CITY OF BURLINGTON

Update to the Surface Water Management Plan

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Prepared for

City of Burlington
Engineering & Public Works
820 E. Washington Avenue
Burlington, WA 98233
(360) 755-9715

Prepared by

Jenna Scholz, Hydrologist
Sheldon & Associates, Inc.
5031 University Way NE #204
Seattle, WA 98105
(206) 522-1214

and

Leonard, Boudinot, & Skodje, Inc.
603 South First Street
PO Box 1228
Mount Vernon, WA 98273
(360) 336-5751

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EXECUTIVE SUMMARY

This Surface Water Management Plan (SWMP) updates the 1993 plan with specific attention to the management of Gages Slough and the City of Burlington's location within the 100-year floodplain of the Skagit River. The purpose of this update is to document current surface and stormwater drainage conditions and identify changes that have occurred or improvements that have been made over the past five years. In addition, both the need for flood control in larger storm events and the need to control the potentially deleterious effects of stormwater runoff on water quality are discussed.

Gages Slough is a very low energy system with surface outlets. Though linear in shape, Gages Slough is not an active stream with fast water; it contains slowly flowing water for only a portion of the year. The slough is not located in the active floodplain due to the extent of diking along the Skagit River and the slough receives floodwaters from the river less frequently than every two years. For these reasons, Gages Slough is considered to be a series of linked wetlands classified as Depressional Outflow wetlands. Accordingly, quantity and quality problems and solutions have been recommended to maintain and enhance this wetland ecosystem.

The analysis of Gages Slough hydrology indicates that, generally the water body can maintain the current quantity of stormwater passing through it without flooding. The pumps emptying the slough are able to pump the 25-year storm out of the slough in three days. This is fast enough that during infrequent large storms plants along the slough will not be damaged by inundation. However, in the upper reaches of the slough there is a lack of capacity for large storms across the west Highway 20 crossing, Lei Garden Road, Gages Lane and Peacock Lane. A series of culvert improvements are recommended to minimizing flooding in this area.

A comprehensive water quality assessment conducted to characterize general surface water conditions in Gages Slough and the Skagit River indicates that physical, chemical, and biological water quality parameters are in violation of state and federal standards. Sampling was conducted of both surface and stormwater along the length of Gages Slough. Results for several parameters tested are not considered a water quality concern for Gages Slough including dissolved oxygen, pH, temperature, nitrate+nitrite-nitrogen, total copper, total lead, and pesticides. Therefore, no recommendations are given for these parameters

Parameters degrading the health of the Gages Slough wetland system and water quality in the Skagit River include fecal coliform bacteria, total nitrogen, total phosphorus, and zinc. Cattle grazing within the floodplain and waters of the slough as well as a chicken-processing farm located upstream are likely the primary contributors of nutrients (nitrogen and phosphorus) and bacteria to the slough. The highest concentrations of zinc were detected near the mouth of Gages Slough. The most likely sources of zinc are associated with automobiles and include upstream roads and parking lots as well as highway runoff. Source control and treatment recommendations are provided for each of these water quality problems.

1.0 INTRODUCTION

This Surface Water Management Plan (SWMP) outlines strategies and provides recommendations that will update the City of Burlington's (City) water quantity, water quality, and wetlands management and regulations. These strategies are specifically deigned to address the management of Gages Slough and the City's location within the 100-year floodplain of the Skagit River. Accordingly, both the need for flood control in larger storm events and the need to control the potentially deleterious effects of stormwater runoff from smaller storms are discussed.

In 1993, the City of Burlington contracted KCM to prepare a Surface Water Management Plan. In order to maintain consistency with state, federal, and local programs affecting storm and surface water management, this plan is updated approximately every five years. The plan was last updated in 1998 to reflect changes to Surface Water Management strategies. This report serves as a second update to the original 1993 Surface Water Management Plan.

The purpose of this plan is to document current surface and stormwater drainage conditions to reflect changes that have occurred in these systems over the past five years. The framework and goals for this SWMP have also been updated to reflect the City's interest in a basin-wide planning approach (Table 1). Specific additions to this report that have not been examined in previous iterations include:

- an evaluation of surface and stormwater quality issues and the establishment of a long-term monitoring program;
- an assessment of the feasibility of using wetlands for water quality treatment and;
- an examination of the regulatory and environmental issues related to stormwater detention within the City limits.

Table 1. Goals and Objectives for the Update to the City of Burlington Surface Water Management Plan

Goal	Description	Objectives
Improve Water Quality	The quality of runoff should be maintained and where possible improved	• Measures to protect water quality should be incorporated in all new development. • Water quality analyses should be used to direct improvements to existing problems. • Apply best management practices to reduce pollutant loading • Protect downstream resources such as shellfish beds, fish habitat, and other resources impacted by urban runoff.
Implement	Use Plan to avoid future	• Non-structural measures preferred over

non-structural recommendations and adopt new drainage standards	problems associated with new construction Preserve the water storage capacity of Gages Slough and the fish and wildlife habitat it provides.	structural measures • Continue to use the Ecology SWMM to regulate new development
Continue Public Education	Provide for ongoing public education aimed at residents, businesses, and industries in the urban area.	• Continue the program in place which informs residents of the dangers of flooding, their responsibilities, and how to protect themselves and their property. • Improve the publics understanding of stormwater effects on water quality, fish and wildlife, and flooding. • Discourage the dumping of waste materials or pollutants into storm drains.
Update Capital Improvements Plan	Review status of previously identified improvements.	• Prioritize completions of outstanding projects • Direct funds for future improvements
Prevent Loss of Life and Property	Prevent the loss of life or property due to storm events caused by inadequate or improper drainage. Regulate the Special Flood Risk Zone and 100 year Floodplain to protect human life, public health and safety, minimize public expenditure.	• Maintain City's flood insurance eligibility while avoiding regulations which are unnecessarily restrictive or difficult to administer. • Use of non-structural measures over structural measures. • Land use and related regulations and zoning that reflect the natural constraints and topography in the City.
Compliance with State Regulations	Require new development and re-development to comply with the Ecology standards for the Puget Sound Basin. Implement the SWMP using ordinances that regulate drainage on private property for new developments Apply capital improvements plan Citywide.	• The control of off-site water quality and associated improvement in water quality. • Use of source control BMPs • Protection of wetlands and streams • Erosion and sedimentation control

Update Surface Water Management Plan	An ongoing, systematic, and comprehensive approach to stormwater management should continue.	• Strategies should balance engineering, economic, environmental and social factors. • Evaluate Plan at regular intervals (i.e., every 5 years) to maintain consistency with regulatory programs.
Ensure Future State and local funding	Use available sources of funding such as public utilities to implement plan. Apply for grants that will assist the City with the cost of enforcing the plan.	• Maintain the program for operation and maintenance of storm drains, detention systems, ditches, and culverts. • Provide inspection, compliance, and enforcement measures. • Develop a water quality response program to investigate spills, illegal hookups, dumping, and other water quality problems.

1.1 Regulatory and Environmental Issues

Specific water quality standards must be considered to ensure regulatory compliance. Of specific concern in the lower Skagit River are violations to current water quality standards associated with agricultural land use and Total Maximum Daily Loads (TMDLs), as well as stormwater, and combined sewer overflows associated with the National Pollution Discharge Elimination System (NPDES) permit. Water quality regulations as well as the details of these programs are discussed below.

1.1.1 Water quality Regulations

The Federal Clean Water Act (CWA) requires states to set standards for pollution and to enforce violations. The goals of the CWA include maintaining surface water that does not threaten the health of fish, shellfish, or wildlife. These goals establish standards for the specific chemical criteria set by the State of Washington Department of Ecology (Ecology).

Ecology has established water quality criteria for the protection of fresh waters of the state (WAC 173-201A-200). These surface water criteria are used to highlight discrepancies between the quality of the water body being analyzed and the quality of water needed to support a healthy aquatic ecosystem. In the case of non-point source wetland analysis, these surface water criteria are not used to determine exceedances in a regulatory context, as there are currently no specific water quality criteria for wetlands. Rather, the standards are used in an ecological context to highlight the pollutants of concern within a given water body.

In 2003, new criteria were adopted by Ecology. These criteria are based designations that apply to Gages Slough for salmon and trout spawning, core rearing and migration, and extraordinary primary contact recreation (WAC 173-201A-600). Ecology has developed criteria for fecal coliform bacteria, dissolved oxygen, temperature, pH, and turbidity (Appendix A).

Ecology criteria are also provided for trace metals (WAC-173-201A). Unlike other criteria, which are adjusted by designated use, criteria for trace metals are based on the specific hardness of the water sampled, the harder the water the less toxic the metal. In order to determine the correct criteria, it is important to use a hardness value, which reflects ambient conditions because the higher the hardness value the higher the criteria will be. Criteria for this assessment is based on a hardness of 30.0 mg/L (Appendix A), which is the mean value reported within samples collected in the study area.

The Environmental Protection Agency (EPA) has recommended section 304(a) water quality criteria for nutrients (Appendix A). These criteria were developed with the aim of reducing and preventing eutrophication on a national scale. Criteria are recommended for both causal (total nitrogen and total phosphorus) and response (chlorophyll a) variables. Different criteria apply to different eco-regions across the United States. The criteria that apply to Washington State fall under Ecoregion II, Western Mountain Regions. Results from the sampling effort are compared against these criteria to determine the potential of nutrients to increase the rate of eutrophication in Gages Slough.

1.1.2 Total Maximum Daily Load (TMDL)

In 1998, Gages Slough was placed on the Washington Department of Ecology's 303(d) list for violations of the fecal coliform standard. The state sets surface water quality standards to protect, preserve, and restore lakes, rivers and marine waters. Section 303 (d) of the federal Clean Water Act (CWA) mandates that the state establish the Total Maximum Daily Load (TMDL) of pollutants for surface waters that do not meet standards after application of technology-based pollution controls. The TMDL determines the amount of a given pollutant that can be discharged to the water body and still meet water quality standards. The Skagit River has a TMDL for dissolved oxygen and fecal coliform bacteria. This TMDL was prepared to address impairments to contact recreation in the Lower Skagit River Basin, and all the tributaries in the lower Skagit River basin to their headwaters (Ecology 2000). Gages Slough is a tributary to the Skagit River and stormwater from the City of Burlington is discharged either to Gages Slough or directly to the Skagit River. Therefore, concentrations of both fecal coliform bacteria and dissolved oxygen are of specific concern to this assessment.

1.1.3 Stormwater

The Puget Sound Water Quality Management Plan (PSWQMP) serves as the federally approved Comprehensive Conservation and Management Plan (CCMP) for Puget Sound under Section 320 of the federal Clean Water Act. This management plan guides the efforts of federal and state agencies as well as tribal and local governments including Snohomish County. The plan contains a program for Stormwater and Combined Sewer Overflows. The state completed a Stormwater Management Manual for Western Washington in August 2001. The latter is a revision of the 1992 Stormwater Program Guidance Manual for the Puget Sound Basin. Furthermore, the listing of salmon under the Environmental Species Act (ESA) requires that streams and wetlands be protected. All local governments with salmon habitats are encouraged to develop storm water management plans. Those seeking 4(d) rule exemptions will be required to meet National Marine Fisheries Service (NMFS) stormwater requirements.

Under the Federal Clean Water Act, The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Under these regulations, local governments in the Puget Sound Basin and those subject to the federal National Pollutant Discharge Elimination System (NPDES) Storm Water Program are required to have storm water management programs.

Currently the NPDES storm water permit program (Phase I) applies to only six local governments (Seattle, Tacoma, and the unincorporated areas of Snohomish, King, Pierce and Clark counties) and to Washington State Department of Transportation (WSDOT) facilities within the legal boundaries of those jurisdictions. Industrial facilities that were owned or operated by municipalities with a population of less than 100,000 were previously exempted from the requirement to obtain a stormwater discharge permit. In December 1999, new NPDES rules (Phase II) were published and extended coverage to operators of regulated small municipal separate storm sewer systems serving less than 100,000.

The City of Burlington, as part of incorporated Skagit County, is a regulated municipality under the Federal NPDES Phase II Rule. This rule requires that the City submit an application for a stormwater permit by March 2003. Additional permit requirements are pending. DOE is currently beginning a process to update and reissue the NPDES and state waste discharge baseline general permit for stormwater discharges. Permit conditions include a requirement to have a Stormwater Pollution Prevention Plan (SWPP) and Best Management Practices (BMPs) implemented to eliminate or minimize the potential to contaminate stormwater.

2.0 STUDY AREA

Gages Slough is located in western Skagit County, on the north side of the Skagit River, in townships 34 and 35 north, and ranges 3 and 4 east (Figure 1). The slough originates east of city limits on the north side of State Route (SR) 20, at a culvert leading from the north end of a forested wetland at Hart Island.

The slough is comprised of a series of wetlands on the south side of SR 20 adjacent to the Skagit River, and receives overbank flow from the Skagit River. The slough meanders through the City of Burlington, discharging eventually to the Skagit River, roughly one mile west of Interstate 5, south of the intersection of Bennett and Pulver roads.

The total length of the slough is approximately 7.3 miles, with roughly 3.5 miles within the urban growth boundary (UGB) for the City of Burlington. The slough enters the UGB just east of Gardner Road where the slough is adjacent to the cemetery, northeast of Burlington city limits. It exits the UGB at Pulver Road, to the southwest of the City.

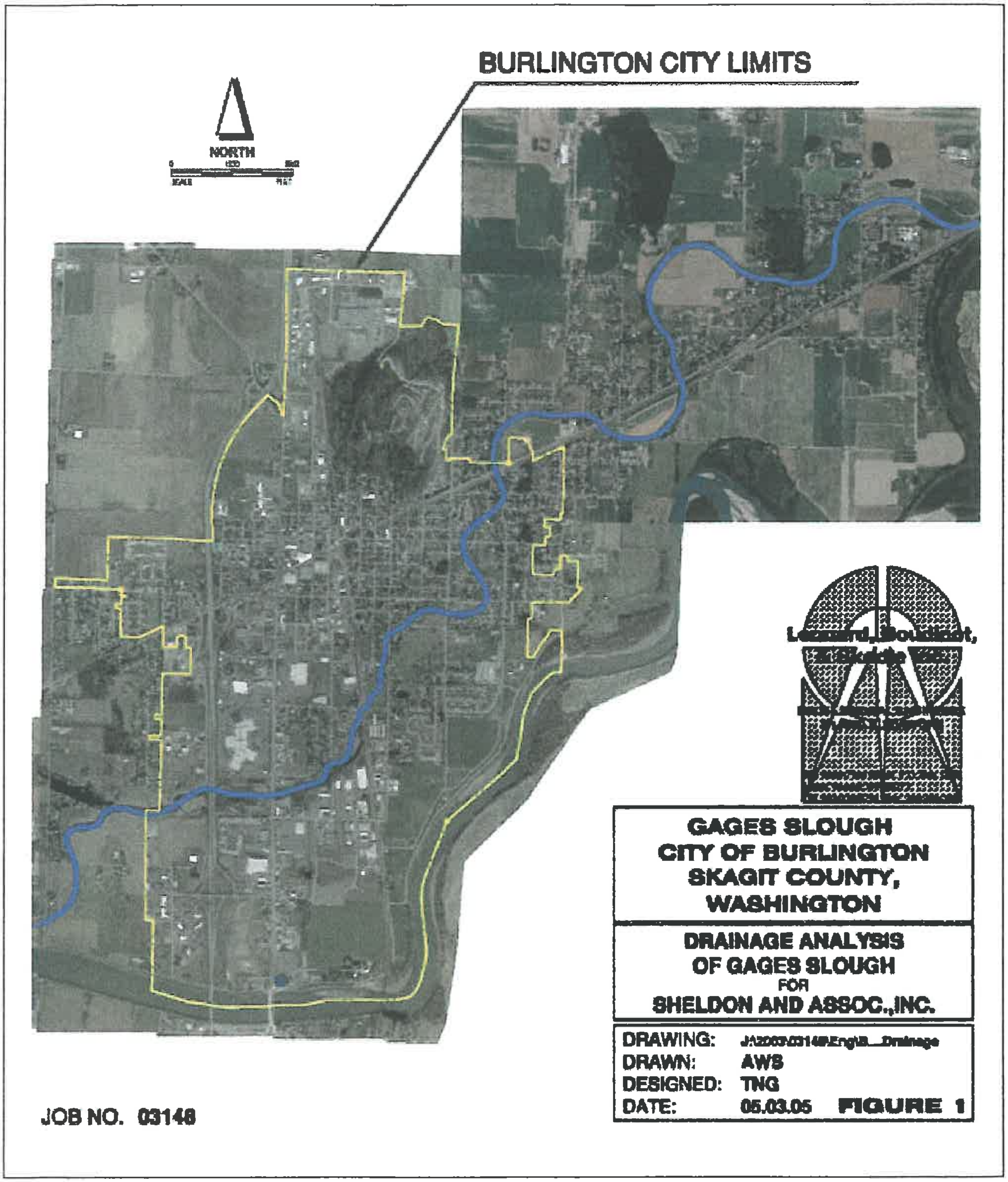


Figure 1. Gages Slough within Skagit County and the City of Burlington.

Gages Slough lays in the historic floodplain of the Skagit River, in a very broad, almost flat valley bottom. The slough no longer lies within the active floodplain of the river due to extensive diking along the north bank of the river, with the eastern extent of the dike located just east of Burlington city limits in the northeast corner of section 33, township 35 north, range 4 east. It is assumed that the slough is one of the old meander channels from the Skagit River.

Currently, water in the slough is generally slow moving or standing, depending on the season and the volume of runoff draining to the slough. When moving, the flow of water in the slough is slowed by culverts under the road crossings that regulate the rate of discharge from each cell. Water depths in the slough range up to four feet in the deeper pools during high water conditions. The slough has a high sinuosity with very low gradient and a bottom substrate that is comprised of fine silt. The channel ranges in width from about 20 feet to over 100 feet. The banks of the slough are relatively steep, but generally low, either bare or vegetated with grasses, shrubs, or blackberry.

2.1 Topography and Soils

Natural geomorphic processes in association with the Skagit River presumably formed the slough. Study area elevations range from a low of approximately 15 feet mean sea level (msl) in Gages Slough to a maximum of approximately 40 feet msl in the northeastern section of the City of Burlington (KCM 1993). The City has historically experienced frequent localized stormwater flooding caused by moderate to heavy rains and the flatness of the terrain. Since both the City and Slough are situated in the historic floodplain of the Skagit River, they both have at times suffered severe flooding associated with the river. The majority of the City currently drains into Gages Slough, while other areas of the City are either isolated with no outlet (due to opposing grades), or drain to Drainage District numbers 14 or 19 (away from the slough) following the local grade.

The types of soils encountered in the study are described in Table 2 (SCS 1989). These soils are alluvial and originated from the Skagit River, and extend fairly uniformly throughout the study area.

2.2 Wetlands and Streams

Though located on a channelized slough that was historically formed by floodwaters from the Skagit River, the wetlands that comprise Gages Slough would not be classified as Riverine. Gages Slough wetlands are very low energy systems with surface outlets. Though linear in shape, Gages Slough is not an active stream with fast water; it has only slowly flowing water for only a portion of the year. The slough is not located in active floodplain due to the extent of diking along the Skagit River. Gages Slough receives floodwaters from the river less frequently than every two years. For these reasons, the wetlands of Gages Slough are classified as Depressional Outflow wetlands (Hruby et al. 1999).

Table 2. Soil Types in the City of Burlington and Adjacent Area.

Soil Series	Building Site Development for Dwellings	Permeability for first 5-ft depth (in/hr)	Textural Class Inclusions
Andic Xerochrepts	Severe Slope	0.6 - 2.0	None
Briscot fine sandy loam	Severe Flooding	0.6 - 2.0	Fine sandy loam, loamy fine sand, silt loam
Field silt loam, protected	Severe Flooding	0.6 - 2.0	Silty loam, loamy fine sand, fine sand, very fine sand
Mt. Vernon very fine sandy loam	Severe Flooding	0.6 - 2.0	Silty loam, fine silty loam, very fine sandy loam, fine sand
Pilchuck loamy sand	Severe Flooding	0.6 - 2.0	Loamy sand, fine sand, sand, gravely sand
Pilchuck variant fine sandy loam	Severe Flooding	2.0 – 20.0	Fine sandy loam, loamy fine sand, fine sand
Sedrowooley silt loam	Severe Flooding	0.6 - 20.0	Silt loam, very fine sandy loam
Skagit silt loam	Severe Flooding	0.6 - 2.0	Silt loam, silty clay loam, very fine sandy loam
Sumas silt loam	Severe Flooding	0.6 - 20.0	Silt loam, silty clay loam, loamy sand, coarse sand
Urban-Mt. Vernon-Field complex	On floodplain	0.6 - 2.0	Urban land, Mt. Vernon very fine sandy loam, field silt loam

The City of Burlington initiated a wetland study of Gages Slough in the winter of 1997-98 under a Coastal Zone Management grant provided by the Washington State Department of Ecology (Appendix B). The purpose of the study is to assess the wetland functions and water quality of Gages Slough, and to determine the extent and cause of degraded areas and ongoing impacts along the slough. Findings from this study indicate that, relative to the reference wetlands that were assessed in developing the Washington State function assessment method, the wetlands that comprise Gages Slough generally rate above average for several functions. These functions include removing sediment, reducing peak flows, and primary production and export. The wetlands generally rate below average for general habitat suitability and suitability for aquatic mammals.

For the remainder of the assessed functions, the wetlands of Gages Slough generally rate average. These functions include removing nutrients, removing heavy metals and toxic organics, reducing downstream erosion, recharging groundwater, suitability for invertebrates, suitability for amphibians, suitability for anadromous fish, suitability for resident fish, suitability for aquatic birds, and habitat for native plant communities. These functional scores indicate an overall condition for the slough wetlands that is intuitively apparent from casual observations.

The wetlands are not in pristine condition, but for the most part, they have not been disturbed to the extent that their functions are seriously compromised.

2.3 Climate and Precipitation

The study area's climate is greatly tempered by winds from the Pacific Ocean, and is typical of the areas west of the Cascades. Winters are wet and relatively mild. Temperatures normally range from 30 degrees Fahrenheit (F) to 50 degrees F in the winter, with brief periods below 30 degrees F. Summers are characteristically cool and dry with temperatures rarely exceeding 85 degrees F, although temperatures around 100 degrees F have been recorded. The average precipitation is approximately 33 inches per year, and the majority of the precipitation falls between the first of October and the end of March.

The City of Burlington maintains rain gages at the wastewater treatment facility. The gage is part of the national system of weather gages supervised by the National Weather Service (NWS). The gage records precipitation automatically every 15 minutes to within 0.01 inches.

2.4 Major Hydraulic Elements

The flow in the slough is likely provided by shallow groundwater, seeps, and hyporheic flow from the Skagit River. However, some flow is provided from collection areas for storm water runoff from roads, parking lots, and agricultural areas.

Discharge from the slough is by gravity when the Skagit River elevation is below the slough elevation, via a pipe with a flap gate through the levee of the Skagit River downstream of the City of Burlington (Figure 2). When the water level in the slough reaches an elevation of 19 feet at the pump station, water is pumped through the levee (approximately a 10 foot lift in elevation) into the river.

Due to the flap gate on the outlet pipe and hydraulic modifications at the outlet, access to the slough by salmonids is thought to be rare. Salmonids have been infrequently observed in the slough, and have likely accessed the channel during an extreme flood (Rich Johnson, pers. comm. 2001). Only resident fish species, such as bluegills and perch, are known to be present year-round in the slough.

Surface flows into Gages Slough from the Skagit River occur only during major floods. The most recent records of floodwaters entering the slough are 11/25/1990 and 11/30/1995, where the discharge of the Skagit River was 152,000 cfs and 141,000 cfs, respectively. The minimum stage of the Skagit River that is known to allow floodwaters into the slough is 37.37 feet (at the USGS gage near Mt. Vernon), based on the events occurring during the 1990 and 1995 floods. The City of Burlington becomes inundated when the Skagit River reaches a stage of 38.1 feet (City of Burlington 1999).

The three major hydraulic elements that impact the study area are the Skagit River, the Gages Slough outfall, and the City's storm water drainage network. The relationships between these elements and flooding in the study area are described below.

2.4.1 Skagit River

Burlington is protected from Skagit River flooding by a levee which is maintained by Skagit County Diking District #12. This levee ends near the intersection of District Line Road and SR-20. River flows of greater than 140,000 cfs can flow into Gages Slough in the vicinity of District Line Road. On November 24, 1990 a minor flow of flood water into the slough occurred when the river crested at 37.4' on the Riverside gage. The flow in the river was estimated at 152,000 cfs during this flood, which has a recurrence interval of approximately 30 years.

2.4.2 Gages Slough

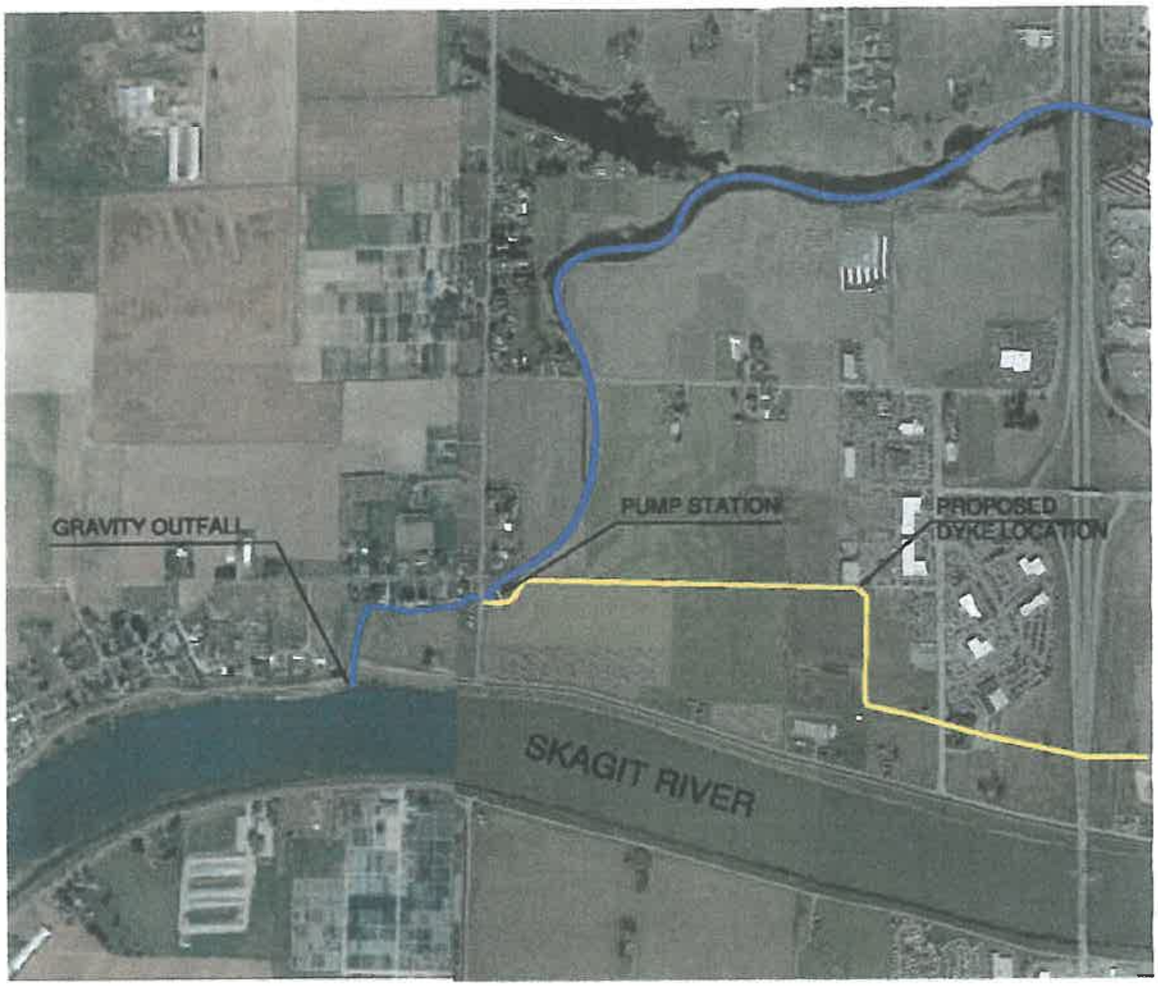
Gages Slough conveys most of the stormwater out of the City to City pump station (Figure 2). From there, the stormwater either drains into the Skagit River when the river is low, or is pumped into the river when the river water level is above that of the slough. The pump station facility was designed to pump 5,000 gallons per minute (gpm), or 11.1 cfs against a pressure head of 18 feet. The gravity outfall downstream of the pump station consists of 200 feet of open ditch; 65 feet of 36-inch-diameter corrugated metal culvert; 600 feet of 48-inch-diameter corrugated metal pipe; and 200 feet of 18-inch-diameter concrete outfall pipe. This report found that the Gages Slough outfall/pump station system is adequately sized to pump flows generated within the slough's drainage basin. This report did not examine how Skagit River overflow into Gages Slough effects pump performance.

