES2456	80.0	76.39	76.44	76.49	-3.6	-3.56	-3.51	76.42	76.47	76.52	-3.6	-3.53	-3.48	Birch Point Road West of Selder
LDES2457	77.6	75.02	75.03	75.05	-2.6	-2.57	-2.55	75.03	75.04	75.05	-2.6	-2.56	-2.55	Birch Point Road West of Selder
LDES2463	50.3	48.20	48.20	49.61	-2.1	-2.10	-0.69	50.01	50.30	50.30	-0.3	0.00	0.00	Birch Point Road West of Selder
LDES2464	51.1	46.29	47.73	49.60	-4.8	-3.37	-1.50	50.01	50.57	50.95	-1.1	-0.53	-0.15	Birch Point Road West of Selder
LDES2470	51.1	46.58	47.87	49.75	-4.5	-3.23	-1.35	50.16	50.87	51.34	-0.9	-0.23	0.24	Birch Point Road West of Selder
Od1010_3	55.3	51.72	51.82	51.93	-3.6	-3.48	-3.37	51.82	51.92	51.99	-3.5	-3.38	-3.31	Birch Point Road West of Selder
OD1010-1	62.3	61.92	61.94	61.96	-0.4	-0.36	-0.34	61.93	61.95	61.98	-0.4	-0.35	-0.32	Birch Point Road West of Selder
OD1010-2	59.4	56.86	56.96	57.07	-2.5	-2.44	-2.33	56.97	57.06	57.13	-2.4	-2.34	-2.27	Birch Point Road West of Selder
TT1018	117.0	115.36	115.38	115.40	-1.6	-1.62	-1.60	115.37	115.39	115.41	-1.6	-1.61	-1.59	Birch Point Road West of Selder
TT1019	72.0	68.00	68.00	68.00	-4.0	-4.00	-4.00	68.00	68.00	68.00	-4.0	-4.00	-4.00	Birch Point Road West of Selder
2886	28.1	26.65	26.99	27.54	-1.5	-1.11	-0.56	27.76	27.97	28.07	-0.3	-0.13	-0.03	Birch Point Road West of Selder
2887	39.1	36.32	36.42	36.67	-2.8	-2.68	-2.43	36.91	37.11	37.34	-2.2	-1.99	-1.76	Birch Point Road West of Selder
2888	29.4	25.31	25.45	25.66	-4.1	-3.95	-3.74	25.79	26.24	26.36	-3.6	-3.16	-3.04	Birch Point Road West of Selder
LDES2482	46.3	44.25	44.30	44.41	-2.1	-2.00	-1.89	44.50	44.58	44.66	-1.8	-1.72	-1.64	Birch Point Road West of Selder
LDES2490	52.2	51.10	51.10	51.10	-1.1	-1.10	-1.10	51.10	51.10	51.10	-1.1	-1.10	-1.10	Birch Point Road West of Selder
LDES2491	52.2	50.80	50.80	50.80	-1.4	-1.40	-1.40	50.80	50.80	50.80	-1.4	-1.40	-1.40	Birch Point Road West of Selder
LDES2498	36.0	34.02	34.06	34.15	-2.0	-1.94	-1.85	34.23	34.29	34.36	-1.8	-1.71	-1.64	Birch Point Road West of Selder
LDES2502	28.7	27.27	27.59	28.20	-1.4	-1.11	-0.50	28.46	28.60	28.68	-0.2	-0.10	-0.02	Birch Point Road West of Selder
LDES2503	28.0	24.88	24.94	25.03	-3.1	-3.06	-2.97	25.07	25.14	25.34	-2.9	-2.86	-2.66	Birch Point Road West of Selder
LDES2508	30.2	27.32	27.62	28.20	-2.9	-2.58	-2.00	28.46	28.60	28.68	-1.7	-1.60	-1.52	Birch Point Road West of Selder
LDES2509	30.2	27.27	27.59	28.19	-2.9	-2.61	-2.01	28.45	28.59	28.66	-1.8	-1.61	-1.54	Birch Point Road West of Selder
LDES2516	27.8	27.10	27.50	28.16	-0.7	-0.30	0.36	28.42	28.54	28.60	0.6	0.74	0.80	Birch Point Road West of Selder
LDES2521	27.8	25.30	25.44	25.64	-2.5	-2.36	-2.16	25.76	26.24	26.36	-2.0	-1.56	-1.44	Birch Point Road West of Selder
OD1020-1	53.4	53.09	53.17	53.27	-0.3	-0.23	-0.13	53.35	53.40	53.45	0.0	0.00	0.05	Birch Point Road West of Selder
OD1020-2	53.4	53.19	53.29	53.39	-0.2	-0.11	-0.01	53.47	53.51	53.55	0.1	0.11	0.15	Birch Point Road West of Selder
OD1020-3	53.3	52.50	52.57	52.69	-0.8	-0.73	-0.61	52.80	52.86	52.92	-0.5	-0.44	-0.38	Birch Point Road West of Selder
OF-TT6	29.4	23.66	23.67	23.69	-5.7	-5.73	-5.71	23.70	23.72	23.73	-5.7	-5.68	-5.67	Birch Point Road West of Selder
TT1020	52.2	50.46	50.55	50.71	-1.7	-1.65	-1.49	50.87	50.99	51.12	-1.3	-1.21	-1.08	Birch Point Road West of Selder
TT1021	52.2	51.60	51.60	51.60	-0.6	-0.60	-0.60	51.60	51.60	51.60	-0.6	-0.60	-0.60	Birch Point Road West of Selder
TT1022	52.2	48.99	49.07	49.25	-3.2	-3.13	-2.95	49.40	49.50	49.61	-2.8	-2.70	-2.59	Birch Point Road West of Selder
TT1023	28.0	25.15	25.27	25.42	-2.9	-2.73	-2.58	25.49	25.67	25.72	-2.5	-2.33	-2.28	Birch Point Road West of Selder
35701	53.4	51.86	51.86	51.86	-1.5	-1.54	-1.54	52.02	52.15	52.25	-1.4	-1.25	-1.15	Bay Ridge Estates - West Shoreview Road
35702	53.3	52.25	52.27	52.28	-1.1	-1.03	-1.02	52.26	52.27	52.28	-1.0	-1.03	-1.02	Bay Ridge Estates - West Shoreview Road
35711	53.3	52.25	52.27	52.28	-1.1	-1.03	-1.02	52.26	52.27	52.28	-1.0	-1.03	-1.02	Bay Ridge Estates - West Shoreview Road
35712	52.8	52.25	52.26	52.26	-0.5	-0.54	-0.54	52.25	52.26	52.26	-0.5	-0.54	-0.54	Bay Ridge Estates - West Shoreview Road
35721	52.2	52.25	52.26	52.26	0.0	0.06	0.06	52.25	52.26	52.26	0.0	0.06	0.06	Bay Ridge Estates - West Shoreview Road
10001	53.8	53.55	53.55	53.55	-0.2	-0.20	-0.20	53.55	53.55	53.55	-0.2	-0.20	-0.20	Bay Ridge Estates - West Shoreview Road
35861	52.1	51.02	51.09	51.25	-1.1	-1.01	-0.85	51.27	51.28	51.39	-0.8	-0.82	-0.71	Bay Ridge Estates - West Shoreview Road
6365	52.8	51.61	51.63	51.73	-1.2	-1.17	-1.07	51.86	52.01	52.31	-0.9	-0.79	-0.49	Bay Ridge Estates - West Shoreview Road
LDES2476	52.1	51.23	51.24	51.29	-0.9	-0.86	-0.81	51.34	51.42	51.56	-0.8	-0.68	-0.54	Bay Ridge Estates - West Shoreview Road
LDES2478	52.7	51.84	51.86	52.00	-0.9	-0.84	-0.70	52.19	52.41	53.09	-0.5	-0.29	0.39	Bay Ridge Estates - West Shoreview Road
35722	52.4	51.39	51.40	51.40	-1.0	-1.00	-1.00	51.40	51.40	51.40	-1.0	-1.00	-1.00	Bay Ridge Estates - East Shoreview Road
35751	51.5	51.39	51.39	51.39	-0.1	-0.11	-0.11	51.39	51.39	51.40	-0.1	-0.11	-0.10	Bay Ridge Estates - East Shoreview Road
35752	52.5	50.88	50.88	50.88	-1.6	-1.62	-1.62	50.88	50.88	50.88	-1.6	-1.62	-1.62	Bay Ridge Estates - East Shoreview Road
35862	51.9	50.90	50.94	50.96	-1.0	-0.96	-0.94	50.94	50.97	50.99	-1.0	-0.93	-0.91	Bay Ridge Estates - East Shoreview Road
6399	50.1	50.06	50.07	50.10	-0.1	-0.05	-0.02	50.06	50.08	50.10	-0.1	-0.04	-0.02	Bay Ridge Estates - East Shoreview Road
6501	49.8	50.22	50.33	50.37	0.4	0.53	0.57	50.33	50.37	50.40	0.5	0.57	0.60	Bay Ridge Estates - East Shoreview Road
6502	49.5	48.56	48.57	48.58	-0.9	-0.89	-0.88	48.56	48.57	48.58	-0.9	-0.89	-0.88	Bay Ridge Estates - East Shoreview Road
6503	49.0	49.61	49.75	49.79	0.6	0.71	0.75	49.75	49.79	49.82	0.7	0.75	0.78	Bay Ridge Estates - East Shoreview Road
6504	49.6	48.08	48.45	48.80	-1.6	-1.19	-0.84	48.46	48.80	49.22	-1.2	-0.84	-0.42	Bay Ridge Estates - East Shoreview Road
6505	48.8	47.29	47.33	47.38	-1.5	-1.42	-1.37	47.33	47.37	47.42	-1.4	-1.38	-1.33	Bay Ridge Estates - East Shoreview Road
6506	50.3	47.71	47.73	47.75	-2.6	-2.58	-2.56	47.71	47.73	47.75	-2.6	-2.58	-2.56	Bay Ridge Estates - East Shoreview Road
7801	50.4	50.88	50.88	50.88	0.5	0.48	0.48	50.88	50.88	50.88	0.5	0.48	0.48	Bay Ridge Estates - East Shoreview Road
7881	50.6	50.90	50.93	50.95	0.3	0.33	0.35	50.94	50.96	50.98	0.3	0.36	0.38	Bay Ridge Estates - East Shoreview Road
35441	52.7	52.74	52.74	52.74	0.0	0.04	0.04	52.74	52.74	52.74	0.0	0.04	0.04	Bay Ridge Estates - Bay Ridge Drive South
35442	52.7	52.25	52.26	52.26	-0.5	-0.46	-0.46	52.25	52.26	52.26	-0.5	-0.46	-0.46	Bay Ridge Estates - Bay Ridge Drive South
35962	51.8	50.68	50.69	50.69	-1.1	-1.11	-1.11	50.69	50.69	50.69	-1.1	-1.11	-1.11	Bay Ridge Estates - Bay Ridge Drive South
6370	34.2	31.48	31.51	31.54	-2.7	-2.65	-2.62	31.54	31.58	31.62	-2.6	-2.58	-2.54	Bay Ridge Estates - Bay Ridge Drive South
6387	52.5	51.46	51.49	51.55	-1.0	-1.01	-0.95	51.50	51.54	51.67	-1.0	-0.96	-0.83	Bay Ridge Estates - Bay Ridge Drive South
6388	52.9	53.42	53.44	53.41	0.5	0.53	0.50	53.43	53.40	53.47	0.5	0.49	0.56	Bay Ridge Estates - Bay Ridge Drive South
6389	52.5	51.45	51.48	51.53	-1.1	-1.04	-0.99	51.48	51.52	51.62	-1.0	-1.00	-0.90	Bay Ridge Estates - Bay Ridge Drive South
6390	53.2	53.25	53.27	53.22	0.0	0.03	-0.02	53.26	53.20	53.32	0.0	-0.04	0.08	Bay Ridge Estates - Bay Ridge Drive South
6398	53.1	53.14	53.17	53.10	0.0	0.07	0.00	53.15	53.08	53.21	0.0	-0.02	0.11	Bay Ridge Estates - Bay Ridge Drive South
7552	52.8	52.78	52.78	52.78	0.0	-0.02	-0.02	52.78	52.78	52.78	0.0	-0.02	-0.02	Bay Ridge Estates - Bay Ridge Drive South
6386	52.8	53.50	53.51	53.51	0.7	0.67	0.67	53.51	53.52	53.53	0.7	0.68	0.69	Bay Ridge Estates - Bay Ridge Drive South
757753	52.8	51.45	51.49	51.55	-1.3	-1.31	-1.25	51.50	51.54	51.69	-1.3	-1.26	-1.11	Bay Ridge Estates - Bay Ridge Drive South
7612	52.8	51.39	51.40	51.40	-1.4	-1.40	-1.40	51.40	51.40	51.40	-1.4	-1.40	-1.40	Bay Ridge Estates - Bay Ridge Drive South
33461	60.6	56.05	56.07	56.10	-4.6	-4.55	-4.52	56.13	56.16	56.20	-4.5	-4.46	-4.42	Bay Ridge Estates - Seawan Place
33571	61.5	59.99	60.02	60.07	-1.5	-1.48	-1.43	60.11	60.19	60.56	-1.4	-1.31	-0.94	Bay Ridge Estates - Seawan Place
33572	61.0	59.44	59.49	59.62	-1.6	-1.51	-1.38	59.65	59.88	60.28	-1.4	-1.12	-0.72	Bay Ridge Estates - Seawan Place
33771	60.8	59.43	59.48	59.61	-1.4	-1.32	-1.19	59.64	59.88	60.27	-1.2	-0.92	-0.53	Bay Ridge Estates - Seawan Place
33772	60.5	58.91	59.04	59.29	-1.6	-1.46	-1.21	59.33	59.57	59.88	-1.2	-0.93	-0.62	Bay Ridge Estates - Seawan Place
33991	60.0	58.91	59.04	59.29	-1.1	-0.96	-0.71	59.33	59.56	59.88	-0.7	-0.44	-0.12	Bay Ridge Estates - Seawan Place
33992	59.2	57.34	57.35	57.36	-1.9	-1.85	-1.84	57.36	57.36	58.15	-1.8	-1.84	-1.05	Bay Ridge Estates - Seawan Place
34341	57.5	56.45	56.61	56.87	-1.1	-0.89	-0.63	56.85	57.08	58.14	-0.6	-0.42	0.64	Bay Ridge Estates - Seawan Place
34342	55.6	54.98	54.99	55.00	-0.6	-0.56	-0.55	55.00	55.01	55.60	-0.5	-0.54	0.05	Bay Ridge Estates - Seawan Place
6385	57.0	54.37	54.38	54.41	-2.6	-2.62	-2.59	54.42	54.45	54.46	-2.6	-2.55	-2.54	Bay Ridge Estates - Seawan Place
7141	56.1	54.67	54.71	54.77	-1.4	-1.40	-1.34	54.76	54.81	55.59	-1.4	-1.30	-0.52	Bay Ridge Estates - Seawan Place
6380	49.8	48.60	48.63	48.67	-1.2	-1.14	-1.10	48.62	48.65	48.71	-1.2	-1.12	-1.06	Bay Ridge Estates - Bay Ridge Drive Middle
6381	51.2	50.27	50.53	50.85	-1.0	-0.70	-0.38	50.69	50.96	51.20	-0.5	-0.27	-0.03	Bay Ridge Estates - Bay Ridge Drive Middle
6383	51.1	50.44	50.73	51.10	-0.6	-0.35	0.02	50.92	51.23	51.49	-0.2	0.15	0.41	Bay Ridge Estates - Bay Ridge Drive Middle
6384	52.5	51.12	51.17	51.24	-1.4	-1.35	-1.28	51.17	51.22	51.38	-1.4	-1.30	-1.14	Bay Ridge Estates - Bay Ridge Drive Middle
6951	50.1	48.37	48.53	48.80	-1.7	-1.54	-1.27	48.59	48.77	49.00	-1.5	-1.30	-1.07	Bay Ridge Estates - Bay Ridge Drive Middle
7042	52.3	51.13	51.14	51.42	-1.2	-1.16	-0.88	51.24	51.59	51.84	-1.1	-0.71	-0.46	Bay Ridge Estates - Bay Ridge Drive Middle
7052	50.8	48.45	48.55	48.81	-2.3	-2.24	-1.98	48.60	48.78	49.01	-2.2	-2.01	-1.78	Bay Ridge Estates - Bay Ridge Drive Middle
7102	51.0	48.79	48.84	48.92	-2.2	-2.16	-2.08	48.83	48.89	49.05	-2.2	-2.11	-1.95	Bay Ridge Estates - Bay Ridge Drive Middle
7201	52.1	48.80	48.84	48.93	-3.3	-3.26	-3.17	48.84	48.90	49.05	-3.3	-3.20	-3.05	Bay Ridge Estates - Bay Ridge Drive Middle
72011	51.6	50.38	50.43	50.49	-1.2	-1.14	-1.08	50.43	50.47	50.57	-1.1	-1.10	-1.00	Bay Ridge Estates - Bay Ridge Drive Middle
7242	51.8	50.70	50.96	51.41	-1.1	-0.84	-0.39	51.22	51.58	51.83	-0.6	-0.22	0.03	Bay Ridge Estates - Bay Ridge Drive Middle
6371	34.1	30.95	30.98	31.02	-3.2	-3.14	-3.10	31.00	31.04	31.07	-3.1	-3.08	-3.05	Bay Ridge Estates - Bay Ridge Drive West