2.4.3 City Drainage Network

In the 1993 Surface Water Management Plan, KCM observed that water in pipes and ditches entering Gages Slough back up when the water in the slough is high. Since the 1993 report, the City of Burlington has increased the pump capacity at the outlet of Gages Slough. This reduced the high water level in the lower reaches of the slough during large storm events, reducing the chance of the storm system operating in a surcharged condition. The City has also increased the size of many of their storm mains through the capital improvements plan. Larger storm mains require less energy to move water, so they can function better then the replaced pipes in a surcharged condition.

This study discovered that the high water elevation in the upper reaches of the slough is more likely controlled by culvert restrictions than the pump capacity at the outlet of Gages Slough. Since the upper reaches did not see much reduction in flooding from the pump station improvement, areas draining into the upper reaches of the slough may still see ponding occur at pipe entrances.

IMAGE NOT TO SCALE



DIKE, PUMP STATION, AND DISCHARGE FOR GAGES SLOUGH

DRAINAGE ANALYSIS OF GAGES SLOUGH FOR SHELDON AND ASSOC.,INC.

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FIGURE 2

JOB NO. 03148

Figure 2. Dike, pump station and discharge point for Gages Slough to the Skagit River.

The stormwater pipe system throughout the study area was examined and inventoried in the 1993 Surface Water Management Plan. The City of Burlington keeps the map of their storm mains updated. A large-scale map of the City's storm mains is included in Appendix C. To characterize the 1993 study area's stormwater pipe system, capacities of over 300 of the City's storm pipe sections were calculated using Manning's equation. Manning's roughness coefficients were based on the type of pipe material except for where the material is unknown. For these pipes a Manning's roughness coefficient of 0.030 (which is very conservative) was assumed.

2.5 Land Use

Gages Slough within the City of Burlington travels through areas representing a variety of land uses including farmland, commercial and industrial areas, and high-density residential areas. In addition, the slough is traversed by several major highways. All of these land use types represent areas of potential non-point source pollution to downstream aquatic resources. Pollution from urban stormwater, agricultural practices, forest practices, and failing on-site septic systems can be received via dissolved or adhered to sediment particles into downstream aquatic systems, including wetlands.

Because runoff associated with urbanization can have a dramatic effect on the quality and quantity of stormwater runoff drainage to wetlands and streams, past, existing, and future land use within the City were investigated.

In 1993 the land use types in the contributing basin to Gages Slough included agricultural, comprising roughly 35% of the basin, commercial (20%), high-density residential (20%), low density residential (15%), and undeveloped open space (10%). Percent area estimates were approximate, based on the USGS quad map (Mt. Vernon Quadrangle) and aerial photos. At that time the construction of several shopping malls along the I-5 corridor indicated an increasing trend in commercial land use in the basin and a related decrease in agricultural uses. Most of the area directly adjacent to the slough was cleared of vegetation and maintained as lawn, pasture, or cropped fields. The majority of this land was also privately owned and used for residential purposes or small farms. In addition, one commercial/industrial area about one mile long contained a small number of businesses that abutted the slough.

Since the 1993 SWMP was written the City of Burlington has grown. The Burlington Boulevard corridor has been developed with commercial development from Highway 20 south to the Skagit River Bridge. Many housing developments have been built resulting in filling of previously undeveloped lots and subdivision of larger lots. In 2004, the land use types in the contributing basin to the slough included agricultural, comprising roughly 35% of the basin, commercial (25%), high-density residential (38%), and undeveloped open space (2%). Percent area estimates are approximate, based on the USGS quad map (Mt. Vernon Quadrangle) and 2004 aerial photos. Currently, land use within the City of Burlington reflects that of a highly urbanized watershed (Table 3)

Table 3. Comparison of past current and future urbanization within the City of Burlington.

Assessment Year	Total Impervious Area (%)	Agricultural Area (%)	Commercial Area (%)	High Density Residential (%)	Undeveloped Area (%)
1993	26	35	20	20	15
2004	36	35	25	38	2
Complete Build Out	48	22	31	47	0

It is estimated that that there will be no available undeveloped land under the projected complete build out scenario for the City of Burlington. Furthermore, about 48 % of the land will be impervious and there will be less agricultural area and more commercial and high-density residential area in the future (Table 3).

Wetlands have received increased attention in recent years as a result of continuing wetland losses and impacts resulting from new development. In urbanizing areas, the quantity and quality of stormwater can change significantly as a result of land-use conversion in a watershed. Increases in the quantity of stormwater may result from new impervious surfaces (e.g., roads, buildings), installation of storm sewer piping systems, and removal of trees and other vegetation. On the other hand, decreased inflow of water can result from modifications in surface and groundwater flows. For cases where wetlands are the primary receiving water for urban stormwater from new developments, it is hypothesized that the effects of watershed changes will be manifested through changes in the hydrology of wetlands.

Wetland hydrology is often described in terms of its hydroperiod, the pattern of fluctuating water levels resulting from the balance between water inflows and outflows, topography, subsurface soil, geology, and groundwater conditions (Mitsch and Gosselink, 1986). Wald and Schaefer (1986) referred to seasonal water level changes as the "heartbeat" of Pacific Northwest palustrine systems.

Agricultural practices include those from crops as well as small hobby farms and large farms. Improper agricultural practices can lead to physical erosion of pasture areas or stream banks by the animals as well as increased inputs of nutrients and bacteria from the animals. They can further affect water quality through the loss of riparian vegetation and subsequent increase in water temperatures. Increased inputs of organic materials and lower water temperatures lead to decrease dissolved oxygen concentrations.

Forest practices include not only logging activities for timber production, but also logging to clear land for development. Improper forest practices can lead to erosion, loss of riparian vegetation, increased temperature, input of nutrients, increased suspended solids, turbidity, and sedimentation, and decreased in stream complexity due to fewer inputs of woody debris.

Failing on-site septic systems can allow bacteria and other disease causing organisms to enter surfaces waters. Additions of nutrients may also be associated with organic chemicals that enter the water following the failure.

3.0 HYDRAULIC MODELING

3.1 Surface Water Management Model Description

Two programs were used to model Gages Slough. StormShed used drainage basin information developed from a Combined City of Burlington 2003 Drainage Map and 1984 aerial topography map to produce run-off hydrographs for the 2-year, 10-year, and 25-year storms. The hydrographs were then transferred to HEC-RAS, which combined the hydrographs and the 2004 Burlington aerial topography to model slough elevations during the 2-year, 10-year, and 25-year storms.

3.2 Model Construction

3.2.1 Basins

A combination of the 2003 City of Burlington Drainage Map and the 1984 Burlington aerial topographic map was used to delineate drainage basins and time of concentration paths within the City (Figures 3). Since the Burlington maps do not extend much beyond the City limit, the Skagit County Assessor map (Figure 4) and the United States Geological Survey (USGS) map were used to determine drainage basins in areas draining to the slough that are outside the City. The USGS map has ten-foot contours, so the information from cross-referencing the USGS map with the county assessor map is much less accurate than the information from the City's aerial topography. Basins in the City that do not drain into Gages Slough were delineated, but no analysis was performed on them. Time of concentration paths were calculated to the point where the drainage basin outlets into Gages Slough (Figure 5).

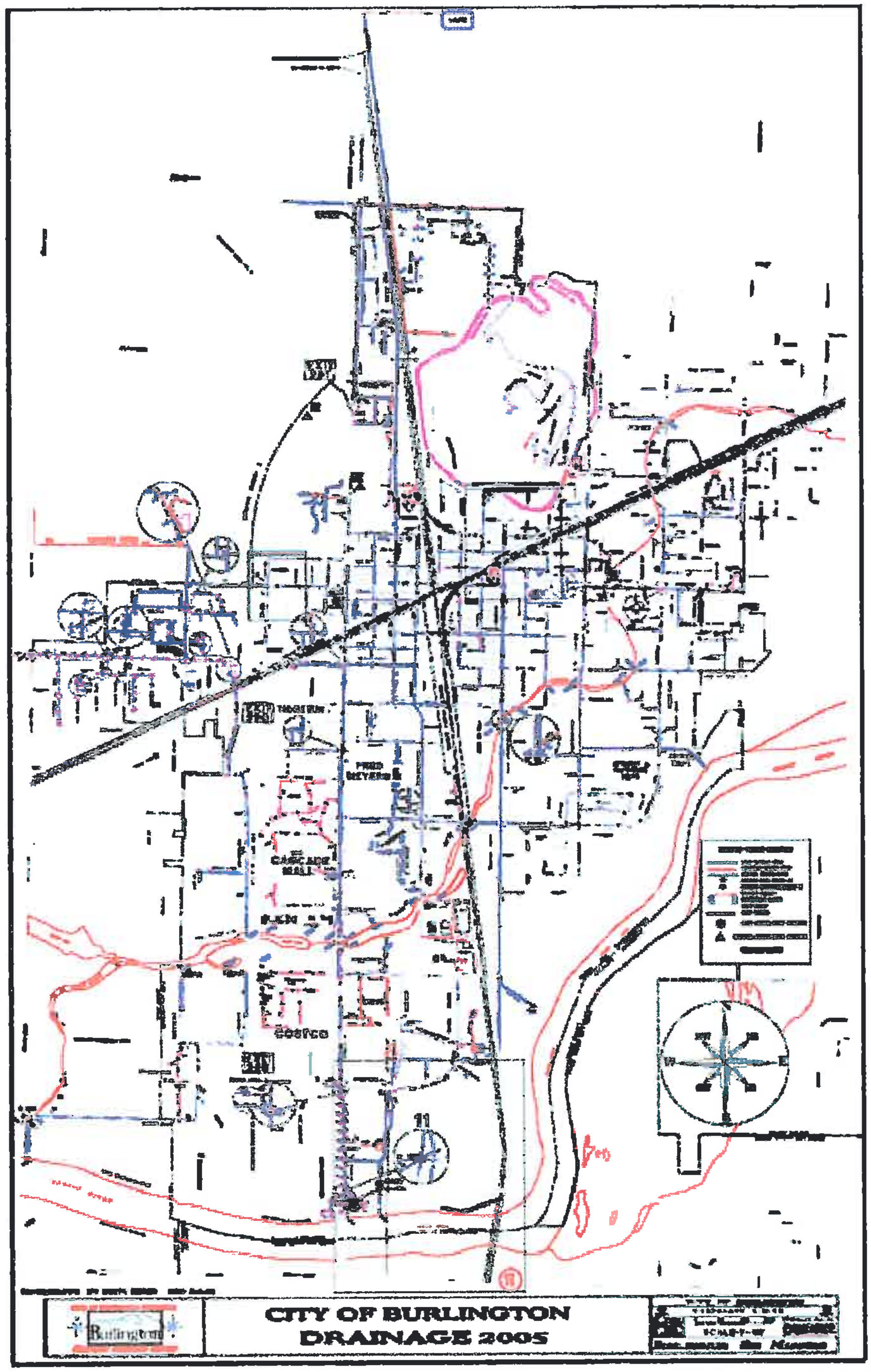
When determining the future pervious and impervious areas for basins, it was necessary to decide on whether detention will be represented in the model. The City expressed interest in knowing if they needed to continue their current detention policy, so an undetained future condition was modeled. In order to estimate future impervious cover, the City of Burlington's Zoning Codes were examined. The City's zoning boundaries were overlaid on the drainage basins and the acres of each zone within the basins was determined. The Zoning Code's restrictions to lot coverage were used as the developed impervious percentage when available. When the Code did not place restrictions, based on the percentage of the lot covered, then a percentage was estimated. For drainage basins outside the City of Burlington, the Skagit Zoning Code was used to determine impervious percentages. Urban growth areas were assumed to have the same characteristics as the City's Land Use District, R-1. See Table 4 for the estimated impervious percentage used for each zone.

The developed impervious percentage for each zone was multiplied by the area of the zone within a drainage basin to calculate the impervious area of that drainage basin. The impervious areas from all the different zones within a basin were added to determine the total impervious area for a basin. The impervious area was subtracted from the total area to get the pervious area of each basin.

According to the Soil Survey of Skagit County Area, Washington, Burlington sits primarily on soils of Hydrologic Type C with small areas of Type B and Type D soils. Gages Slough drainage basins were examined to determine the percentage of each soil type they contained.

Table 4. Assumed Impervious Percentage by Zoning District

Zoning	Impervious Percentage	Zoning	Impervious Percentage
R-1 Land Use District	45	C-2 Hvy. Commercial	90
R-2 Two-Family Residence	50	M-1 Industrial	90
R-3 Multi-family Residence	70	BP Business Park	90
R-A Residence and Agric.	40	OSPA Open Space, Parks, Ag	10
R-S Semi-public District	55	AG-NRL Agricultural	3
MR-NB Med.Res & Business	70	RI Rural Intermediate	35
B-1 Business District	90	UGA Urban Growth	45
C-1 Gen. Commercial	90		



ORIGINAL MAP SIZE IS APPROXIMATELY 3' X 5' - AVAILABLE IN APPENDIX C

Figure 3. City of Burlington 2003 Drainage Map.

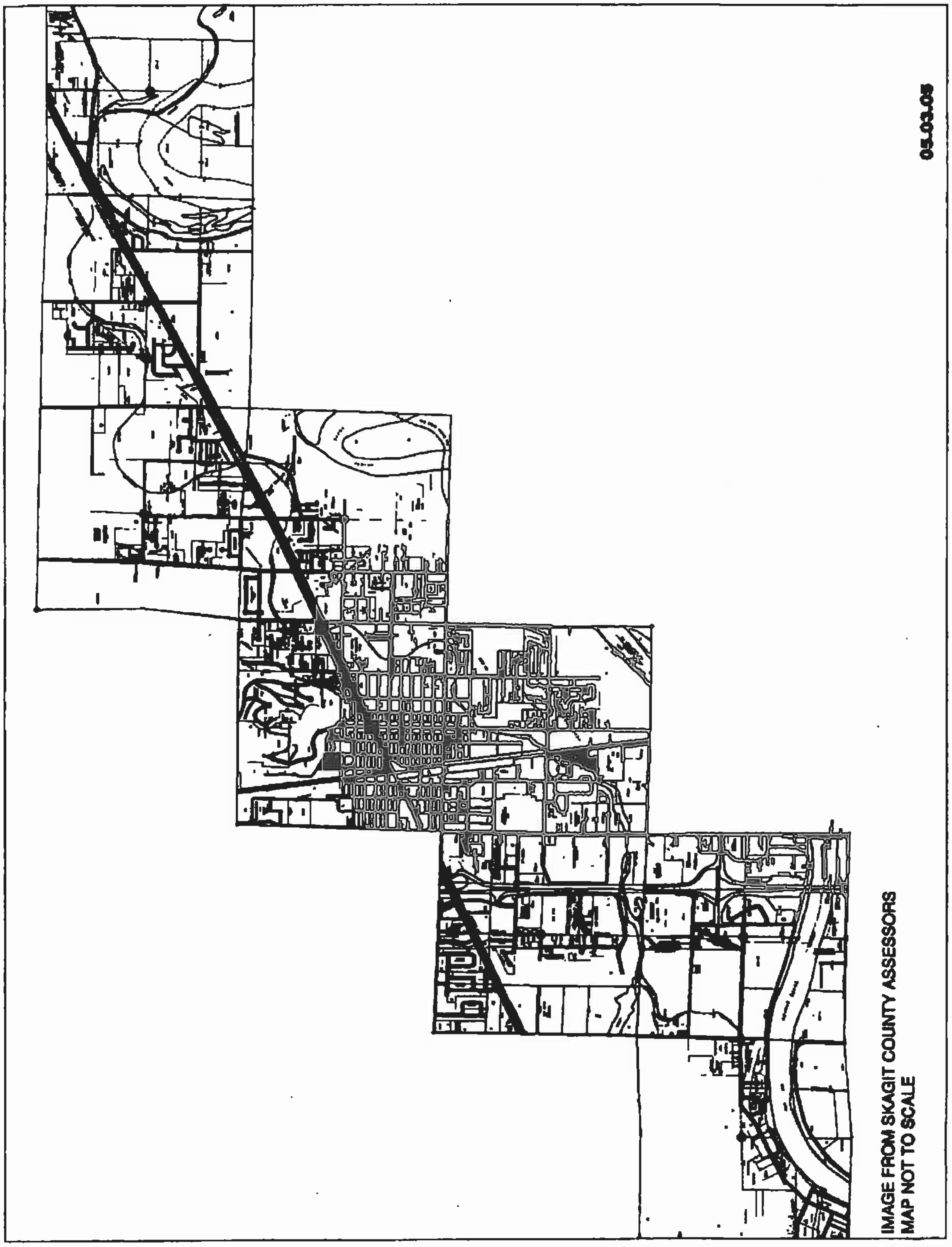


Figure 4. Skagit County Assessor's Map.

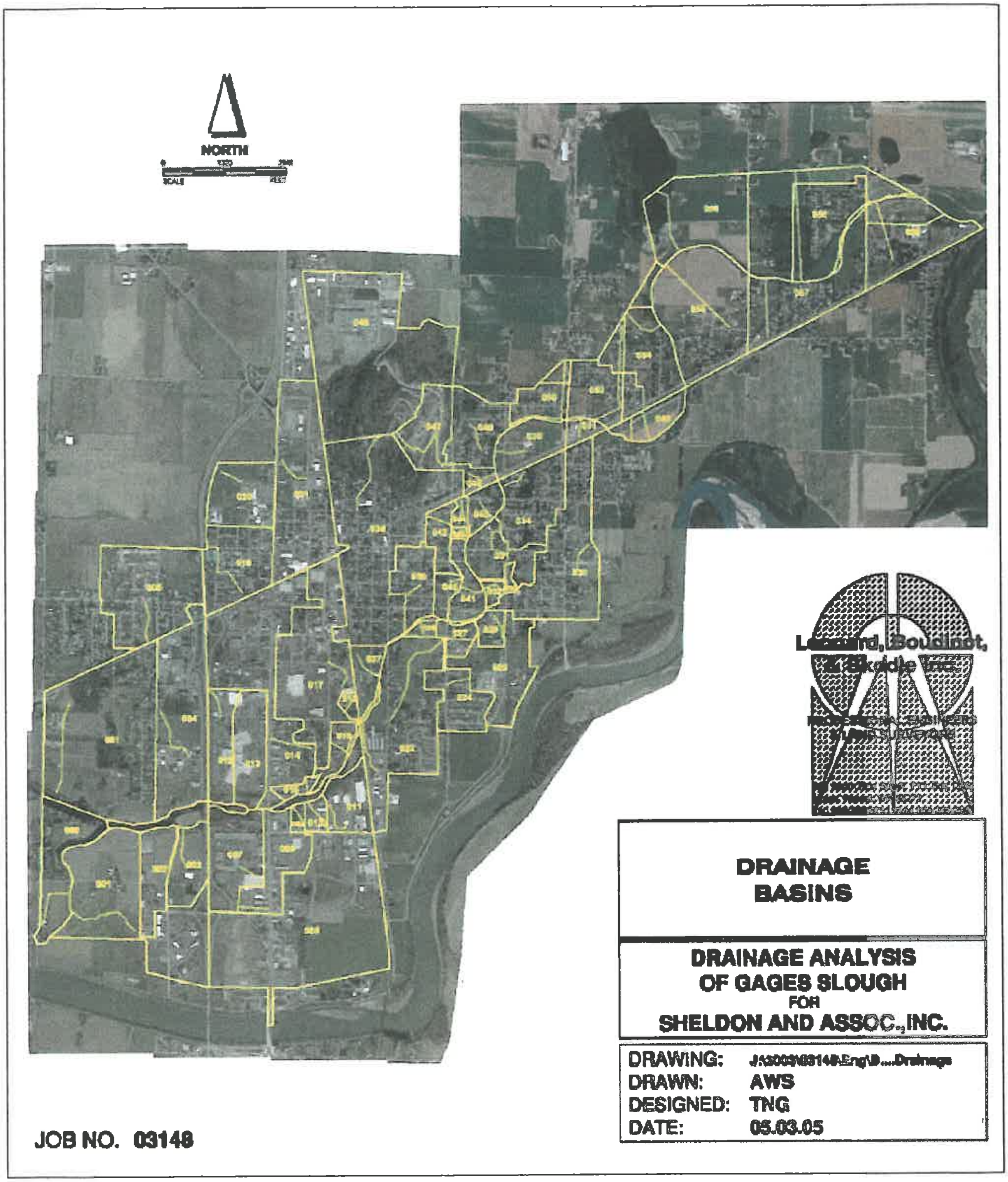


Figure 5. City of Burlington 2004 Drainage Basins.

The percentage of each soil type was multiplied by the area of pervious surface within a basin to determine the acreage of each soil type within a drainage basin. This method assumes that the soil types within a basin are covered by the same percentage of impervious surface as the drainage basin as a whole.

The drainage basin information was input into StormShed. StormShed is a storm drainage run-off computer simulation model following the SBUH hydrograph method. Curve numbers are from Table III-1.3 of the 2001 Storm Management Manual for Puget Sound. All pervious areas are assumed to be Open Space in good condition, and all impervious areas are assumed to be paved. The 1997 Surface Water Management Update, by R.W. Beck, examined the rainfall distributions and concluded that the Region 3 - Puget Sound Lowlands hyetograph reflected local storms more accurately than a Type-1a storm and that the 6-hour event distribution produced the highest peak flows during a 25-year event. Because of these findings the Region 3 - Puget Sound Lowlands hyetograph was used in this study with the rainfall intensities shown below in Table 5.

Table 5. Rainfall Precipitation Values

Storm Event	Precipitation Value (Source)
2-year, 6-hour	0.95-inches (NOAA Atlas)
10-year, 6-hour	1.40-inches (NOAA Atlas)
25-year, 6-hour	1.51-inches (R.W. Beck Report)

A summary of the basin data input into StormShed and those results are shown in Table 6. A table showing the breakdown of the zoning within the basins is included in Appendix D. StormShed basin results are included in Appendix E.

Table 6. Basin Data and Peak Flows

Basin	Pervious Area (Acres)			Impervious Areas (Acres)	Tc	Storm Event (cfs)		
	Hydrolic Type B	Hydrolic Type C	Hydrolic Type D			2-yr	10-yr	25-yr
001	0.0	84.2	10.1	51.4	124.42	4.24	8.42	9.57
002	0.0	3.4	0.2	32.0	78.62	3.00	4.93	5.41
003	0.0	3.2	0.2	30.3	74.35	2.91	4.77	5.23
004	0.0	12.4	1.9	102.4	132.87	7.28	12.13	13.34
005	0.0	45.8	7.7	52.5	89.04	4.86	8.96	10.06
007	0.0	5.5	0.6	54.5	101.74	4.45	7.35	8.03
008	0.0	4.7	0.2	43.7	83.12	3.97	6.52	7.15
009	0.0	0.4	0.1	4.3	44.06	0.52	0.85	0.93
010	0.0	0.8	0.1	7.9	61.08	0.83	1.36	1.49
011	0.0	2.8	0.3	27.0	98.98	2.24	3.69	4.05
012	0.0	2.1	1.6	33.0	74.57	3.18	5.22	5.72
013	0.0	3.7	0.9	41.2	143.53	2.81	4.64	5.09
014	0.0	18.9	0.4	116.7	124.6	8.59	14.28	15.7
015	0.0	0.5	0.2	5.8	42.09	0.71	1.16	1.27
016	0.0	3.1	1.2	10.5	40.65	1.35	2.31	2.56
017	0.0	22.8	0.0	101.5	96.72	8.56	14.3	15.75
018	0.0	0.5	0.0	4.5	71.3	0.44	0.72	0.79
019	0.0	15.0	5.0	42.4	154.12	2.87	4.97	5.51
020	0.0	6.8	4.0	40.2	120.66	3.06	5.16	5.7
021	0.0	12.8	4.5	105.4	123.9	7.81	13.00	14.3
022	0.0	52.5	1.3	65.4	116.56	5.16	9.27	10.36
024	0.0	20.0	0.0	16.3	116.63	1.31	2.46	2.77
025	0.6	29.2	0.0	31.5	32.7	4.49	8.23	9.23
026	0.0	2.7	0.0	2.2	32.7	0.32	0.61	0.68
027	0.0	7.2	0.0	5.9	75.73	0.59	1.11	1.25
029	0.0	7.3	0.0	4.1	64.44	0.45	0.91	1.04
030	4.3	63.6	0.0	41.9	65.11	4.52	8.87	10.08
031	0.0	19.5	0.0	16.2	63.15	1.77	3.32	3.74
032	0.0	3.2	0.0	2.1	35.96	0.29	0.58	0.66
033	0.0	2.5	0.0	1.6	68.17	0.17	0.33	0.38
034	0.0	31.8	0.0	25.7	84.44	2.43	4.58	5.17
035	0.0	19.5	0.0	15.9	53.52	1.87	3.53	3.98
036	0.0	0.0	0.0	0.0				
037	0.0	11.0	0.4	9.0	62.91	0.99	1.88	2.12
038	17.7	72.4	0.0	110.9	105.65	9.01	16.01	17.89
039	0.0	18.9	0.0	15.0	79.9	1.46	2.76	3.12
040	0.0	6.8	0.0	4.4	63.33	0.49	0.95	1.08
041	0.0	11.0	0.0	11.2	38.95	1.48	2.73	3.07
042	0.0	10.2	0.0	8.2	99.39	0.72	1.35	1.52
043	0.0	0.7	0.0	1.5	61.99	0.16	0.27	0.3
044	0.0	3.1	0.0	2.5	79.65	0.24	0.46	0.52

Table 6. Basin Data and Peak Flows - CONTINUED

Basin	Pervious Area (Acres)			Impervious Areas	Tc	Storm Event (cfs)		
	Hydrolic Type B	Hydrolic Type C	Hydrolic Type D	(Acres)		2-yr	10-yr	25-yr
045	0.0	9.2	0.0	6.5	57.87	0.74	1.44	1.62
046	0.0	5.4	0.0	4.1	60.21	0.46	0.88	0.99
047	21.8	1.7	0.0	17.6	25.68	2.64	4.43	4.99
048	34.9	4.5	30.4	155.3	75.24	14.87	25.33	28.03
049	1.2	16.1	7.5	20.3	90.32	1.91	3.61	4.06
050	0.0	17.4	0.0	10.1	67.42	1.09	2.17	2.47
051	0.0	5.2	0.0	4.2	37.41	0.57	1.09	1.23
052	0.0	27.7	0.0	20.8	109.72	1.73	3.29	3.71
053	0.0	21.1	0.0	2.3	72.22	0.35	1.01	1.22
054	0.0	44.5	0.3	22.2	67.75	2.43	4.98	5.69
055	0.0	94.0	4.2	23.7	81.25	2.69	6.38	7.48
056	14.3	69.0	6.7	2.8	58.39	1.08	3.31	4.12
057	0.0	47.7	4.6	28.1	61.1	3.26	6.6	7.52
058	0.0	112.4	7.9	25.2	100.85	2.72	6.63	7.77
059	0.0	52.4	3.3	19.4	63.46	2.31	5.12	5.92
060	7.0	39.3	10.6	1.8	82.67	0.73	1.98	2.43
061	20.7	150.1	0.0	31.9	166.37	2.92	6.56	7.63

3.2.2 Channel Model

The 2004 Burlington aerial topography was used to create the channel cross-sections and model the top of road crossings. The model starts between Highway 20 and Gardner Road and ends at the pump station at the corner of Pulver and Whitmarsh Roads. The 2003 City of Burlington Drainage Map (Figure 3) was used to input data on the culverts along the slough. The slough is shown shallower in the model than it actually is because the aerial topography shows the water surface elevation wherever there was pooled water during the flights. When the Drainage Map showed culvert inverts that were lower than the aerial derived channel bottom, the channel was modified to lower the channel to the elevation of the culvert between the culvert and the next culvert downstream. The slough model includes sixty-eight cross-sections, 13 culverts, and the Goldenrod Bridge. The I-5 Bridge and Railroad Bridge were not included in the model, since information was not available. These bridges should have little effect on water levels when compared to the culverts. Inverts had to be assumed for both ends of the Monroe Street culvert.

3.2.3 Gages Slough Model

The hydrographs produced in StormShed and the channel model were combined using Hydraulic Engineering Center – River Analysis System (HEC-RAS) 3.1.2. HEC-RAS is the river analysis program that was produced for the U.S. Army Corps of Engineers. It is available free on-line at http://www.hec.usace.army.mil/software/hec-ras/hecras-hecras.html. This program takes stream geometry and hydrographs or constant flows and produces water elevations along the length of the geometry.

The 2-year, 10-year and 25-year storm events were examined in HEC-RAS. In order to get HEC-RAS to read the hydrographs generated by StormShed, the hydrographs had to first be transferred to a HEC-DSS file. HEC-DSS files are used to store and transfer flow information between HEC programs. In order to represent flows in different portions of the slough accurately, the hydrographs were grouped to enter the slough at 27 locations. Table 7 shows the basins entered and the stations where they connect to the channel model. A disk with a copy of HEC-RAS and the Gages Slough Model is included in the back of this report.

Table 7. Locations of Flows Entering Slough

Cross-Section	Basins	Cross-Section	Basins	Cross-Section	Basins
8+72	1	93+57	10,15	163+50	31,33,42
14+90	60	99+43	11	178+32	43,44
51+04	61	105+00	16	186+58	45
53+59	2	107+18	17,18,21,22	192+50	34,46
59+27	3	127+00	37	200+50	35
61+57	4,5,19	131+94	38	214+36	47,49
63+57	7,12	142+00	26,39	218+50	50
74+00	8,13,14,20	149+81	24,27,29,30,40	222+42	51,52
83+99	9	160+16	32,41	231+30	53-59

3.3 Model Results

Hec-Ras produced profiles of Gages Slough showing the water surface elevation for the 2-year, 10-year, and 25-year undetained storms (Figures 6,7, and 8). These profiles have been included on the following pages and in Appendix F. The water elevation of the different reaches of the slough during a 25-year storm was mapped on the 2004 aerial topography to show the area expected to flood during this storm (Figure 9). It is important to note that water is over Gages Lane during the 10-year storm (Figure 7) and water is over Gages Lane. Water threatens to overtop Lei Garden Road and Peacock Lane during the 25-year storm (Figure 9).

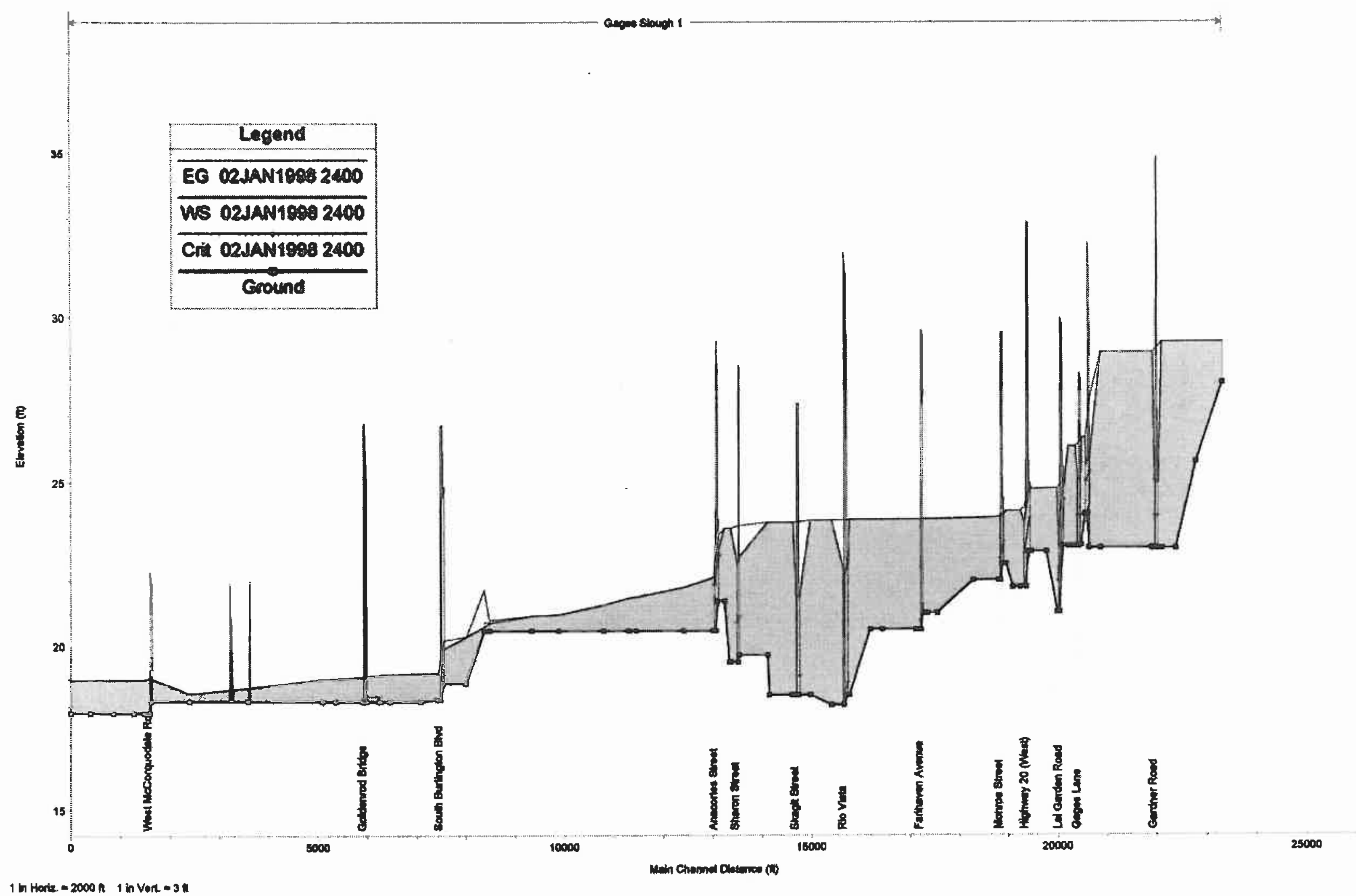


Figure 6. Water Surface Elevation Profile for the 2-year Storm.

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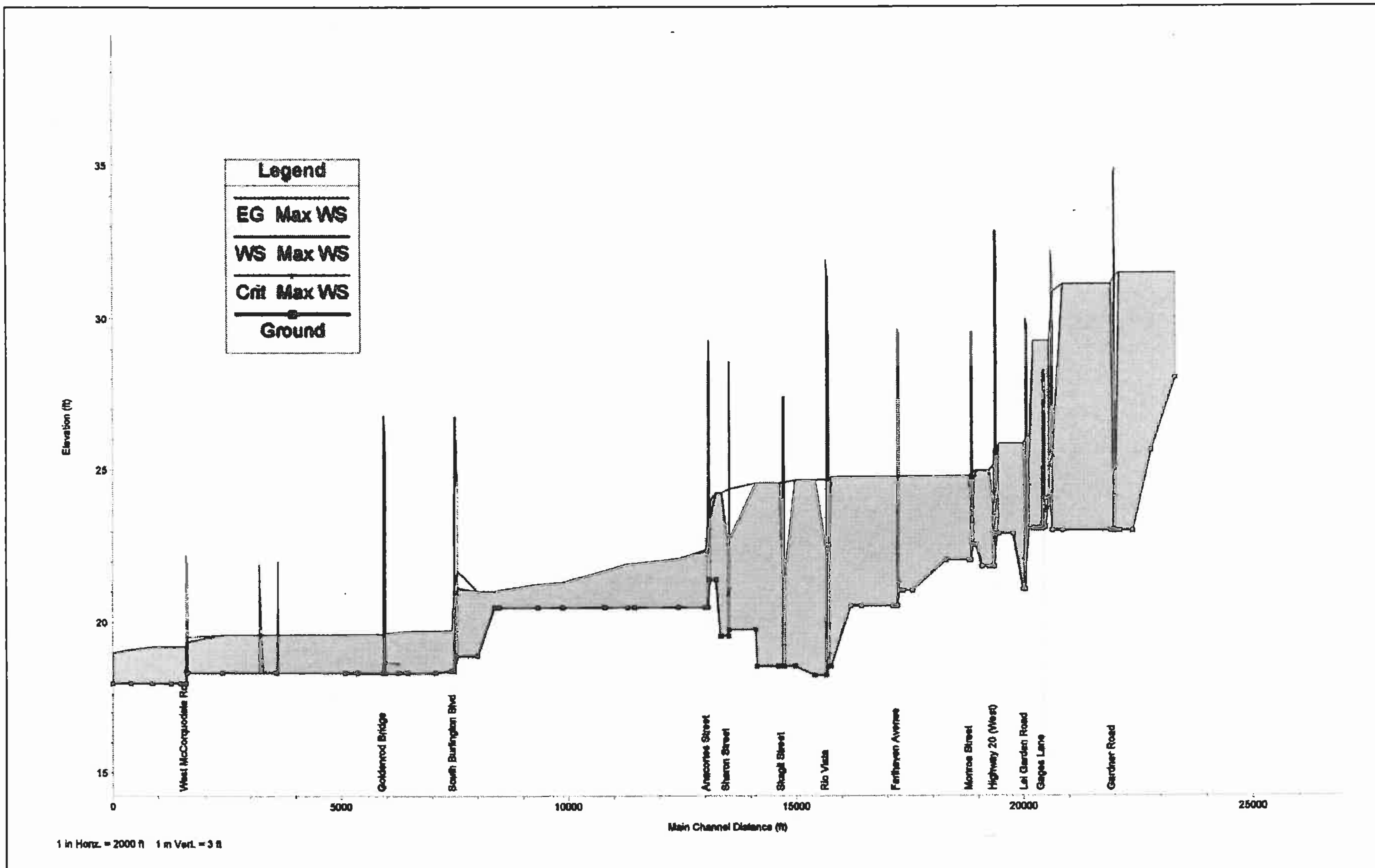

Figure 7. Water Surface Elevation Profile for the 10-year Storm.

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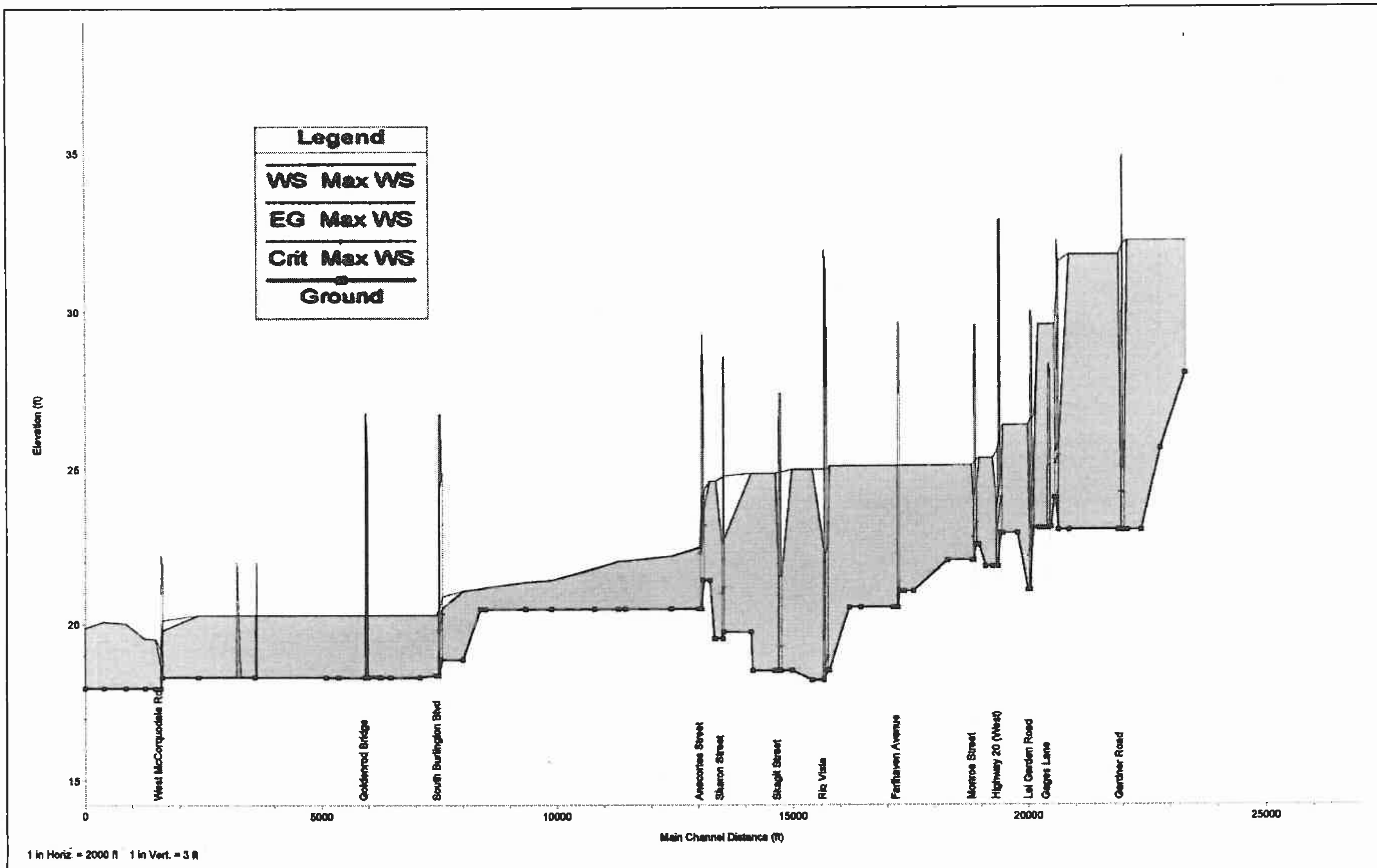

Figure 8. Water Surface Elevation Profile for the 25-year Storm.

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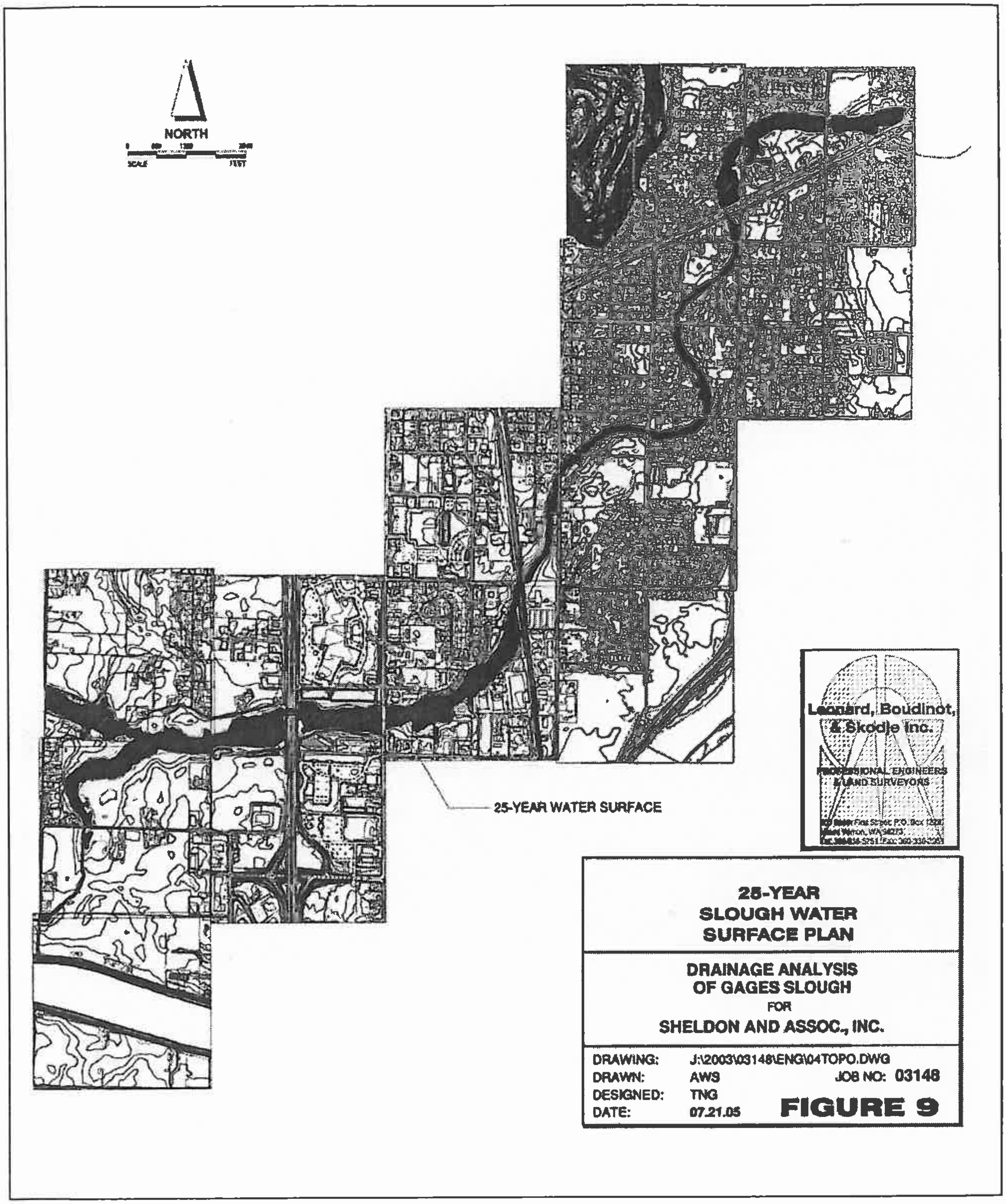

Figure 9. Water elevation of gages slough areas expected to flood during a 25-year storm.

4.0 STORM AND SURFACE WATER MANAGEMENT

4.1 Water Quantity

The majority of Gages Slough was not shown to have a problem with the quantity of stormwater passing through it. The pumps emptying the slough are able to pump the undetained 25-year storm out of the slough in three days. This is fast enough that during infrequent large storms plants along the slough will not be damaged by inundation. However, in the upper reaches of the slough there is a lack of capacity for large storms across the west Highway 20 crossing, Lei Garden Road, Gages Lane and Peacock Lane. A series of culvert improvements to minimizing flooding are outlined in Section 5.0.

4.1.1 Stormwater Detention

The City's policy of requiring stormwater detention is examined in this section. The City of Burlington adopted the Department of Ecology (DOE) 2001 Stormwater Management Manual for Western Washington in the early part of 2004 for their stormwater standards. Volume 1 Section 1.7 of the DOE manual talks about the effects of urbanization and is the basis of the requirements outlined in the manual.

Stormwater detention is one of the methods the DOE manual uses to mitigate the effects of converting the natural landscape into an urban environment. The effects of urbanization are listed below with discussions of how these effects relate to the City of Burlington's stormwater.

<u>4.1.1.1 Increased Flows and Volumes</u>

Increased storm-water flows resulting from development in which detention is not required will affect the demand on the City's stormwater system, water flows within Gages Slough, and the rate at which water is released into the Skagit River. The majority of Gages Slough and the Pulver Road Pump Station have the capacity to transport an undetained 25-year storm. The D.O.E. Stormwater Manual does not apply to man-made systems and the Skagit River, which is included on the list of water bodies exempt from flow control in the 2005 D.O.E. Manual, so the City of Burlington can determine its own detention policy. Since the need for detention will be based on the capacity of the City's stormwater system, the City Engineer shall determine where and when detention will be required.

Gages Slough and Gages Lake are a series of wetlands that flow to a pump station, which pumps into the Skagit River. Storm profiles showing the 2-, 10- and 25-year high-water elevations are included in this report, as well as Figure 9 showing the extent of the water surface of the undetained, fully developed 25-year flow. The model of the slough shows the biggest flooding issues during a 25-year storm occur north of Highway 20. Since the majority of the stormwater in this area originates from the county, the City's detention plan has very little affect on this area. The western portions of Gages Slough and Gages Lake act as a storage area during these large events, until the pump system can pump the stormwater into the Skagit River. The existing pump station draining Gages Slough can pump the 25-year storm volume out of the slough in three days.

4.1.1.2 Decreased Time to Reach Natural Waters

The City of Burlington's stormwater drains into Gages Slough before being pumped into the Skagit River, which is on the proposed flow-control exempt list.

4.1.1.3 Reduced Groundwater Recharge

There are no major drains on groundwater within the City. A water system provides the City of Burlington with water from reservoirs in the Cascades. There are no known users of ground water for household uses. Some wells may be used within the city for watering lawns.

4.1.1.4 Increased Frequency and Duration of High-Stream Flows

The City of Burlington's stormwater drains into Gages Slough before being pumped into the Skagit River, which is on the proposed flow-control exempt list. Since the City is in the lower reaches of the Skagit River, stormwater that is not detained enters the river before the river peaks and does not affect the high flow.

4.1.1.5 Increased Frequency and Duration of Wetland Inundation

The pumps at the outlet of Gages Slough return the slough to normal levels soon after a storm. It would take the pumps slightly over three days to return the slough to its original water levels after a 25-year storm.

4.1.1.6 Reduced Stream Flows and Wetland Water Levels During the Dry Season

Detention ponds do not have a significant affect on increasing water availability to streams and wetlands during the summer, since they detain a two-year storm for only a few of days.

4.1.1.7 Greater Stream Velocities

During a 25-year storm, undetained flows within Gages Slough were calculated as reaching a maximum velocity of 1.4 feet per second. Flows under 2 feet per second are considered non-erosive. After the water is pumped out of Gages Slough the stormwater drains into the Skagit River, which is on the proposed flow-control exempt list.

4.2 Water Quality

In 1998, water quality samples were collected by the City of Burlington from April through June and then again in December. Sampling was performed at 14 locations along the slough. Results from this study indicated that some areas along the slough were in violation of water quality standards and were at levels above those observed in other highly urbanized wetlands in the Puget Sounds lowlands. Specifically several sites reported high fecal coliform and nutrient levels (NOAA 1998).

In 2004, a comprehensive water quality monitoring plan was established to investigate water quality conditions within Gages Slough (Appendix G). This assessment was conducted to characterize general surface water conditions and identify existing point and non-point sources of pollution to both Gages Slough and the Skagit River. Physical, chemical, and biological water quality parameters were monitored in 2004 at eight locations within the City limits (Figure 10). Sampling was conducted of both surface and stormwater along the length of Gages Slough to assess current conditions and highlight any potential contaminants of concern. In addition, water quality data were compared with state and federal criteria. Using these criteria, parameters of specific concern were identified.

A water quality assessment memo was prepared for Gages Slough and the Skagit River (Appendix H). Parameters degrading the health of the Gages Slough wetland system and water quality in the Skagit River were identified (Table 8). These include fecal coliform bacteria, total nitrogen, total phosphorus, and zinc.

Table 8. Gages Slough water quality parameters of concern.

Parameter of Concern	Potential Risk to Gages Slough	Water Quality Issue for Skagit River
Fecal Coliform Bacteria		X
Total nitrogen	X	X
Total Phosphorus	X	X
Zinc	X	X

Wetlands naturally intercept bacteria, nutrients, and metals transported from upstream and adjacent areas. They are therefore natural sinks for these pollutants and have been increasingly used to remove them from wastewater, septic effluent, and enriched agricultural drainage (Johnston 1991; Craft and Richardson 1993). However, when wetlands receive excessive pollutant loadings, ecosystem processes such as plant productivity and nutrient cycling are altered. Some of these alterations include changes in wetland structure and function (Carpenter et al. 1998) such as replacement of the slow growing native vegetation by faster growing invasive species (Davis 1991). Data from this first year of monitoring indicates that the wetlands in Gages Slough contain high levels of fecal coliform bacteria, nutrients (both TN and TP), and zinc that are above that observed in other wetland habitats in Puget Sound, even those experiencing a high degree of urbanization. Therefore, eutrophication is a concern for Gages Slough and should continue to be monitored.

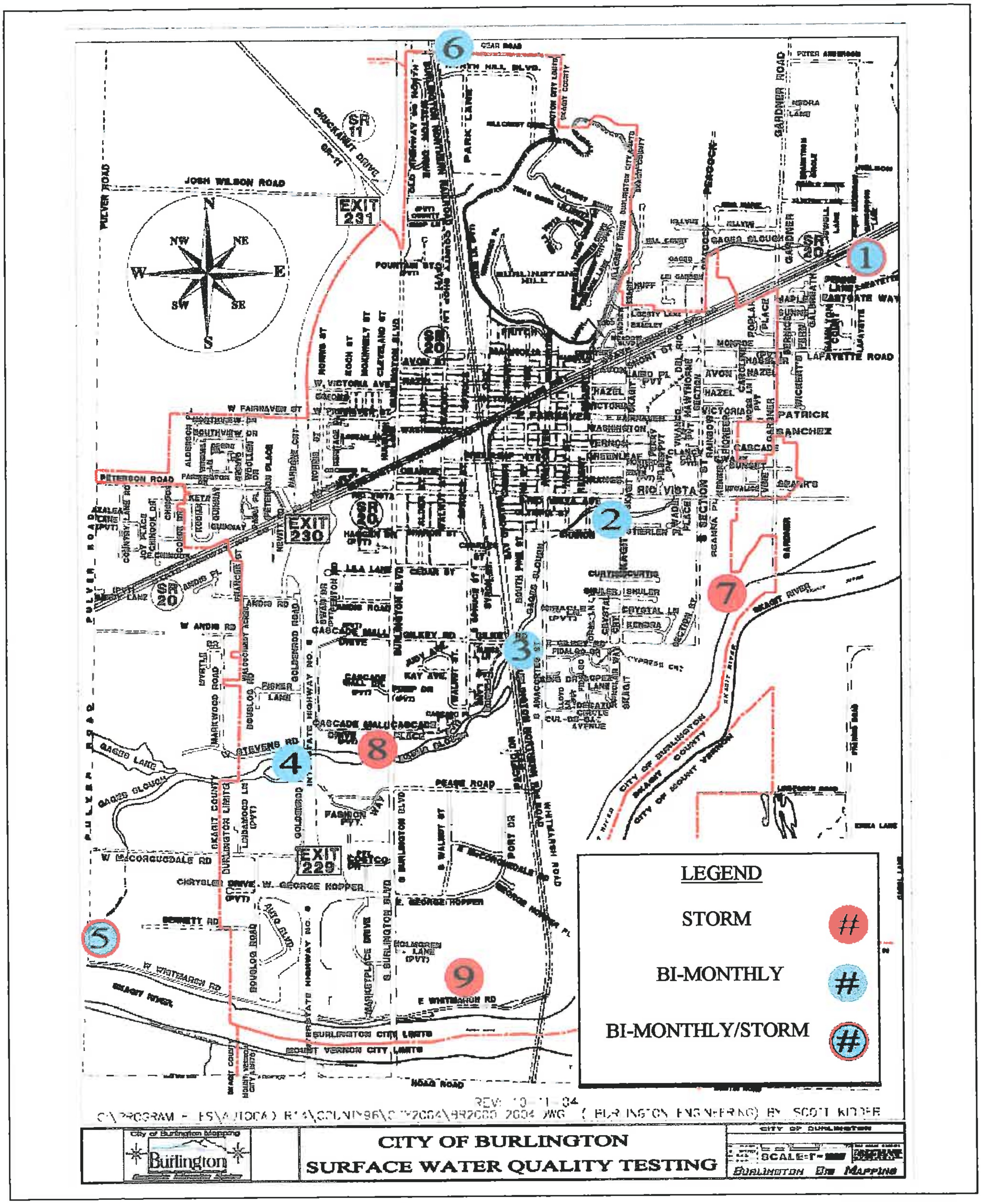

Figure 10. Water quality sampling sites in Gages Slough to the Skagit River.