HGL_Node_Summary_v8prop_rpt2.xlsx

Table A-4

Birch Point Drainage Study - Peak Stage Summary, with Project

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
6372	35.2	35.47	36.16	36.42	0.3	1.01	1.27	35.98	36.41	36.43	0.8	1.26	1.28	Bay Ridge Estates - Bay Ridge Drive West
6373	39.6	38.20	38.20	38.21	-1.4	-1.43	-1.42	38.20	38.21	38.21	-1.4	-1.42	-1.42	Bay Ridge Estates - Bay Ridge Drive West
6374	46.5	47.31	47.31	47.32	0.8	0.84	0.85	47.31	47.32	47.32	0.8	0.85	0.85	Bay Ridge Estates - Bay Ridge Drive West
6972	43.8	43.64	43.64	43.64	-0.2	-0.16	-0.16	43.64	43.64	43.64	-0.2	-0.16	-0.16	Bay Ridge Estates - Bay Ridge Drive West
7271	35.5	33.08	33.09	33.11	-2.4	-2.42	-2.40	33.09	33.10	33.12	-2.4	-2.41	-2.39	Bay Ridge Estates - Bay Ridge Drive West
7311	34.2	32.60	32.64	32.69	-1.6	-1.56	-1.51	32.74	32.80	32.92	-1.5	-1.40	-1.28	Bay Ridge Estates - Bay Ridge Drive West
734738	34.4	32.33	32.38	32.41	-2.1	-2.02	-1.99	32.36	32.40	32.41	-2.0	-2.00	-1.99	Bay Ridge Estates - Bay Ridge Drive West
9581	36.6	35.38	35.39	35.39	-1.2	-1.21	-1.21	35.39	35.39	35.40	-1.2	-1.21	-1.20	Bay Ridge Estates - Bay Ridge Drive West
6375	49.1	47.94	48.04	48.21	-1.1	-1.03	-0.86	48.07	48.19	48.33	-1.0	-0.88	-0.74	Bay Ridge Estates - Bay Ridge Drive West
6376	48.9	46.52	46.54	46.57	-2.3	-2.31	-2.28	46.53	46.56	46.60	-2.3	-2.29	-2.25	Bay Ridge Estates - Bay Ridge Drive West
9391	43.1	43.16	43.18	43.20	0.1	0.08	0.10	43.22	43.25	43.28	0.1	0.15	0.18	Bay Ridge Estates
BayRidgePond	30.5	29.48	29.50	29.53	-1.0	-1.00	-0.97	29.52	29.55	29.58	-1.0	-0.95	-0.92	Bay Ridge Estates
9391	43.1	43.16	43.18	43.20	0.1	0.08	0.10	43.22	43.25	43.28	0.1	0.15	0.18	Bay Ridge Estates
BBV-0009	8.7	7.49	7.55	7.62	-1.2	-1.14	-1.07	7.53	7.59	7.66	-1.2	-1.10	-1.03	Birch Bay Village
BBVJ-005	12.6	11.34	11.36	11.39	-1.2	-1.21	-1.18	11.40	11.59	11.75	-1.2	-0.98	-0.82	Birch Bay Village
BBVJ-007	45.0	39.58	39.61	39.64	-5.4	-5.39	-5.36	39.65	39.67	39.69	-5.4	-5.33	-5.31	Birch Bay Village
BBVJ-008	35.0	28.62	29.18	29.75	-6.4	-5.82	-5.25	29.48	29.88	30.33	-5.5	-5.12	-4.67	Birch Bay Village
BBVJ-009	7.8	7.35	7.51	7.70	-0.4	-0.24	-0.05	7.50	7.66	7.79	-0.3	-0.09	0.04	Birch Bay Village
BBVJ-009a	7.6	7.41	7.60	7.82	-0.2	-0.03	0.19	7.62	7.81	7.97	0.0	0.18	0.34	Birch Bay Village
BBVJ-20	10.8	11.55	12.35	12.39	0.7	1.50	1.54	12.40	12.42	12.43	1.6	1.57	1.58	Birch Bay Village
BBVJ-21	21.9	17.52	17.59	17.73	-4.3	-4.26	-4.12	17.78	17.91	17.99	-4.1	-3.94	-3.86	Birch Bay Village
BBVJ-22	22.2	20.04	20.12	20.26	-2.2	-2.12	-1.98	20.31	20.92	21.44	-1.9	-1.32	-0.80	Birch Bay Village
BBVJ-23	28.0	23.85	23.93	24.07	-4.2	-4.07	-3.93	24.14	24.27	24.96	-3.9	-3.73	-3.04	Birch Bay Village
BBVJ-24	18.8	18.48	18.63	18.87	-0.3	-0.14	0.10	18.92	19.30	19.57	0.1	0.53	0.80	Birch Bay Village
BBVJ-26	9.0	8.66	8.71	8.76	-0.3	-0.26	-0.21	8.74	8.89	9.07	-0.2	-0.08	0.10	Birch Bay Village
BBVJ-27	9.9	8.83	8.88	8.93	-1.1	-1.03	-0.98	8.91	9.10	9.32	-1.0	-0.81	-0.59	Birch Bay Village
BBVJ-28	11.5	8.95	8.99	9.03	-2.6	-2.54	-2.50	9.03	9.24	9.48	-2.5	-2.29	-2.05	Birch Bay Village
BBVJ-29	15.8	9.16	9.63	8.39	-6.6	-6.14	-7.38	8.48	9.41	8.39	-7.3	-6.36	-7.38	Birch Bay Village
BBVJ-30	7.9	7.26	7.36	7.47	-0.6	-0.51	-0.40	7.31	7.40	7.52	-0.6	-0.47	-0.35	Birch Bay Village
BBVJ-31	9.7	7.41	7.59	7.82	-2.3	-2.10	-1.87	7.61	7.80	8.02	-2.1	-1.89	-1.67	Birch Bay Village
BBVJ-32	8.6	7.40	7.58	7.80	-1.2	-1.02	-0.80	7.59	7.78	7.99	-1.0	-0.82	-0.61	Birch Bay Village
BBVJ-33	8.6	7.37	7.54	7.74	-1.2	-1.06	-0.86	7.54	7.71	7.91	-1.1	-0.89	-0.69	Birch Bay Village
BBVJ-34	8.6	7.35	7.51	7.70	-1.2	-1.09	-0.90	7.51	7.67	7.85	-1.1	-0.93	-0.75	Birch Bay Village
BBVJ-35	8.2	7.35	7.50	7.69	-0.9	-0.70	-0.51	7.49	7.65	7.83	-0.7	-0.55	-0.37	Birch Bay Village
BBVJ-36	23.7	21.69	21.56	22.05	-2.0	-2.13	-1.64	21.82	21.89	22.40	-1.9	-1.80	-1.29	Birch Bay Village
BBVJ-37	10.0	7.87	8.42	9.08	-2.1	-1.58	-0.92	8.28	8.03	10.09	-1.7	-1.97	0.09	
BBVJ-39	12.6	11.34	11.37	11.40	-1.3	-1.23	-1.20	11.40	11.59	11.75	-1.2	-1.01	-0.85	
BBVS_Pond1	8.4	8.53	8.57	8.61	0.1	0.17	0.21	8.59	8.64	8.69	0.2	0.24	0.29	Birch Bay Village
BBVS_Pond2	8.4	7.54	7.78	8.10	-0.9	-0.62	-0.30	7.84	8.12	8.41	-0.6	-0.28	0.01	Birch Bay Village
BBVS_Pond3	8.4	7.30	7.43	7.59	-1.1	-0.97	-0.81	7.39	7.53	7.71	-1.0	-0.87	-0.69	Birch Bay Village
Kwan_Pond	12.0	7.69	7.75	7.82	-4.3	-4.25	-4.18	7.72	7.78	7.86	-4.3	-4.22	-4.14	Birch Bay Village
underbird_Po	11.5	7.25	7.34	7.46	-4.3	-4.16	-4.04	7.29	7.39	7.51	-4.2	-4.11	-3.99	Birch Bay Village
Kwan_Pond	12.0	7.69	7.75	7.82	-4.3	-4.25	-4.18	7.72	7.78	7.86	-4.3	-4.22	-4.14	Birch Bay Village
3V_BeaverCre	26.3	25.13	25.25	25.47	-1.2	-1.05	-0.83	25.23	25.41	25.68	-1.1	-0.89	-0.62	Birch Bay Village
LDES2569	42.9	39.70	39.70	39.70	-3.2	-3.20	-3.20	39.70	39.70	39.70	-3.2	-3.20	-3.20	Selder Road
LDES2570	44.0	40.60	40.60	40.60	-3.4	-3.40	-3.40	40.60	40.60	40.60	-3.4	-3.40	-3.40	Selder Road
LDES2578	66.1	63.32	63.37	63.43	-2.8	-2.73	-2.67	63.58	63.65	63.74	-2.5	-2.45	-2.36	Selder Road
LDES2586	66.0	64.45	64.65	64.82	-1.6	-1.35	-1.18	64.49	64.71	64.90	-1.5	-1.29	-1.10	Selder Road
LDES2587	67.5	67.62	67.65	67.68	0.1	0.15	0.18	67.62	67.65	67.68	0.1	0.15	0.18	Selder Road
LDES2594	74.5	73.01	73.06	73.10	-1.5	-1.44	-1.40	73.01	73.06	73.10	-1.5	-1.44	-1.40	Selder Road
LDES2595	79.6	79.77	79.81	79.83	0.2	0.21	0.23	79.78	79.81	79.83	0.2	0.21	0.23	Selder Road
LDES2602	81.7	81.01	81.05	81.09	-0.7	-0.65	-0.61	81.01	81.06	81.09	-0.7	-0.64	-0.61	Selder Road
LDES2603	85.8	85.95	85.98	86.00	0.2	0.18	0.20	85.95	85.98	86.00	0.2	0.18	0.20	Selder Road
LDES2610	86.8	86.48	86.52	86.56	-0.3	-0.28	-0.24	86.48	86.53	86.56	-0.3	-0.27	-0.24	Selder Road
LDES2611	93.0	93.15	93.18	93.21	0.2	0.18	0.21	93.15	93.18	93.21	0.2	0.18	0.21	Selder Road
LDES2618	99.9	98.13	98.18	98.21	-1.8	-1.72	-1.69	98.13	98.18	98.21	-1.8	-1.72	-1.69	Selder Road
LDES2619	102.5	102.43	102.55	102.57	-0.1	0.05	0.07	102.46	102.55	102.58	0.0	0.05	0.08	Selder Road
LDES2626	111.0	108.97	108.98	109.01	-2.0	-2.02	-1.99	108.97	108.99	109.01	-2.0	-2.01	-1.99	Selder Road
LDES2627	112.4	112.47	112.48	112.50	0.1	0.08	0.10	112.47	112.48	112.50	0.1	0.08	0.10	Selder Road
LDES2634	116.8	115.87	115.89	115.91	-0.9	-0.91	-0.89	115.87	115.89	115.92	-0.9	-0.91	-0.88	Selder Road
LDES2635	118.9	119.01	119.03	119.04	0.1	0.13	0.14	119.01	119.03	119.04	0.1	0.13	0.14	Selder Road
LDES2639	126.3	124.58	124.66	124.75	-1.7	-1.64	-1.55	124.59	124.66	124.75	-1.7	-1.64	-1.55	Selder Road
LDES2646	124.0	122.19	122.21	122.24	-1.8	-1.79	-1.76	122.19	122.21	122.24	-1.8	-1.79	-1.76	Selder Road
TT1009	80.0	76.90	76.90	76.90	-3.1	-3.10	-3.10	76.89	76.90	76.89	-3.1	-3.10	-3.11	Selder Road
TT9	47.0	43.22	43.27	43.32	-3.8	-3.73	-3.68	43.45	43.52	43.60	-3.6	-3.48	-3.40	Selder Road
LDES2674	144.3	142.91	142.95	142.99	-1.4	-1.35	-1.31	143.14	143.20	143.26	-1.2	-1.10	-1.04	Selder Road
LDES2675	144.7	144.87	144.90	144.93	0.2	0.20	0.23	145.10	145.12	145.15	0.4	0.42	0.45	Selder Road
LDES4214	160.7	160.92	160.94	160.96	0.2	0.24	0.26	161.12	161.15	161.18	0.4	0.45	0.48	Selder Road
LDES4215	160.1	159.62	159.66	159.70	-0.5	-0.44	-0.40	160.01	160.06	160.12	-0.1	-0.04	0.02	Selder Road
LDES4222	155.6	155.71	155.73	155.74	0.1	0.13	0.14	155.86	155.88	155.90	0.3	0.28	0.30	Selder Road
LDES4223	154.8	153.41	153.46	153.51	-1.4	-1.34	-1.29	153.88	153.95	154.02	-0.9	-0.85	-0.78	Selder Road
LDES4278	170.5	170.88	170.90	170.93	0.4	0.40	0.43	171.36	171.48	171.64	0.9	0.98	1.14	Selder Road
LDES4279	174.2	173.77	173.81	173.86	-0.4	-0.39	-0.34	174.22	174.28	174.35	0.0	0.08	0.15	Selder Road
TT1007	170.7	169.46	169.50	169.55	-1.2	-1.20	-1.15	169.87	169.92	169.99	-0.8	-0.78	-0.71	Selder Road
2728	29.7	25.31	25.45	25.66	-4.4	-4.25	-4.04	25.79	26.24	26.39	-3.9	-3.46	-3.31	Birch Point Road East of Selder
3897	28.0	24.62	24.71	25.50	-3.4	-3.29	-2.50	26.82	28.02	28.02	-1.2	0.02	0.02	Birch Point Road East of Selder
5382	29.2	24.05	24.15	24.92	-5.2	-5.05	-4.28	26.15	27.40	27.58	-3.1	-1.80	-1.62	Birch Point Road East of Selder
LDES2552	30.0	25.31	25.45	25.66	-4.7	-4.55	-4.34	25.79	26.24	26.36	-4.2	-3.76	-3.64	Birch Point Road East of Selder
OD1038_In	29.7	27.80	27.80	27.80	-1.9	-1.90	-1.90	27.80	28.05	28.08	-1.9	-1.65	-1.62	Birch Point Road East of Selder
SM800_In	28.0	25.63	25.67	25.87	-2.4	-2.33	-2.13	27.07	28.37	28.48	-0.9	0.37	0.48	Birch Point Road East of Selder
SM802_In	29.2	25.41	25.44	25.55	-3.8	-3.76	-3.65	26.35	27.68	27.93	-2.9	-1.52	-1.27	Birch Point Road East of Selder
TR19	28.0	24.62	24.71	25.50	-3.4	-3.29	-2.50	26.82	28.04	28.06	-1.2	0.04	0.06	Birch Point Road East of Selder
1	12.0	8.23	8.44	8.61	-3.8	-3.56	-3.39	8.71	8.77	8.84	-3.3	-3.23	-3.16	Birch Bay Drive at Birch Loop
5380	36.5	34.54	34.59	34.66	-2.0	-1.92	-1.85	36.51	36.51	36.51	0.0	0.00	0.00	Birch Bay Drive at Birch Loop
7851	9.8	8.23	8.44	8.61	-1.6	-1.36	-1.19	8.71	8.77	8.83	-1.1	-1.03	-0.97	Birch Bay Drive at Birch Loop
CS52	25.9	22.74	22.77	22.81	-3.2	-3.13	-3.09	22.85	22.86	22.88	-3.1	-3.04	-3.02	Birch Bay Drive at Birch Loop
CS52-D	25.9	22.89	22.90	22.92	-3.0	-3.00	-2.98	22.94	22.95	22.97	-3.0	-2.95	-2.93	Birch Bay Drive at Birch Loop
CV2738-1	12.0	11.85	11.85	11.85	-0.2	-0.15	-0.15	11.85	11.85	11.85	-0.2	-0.15	-0.15	Birch Bay Drive at Birch Loop
CV3690-1	19.0	15.36	15.39	15.42	-3.6	-3.61	-3.58	15.46	15.48	15.50	-3.5	-3.52	-3.50	Birch Bay Drive at Birch Loop
CV3690-2	11.2	10.08	10.11	10.15	-1.1	-1.09	-1.05	10.20	10.22	10.25	-1.0	-0.98	-0.95	Birch Bay Drive at Birch Loop
CV3714-1	12.1	10.21	10.50	10.79	-1.9	-1.60	-1.31	10.81	11.00	11.14	-1.3	-1.10	-0.96	Birch Bay Drive at Birch Loop
CV3714-2	9.2	8.26	8.46	8.66	-1.0	-0.75	-0.55	8.77	8.84	8.91	-0.4	-0.37	-0.30	Birch Bay Drive at Birch Loop
CV3723-1	12.0	10.20	10.49	10.77	-1.8	-1.51	-1.23	10.79	10.98	11.12	-1.2	-1.02	-0.88	Birch Bay Drive at Birch Loop

Table A-4

Birch Point Drainage Study - Peak Stage Summary, with Project

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
CV3723-2	12.0	10.20	10.49	10.78	-1.8	-1.51	-1.22	10.79	10.98	11.12	-1.2	-1.02	-0.88	Birch Bay Drive at Birch Loop
CV3732-1	11.2	9.93	10.14	10.31	-1.3	-1.06	-0.89	10.28	10.40	10.50	-0.9	-0.80	-0.70	Birch Bay Drive at Birch Loop
CV3732-2	12.2	8.94	8.94	8.94	-3.3	-3.26	-3.26	8.95	8.95	8.95	-3.3	-3.25	-3.25	Birch Bay Drive at Birch Loop
CV3738-2	11.9	11.40	11.40	11.40	-0.5	-0.50	-0.50	11.40	11.40	11.40	-0.5	-0.50	-0.50	Birch Bay Drive at Birch Loop
CV3740-1	9.2	8.26	8.46	8.66	-1.0	-0.75	-0.55	8.77	8.84	8.91	-0.4	-0.37	-0.30	Birch Bay Drive at Birch Loop
CV3740-2	9.8	8.23	8.44	8.62	-1.6	-1.36	-1.18	8.71	8.77	8.84	-1.1	-1.03	-0.96	Birch Bay Drive at Birch Loop
DP-77	19.3	17.34	17.35	17.36	-2.0	-1.95	-1.94	17.37	17.38	17.38	-1.9	-1.92	-1.92	Birch Bay Drive at Birch Loop
DP-78	15.0	14.97	15.06	15.12	0.0	0.06	0.12	15.16	15.19	15.20	0.2	0.19	0.20	Birch Bay Drive at Birch Loop
OD1058-1	11.2	10.00	10.20	10.36	-1.2	-1.00	-0.84	10.31	10.43	10.54	-0.9	-0.77	-0.66	Birch Bay Drive at Birch Loop
OD1058-2	11.8	11.09	11.14	11.17	-0.7	-0.66	-0.63	10.63	10.71	10.80	-1.2	-1.09	-1.00	Birch Bay Drive at Birch Loop
OD1058-3	13.0	13.07	13.23	13.31	0.1	0.26	0.34	13.35	13.42	13.48	0.4	0.45	0.51	Birch Bay Drive at Birch Loop
OD1071_2	12.2	10.24	10.52	10.81	-2.0	-1.68	-1.39	10.83	11.01	11.15	-1.4	-1.19	-1.05	Birch Bay Drive at Birch Loop
OD1071_3	12.2	10.22	10.51	10.80	-2.0	-1.69	-1.40	10.82	11.01	11.15	-1.4	-1.19	-1.05	Birch Bay Drive at Birch Loop
OD1073-up	23.6	19.75	19.77	19.79	-3.9	-3.83	-3.81	19.82	19.83	19.85	-3.8	-3.77	-3.75	Birch Bay Drive at Birch Loop
OD1075-1	11.1	9.91	9.93	9.95	-1.2	-1.17	-1.15	9.99	10.01	10.03	-1.1	-1.09	-1.07	Birch Bay Drive at Birch Loop
OD1075-2	11.0	9.26	9.28	9.29	-1.7	-1.72	-1.71	9.32	9.33	9.35	-1.7	-1.67	-1.65	Birch Bay Drive at Birch Loop
OD1075-3	11.1	8.86	8.87	8.89	-2.2	-2.23	-2.21	8.93	8.95	9.00	-2.2	-2.15	-2.10	Birch Bay Drive at Birch Loop
OD1075-4	11.4	8.54	8.56	8.69	-2.9	-2.84	-2.71	8.79	8.86	8.94	-2.6	-2.54	-2.46	Birch Bay Drive at Birch Loop
OD1075-5	10.6	8.27	8.46	8.66	-2.3	-2.14	-1.94	8.77	8.84	8.92	-1.8	-1.76	-1.68	Birch Bay Drive at Birch Loop
OD1075-6	11.1	8.26	8.46	8.66	-2.8	-2.64	-2.44	8.77	8.84	8.91	-2.3	-2.26	-2.19	Birch Bay Drive at Birch Loop
PD46_In	28.0	23.12	23.13	23.15	-4.9	-4.87	-4.85	23.17	23.18	23.19	-4.8	-4.82	-4.81	Birch Bay Drive at Birch Loop
PD46_Out	28.0	23.12	23.13	23.15	-4.9	-4.87	-4.85	23.17	23.18	23.19	-4.8	-4.82	-4.81	Birch Bay Drive at Birch Loop
SM840-2	12.2	10.43	10.69	11.01	-1.8	-1.51	-1.19	11.04	11.23	11.35	-1.2	-0.97	-0.85	Birch Bay Drive at Birch Loop
SM9799	9.8	8.23	8.44	8.61	-1.6	-1.36	-1.19	8.71	8.77	8.84	-1.1	-1.03	-0.96	Birch Bay Drive at Birch Loop
TG-1	12.0	8.94	8.94	8.94	-3.1	-3.06	-3.06	8.94	8.95	8.95	-3.1	-3.05	-3.05	Birch Bay Drive at Birch Loop
1366	52.5	50.75	50.90	51.08	-1.7	-1.56	-1.38	50.74	50.90	51.08	-1.7	-1.56	-1.38	Pheasant - Grouse Cress
1367	52.3	50.75	50.90	51.09	-1.5	-1.36	-1.17	50.74	50.90	51.08	-1.5	-1.36	-1.18	Pheasant - Grouse Cress
1368	53.1	51.43	51.64	51.89	-1.6	-1.42	-1.17	51.42	51.63	51.88	-1.6	-1.43	-1.18	Pheasant - Grouse Cress
1372	53.0	45.34	45.45	45.69	-7.6	-7.50	-7.26	45.43	45.63	45.91	-7.5	-7.32	-7.04	Pheasant - Grouse Cress
1373	52.7	51.21	51.40	51.64	-1.5	-1.27	-1.03	51.20	51.39	51.66	-1.5	-1.28	-1.01	Pheasant - Grouse Cress
1374	53.3	51.50	51.71	51.98	-1.8	-1.62	-1.35	51.49	51.70	51.96	-1.8	-1.63	-1.37	Pheasant - Grouse Cress
1375	52.5	51.43	51.64	51.89	-1.0	-0.84	-0.59	51.42	51.63	51.88	-1.1	-0.85	-0.60	Pheasant - Grouse Cress
1376	52.7	51.66	51.90	52.17	-1.0	-0.80	-0.53	51.65	51.89	52.16	-1.1	-0.81	-0.54	Pheasant - Grouse Cress
1377	53.3	51.50	51.71	51.98	-1.8	-1.58	-1.31	51.49	51.70	51.97	-1.8	-1.59	-1.32	Pheasant - Grouse Cress
1378	52.8	51.79	52.03	52.32	-1.0	-0.81	-0.52	51.78	52.02	52.31	-1.1	-0.82	-0.53	Pheasant - Grouse Cress
1379	53.7	51.67	51.91	52.17	-2.0	-1.79	-1.53	51.66	51.89	52.16	-2.0	-1.81	-1.54	Pheasant - Grouse Cress
1380	53.6	51.95	52.22	52.52	-1.7	-1.39	-1.09	51.94	52.21	52.50	-1.7	-1.40	-1.11	Pheasant - Grouse Cress
1381	53.3	51.80	52.04	52.33	-1.5	-1.26	-0.97	51.79	52.02	52.31	-1.5	-1.28	-0.99	Pheasant - Grouse Cress
1382	54.4	52.11	52.37	52.70	-2.3	-2.02	-1.69	52.10	52.36	52.68	-2.3	-2.03	-1.71	Pheasant - Grouse Cress
1383	53.8	51.95	52.22	52.52	-1.9	-1.61	-1.31	51.94	52.21	52.51	-1.9	-1.62	-1.32	Pheasant - Grouse Cress
1384	53.9	52.25	52.56	52.89	-1.6	-1.31	-0.98	52.24	52.54	52.88	-1.6	-1.33	-0.99	Pheasant - Grouse Cress
1385	54.2	52.12	52.37	52.70	-2.0	-1.80	-1.47	52.11	52.36	52.68	-2.1	-1.81	-1.49	Pheasant - Grouse Cress
1386	54.9	52.39	52.67	53.03	-2.5	-2.25	-1.89	52.38	52.66	53.02	-2.5	-2.26	-1.90	Pheasant - Grouse Cress
1387	53.7	52.26	52.56	52.89	-1.4	-1.11	-0.78	52.24	52.54	52.88	-1.4	-1.13	-0.79	Pheasant - Grouse Cress
1388	53.5	52.64	52.99	53.37	-0.9	-0.53	-0.15	52.62	52.97	53.36	-0.9	-0.55	-0.16	Pheasant - Grouse Cress
1389	54.2	52.64	52.99	53.38	-1.6	-1.20	-0.81	52.63	52.97	53.36	-1.6	-1.22	-0.83	Pheasant - Grouse Cress
1390	53.6	53.10	53.52	53.97	-0.5	-0.12	0.33	53.08	53.50	53.95	-0.6	-0.14	0.31	Pheasant - Grouse Cress
1391	53.7	52.40	52.67	53.04	-1.3	-1.07	-0.70	52.39	52.66	53.02	-1.3	-1.08	-0.72	Pheasant - Grouse Cress
1392	53.5	52.40	52.68	53.04	-1.1	-0.82	-0.46	52.39	52.66	53.02	-1.1	-0.84	-0.48	Pheasant - Grouse Cress
1393	54.1	53.10	53.52	53.97	-1.0	-0.63	-0.18	53.08	53.50	53.95	-1.1	-0.65	-0.20	Pheasant - Grouse Cress
1394	54.5	53.10	53.52	53.98	-1.4	-0.93	-0.47	53.08	53.50	53.96	-1.4	-0.95	-0.49	Pheasant - Grouse Cress
1395	55.6	52.40	52.68	53.04	-3.2	-2.95	-2.59	52.39	52.66	53.02	-3.2	-2.97	-2.61	Pheasant - Grouse Cress
1396	55.5	52.40	52.68	53.04	-3.1	-2.84	-2.48	52.39	52.66	53.02	-3.1	-2.86	-2.50	Pheasant - Grouse Cress
1397	55.6	52.40	52.68	53.04	-3.2	-2.87	-2.51	52.39	52.66	53.02	-3.2	-2.89	-2.53	Pheasant - Grouse Cress
1398	55.9	52.40	52.68	53.04	-3.5	-3.27	-2.91	52.39	52.66	53.02	-3.6	-3.29	-2.93	Pheasant - Grouse Cress
1399	54.8	53.10	53.52	53.98	-1.7	-1.29	-0.83	53.08	53.50	53.96	-1.7	-1.31	-0.85	Pheasant - Grouse Cress
1400	55.8	53.10	53.52	53.98	-2.7	-2.33	-1.87	53.08	53.50	53.96	-2.8	-2.35	-1.89	Pheasant - Grouse Cress
1401	56.2	53.66	53.66	53.98	-2.6	-2.56	-2.24	53.66	53.66	53.96	-2.6	-2.56	-2.26	Pheasant - Grouse Cress
1402	56.3	53.43	53.43	53.98	-2.9	-2.85	-2.30	53.43	53.43	53.96	-2.9	-2.85	-2.32	Pheasant - Grouse Cress
1403	55.7	53.33	53.33	53.33	-2.4	-2.39	-2.39	53.33	53.33	53.33	-2.4	-2.39	-2.39	Pheasant - Grouse Cress
1404	55.5	53.42	53.42	53.42	-2.1	-2.06	-2.06	53.42	53.42	53.42	-2.1	-2.06	-2.06	Pheasant - Grouse Cress
1405	55.0	53.67	53.67	53.67	-1.4	-1.35	-1.35	53.67	53.67	53.67	-1.4	-1.35	-1.35	Pheasant - Grouse Cress
1406	55.9	54.15	54.15	54.15	-1.8	-1.76	-1.76	54.15	54.15	54.15	-1.8	-1.76	-1.76	Pheasant - Grouse Cress
1407	57.1	55.56	55.56	55.56	-1.5	-1.52	-1.52	55.56	55.56	55.56	-1.5	-1.52	-1.52	Pheasant - Grouse Cress
1408	58.4	57.19	57.19	57.19	-1.2	-1.17	-1.17	57.19	57.19	57.19	-1.2	-1.17	-1.17	Pheasant - Grouse Cress
1409	57.9	55.10	55.10	55.10	-2.8	-2.79	-2.79	55.10	55.10	55.10	-2.8	-2.79	-2.79	Pheasant - Grouse Cress
1410	57.7	54.68	54.68	54.68	-3.0	-3.02	-3.02	54.68	54.68	54.68	-3.0	-3.02	-3.02	Pheasant - Grouse Cress
1411	57.5	54.75	54.75	54.75	-2.7	-2.75	-2.75	54.75	54.75	54.75	-2.7	-2.75	-2.75	Pheasant - Grouse Cress
1412	57.1	54.37	54.37	54.39	-2.7	-2.69	-2.67	54.38	54.39	54.41	-2.7	-2.67	-2.65	Pheasant - Grouse Cress
1413	57.1	54.35	54.37	54.38	-2.8	-2.76	-2.75	54.38	54.39	54.41	-2.8	-2.74	-2.72	Pheasant - Grouse Cress
1414	56.9	54.35	54.37	54.38	-2.6	-2.57	-2.56	54.38	54.39	54.41	-2.6	-2.55	-2.53	Pheasant - Grouse Cress
1415	56.7	53.53	53.56	53.60	-3.1	-3.10	-3.06	53.58	53.61	53.65	-3.1	-3.05	-3.01	Pheasant - Grouse Cress
1416	56.0	53.53	53.56	53.60	-2.5	-2.47	-2.43	53.58	53.61	53.65	-2.4	-2.42	-2.38	Pheasant - Grouse Cress
1417	56.1	53.18	53.19	53.21	-3.0	-2.96	-2.94	53.20	53.22	53.24	-2.9	-2.93	-2.91	Pheasant - Grouse Cress
1418	56.6	52.51	52.51	52.51	-4.1	-4.08	-4.08	52.51	52.51	52.51	-4.1	-4.08	-4.08	Pheasant - Grouse Cress
1419	54.6	53.00	53.03	53.07	-1.6	-1.52	-1.48	53.05	53.08	53.12	-1.5	-1.47	-1.43	Pheasant - Grouse Cress
1420	54.9	52.57	52.59	52.60	-2.4	-2.36	-2.35	52.59	52.61	52.62	-2.4	-2.34	-2.33	Pheasant - Grouse Cress
1421	56.7	52.42	52.42	52.42	-4.3	-4.29	-4.29	52.42	52.42	52.42	-4.3	-4.29	-4.29	Pheasant - Grouse Cress
1422	54.9	52.50	52.50	52.50	-2.4	-2.40	-2.40	52.50	52.50	52.50	-2.4	-2.40	-2.40	Pheasant - Grouse Cress
1423	54.5	52.53	52.53	52.53	-2.0	-2.00	-2.00	52.53	52.53	52.53	-2.0	-2.00	-2.00	Pheasant - Grouse Cress
1424	54.4	51.78	51.78	51.78	-2.6	-2.60	-2.60	51.78	51.78	51.78	-2.6	-2.60	-2.60	Pheasant - Grouse Cress
1425	54.7	51.75	51.75	51.75	-2.9	-2.94	-2.94	51.75	51.75	51.75	-2.9	-2.94	-2.94	Pheasant - Grouse Cress
1426	54.5	51.79	51.81	51.84	-2.7	-2.64	-2.61	51.82	51.84	51.87	-2.6	-2.61	-2.58	Pheasant - Grouse Cress
1427	53.3	49.59	49.59	49.59	-3.8	-3.76	-3.76	49.59	49.59	49.59	-3.8	-3.76	-3.76	Pheasant - Grouse Cress
1428	51.4	48.18	48.18	48.18	-3.3	-3.26	-3.26	48.18	48.18	48.18	-3.3	-3.26	-3.26	Pheasant - Grouse Cress
1429	51.9	48.97	48.97	48.98	-2.9	-2.91	-2.90	48.98	48.98	48.99	-2.9	-2.90	-2.89	Pheasant - Grouse Cress
1430	49.6	47.45	47.61	47.79	-2.2	-1.99	-1.81	47.70	47.87	48.07	-1.9	-1.73	-1.53	Pheasant - Grouse Cress
1431	49.2	46.51	46.54	46.58	-2.7	-2.69	-2.65	46.56	46.59	46.70	-2.7	-2.64	-2.53	Pheasant - Grouse Cress
1434	50.2	46.00	46.04	46.17	-4.2	-4.12	-3.99	46.07	46.16	46.46	-4.1	-4.00	-3.70	Pheasant - Grouse Cress
1436	49.4	48.16	48.17	48.18	-1.2	-1.21	-1.20	48.18	48.18	48.19	-1.2	-1.20	-1.19	Pheasant - Grouse Cress
1437	50.8	48.29	48.31	48.34	-2.6	-2.53	-2.50	48.32	48.35	48.39	-2.5	-2.49	-2.45	Pheasant - Grouse Cress
1438	52.2	49.60	49.62	49.64	-2.6	-2.61	-2.59	49.63	49.65	49.67	-2.6	-2.58	-2.56	Pheasant - Grouse Cress
1439	52.1	49.76	49.78	49.80	-2.4	-2.34	-2.32	49.79	49.81	49.83	-2.3	-2.31	-2.29	Pheasant - Grouse Cress

Table A-4

Birch Point Drainage Study - Peak Stage Summary, with Project

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
1440	51.8	50.18	50.20	50.24	-1.6	-1.61	-1.57	50.22	50.25	50.29	-1.6	-1.56	-1.52	Pheasant - Grouse Cress
1441	50.4	47.45	47.61	47.79	-2.9	-2.78	-2.60	47.70	47.87	48.07	-2.7	-2.52	-2.32	Pheasant - Grouse Cress
1442	48.9	46.52	46.55	46.59	-2.4	-2.36	-2.32	46.57	46.60	46.70	-2.3	-2.31	-2.21	Pheasant - Grouse Cress
1443	52.3	50.30	50.33	50.36	-2.0	-1.96	-1.93	50.35	50.37	50.41	-1.9	-1.92	-1.88	Pheasant - Grouse Cress
1446	51.3	50.43	50.47	50.52	-0.9	-0.84	-0.79	50.50	50.55	50.61	-0.8	-0.76	-0.70	Pheasant - Grouse Cress
1447	52.5	50.43	50.47	50.53	-2.1	-2.03	-1.97	50.50	50.55	50.61	-2.0	-1.95	-1.89	Pheasant - Grouse Cress
1448	53.1	51.36	51.36	51.36	-1.8	-1.78	-1.78	51.36	51.36	51.36	-1.8	-1.78	-1.78	Pheasant - Grouse Cress
1449	49.6	47.45	47.61	47.79	-2.2	-1.99	-1.81	47.70	47.87	48.07	-1.9	-1.73	-1.53	Pheasant - Grouse Cress
1450	48.6	46.51	46.54	46.58	-2.1	-2.09	-2.05	46.56	46.59	46.70	-2.1	-2.04	-1.93	Pheasant - Grouse Cress
1460	53.4	43.63	43.67	43.72	-9.7	-9.70	-9.65	43.66	43.71	43.77	-9.7	-9.66	-9.60	Pheasant - Grouse Cress
1239	52.4	50.85	50.85	50.85	-1.5	-1.54	-1.54	50.85	50.85	50.85	-1.5	-1.54	-1.54	Deer Trail Area
1240	52.4	50.60	50.60	50.60	-1.8	-1.80	-1.80	50.60	50.60	50.60	-1.8	-1.80	-1.80	Deer Trail Area
1241	52.1	50.57	50.57	50.57	-1.5	-1.54	-1.54	50.57	50.57	50.57	-1.5	-1.54	-1.54	Deer Trail Area
1242	52.0	49.84	49.84	49.84	-2.1	-2.13	-2.13	49.84	49.84	49.84	-2.1	-2.13	-2.13	Deer Trail Area
1243	50.6	50.00	50.00	50.01	-0.6	-0.58	-0.57	50.00	50.00	50.01	-0.6	-0.58	-0.57	Deer Trail Area
1451	42.7	36.98	37.13	37.31	-5.7	-5.60	-5.42	37.12	37.28	37.46	-5.6	-5.45	-5.27	Deer Trail Area
1452	46.2	45.01	45.01	45.01	-1.1	-1.15	-1.15	45.01	45.01	45.01	-1.1	-1.15	-1.15	Deer Trail Area
1453	49.1	46.30	46.30	46.30	-2.8	-2.75	-2.75	46.30	46.30	46.30	-2.8	-2.75	-2.75	Deer Trail Area
1454	49.3	47.01	47.01	47.01	-2.3	-2.28	-2.28	47.01	47.01	47.01	-2.3	-2.28	-2.28	Deer Trail Area
1457	47.9	35.91	35.95	36.01	-12.0	-11.99	-11.93	35.95	35.99	36.05	-12.0	-11.95	-11.89	Deer Trail Area
1463	51.8	50.44	50.45	50.46	-1.3	-1.31	-1.30	50.44	50.45	50.46	-1.3	-1.31	-1.30	Deer Trail Area
1464	52.0	49.98	49.99	50.00	-2.0	-2.00	-1.99	49.98	49.99	50.00	-2.0	-2.00	-1.99	Deer Trail Area
1467	51.1	49.71	49.74	49.78	-1.4	-1.36	-1.32	49.71	49.74	49.78	-1.4	-1.36	-1.32	Deer Trail Area
1468	52.3	50.67	50.69	50.70	-1.6	-1.63	-1.62	50.67	50.68	50.70	-1.6	-1.64	-1.62	Deer Trail Area
1469	52.5	51.01	51.03	51.05	-1.5	-1.45	-1.43	51.01	51.01	51.03	-1.5	-1.47	-1.45	Deer Trail Area
1472	50.4	51.02	51.01	51.03	0.6	0.61	0.63	51.00	51.02	51.04	0.6	0.62	0.64	Deer Trail Area
1473	51.4	50.98	50.99	51.01	-0.5	-0.45	-0.43	50.98	50.99	51.01	-0.5	-0.45	-0.43	Deer Trail Area
1474	51.7	50.98	50.99	51.01	-0.7	-0.73	-0.71	50.98	50.99	51.01	-0.7	-0.73	-0.71	Deer Trail Area
1475	52.6	50.96	50.98	50.99	-1.6	-1.60	-1.59	50.96	50.98	50.99	-1.6	-1.60	-1.59	Deer Trail Area
1476	52.5	50.94	50.96	50.97	-1.5	-1.51	-1.50	50.94	50.96	50.97	-1.5	-1.51	-1.50	Deer Trail Area
1477	52.8	50.67	50.69	50.70	-2.2	-2.13	-2.12	50.67	50.68	50.70	-2.2	-2.14	-2.12	Deer Trail Area
1478	52.7	50.54	50.55	50.56	-2.1	-2.13	-2.12	50.54	50.55	50.56	-2.1	-2.13	-2.12	Deer Trail Area
1479	52.7	49.99	50.00	50.01	-2.7	-2.68	-2.67	49.99	50.00	50.00	-2.7	-2.68	-2.68	Deer Trail Area
1481	50.1	47.59	47.60	47.61	-2.6	-2.55	-2.54	47.59	47.60	47.61	-2.6	-2.55	-2.54	Deer Trail Area
1348	12.8	12.16	12.38	12.65	-0.6	-0.38	-0.11	12.06	12.08	12.15	-0.7	-0.68	-0.61	Birch Bay Drive East at Deer Trail
1349	12.9	12.16	12.38	12.65	-0.7	-0.51	-0.24	12.06	12.08	12.15	-0.8	-0.81	-0.74	Birch Bay Drive East at Deer Trail
1350	13.2	12.16	12.38	12.65	-1.0	-0.79	-0.52	12.06	12.08	12.15	-1.1	-1.09	-1.02	Birch Bay Drive East at Deer Trail
1351	13.0	12.16	12.38	12.65	-0.9	-0.64	-0.37	12.00	12.05	12.12	-1.0	-0.97	-0.90	Birch Bay Drive East at Deer Trail
1352	13.9	12.12	12.34	12.61	-1.8	-1.56	-1.29	11.25	11.26	11.28	-2.7	-2.64	-2.62	Birch Bay Drive East at Deer Trail
1353	12.9	12.12	12.34	12.61	-0.8	-0.58	-0.31	10.89	10.96	11.05	-2.0	-1.96	-1.87	Birch Bay Drive East at Deer Trail
1483	18.0	12.15	12.36	12.62	-5.9	-5.64	-5.38	11.31	11.35	11.41	-6.7	-6.65	-6.59	Birch Bay Drive East at Deer Trail
1355	15.4	12.12	12.34	12.61	-3.2	-3.01	-2.74	10.93	11.00	11.08	-4.4	-4.35	-4.27	Birch Bay Drive East at Deer Trail
1339	13.2	10.19	10.22	10.25	-3.0	-3.00	-2.97	10.46	10.50	10.55	-2.8	-2.72	-2.67	Birch Bay Drive East at Deer Trail
1340	12.6	11.20	11.25	11.32	-1.4	-1.36	-1.29	12.58	12.91	13.34	0.0	0.30	0.73	Birch Bay Drive East at Deer Trail
1346	12.9	11.98	11.98	11.98	-0.9	-0.95	-0.95	12.58	12.91	13.34	-0.4	-0.02	0.41	Birch Bay Drive East at Deer Trail
1347	12.6	10.89	10.94	11.00	-1.7	-1.65	-1.59	11.86	12.09	12.37	-0.7	-0.50	-0.22	Birch Bay Drive East at Deer Trail
1356	14.0	12.70	12.72	12.74	-1.3	-1.28	-1.26	12.74	12.75	12.88	-1.3	-1.25	-1.12	Birch Bay Drive West at Deer Trail
1357	12.4	11.38	11.68	12.05	-1.1	-0.75	-0.38	11.97	12.35	12.87	-0.5	-0.08	0.44	Birch Bay Drive West at Deer Trail
1358	12.3	10.99	11.19	11.46	-1.3	-1.15	-0.88	11.40	11.68	12.06	-0.9	-0.66	-0.28	Birch Bay Drive West at Deer Trail
1359	12.2	10.99	11.19	11.46	-1.2	-1.04	-0.77	11.40	11.68	12.06	-0.8	-0.55	-0.17	Birch Bay Drive West at Deer Trail
1360	11.8	10.80	10.97	11.20	-1.0	-0.86	-0.63	11.15	11.39	11.71	-0.7	-0.44	-0.12	Birch Bay Drive West at Deer Trail
1361	11.6	10.80	10.97	11.20	-0.8	-0.64	-0.41	11.15	11.39	11.71	-0.5	-0.22	0.10	Birch Bay Drive West at Deer Trail
1362	11.4	10.80	10.97	11.20	-0.6	-0.40	-0.17	11.15	11.39	11.71	-0.2	0.02	0.34	Birch Bay Drive West at Deer Trail
1363	11.9	10.99	11.19	11.45	-0.9	-0.71	-0.45	11.39	11.67	12.05	-0.5	-0.23	0.15	Birch Bay Drive West at Deer Trail
1364	11.9	11.07	11.23	11.47	-0.8	-0.64	-0.40	11.42	11.68	12.05	-0.4	-0.19	0.18	Birch Bay Drive West at Deer Trail
1171	52.0	50.61	50.63	50.65	-1.4	-1.35	-1.33	50.65	50.67	50.70	-1.3	-1.31	-1.28	Richmond Park - Richmond Park Road South
1172	51.5	49.89	49.91	49.95	-1.6	-1.63	-1.59	49.95	50.00	50.16	-1.6	-1.54	-1.38	Richmond Park - Richmond Park Road South
1173	50.7	48.92	48.99	49.26	-1.8	-1.74	-1.47	49.23	49.46	49.76	-1.5	-1.27	-0.97	Richmond Park - Richmond Park Road South
1180	50.6	47.91	47.93	47.95	-2.7	-2.63	-2.61	47.94	47.96	47.98	-2.6	-2.60	-2.58	Richmond Park - Richmond Park Road South
1181	50.7	48.72	48.81	49.03	-1.9	-1.84	-1.62	49.01	49.19	49.43	-1.6	-1.46	-1.22	Richmond Park - Richmond Park Road South
1182	49.3	47.51	47.52	47.53	-1.8	-1.81	-1.80	47.51	47.52	47.53	-1.8	-1.81	-1.80	Richmond Park - Richmond Park Road South
1184	51.7	44.23	44.25	44.27	-7.5	-7.44	-7.42	44.25	44.26	44.28	-7.4	-7.43	-7.41	Richmond Park - Richmond Park Road South
1188	49.2	47.26	47.27	47.28	-2.0	-1.97	-1.96	47.26	47.27	47.28	-2.0	-1.97	-1.96	Richmond Park - Richmond Park Road South
1189	50.1	47.02	47.06	47.10	-3.1	-3.05	-3.01	47.05	47.08	47.13	-3.1	-3.03	-2.98	Richmond Park - Richmond Park Road South
1190	50.5	46.87	46.91	46.96	-3.6	-3.59	-3.54	46.90	46.94	46.99	-3.6	-3.56	-3.51	Richmond Park - Richmond Park Road South
1191	50.2	46.98	47.01	47.05	-3.2	-3.18	-3.14	47.00	47.04	47.07	-3.2	-3.15	-3.12	Richmond Park - Richmond Park Road South
1192	50.7	47.01	47.05	47.10	-3.7	-3.64	-3.59	47.04	47.08	47.12	-3.6	-3.61	-3.57	Richmond Park - Richmond Park Road South
1193	50.7	48.27	48.28	48.28	-2.5	-2.46	-2.46	48.27	48.28	48.28	-2.5	-2.46	-2.46	Richmond Park - Richmond Park Road South
1194	51.1	48.08	48.10	48.11	-3.0	-2.95	-2.94	48.09	48.11	48.13	-3.0	-2.94	-2.92	Richmond Park - Richmond Park Road North
1195	50.9	49.39	49.43	49.48	-1.5	-1.51	-1.46	49.42	49.46	49.51	-1.5	-1.48	-1.43	Richmond Park - Richmond Park Road North
1196	51.9	49.40	49.44	49.48	-2.5	-2.44	-2.40	49.43	49.47	49.52	-2.5	-2.41	-2.36	Richmond Park - Richmond Park Road North
1197	51.2	50.11	50.16	50.22	-1.1	-1.04	-0.98	50.15	50.21	50.27	-1.0	-0.99	-0.93	Richmond Park - Richmond Park Road North
1198	51.1	50.11	50.16	50.22	-1.0	-0.91	-0.85	50.15	50.21	50.28	-0.9	-0.86	-0.79	Richmond Park - Richmond Park Road North
1199	52.0	50.56	50.61	50.69	-1.4	-1.36	-1.28	50.59	50.66	50.73	-1.4	-1.31	-1.24	Richmond Park - Richmond Park Road North
1200	51.6	50.55	50.60	50.68	-1.1	-1.04	-0.96	50.60	50.66	50.73	-1.0	-0.98	-0.91	Richmond Park - Richmond Park Road North
1201	52.5	51.18	51.27	51.37	-1.3	-1.22	-1.12	51.20	51.28	51.36	-1.3	-1.21	-1.13	Richmond Park - Richmond Park Road North
1202	52.3	51.57	51.69	51.81	-0.7	-0.58	-0.46	51.56	51.65	51.77	-0.7	-0.62	-0.50	Richmond Park - Richmond Park Road North
1203	52.4	52.14	52.28	52.44	-0.3	-0.13	0.03	52.09	52.21	52.33	-0.3	-0.20	-0.08	Richmond Park - Richmond Park Road North
1204	52.4	52.15	52.29	52.45	-0.3	-0.11	0.05	52.10	52.22	52.33	-0.3	-0.18	-0.07	Richmond Park - Richmond Park Road North
1204B	52.0	52.16	52.30	52.45	0.2	0.30	0.45	52.17	52.29	52.41	0.2	0.29	0.41	Richmond Park - Richmond Park Road North
1205	52.2	51.18	51.27	51.37	-1.1	-0.96	-0.86	51.21	51.28	51.36	-1.0	-0.95	-0.87	Richmond Park - Richmond Park Road North
1206	53.2	51.18	51.23	51.31	-2.0	-1.94	-1.86	51.18	51.24	51.30	-2.0	-1.93	-1.87	Richmond Park - Richmond Park Road North
1207	53.1	51.15	51.21	51.28	-1.9	-1.85	-1.78	51.18	51.24	51.30	-1.9	-1.82	-1.76	Richmond Park - Richmond Park Road North
1208	52.6	51.12	51.16	51.20	-1.5	-1.44	-1.40	51.15	51.19	51.24	-1.4	-1.41	-1.36	Richmond Park - Richmond Park Road North
1209	52.6	51.12	51.16	51.20	-1.5	-1.49	-1.45	51.15	51.19	51.24	-1.5	-1.46	-1.41	Richmond Park - Richmond Park Road North
1210	52.8	51.07	51.09	51.10	-1.7	-1.67	-1.66	51.08	51.09	51.10	-1.7	-1.67	-1.66	Richmond Park - Richmond Park Road North
1211	51.8	51.07	51.09	51.10	-0.7	-0.72	-0.71	51.08	51.09	51.10	-0.7	-0.72	-0.71	Richmond Park - Richmond Park Road North
1220	51.9	49.44	49.50	49.56	-2.5	-2.41	-2.35	49.49	49.54	49.60	-2.4	-2.37	-2.31	Richmond Park - Richmond Park Road North
1221	51.0	49.40	49.44	49.48	-1.6	-1.52	-1.48	49.43	49.47	49.52	-1.5	-1.49	-1.44	Richmond Park - Richmond Park Road North
1222	51.4	50.06	50.07	50.08	-1.4	-1.34	-1.33	50.06	50.07	50.08	-1.4	-1.34	-1.33	Richmond Park - Richmond Park Road North
1227	52.1	51.04	51.05	51.07	-1.0	-1.03	-1.01	51.04	51.05	51.07	-1.0	-1.03	-1.01	Richmond Park - Richmond Crescent
1228	53.5	51.04	51.05	51.07	-2.5	-2.44	-2.42	51.04	51.05	51.07	-2.5	-2.44	-2.42	Richmond Park - Richmond Crescent
1229	52.4	51.02	51.04	51.05	-1.4	-1.36	-1.35	51.02	51.04	51.06	-1.4	-1.36	-1.34	Richmond Park - Richmond Crescent