Fecal coliform bacteria (FCB) concentrations were generally above Ecology criteria (50 CFU/100 mL) and varied seasonally (S&A 2005). Levels of bacteria observed in May and September were the lowest observed, while those observed in December were generally the highest reaching as many as 5000 CFU/100 mL near the mouth of Gages Slough. Cattle grazing within the floodplain and waters of the slough as well as a chicken-processing farm located upstream are likely the primary contributors of FCB. Other contributors include the few remaining septic systems adjacent to the slough and runoff draining as sheet flow as well as direct discharge from storm drains along the slough.

Fecal coliform bacteria are an indicator of pathogens from sewer and manure. FCB bacteria levels have historically exceeded state standards in the Skagit River and its tributaries. As discussed earlier, a TMDL for FCB was prepared (Ecology 2000) to address contamination issues and loading of this pollutant. FCB can pose a public health threat with primary contact, and can degrade shellfish beds near the mouth of the river. In fact, these beds have been subject to harvest restrictions in the past. Because of these issues and the high levels of FC observed at the site of discharge to the Skagit River (site 5), FCB is considered a parameter of concern for the City of Burlington.

Total nitrogen and total phosphorus results indicate that nutrient concentrations in Gages Slough are above state and federally recommended standards (0.31 mg/L and 0.05 mg/L, respectively). For TN, 100 percent of the samples collected during the 2004 monitoring period were above EPA criteria. Concentrations of TN were highest in July. TN was particularly high at the site of the chicken farming operation (Site 2) in July when concentrations were more than seven times those measured in May or at any of the other monitoring sites. Wetlands produce ammonia by decomposing the abundant organic matter internally produced (Mitsch and Gosselink 1993). High concentration of ammonia and the associated levels of TN in July are possibly a result of greater fertilizer applications and lower water levels that concentrate nutrients at this time of year.

Concentrations of total phosphorus (TP) were also measured and the seasonal patterns for this nutrient were similar to those observed for TN, with the highest concentrations being observed in the summer. TP concentrations were above EPA criteria (0.050 mg/L) in 79 percent of samples collected. Again, the highest were values were observed at Site 2 in concentrations as much as five times higher than those observed at other stations that month. Wetlands are recognized as systems prone to nutrient enrichment for a number of reasons including rapid nutrient cycling, and the fact that nearly their entire water column is within a depth that light can penetrate.

Zinc was found in concentrations above detection limits in nearly all of the samples. Seventy-eight percent of the sites with concentrations above detection were above the Ecology criteria of 8.5 µg/L and concentrations reported at site 5 in November were 28 times higher than the criteria. Zinc is typically the most frequently detected metal in wetlands (Horner et al. 1996). Furthermore, stormwater runoff tends to contain higher concentrations than surface water, as seen in Gages Slough. This is because zinc is collected on impervious surfaces where it accumulates over time and is then washed into receiving waters and subsequently diluted. The high concentrations reported for Zinc in Gages Slough make it a parameter of concern.

The most likely sources of zinc detected in stormwater runoff from the study area are associated with automobiles. Tires contain zinc and it is released as they wear along the roadway. Zinc is also a component of several moss repellents. The highest concentrations of Zinc were detected near the mouth of Gages Slough. Upstream sources of zinc include roads and parking lots as well as highway runoff.

It is recognized that wetlands are inherently dynamic systems, with annual, seasonal, and diurnal variability in water chemistry. In addition, they often have several sources of water supply, each possessing a distinctive chemical blend that varies from year to year. To better characterize the water quality in Gages Slough and to track changes in water quality over time, additional monitoring is needed. A complete list of monitoring recommendations and a plan to continue with the monitoring effort are provided in Section 5 of this update to the City of Burlington Surface Water Management Plan.

4.3 Wetlands

The City of Burlington initiated a wetland study of Gages Slough in the winter of 1997-98 under a Coastal Zone Management grant provided by the Washington State Department of Ecology. The purpose of the study was to assess the wetland functions and water quality of Gages Slough, and to determine the extent and cause of degraded areas and ongoing impacts along the slough.

Past and ongoing impacts to, and existing problems of degradation in the wetlands of Gages Slough are summarized as follows:

4.3.1 Impacts from Private Lands

1. Active clearing of vegetation, cultivation and/or mowing in the slough or buffer area.
2. Water quality impacts from lawn chemicals.
3. Water quality impacts from livestock waste.
4. Water quality impacts from inadequate private septic systems.
5. Dumping of refuse (including yard waste) in slough by private landowners.
6. Impacts to vegetation in buffer area from livestock grazing.

4.3.2 Impacts from Public Lands or Public Services

7. Water quality impacts from storm drains.
8. Blocked or undersized culverts preventing adequate flow-through of water.
9. Dumping of refuse in slough by general public.
10. Significant wetland buffer encroachment permitted by City.
11. Lack of citizen awareness of ecological functions of slough.

4.3.3 Problems of Degradation or Low Wetland Function

12. Lack of woody vegetation in buffer area adjacent to slough.
13. Lack of snags or large woody debris in slough.
14. High percent cover by non-native invasive plant species in slough.
15. High percent of high intensity land uses in vicinity of slough.

5.0 SURFACE AND STORM WATER RECOMMENDATIONS

Management recommendations were developed for Gages Slough to address the issues identified in section 4.0. The recommendations are intended to cover both ongoing impacts to the slough and the need for restoration in degraded areas of the wetlands and buffer. Recommendations include both non-structural and structural solutions.

5.1 Non-structural Measures

Non-structural measures are a means of modifying undesirable conditions without altering or destroying the natural condition. They can include the acquisition of land, economic incentives for resource protection (such as mitigation banking), education programs, passive water quality treatment, and monitoring.

5.1.1 Floodplain/Wetland Acquisition

By developing a land acquisition and management plan, the City can accumulate sites along Gages Slough that could be preserved, restored, and protected. These land acquisitions would provide for the protection of many important wetland and natural vegetation communities, including river floodplains and wetlands.

Benefits of land acquisition include:

- Protection of buffers along the river and major creeks throughout the planning area to maintain surface water quality.
- Preservation of floodplain areas throughout the planning area to maintain storage capacity, attenuate floodwaters, and prevent inappropriate development.
- Maintenance of low intensity use to prevent groundwater contamination.
- Preservation or restoration of wetland areas to improve inputs to surface water and ground water and to protect wetland communities.
- Preservation or restoration of natural communities throughout the planning area to support or enhance populations of native aquatic or wetland dependent species.

5.1.1.1 Sites Recommended for Preservation, Enhancement, or Restoration

Several sites within the City limits have been identified for preservation, enhancement and/or restoration. These sites are either currently owned by the City or could be purchased in the future. These sites could also be used for mitigation banking.

1. The Dynes Chicken- farm has been identified as a potential area for acquisition. This site is associated with water quality degradation to the slough primarily from livestock (Section 4.2). Approximately 9.0 acres of land adjacent to the slough could be used for water quality improvement and wetland enhancement.

2. The South-end of the Cascade Mall – has been identified as a potential area for wetland creation and enhancement. Currently, there is a 140-foot wide detention area that serves the mall. There is also a 150-foot wide area between the pond and the slough that serves as a wetland buffer. These areas cover approximately 9.5 acres of land. Since hydraulic analysis shows that Gages slough has the capacity in the lower reaches to transport undetained stormwater, converting these areas into wetland could provide more benefits then the existing detention ponds. The mall owns the detention ponds, so by freeing up some of the detention pond land for the Mall's use the City could receive help funding the project from the mall. A project could make available approximately 7 acres for wetland creation and enhancement and free 2.5 acres of land for the malls use. Flows from the mall would be routed to the new wetland area for treatment before being discharged into the slough.

3. The site between Pulver Road pump station and McCorquodale Road – could be either annexed into the City or through county agreement. This area is currently the site of water quality violations primarily related to livestock. Restoration activities such as fencing and wetland enhancement could improve the functions of the wetlands adjacent to the slough in this area.

4. The site north of Pease Road and west of Burlington Northern Railroad - was recently purchased by the City for wetland preservation and enhancement. Avoiding future development in this approximately 9-acre area would maintain the wetland functions and values of the slough and adjacent wetlands.

5.1.2 Mitigation Banking

A wetlands mitigation bank is a wetland area that has been restored, created, enhanced, or (in exceptional circumstances) preserved, which is then set aside to compensate for future conversions of wetlands for development activities. A wetland bank may be created when a government agency, a corporation, or a nonprofit organization undertakes such activities under a formal agreement with a regulatory agency. The value of a bank is determined by quantifying the wetland values restored or created in terms of "credits."

Mitigation banking has the potential to play a significant role in the Section 404 regulatory program by reducing uncertainty and delays, as well as improving the success of wetlands mitigation efforts. Landowners needing to mitigate or compensate for authorized impacts to wetlands associated with development activities may have the option of purchasing credits from an approved mitigation bank rather than restoring or creating wetlands on or near the development site.

The EPA supports mitigation banking and is currently developing interagency guidance for the establishment and use of mitigation banks. Approximately 100 mitigation banks are in operation or are proposed for construction in 34 States across the country, including the first private entrepreneurial banks.

In 2004, the legislature appropriated $120,000 for the Ecology to implement a pilot rule for wetland banking during fiscal year 2005. The pilot project is funded for one year, and Ecology hopes to evaluate and process 4-5 bank proposals throughout the pilot certification process.

Some of the benefits of wetland mitigation banking are:

- Banking can provide more cost effective mitigation and reduce uncertainty and delays for qualified projects, especially when the project is associated with a comprehensive planning effort.
- Successful mitigation can be ensured since the wetlands can be functional in advance of project impacts.
- Banking eliminates the temporal losses of wetland values that typically occur when mitigation is initiated during or after the development impacts occur.
- Consolidation of numerous small, isolated or fragmented mitigation projects into a single large parcel may have greater ecological benefit.
- A mitigation bank can bring scientific and planning expertise and financial resources together, thereby increasing the likelihood of success in a way not practical for individual mitigation efforts.

5.1.3 Water Quality Treatment Options

Currently, existing wetland areas may not be used for stormwater treatment within the City of Burlington (15.15.230). These areas may, however, receive water following treatment.

A. A regulated wetland or its required buffer can only be altered if the wetland site assessment shows that the proposed alteration does not degrade the quantitative and qualitative functioning of the wetland, or any degradation can be adequately mitigated to protect the wetland function. Any alteration approved pursuant to this section shall include mitigation necessary to mitigate the impacts of the proposed alteration on the wetland as described in BMC 15.15.240, Wetland mitigation standards.

B. Storm water discharges to wetlands shall be flow controlled and treated to provide all known and reasonable methods of prevention, control, and treatment as mandated in the State Water Quality Standards, chapter 173-201A WAC, as required by state law and implemented in BMC Title 14, Surface Water Management. (Ord. 1495 § 2, 2002).

C. The Department of Ecology's 2001 Stormwater Management Manual for Western Washington describes the use of biofiltration treatment facilities, wet ponds, and oil/water separators. The DOE website (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/) has a list of new technologies for treatment as well.

5.1.4 Education

Public education around Gages Slough should include programs for water quality and wetlands. The public education program should be continued that encourages the source control of stormwater pollution such as:

- reduced use of household products that are harmful to the environment
- elimination of illegal dumping of oils, liquid waste, lawn clippings, pet waste, and other pollution sources
- the wise-use of pesticides and herbicides
- discussion of the effects of fertilizer on downstream water bodies

5.1.5 Monitoring

A Water Quality Monitoring Plan was prepared in 2004 and has provided monitoring guidelines and procedures evaluating surface and stormwater within the City of Burlington. To date, the program has been used to assess surface water quality and identify parameters of concern within the study area including identification of potential point and non-point sources of water contamination in Gages Slough and at discharge points to the Skagit River.

This plan specifies the number, location, and frequency of monitoring efforts as well as the parameters to be analyzed in each sample collected. City staff have been trained and are collecting samples bi-monthly. Sheldon & Associates the conducts the data analysis and prepares an annual report.

The long-term goals of this monitoring program are:

- Characterize surface water quality conditions annually in the portion of Gages Slough within the City of Burlington
- Assess future trends in slough quality as the City continues to grow
- Identify any new parameters of concern and their specific sources
- Assess stormwater quality from outfalls discharging directly to both the slough and the Skagit River to ensure permit compliance.

Although the monitoring program outlined in 2004 was successfully implemented, several suggested changes are recommended. Changes to the existing program include:

- Limiting metals and pesticide sampling to one time annually, with the exception of zinc
- Measure fecal coliform, total nitrogen, total phosphorus and zinc bi-monthly
- Site 1 will be moved to the pond at Gages Circle and Peacock Road.

- Sampling will be collected at sites 1 through 5 within the Slough bi-monthly.
- Samples will be collected from sites 1 through 5 and sites 6, 7, 8, and 9 once per year during a winter storm event. All analytes will be tested during this storm sampling effort.
- Sampling will be conducted by the City of Burlington.
- Analysis will be performed by Sheldon & Associates.

5.2 Structural Measures

Structural measures are engineered and constructed efforts undertaken to alter the natural environment to improve undesirable conditions. Structural measures can include dams, floodwalls, pipelines, overflow channels, detention facilities, culverts, and improved channels.

5.2.1 Quantity

The City of Burlington's previous stormwater management plans have focused on the quantities of water that can be expected and developed plans to mitigate the impact of large storms. This section reviews the status of the projects proposed in past reports, adds a slough conveyance project to the CIP list, and mentions an improvement that would have been added to the list if development pressures had not forced the City to construct the project before this report was complete.

5.2.1.1 Review of 1993 Capital Improvements Plan

In developing the CIP, the conveyance along Gages Slough was examined to lower 25-year storm water surface elevations and improvements to transport the City's storm water from the north end of the City to Gages Slough. The 1993 Surface Water Management Plan (KCM 1993), which has been adopted as part of this document, included a list of recommended series of capital improvements. Many of the improvements listed in the 1993 Capital Improvement Plan have been completed or partially completed (Appendix I). Table 9 reviews the status of the projects included in the 1993 CIP.

A capital stormwater improvement was completed between capital improvement plan reports. This improvement was the installation of a 36-inch line along Rio Vista west of Gages Slough and north along Gardner Road to 400 feet south of Lafayette. This storm line provides storm drainage to an area of the city that did not have any storm drainage. It was decided that this capital improvement needed to be completed before this report was finished due to the rapid development in the area served by this new storm line. The project was built in 2004 and the system was designed using storm flow information that was generated for this report.

Table 9. 1993 Capital Improvement Plan Review

Construction Project	Status
Gages Slough Outfall/Pump Station Improvement	Modified by 1997 R.W. Beck Report, completed
West I-5 Improvement – South of STH 20	Completed
Spruce Street Improvement – South of Pump Station	In Design
West I-5 Improvement – North of STH 20	Partially Completed
High School Improvements – North Pump Station	Revised in 1998 Leonard, Boudinot & Skodje Report, partially complete
South Pease Road Improvement	Completed
Anacortes Avenue Improvement	Pending
Rio Vista and Gardner Road Improvement	Completed

5.2.1.2 Completion of Outstanding Projects

The progress of the projects in the 1993 CIP that have not been completed are summarized below:

Spruce Street Improvement – South of Pump Station
Leonard, Boudinot and Skodje is currently designing this project. This pump station is being designed to drain the area north of the Burlington Northern Railroad, but south of Highway 20. The location of the pump station has been moved from the one mentioned in the 1993 Surface Water Management Plan to the corner of Walnut Street and Washington Avenue.

West I-5 Improvement – North of SR 20
A pump station has been installed at the corner of Peterson Road and Woollen Road and a piped storm system installed along Peterson Road. The pump station was designed to convey peak flows of approximately 15 cfs. The pump station was designed to be decommissioned when the Fairhaven and Woollen Road pump station is built. Connecting the area flowing to the Peterson pump station to the Fairhaven pump station will lower the Fairhaven pump station by one foot to 1.5-feet below the elevation called out in the 1997 R.W. Beck report.

Completing this project will consist of installing a 30-inch diameter pipe from Norris Street under I-5 along Fairhaven to Woollen Road, installing a new pump station at Woollen Road and Fairhaven, decommissioning the pump station at Peterson Road and Woollen Road, and connecting the new pump station to receive the Peterson drainage system and discharge to the Goldenrod storm system.

High School Improvements – North Pump Station
The high school has installed a pump station that collects the high school campus' stormwater and the west side of Burlington Boulevard between Victoria and West Fairhaven and pumps into the South Burlington Boulevard system. This project has been updated in a report by Leonard, Boudinot, and Skodje Inc. titled "North Burlington Area Update – Surface Water Management Plan".

Anacortes Street Improvement
Leonard, Boudinot and Skodje are currently designing the Pine Street and Hazel street storm improvements. The Anacortes Street improvements are still pending.

5.2.1.3 Proposed Slough Conveyance Improvements

The 25-year water surface elevation model produced for this report was examined to look for improvements that would lower Gages Slough's elevations. An examination of the results of the 25-year Gages Slough model shows that the largest increases in water elevation across roadways occur at Anacortes Street and at the Highway 20 crossing west of Peacock Lane. Preliminary investigation showed that the elevation jump across Anacortes Street was not sensitive to increases in culvert size. The roadways upstream of Anacortes are not flooded during a 25-year storm, so no project is recommended at this crossing. The Highway 20 crossing, however, decreases the upstream surface elevation significantly with capacity increases, and the model predicts flooding of both Lei Garden Road and Gages Lane. A series of four projects are suggested to reduce the flooding at Lei Garden Road and Gages Lane. These projects will increase conveyance capacity across the west crossing of Highway 20, Lei Garden Road, Gages Lane, and Peacock Lane. A slough profile showing slough levels after the following improvements is included in Appendix I. These projects should also include recommendations by a wetland biologist to decide if raising the inverts from the existing inverts would have benefits to water quality and habitat in the slough.

Highway 20
The boring of a new 24-inch pipe parallel to the existing line will reduce the water surface elevation change across the highway by 2.25 feet to a head loss of 1.25 feet. Boring is the recommended installation method because trenching across a major road is not desirable and the existing pipe is corrugated metal, which is not easily pipe-burst.

Lei Garden Road
Replace the existing 24-inch culvert across Lei Gardner Road with a 36-inch culvert.

Gages Lane
Replace the existing 24-inch culvert with a 36-inch culvert.

Peacock Lane
Replace the existing 18-inch culvert with a 24-inch culvert.

Table 10. Updated Capital Improvements Plan

Project #	Project Title	Estimated Cost
1	Spruce/Walnut Street Improvement	$ 2,000,000.00
2	West I-5 Improvement - North of HW 20	$ 2,200,000.00
3	High School Improvement - North Pump Station	$ 1,350,000.00
4	Anacortes Avenue Improvement	$ 825,000.00
5	Gages Slough Conveyance Improvement	$ 85,000.00
6	Isolating Gages Slough From Cattle	$ 150,000.00
7	Gages Slough Water Quality Monitoring	$ 10,000.00

5.2.2 Water Quality and Wetlands

No structural capital improvements projects for storm water quality are proposed by this report.

New construction should follow Department of Ecology guild lines on storm water quality treatment. The D.O.E. has issued general use designations to at least one structural treatment device for basic storm water treatment. For specific wetlands information, see section 5.1.1.1, which includes sites recommended for preservation, enhancement, or restoration.

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APPENDIX A –

Washington State Department of Ecology and Environmental Protection Agency Surface Water Quality Standards

Surface water quality criteria for the designated uses of salmon and trout spawning, core rearing and migration; and extraordinary primary contact recreation (Ecology 2003)

Fecal Coliform Bacteria	Dissolved Oxygen	Temperature	pH
Not > 50 colonies/100 mL	9.5 mg/L	16.0 °C (60.8 °F)	6.5 to 8.5

Ecology criteria for total trace metals

Total Copper Criteria	Total Lead Criteria	Total Zinc Criteria
5.3 (µg/L)	14.5 (µg/L)	8.5 (µg/L)

EPA recommended regional criteria for nutrients

Water body type	Total nitrogen (mg/L)	Total phosphorus (mg/L)
Rivers and Streams	0.31	0.05

APPENDIX B –

Gages Slough Wetland Study Technical Report

CITY OF BURLINGTON

GAGES SLOUGH WETLANDS STUDY
TECHNICAL REPORT

Prepared for:

Margaret Fleek
Planning Director
City of Burlington
901 East Fairhaven Avenue
Burlington, Washington 98233-1918
360/755-9717

Prepared by:

Kim Harper
Senior Wetland Ecologist
Sheldon & Associates, Inc.
5031 University Way NE, #208
Seattle, WA 98105-4341
206/522-1302

November 18, 1998

CITY OF BURLINGTON

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Prepared for:

Margaret Fleek.
Planning Director
City of Burlington
901 East Fairhaven Avenue
Burlington, Washington 98233-1918
360/755-9717

Prepared by:

Kim Harper
Senior Wetland Ecologist
Sheldon & Associates, Inc.
5031 University Way NE, #208
Seattle, WA 98105-4341
206/522-1302

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EXECUTIVE SUMMARY

The City of Burlington initiated a wetland study of Gages Slough in the winter of 1997-98 under a Coastal Zone Management grant provided by the Washington State Department of Ecology. The purpose of the study is to assess the wetland functions and water quality of Gages Slough, and to determine the extent and cause of degraded areas and ongoing impacts along the slough. This report presents the results of the study, and is intended to provide City staff with the technical information necessary to prepare a management plan for Gages Slough.

Gages Slough is located in northwestern Washington, in western Skagit County, on the north side of the Skagit River. The slough originates east of city limits, meandering through the City of Burlington, discharging eventually to the Skagit River, roughly one mile west of Interstate 5. The total length of the slough is approximately 7.3 miles. The urban growth boundary for the City of Burlington served as the study area limits for this project, with roughly 3.5 miles of the slough lying within this boundary.

Wetland boundaries were determined using the criteria and methodology of the *Washington State Wetlands Identification and Delineation Manual* (Washington Department of Ecology 1997). Boundaries were mapped in the field by Sheldon & Associates, Inc. and later digitized into a Geographic Information System by the City of Burlington.

An ongoing water quality sampling program was initiated by the City of Burlington as part of this study. A total of 14 water quality sampling stations were established along the slough within the study area. The following water quality parameters were tested for: pH, dissolved oxygen, turbidity, fecal coliform, total phosphorus, and ammonia-nitrogen. Results were compared to water quality test results for other wetlands in highly urbanized watersheds in the Puget Sound area, as studied by the Puget Sound Wetlands & Stormwater Management Research Program. Preliminary observations of trends in the data are based on only three sampling events, but continuing sampling and analysis by City staff are planned.

The methods developed by the Washington State Wetland Function Assessment Project (Hruby et al. 1998) were used by Sheldon & Associates, Inc. to assess the wetlands of Gages Slough. The assessment method is currently being developed under the lead of the Washington State Department of Ecology with technical input from ecologists and hydrologists from numerous agencies. The method is based on the hydrogeomorphic (HGM) approach which classifies wetlands based on landscape position and water regime, and provides guidance on arriving at technical assumptions on which assessments of performance of functions are based. According to the HGM approach, the wetlands of Gages Slough are classified as Depression Outflow wetlands.

The Washington State function assessment method relies on indicators of functions to assess potential performance, rather than direct measurements. Indicators are usually physical characteristics of the wetland or its surrounding area that can be correlated to a specific function. After collecting detailed data on indicators, mechanistic models (mathematical equations) are applied to the data to arrive at a numeric indexed score. Different models were developed for each function and for each subclass of wetland. The models are calibrated on reference wetlands, which were selected for western Washington by the technical committee developing the method. A total of 15 categories of functions are assessed in the Washington State method.
Analysis of preliminary water quality results for Gages Slough indicate that total suspended solids, fecal coliform, total phosphorus, and ammonia nitrogen levels in Gages Slough were elevated

above average for similar wetlands in other highly urbanized watersheds in western Washington. It is recommended that the City add additional testing for conductivity, oil/grease and zinc, if feasible.

Relative to the reference wetlands that were assessed in developing the Washington State function assessment method, the wetlands that comprise Gages Slough generally rate above average for the following functions: removing sediment, reducing peak flows, and primary production and export. The wetlands generally rate below average for general habitat suitability and suitability for aquatic mammals. For the remainder of the assessed functions, the wetlands of Gages Slough generally rate average. These include removing nutrients, removing heavy metals and toxic organics, reducing downstream erosion, recharging groundwater, suitability for invertebrates, suitability for amphibians, suitability for anadromous fish, suitability for resident fish, suitability for aquatic birds, and habitat for native plant communities. These average indexes indicate an overall condition for the slough wetlands that is intuitively apparent from casual observations, i.e., the wetlands are not in pristine condition, but they, for the most part, have not been disturbed to the extent that their functions are seriously compromised.

Past and ongoing impacts to, and existing problems of degradation in the wetlands of Gages Slough are summarized as follows:

Impacts from Private Lands

1. Active clearing of vegetation, cultivation and/or mowing in the slough or buffer area.
2. Water quality impacts from lawn chemicals.
3. Water quality impacts from livestock waste.
4. Dumping of refuse (including yard waste) in slough by private landowners.
5. Impacts to vegetation in buffer area from livestock grazing.

Impacts from Public Lands or Public Services

6. Water quality impacts from storm drains.
7. Water quality impacts from inadequate private septic systems.
8. Blocked or undersized culverts preventing adequate flow-through of water.
9. Dumping of refuse in slough by general public.
10. Significant wetland buffer encroachment permitted by City.
11. Lack of citizen awareness of ecological functions of slough.

Problems of Degradation or Low Wetland Function

12. Lack of woody vegetation in buffer area adjacent to slough.
13. Lack of snags or large woody debris in slough.
14. High percent cover by non-native invasive plant species in slough.
15. High percent of high intensity land uses in vicinity of slough.

Management recommendations were developed for Gages Slough to address the problems identified during the field study. The recommendations are intended to cover both ongoing impacts to the slough and the need for restoration in degraded areas of the wetlands and buffer. Each recommendation may address one or more of the 15 problem areas identified. The following management recommendations are not listed in any order of priority.

Management Recommendations

1. Continue the slough clean-up campaign.
2. Post interpretive signs at road crossings of slough.
3. Post warning signs regarding littering fines.
4. Develop agricultural land use guidelines.
5. Develop subsidized planting program.
6. Enforce a 50 foot building setback along the slough.
7. Enforce 25 foot buffer in which vegetation clearing is prohibited.
8. Develop educational program on slough for use in schools.
9. Manage public open space along slough to restore wetlands and educate public.
10. Continue program to purchase and conserve open space on slough.
11. Provide sanitary sewer service for all buildings within the UGB.
12. Develop a lawn care display for local hardware stores regarding low-wetland impact techniques.
13. Make available inexpensive composting containers.
14. Construct biofiltration swales or other water treatment features for storm drains where possible.
15. Excavate sediment around upstream ends of culverts as regular maintenance procedure.
16. Replace specific undersized culverts.
17. Develop program for managing invasive plant species.
18. Install snags and large woody debris in slough.
19. Increase species diversity and structural complexity of the wetland and buffer.

1. INTRODUCTION

1.1 Purpose and Need for Study

The City of Burlington initiated a wetland study of Gages Slough in the winter of 1997-98 under a Coastal Zone Management grant provided by the Washington State Department of Ecology. The purpose of the study is to assess the wetland functions and water quality of Gages Slough, and to determine the extent and cause of degraded areas and ongoing impacts along the slough. The resulting product will be a wetland management plan for Gages Slough, to be used by the City in making planning and management decisions that will help protect and restore the slough wetlands. The plan summarizes the results of the study, and is intended to lead toward an integrated shoreline master program. This report is intended to provide City staff with the technical information necessary to prepare the management plan.