Table A-4

Birch Point Drainage Study - Peak Stage Summary, with Project

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
1230	51.8	50.98	51.00	51.01	-0.8	-0.81	-0.80	50.98	51.00	51.01	-0.8	-0.81	-0.80	Richmond Park - Richmond Crescent
1272	61.1	59.70	59.73	59.75	-1.4	-1.37	-1.35	59.72	59.75	59.77	-1.4	-1.35	-1.33	Shintaffer north of Semiahmoo Parkway
1273	60.3	59.71	59.73	59.76	-0.6	-0.56	-0.53	59.73	59.76	59.78	-0.6	-0.53	-0.51	Shintaffer north of Semiahmoo Parkway
1274	63.2	61.18	61.18	61.19	-2.0	-2.02	-2.01	61.18	61.19	61.19	-2.0	-2.01	-2.01	Shintaffer north of Semiahmoo Parkway
1275	59.7	59.65	59.67	59.70	0.0	0.01	0.04	59.67	59.69	59.71	0.0	0.03	0.05	Shintaffer north of Semiahmoo Parkway
1276	59.3	57.88	57.92	57.96	-1.4	-1.39	-1.35	57.86	57.89	57.93	-1.4	-1.42	-1.38	Shintaffer north of Semiahmoo Parkway
1277	64.1	63.35	63.55	63.79	-0.7	-0.55	-0.31	63.54	63.76	64.02	-0.6	-0.34	-0.08	Shintaffer north of Semiahmoo Parkway
1278	64.3	61.76	61.78	61.80	-2.5	-2.47	-2.45	61.78	61.80	61.82	-2.5	-2.45	-2.43	Shintaffer north of Semiahmoo Parkway
1280	63.7	61.65	61.66	61.68	-2.0	-2.00	-1.98	61.66	61.67	61.69	-2.0	-1.99	-1.97	Shintaffer north of Semiahmoo Parkway
1281	64.8	63.41	63.51	63.60	-1.4	-1.29	-1.20	63.50	63.59	63.69	-1.3	-1.21	-1.11	Shintaffer north of Semiahmoo Parkway
1284	58.2	54.48	54.75	55.09	-3.7	-3.40	-3.06	57.28	57.23	57.28	-0.9	-0.92	-0.87	Shintaffer north of Semiahmoo Parkway
1298	56.9	54.86	54.88	55.12	-2.1	-2.05	-1.81	56.59	57.23	57.28	-0.3	0.30	0.35	Shintaffer north of Semiahmoo Parkway
1308	65.7	63.41	63.51	63.60	-2.2	-2.14	-2.05	63.50	63.59	63.70	-2.2	-2.06	-1.95	Shintaffer north of Semiahmoo Parkway
1309	64.7	63.42	63.51	63.61	-1.3	-1.19	-1.09	63.51	63.60	63.70	-1.2	-1.10	-1.00	Shintaffer north of Semiahmoo Parkway
1310	65.5	63.42	63.51	63.61	-2.1	-2.04	-1.94	63.51	63.60	63.70	-2.0	-1.95	-1.85	Shintaffer north of Semiahmoo Parkway
1311	66.3	63.82	63.84	63.86	-2.5	-2.45	-2.43	63.84	63.86	63.87	-2.4	-2.43	-2.42	Shintaffer north of Semiahmoo Parkway
1316	67.0	64.48	64.50	64.53	-2.6	-2.54	-2.51	64.50	64.53	64.55	-2.5	-2.51	-2.49	Shintaffer north of Semiahmoo Parkway
1317	65.5	64.37	64.38	64.40	-1.1	-1.09	-1.07	64.38	64.40	64.41	-1.1	-1.07	-1.06	Shintaffer north of Semiahmoo Parkway
1253	78.6	77.17	77.17	77.17	-1.5	-1.47	-1.47	77.17	77.17	77.17	-1.5	-1.47	-1.47	Semiahmoo Parkway
1254	82.3	80.43	80.43	80.43	-1.9	-1.86	-1.86	80.43	80.43	80.43	-1.9	-1.86	-1.86	Semiahmoo Parkway
1256	66.6	65.62	65.69	65.78	-1.0	-0.95	-0.86	66.19	66.29	66.44	-0.4	-0.35	-0.20	Semiahmoo Parkway
1257	67.0	65.44	65.51	65.59	-1.6	-1.54	-1.46	66.00	66.11	66.29	-1.0	-0.94	-0.76	Semiahmoo Parkway
1258	80.8	77.45	77.45	77.45	-3.4	-3.36	-3.36	77.45	77.45	77.45	-3.4	-3.36	-3.36	Semiahmoo Parkway
1259	67.0	63.87	63.98	64.11	-3.2	-3.04	-2.91	65.07	65.43	65.89	-2.0	-1.59	-1.13	Semiahmoo Parkway
1260	68.6	62.96	62.98	63.01	-5.7	-5.66	-5.63	63.17	63.20	63.24	-5.5	-5.44	-5.40	Semiahmoo Parkway
1261	64.7	63.53	63.54	63.55	-1.1	-1.12	-1.11	63.60	63.61	63.63	-1.1	-1.05	-1.03	Semiahmoo Parkway
1262	64.0	62.77	62.77	62.78	-1.3	-1.26	-1.25	62.79	62.80	62.80	-1.2	-1.23	-1.23	Semiahmoo Parkway
1263	64.9	61.79	61.83	61.87	-3.1	-3.07	-3.03	62.01	62.04	62.07	-2.9	-2.86	-2.83	Semiahmoo Parkway
1264	65.8	61.41	61.45	61.49	-4.4	-4.35	-4.31	61.69	61.74	61.79	-4.1	-4.06	-4.01	Semiahmoo Parkway
1265	64.5	61.40	61.44	61.48	-3.1	-3.02	-2.98	61.69	61.73	61.78	-2.8	-2.73	-2.68	Semiahmoo Parkway
1266	60.0	57.67	57.75	57.86	-2.3	-2.26	-2.15	58.42	58.55	58.71	-1.6	-1.46	-1.30	Semiahmoo Parkway
1267	60.1	56.99	57.03	57.08	-3.2	-3.12	-3.07	57.32	57.53	57.69	-2.8	-2.62	-2.46	Semiahmoo Parkway
1268	59.8	58.26	58.27	58.29	-1.5	-1.51	-1.49	58.35	58.37	58.38	-1.4	-1.41	-1.40	Semiahmoo Parkway
1269	60.2	58.04	58.05	58.06	-2.2	-2.17	-2.16	58.12	58.13	58.14	-2.1	-2.09	-2.08	Semiahmoo Parkway
1270	60.2	58.04	58.05	58.06	-2.2	-2.16	-2.15	58.11	58.12	58.14	-2.1	-2.09	-2.07	Semiahmoo Parkway
1271	60.0	57.54	57.55	57.56	-2.5	-2.48	-2.47	57.59	57.60	57.61	-2.4	-2.43	-2.42	Semiahmoo Parkway
1286	56.8	55.84	55.85	55.85	-0.9	-0.92	-0.92	56.06	56.47	56.48	-0.7	-0.30	-0.29	Semiahmoo Parkway
1297	56.4	54.21	54.43	54.70	-2.2	-1.95	-1.68	56.38	56.35	56.38	0.0	-0.03	0.00	Semiahmoo Parkway
1327	67.8	64.43	64.49	64.56	-3.3	-3.27	-3.20	65.14	65.47	65.91	-2.6	-2.29	-1.85	Semiahmoo Parkway
1328	67.7	65.00	65.07	65.14	-2.7	-2.62	-2.55	65.56	65.73	66.03	-2.1	-1.96	-1.66	Semiahmoo Parkway
1329	66.7	65.27	65.34	65.41	-1.5	-1.40	-1.33	65.82	65.95	66.17	-0.9	-0.79	-0.57	Semiahmoo Parkway
1330	67.5	65.58	65.66	65.74	-1.9	-1.82	-1.74	66.14	66.24	66.40	-1.3	-1.24	-1.08	Semiahmoo Parkway
1331	64.5	63.67	63.68	63.69	-0.8	-0.84	-0.83	63.74	63.75	63.77	-0.8	-0.77	-0.75	Semiahmoo Parkway
1332	65.5	64.06	64.06	64.06	-1.4	-1.42	-1.42	64.06	64.06	64.06	-1.4	-1.42	-1.42	Semiahmoo Parkway
1333	64.8	63.68	63.69	63.70	-1.1	-1.07	-1.06	63.75	63.76	63.78	-1.0	-1.00	-0.98	Semiahmoo Parkway
1291	55.0	52.94	53.00	53.07	-2.1	-2.00	-1.93	53.18	53.26	53.29	-1.8	-1.74	-1.71	Shintaffer North of Richmond Park - West Side
1296	56.3	54.18	54.39	54.66	-2.1	-1.91	-1.64	56.30	56.30	56.30	0.0	0.00	0.00	Shintaffer North of Richmond Park - West Side
1318	54.3	52.94	53.00	53.07	-1.4	-1.30	-1.23	53.18	53.25	53.28	-1.1	-1.05	-1.02	Shintaffer North of Richmond Park - West Side
1326	55.2	52.59	52.68	52.78	-2.6	-2.52	-2.42	52.74	52.91	53.01	-2.5	-2.29	-2.19	Shintaffer North of Richmond Park - West Side
1326A	54.4	52.52	52.60	52.68	-1.9	-1.80	-1.72	52.58	52.74	52.82	-1.8	-1.66	-1.58	Shintaffer North of Richmond Park - West Side
1326B	53.1	52.46	52.52	52.59	-0.6	-0.53	-0.46	52.43	52.56	52.64	-0.6	-0.49	-0.41	Shintaffer North of Richmond Park - West Side
1326C	52.8	52.39	52.45	52.51	-0.4	-0.30	-0.24	52.27	52.39	52.46	-0.5	-0.36	-0.29	Shintaffer North of Richmond Park - West Side
1319	54.2	52.33	52.49	52.71	-1.9	-1.70	-1.48	52.75	52.96	53.36	-1.4	-1.23	-0.83	Middle Shintaffer
1320	53.0	52.33	52.49	52.71	-0.7	-0.51	-0.29	52.75	52.96	53.36	-0.3	-0.04	0.36	Middle Shintaffer
1321	53.2	52.33	52.49	52.71	-0.9	-0.74	-0.52	52.75	53.00	53.41	-0.5	-0.23	0.18	Middle Shintaffer
1322	52.4	52.33	52.49	52.71	-0.1	0.05	0.27	52.78	53.00	53.42	0.3	0.56	0.98	Middle Shintaffer
1323	52.7	52.04	52.17	52.32	-0.6	-0.51	-0.36	52.34	52.56	52.95	-0.3	-0.12	0.27	Middle Shintaffer
1323	52.7	52.04	52.17	52.32	-0.6	-0.51	-0.36	52.34	52.56	52.95	-0.3	-0.12	0.27	Middle Shintaffer
1323A	52.7	52.04	52.17	52.32	-0.7	-0.53	-0.38	52.34	52.56	52.96	-0.4	-0.14	0.26	Middle Shintaffer
1324	52.4	52.34	52.39	52.47	-0.1	-0.01	0.07	52.11	52.23	52.32	-0.3	-0.17	-0.08	Middle Shintaffer
1235	53.2	51.82	51.93	52.07	-1.4	-1.30	-1.16	52.10	52.27	52.58	-1.1	-0.96	-0.65	Middle Shintaffer
1236	53.6	51.82	51.93	52.07	-1.8	-1.67	-1.53	52.10	52.27	52.58	-1.5	-1.33	-1.02	Middle Shintaffer
1237	52.9	52.04	52.17	52.32	-0.8	-0.68	-0.53	52.34	52.56	52.95	-0.5	-0.29	0.10	Middle Shintaffer
1238	53.9	51.81	51.92	52.06	-2.1	-1.96	-1.82	52.09	52.26	52.56	-1.8	-1.62	-1.32	Middle Shintaffer
1292	54.6	52.60	52.70	52.79	-2.0	-1.90	-1.81	52.76	52.94	53.05	-1.8	-1.66	-1.55	Middle Shintaffer
1293	55.4	52.59	52.68	52.78	-2.8	-2.68	-2.58	52.74	52.91	53.01	-2.6	-2.45	-2.35	Middle Shintaffer
1294	54.9	53.45	53.47	53.48	-1.5	-1.47	-1.46	53.52	53.54	53.56	-1.4	-1.40	-1.38	Middle Shintaffer
1295	55.9	53.94	53.96	53.98	-1.9	-1.90	-1.88	54.06	54.09	54.13	-1.8	-1.77	-1.73	Middle Shintaffer
1300	54.9	53.96	53.96	53.98	-1.0	-0.97	-0.95	54.06	54.09	54.13	-0.9	-0.84	-0.80	Middle Shintaffer
1325	54.8	52.60	52.70	52.79	-2.2	-2.10	-2.01	52.76	52.94	53.05	-2.0	-1.86	-1.75	Middle Shintaffer
501	26.5	23.17	23.18	23.19	-3.4	-3.36	-3.35	23.59	23.61	23.63	-2.9	-2.93	-2.91	Lower Shintaffer
505	30.0	27.11	27.11	27.11	-2.9	-2.92	-2.92	27.11	27.11	27.11	-2.9	-2.92	-2.92	Lower Shintaffer
507	48.9	45.23	45.24	45.25	-3.7	-3.67	-3.66	45.55	45.56	45.58	-3.4	-3.35	-3.33	Lower Shintaffer
508	51.7	47.62	47.63	47.64	-4.1	-4.04	-4.03	48.10	48.12	48.15	-3.6	-3.55	-3.52	Lower Shintaffer
509	52.5	47.94	47.94	47.94	-4.6	-4.59	-4.59	48.08	48.11	48.12	-4.5	-4.42	-4.41	Lower Shintaffer
511	52.5	48.11	48.12	48.15	-4.4	-4.43	-4.40	48.78	48.84	48.89	-3.8	-3.71	-3.66	Lower Shintaffer
514	52.4	48.49	48.52	48.56	-3.9	-3.88	-3.84	49.06	49.12	49.20	-3.3	-3.28	-3.20	Lower Shintaffer
518	52.2	48.85	48.90	48.96	-3.3	-3.29	-3.23	49.43	49.45	49.56	-2.8	-2.74	-2.63	Lower Shintaffer
519	52.2	48.89	48.93	49.00	-3.3	-3.24	-3.17	49.47	49.52	49.61	-2.7	-2.65	-2.56	Lower Shintaffer
520	51.9	49.00	49.05	49.14	-2.9	-2.82	-2.73	49.58	49.65	49.72	-2.3	-2.22	-2.15	Lower Shintaffer
521	52.4	49.23	49.29	49.39	-3.2	-3.15	-3.05	49.78	49.87	49.93	-2.7	-2.57	-2.51	Lower Shintaffer
522	51.7	49.35	49.43	49.53	-2.3	-2.23	-2.13	49.89	50.00	50.05	-1.8	-1.66	-1.61	Lower Shintaffer
523	52.9	51.33	51.42	51.53	-1.6	-1.48	-1.37	51.56	51.69	51.94	-1.3	-1.21	-0.96	Lower Shintaffer
524	52.4	50.88	50.95	51.04	-1.5	-1.44	-1.35	51.05	51.16	51.35	-1.3	-1.23	-1.04	Lower Shintaffer
525	51.8	50.88	50.95	51.04	-0.9	-0.86	-0.77	51.05	51.16	51.35	-0.8	-0.65	-0.46	Lower Shintaffer
527	51.5	49.28	49.29	49.29	-2.2	-2.21	-2.21	49.33	49.33	49.34	-2.2	-2.17	-2.16	Lower Shintaffer
1244	51.8	49.61	49.71	49.80	-2.2	-2.08	-1.99	50.10	50.23	50.27	-1.7	-1.56	-1.52	Lower Shintaffer
1245	52.9	51.33	51.42	51.54	-1.6	-1.52	-1.40	51.56	51.70	51.94	-1.4	-1.24	-1.00	Lower Shintaffer
1246	53.3	51.81	51.92	52.06	-1.5	-1.42	-1.28	52.09	52.26	52.56	-1.3	-1.08	-0.78	Lower Shintaffer
BP21aPond	164.2	160.51	160.72	160.98	-3.7	-3.48	-3.22	163.32	163.85	164.43	-0.9	-0.35	0.23	Semiahmoo Uplands
FieldPond1	152.7	147.65	147.75	147.87	-5.0	-4.95	-4.83	148.08	148.23	148.45	-4.6	-4.47	-4.25	Semiahmoo Uplands
G1-1	81.8	82.66	82.71	82.77	0.9	0.92	0.98	82.70	82.75	82.81	0.9	0.96	1.02	Semiahmoo Uplands
G1-2	90.3	90.33	90.48	90.62	0.0	0.18	0.32	90.57	90.66	90.72	0.3	0.36	0.42	Semiahmoo Uplands

Table A-4

Birch Point Drainage Study - Peak Stage Summary, with Project

		Existing Land Use						Future Land Use						
		Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			Peak HGL (feet NAVD 88)			Height Above Flood Depth (ft)			
Junction	Flood Elev	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	100-year	Nov-21	imate Chang	Location
G2-1	75.5	75.69	75.85	75.95	0.2	0.35	0.45	76.25	76.31	76.39	0.8	0.81	0.89	Semiahmoo Uplands
G2-2	74.0	74.95	75.02	75.11	1.0	1.02	1.11	75.05	75.13	75.22	1.1	1.13	1.22	Semiahmoo Uplands
SU-1b	229.0	226.57	226.76	226.98	-2.4	-2.24	-2.02	227.21	227.45	227.74	-1.8	-1.55	-1.26	Semiahmoo Uplands
TF-1	80.6	80.92	81.10	81.29	0.3	0.46	0.65	81.11	81.28	81.43	0.5	0.64	0.79	Semiahmoo Uplands
HorizonPond	32.4	33.15	33.34	33.58	0.7	0.92	1.16	34.35	34.59	34.92	1.9	2.17	2.50	Horizon Pond
PD63	33.7	32.08	32.56	33.12	-1.6	-1.11	-0.55	32.59	33.07	33.70	-1.1	-0.60	0.03	Horizon Pond
Lake6	181.0	179.75	179.80	179.86	-1.3	-1.20	-1.14	179.90	179.96	180.04	-1.1	-1.04	-0.96	Semiahmoo Golf Course
Lake9	235.0	231.75	231.78	231.82	-3.3	-3.22	-3.18	231.85	231.88	231.93	-3.2	-3.12	-3.07	Semiahmoo Golf Course
Lake12	229.2	226.58	226.76	226.98	-2.6	-2.44	-2.22	227.21	227.45	227.74	-2.0	-1.75	-1.46	Semiahmoo Golf Course
Lake18	235.0	233.13	233.20	233.30	-1.9	-1.80	-1.70	233.32	233.41	233.53	-1.7	-1.59	-1.47	Semiahmoo Golf Course
Pond3Dn_In	8.4	7.30	7.43	7.59	-1.1	-0.97	-0.81	7.39	7.53	7.71	-1.0	-0.87	-0.69	Birch Bay Village

Table A-6 Birch Point Drainage Study - Peak Flow Summary, with Project							
	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
C1006	2.9	3.2	3.6	3.1	3.4	3.7	Birch Point Road West of Selder
OD1752	2.9	3.2	3.5	3.0	3.3	3.7	Birch Point Road West of Selder
C1007	2.8	3.1	3.4	2.9	3.2	3.6	Birch Point Road West of Selder
OF-C1007	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1010_1	2.8	3.1	3.4	2.9	3.2	3.6	Birch Point Road West of Selder
OD1756	0.0	0.0	2.9	4.1	25.5	39.8	Birch Point Road West of Selder
OD1757	53.2	59.9	67.7	69.9	77.9	78.4	Birch Point Road West of Selder
C1008	55.1	64.5	78.0	64.6	66.7	68.8	Birch Point Road West of Selder
C1008-OF	0.0	0.0	0.0	31.3	54.6	71.9	Birch Point Road West of Selder
OD1010_4	2.9	4.3	6.7	4.6	6.5	8.3	Birch Point Road West of Selder
OD1010_2	2.8	3.0	3.4	2.9	3.2	3.5	Birch Point Road West of Selder
OD1010_3	3.0	4.3	6.7	4.4	6.4	8.3	Birch Point Road West of Selder
OD1753	3.0	3.2	3.6	3.1	3.4	3.8	Birch Point Road West of Selder
OD1755	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
GM3875	17.7	19.0	20.9	21.7	21.8	22.0	Birch Point Road West of Selder
GM3873	4.6	6.0	9.8	14.0	18.2	23.9	Birch Point Road West of Selder
GM3878	16.2	16.8	17.7	18.2	20.1	20.5	Birch Point Road West of Selder
GM3872	4.6	6.0	9.8	14.0	18.2	23.9	Birch Point Road West of Selder
C1009	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1759	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1031	0.8	1.2	2.3	3.7	5.1	7.1	Birch Point Road West of Selder
C1025	8.0	9.2	11.1	11.9	12.4	12.7	Birch Point Road West of Selder
C1025-OF	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
BBVC18	9.4	11.3	14.2	15.5	17.8	19.1	Birch Point Road West of Selder
C1026	9.9	11.3	13.8	15.2	20.6	28.1	Birch Point Road West of Selder
OD1032	6.0	6.2	7.2	6.1	6.4	6.6	Birch Point Road West of Selder
OD1034	18.3	20.0	23.2	24.2	31.2	39.7	Birch Point Road West of Selder
GM3874	17.7	19.0	20.9	21.7	21.8	22.0	Birch Point Road West of Selder
GM3877	1.5	2.2	3.2	3.5	3.5	3.6	Birch Point Road West of Selder
OD1020_1	3.4	5.2	8.5	12.3	15.8	20.2	Birch Point Road West of Selder
OD1020_2	3.5	4.3	5.1	5.7	6.5	7.0	Birch Point Road West of Selder
OD1020_3	18.2	22.1	26.5	30.3	32.0	34.3	Birch Point Road West of Selder
OD1020_4	19.1	23.5	28.6	33.2	35.6	39.1	Birch Point Road West of Selder
BBVC1	16.2	16.8	17.7	18.3	20.2	20.7	Birch Point Road West of Selder
OD1761	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road West of Selder
OD1782	1.5	2.1	3.1	3.7	5.5	5.9	Birch Point Road West of Selder
OD1784	1.5	2.2	3.1	3.8	5.5	5.9	Birch Point Road West of Selder
CV3570	0.0	0.0	0.0	0.0	0.0	0.0	Bay Ridge Estates - West Shoreview Road
OD1001	0.6	0.6	0.4	0.6	0.6	0.7	Bay Ridge Estates - West Shoreview Road
CV3571	1.0	1.0	0.9	1.0	1.0	1.1	Bay Ridge Estates - West Shoreview Road
OD1002	6.2	6.2	5.8	6.2	6.2	6.2	Bay Ridge Estates - West Shoreview Road
CV3572	3.1	3.1	3.1	3.1	3.1	3.1	Bay Ridge Estates - West Shoreview Road
OD1000	0.0	0.0	0.0	0.0	0.0	0.0	Bay Ridge Estates - West Shoreview Road
CV3586	1.3	1.5	1.9	2.0	2.0	2.3	Bay Ridge Estates - West Shoreview Road
OD1762_2	0.0	0.3	3.1	0.8	1.4	2.5	Bay Ridge Estates - West Shoreview Road
GM3867	0.7	0.8	1.1	1.5	1.9	2.6	Bay Ridge Estates - West Shoreview Road
OD1762_1	1.0	1.1	1.4	2.1	3.0	4.1	Bay Ridge Estates - West Shoreview Road
GM3866	0.4	0.5	0.8	1.2	1.6	2.3	Bay Ridge Estates - West Shoreview Road
OD0985lower	3.9	4.2	4.4	4.1	4.3	4.5	Bay Ridge Estates - East Shoreview Road
CV3575	2.1	2.1	2.1	2.1	2.1	2.1	Bay Ridge Estates - East Shoreview Road
OD1004	2.2	2.2	2.2	2.2	2.2	2.2	Bay Ridge Estates - East Shoreview Road
CV3592.1	0.5	0.5	0.6	0.6	0.6	0.6	Bay Ridge Estates - East Shoreview Road
OD1009	1.6	1.8	1.9	2.2	2.2	2.3	Bay Ridge Estates - East Shoreview Road
SM781	2.3	2.3	2.3	2.3	2.3	2.3	Bay Ridge Estates - East Shoreview Road
SM789	3.1	3.1	3.1	3.2	3.2	3.2	Bay Ridge Estates - East Shoreview Road
SM778	2.6	2.6	2.7	2.6	2.7	2.7	Bay Ridge Estates - East Shoreview Road
SM790	4.0	4.1	4.1	4.1	4.1	4.1	Bay Ridge Estates - East Shoreview Road
SM782	4.3	5.1	5.8	5.1	5.8	6.6	Bay Ridge Estates - East Shoreview Road
SM783	7.4	8.3	9.2	8.3	9.0	10.0	Bay Ridge Estates - East Shoreview Road
SM777	2.9	3.0	3.1	2.9	3.0	3.1	Bay Ridge Estates - East Shoreview Road
SM780	2.1	2.1	2.1	2.1	2.1	2.1	Bay Ridge Estates - East Shoreview Road
SM788	2.9	2.9	3.0	3.1	3.1	3.1	Bay Ridge Estates - East Shoreview Road
CV3544	3.0	3.0	2.8	3.0	3.0	3.0	Bay Ridge Estates - Bay Ridge Drive South
OD994	24.5	24.6	24.1	24.6	24.7	24.9	Bay Ridge Estates - Bay Ridge Drive South
OD1015	0.5	0.5	0.6	0.6	0.6	0.6	Bay Ridge Estates - Bay Ridge Drive South
SM732	6.3	6.7	7.2	7.3	7.7	8.3	Bay Ridge Estates - Bay Ridge Drive South
SM757	0.5	0.5	0.5	0.5	0.5	0.5	Bay Ridge Estates - Bay Ridge Drive South
SM758	0.5	0.5	0.6	0.5	0.6	0.9	Bay Ridge Estates - Bay Ridge Drive South
SM748	2.2	2.2	2.1	2.2	2.2	2.2	Bay Ridge Estates - Bay Ridge Drive South
SM761	0.8	0.8	0.9	0.8	0.9	1.2	Bay Ridge Estates - Bay Ridge Drive South
SM749	2.4	2.4	2.4	2.5	2.4	2.4	Bay Ridge Estates - Bay Ridge Drive South
SM755	2.7	2.7	2.7	2.7	2.7	2.7	Bay Ridge Estates - Bay Ridge Drive South
OD984	8.1	8.2	7.3	8.2	8.3	8.4	Bay Ridge Estates - Bay Ridge Drive South
SM743	1.9	1.9	1.9	2.1	2.0	2.0	Bay Ridge Estates - Bay Ridge Drive South
SM753	1.5	1.6	1.9	1.7	1.8	2.3	Bay Ridge Estates - Bay Ridge Drive South
OD985Upper	1.1	1.3	1.3	1.3	1.4	1.6	Bay Ridge Estates - Bay Ridge Drive South
CV3346	1.0	1.1	1.2	1.4	1.5	1.7	Bay Ridge Estates - Seawan Place
CV3357	1.5	1.6	1.8	2.0	2.2	2.5	Bay Ridge Estates - Seawan Place
OD907	1.5	1.6	1.8	2.0	2.1	2.6	Bay Ridge Estates - Seawan Place
CV3377	1.7	1.9	2.1	2.3	2.4	3.2	Bay Ridge Estates - Seawan Place
OD918	1.8	1.9	2.1	2.2	2.4	3.6	Bay Ridge Estates - Seawan Place
CV3399	2.0	2.2	2.4	2.5	2.7	4.4	Bay Ridge Estates - Seawan Place
OD935	2.0	2.2	2.4	2.5	2.7	5.0	Bay Ridge Estates - Seawan Place
CV3434	2.3	2.5	2.8	2.7	3.0	5.3	Bay Ridge Estates - Seawan Place
OD950	2.3	2.5	2.8	2.7	3.0	5.3	Bay Ridge Estates - Seawan Place

Table A-6

Birch Point Drainage Study - Peak Flow Summary, with Project

	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
SM704	1.3	1.4	1.6	1.7	1.9	2.1	Bay Ridge Estates - Seawan Place
SM714	2.6	2.8	3.1	3.0	3.3	4.5	Bay Ridge Estates - Seawan Place
SM702	2.4	2.6	2.9	2.5	2.8	3.3	Bay Ridge Estates - Bay Ridge Drive Middle
SM705	2.2	2.4	2.6	2.5	2.7	2.9	Bay Ridge Estates - Bay Ridge Drive Middle
SM715	1.9	2.2	2.3	2.3	2.4	2.6	Bay Ridge Estates - Bay Ridge Drive Middle
SM7201	1.8	2.0	2.2	2.0	2.2	2.6	Bay Ridge Estates - Bay Ridge Drive Middle
SM695	2.8	3.0	3.3	3.1	3.3	3.5	Bay Ridge Estates - Bay Ridge Drive Middle
OD967	1.4	1.5	1.7	1.7	1.9	2.2	Bay Ridge Estates - Bay Ridge Drive Middle
OD938	2.5	2.7	2.9	2.8	3.0	3.2	Bay Ridge Estates - Bay Ridge Drive Middle
SM710	2.1	2.3	2.6	2.2	2.5	3.0	Bay Ridge Estates - Bay Ridge Drive Middle
OD954	2.1	2.3	2.6	2.3	2.5	3.1	Bay Ridge Estates - Bay Ridge Drive Middle
SM720	1.8	2.0	2.2	2.0	2.2	2.5	Bay Ridge Estates - Bay Ridge Drive Middle
SM724	1.8	2.0	2.1	2.1	2.2	2.3	Bay Ridge Estates - Bay Ridge Drive Middle
SM740	9.9	10.7	11.4	11.1	11.9	12.6	Bay Ridge Estates - Bay Ridge Drive West
SM734	3.1	3.4	3.5	3.3	3.5	3.5	Bay Ridge Estates - Bay Ridge Drive West
SM707	3.0	3.0	3.1	3.0	3.0	3.1	Bay Ridge Estates - Bay Ridge Drive West
SM697	2.7	2.7	2.7	2.7	2.7	2.7	Bay Ridge Estates - Bay Ridge Drive West
SM701	2.9	2.9	2.9	2.9	2.9	2.9	Bay Ridge Estates - Bay Ridge Drive West
SM727	3.3	3.4	3.6	3.4	3.5	3.6	Bay Ridge Estates - Bay Ridge Drive West
SM731	2.7	3.0	3.3	3.6	4.0	4.4	Bay Ridge Estates - Bay Ridge Drive West
SM738	3.3	3.7	3.9	3.6	3.8	3.9	Bay Ridge Estates - Bay Ridge Drive West
OD958	3.3	3.4	3.5	3.4	3.5	3.6	Bay Ridge Estates - Bay Ridge Drive West
SM694	3.0	3.3	3.6	3.3	3.6	3.8	Bay Ridge Estates - Bay Ridge Drive West
SM703	2.7	2.9	3.3	2.8	3.1	3.6	Bay Ridge Estates - Bay Ridge Drive West
C1156-OF_2	1.7	1.9	2.1	2.3	2.6	2.9	
OD939	2.5	2.7	3.0	3.3	3.6	4.0	Bay Ridge Estates
BBVC27	9.4	11.0	12.9	10.2	11.9	14.1	Birch Bay Village
BBVC22	17.3	18.0	18.9	19.0	25.1	31.4	Birch Bay Village
BBVC29	0.0	0.0	0.0	0.0	0.1	0.2	Birch Bay Village
3	55.0	61.0	68.1	69.2	71.6	73.1	
BBV_Canal_chnl	65.9	70.9	77.9	75.4	82.5	88.3	Birch Bay Drive at Birch Loop
BBV_CHNL_POND9	92.6	96.8	108.9	96.6	108.0	118.4	Birch Bay Village
BBVC4_1	2.6	3.2	6.2	3.6	6.1	6.4	Birch Bay Village
BBVC4_2	2.6	3.2	4.2	3.6	4.5	5.3	Birch Bay Village
BBVC16	10.8	12.1	12.1	12.3	12.2	12.2	Birch Bay Village
BBVC15	10.8	12.6	15.4	16.4	19.0	20.4	Birch Bay Village
BBVC13	10.8	12.6	15.4	16.4	19.0	20.4	Birch Bay Village
BBVC17	9.4	11.3	14.2	15.5	17.8	19.3	Birch Bay Village
BBVC14	10.8	12.6	15.9	17.0	19.0	20.4	Birch Bay Village
BBVC20	10.2	10.5	11.1	11.1	14.6	20.2	Birch Bay Village
BBVC21	10.2	10.6	11.1	11.1	14.6	20.2	Birch Bay Village
BBVC23	8.8	9.1	9.4	9.8	13.5	19.2	Birch Bay Village
BBVC24	8.4	8.9	9.5	9.3	11.6	14.4	Birch Bay Village
BBVC26	11.1	12.4	13.8	12.1	13.7	13.8	Birch Bay Village
BBVC28	1.5	1.6	1.8	2.0	2.0	2.0	Birch Bay Village
Thunderbird_Pond	10.9	12.3	13.8	12.1	13.7	13.8	
BBVC_1_1	5.9	5.8	5.8	6.0	5.9	5.9	
BBVC1_2	5.9	5.8	5.8	6.0	5.9	5.8	Birch Bay Village
BBVC2	7.3	8.7	10.1	9.7	10.8	12.1	
BBVC2_3	7.3	8.7	10.1	9.7	10.8	12.1	Birch Bay Village
BBVC2_2	7.3	8.7	10.1	9.7	10.8	12.1	Birch Bay Village
BBVC2_4	7.3	8.7	10.1	9.7	10.8	12.1	Birch Bay Village
BBVC2_1	7.3	8.7	10.1	9.7	10.8	12.1	Birch Bay Village
BBVC2_5	7.3	8.7	10.1	9.7	10.8	12.1	Birch Bay Village
BBVC11	130.5	134.8	139.8	132.9	137.3	141.7	Birch Bay Village
BBVC12	130.5	134.8	139.8	132.9	137.3	141.7	
BBVC6	2.6	3.0	3.6	3.4	4.7	3.8	Birch Bay Village
OD1904_1	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
C1157	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
OD1793_3	85.0	92.4	102.2	126.3	140.1	156.8	Selder Road
C1156	21.9	25.8	29.2	22.0	26.0	29.3	Selder Road
C1156-OF_1	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road
C1125	15.3	16.2	16.6	15.5	16.3	16.6	Selder Road
C1125-OF	6.6	9.7	12.7	6.5	9.7	12.8	Selder Road
OD1873	14.6	17.3	19.6	14.7	17.4	19.7	Selder Road
C1123	6.9	6.9	7.0	6.9	6.9	7.0	Selder Road
F-LDES2595_LDES25	7.7	10.4	12.6	7.8	10.5	12.7	Selder Road
OD1872	14.6	17.4	19.6	14.7	17.5	19.7	Selder Road
C1122	7.8	8.0	8.1	7.8	8.0	8.1	Selder Road
F-LDES2603_LDES26	6.8	9.4	11.5	6.8	9.5	11.5	Selder Road
OD1871	14.6	17.4	19.6	14.7	17.5	19.7	Selder Road
C1121	7.7	7.8	7.9	7.7	7.8	7.9	Selder Road
F-LDES2611_LDES26	6.9	9.6	11.6	7.0	9.7	11.7	Selder Road
OD1870	14.6	17.4	19.6	14.7	17.5	19.7	Selder Road
C1120	14.6	15.2	15.5	14.7	15.2	15.5	Selder Road
C1120-OF	0.0	2.2	4.1	0.0	2.3	4.2	Selder Road
OD1869	8.0	8.8	9.8	8.1	8.9	9.9	Selder Road
C1119	6.4	6.5	6.6	6.4	6.5	6.6	Selder Road
C1119-OF	1.7	2.4	3.2	1.7	2.4	3.3	Selder Road
OD1868	8.0	8.8	9.9	8.1	8.9	9.9	Selder Road
C1118	5.0	5.1	5.1	5.0	5.1	5.1	Selder Road
F-LDES2635_LDES26	3.0	3.8	4.8	3.1	3.8	4.8	Selder Road
C1038	8.1	8.9	9.9	8.2	9.0	10.0	Selder Road
OD1836	8.1	8.9	9.9	8.1	8.9	9.9	Selder Road
C1124	6.9	6.9	7.0	6.9	6.9	7.0	Selder Road
OD630	0.0	0.0	0.0	0.0	0.0	0.0	Selder Road

Table A-6 Birch Point Drainage Study - Peak Flow Summary, with Project							
	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
RS_Creek_4	85.0	92.4	102.2	126.3	140.1	156.8	Selder Road
10_2	15.2	16.2	17.5	24.6	28.1	33.8	
OD1793_1	64.0	69.8	76.9	105.3	116.6	130.5	Selder Road
C1032	6.1	6.1	6.1	6.4	6.4	6.4	Selder Road
C1032-OF	4.8	6.4	8.2	22.0	24.8	28.4	Selder Road
C1017	4.5	4.6	4.6	4.7	4.7	4.7	Selder Road
C1017-OF	7.5	8.7	10.1	23.9	26.8	30.4	Selder Road
OD1774	12.0	13.2	14.7	28.4	31.2	34.8	Selder Road
C1022	7.4	7.4	7.4	7.5	7.5	7.5	Selder Road
C1022-OF	4.8	6.1	7.6	21.8	24.7	28.3	Selder Road
OD1776	11.8	13.0	14.5	28.2	31.0	34.5	Selder Road
C1012	4.6	4.6	4.6	4.6	4.7	4.9	Selder Road
C1012-OF	7.6	8.8	10.3	23.9	26.6	30.0	Selder Road
OD1767	12.1	13.3	14.8	28.5	31.3	34.9	Selder Road
OD1768	12.0	13.2	14.7	28.4	31.3	34.8	Selder Road
GM3879	0.1	0.1	0.3	0.5	0.5	0.9	Birch Point Road East of Selder
SM806	5.3	5.8	6.7	7.6	8.5	8.7	Birch Point Road East of Selder
SM807	10.6	11.6	12.6	13.4	14.4	14.5	Birch Point Road East of Selder
GM3880	0.0	0.0	0.3	0.5	0.5	0.9	Birch Point Road East of Selder
OD1904_2	0.0	0.0	0.0	0.0	0.0	0.0	
OF-LDES2552_2728	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road East of Selder
OF-LDES2552_2888	0.0	0.0	0.0	0.0	0.0	0.0	Birch Point Road East of Selder
OD1038	0.0	0.0	0.0	0.0	0.7	2.6	Birch Point Road East of Selder
SM800	5.4	5.9	6.6	7.5	8.3	9.2	Birch Point Road East of Selder
SM802	5.4	5.9	6.6	7.5	8.3	9.2	Birch Point Road East of Selder
SM815	0.3	0.3	1.5	3.0	4.6	4.7	Birch Point Road East of Selder
OD1093_2	0.2	0.2	0.8	1.3	1.7	2.1	Birch Bay Drive at Birch Loop
SM822	2.1	2.3	2.6	2.8	2.8	2.8	Birch Bay Drive at Birch Loop
CV3751	0.0	0.1	0.8	1.3	1.7	2.1	Birch Bay Drive at Birch Loop
11	3.1	3.1	3.1	3.1	3.2	3.2	Birch Bay Drive at Birch Loop
92608	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
CV3738	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
13	2.2	2.7	3.4	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_1	2.2	2.7	3.4	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
5CV3714	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
OD1075-L	1.7	1.9	2.7	3.3	3.8	4.2	Birch Bay Drive at Birch Loop
CV3723	27.1	26.3	16.2	19.8	29.9	30.4	Birch Bay Drive at Birch Loop
Rogers_Slough_1	122.5	134.8	145.3	163.5	172.3	180.2	Birch Bay Drive at Birch Loop
OD1086	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive at Birch Loop
CV3740	1.7	1.8	2.7	3.3	3.8	4.2	Birch Bay Drive at Birch Loop
OD1093_1	0.4	0.4	0.9	1.3	1.7	2.1	Birch Bay Drive at Birch Loop
5	13.7	14.7	15.7	16.6	17.5	17.7	Birch Bay Drive at Birch Loop
SM840	11.9	12.1	12.1	12.0	12.0	11.9	Birch Bay Drive at Birch Loop
SM840-OF	1.1	2.7	4.2	5.2	6.4	6.6	Birch Bay Drive at Birch Loop
OD1058_1	107.1	115.5	121.1	138.7	144.5	151.8	Birch Bay Drive at Birch Loop
OD1058_2	107.1	111.2	113.5	128.8	131.3	134.2	Birch Bay Drive at Birch Loop
OD1058_3	106.5	109.5	110.9	125.5	125.8	126.0	Birch Bay Drive at Birch Loop
RS_Creek_1	108.3	120.3	129.9	148.7	158.0	169.5	
OD1071_2	17.4	19.0	20.3	21.8	23.2	23.7	Birch Bay Drive at Birch Loop
OD1071_3	16.7	19.8	21.7	20.2	21.3	21.3	Birch Bay Drive at Birch Loop
OD1073	2.2	2.7	3.4	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_2	2.2	2.7	3.4	4.1	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_3	2.5	2.8	3.4	4.1	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_4	2.6	2.9	3.4	4.1	4.6	5.1	Birch Bay Drive at Birch Loop
OD1075-U_5	2.6	3.0	3.4	4.2	4.7	5.1	Birch Bay Drive at Birch Loop
OD1075-U_6	2.9	3.3	3.7	4.0	4.3	4.6	Birch Bay Drive at Birch Loop
OD1075-U_7	2.8	2.9	3.2	3.4	3.9	4.3	Birch Bay Drive at Birch Loop
PD46	5.3	5.8	6.5	7.3	7.8	8.3	Birch Bay Drive at Birch Loop
92971	2.2	2.7	3.4	4.2	4.6	5.1	Birch Bay Drive at Birch Loop
SM838	1.8	1.8	1.9	1.9	1.9	1.9	Birch Bay Drive at Birch Loop
SM839	1.3	1.3	1.3	1.3	1.3	1.3	Birch Bay Drive at Birch Loop
OD1071_1	17.7	19.6	21.3	23.0	24.8	25.5	Birch Bay Drive at Birch Loop
SM9799	0.2	0.2	0.8	1.3	1.7	2.1	Birch Bay Drive at Birch Loop
Rogers_Slough_2	122.5	134.8	145.3	163.5	172.2	180.1	Birch Bay Drive at Birch Loop
P-1366-1372	4.3	4.5	4.7	4.3	4.4	4.6	Pheasant - Grouse Cress
D-1367-1366	4.3	4.5	4.7	4.3	4.4	4.6	Pheasant - Grouse Cress
P-1368-1367	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1372-1460	6.1	6.4	6.8	6.3	6.7	7.1	Pheasant - Grouse Cress
P-1373-1367	2.2	2.3	2.5	2.2	2.3	2.4	Pheasant - Grouse Cress
P-1374-1373	2.2	2.3	2.5	2.2	2.3	2.4	Pheasant - Grouse Cress
D-1375-1368	2.1	2.2	2.3	2.1	2.2	2.3	Pheasant - Grouse Cress
P-1376-1375	2.1	2.2	2.3	2.1	2.2	2.3	Pheasant - Grouse Cress
D-1377-1374	2.3	2.3	2.5	2.2	2.3	2.5	Pheasant - Grouse Cress
P-1378-1377	2.3	2.4	2.5	2.3	2.3	2.5	Pheasant - Grouse Cress
D-1379-1376	2.2	2.3	2.4	2.2	2.3	2.4	Pheasant - Grouse Cress
P-1380-1379	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1381-1378	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1382-1381	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1383-1380	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
P-1384-1383	2.3	2.4	2.5	2.3	2.4	2.5	Pheasant - Grouse Cress
D-1385-1382	2.3	2.4	2.6	2.3	2.4	2.6	Pheasant - Grouse Cress
P-1386-1385	2.3	2.5	2.6	2.3	2.4	2.6	Pheasant - Grouse Cress
D-1387-1384	2.4	2.5	2.6	2.4	2.5	2.6	Pheasant - Grouse Cress
P-1388-1387	2.4	2.5	2.6	2.4	2.5	2.6	Pheasant - Grouse Cress
D-1389-1388	2.4	2.6	2.7	2.4	2.6	2.7	Pheasant - Grouse Cress
P-1390-1389	2.5	2.6	2.7	2.5	2.6	2.7	Pheasant - Grouse Cress