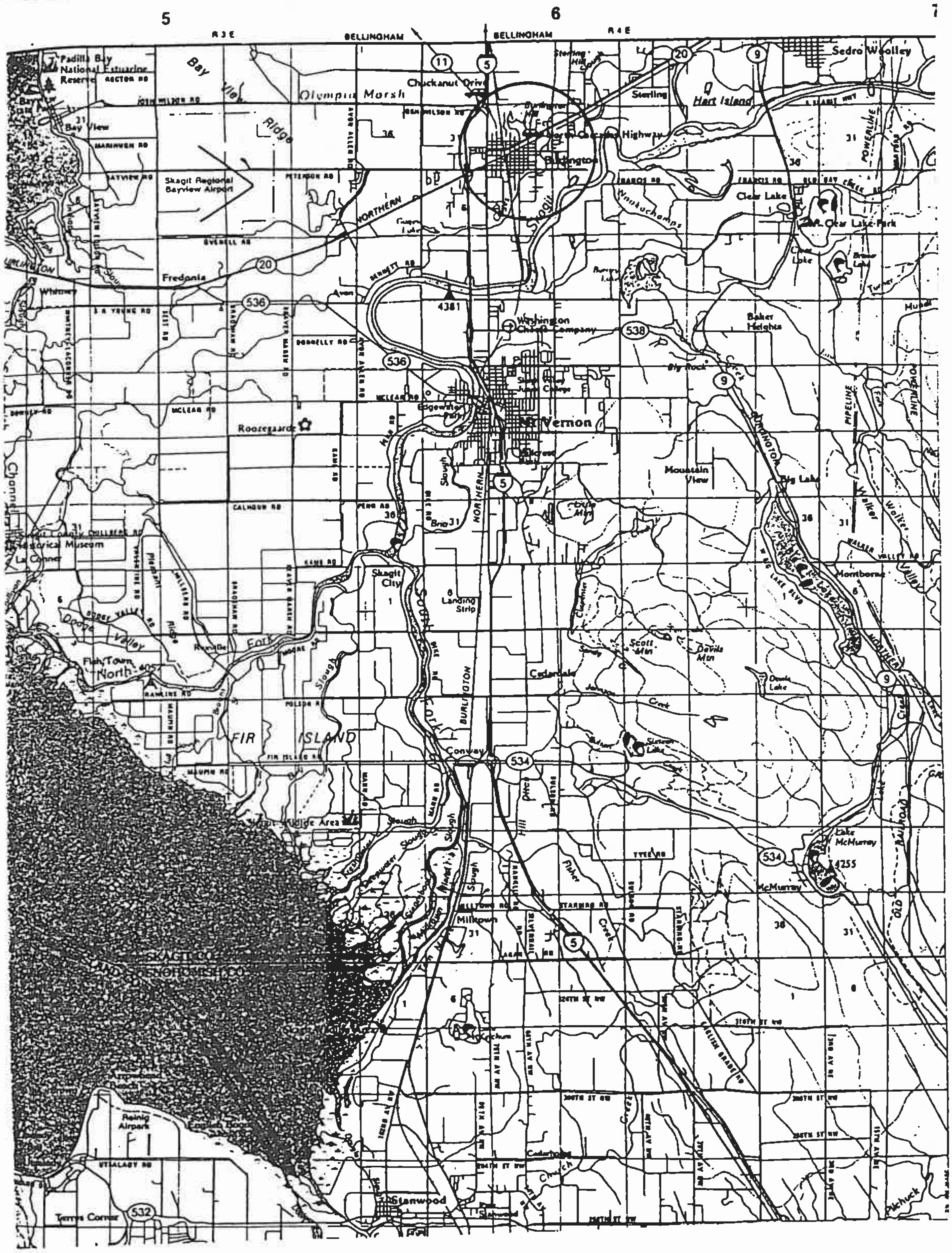
1.2 Study Area Description

Gages Slough is located in western Skagit County, on the north side of the Skagit River, in townships 34 and 35 north, and ranges 3 and 4 east (Figure 1 - Vicinity Map). The slough originates east of city limits on the north side of State Route (SR) 20, at a culvert leading from the north end of the extensive forested wetland at Hart Island. This wetland is located just west of Sedro Wooley, on the south side of SR 20 adjacent to the Skagit River, and receives overbank flow from the Skagit River. The culvert inlet is set at an elevation such that water from the Hart Island wetland only enters the slough during the wetter months of the year, roughly from November through May. The slough meanders through the City of Burlington, discharging eventually to the Skagit River, roughly one mile west of Interstate 5, south of the intersection of Bennett and Pulver roads.

The total length of the slough is approximately 7.3 miles, with roughly 3.5 miles within the urban growth boundary (UGB) for the City of Burlington. The UGB served as the study area limits for this project. The slough enters the UGB just east of Gardner Road where the slough is adjacent to the cemetery, northeast of Burlington city limits. It exits the UGB at Pulver Road, to the southwest of the City.

Gages Slough lies in the historic floodplain of the Skagit River, in a very broad, almost flat valley bottom. The slough no longer lies within the active floodplain of the river due to extensive diking along the north bank of the river, with the eastern extent of the dike located just east of Burlington city limits in the northeast corner of section 33, township 35 north, range 4 east. It is assumed that the slough is one of the old meander channels from the Skagit River.

Currently, water in the slough is generally slow-moving or standing, depending on the season and the volume of runoff draining to the slough. When moving, the flow of water in the slough is slowed by culverts under the road crossings that regulate the rate of discharge from each cell. Water depths in the slough range up to four feet in the deeper pools during high water conditions. The slough has a high sinuosity with very low gradient and a bottom substrate that is comprised of fine silt. The channel ranges in width from about 20 feet to over 100 feet. The banks of the slough are relatively steep, but generally low, either bare or vegetated with grasses, shrubs, or blackberry



Source: DeLorme Atlas & Gazetteer

Figure 1 - Vicinity Map

vines. Most of the slough is vegetated with grasses or herbaceous species tolerant of inundation. Several lengths of the slough are dominated by dense stands of willow trees and shrubs. Non-native invasive plant species such as reed canarygrass and yellow iris are common throughout the slough.

Gages Slough lies in an area of the Skagit River Valley that is rapidly increasing in its extent of urbanization. Land use types in the contributing basin to the slough currently include agricultural, comprising roughly 35% of the basin, commercial (20%), high density residential (20%), low density residential (15%), and undeveloped open space (10%). Percent area estimates are approximate, based on the USGS quad map (Mt. Vernon Quadrangle) and aerial photos. Recent construction of several shopping malls along the I-5 corridor indicate an increasing trend in commercial land use in the basin and a related decrease in agricultural uses. Most of the area directly adjacent to the slough has been cleared of vegetation and is either in maintained lawn, pasture or cropped fields. The majority of this land is privately owned and used for residential purposes or small farms. There is also one commercial industrial area that stretches for about a mile with a handful of businesses that abut the slough.

2. METHODS

2.1 Methods for Wetland Boundary Determination & Mapping

The wetland boundaries along Gages Slough were mapped using a combination of aerial photo and map review with field verification. The following documents were reviewed to obtain information on the site:

- Color aerial photographs from City of Burlington, scale 1" = 400', dated July 1997;
- Soil Survey of Skagit County Area, Washington (Klungland & McArthur 1989);
- USGS Topographic Map, Mount Vernon Quadrangle, scale 1:24,000; and
- National Wetlands Inventory Map, Mount Vernon Quadrangle, scale 1:24,000.

Prior to fieldwork, preliminary wetland boundaries were marked on mylar overlays of the aerial photos provided by the City. These preliminary boundaries were based primarily on changes in vegetation and hydrology observed in the photos. Wetland boundaries were then confirmed on the ground during fieldwork, and the mylar overlays corrected as needed. The boundaries were then digitized from the mylar overlays into a Geographic Information System (GIS) by City of Burlington staff. The slough was divided into separate wetland sections based on observed changes in the hydrology where water from the slough is backed up by culverts at road crossings. The wetlands were classified for mapping purposes based on water regime and vegetation type using the U.S. Fish and Wildlife Service system of wetland classification (Cowardin et al. 1979). Under this system, the wetlands of Gages Slough were divided into forested, scrub-shrub, emergent, aquatic bed, or open water classes.

Wetland boundaries were determined in the field using the criteria and methodology of the *Washington State Wetlands Identification and Delineation Manual* (Washington State Department of Ecology 1997). This manual requires examination of three parameters: vegetation, soils, and hydrology. For an area to be classified as wetland, hydrophytic vegetation, hydric soils, and wetland hydrology must be exhibited. The specified criteria are mandatory and must all be met for an area to be identified as wetland, except under circumstances when a wetland is considered a disturbed area or problem wetland.

Hydrophytic Vegetation

Hydrophytic vegetation is defined as macrophytic plant life growing in water, soil, or substrate that is periodically deficient in oxygen (Washington State Department of Ecology 1997). The hydrophytic vegetation criterion is met in the 1997 methodology when more than 50 percent of the dominant species are hydrophytic, based on the wetland plant species indicator status listed in the U.S. Fish and Wildlife Service publication *National List of Plant Species That Occur in Wetlands: Northwest, Region 9* (Reed 1988, revised in 1993). Plants are considered hydrophytic if they are listed as obligate wetland species, facultative wetland species, or facultative species. These terms are defined below:

Plant Indicator Status	Definition
Obligate Wetland Plants (OBL)	Plants that occur almost always in wetlands: estimated probability in wetlands greater than 99% under natural conditions.
Facultative Wetland Plants (FACW)	Plants that have an estimated probability of 67% - 99% to be found in wetlands.
Facultative Plants (FAC)	Plants that are equally likely to occur in wetlands or non-wetlands: estimated probability of 34% - 66% to be found in wetlands.
Facultative Upland Plants (FACU)	Plants that usually occur in non-wetlands, estimated probability of 1% - 33% to be found in wetlands.
Obligate Upland (UPL)	Plants that occur almost always in non-wetlands under natural conditions, estimated probability greater that 99%.

At each plot, percent areal coverage was estimated for each plant species present, and dominant species were determined. Plant species were identified for this project using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973).

Hydric Soils

A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part is considered a hydric soil. Examples of hydric field indicators include the presence of organic soils, or mottling and/or gleyed mineral soils. Mottles are spots or blotches of contrasting color occurring within the soil matrix. Gleyed soils are predominantly neutral gray in color. Soil chroma, or color, was determined using a Munsell color chart (Kollmorgen Corporation 1975). Soil characteristics were compared to Soil Conservation Service (SCS) descriptions of mapped soils to either confirm the mapping or determine if an inclusion of another soil type was present.

Wetland Hydrology

Indicators of wetland hydrology may be present throughout the year that confirm the occurrence of saturation or inundation for periods of time adequate to satisfy criteria designated in the 1997 Ecology Manual. Indicators for hydrology under this methodology include recorded data and field data such as visual observation of inundation or saturation, watermarks, drift lines, sediment deposits, drainage patterns, oxidized rhizospheres, local soil survey data, water-stained leaves, and the FAC neutral test (using the dominant plant species to infer presence of wetland hydrology).

To meet the criteria for the presence of wetland hydrology, an area must have inundation and/or soil saturation a minimum of 12.5% of the growing season, which is defined as the number of days that are at 32° Fahrenheit or above. According to temperature records for the Mt. Vernon area, the nearest town to the project area for which SCS keeps official temperature records, the growing season averages about 178 days (Klungland & McArthur 1989). Therefore, the wetlands in the vicinity of the Burlington area must have a minimum of 22 days of continuous saturation or inundation within the growing season of average rainfall years to definitively meet the criteria for wetland hydrology.

2.2 Methods for Water Quality Assessment

A total of 14 water quality sampling stations were established along the slough within the study area. Staff gages were installed at five of these stations to monitor changes in water levels. Water quality sampling sites were located to provide samples from all sections of the slough, and to try and isolate suspected source areas of pollutants. For example, sampling stations were located both above and below the area near the intersection of Sharon Street and South Anacortes Street where numerous storm drain outfalls flow into the slough. The following water quality parameters were tested for: pH, dissolved oxygen, turbidity, fecal coliform, total phosphorus, and ammonia-nitrogen. Water quality sampling and laboratory testing were conducted by the City of Burlington. Results were compared to water quality test results for other wetlands in highly urbanized watersheds in the Puget Sound area, as presented in *Wetlands & Urbanization - Implications for the Future* (Puget Sound Wetlands & Stormwater Management Research Program 1996). Preliminary observations of trends in the data were made based on only three sampling events. Ongoing sampling on a monthly basis will provide additional data that will be analyzed by City of Burlington staff.

2.3 Methods for Function Assessment

The methods developed by the Washington State Wetland Function Assessment Project (Hruby et al. 1998) were used to assess the wetlands of Gages Slough. This is a draft method that is currently being developed under the lead of the Washington State Department of Ecology (Ecology) with technical input from ecologists and hydrologists from numerous agencies. This is the first regional effort in the State of Washington to create a method for quantifying the performance of a function by a wetland relative to the function performance level of local reference wetlands.

The method is based on the nationally recognized hydrogeomorphic (HGM) approach (Brinson 1993) which classifies wetlands based on landscape position and water regime, and provides guidance on arriving at technical assumptions on which assessments of performance of functions are based. The HGM method proposes the following classes of wetlands: Depression, Fringe, Slope, Riverine, and Flats. The Washington State approach has thus far developed methods only for Depression and Riverine Wetlands. Gages Slough is a Depression Wetland, but could be mistaken for Riverine, so both classes are defined in Table 1. Relevant subclasses used by the Washington State method are also defined in Table 1.

Table 1. Definitions of Wetland Classes and Subclasses Used by the Washington Wetland Function Assessment Project (Hruby et al. 1998).

<table>
<tr><th>Wetland Class</th><th colspan="2">Definition</th></tr>
<tr><td rowspan="4">Depression</td><td colspan="2">Depression wetlands occur in topographic lows, such that the elevations of the surrounding landscape are higher. Possible sources of water include precipitation, surface water (sheetflow or channelized), subsurface water moving through an unsaturated or saturated zone, or any combination of these. These wetlands generally have low hydrologic energy. If located in or near a floodplain, these wetlands receive flood waters less frequently than every two years.</td></tr>
<tr><td colspan="2">Wetland Subclass</td></tr>
<tr><td>Outflow</td><td>Depression Outflow wetlands are depressions that have surface water outflow.</td></tr>
<tr><td>Closed</td><td>Depression Closed wetlands are depressions that have no surface water outflow.</td></tr>
<tr><td rowspan="5">Riverine</td><td colspan="2">Definition</td></tr>
<tr><td colspan="2">Riverine wetlands occurs in topographic valleys adjacent to stream channels ranging from perennial higher order streams to intermittent headwaters. Possible sources of water can be precipitation, overbank flooding from adjacent stream channels, subsurface water, or any combination. These wetlands are generally high energy relative to Depression Wetlands. These wetlands occur in the floodplain and receive flood water at least every two years.</td></tr>
<tr><td colspan="2">Wetland Subclass</td></tr>
<tr><td>Flow-through</td><td>Riverine Flow-through wetlands do not retain flood waters.</td></tr>
<tr><td>Impounding</td><td>Riverine Impounding wetlands retain flood waters due to a constricted outlet such as a beaver dam.</td></tr>
</table>

Though located on a channelized slough that was historically formed by flood waters from the Skagit River, the wetlands that comprise Gages Slough would not be classified as Riverine. Gages Slough wetlands are very low energy systems with surface outlets. Though linear in shape, Gages Slough is not an active stream with fast water; it has only slowly flowing water for only a portion of the year. The slough is not located in active floodplain, due to the extent of diking along the Skagit River. Gages Slough receives flood waters from the river less frequently than every two years. For these reasons, the wetlands of Gages Slough are classified as Depression Outflow wetlands.

The Washington State method relies on indicators of functions to assess potential performance, rather than direct measurements. Indicators are usually physical characteristics of the wetland or its surrounding area that can be correlated to a specific function. For example, rather than trying to directly sample aquatic mammals, the presence of steep banks in the wetland can be used as an indicator of the suitability of the wetland habitat for aquatic mammals. After collecting detailed data on indicators, mechanistic models (mathematical equations) are applied to the data to arrive at a numeric indexed score. This step is based on the assumption that the relationship between indicators and the actual performance level for a function can be defined by a simple mathematical expression. Different models were developed for each function and for each subclass of wetland.

The models that were developed for each function are calibrated on reference wetlands. Reference Standards wetlands for western Washington were selected by the technical committee developing the method, with the intention that the broad range in performance of functions that can be found in local wetlands would be represented. A minimum of 20 sites were chosen as reference wetlands for each wetland subclass. For each function assessed, the reference wetlands range from not performing the function at all, to providing among the highest level of function observed in this region. By running the data for an assessment wetland through the models, a score or index is arrived at for each of the assessed functions. This score directly compares the assessment wetland to the pool of reference wetlands.

Wetlands are divided into assessment units (AUs) for the purposes of this method, based on differences in water regime. AU boundaries occur where the volume, flow, or velocity of the water changes rapidly, whether created by natural or artificial features. An entire wetland may be uniform in its water regime and would therefore be comprised of one AU. However, the water flow in Gages Slough is repeatedly constricted at culverted road crossings, where the velocity slows upstream of most of the culverts. From the point at which Gages Slough crosses the northern Urban Growth Boundary of the City of Burlington at Gardner Road, to the downstream point at which the slough discharges into the Skagit River, the slough was divided into 13 AUs based on distinct points of hydrologic change such as culverts. (Note: not all culverts caused a constriction to water movement, therefore, not all culvert locations became AU boundaries.)

A total of 15 categories of functions are assessed in the Washington State method. These are defined in Table 2. Also listed are the specific indicators or measures that are entered into each model as the basic data collected in the assessment. A numeric value for each indicator is measured, estimated or assigned based on observations from background documents or fieldwork. The numeric values are entered into the model for each function, resulting in a quantitative index for each function.

Table 2. Functions Assessed Under the Washington State Method and Corresponding Indicators or Measures.

Function	Function Definition[1]	Indicators or Measures
	Water Quality Functions	
Potential for Removing Sediment	The wetland processes that retain sediment within a wetland, and keep them from going to downstream waters in the watershed.	•corrected depth of permanent open water and seasonal inundation •qualitative descriptors of outlet constriction, water marks, moss lines, evidence of deposition •% of wetland that is seasonally inundated •weighted scaling of forest, shrub, and emergent cover •% cover of herbaceous understory
Potential for Removing Nutrients	The wetland processes that remove nutrients (particularly phosphorus and nitrogen) from incoming water, and keep them from going to downstream waters in the watershed.	•index for sediment removal •amount of clay in soil •amount of organics in soil •evidence (e.g. high water marks) indicating aerial extent of AU that undergoes changes between oxic and anoxic conditions •qualitative description of outlet characteristics

Table 2. Functions Assessed Under the Washington State Method and Corresponding Indicators or Measures.

Function	Function Definition[1]	Indicators or Measures
Potential for Removing Heavy Metals and Toxic Organics	The wetland processes that retain metals and toxic organic compounds, and keep them from going to downstream waters in the watershed.	•index for sediment removal •amount of clay in soil •amount of organics in soil •pH of interstitial water •% cover of emergent vegetation •% of AU that is seasonally inundated
	Water Quantity Functions	
Potential for Reducing Peak Flows	The wetland processes or characteristics by which the peak flow in a watershed can be reduced during major storm events that cause flooding.	•elevation difference between bottom of outlet and flood marks •qualitative descriptors of outlet constriction •ratio of area of inundation to contributing basin
Potential for Reducing Downstream Erosion	The wetland processes that detain high flows during storms and reduce the duration of erosive flows, thus decreasing downstream erosion of stream.	•elevation difference between bottom of outlet and flood marks •qualitative descriptors of outlet constriction •coverage of forest and shrubs •ratio of area of inundation to contributing basin
Potential for Recharging Groundwater	The wetland processes by which surface water coming into a wetland is transported into subsurface water that flows either into unconfined aquifers, or interflow, that support flows in streams during the dry season.	•rating permeability of soils •area of seasonal inundation minus permanent open water
	Habitat Suitability Functions	
General Habitat Suitability	The characteristics or processes present in a wetland that indicate a general suitability as habitat for a broad range of animal species. It also includes processes or characteristics within a wetland that help maintain ecosystem resilience (characteristics that are important in maintaining the ecosystem when it is of different habitats).	•condition of buffer around AU in terms of plant structure and level of disturbance •% canopy closure over AU •maximum number of strata in any one plant association •categories of snags present •interspersion between vegetation classes •categories of large woody debris present •number of water regimes present in AU •number of water depth categories in AU •characteristics of open water interspersion with vegetated areas •number of plant species present in AU •presence/absence of mature trees •characteristics of AU edge

Table 2. Functions Assessed Under the Washington State Method and Corresponding Indicators or Measures.

Function	Function Definition[1]	Indicators or Measures
Habitat Suitability for Invertebrates	The wetland processes and characteristics that help maintain a high number of invertebrate species in the wetland.	•presence of channels or streams in AU with permanently flowing water •types of surface substrates present •characteristics of open water interspersion with vegetated areas •categories of large woody debris present •maximum number of strata in any one plant association •interspersion between vegetation classes •number of plant associations in AU •number of water regimes present in AU •categories of different aquatic bed structures Reducers[2]: •qualitative estimate of presence/absence of tannins
Habitat Suitability for Amphibians	The wetland processes and characteristics that contribute to the feeding, breeding, or refuge needs of amphibian species using wetlands of the regional subclass.	•condition of buffer around AU in terms of plant structure and level of disturbance •types of surface substrates present •characteristics of open water interspersion with vegetated areas •categories of large woody debris present •% of AU with permanent water, or permanent water under forest or scrub-shrub areas •physical structures present under the water surface for egg laying Reducers: •pH of surface water •types of land uses within 1 km of AU
Habitat Suitability for Anadromous Fish	The environmental characteristics that contribute to the feeding, breeding, or refuge needs of anadromous fish species that are using wetlands.	•characteristics of open water interspersion with vegetated areas •the water depth classes present in AU •number and type of refuge present in water •% of AU in permanent open water •index for invertebrate habitat suitability Reducers: •percent are of AU covered by sphagnum bog
Habitat Suitability for Resident Fish	The wetland processes and characteristics that contribute to the feeding, breeding, or refuge needs of resident native fish.	•characteristics of open water interspersion with vegetated areas •the water depth classes present in AU •number and type of refuge present in water •% of AU in permanent open water •presence/absence of permanently flowing water in channel •composition of substrate or surface layer •index for invertebrate habitat suitability

Table 2. Functions Assessed Under the Washington State Method and Corresponding Indicators or Measures.

Function	Function Definition[1]	Indicators or Measures
Habitat Suitability for Aquatic Birds	The processes and environmental conditions in a wetland that provide habitats or life resources for species of wetland-dependent birds.	•condition of buffer around AU in terms of plant structure and level of disturbance •categories of snags present •interspersion between vegetation classes •characteristics of AU edge •presence of special habitat features (e.g. adjacent agricultural land use, islands, etc.) •% permanent open water •index for invertebrate habitat suitability •index for amphibian habitat suitability •index for anadromous or resident fish habitat suitability (the higher of the two) reducers: •% canopy closure over AU •AU is above 300 meters in elevation
Habitat Suitability for Aquatic Mammals	Wetland features and processes that support one or more life requirements of economically important aquatic or semi-aquatic mammals. i.e. beaver, muskrat, river otter, and mink	•condition of buffer around AU in terms of plant structure and level of disturbance •the water depth classes present in AU •condition of corridors to and from AU •area of woody vegetation for beaver •has minimum of .25 hectare of emergent vegetation •characteristics of open water interspersion with vegetated areas, if AU is at least .25 hectare •% of AU in permanent open water and aquatic bed •presence of steep banks comprised of fine material for denning •AU has channel with permanent flowing water •index for anadromous or resident fish habitat suitability (the higher of the two) Reducers: •types of land uses present within 1 km of AU
Habitat for Native Plant Communities	The wetland processes and characteristics that help maintain a high number of native plant species as well as providing specialized habitats for less common species.	•number of strata present in any plant association •number of plant associations •presence/absence of mature trees •number of native plant species •% of AU covered by sphagnum bog Reducers: •% of AU covered by non-native plant species
Primary Production and Export	Wetland processes that result in the production of plant material and its subsequent export to surface waters.	•% of AU with vegetation cover •% cover of all non-evergreen vegetation •% cover of herbaceous understory •extent of organic soils in AU •% of wetland that is seasonally inundated • Reducers: % area of AU covered by sphagnum bog

[1] Definitions are quoted directly from *Methods for Assessing Wetland Functions Volume I: Riverine and Depressional Wetlands in the Lowlands of Western Washington* (Hruby et al. 1998).
[2] Reducers are factors that would lower the index for that function.

3. FINDINGS

3.1 Results of Wetland Boundary Determination

The entire length of Gages Slough, where it occurs within the City of Burlington UGB, was determined to be jurisdictional wetland. The slough was divided into 13 separate wetland assessment units based on observed changes in the hydrology at culvert constrictions. These were termed assessment units (AUs) for consistency with the terminology used by the Washington State Wetland Function Assessment Project. Total wetland area within the study area is roughly 72 acres. Table 3 summarizes the location, area, and Cowardin classification for each AU. Figure 2 - Wetland Boundary Map shows the numbered AU locations.

Table 3. Wetland Area and Characteristics of Gages Slough within City of Burlington UGB.

AU #	Location Description	Area[1] (acres)	Cowardin Class[2]	Dominant Plant Species	Mapped Soil Type	Avg. Water Depth in March 1998
1	west from pipe end near cemetery maintenance building to Gardner Rd.	0.75	PFO 30%	Sitka willow, Pacific willow, red alder, spirea	Field silt loam, protected	18"
			PSS 50%	spiraea, rose, Himalayan blackberry		
			PEM 20%	skunk cabbage, American speedwell, yellow pond lily, yellow iris, reed canarygrass		
2	between Gardner and Peacock Roads	1.87	PEM 85%	yellow iris, soft rush, reed canarygrass	Field silt loam, protected	12"
			PSS 15%	willow, yellow iris, reed canarygrass		
3	northwest of intersection of Peacock Road and Gages Lane	0.24	PEM 40%	soft rush, yellow pond lily, reed canarygrass	Field silt loam, protected	24"
			PSS 10%	willow, Himalayan blackberry		
			POW 50%	yellow pond lily		
4	between Gages Lane and Lei Garden Rd.	0.26	PFO 45%	red alder, spiraea, reed canarygrass	Field silt loam, protected	12"
			PEM 15%	soft rush, reed canarygrass		
			POW 40%	N/A		
5	between Lei Garden Rd. and SR 20	0.44	PSS 80%	willow, spiraea, red-osier dogwood, Himalayan blackberry	Field silt loam, protected	12"
			PEM 15%	reed canarygrass, cattail, yellow iris		
			POW 5%	N/A		
6	between SR 20 and Monroe St.	0.32	PSS 50%	willow, spiraea, Himalayan blackberry, reed canarygrass	Field silt loam, protected	12"
			PEM 25%	reed canarygrass, skunk cabbage		
			PFO 10%	red alder, willow, reed canarygrass		
			POW 15%	N/A		
7	between Monroe St. and Hawthorne St.	0.40	PEM 55%	reed canarygrass, burreed, cattail	Urban Land-Mt. Vernon - Field Complex	12"
			PAB 30%	waterpepper, duckweed, purple-fringed riccia		
			POW 15%	N/A		

Table 3. Wetland Area and Characteristics of Gages Slough within City of Burlington UGB.