Table A-6 Birch Point Drainage Study - Peak Flow Summary, with Project							
	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
D-1391-1386	2.4	2.5	2.7	2.4	2.5	2.7	Pheasant - Grouse Cress
P-1392-1391	0.3	0.3	0.4	0.3	0.3	0.4	Pheasant - Grouse Cress
D-1393-1390	0.4	0.5	0.6	0.4	0.5	0.6	Pheasant - Grouse Cress
P-1394-1393	0.3	0.4	0.5	0.3	0.4	0.5	Pheasant - Grouse Cress
D-1395-1392	0.2	0.2	0.2	0.1	0.2	0.2	Pheasant - Grouse Cress
P-1396-1395	0.1	0.1	0.1	0.1	0.1	0.1	Pheasant - Grouse Cress
D-1397-1396	0.0	0.1	0.1	0.0	0.1	0.1	Pheasant - Grouse Cress
P-1398-1397	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1399-1394	0.1	0.2	0.3	0.1	0.2	0.3	Pheasant - Grouse Cress
P-1400-1399	0.0	0.1	0.2	0.0	0.1	0.2	Pheasant - Grouse Cress
D-1401-1400	0.0	0.0	0.2	0.0	0.0	0.2	Pheasant - Grouse Cress
P-1402-1401	0.0	0.0	0.2	0.0	0.0	0.2	Pheasant - Grouse Cress
D-1403-1398	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1404-1403	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1405-1404	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1406-1402	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1407-1406	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1408-1409	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1409-1410	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1410-1411	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1411-1412	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1412-1413	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1413-1414	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1414-1415	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1415-1416	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1416-1417	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1417-1419	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1418-1421	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1419-1420	0.9	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1420-1426	0.9	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1421-1422	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1422-1423	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1423-1424	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1424-1425	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1425-1427	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
P-1426-1429	0.9	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1427-1428	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1428-1450	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1429-1449	0.9	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1430-1441	1.0	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1431-1434	1.8	2.0	2.2	2.1	2.3	2.6	Pheasant - Grouse Cress
P-1434-1372	1.8	2.0	2.2	2.1	2.3	2.5	Pheasant - Grouse Cress
P-1436-1430	1.1	1.2	1.3	1.2	1.3	1.4	Pheasant - Grouse Cress
P-1437-1436	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1438-1437	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1439-1438	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1440-1439	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1441-1442	1.9	2.0	2.2	2.1	2.3	2.6	Pheasant - Grouse Cress
D-1442-1450	1.9	2.0	2.2	2.1	2.3	2.6	Pheasant - Grouse Cress
D-1443-1440	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1446-1443	0.9	1.0	1.2	1.1	1.2	1.3	Pheasant - Grouse Cress
P-1447-1446	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1448-1447	0.0	0.0	0.0	0.0	0.0	0.0	Pheasant - Grouse Cress
D-1449-1441	0.9	1.0	1.1	1.1	1.2	1.3	Pheasant - Grouse Cress
D-1450-1431	1.8	2.0	2.2	2.1	2.3	2.6	Pheasant - Grouse Cress
P-1460-1457	6.1	6.4	6.8	6.3	6.7	7.1	Pheasant - Grouse Cress
D-1239-1240	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1240-1241	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1241-1242	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1242-1243	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1243-1451	1.0	1.1	1.2	1.0	1.1	1.2	Deer Trail Area
P-1451-1457	17.0	17.8	18.7	17.7	18.5	19.5	Deer Trail Area
D-1452-1451	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1453-1452	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1454-1453	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
D-1457-1483	23.6	24.9	26.3	24.7	25.9	27.3	Deer Trail Area
D-1463-1464	0.5	0.6	0.6	0.5	0.6	0.6	Deer Trail Area
P-1464-1467	0.5	0.6	0.6	0.5	0.6	0.6	Deer Trail Area
P-1467-1481	1.0	1.1	1.3	1.0	1.1	1.3	Deer Trail Area
D-1468-1477	0.0	0.0	0.0	0.0	0.0	0.0	Deer Trail Area
P-1469-1472	0.1	0.1	0.1	0.1	0.1	0.1	Deer Trail Area
P-1472-1473	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
D-1473-1474	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
P-1474-1475	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
D-1475-1476	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
P-1476-1478	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
P-1477-1467	0.5	0.6	0.6	0.5	0.6	0.6	Deer Trail Area
P-1478-1479	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
P-1479-1481	0.3	0.3	0.3	0.3	0.3	0.3	Deer Trail Area
D-1481-1356	0.7	0.7	0.8	0.6	0.7	0.8	Deer Trail Area
D-1348-1349	0.1	0.1	0.1	0.0	0.0	0.0	Birch Bay Drive East at Deer Trail
OF-1348-1354A	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive East at Deer Trail
OF-1349-1350	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive East at Deer Trail
P-1349-1350	0.1	0.2	0.2	0.1	0.1	0.1	Birch Bay Drive East at Deer Trail
D-1350-1351	1.5	1.7	1.8	2.2	2.3	2.6	Birch Bay Drive East at Deer Trail
OF-1351-1352	0.0	0.0	0.0	0.0	0.0	0.0	Birch Bay Drive East at Deer Trail

Table A-6							
Birch Point Drainage Study - Peak Flow Summary, with Project							
	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
P-1351-1352	1.5	1.7	1.9	2.1	2.3	2.5	Birch Bay Drive East at Deer Trail
D-1352-1353	1.5	1.9	2.3	2.1	2.3	2.5	Birch Bay Drive East at Deer Trail
P-1353-1354_1	24.9	26.0	27.4	27.8	29.4	31.2	Birch Bay Drive East at Deer Trail
D-1483-1355	24.7	26.1	27.6	26.1	27.4	29.0	Birch Bay Drive East at Deer Trail
D-1355-1353	24.7	26.0	27.5	26.1	27.4	29.0	Birch Bay Drive East at Deer Trail
P-1339-1335	1.7	1.9	2.1	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
P-1340-1347	1.7	1.9	2.1	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
D-1346-1340	0.0	0.0	0.0	0.2	0.2	0.3	Birch Bay Drive East at Deer Trail
P-1347-1339	1.7	1.9	2.1	3.3	3.6	3.9	Birch Bay Drive East at Deer Trail
D-1356-1357	2.0	2.2	2.4	2.4	2.6	2.9	Birch Bay Drive West at Deer Trail
P-1357-1358	1.9	2.1	2.3	2.3	2.5	2.7	Birch Bay Drive West at Deer Trail
D-1358-1359	1.9	2.1	2.3	2.2	2.4	2.7	Birch Bay Drive West at Deer Trail
P-1359-1360	1.9	2.1	2.3	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
D-1360-1361	1.9	2.0	2.2	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
P-1361-1365	3.7	4.0	4.4	4.3	4.6	5.1	Birch Bay Drive West at Deer Trail
D-1362-1361	1.9	2.0	2.2	2.1	2.3	2.6	Birch Bay Drive West at Deer Trail
P-1363-1362	1.9	2.0	2.2	2.1	2.3	2.5	Birch Bay Drive West at Deer Trail
D-1364-1363	1.9	2.1	2.2	2.2	2.4	2.6	Birch Bay Drive West at Deer Trail
D-1171-1172	1.2	1.3	1.4	1.5	1.6	1.8	Richmond Park - Richmond Park Road South
P-1172-1173	1.3	1.4	1.6	1.6	1.8	2.0	Richmond Park - Richmond Park Road South
P-1173-1181	1.5	1.6	1.8	1.8	2.0	2.2	Richmond Park - Richmond Park Road South
D-1180-1184	1.8	1.9	2.2	2.1	2.3	2.5	Richmond Park - Richmond Park Road South
P-1181-1180	1.6	1.8	2.0	1.9	2.1	2.3	Richmond Park - Richmond Park Road South
P-1182-1188	0.2	0.2	0.2	0.2	0.2	0.2	Richmond Park - Richmond Park Road South
D-1184-1451	16.5	17.3	18.2	17.3	18.0	18.9	Richmond Park - Richmond Park Road South
P-1188-1189	0.3	0.3	0.4	0.3	0.3	0.4	Richmond Park - Richmond Park Road South
D-1189-1192	0.5	0.5	0.6	0.5	0.5	0.6	Richmond Park - Richmond Park Road South
P-1190-1184	14.7	15.3	15.9	15.1	15.7	16.3	Richmond Park - Richmond Park Road South
D-1191-1190	14.6	15.1	15.8	15.0	15.6	16.2	Richmond Park - Richmond Park Road South
P-1192-1191	0.7	0.8	0.9	0.7	0.8	0.9	Richmond Park - Richmond Park Road South
D-1193-1192	0.2	0.2	0.2	0.2	0.2	0.2	Richmond Park - Richmond Park Road South
D-1194-1191	13.8	14.3	14.8	14.2	14.6	15.2	Richmond Park - Richmond Park Road North
P-1195-1194	13.7	14.1	14.6	14.1	14.5	15.0	Richmond Park - Richmond Park Road North
P-1196-1221	0.2	0.2	0.2	0.2	0.2	0.2	Richmond Park - Richmond Park Road North
O-1197-1221	0.0	0.0	0.0	0.0	0.0	0.0	Richmond Park - Richmond Park Road North
P-1197-1196	12.7	13.0	13.4	12.9	13.2	13.6	Richmond Park - Richmond Park Road North
D-1198-1197	11.8	11.9	12.1	11.7	11.8	12.0	Richmond Park - Richmond Park Road North
P-1199-1198	11.8	11.9	12.1	11.7	11.8	11.9	Richmond Park - Richmond Park Road North
D-1200-1199	12.4	12.3	12.3	11.7	12.4	12.4	Richmond Park - Richmond Park Road North
P-1201-1200	11.7	11.9	12.0	11.6	11.7	11.9	Richmond Park - Richmond Park Road North
P-1202-1205	12.3	12.7	13.0	12.1	12.4	12.7	Richmond Park - Richmond Park Road North
O-1203-1205	0.0	0.0	0.0	0.0	0.0	0.0	Richmond Park - Richmond Park Road North
P-1203-1202	12.3	12.6	13.0	12.1	12.4	12.7	Richmond Park - Richmond Park Road North
D-1204-1203	12.3	12.6	13.0	12.0	12.3	12.6	Richmond Park - Richmond Park Road North
D-1204A-1204B	3.4	3.7	4.1	5.9	6.5	7.2	
D-1204B-1204A	2.9	3.1	3.3	5.3	5.8	6.5	Richmond Park - Richmond Park Road North
OF-1204B-1207	0.0	0.0	0.0	0.0	0.0	0.0	Richmond Park - Richmond Park Road North
D-1205-1201	11.7	11.8	12.0	11.6	11.7	11.8	Richmond Park - Richmond Park Road North
P-1206-1205	0.7	0.9	1.1	0.8	0.9	0.9	Richmond Park - Richmond Park Road North
D-1207-1206	1.9	1.8	1.7	0.7	0.8	1.3	Richmond Park - Richmond Park Road North
P-1208-1207	0.8	0.9	1.2	0.7	0.9	1.1	Richmond Park - Richmond Park Road North
D-1209-1208	0.8	1.0	1.2	0.8	1.0	1.2	Richmond Park - Richmond Park Road North
P-1210-1209	0.8	1.0	1.2	1.0	1.1	1.3	Richmond Park - Richmond Park Road North
D-1211-1210	0.9	1.1	1.3	1.1	1.3	1.5	Richmond Park - Richmond Park Road North
P-1220-1221	0.9	1.0	1.1	0.9	1.0	1.1	Richmond Park - Richmond Park Road North
D-1221-1195	13.6	14.0	14.5	13.9	14.3	14.8	Richmond Park - Richmond Park Road North
D-1222-1220	0.8	0.8	0.9	0.8	0.8	0.9	Richmond Park - Richmond Park Road North
P-1227-1228	0.2	0.2	0.2	0.2	0.2	0.2	Richmond Park - Richmond Crescent
P-1228-1229	0.3	0.3	0.4	0.3	0.3	0.4	Richmond Park - Richmond Crescent
D-1229-1230	0.5	0.5	0.6	0.5	0.5	0.6	Richmond Park - Richmond Crescent
D-1230-1222	0.6	0.7	0.7	0.6	0.7	0.7	Richmond Park - Richmond Crescent
D-1272-1275	13.5	14.3	15.2	14.2	15.0	15.9	Shintaffer north of Semiahmoo Parkway
D-1272A-1272	2.4	2.7	3.0	2.7	3.0	3.3	
D-1273-1272	11.3	11.9	12.5	11.8	12.4	13.0	Shintaffer north of Semiahmoo Parkway
O-1274-1273	5.0	5.5	6.1	5.5	6.0	6.5	Shintaffer north of Semiahmoo Parkway
P-1274-1273	5.8	5.8	5.8	5.8	5.8	5.8	Shintaffer north of Semiahmoo Parkway
O-1275-1276	7.6	8.4	9.3	8.3	9.1	10.0	Shintaffer north of Semiahmoo Parkway
P-1275-1276	6.0	6.0	6.0	6.0	6.0	6.0	Shintaffer north of Semiahmoo Parkway
D-1276-1298	15.1	16.0	17.1	16.0	17.0	18.1	Shintaffer north of Semiahmoo Parkway
D-1277A-1277	7.2	7.9	8.8	7.9	8.7	9.6	
O-1277-1278	0.0	0.0	0.0	0.0	0.0	0.0	Shintaffer north of Semiahmoo Parkway
P-1277-1278	5.7	6.0	6.4	6.0	6.3	6.7	Shintaffer north of Semiahmoo Parkway
D-1278-1279	5.7	6.0	6.4	6.0	6.3	6.7	Shintaffer north of Semiahmoo Parkway
D-1279-1274	10.4	10.9	11.4	10.8	11.3	11.8	Shintaffer north of Semiahmoo Parkway
O-1281-1280	0.0	0.0	0.0	0.0	0.0	0.0	Shintaffer north of Semiahmoo Parkway
P-1281-1280	4.8	4.9	5.0	4.9	5.0	5.1	Shintaffer north of Semiahmoo Parkway
P-1284-1296	19.1	20.4	22.1	29.2	32.1	33.2	Shintaffer north of Semiahmoo Parkway
D-1298-1284	15.1	16.0	16.9	47.1	34.8	24.6	Shintaffer north of Semiahmoo Parkway
D-1308-1281	5.9	6.4	7.0	6.4	6.9	7.5	Shintaffer north of Semiahmoo Parkway
O-1309-1308	4.2	4.9	5.7	4.8	5.6	6.3	Shintaffer north of Semiahmoo Parkway
P-1309-1308	4.7	4.8	4.8	4.8	4.8	4.9	Shintaffer north of Semiahmoo Parkway
D-1310-1309	0.7	0.7	0.8	0.7	0.8	0.9	Shintaffer north of Semiahmoo Parkway
P-1311-1310	0.9	1.1	1.2	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
P-1316-1317	1.0	1.1	1.2	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
D-1317-1311	0.9	1.1	1.2	1.0	1.2	1.3	Shintaffer north of Semiahmoo Parkway
D-1253-1332	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway

Table A-6 Birch Point Drainage Study - Peak Flow Summary, with Project							
	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
D-1254-1258	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
D-1256-1330	5.7	6.6	7.8	15.3	17.3	19.6	Semiahmoo Parkway
D-1257-1329	5.6	6.6	7.8	15.3	17.2	19.5	Semiahmoo Parkway
D-1258-1256	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
P-1259-1260	5.6	6.6	7.8	15.2	17.0	19.2	Semiahmoo Parkway
D-1260-1263	5.6	6.6	7.8	15.2	17.0	19.2	Semiahmoo Parkway
P-1261-1262	4.7	4.7	4.8	5.3	5.4	5.5	Semiahmoo Parkway
D-1262-1268	4.6	4.7	4.8	5.3	5.4	5.5	Semiahmoo Parkway
D-1263-1264	5.6	6.5	7.7	15.1	16.9	19.1	Semiahmoo Parkway
O-1264-1265	5.2	6.1	7.3	14.5	16.3	18.5	Semiahmoo Parkway
P-1264-1265	0.2	0.2	0.2	0.3	0.4	0.5	Semiahmoo Parkway
D-1265-1266	5.4	6.2	7.4	14.8	16.6	18.9	Semiahmoo Parkway
P-1266-1267	5.1	6.0	7.1	13.7	15.2	16.9	Semiahmoo Parkway
D-1267-1284	7.4	8.5	9.9	18.2	20.0	22.2	Semiahmoo Parkway
P-1268-1269	4.5	4.6	4.7	5.2	5.3	5.4	Semiahmoo Parkway
D-1269-1270	4.5	4.6	4.7	5.2	5.3	5.4	Semiahmoo Parkway
P-1270-1271	4.5	4.6	4.7	5.2	5.3	5.4	Semiahmoo Parkway
D-1271-1286	4.5	4.6	4.7	5.2	5.3	5.4	Semiahmoo Parkway
P-1286-1297	4.5	4.6	4.7	5.1	5.3	5.4	Semiahmoo Parkway
P-1297-1296	4.5	4.6	4.7	5.2	5.3	5.4	Semiahmoo Parkway
D-1327-1259	5.6	6.6	7.8	15.2	17.0	19.2	Semiahmoo Parkway
D-1328-1327	5.6	6.6	7.8	15.2	17.1	19.2	Semiahmoo Parkway
D-1329-1328	5.6	6.6	7.8	15.3	17.2	19.4	Semiahmoo Parkway
D-1330-1257	5.6	6.6	7.8	15.3	17.2	19.6	Semiahmoo Parkway
D-1331-1261	4.6	4.7	4.8	5.2	5.3	5.4	Semiahmoo Parkway
D-1332-1333	0.0	0.0	0.0	0.0	0.0	0.0	Semiahmoo Parkway
D-1333-1331	4.6	4.7	4.8	5.2	5.3	5.4	Semiahmoo Parkway
D-1291-1318	24.4	25.8	27.6	35.3	38.2	38.7	Shintaffer North of Richmond Park - West Side
P-1296-1291	23.6	25.0	26.7	34.3	36.9	37.0	Shintaffer North of Richmond Park - West Side
D-1318-1326	24.2	25.7	27.5	35.3	37.9	38.6	Shintaffer North of Richmond Park - West Side
D-1326-1324_1	23.7	25.6	27.7	35.5	37.7	38.4	Shintaffer North of Richmond Park - West Side
Rich_Field_1	0.3	0.3	0.3	0.3	0.4	0.5	Shintaffer North of Richmond Park - West Side
D-1326-1324_2	23.0	25.3	27.5	35.0	37.3	37.9	Shintaffer North of Richmond Park - West Side
D-1326-1324_3	22.8	25.2	27.5	34.9	37.3	37.9	Shintaffer North of Richmond Park - West Side
D-1326-1324_4	20.9	21.1	21.1	34.9	35.6	35.1	Shintaffer North of Richmond Park - West Side
D-1319-1320	0.4	0.4	0.7	0.6	0.7	1.9	Middle Shintaffer
P-1320-1321	0.8	1.0	1.6	1.4	1.6	2.0	Middle Shintaffer
D-1321-1322	2.1	2.2	2.8	13.5	2.4	2.6	Middle Shintaffer
P-1322-1323	1.8	2.0	2.2	2.2	2.3	2.5	Middle Shintaffer
D-1323-1237_1	1.5	1.7	2.1	2.0	2.4	4.9	Middle Shintaffer
D-1323-1326C	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
D-1323-1237_2	5.2	5.8	6.5	6.2	7.0	7.8	Middle Shintaffer
D-1324-1204	7.8	7.9	7.9	5.3	5.9	6.4	Middle Shintaffer
OF-1324-1205	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
O-1235-1238	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
P-1235-1238	2.5	2.5	2.6	2.6	2.7	2.7	Middle Shintaffer
D-1236-1235	2.5	2.5	2.6	2.6	2.6	2.7	Middle Shintaffer
O-1237-1236	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
P-1237-1236	2.5	2.5	2.6	2.6	2.6	2.7	Middle Shintaffer
D-1238-1246	2.5	2.6	2.7	2.7	2.8	2.8	Middle Shintaffer
P-1292-1293	0.7	0.7	0.8	1.1	1.2	1.4	Middle Shintaffer
D-1293-1326	0.7	0.7	0.8	1.1	1.2	1.4	Middle Shintaffer
D-1294-1325	0.7	0.8	0.9	1.1	1.2	1.4	Middle Shintaffer
P-1295-1294	0.7	0.8	0.9	1.1	1.3	1.4	Middle Shintaffer
D-1300-1295	0.0	0.0	0.0	0.0	0.0	0.0	Middle Shintaffer
D-1325-1292	0.7	0.7	0.8	1.1	1.2	1.4	Middle Shintaffer
O-507-500A	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-501-500	17.8	18.2	18.8	38.9	40.2	41.1	Lower Shintaffer
P-505-501	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-507-501	17.8	18.2	18.8	39.1	40.4	41.2	Lower Shintaffer
O-509-508	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-509-508	3.0	3.0	3.1	5.2	5.0	5.3	Lower Shintaffer
D-510-507	18.0	18.4	18.9	39.6	40.9	42.3	Lower Shintaffer
P-511-509	16.5	16.9	17.5	41.7	43.1	45.5	Lower Shintaffer
P-514-511	15.0	15.4	15.9	36.5	37.3	38.7	Lower Shintaffer
P-518-514	15.0	15.4	15.9	36.4	37.5	38.1	Lower Shintaffer
D-519-518	12.9	12.9	13.0	36.3	36.9	36.5	Lower Shintaffer
P-520-519	12.9	12.9	13.0	35.6	36.0	35.5	Lower Shintaffer
D-521-520	12.9	12.9	13.0	34.5	35.1	35.2	Lower Shintaffer
P-522-521	12.9	12.9	13.0	34.7	35.0	35.0	Lower Shintaffer
O-525-524	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-523-524	3.0	3.0	3.1	3.1	3.2	3.4	Lower Shintaffer
D-524-525	3.0	3.0	3.1	3.1	3.2	3.4	Lower Shintaffer
O-525-527	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-525-526	3.0	3.0	3.1	3.1	3.2	3.4	Lower Shintaffer
D-527-509	3.0	3.0	3.1	3.2	3.3	3.5	Lower Shintaffer
D-1244-522	12.9	12.9	13.0	34.2	35.0	35.1	Lower Shintaffer
D-1245-523	3.0	3.1	3.2	3.2	3.3	3.4	Lower Shintaffer
O-1246-1245	0.0	0.0	0.0	0.0	0.0	0.0	Lower Shintaffer
P-1246-1245	3.1	3.2	3.3	3.3	3.4	3.6	Lower Shintaffer
BP21aPond_Out	5.5	5.6	5.8	7.3	7.7	8.1	Semiahmoo Uplands
6	36.0	39.5	43.8	47.2	51.9	57.8	
FieldPond1Out	40.0	43.8	48.5	56.4	61.6	68.0	Semiahmoo Uplands
SU-1_3	2.9	3.4	4.0	9.7	10.7	12.0	
SU-1b-Oit	3.4	3.5	3.7	3.8	4.0	4.2	Semiahmoo Uplands
92603	14.6	17.1	19.9	27.7	29.8	31.5	Horizon Pond