AU #	Location Description	Area[1] (acres)	Cowardin Class[2]	Dominant Plant Species	Mapped Soil Type	Avg. Water Depth In March 1998
8	between Hawthorne St. and E. Rio Vista Rd.	2.42	PFO 22%	Pacific willow, Sitka willow, red alder, Himalayan blackberry, red-osier dogwood, reed canarygrass	Urban Land-Mt. Vernon - Field Complex	14"
8	between Hawthorne St. and E. Rio Vista Rd.	2.42	PEM 71%	reed canarygrass, small-fruited bulrush, waterpepper, duckweed	Urban Land-Mt. Vernon - Field Complex	14"
8	between Hawthorne St. and E. Rio Vista Rd.	2.42	POW 7%	N/A	Urban Land-Mt. Vernon - Field Complex	14"
9	between E. Rio Vista Rd. and Anacortes St.	4.54	PFO 75%	Pacific willow, red alder, Himalayan blackberry, red-osier dogwood, reed canarygrass	Mt. Vernon very fine sandy loam	14"
9	between E. Rio Vista Rd. and Anacortes St.	4.54	PEM 5%	reed canarygrass	Mt. Vernon very fine sandy loam	14"
9	between E. Rio Vista Rd. and Anacortes St.	4.54	PAB 10%	yellow pond lily, waterpepper	Mt. Vernon very fine sandy loam	14"
9	between E. Rio Vista Rd. and Anacortes St.	4.54	POW 10%	N/A	Mt. Vernon very fine sandy loam	14"
10	between Anacortes St. and S. Burlington Blvd.	16.20	PFO 25%	willow, red alder, spiraea, reed canarygrass	Mt. Vernon very fine sandy loam & Sumas silt loam	16"
10	between Anacortes St. and S. Burlington Blvd.	16.20	PSS 21%	willow, spiraea, salmonberry	Mt. Vernon very fine sandy loam & Sumas silt loam	16"
10	between Anacortes St. and S. Burlington Blvd.	16.20	PEM 25%	reed canarygrass, soft rush, cattail	Mt. Vernon very fine sandy loam & Sumas silt loam	16"
10	between Anacortes St. and S. Burlington Blvd.	16.20	PAB 12%	yellow pond lily, waterpepper	Mt. Vernon very fine sandy loam & Sumas silt loam	16"
10	between Anacortes St. and S. Burlington Blvd.	16.20	POW 17%	N/A	Mt. Vernon very fine sandy loam & Sumas silt loam	16"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	PFO 4%	Sitka willow, Pacific willow, red alder, spiraea, red elderberry	Sumas silt loam	24"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	PSS 5%	Sitka willow, spiraea, red-osier dogwood, reed canarygrass, Himalayan blackberry	Sumas silt loam	24"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	PEM 32%	cattail, reed canarygrass, skunk cabbage	Sumas silt loam	24"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	PEM/PAB 30%	yellow pond lily, water pepper, water starwort	Sumas silt loam	24"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	PAB 2%	water pepper	Sumas silt loam	24"
11	between S. Burlington Blvd. and W. McCorkindale Rd., including Gages Lake	42.93	POW 29%	N/A	Sumas silt loam	24"
12	between W. McCorkindale Rd. and culvert just west of Pulver Road	1.69	PEM/POW 12%	reed canarygrass	Sumas silt loam	14"
13	south of Bennett Rd. to Skagit River dike	0.20	PEM 40%	reed canarygrass, Himalayan blackberry	Sumas silt loam	14"

1 Wetland area determined by GIS at City of Burlington
2 Wetland classes that comprised low percentages of the smaller AUs were too small to map separately on Figure 2.

3.2 Preliminary Results of Water Quality Assessment

Water quality data was collected monthly for April through June, 1998. Subsequently, water levels in the slough fell too low to collect adequate samples. The collected data for those three months are presented in Table 4. Figure 3 shows the sampling station locations.

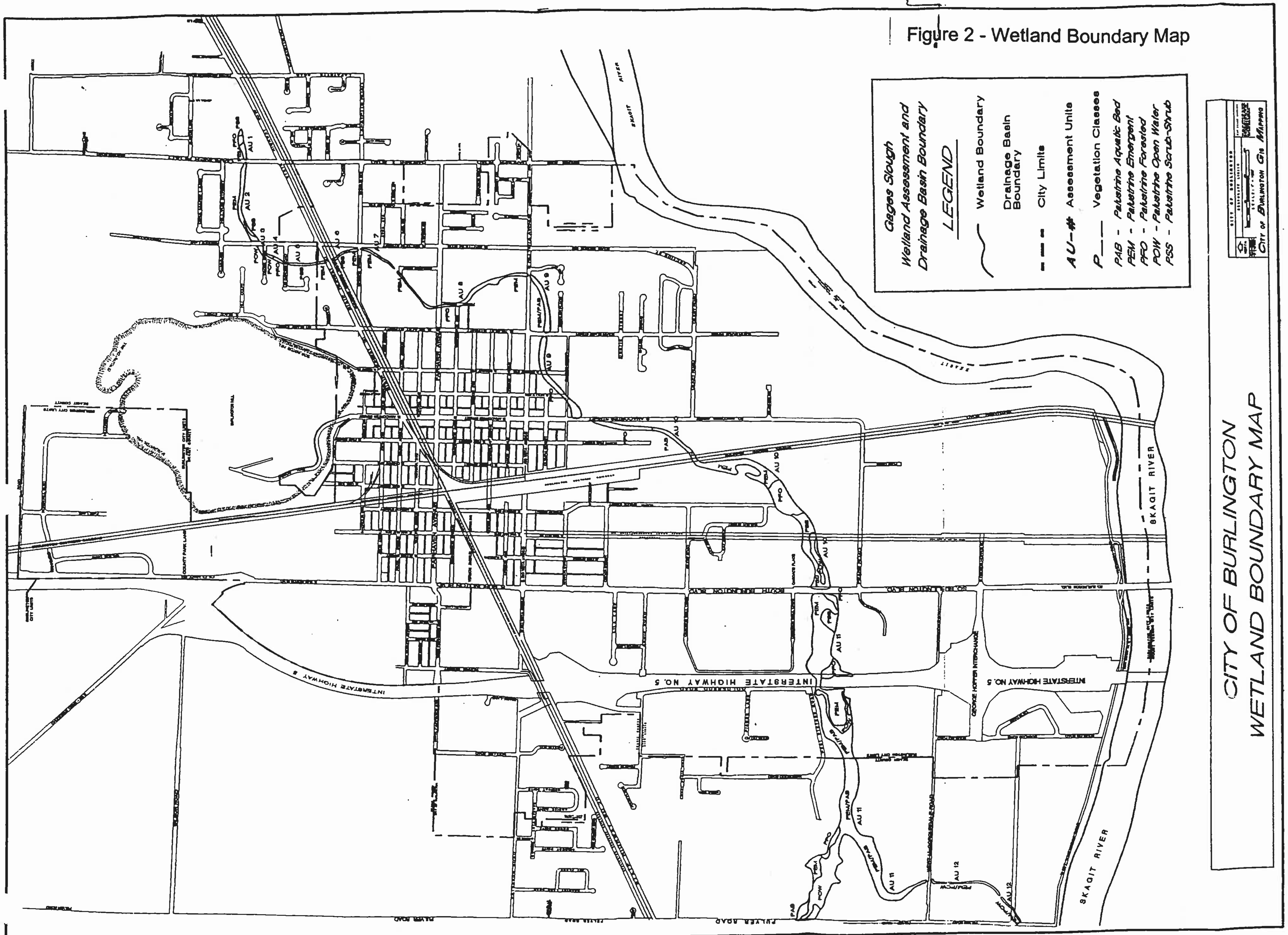


Figure 2 - Wetland Boundary Map

APPENDIX C –

Large Map of the City of Burlington Drainage Facilities

APPENDIX D –

Breakdown of Zoning Within the City of Burlington Sub-basins

	Area	Planing Zone Shown as a Percentage of the Basin															Acres		Soil Type (%)		
Basin	Acres	R-1	R-2	R-3	R-A	R-S	MR-NB	B-1	C-1	C-2	M-1	BP	OSPA	AG-NRL	RI	UGA	Pervious	Impervious	B	C	D
001	145.7								32.8	4.3				62.9			94.3	51.4		89	11
002	35.5								100								3.6	32.0		96	4
003	33.7								100								3.4	30.3		95	5
004	116.7			4.9		3.6			61.5	30							14.3	102.4		87	13
005	106.0	77.1	6.1	16.8													53.5	52.5		86	14
006	235.5								45.8	3.5	50.7						23.6	212.0		100	
007	60.6								100								6.1	54.5		91	9
008	48.6								100								4.9	43.7		97	3
009	4.8								100								0.5	4.3		85	15
010	8.8								84		16						0.9	7.9		93	7
011	30.0										100						3.0	27.0		92	8
012	36.7								100								3.7	33.0		57	43
013	45.8								100								4.6	41.2		80	20
014	136.0	6.7	1	1			2.9	3.8	73.9	8.3	2.4						19.3	116.7		98	2
015	6.4								100								0.6	5.8		70	30
016	14.9	43.1							56.9								4.4	10.5		72	28
017	124.3	11.4	2.4	1		3.7	3.8	3.9	32.6	4.5	36.7						22.8	101.5		100	0
018	5.0								50		50						0.5	4.5		96	4
019	62.3		20.1	61.0					16.7				2.2				20.0	42.4		75	25
020	50.9			55.4					44.6								10.7	40.2		63	37
021	122.8	3.3					13.4	7.2	31.5	13.3	31.4						17.4	105.4		74	26
022	119.2	60		2.3	15.3						22.4						53.8	65.4		98	2
024	36.3	98.7			1.3												20.0	16.3		100	
025	61.4	31.7									37.8		30.5				29.9	31.5	2	98	
026	4.9	100															2.7	2.2		100	
027	13.1	100															7.2	5.9		100	
029	11.4	74											26				7.3	4.1		100	
030	109.8	32.3												16.2		51.5	67.9	41.9	6	94	
031	35.7	76.8		5.3	17.9												19.5	16.2		100	
032	5.3	31.8		11.4	38.3								18.5				3.2	2.1		100	
033	4.1	83.1											16.9				2.5	1.6		100	

	Area	Planing Zone Shown as a Percentage of the Basin															Acres		Soil Type (%)		
Basin	Acres	R-1	R-2	R-3	R-A	R-S	MR-NB	B-1	C-1	C-2	M-1	BP	OSPA	AG-NRL	RI	UGA	Pervious	Impervious	B	C	D
034	57.5	92.3	0.5		7.1												31.8	25.7		100	
035	35.4	23			2.5											74.5	19.5	15.9		100	
037	20.4	81.6			18.4												11.4	9.0		96	4
038	200.9	43.4	17	8.9		14.2	6.6	0.6	4.9	3.9			0.5				90.0	110.9	20	80	
039	33.9	58.5	9.2	2.8		18.4							11.1				18.9	15.0		100	
040	11.2	82.6											17.4				6.8	4.4		100	
041	22.2	54.4		26	19.6												11.0	11.2		100	
042	18.4	56.8		5.7		25.3							12.2				10.2	8.2		100	
043	2.2			88.7	11.3												0.7	1.5		100	
044	5.6	100															3.1	2.5		100	
045	15.7	27.6			72.4												9.2	6.5		100	
046	9.5	72.4			27.6												5.4	4.1		100	
047	41.0	75.9	5.8	6.6									11.7				23.4	17.6	93	7	
048	225.1	45.9	0.3								0.3	53.2	0.3				69.8	155.3	50.0	6.5	43.5
049	45.1															100	24.8	20.3	5	65	30
050	27.5													19.4		80.6	17.4	10.1		100	
051	9.4															100	5.2	4.2		100	
052	48.5														21	79	27.7	20.8		100	
053	23.4													83.4		16.6	21.1	2.3		100	
054	68.9													10.5	74.7	14.8	44.7	22.2		99	1
055	121.9													48.6	51.4		98.2	23.7		96	4
056	92.7													100			89.9	2.8	16	77	7
057	80.4														100		52.3	28.1		91	9
058	145.6													55.2	44.8		120.4	25.2		93	7
059	75.1													28.7	71.3		55.7	19.4		94	6
060	58.6													100			56.8	1.8	12	69	19
061	202.7	0.3							0.1					69.8		29.8	170.8	31.9	12	88	

Testing	Acres Zoned Contributing to Each Test Point															Acres	
Basin	R-1	R-2	R-3	R-A	R-S	MR-NB	B-1	C-1	C-2	M-1	BP	OSPA	AG-NRL	RI	UGA	Pervious	Impervious
1													280.4	311.8	13.8	482.3	123.7
2	201.4	2.7	11.5	23.6	4.7							12.6	23.1	10.2	197.9	281.0	205.2
3	235.9	37.3	21.6	22.5	34.8	13.3	1.2	9.8	7.8	26.7	0.0	4.8	0.0	0.0	0.0	196.8	200.2
4								143.1								14.3	128.8
5	82.3	6.5	23.5		4.2			189.0	41.3				291.7		60.4	396.7	299.0
6	103.3	0.7								0.7	119.8	0.7				69.8	154.9
7	19.5									23.2		18.7				29.9	31.5
8	33.7	4.3	30.8	0.0	4.6	25.1	18.8	280.6	33.2	121.4	0.0	0.0	0.0	0.0	0.0	84.9	465.4
9								107.9	8.2	119.4						23.6	212.0

	B	C	D				
001	0.0	84.2	10.1	034	0.0	31.8	0.0
002	0.0	3.4	0.2	035	0.0	19.5	0.0
003	0.0	3.2	0.2	037	0.0	11.0	0.4
004	0.0	12.4	1.9	038	17.7	72.4	0.0
005	0.0	45.8	7.7	039	0.0	18.9	0.0
006	0.0	23.6	0.0	040	0.0	6.8	0.0
007	0.0	5.5	0.6	041	0.0	11.0	0.0
008	0.0	4.7	0.2	042	0.0	10.2	0.0
009	0.0	0.4	0.1	043	0.0	0.7	0.0
010	0.0	0.8	0.1	044	0.0	3.1	0.0
011	0.0	2.8	0.3	045	0.0	9.2	0.0
012	0.0	2.1	1.6	046	0.0	5.4	0.0
013	0.0	3.7	0.9	047	21.8	1.7	0.0
014	0.0	18.9	0.4	048	34.9	4.5	30.4
015	0.0	0.5	0.2	049	1.2	16.1	7.5
016	0.0	3.1	1.2	050	0.0	17.4	0.0
017	0.0	22.8	0.0	051	0.0	5.2	0.0
018	0.0	0.5	0.0	052	0.0	27.7	0.0
019	0.0	15.0	5.0	053	0.0	21.1	0.0
020	0.0	6.8	4.0	054	0.0	44.5	0.3
021	0.0	12.8	4.5	055	0.0	94.0	4.2
022	0.0	52.5	1.3	056	14.3	69.0	6.7
024	0.0	20.0	0.0	057	0.0	47.7	4.6
025	0.6	29.2	0.0	058	0.0	112.4	7.9
026	0.0	2.7	0.0	059	0.0	52.4	3.3
027	0.0	7.2	0.0	060	7.0	39.3	10.6
029	0.0	7.3	0.0	061	20.7	150.1	0.0
030	4.3	63.6	0.0		0.0	0.0	0.0
031	0.0	19.5	0.0				
032	0.0	3.2	0.0				
033	0.0	2.5	0.0				

APPENDIX E –

Stormwater Results by Sub-basin and HEC-RAS Model

001 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
001	4.24	8.67	4.6165	145.40	SBUH/SCS	Region3-18HR	2 yr
001	8.42	8.67	8.5396	145.40	SBUH/SCS	Region3-18HR	10 yr
001	9.57	8.67	9.5753	145.40	SBUH/SCS	Region3-18HR	25 yr

Drainage Area: 001

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	94.0000 ac	86.43	2.07 hrs			
Impervious	51.4000 ac	98.00	2.07 hrs			
Total	145.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	83.9000 ac			
Open Space Grass Soil Type D		90.00	10.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	51.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.28%	0.1500	63.95 min
Shallow	Flow		1503.00 ft	0.28%	11.0000	29.34 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.28%	0.1500	63.95 min
Shallow	Flow		1503.00 ft	0.28%	11.0000	29.34 min

002 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype	Event
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss		
002	2.99	8.17	2.0349	35.70	SBUH/SCS	Region3-18HR	2 yr
002	4.91	8.17	3.2853	35.70	SBUH/SCS	Region3-18HR	10 yr
002	5.38	8.17	3.5965	35.70	SBUH/SCS	Region3-18HR	25 yr

Drainage Area: 002

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.7000 ac	86.22	1.31 hrs			
Impervious	32.0000 ac	98.00	1.31 hrs			
Total	35.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	3.5000 ac			
Open Space Grass Soil Type D		90.00	0.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	32.0000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.70%	0.1500	44.33 min
Shallow	Flow		702.00 ft	0.70%	11.0000	12.71 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.70%	0.1500	44.33 min
Shallow	Flow		702.00 ft	0.70%	11.0000	12.71 min

003 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
003	2.91	8.17	1.9268	33.80	SBUH/SCS	Region3-18HR 2 yr
003	4.77	8.17	3.1108	33.80	SBUH/SCS	Region3-18HR 10 yr
003	5.23	8.17	3.4055	33.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 003

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.5000 ac	86.23	1.24 hrs			
Impervious	30.3000 ac	98.00	1.24 hrs			
Total	33.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	3.3000 ac			
Open Space Grass Soil Type D		90.00	0.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	30.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.80%	0.1500	42.02 min
Shallow	Flow		701.00 ft	0.80%	11.0000	11.87 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.80%	0.1500	42.02 min
Shallow	Flow		701.00 ft	0.80%	11.0000	11.87 min

004 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
004	7.28	8.33	6.5977	119.50	SBUH/SCS	Region3-18HR 2 yr
004	12.13	8.33	10.7170	119.50	SBUH/SCS	Region3-18HR 10 yr
004	13.34	8.33	11.7456	119.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 004

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	17.1000 ac	86.44	2.21 hrs			
Impervious	102.4000 ac	98.00	2.21 hrs			
Total	119.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	15.2000 ac			
Open Space Grass Soil Type D		90.00	1.9000 ac			
Impervious CN Data:						
Impervious Areas		98.00	102.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.32%	0.1500	60.62 min
Shallow	Flow		1128.00 ft	0.32%	11.0000	20.60 min
Channel	8" pipe		31.00 ft	0.40%	21.0000	0.39 min
Channel	12" pipe		325.00 ft	0.25%	21.0000	5.16 min
Channel	48" pipe		1045.00 ft	0.25%	21.0000	16.59 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.32%	0.1500	60.62 min
Shallow	Flow		1128.00 ft	0.32%	11.0000	20.60 min
Channel	8" pipe		31.00 ft	0.40%	21.0000	0.39 min
Channel	12" pipe		325.00 ft	0.25%	21.0000	5.16 min
Channel	48" pipe		1045.00 ft	0.25%	21.0000	16.59 min

005 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
005	4.86	8.33	4.0817	106.00	SBUH/SCS	Region3-18HR 2 yr
005	8.96	8.17	7.1753	106.00	SBUH/SCS	Region3-18HR 10 yr
005	10.06	8.17	7.9773	106.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 005

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	53.5000 ac	86.58	1.48 hrs			
Impervious	52.5000 ac	98.00	1.48 hrs			
Total	106.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	45.8000 ac			
Open Space Grass Soil Type D		90.00	7.7000 ac			
Impervious CN Data:						
Impervious Areas		98.00	52.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.45%	0.1500	52.90 min
Shallow	Flow		675.00 ft	0.45%	11.0000	10.39 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.45%	0.1500	52.90 min
Shallow	Flow		675.00 ft	0.45%	11.0000	10.39 min

007 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
007	4.45	8.17	3.4649	60.60	SBUH/SCS	Region3-18HR 2 yr
007	7.35	8.17	5.5917	60.60	SBUH/SCS	Region3-18HR 10 yr
007	8.06	8.17	6.1206	60.60	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 007

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	6.1000 ac	86.39	1.70 hrs			
Impervious	54.5000 ac	98.00	1.70 hrs			
Total	60.6000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	5.5000 ac			
Open Space Grass Soil Type D		90.00	0.6000 ac			
Impervious CN Data:						
Impervious Areas		98.00	54.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.51%	0.1500	50.31 min
Shallow	Flow		283.00 ft	0.51%	11.0000	6.00 min
Channel	15" pipe		552.00 ft	0.30%	21.0000	8.00 min
Channel	8" pipe		230.00 ft	0.23%	21.0000	3.81 min
Channel	18" pipe		630.00 ft	0.30%	21.0000	9.13 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.51%	0.1500	50.31 min
Shallow	Flow		283.00 ft	0.51%	11.0000	6.00 min
Channel	8" Pipe		230.00 ft	0.23%	21.0000	3.81 min
Channel	15" Pipe		552.00 ft	0.30%	21.0000	8.00 min
Channel	18" Pipe		630.00 ft	0.30%	21.0000	9.13 min

008 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
008	3.97	8.17	2.7761	48.60	SBUH/SCS	Region3-18HR 2 yr
008	6.52	8.17	4.4802	48.60	SBUH/SCS	Region3-18HR 10 yr
008	7.15	8.17	4.9041	48.60	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 008

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	4.9000 ac	86.16	1.39 hrs			
Impervious	43.7000 ac	98.00	1.39 hrs			
Total	48.6000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	4.7000 ac			
Open Space Grass Soil Type D		90.00	0.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	43.7000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.51%	0.1500	50.31 min
Shallow	Flow		392.00 ft	0.51%	11.0000	8.32 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.51%	0.1500	50.31 min
Shallow	Flow		392.00 ft	0.51%	11.0000	8.32 min

009 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
009	0.52	8.00	0.2741	4.80	SBUH/SCS	Region3-18HR 2 yr
009	0.85	8.00	0.4425	4.80	SBUH/SCS	Region3-18HR 10 yr
009	0.93	8.00	0.4844	4.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 009

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	0.5000 ac	86.80	0.73 hrs			
Impervious	4.3000 ac	98.00	0.73 hrs			
Total	4.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	0.4000 ac			
Open Space Grass Soil Type D		90.00	0.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	2.03%	0.1500	28.95 min
Shallow	Flow		95.00 ft	2.03%	11.0000	1.01 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	2.03%	0.1500	28.95 min
Shallow	Flow		95.00 ft	2.03%	11.0000	1.01 min

010 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
010	0.83	8.17	0.5026	8.80	SBUH/SCS	Region3-18HR 2 yr
010	1.36	8.17	0.8112	8.80	SBUH/SCS	Region3-18HR 10 yr
010	1.49	8.17	0.8880	8.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 010

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	0.9000 ac	86.44	1.02 hrs			
Impervious	7.9000 ac	98.00	1.02 hrs			
Total	8.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	0.8000 ac			
Open Space Grass Soil Type D		90.00	0.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	7.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.18%	0.1500	35.97 min
Shallow	Flow		545.00 ft	1.18%	11.0000	7.60 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.18%	0.1500	35.97 min
Shallow	Flow		545.00 ft	1.18%	11.0000	7.60 min

011 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
011	2.24	8.17	1.7177	30.10	SBUH/SCS	Region3-18HR 2 yr
011	3.69	8.17	2.7730	30.10	SBUH/SCS	Region3-18HR 10 yr
011	4.05	8.17	3.0355	30.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 011

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.1000 ac	86.39	1.65 hrs			
Impervious	27.0000 ac	98.00	1.65 hrs			
Total	30.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	2.8000 ac			
Open Space Grass Soil Type D		90.00	0.3000 ac			
Impervious CN Data:						
Impervious Areas		98.00	27.0000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.35%	0.1500	58.49 min
Shallow	Flow		688.00 ft	0.35%	11.0000	12.01 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.35%	0.1500	58.49 min
Shallow	Flow		688.00 ft	0.35%	11.0000	12.01 min

012 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
——						
012	3.18	8.17	2.1088	36.70	SBUH/SCS	Region3-18HR 2 yr
012	5.22	8.17	3.4031	36.70	SBUH/SCS	Region3-18HR 10 yr
012	5.72	8.17	3.7249	36.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 012

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.7000 ac	87.73	1.24 hrs			
Impervious	33.0000 ac	98.00	1.24 hrs			
Total	36.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	2.1000 ac			
Open Space Grass Soil Type D		90.00	1.6000 ac			
Impervious CN Data:						
Impervious Areas		98.00	33.0000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.68%	0.1500	44.84 min
Shallow	Flow		430.00 ft	0.68%	11.0000	7.90 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.68%	0.1500	44.84 min
Shallow	Flow		430.00 ft	0.68%	11.0000	7.90 min

013 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
——						
013	2.81	8.67	2.6228	45.80	SBUH/SCS	Region3-18HR 2 yr
013	4.63	8.33	4.2326	45.80	SBUH/SCS	Region3-18HR 10 yr
013	5.09	8.33	4.6330	45.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 013

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	4.6000 ac	86.78	2.39 hrs			
Impervious	41.2000 ac	98.00	2.39 hrs			
Total	45.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	3.7000 ac			
Open Space Grass Soil Type D		90.00	0.9000 ac			
Impervious CN Data:						
Impervious Areas		98.00	41.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.10%	0.1500	96.54 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.10%	0.1500	96.54 min

014 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
014	8.59	8.33	7.5022	136.00	SBUH/SCS	Region3-18HR 2 yr
014	14.28	8.33	12.1838	136.00	SBUH/SCS	Region3-18HR 10 yr
014	15.70	8.33	13.3529	136.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 014

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	19.3000 ac	86.08	2.08 hrs			
Impervious	116.7000 ac	98.00	2.08 hrs			
Total	136.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	18.9000 ac			
Open Space Grass Soil Type D		90.00	0.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	116.7000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.20%	0.1500	73.16 min
Shallow	Flow		685.00 ft	0.20%	11.0000	15.82 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.20%	0.1500	73.16 min
Shallow	Flow		685.00 ft	0.20%	11.0000	15.82 min

015 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
015	0.71	8.00	0.3644	6.40	SBUH/SCS	Region3-18HR 2 yr
015	1.16	8.00	0.5889	6.40	SBUH/SCS	Region3-18HR 10 yr
015	1.27	8.00	0.6447	6.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 015

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	0.7000 ac	87.14	0.70 hrs			
Impervious	5.7000 ac	98.00	0.70 hrs			
Total	6.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	0.5000 ac			
Open Space Grass Soil Type D		90.00	0.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	5.7000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	2.25%	0.1500	27.79 min
Shallow	Flow		77.00 ft	2.25%	11.0000	0.78 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	2.25%	0.1500	27.79 min
Shallow	Flow		77.00 ft	2.25%	11.0000	0.78 min

016 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
———						
016	1.35	8.00	0.7216	14.80	SBUH/SCS	Region3-18HR 2 yr
016	2.31	8.00	1.2031	14.80	SBUH/SCS	Region3-18HR 10 yr
016	2.56	8.00	1.3249	14.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 016

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number
Peak Factor:	484.00		SCS Abs:	0.20
Storm Dur:	24.00 hrs		Intv:	10.00 min
	Area	CN	TC	
Pervious	4.3000 ac	87.12	0.68 hrs	
Impervious	10.5000 ac	98.00	0.68 hrs	
Total	14.8000 ac			

Supporting Data:
Pervious CN Data:

Open Space Grass Soil Type B	80.00	0.0000 ac
Open Space Grass Soil Type C	86.00	3.1000 ac
Open Space Grass Soil Type D	90.00	1.2000 ac

Impervious CN Data:

Impervious Areas	98.00	10.5000 ac

Pervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Sheet	Flow	300.00 ft	2.56%	0.1500	26.39 min
Shallow	Flow	150.00 ft	2.56%	11.0000	1.42 min

Impervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Sheet	Flow	300.00 ft	2.56%	0.1500	26.39 min
Shallow	Flow	150.00 ft	2.56%	11.0000	1.42 min

017 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
———						
017	8.56	8.17	6.6091	124.30	SBUH/SCS	Region3-18HR 2 yr
017	14.30	8.17	10.8065	124.30	SBUH/SCS	Region3-18HR 10 yr
017	15.75	8.17	11.8588	124.30	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 017

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number
Peak Factor:	484.00		SCS Abs:	0.20
Storm Dur:	24.00 hrs		Intv:	10.00 min
	Area	CN	TC	
Pervious	22.8000 ac	86.00	1.61 hrs	
Impervious	101.5000 ac	98.00	1.61 hrs	
Total	124.3000 ac			

Supporting Data:
Pervious CN Data:

Open Space Grass Soil Type B	80.00	0.0000 ac
Open Space Grass Soil Type C	86.00	22.8000 ac
Open Space Grass Soil Type D	90.00	0.0000 ac