Table A-6

Birch Point Drainage Study - Peak Flow Summary, with Project

	Existing Condition with Project			Future Condition with Project			
	Peak Flow (cfs)			Peak Flow (cfs)			
Conduit	100 Year	Nov-21	Climate Change	100 Year	Nov-21	Climate Change	Location
92606	9.9	10.9	12.1	30.4	33.4	37.2	
PD63_OF	0.0	0.0	0.0	0.0	0.0	0.0	Horizon Pond
SM723	3.9	4.0	4.1	4.0	4.2	4.3	Horizon Pond
Lake6_Out	36.0	39.5	43.9	47.3	51.9	57.8	Semiahmoo Golf Course
Lake9_Out	6.7	7.3	7.9	8.4	9.1	9.9	Semiahmoo Golf Course
Lake12_Out	2.4	2.8	3.3	8.8	9.6	10.8	Semiahmoo Golf Course
Lake18_Out	3.5	3.8	4.1	4.1	4.3	4.5	Semiahmoo Golf Course
SU-2_1	15.5	16.9	18.7	24.7	27.0	29.9	

Whatcom County Public Works Department—Stormwater Division
Birch Bay Watershed and Aquatic Resources Management District
Birch Point Drainage Study

APPENDIX B. CAPITAL IMPROVEMENT PROJECT DESCRIPTION

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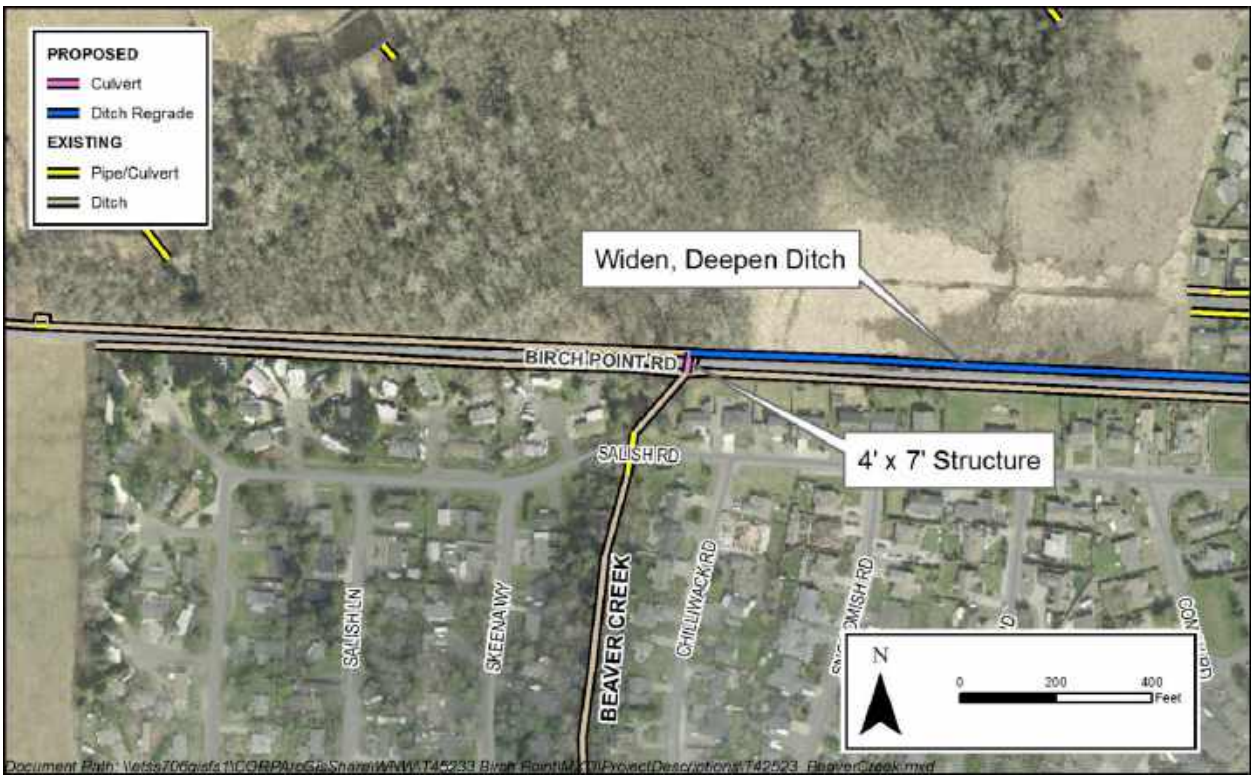
Birch Point Drainage Study

Project: Beaver Creek Drainage Improvements Project

Location:	Beaver Creek
Description:	Culverts and roadside ditches along Birch Point Road, Salish Road, and Quinault Road overflow during November 2021 and larger existing conditions storm event. The new culvert will be designed for fish passage.
Estimated Total Project Cost:	$1,250,000

Project Description:

- Replace existing culvert along Birch Point Road with a 4' high by 7' wide fish passable culvert.
- Regrade 1,170 lineal feet of existing ditch along Birch Point Road.



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**Beaver Creek Drainage Improvements**	**BY:**	**ZMS**
DESCRIPTION:	**Incall fish passable culverts**	**CHECKED BY:**	**GMS**
SUBBASIN:	**Birch Point Subwatershed**	**DATE:**	**7/19/2023**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	2470	SY	$40	$ 98,800
STRUCTURE EXCAVATION CLASS B INCL. HAUL	830	CY	$ 40	$ 33,200
REGRADE EXISTING DITCH	1,170	CY	$ 40	$ 46,800
GRAVEL BACKFILL FOR PIPE ZONE BEDDING	16	CY	$ 65	$ 1,040
COMMON BORROW INCL. HAUL	740	CY	$ 60	$ 44,400
CONTRACTOR DESIGNED BURIED STRUCTURE	44	LF	$ 3,000	$ 132,000
CHECK DAM	120	LF	$ 30	$ 3,600
ASPHALT CONC. PAVEMENT	40	TN	$ 500	$ 20,000
CRUSHED SURFACING BASE COURSE	110	TN	$ 120	$ 13,200
CRUSHED SURFACING TOP COURSE	30	TN	$ 90	$ 2,700
			Material Subtotal	$ 395,740
CONTINGENCY	50%			$ 197,870
			Material Subtotal with Contingency	$ 593,610
CLEAR AND GRUB	5%			$ 29,690
DEWATERING	5%			$ 29,690
ARCHEOLOGICAL MONITORING 2	2%			$ 11,880
TRAFFIC CONTROL	2%			$ 11,880
SITE RESTORATION 2	5%			$ 29,690
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 70,650
			Construction Subtotal (Rounded)	$ 777,000
STATE SALES TAX	8.6%			$ 66,830
ENGINEERING	33%			$ 278,470
CONSTRUCTION MANAGEMENT	7.5%			$ 63,290
PERMITTING	7.5%			$ 63,290
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 1,250,000**

Notes:

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2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.

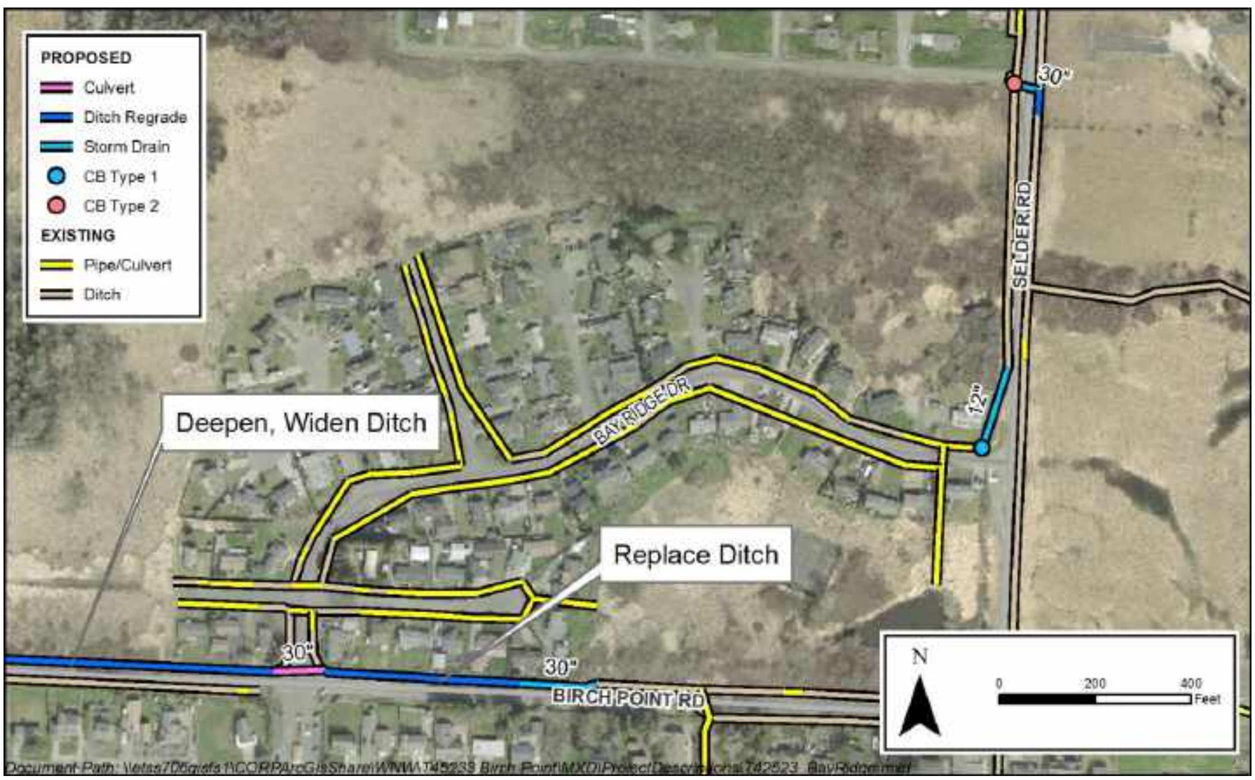
Birch Point Drainage Study

Project: Bay Ridge Estates Stormwater Improvements Project

Location:	Bay Ridge Estates
Description:	Culverts and roadside ditches along Birch Point Road and Selder Road capacity and overflow during the 2-year and larger existing and future conditions storm event.
Cost Estimate:	$770,000

Project Description:

- Replace 52 lineal feet of 18-inch diameter pipe with 30-inch diameter PVC pipe on Selder Road at Skyvue Road.
- Install 200 lineal feet of new 12-inch diameter ductile iron pipe along Selder Road.
- Install 108 lineal feet of new 30-inch diameter PVC pipe on Birch Point Road.
- Install 1 new CB Type 1 structures on Selder Road and 1 new CB Type 2 structure on Birch Point Road.
- Regrade 50 lineal feet of existing ditch on Selder Road to lower an invert.
- Regrade 960 feet of existing ditch on Birch Point.
- Install 135 lineal feet of new 30-inch diameter PVC pipe along Birch Point Road



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**Bay Ridge Estates Stormwater Improvements**	**BY:**	**ZMS**
DESCRIPTION:	**Install cross culvert**	**CHECKED BY:**	**GMS**
SUBBASIN:	**Birch Point Subwatershed**	**DATE:**	**7/19/2023**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	110	SY	$40	$ 4,400
STRUCTURE EXCAVATION CLASS B INCL. HAUL	270	CY	$ 40	$ 10,800
REMOVE STORM SEWER PIPE 18 IN. DIAM.	52	LF	$ 15	$ 780
REGRADE EXISTING DITCH	1010	CY	$ 50	$ 50,500
DUCTILE IRON SEWER PIPE 12 IN. DIAM.	200	LF	$ 115	$ 23,000
SCHEDULE A STORM SEWER PIPE 30 IN. DIAM.	300	LF	$ 240	$ 72,000
CATCH BASIN TYPE 1	1	EA	$ 3,200	$ 3,200
CATCH BASIN TYPE 2, 48 IN. DIAM.	1	EA	$ 4,500	$ 4,500
GRAVEL BACKFILL FOR PIPE ZONE BEDDING	160	CY	$ 65	$ 10,400
COMMON BORROW INCL. HAUL	100	CY	$ 60	$ 6,000
CHECK DAM	920	LF	$ 30	$ 27,600
INLET PROTECTION	2	EA	$ 220	$ 440
ASPHALT CONC. PAVEMENT	15	TN	$ 500	$ 7,500
CRUSHED SURFACING BASE COURSE	45	TN	$ 120	$ 5,400
CRUSHED SURFACING TOP COURSE	10	TN	$ 90	$ 900
			Material Subtotal	$ 227,420
CONTINGENCY	50%			$ 113,710
			Material Subtotal with Contingency	$ 341,130
CLEAR AND GRUB	5%			$ 17,060
DEWATERING	5%			$ 17,060
ARCHEOLOGICAL MONITORING	5%			$ 17,060
TRAFFIC CONTROL	2%			$ 6,830
SITE RESTORATION	10%			$ 34,120
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 43,330
			Construction Subtotal (Rounded)	$ 477,000
STATE SALES TAX	8.6%			$ 41,030
ENGINEERING	33%			$ 170,950
CONSTRUCTION MANAGEMENT	7.5%			$ 38,860
PERMITTING	7.5%			$ 38,860
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 770,000**

Notes:

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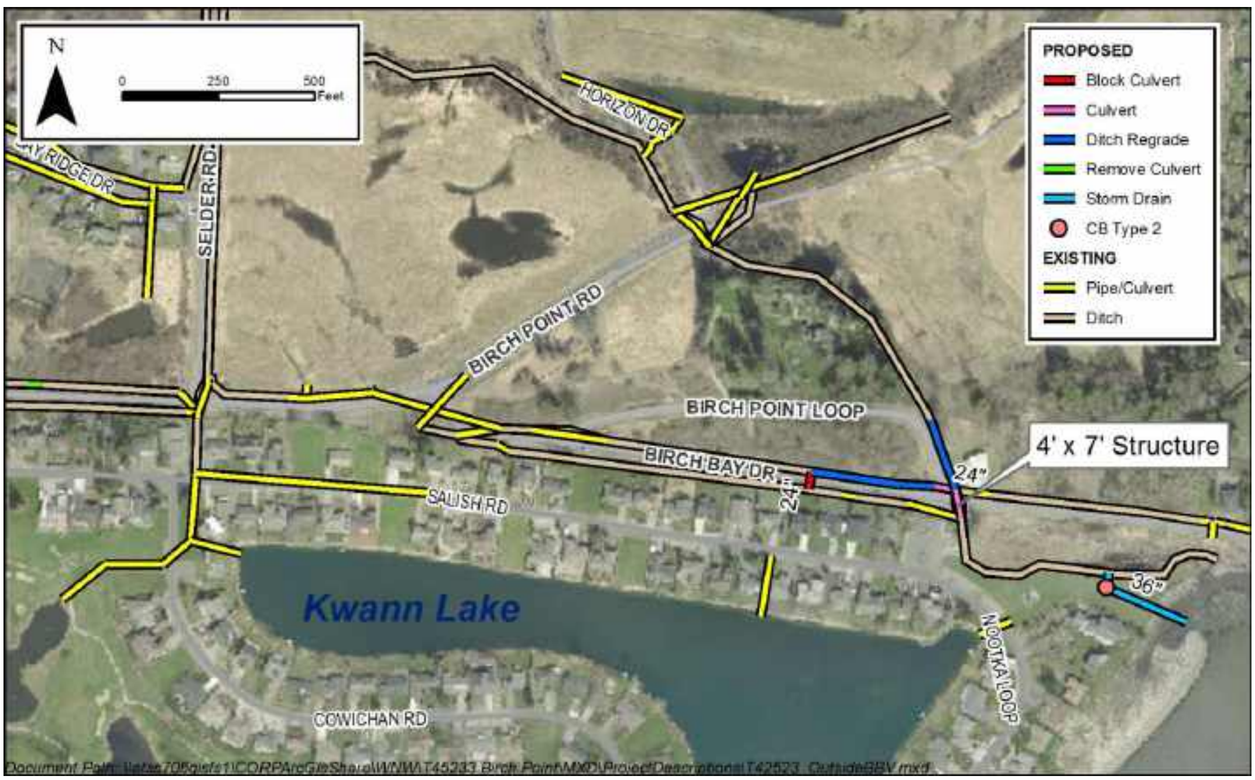
Birch Point Drainage Study

Project: Rogers Slough Drainage Improvements – Existing Conditions

Location:	Birch Bay Village - Birch Bay Drive and Birch Point Loop
Description:	Driveway culverts and roadside ditches along Birch Point Road are undersized and flooding for the 2-year and larger storm existing and future conditions storm events.
Cost Estimate:	$2,444,000

Project Description:

- Block an existing 24-inch diameter culvert with CDF.
- Install 55 lineal feet of 24-inch diameter PVC pipe under Birch Point Loop.
- Replace 144 lineal feet of existing twin 30-inch diameter culvert with a 4-foot by 7-foot rectangular concrete culvert.
- Remove existing 18-inch culvert under Birch Bay Drive between east and west intersection of Birch Point Loop.
- Regrade 319 feet of existing roadside ditch along Birch Point Road.
- Regrade 185 feet of channel along Birch Point Loop to establish positive drainage over entire length roadside ditch along north side of Birch Bay Drive.
- Install one new Type 2 CB near Nootka Loop.
- Install 230 lineal feet of new 36-inch diameter PVC pipe.



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**Rogers Slough Drainage Improvements Project**	**BY:**	**ZMS**
DESCRIPTION:	**Install fish passable culvert under Birch Bay Drive**	**CHECKED BY:**	**GMS**
SUBBASIN:	**Birch Point Subwatershed**	**DATE:**	**7/19/2023**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	140	SY	$40	$ 5,600
REMOVE STORM SEWER PIPE 30 IN. DIAM.	144	LF	$ 25	$ 3,600
SCHEDULE A STORM SEWER PIPE 24 IN. DIAM.	60	LF	$ 100	$ 6,000
SCHEDULE A STORM SEWER PIPE 36 IN. DIAM.	230	LF	$ 285	$ 65,550
STRUCTURE EXCAVATION CLASS A INCL. HAUL	1,010	CY	$ 55	$ 55,550
STRUCTURE EXCAVATION CLASS B INCL. HAUL	420	CY	$ 40	$ 16,800
CHECK DAM	360	LF	$ 30	$ 10,800
CONTRACTOR DESIGNED BURIED STRUCTURE	144	LF	$ 3,000	$ 432,000
CATCH BASIN TYPE 2, 54 IN. DIAM.	1	EA	$ 4,750	$ 4,750
4 FOOT X 7 FOOT TRASH RACK	1	LS	$ 1,500	$ 1,500
CONTROL DENSITY FILL EXISTING CULVERT	4	CY	$ 235	$ 941
GRAVEL BACKFILL FOR FOUNDATIONS CLASS A	230	CY	$ 70	$ 16,100
COMMON BORROW INCL. HAUL	950	CY	$ 60	$ 57,000
ASPHALT CONC. PAVEMENT	20	TN	$ 200	$ 4,000
CRUSHED SURFACING BASE COURSE	58	TN	$ 120	$ 6,960
CRUSHED SURFACING TOP COURSE	15	TN	$ 90	$ 1,350
REGRADE EXISTING DITCH	504	CY	$ 40	$ 20,160
			Material Subtotal	$ 708,661
CONTINGENCY	50%			$ 354,340
			Material Subtotal with Contingency	$ 1,063,001
CLEAR AND GRUB	5%			$ 53,160
DEWATERING	5%			$ 53,160
ARCHEOLOGICAL MONITORING	5%			$ 53,160
TRAFFIC CONTROL 3	5%			$ 53,160
SITE RESTORATION	10%			$ 106,310
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 138,200
			Construction Subtotal (Rounded)	$ 1,520,000
STATE SALES TAX	8.6%			$ 130,720
ENGINEERING	33%			$ 544,740
CONSTRUCTION MANAGEMENT	7.5%			$ 123,810
PERMITTING	7.5%			$ 123,810
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 2,444,000**

Notes:

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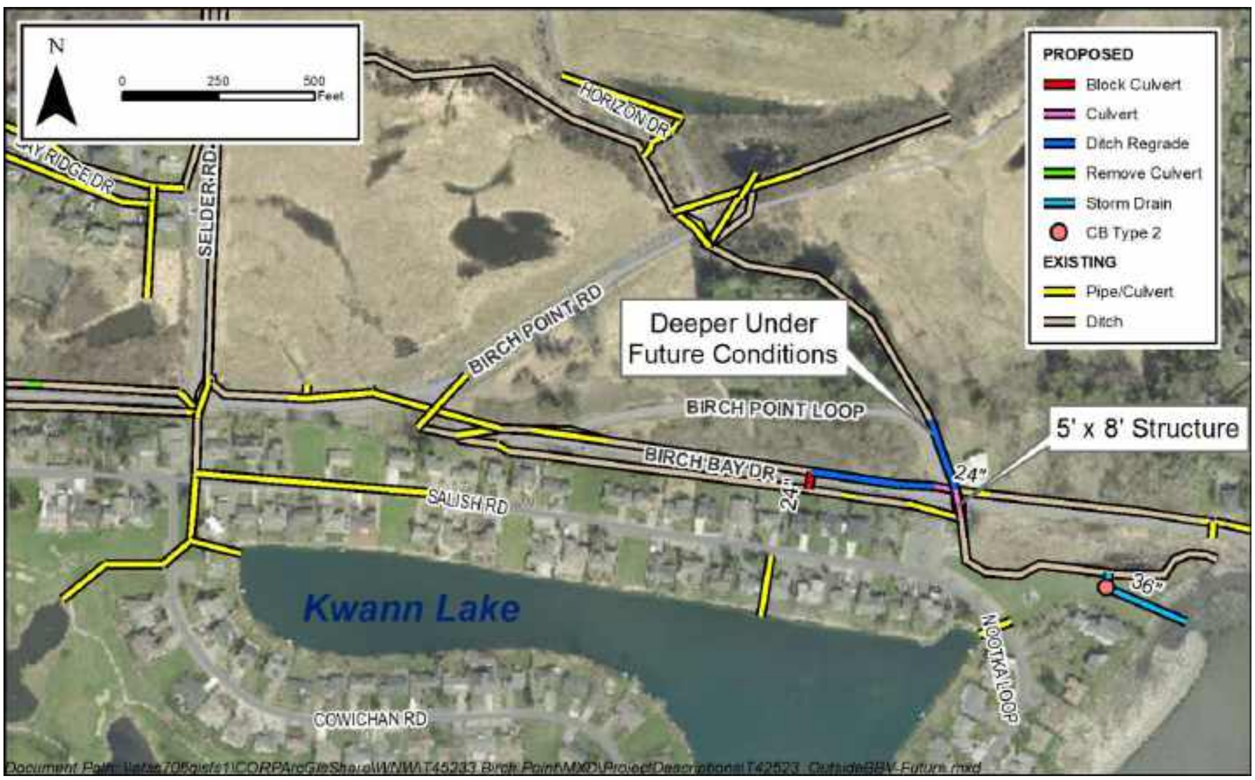
Birch Point Drainage Study

Project: Rogers Slough Drainage Improvements – Future Conditions

Location:	Birch Bay Village - Birch Bay Drive and Birch Point Loop
Description:	Driveway culverts and roadside ditches along Birch Point Road are undersized and flooding for the 2-year and larger storm existing and future conditions storm events.
Cost Estimate:	$2,850,000

Project Description:

- Block an existing 24-inch diameter culvert with CDF.
- Install 55 lineal feet of 24-inch diameter PVC pipe on Birch Point Loop.
- Replace 144 lineal feet of existing twin 30-inch diameter culvert with a 5-foot by 8-foot rectangular concrete culvert.
- Remove existing 18-inch culvert under Birch Bay Drive between east and west intersection of Birch Point Loop.
- Regrade 319 feet of existing roadside ditch along Birch Point Road.
- Regrade 185 feet of channel along Birch Point Loop to establish positive drainage over entire length roadside ditch along north side of Birch Bay Drive.
- Install one new Type 2 CB near Nootka Loop
- Install 230 lineal feet of new 36-inch diameter PVC pipe near Nootka Loop



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Rogers Slough Drainage Improvements Project - Future — **BY:** ZMS
DESCRIPTION: Install fish passable culvert under Birch Bay Drive — **CHECKED BY:** GMS
SUBBASIN: Birch Point Subwatershed — **DATE:** 7/19/2023

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	200	SY	$40	$ 8,000
REMOVE STORM SEWER PIPE 30 IN. DIAM.	144	LF	$ 25	$ 3,600
SCHEDULE A STORM SEWER PIPE 24 IN. DIAM.	60	LF	$ 100	$ 6,000
SCHEDULE A STORM SEWER PIPE 36 IN. DIAM.	230	LF	$ 285	$ 65,550
STRUCTURE EXCAVATION CLASS A INCL. HAUL	1,390	CY	$ 55	$ 76,450
STRUCTURE EXCAVATION CLASS B INCL. HAUL	420	CY	$ 40	$ 16,800
CHECK DAM	360	LF	$ 30	$ 10,800
CONTRACTOR DESIGNED BURIED STRUCTURE	144	LF	$ 3,500	$ 504,000
CATCH BASIN TYPE 2, 54 IN. DIAM.	1	EA	$ 4,750	$ 4,750
5 FOOT X 8 FOOT TRASH RACK	1	LS	$ 1,500	$ 1,500
CONTROL DENSITY FILL EXISTING CULVERT	4	CY	$ 235	$ 941
GRAVEL BACKFILL FOR FOUNDATIONS CLASS A	230	CY	$ 70	$ 16,100
COMMON BORROW INCL. HAUL	1,250	CY	$ 60	$ 75,000
ASPHALT CONC. PAVEMENT	30	TN	$ 200	$ 6,000
CRUSHED SURFACING BASE COURSE	81	TN	$ 120	$ 9,720
CRUSHED SURFACING TOP COURSE	20	TN	$ 90	$ 1,800
REGRADE EXISTING DITCH	504	CY	$ 40	$ 20,160
			Material Subtotal	$ 827,171
CONTINGENCY	50%			$ 413,590
			Material Subtotal with Contingency	$ 1,240,761
CLEAR AND GRUB	5%			$ 62,040
DEWATERING	5%			$ 62,040
ARCHEOLOGICAL MONITORING	5%			$ 62,040
TRAFFIC CONTROL 3	5%			$ 62,040
SITE RESTORATION	10%			$ 124,080
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 161,310
			Construction Subtotal (Rounded)	$ 1,774,000
STATE SALES TAX	8.6%			$ 152,570
ENGINEERING	33%			$ 635,770
CONSTRUCTION MANAGEMENT	7.5%			$ 144,500
PERMITTING	7.5%			$ 144,500
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 2,850,000**

Notes:

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Birch Point Drainage Study

Project: Birch Bay Village Stormwater Improvements Project

Location:	Birch Bay Village at Kwann Lake
Description:	Roadway flooding predicted at multiple areas in the vicinity of Kwann Lake at the 10-year and larger existing conditions storm event.
Cost Estimate:	$1,260,000

Project Description:

- Replace 140 lineal feet of 12-inch diameter pipe with 24-inch diameter corrugated polyethylene pipe from Cowichan Road to Kwann Lake.
- Replace 160 lineal feet of 12-inch diameter pipe with 18-inch-inch diameter PVC pipe from Salish Road to Kwann Lake.
- Replace 176 lineal feet of 24-inch diameter pipe with 36-inch diameter PVC pipe along Cowichan Road.
- Install 390 lineal feet of new 12-inch diameter PVC pipe along Salish Road.
- Install 3 new CB Type 2, 48-inch diameter structures along Salish Road.
- Install one new CB Type 2, 54-inch diameter structure near Nootka Loop.
- Install new 36-inch diameter flap gate near Nootka Loop
- Install 290 lineal feet of 24-inch diameter PVC pipe near Nootka Loop
- Install 230 lineal feet of new 36-inch diameter PVC pipe near Nootka Loop

PROJECT:	**Birch Point Village Stormwater Improvements**		**BY:**	**ZMS**
DESCRIPTION:	**Birch Point Village Stormwater Improvements**		**CHECKED BY:**	**GMS**
SUBBASIN:	**Birch Point Subwatershed**		**DATE:**	**7/19/2023**

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	690	SY	$4.50	$ 3,105
STRUCTURE EXCAVATION CLASS B INCL. HAUL	957	CY	$ 40	$ 38,280
REMOVE STORM SEWER PIPE 12 IN. DIAM.	300	LF	$ 12	$ 3,600
REMOVE STORM SEWER PIPE 24 IN. DIAM.	176	LF	$ 12	$ 2,112
REMOVE CULVERT 18 IN. DIAM.	41	LF	$ 12	$ 492
SCHEDULE A STORM SEWER PIPE 12 IN. DIAM.	390	LF	$ 75	$ 29,250
SCHEDULE A STORM SEWER PIPE 18 IN. DIAM.	160	LF	$ 90	$ 14,400
SCHEDULE A STORM SEWER PIPE 24 IN. DIAM.	290	LF	$ 100	$ 29,000
SCHEDULE A STORM SEWER PIPE 36 IN. DIAM.	406	LF	$ 285	$ 115,710
CORRUGATED POLYETHYLENE STORM SEWER PIPE 24 IN. DIAM.	140	LF	$ 130	$ 18,200
CATCH BASIN TYPE 2, 48 IN. DIAM.	3	EA	$ 4,500	$ 13,500
CATCH BASIN TYPE 2, 54 IN. DIAM.	1	EA	$ 4,750	$ 4,750
INLINE CHECK VALVE	1	EA	$ 5,000	$ 5,000
CHECK DAM	860	LF	$ 30	$ 25,800
INLET PROTECTION	3	EA	$ 205	$ 615
GRAVEL BACKFILL FOR FOUNDATIONS CLASS A	392	CY	$ 70	$ 27,440
COMMON BORROW INCL. HAUL	534	CY	$ 60	$ 32,065
ASPHALT CONC. PAVEMENT	11	TN	$ 200	$ 2,200
CRUSHED SURFACING BASE COURSE	32	TN	$ 120	$ 3,840
CRUSHED SURFACING TOP COURSE	8	TN	$ 345	$ 2,760
			Material Subtotal	$ 372,119
CONTINGENCY	50%			$ 186,060
			Material Subtotal with Contingency	$ 558,179
CLEAR AND GRUB	5%			$ 27,910
DEWATERING	5%			$ 27,910
ARCHEOLOGICAL MONITORING	5%			$ 27,910
TRAFFIC CONTROL	2%			$ 11,170
SITE RESTORATION	10%			$ 55,820
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 70,890
			Construction Subtotal (Rounded)	$ 780,000
STATE SALES TAX	8.6%			$ 67,080
ENGINEERING	33%			$ 279,540
CONSTRUCTION MANAGEMENT	7.5%			$ 63,540
PERMITTING	7.5%			$ 63,540
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 1,260,000**

Notes:

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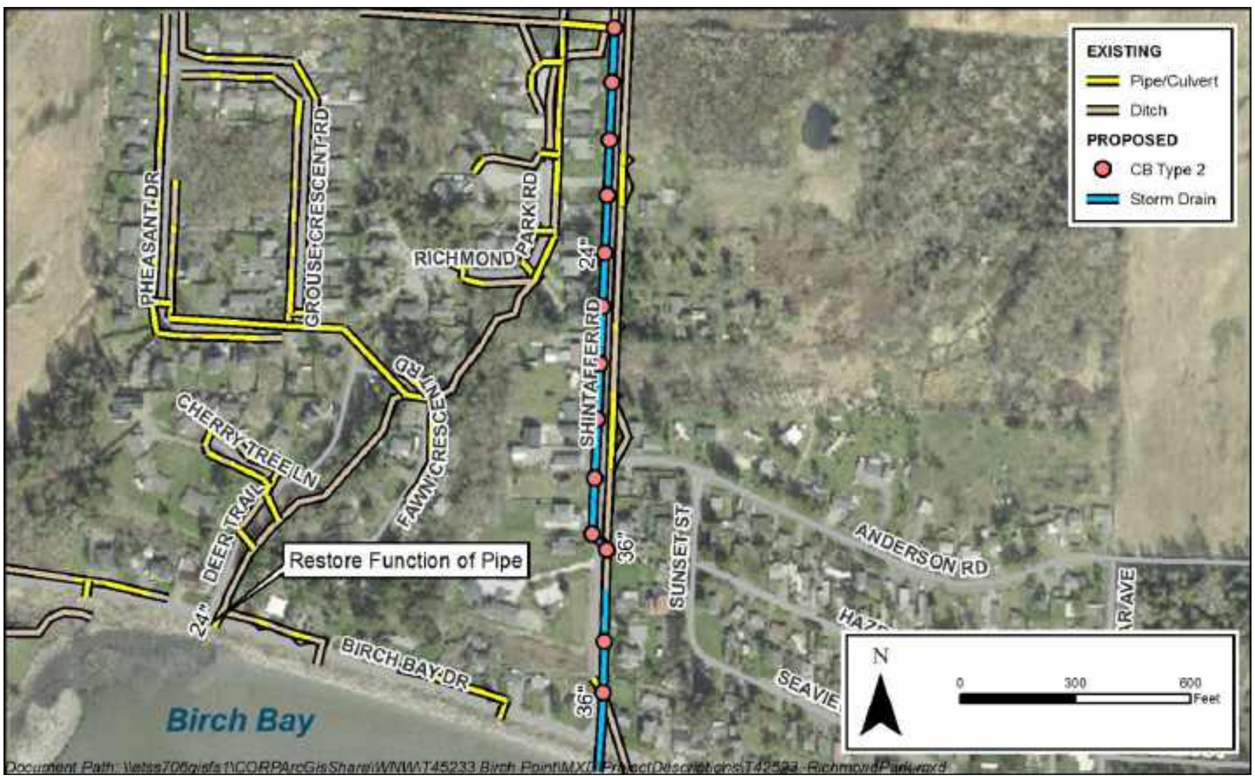
Birch Point Drainage Study

Project: Richmond Park Stormwater Improvements Project – Existing Conditions

Location:	Shintaffer Road, Birch Bay Drive at Birch Bay
Description:	Ditches and existing culverts and pipe network in Richmond Park and along Shintaffer Road overflow during the 25-year and larger existing and future conditions storm events.
Cost Estimate:	$1,770,000

Project Description:

- Replace 810 lineal feet of 12-inch diameter pipe with 24-, and 36-inch diameter PVC pipe, and 36-inch diameter corrugated polyethylene pipe along Shintaffer Road.
- Replace 560 lineal feet of existing ditch with new 24-inch diameter PVC pipe along Shintaffer Road.
- Replace 24 lineal feet of 24-inch diameter pipe at Deer Trail and Birch Bay to restore conveyance function.
- Install 11 new CB Type 2, 48-inch diameter structures and 2 new CB Type 2, 54-inch diameter structures along Shintaffer Road.



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT:	**Richmond Park Stormwater Improvements - Existing**	**BY:**	**ZMS**
DESCRIPTION:	**Install 24 inch pipeline along Shintaffer Road**	**CHECKED BY:**	**GMS**
SUBBASIN:	**Birch Point Subwatershed**	**DATE:**	**7/19/2023**

BID ITEM	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**
REMOVE ASPHALT CONC. PAVEMENT	180	SY	$40	$ 7,200
REMOVE STORM SEWER PIPE 12 IN. DIAM.	810	LF	$ 12	$ 9,720
STRUCTURE EXCAVATION CLASS B INCL. HAUL	2,100	CY	$ 40	$ 84,000
CHECK DAM	280	LF	$ 30	$ 8,400
INLET PROTECTION	13	EA	$ 205	$ 2,665
SCHEDULE A STORM SEWER PIPE 24 IN. DIAM.	1,370	LF	$ 100	$ 137,000
SCHEDULE A STORM SEWER PIPE 36 IN. DIAM.	270	LF	$ 285	$ 76,950
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	210	LF	$ 130	$ 27,300
CATCH BASIN TYPE 2, 48 IN. DIAM.	11	EA	$ 4,500	$ 49,500
CATCH BASIN TYPE 2, 54 IN. DIAM.	2	EA	$ 4,750	$ 9,500
GRAVEL BACKFILL FOR PIPE ZONE BEDDING	830	CY	$ 65	$ 53,950
COMMON BORROW INCL. HAUL	950	CY	$ 60	$ 57,000
ASPHALT CONC. PAVEMENT	2.9	TN	$ 200	$ 580
CRUSHED SURFACING BASE COURSE	8.3	TN	$ 120	$ 996
CRUSHED SURFACING TOP COURSE	2.1	TN	$ 345	$ 725
			Material Subtotal	$ 525,486
CONTINGENCY	50%			$ 262,750
			Material Subtotal with Contingency	$ 788,236
CLEAR AND GRUB	5%			$ 39,420
DEWATERING	5%			$ 39,420
ARCHEOLOGICAL MONITORING	5%			$ 39,420
TRAFFIC CONTROL	2%			$ 15,770
SITE RESTORATION	10%			$ 78,830
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 100,110
			Construction Subtotal (Rounded)	$ 1,101,000
STATE SALES TAX	8.6%			$ 94,690
ENGINEERING	33%			$ 394,580
CONSTRUCTION MANAGEMENT	7.5%			$ 89,680
PERMITTING	7.5%			$ 89,680
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 1,770,000**

Notes:

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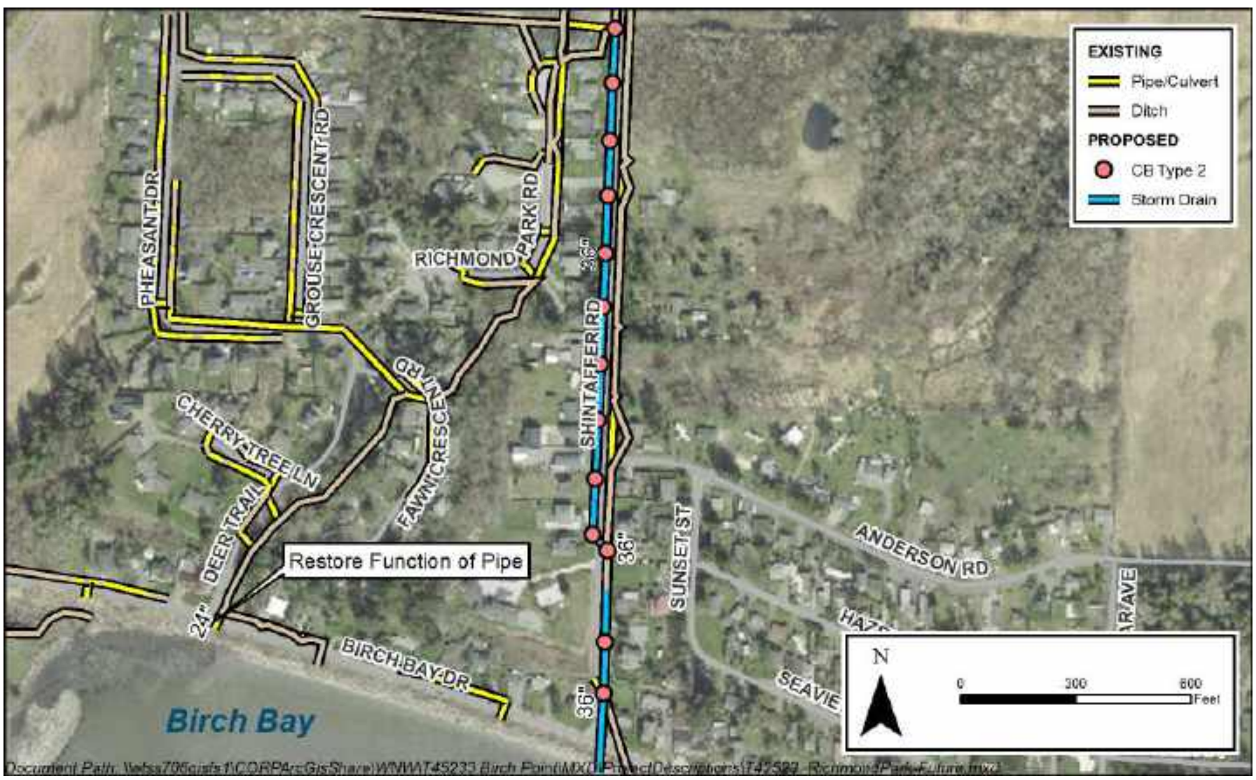
Birch Point Drainage Study

Project: Richmond Park Stormwater Improvements Project – Future Conditions

Location:	Shintaffer Road, Birch Bay Drive at Birch Bay
Description:	Ditches and existing culverts and pipe network in Richmond Park and along Shintaffer Road overflow during the 25-year and larger existing and future conditions storm events.
Cost Estimate:	$2,605,000

Project Description:

- Replace 1640 lineal feet of 12-inch diameter pipe with 36-inch diameter PVC pipe, and 36-inch diameter corrugated polyethylene pipe along Shintaffer Road.
- Replace 24 lineal feet of 24-inch diameter pipe at Deer Trail and Birch Bay to restore conveyance function.
- Install 11 new CB Type 2, 48-inch diameter structures and 2 new CB Type 2, 54-inch diameter structures along Shintaffer Road.



BIRCH POINT DRAINAGE STUDY
CAPITAL PROJECT PLANNING LEVEL CONSTRUCTION COST OPINION

PROJECT: Richmond Park Stormwater Improvements - Future
DESCRIPTION: Install 36 inch pipeline along Shintaffer Road
SUBBASIN: Birch Point Subwatershed

BY: ZMS
CHECKED BY: GMS
DATE: 7/19/2023

BID ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
REMOVE ASPHALT CONC. PAVEMENT	180	SY	$40	$ 7,200
REMOVE STORM SEWER PIPE 12 IN. DIAM.	810	LF	$ 12	$ 9,720
CLASS B EXCAVATION INCL. HAUL	2,100	CY	$ 40	$ 84,000
CHECK DAM	280	LF	$ 30	$ 8,400
INLET PROTECTION	13	EA	$ 205	$ 2,665
SCHEDULE A STORM SEWER PIPE 36 IN. DIAM.	1,640	LF	$ 285	$ 467,400
CORRUGATED POLYETHYLENE STORM SEWER PIPE 36 IN. DIAM.	210	LF	$ 130	$ 27,300
CATCH BASIN TYPE 2, 48 IN. DIAM.	11	EA	$ 4,000	$ 44,000
CATCH BASIN TYPE 2, 54 IN. DIAM.	2	EA	$ 4,750	$ 9,500
GRAVEL BACKFILL FOR PIPE ZONE BEDDING	830	CY	$ 65	$ 53,950
COMMON BORROW INCL. HAUL	950	CY	$ 60	$ 57,000
ASPHALT CONC. PAVEMENT	2.9	TN	$ 200	$ 580
CRUSHED SURFACING BASE COURSE	8.3	TN	$ 120	$ 996
CRUSHED SURFACING TOP COURSE	2.1	TN	$ 345	$ 725
			Material Subtotal	$ 773,436
CONTINGENCY	50%			$ 386,718
			Material Subtotal with Contingency	$ 1,160,153
CLEAR AND GRUB	5%			$ 58,010
DEWATERING	5%			$ 58,010
ARCHEOLOGICAL MONITORING	5%			$ 58,010
TRAFFIC CONTROL	2%			$ 23,210
SITE RESTORATION	10%			$ 116,020
MOBILIZATION (GENERAL REQUIREMENT)	10%			$ 147,350
			Construction Subtotal (Rounded)	$ 1,620,800
STATE SALES TAX	8.6%			$ 139,390
ENGINEERING	33%			$ 580,860
CONSTRUCTION MANAGEMENT	7.5%			$ 132,010
PERMITTING	7.5%			$ 132,010
2023 Dollars			**Total Estimated Project Cost (Rounded)**	**$ 2,605,000**

Notes:

1. The above cost opinion is in 2023 dollars and does not include future escalation, financing, or O&M costs.
2. The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for assumptions stated. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variable factors. As a result, the final project costs will vary from those presented above. Because of these factors, funding needs for individual projects must be scrutinized prior to establishing the final project budgets.