Impervious CN Data:

Impervious Areas	98.00	101.5000 ac

Pervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Sheet	Flow	300.00 ft	0.35%	0.1500	58.49 min
Shallow	Flow	559.00 ft	0.35%	11.0000	9.76 min

Impervious TC Data:

Flow type:	Description:	Length:	Slope:	Coeff:	Travel Time
Sheet	Flow	300.00 ft	0.35%	0.1500	58.49 min
Shallow	Flow	559.00 ft	0.35%	11.0000	9.76 min

018 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
018	0.44	8.17	0.2856	5.00	SBUH/SCS	Region3-18HR 2 yr
018	0.72	8.17	0.4609	5.00	SBUH/SCS	Region3-18HR 10 yr
018	0.79	8.17	0.5045	5.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 018

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	0.5000 ac	86.00	1.19 hrs			
Impervious	4.5000 ac	98.00	1.19 hrs			
Total	5.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	0.5000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.59%	0.1500	47.46 min
Shallow	Flow		37.00 ft	0.59%	11.0000	0.73 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.59%	0.1500	47.46 min
Shallow	Flow		37.00 ft	0.59%	11.0000	0.73 min

019 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
019	2.87	8.67	2.9528	62.40	SBUH/SCS	Region3-18HR 2 yr
019	4.97	8.67	4.9538	62.40	SBUH/SCS	Region3-18HR 10 yr
019	5.51	8.67	5.4616	62.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 019

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	20.0000 ac	87.00	2.57 hrs			
Impervious	42.4000 ac	98.00	2.57 hrs			
Total	62.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	15.0000 ac			
Open Space Grass Soil Type D		90.00	5.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	42.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.54%	0.1500	53.12 min
Shallow	Flow		530.00 ft	0.54%	11.0000	10.93 min
Channel	Flow Through Pipe		8830.00 ft	1.00%	21.0000	70.08 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.54%	0.1500	53.12 min
Shallow	Flow		530.00 ft	0.54%	11.0000	10.93 min
Channel	Through Pipe		8830.00 ft	1.00%	21.0000	70.08 min

020 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
020	3.06	8.33	2.6766	51.00	SBUH/SCS	Region3-18HR 2 yr
020	5.16	8.33	4.3973	51.00	SBUH/SCS	Region3-18HR 10 yr
020	5.70	8.33	4.8290	51.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 020

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	10.8000 ac	87.48	2.01 hrs			
Impervious	40.2000 ac	98.00	2.01 hrs			
Total	51.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	6.8000 ac			
Open Space Grass Soil Type D		90.00	4.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	40.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow Through Grass		300.00 ft	1.48%	0.1500	35.49 min
Shallow	Flow Through Grass		207.00 ft	1.48%	11.0000	2.58 min
Channel	Through Pipe		1138.00 ft	1.00%	21.0000	9.03 min
Channel	Through Pipe		7586.00 ft	1.00%	21.0000	60.21 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.48%	0.1500	35.49 min
Shallow	Flow		207.00 ft	1.48%	11.0000	2.58 min
Channel	Flow through Pipe		1138.00 ft	1.00%	21.0000	9.03 min
Channel	Flow through Pipe		7586.00 ft	1.00%	21.0000	60.21 min

021 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
021	7.81	8.33	6.8079	122.70	SBUH/SCS	Region3-18HR 2 yr
021	13.00	8.33	11.0548	122.70	SBUH/SCS	Region3-18HR 10 yr
021	14.30	8.33	12.1146	122.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 021

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	17.3000 ac	87.04	2.07 hrs			
Impervious	105.4000 ac	98.00	2.07 hrs			
Total	122.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	12.8000 ac			
Open Space Grass Soil Type D		90.00	4.5000 ac			
Impervious CN Data:						
Impervious Areas		98.00	105.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.72%	0.1500	47.34 min
Shallow	Flow		466.00 ft	0.72%	11.0000	8.32 min
Channel	Flow Through Pipe		2135.00 ft	1.00%	21.0000	16.94 min
Channel	Flow Through Pipe		4217.00 ft	1.00%	21.0000	33.47 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.72%	0.1500	47.34 min
Shallow	Flow		466.00 ft	0.72%	11.0000	8.32 min
Channel	Flow Through Pipe		2135.00 ft	1.00%	21.0000	16.94 min
Channel	Flow Through Pipe		4217.00 ft	1.00%	21.0000	33.47 min

022 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
022	5.16	8.33	4.8328	119.20	SBUH/SCS	Region3-18HR 2 yr
022	9.27	8.33	8.3719	119.20	SBUH/SCS	Region3-18HR 10 yr
022	10.36	8.33	9.2849	119.20	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 022

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	53.8000 ac	86.10	1.94 hrs			
Impervious	65.4000 ac	98.00	1.94 hrs			
Total	119.2000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	52.5000 ac			
Open Space Grass Soil Type D		90.00	1.3000 ac			
Impervious CN Data:						
Impervious Areas		98.00	65.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.41%	0.1500	54.90 min
Shallow	Flow		2165.00 ft	0.41%	11.0000	34.93 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.41%	0.1500	54.90 min
Shallow	Flow		2165.00 ft	0.41%	11.0000	34.93 min

024 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
024	1.31	8.67	1.2970	36.30	SBUH/SCS	Region3-18HR 2 yr
024	2.46	8.67	2.3170	36.30	SBUH/SCS	Region3-18HR 10 yr
024	2.77	8.67	2.5835	36.30	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 024

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	20.0000 ac	86.00	1.94 hrs			
Impervious	16.3000 ac	98.00	1.94 hrs			
Total	36.3000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	20.0000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	16.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.19%	0.1500	74.68 min
Shallow	Flow		236.00 ft	0.19%	11.0000	5.59 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.19%	0.1500	74.68 min
Shallow	Flow		236.00 ft	0.19%	11.0000	5.59 min

025 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
———						
025	4.49	8.00	2.3719	61.30	SBUH/SCS	Region3-18HR 2 yr
025	8.23	8.00	4.1511	61.30	SBUH/SCS	Region3-18HR 10 yr
025	9.23	8.00	4.6121	61.30	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 025

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	29.8000 ac	85.88	0.55 hrs			
Impervious	31.5000 ac	98.00	0.55 hrs			
Total	61.3000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.6000 ac			
Open Space Grass Soil Type C		86.00	29.2000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	31.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	4.08%	0.1500	21.90 min
Shallow	Flow		19.00 ft	4.08%	11.0000	0.14 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	4.08%	0.1500	21.90 min
Shallow	Flow		19.00 ft	4.08%	11.0000	0.14 min

026 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
———						
026	0.32	8.00	0.1751	4.90	SBUH/SCS	Region3-18HR 2 yr
026	0.61	8.00	0.3127	4.90	SBUH/SCS	Region3-18HR 10 yr
026	0.68	8.00	0.3487	4.90	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 026

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	2.7000 ac	86.00	0.55 hrs			
Impervious	2.2000 ac	98.00	0.55 hrs			
Total	4.9000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	2.7000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	2.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	4.08%	0.1500	21.90 min
Shallow	Flow		19.00 ft	4.08%	11.0000	0.14 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	4.08%	0.1500	21.90 min
Shallow	Flow		19.00 ft	4.08%	11.0000	0.14 min

027 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
——	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
027	0.59	8.17	0.4689	13.10	SBUH/SCS	Region3-18HR 2 yr
027	1.11	8.17	0.8373	13.10	SBUH/SCS	Region3-18HR 10 yr
027	1.25	8.17	0.9335	13.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 027

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	7.2000 ac	86.00	1.26 hrs			
Impervious	5.9000 ac	98.00	1.26 hrs			
Total	13.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	7.2000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	5.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.60%	0.1500	47.15 min
Shallow	Flow		288.00 ft	0.60%	11.0000	5.63 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.60%	0.1500	47.15 min
Shallow	Flow		288.00 ft	0.60%	11.0000	5.63 min

029 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
——	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
029	0.45	8.17	0.3590	11.40	SBUH/SCS	Region3-18HR 2 yr
029	0.91	8.17	0.6636	11.40	SBUH/SCS	Region3-18HR 10 yr
029	1.04	8.17	0.7442	11.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 029

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	7.3000 ac	86.00	1.07 hrs			
Impervious	4.1000 ac	98.00	1.07 hrs			
Total	11.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	7.3000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.1000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.88%	0.1500	40.45 min
Shallow	Flow		266.00 ft	0.88%	11.0000	4.30 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.88%	0.1500	40.45 min
Shallow	Flow		266.00 ft	0.88%	11.0000	4.30 min

030 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
———	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
030	4.52	8.17	3.5225	109.80	SBUH/SCS	Region3-18HR 2 yr
030	8.87	8.17	6.4610	109.80	SBUH/SCS	Region3-18HR 10 yr
030	10.08	8.17	7.2374	109.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 030

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	67.9000 ac	85.62	1.09 hrs			
Impervious	41.9000 ac	98.00	1.09 hrs			
Total	109.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	4.3000 ac			
Open Space Grass Soil Type C		86.00	63.6000 ac			
Impervious CN Data:						
Impervious Areas		98.00	41.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.93%	0.1500	42.74 min
Shallow	Flow		400.00 ft	0.93%	11.0000	6.28 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.93%	0.1500	42.74 min
Shallow	Flow		400.00 ft	0.93%	11.0000	6.28 min

031 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
———	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
031	1.77	8.17	1.2836	35.70	SBUH/SCS	Region3-18HR 2 yr
031	3.32	8.17	2.2894	35.70	SBUH/SCS	Region3-18HR 10 yr
031	3.74	8.17	2.5520	35.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 031

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	19.5000 ac	86.00	1.05 hrs			
Impervious	16.2000 ac	98.00	1.05 hrs			
Total	35.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	19.5000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	16.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		205.00 ft	3.90%	0.1500	17.76 min
Sheet	Flow		95.00 ft	0.61%	0.1500	20.16 min
Shallow	Flow		315.00 ft	0.61%	11.0000	6.11 min
Channel	Flow through Pipe		610.00 ft	1.00%	21.0000	4.84 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		205.00 ft	3.90%	0.1500	17.76 min
Sheet	Flow		95.00 ft	0.61%	0.1500	20.16 min
Shallow	Flow		315.00 ft	0.61%	11.0000	6.11 min
Channel	Flow Through Pipe		610.00 ft	1.00%	21.0000	4.84 min

032 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
-----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
032	0.29	8.00	0.1761	5.30	SBUH/SCS	Region3-18HR 2 yr
032	0.58	8.00	0.3207	5.30	SBUH/SCS	Region3-18HR 10 yr
032	0.66	8.00	0.3588	5.30	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 032

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.2000 ac	86.00	0.60 hrs			
Impervious	2.1000 ac	98.00	0.60 hrs			
Total	5.3000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	3.2000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	2.1000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.64%	0.1500	22.92 min
Shallow	Flow		236.00 ft	3.64%	11.0000	1.87 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.64%	0.1500	22.92 min
Shallow	Flow		236.00 ft	3.64%	11.0000	1.87 min

033 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
-----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
033	0.17	8.17	0.1350	4.10	SBUH/SCS	Region3-18HR 2 yr
033	0.33	8.17	0.2465	4.10	SBUH/SCS	Region3-18HR 10 yr
033	0.38	8.17	0.2759	4.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 033

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	2.5000 ac	86.00	1.14 hrs			
Impervious	1.6000 ac	98.00	1.14 hrs			
Total	4.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	2.5000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	1.6000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		253.00 ft	0.64%	0.1500	43.30 min
Shallow	Flow		138.00 ft	0.64%	11.0000	2.61 min
Channel	12" Pipe		530.00 ft	0.50%	21.0000	5.95 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		253.00 ft	0.64%	0.1500	43.30 min
Shallow	Flow		138.00 ft	0.64%	11.0000	2.61 min
Channel	12" Pipe		530.00 ft	0.50%	21.0000	5.95 min

034 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
034	2.43	8.17	2.0489	57.50	SBUH/SCS	Region3-18HR 2 yr
034	4.58	8.17	3.6627	57.50	SBUH/SCS	Region3-18HR 10 yr
034	5.17	8.17	4.0845	57.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 034

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	31.8000 ac	86.00	1.41 hrs			
Impervious	25.7000 ac	98.00	1.41 hrs			
Total	57.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	31.8000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	25.7000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.43%	0.1500	53.87 min
Shallow	Flow		276.00 ft	0.43%	11.0000	4.35 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.43%	0.1500	53.87 min
Shallow	Flow		276.00 ft	0.43%	11.0000	4.35 min

035 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
035	1.87	8.17	1.2651	35.40	SBUH/SCS	Region3-18HR 2 yr
035	3.53	8.17	2.2598	35.40	SBUH/SCS	Region3-18HR 10 yr
035	3.98	8.17	2.5198	35.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 035

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	19.5000 ac	86.00	0.89 hrs			
Impervious	15.9000 ac	98.00	0.89 hrs			
Total	35.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	0.0000 ac			
Open Space Grass Soil Type C		86.00	19.5000 ac			
Open Space Grass Soil Type D		90.00	0.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	15.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.50%	0.1500	32.68 min
Shallow	Flow		399.00 ft	1.50%	11.0000	4.94 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.50%	0.1500	32.68 min
Shallow	Flow		399.00 ft	1.50%	11.0000	4.94 min

037 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
037	0.99	8.17	0.7244	20.40	SBUH/SCS	Region3-18HR 2 yr
037	1.88	8.17	1.2972	20.40	SBUH/SCS	Region3-18HR 10 yr
037	2.12	8.17	1.4469	20.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 037

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	11.4000 ac	86.14	1.05 hrs			
Impervious	9.0000 ac	98.00	1.05 hrs			
Total	20.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	11.0000 ac			
Open Space Grass Soil Type D		90.00	0.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	9.0000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.03%	0.1500	37.98 min
Shallow	Flow		431.00 ft	1.03%	11.0000	6.43 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.03%	0.1500	37.98 min
Shallow	Flow		431.00 ft	1.03%	11.0000	6.43 min

038 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
038	9.01	8.33	7.9671	201.00	SBUH/SCS	Region3-18HR 2 yr
038	16.01	8.33	13.8001	201.00	SBUH/SCS	Region3-18HR 10 yr
038	17.89	8.33	15.3089	201.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 038

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	90.1000 ac	84.82	1.76 hrs			
Impervious	110.9000 ac	98.00	1.76 hrs			
Total	201.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	17.7000 ac			
Open Space Grass Soil Type C		86.00	72.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	110.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Shallow	Flow		858.00 ft	0.55%	11.0000	17.53 min
Sheet	Flow		300.00 ft	26.39%	0.1500	10.38 min
Shallow	Flow		852.00 ft	26.39%	11.0000	2.51 min
Channel	8" Pipe		276.00 ft	0.10%	21.0000	6.93 min
Channel	10" Pipe		1312.00 ft	0.20%	21.0000	23.28 min
Channel	12" Pipe		2252.00 ft	0.20%	21.0000	39.97 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	26.39%	0.1500	10.38 min
Shallow	Flow		858.00 ft	0.55%	11.0000	17.53 min
Shallow	Flow		852.00 ft	26.39%	11.0000	2.51 min
Channel	8" Pipe		276.00 ft	0.10%	21.0000	6.93 min
Channel	10" Pipe		1312.00 ft	0.20%	21.0000	23.28 min
Channel	12" Pipe		2252.00 ft	0.20%	21.0000	39.97 min

039 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
039	1.46	8.17	1.2007	33.90	SBUH/SCS	Region3-18HR 2 yr
039	2.76	8.17	2.1498	33.90	SBUH/SCS	Region3-18HR 10 yr
039	3.12	8.17	2.3981	33.90	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 039

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	18.9000 ac	86.00	1.33 hrs			
Impervious	15.0000 ac	98.00	1.33 hrs			
Total	33.9000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	18.9000 ac			
Impervious CN Data:						
Impervious Areas		98.00	15.0000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.70%	0.1500	44.33 min
Shallow	Flow		56.00 ft	0.70%	11.0000	1.01 min
Channel	15" pipe		818.00 ft	0.25%	21.0000	12.98 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.70%	0.1500	44.33 min
Shallow	Flow		56.00 ft	0.70%	11.0000	1.01 min
Channel	15" Pipe		818.00 ft	0.25%	21.0000	12.98 min

040 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
040	0.49	8.17	0.3703	11.20	SBUH/SCS	Region3-18HR 2 yr
040	0.95	8.17	0.6753	11.20	SBUH/SCS	Region3-18HR 10 yr
040	1.08	8.17	0.7556	11.20	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 040

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	6.8000 ac	86.00	1.06 hrs			
Impervious	4.4000 ac	98.00	1.06 hrs			
Total	11.2000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	6.8000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		282.00 ft	0.89%	0.1500	38.32 min
Channel	6"-8" Pipe		114.00 ft	1.50%	21.0000	0.74 min
Channel	12" Pipe		702.00 ft	1.31%	21.0000	4.87 min
Channel	15" Pipe		138.00 ft	2.17%	21.0000	0.74 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Channel	6"-8" Pipe		114.00 ft	1.50%	21.0000	0.74 min
Sheet	Flow		282.00 ft	0.89%	0.1500	38.32 min
Channel	12" Pipe		702.00 ft	1.31%	21.0000	4.87 min
Channel	15" Pipe		138.00 ft	2.17%	21.0000	0.74 min

041 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
041	1.48	8.00	0.8517	22.20	SBUH/SCS	Region3-18HR 2 yr
041	2.73	8.00	1.4944	22.20	SBUH/SCS	Region3-18HR 10 yr
041	3.07	8.00	1.6612	22.20	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 041

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	11.0000 ac	86.00	0.65 hrs			
Impervious	11.2000 ac	98.00	0.65 hrs			
Total	22.2000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	11.0000 ac			
Impervious CN Data:						
Impervious Areas		98.00	11.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.03%	0.1500	24.67 min
Shallow	Flow		261.00 ft	3.03%	11.0000	2.27 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.03%	0.1500	24.67 min
Shallow	Flow		261.00 ft	3.03%	11.0000	2.27 min

042 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
042	0.72	8.33	0.6545	18.40	SBUH/SCS	Region3-18HR 2 yr
042	1.35	8.33	1.1705	18.40	SBUH/SCS	Region3-18HR 10 yr
042	1.52	8.33	1.3055	18.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 042

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	10.2000 ac	86.00	1.66 hrs			
Impervious	8.2000 ac	98.00	1.66 hrs			
Total	18.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	10.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	8.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.37%	0.1500	57.20 min
Shallow	Flow		238.00 ft	0.37%	11.0000	4.04 min
Channel	8" Pipe		521.00 ft	0.30%	21.0000	7.55 min
Channel	8" Pipe		346.00 ft	1.00%	21.0000	2.75 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.37%	0.1500	57.20 min
Shallow	Flow		238.00 ft	0.37%	11.0000	4.04 min
Channel	8" pipe		521.00 ft	0.30%	21.0000	7.55 min
Channel	8" pipe		346.00 ft	1.00%	21.0000	2.75 min

043 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
043	0.16	8.17	0.1029	2.20	SBUH/SCS	Region3-18HR 2 yr
043	0.27	8.17	0.1726	2.20	SBUH/SCS	Region3-18HR 10 yr
043	0.30	8.17	0.1903	2.20	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 043

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	0.7000 ac	86.00	1.03 hrs			
Impervious	1.5000 ac	98.00	1.03 hrs			
Total	2.2000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	0.7000 ac			
Impervious CN Data:						
Impervious Areas		98.00	1.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		160.00 ft	0.31%	0.1500	37.13 min
Channel	8" Pipe		401.00 ft	0.40%	21.0000	5.03 min
Channel	Bioswale		178.00 ft	1.00%	17.0000	1.75 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		160.00 ft	0.31%	0.1500	37.13 min
Channel	8" Pipe		401.00 ft	0.40%	21.0000	5.03 min
Channel	Bioswale		178.00 ft	1.00%	17.0000	1.75 min

044 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
044	0.24	8.17	0.1994	5.60	SBUH/SCS	Region3-18HR 2 yr
044	0.46	8.17	0.3565	5.60	SBUH/SCS	Region3-18HR 10 yr
044	0.52	8.17	0.3976	5.60	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 044

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	3.1000 ac	86.00	1.33 hrs			
Impervious	2.5000 ac	98.00	1.33 hrs			
Total	5.6000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	3.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	2.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.60%	0.1500	47.15 min
Shallow	Flow		115.00 ft	0.60%	11.0000	2.25 min
Channel	8" Pipe		582.00 ft	0.40%	21.0000	7.30 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.60%	0.1500	47.15 min
Shallow	Flow		115.00 ft	0.60%	11.0000	2.25 min
Channel	8" pipe		582.00 ft	0.40%	21.0000	7.30 min

045 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
045	0.74	8.17	0.5349	15.70	SBUH/SCS	Region3-18HR 2 yr
045	1.44	8.17	0.9675	15.70	SBUH/SCS	Region3-18HR 10 yr
045	1.62	8.17	1.0811	15.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 045

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	9.2000 ac	86.00	0.96 hrs			
Impervious	6.5000 ac	98.00	0.96 hrs			
Total	15.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	9.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	6.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.10%	0.1500	37.00 min
Shallow	Flow		198.00 ft	1.10%	11.0000	2.86 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.10%	0.1500	37.00 min
Shallow	Flow		198.00 ft	1.10%	11.0000	2.86 min

046 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
046	0.46	8.17	0.3316	9.50	SBUH/SCS	Region3-18HR 2 yr
046	0.88	8.17	0.5959	9.50	SBUH/SCS	Region3-18HR 10 yr
046	0.99	8.17	0.6652	9.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 046

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	5.4000 ac	86.00	1.00 hrs			
Impervious	4.1000 ac	98.00	1.00 hrs			
Total	9.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	5.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.1000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.11%	0.1500	36.86 min
Shallow	Flow		376.00 ft	1.11%	11.0000	5.41 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.11%	0.1500	36.86 min
Shallow	Flow		376.00 ft	1.11%	11.0000	5.41 min

047 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
047	2.64	8.00	1.2278	41.00	SBUH/SCS	Region3-18HR 2 yr
047	4.43	8.00	2.2116	41.00	SBUH/SCS	Region3-18HR 10 yr
047	4.99	8.00	2.4746	41.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 047

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	23.5000 ac	80.43	0.43 hrs			
Impervious	17.5000 ac	98.00	0.43 hrs			
Total	41.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	21.8000 ac			
Open Space Grass Soil Type C		86.00	1.7000 ac			
Impervious CN Data:						
Impervious Areas		98.00	17.5000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	17.46%	0.1500	12.24 min
Shallow	Flow		2063.00 ft	17.46%	11.0000	7.48 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	17.46%	0.1500	12.24 min
Shallow	Flow		2063.00 ft	17.46%	11.0000	7.48 min

048 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
048	14.87	8.17	10.4558	225.10	SBUH/SCS	Region3-18HR 2 yr
048	25.33	8.17	17.5071	225.10	SBUH/SCS	Region3-18HR 10 yr
048	28.03	8.17	19.3009	225.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 048

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	69.8000 ac	84.74	1.25 hrs			
Impervious	155.3000 ac	98.00	1.25 hrs			
Total	225.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	34.9000 ac			
Open Space Grass Soil Type C		86.00	4.5000 ac			
Open Space Grass Soil Type D		90.00	30.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	155.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.65%	0.1500	45.66 min
Shallow	Flow		391.00 ft	0.65%	11.0000	7.35 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.65%	0.1500	45.66 min
Shallow	Flow		391.00 ft	0.65%	11.0000	7.35 min

049 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
049	1.91	8.33	1.6602	45.10	SBUH/SCS	Region3-18HR 2 yr
049	3.61	8.33	2.9576	45.10	SBUH/SCS	Region3-18HR 10 yr
049	4.06	8.33	3.2951	45.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 049

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	24.8000 ac	86.92	1.51 hrs			
Impervious	20.3000 ac	98.00	1.51 hrs			
Total	45.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	1.2000 ac			
Open Space Grass Soil Type C		86.00	16.1000 ac			
Open Space Grass Soil Type D		90.00	7.5000 ac			
Impervious CN Data:						
Impervious Areas		98.00	20.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.65%	0.1500	45.66 min
Shallow	Flow		391.00 ft	0.65%	11.0000	7.35 min
Channel	18" Pipe		950.00 ft	0.25%	21.0000	15.08 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.65%	0.1500	45.66 min
Shallow	Flow		391.00 ft	0.65%	11.0000	7.35 min
Channel	18" Pipe		950.00 ft	0.25%	21.0000	15.08 min

050 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
------						
050	1.09	8.17	0.8759	27.50	SBUH/SCS	Region3-18HR 2 yr
050	2.17	8.17	1.6139	27.50	SBUH/SCS	Region3-18HR 10 yr
050	2.47	8.17	1.8090	27.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 050

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	17.4000 ac	86.00	1.12 hrs			
Impervious	10.1000 ac	98.00	1.12 hrs			
Total	27.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	17.4000 ac			
Impervious CN Data:						
Impervious Areas		98.00	10.1000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.20%	0.1500	35.73 min
Shallow	Flow		1034.00 ft	1.20%	11.0000	14.30 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.20%	0.1500	35.73 min
Shallow	Flow		1034.00 ft	1.20%	11.0000	14.30 min

051 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
051	0.57	8.00	0.3349	9.40	SBUH/SCS	Region3-18HR 2 yr
051	1.09	8.00	0.5987	9.40	SBUH/SCS	Region3-18HR 10 yr
051	1.23	8.00	0.6676	9.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 051

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	5.2000 ac	86.00	0.62 hrs			
Impervious	4.2000 ac	98.00	0.62 hrs			
Total	9.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	5.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	4.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.07%	0.1500	24.54 min
Shallow	Flow		107.00 ft	3.07%	11.0000	0.93 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	3.07%	0.1500	24.54 min
Shallow	Flow		107.00 ft	3.07%	11.0000	0.93 min

052 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
-------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
052	1.73	8.67	1.6865	48.50	SBUH/SCS	Region3-18HR 2 yr
052	3.29	8.33	3.0342	48.50	SBUH/SCS	Region3-18HR 10 yr
052	3.71	8.33	3.3874	48.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 052

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	27.7000 ac	86.00	1.83 hrs			
Impervious	20.8000 ac	98.00	1.83 hrs			
Total	48.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	27.7000 ac			
Impervious CN Data:						
Impervious Areas		98.00	20.8000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.66%	0.1500	45.38 min
Shallow	Flow		2265.00 ft	0.66%	11.0000	42.24 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.66%	0.1500	45.38 min
Shallow	Flow		2265.00 ft	0.66%	11.0000	42.24 min

053 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
———	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
053	0.35	8.83	0.4467	23.40	SBUH/SCS	Region3-18HR 2 yr
053	1.01	8.67	0.9776	23.40	SBUH/SCS	Region3-18HR 10 yr
053	1.22	8.33	1.1243	23.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 053

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	21.1000 ac	86.00	1.20 hrs			
Impervious	2.3000 ac	98.00	1.20 hrs			
Total	23.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	21.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	2.3000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.71%	0.1500	44.08 min
Shallow	Flow		372.00 ft	0.71%	11.0000	6.69 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.71%	0.1500	44.08 min
Shallow	Flow		372.00 ft	0.71%	11.0000	6.69 min

054 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
———	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
054	2.43	8.17	2.0222	67.00	SBUH/SCS	Region3-18HR 2 yr
054	4.98	8.17	3.7847	67.00	SBUH/SCS	Region3-18HR 10 yr
054	5.69	8.17	4.2529	67.00	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 054

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	44.8000 ac	86.03	1.13 hrs			
Impervious	22.2000 ac	98.00	1.13 hrs			
Total	67.0000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	44.5000 ac			
Open Space Grass Soil Type D		90.00	0.3000 ac			
Impervious CN Data:						
Impervious Areas		98.00	22.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.00%	0.1500	41.51 min
Shallow	Flow		700.00 ft	1.00%	11.0000	10.61 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.00%	0.1500	41.51 min
Shallow	Flow		700.00 ft	1.00%	11.0000	10.61 min

055 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
-------						
055	2.69	8.67	2.9159	121.90	SBUH/SCS	Region3-18HR 2 yr
055	6.38	8.33	5.8835	121.90	SBUH/SCS	Region3-18HR 10 yr
055	7.48	8.33	6.6886	121.90	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 055

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	98.2000 ac	86.17	1.35 hrs			
Impervious	23.7000 ac	98.00	1.35 hrs			
Total	121.9000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	94.0000 ac			
Open Space Grass Soil Type D		90.00	4.2000 ac			
Impervious CN Data:						
Impervious Areas		98.00	23.7000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.07%	0.1500	37.41 min
Shallow	Flow		1750.00 ft	1.07%	11.0000	25.63 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.07%	0.1500	37.41 min
Shallow	Flow		1750.00 ft	1.07%	11.0000	25.63 min

056 Event Summary:

BasinID	Peak Q Event (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Area ac	Method /Loss	Raintype
-------						
056	1.08	12.67	1.3606	92.80	SBUH/SCS	Region3-18HR 2 yr
056	3.31	8.67	3.2934	92.80	SBUH/SCS	Region3-18HR 10 yr
056	4.12	8.33	3.8396	92.80	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 056

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	90.0000 ac	85.34	0.97 hrs			
Impervious	2.8000 ac	98.00	0.97 hrs			
Total	92.8000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	14.3000 ac			
Open Space Grass Soil Type C		86.00	69.0000 ac			
Open Space Grass Soil Type D		90.00	6.7000 ac			
Impervious CN Data:						
Impervious Areas		98.00	2.8000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		270.00 ft	8.00%	0.1500	16.61 min
Sheet	Flow		30.00 ft	0.75%	0.1500	7.38 min
Shallow	Flow		1450.00 ft	0.75%	11.0000	25.37 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		30.00 ft	0.75%	0.1500	7.38 min
Sheet	Flow		270.00 ft	8.00%	0.1500	16.61 min
Shallow	Flow		1450.00 ft	0.75%	11.0000	25.37 min

057 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
057	3.26	8.17	2.5295	80.40	SBUH/SCS	Region3-18HR 2 yr
057	6.60	8.17	4.6887	80.40	SBUH/SCS	Region3-18HR 10 yr
057	7.52	8.17	5.2595	80.40	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 057

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	52.3000 ac	86.35	1.02 hrs			
Impervious	28.1000 ac	98.00	1.02 hrs			
Total	80.4000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	47.7000 ac			
Open Space Grass Soil Type D		90.00	4.6000 ac			
Impervious CN Data:						
Impervious Areas		98.00	28.1000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.51%	0.1500	32.59 min
Shallow	Flow		1025.00 ft	1.51%	11.0000	12.64 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.51%	0.1500	32.59 min
Shallow	Flow		1025.00 ft	1.51%	11.0000	12.64 min

058 Event Summary:

BasinID	Peak Q Event	Peak T	Peak Vol	Area	Method	Raintype
------	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
058	2.72	8.83	3.3568	145.50	SBUH/SCS	Region3-18HR 2 yr
058	6.63	8.67	6.8658	145.50	SBUH/SCS	Region3-18HR 10 yr
058	7.77	8.67	7.8207	145.50	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 058

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	120.3000 ac	86.26	1.68 hrs			
Impervious	25.2000 ac	98.00	1.68 hrs			
Total	145.5000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	112.4000 ac			
Open Space Grass Soil Type D		90.00	7.9000 ac			
Impervious CN Data:						
Impervious Areas		98.00	25.2000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.80%	0.1500	42.02 min
Shallow	Flow		2265.00 ft	0.80%	11.0000	38.37 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.80%	0.1500	42.02 min
Shallow	Flow		2265.00 ft	0.80%	11.0000	38.37 min

059 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
-----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
059	2.31	8.17	2.0298	75.10	SBUH/SCS	Region3-18HR 2 yr
059	5.12	8.17	3.9357	75.10	SBUH/SCS	Region3-18HR 10 yr
059	5.92	8.17	4.4472	75.10	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 059

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	55.7000 ac	86.24	1.06 hrs			
Impervious	19.4000 ac	98.00	1.06 hrs			
Total	75.1000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type C		86.00	52.4000 ac			
Open Space Grass Soil Type D		90.00	3.3000 ac			
Impervious CN Data:						
Impervious Areas		98.00	19.4000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.43%	0.1500	33.31 min
Shallow	Flow		1100.00 ft	1.43%	11.0000	13.94 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	1.43%	0.1500	33.31 min
Shallow	Flow		1100.00 ft	1.43%	11.0000	13.94 min

060 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
-----	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
060	0.73	12.67	0.9330	58.70	SBUH/SCS	Region3-18HR 2 yr
060	1.98	8.83	2.2040	58.70	SBUH/SCS	Region3-18HR 10 yr
060	2.43	8.67	2.5601	58.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 060

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	56.9000 ac	86.01	1.38 hrs			
Impervious	1.8000 ac	98.00	1.38 hrs			
Total	58.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	7.0000 ac			
Open Space Grass Soil Type C		86.00	39.3000 ac			
Open Space Grass Soil Type D		90.00	10.6000 ac			
Impervious CN Data:						
Impervious Areas		98.00	1.8000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.67%	0.1500	45.11 min
Shallow	Flow		843.00 ft	0.67%	11.0000	15.60 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.67%	0.1500	45.11 min
Shallow	Flow		843.00 ft	0.67%	11.0000	15.60 min

061 Event Summary:

BasinID	Peak Q	Peak T	Peak Vol	Area	Method	Raintype
	Event					
——	(cfs)	(hrs)	(ac-ft)	ac	/Loss	
061	2.92	12.67	4.2051	202.70	SBUH/SCS	Region3-18HR 2 yr
061	6.56	10.83	8.8310	202.70	SBUH/SCS	Region3-18HR 10 yr
061	7.63	10.83	10.1042	202.70	SBUH/SCS	Region3-18HR 25 yr

Drainage Area: 061

Hyd Method:	SBUH Hyd		Loss Method:	SCS CN Number		
Peak Factor:	484.00		SCS Abs:	0.20		
Storm Dur:	24.00 hrs		Intv:	10.00 min		
	Area	CN	TC			
Pervious	170.8000 ac	85.27	2.77 hrs			
Impervious	31.9000 ac	98.00	2.77 hrs			
Total	202.7000 ac					
Supporting Data:						
Pervious CN Data:						
Open Space Grass Soil Type B		80.00	20.7000 ac			
Open Space Grass Soil Type C		86.00	150.1000 ac			
Impervious CN Data:						
Impervious Areas		98.00	31.9000 ac			
Pervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.16%	0.1500	79.99 min
Shallow	Flow		1837.00 ft	0.16%	11.0000	47.44 min
Impervious TC Data:						
Flow type:	Description:		Length:	Slope:	Coeff:	Travel Time
Sheet	Flow		300.00 ft	0.16%	0.1500	79.99 min

Shallow Flow 1837.00 ft0.16% 11.0000 47.44 min

BURL STORM 2008.DWG BY: SCOTT KIDDER REV: 9-23-08

City of Burlington Mapping

Burlington

Geographic Information System

CITY OF BURLINGTON DRAINAGE 2008

CITY OF BURLINGTON

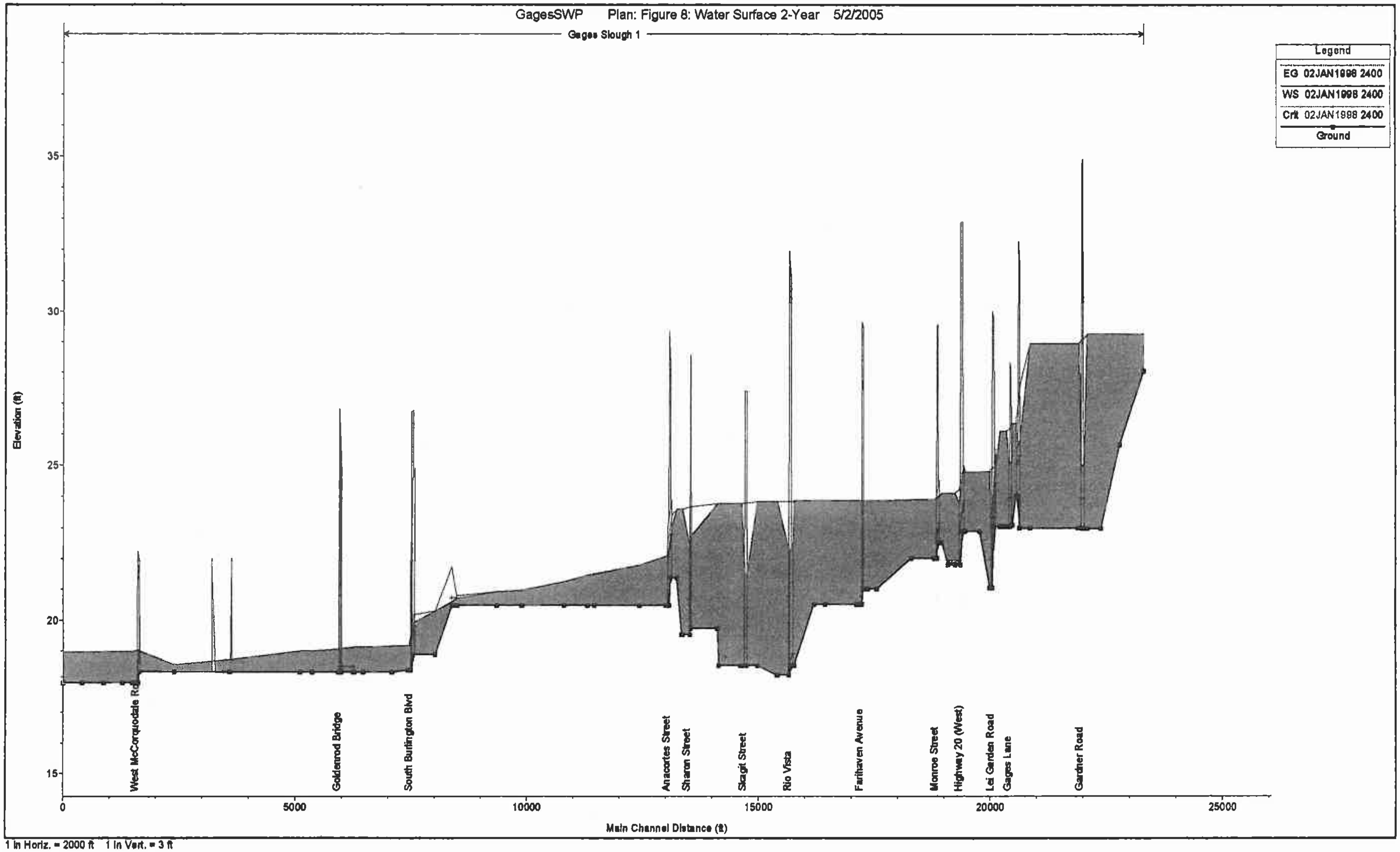
CORPORATE LIMITS

SCALE: 1" = 400'

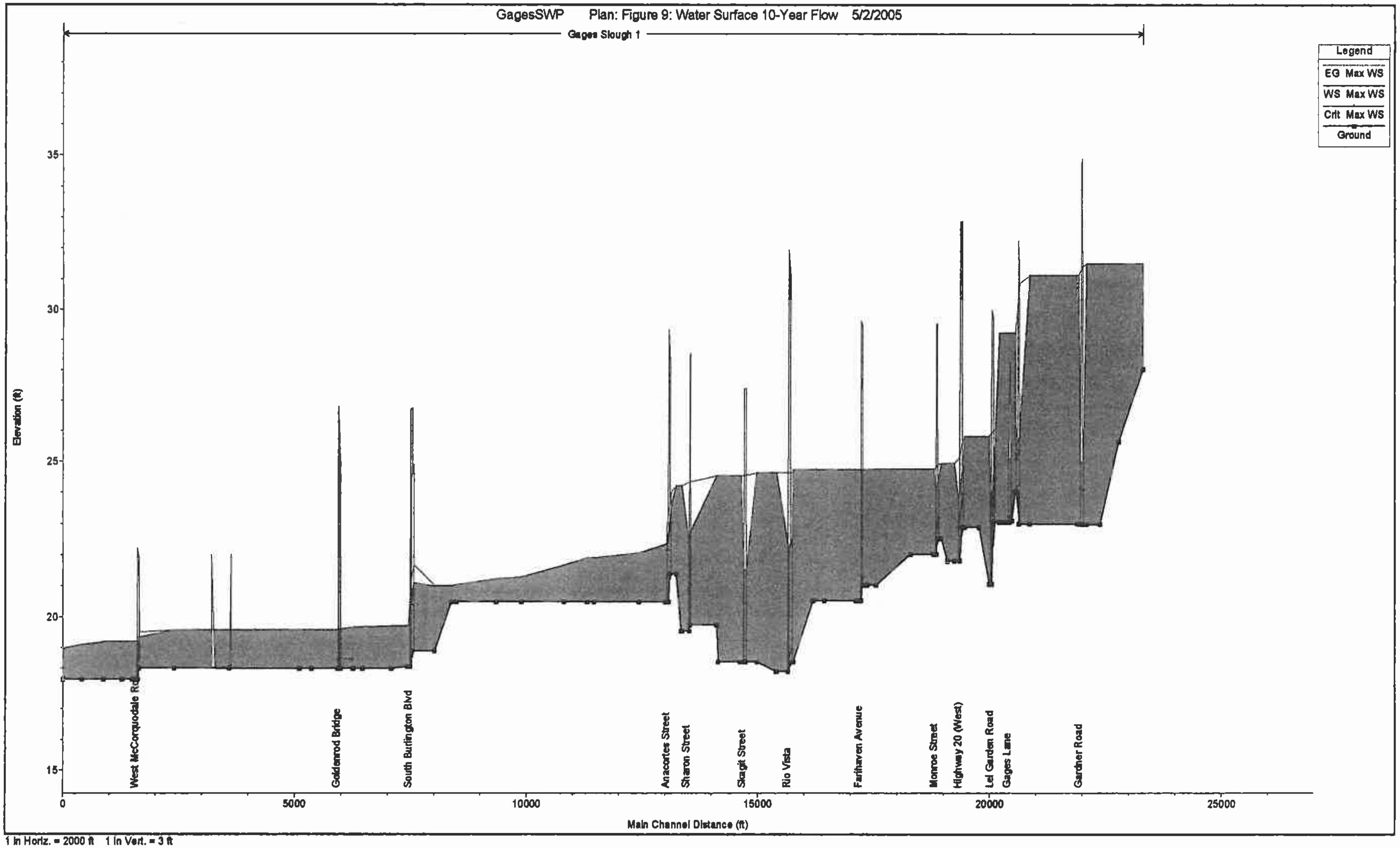
BURLINGTON GIS MAPPING

APPENDIX F –

Existing Water Surface Elevations For the Two, Ten and Twenty-Five Year Storms

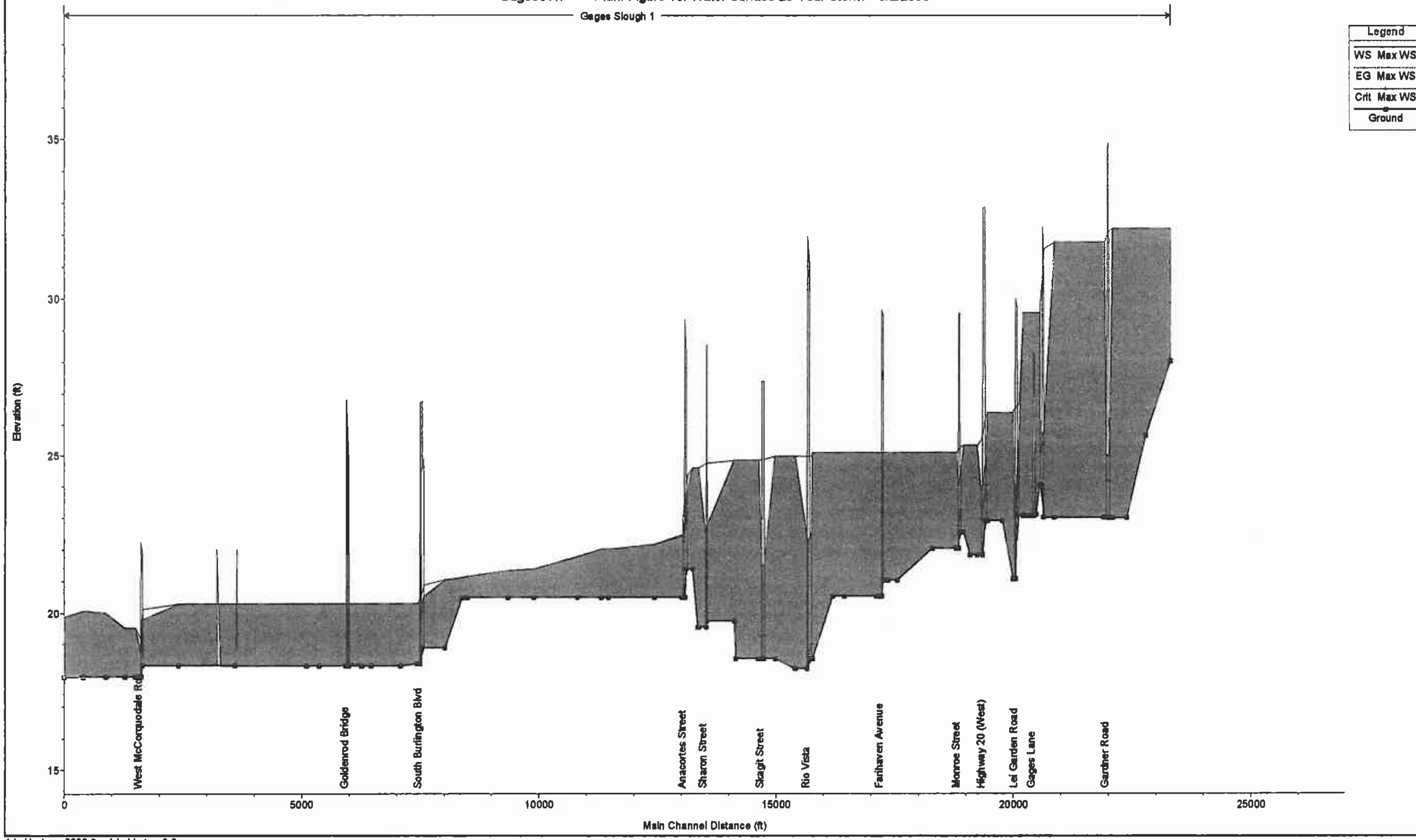


GagesSWP Plan: Figure 8: Water Surface 2-Year 5/2/2005
Gages Slough 1
Legend
EG 02JAN1998 2400
WS 02JAN1998 2400
Crit 02JAN1998 2400
Ground
Elevation (ft)
35
30
25
20
15
West McCorquodale Rd
Goldenrod Bridge
South Burlington Blvd
Anacortes Street
Sharon Street
Skagit Street
Rio Vista
Fairhaven Avenue
Monroe Street
Highway 20 (West)
Lei Garden Road
Gages Lane
Gardner Road
0
5000
10000
15000
20000
25000
Main Channel Distance (ft)
1 in Horiz. = 2000 ft 1 in Vert. = 3 ft



GagesSWP Plan: Figure 9: Water Surface 10-Year Flow 5/2/2005
Gages Slough 1
Legend
EG Max WS
WS Max WS
Crit Max WS
Ground
Elevation (ft)
35
30
25
20
15
West McCorquodale Rd
Goldenrod Bridge
South Burlington Blvd
Anacortes Street
Sharon Street
Skagit Street
Rio Vista
Fairhaven Avenue
Monroe Street
Highway 20 (West)
Lel Garden Road
Gages Lane
Gardner Road
0
5000
10000
15000
20000
25000
Main Channel Distance (ft)
1 in Horiz. = 2000 ft 1 in Vert. = 3 ft

GagesSWP Plan: Figure 10: Water Surface 25-Year Storm 5/2/2005



1 in Horiz. = 2000 ft 1 in Vert. = 3 ft

APPENDIX G –

Surface and Stormwater Quality Monitoring Plan

WATER QUALITY MONITORING PLAN FOR GAGES SLOUGH AND THE SKAGIT RIVER WITHIN THE CITY OF BURLINGTON

Prepared by:

Jenna G. Scholz
Sheldon & Associates, Inc.
5031 University Way NE #204
Seattle, WA 98105

May 2004

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1.0 Introduction

Water Quality Monitoring Plan provides monitoring guidelines and procedures for the City of Burlington. The program is designed to assess current surface water quality and identify parameters of concern within the study area. This includes identification of potential point and non-point sources of water contamination in Gages Slough and at discharge points to the Skagit River.

This plan specifies the number, location, and frequency of monitoring efforts as well as the parameters to be analyzed in each sample collected. Chain of custody procedures and data reduction as well as analysis procedures are also included. It is our understanding that City staff will be responsible for the collection of samples and laboratory analysis. Sheldon & Associates will conduct the data analysis and prepare an annual.

1.1 Background Information

Gages Slough is a channelized water body, historically formed by floodwater from the Skagit River. Though linear in shape, the slough is not an active stream system with a gradient of < 1% and flow is not present within the slough throughout the year. The slough is no longer in the active floodplain of the Skagit River due to extensive diking. Residence time in the slough is > 15 days which qualifies it as a lake under the WDOE water quality standards.

Currently there is no on-going monitoring being conducted for Gages Slough. In 1998, water quality samples were collected from April through June and then again in December. Sampling was performed at 14 locations along the slough with varying results (see Technical Report). Sampling included measures of pH, dissolved oxygen, total suspended solids, conductivity, turbidity, and nitrogen and phosphorus. Results from this study indicate that some areas along the slough are in violation of water quality standards and are at levels above those observed in other highly urbanized wetlands in the Puget Sounds lowlands. Specifically several sites reported high fecal coliform and nutrient levels. This existing data will be used in the water quality assessment, however, these data are limited and their analytical accuracy is not documented. Furthermore, the 1998 study did not include testing of stormwater and lacks information for metals and petroleum products as well as pesticide concentrations. Therefore, further sampling over a greater seasonal variability and at different site locations, including a minimum of two precipitation events, in needed to characterize existing surface and storm water conditions within Gages Slough.

In addition to water quality, water quantity was also monitored in 1998 at five staff gages installed within the slough. These sites will also be monitored during this study. This supplementary information will be used to account for sources of variability in water quality results that may be associated with changing water volumes and weather patterns. Accounting for most of the major sources of variability increases the likelihood of identifying the effect of a particular land use or management practice on water quality.

1.2 Monitoring Program Objectives

There are three primary objectives of this monitoring program. First, the program is designed to characterize general surface water quality conditions in the portion of Gages Slough within the City of Burlington. The data gathered during the first year of this effort will be used to assess current conditions. Information gathered over the next five to ten years will be used to assess future trends in slough quality. Second, the program is designed to assess stormwater quality from outfalls discharging directly to both the slough and the Skagit River. The third objective is to identify existing point and non-point sources of pollution to Gages Slough and the Skagit River.

To these ends, both comparison and compliance monitoring will be conducted. Comparison monitoring will be conducted by collecting samples in key wetland habitats within the slough and comparing them to other highly urbanized wetland systems in Puget Sound. Compliance monitoring will be conducted by collecting samples from specific stormwater outfalls and within the slough comparing them to water quality criteria established by the Washington State Department of Ecology (Ecology) in the Washington Administrative Code [WAC] 173-201A.

1.3 Regulatory Agency Involvement

The state's surface water quality standards set limits on pollution in lakes, rivers and marine waters in order to protect water quality. In 1998, Gages Slough was placed on the Washington Department of Ecology's 303(d) list for violations of the fecal coliform standard.

The Clean Water Act requires that the water quality standards protect beneficial uses, such as swimming, fishing, aquatic life habitat, and agricultural and drinking water supplies. The state has issued (June 25, 2003) final revisions to the Surface Water Quality Standards (Chapter 173-201A WAC). The updated standards must be approved by the federal Environmental Protection Agency and federal fish agencies before they take effect.

The Puget Sound Water Quality Management Plan (PSWQMP) serves as the federally approved Comprehensive Conservation and Management Plan (CCMP) for Puget Sound under Section 320 of the federal Clean Water Act. This management plan guides the efforts of federal and state agencies as well as tribal and local governments including Snohomish County. The plan contains a program for Stormwater and Combined Sewer Overflows. The state completed a Stormwater Management Manual for Western Washington in August 2001. The latter is a revision of the 1992 Stormwater Program Guidance Manual for the Puget Sound Basin. Furthermore, the listing of salmon under the Environmental Species Act (ESA) requires that streams and wetlands be protected. All local governments with salmon habitats are encouraged to develop storm water management plans. Those seeking 4(d) rule exemptions will be required to meet National Marine Fisheries Service (NMFS) stormwater requirements.

Under the Federal Clean Water Act, The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Under these regulations, local governments in the Puget Sound Basin and those subject to the federal National Pollutant Discharge Elimination System (NPDES) Storm Water Program are required to have storm water management programs.

Currently the NPDES storm water permit program (Phase I) applies to only six local governments (Seattle, Tacoma, and the unincorporated areas of Snohomish, King, Pierce and Clark counties) and to Washington State Department of Transportation (WSDOT) facilities within the legal boundaries of those jurisdictions. Industrial facilities that were owned or operated by municipalities with a population of less than 100,000 were previously exempted from the requirement to obtain a stormwater discharge permit. In December 1999, new NPDES rules (Phase II) were published and extended coverage to operators of regulated small municipal separate storm sewer systems serving less than 100,000.

The City of Burlington, as part of incorporated Skagit County, is a regulated municipality under the Federal NPDES Phase II Rule. This rule requires that the City submit an application for a stormwater permit by March 2003. Additional permit requirements are pending. DOE is currently beginning a process to update and reissue the NPDES and state waste discharge baseline general permit for stormwater discharges. Permit conditions include a requirement to have a Stormwater Pollution Prevention Plan (SWPP) and Best Management Practices (BMPs) implemented to eliminate or minimize the potential to contaminate stormwater.

1.4 Potential sources of contamination

There are two primary categories of contamination: point and non-point source pollution. Point source pollution is the release of contaminants through the outlet of a single conduit, such as a pipe or ditch. Discharges into streams, lakes and rivers by wastewater treatment plants, paper mills, and other industrial facilities are classified as point sources of pollution. Runoff from a feedlot pen or overflows from a hog lagoon to a stream or lake are examples of agricultural point sources of contamination. Because point source pollution is usually concentrated, it is the most significant contamination source, but it is also the easiest to resolve. For example, runoff ponds or catch basins can be constructed to contain point sources.

Non-point source pollution does not originate from one location. Diffuse runoff from land and atmospheric-deposited pollutants not attributed to a single point of origin are considered non-point sources. Agricultural examples include runoff from agricultural land and water erosion from cropped fields. Controlling non-point source pollution tends to be very difficult and usually requires a change in land management practices.

Urbanization also increases the variety and amount of pollutants transported to receiving waters. Sediment from development and new construction; oil, grease, and toxic chemicals from automobiles; nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; road salts; and heavy metals are examples of pollutants generated in urban areas. Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas.

2.0 WATER QUALITY MONITORING PLAN DESIGN

This plan shall form the basis for water quality monitoring efforts to be performed by the City of Burlington. Procedures and protocols outlined in the plan were developed in consultation with the City.

2.1 Sampling Parameters

This program is designed to identify pollutants entering Gages Slough and the Skagit River from both point and non-point sources contained in outfall discharge and storm and surface water. Physical, chemical and biological parameters will be measured (Table 1). Although most of these pollutants are transported in surface runoff, some may enter water bodies through atmospheric deposition, from direct application, or from sub-surface or shallow groundwater flow.

Physical parameters to be measured include temperature, total dissolved solids, total suspended solids, dissolved oxygen, and pH. Chemical parameters include nutrients such as nitrogen and phosphorus which are essential components of plant and animal diets; metals such as copper, lead, and zinc; total petroleum hydrocarbons associated with roadways and vehicles; and pesticides (e.g. insecticides) used to protect crops and gardens.

Biological parameters include microorganisms such as fecal coliform from human sewage or animal manure. These disease-causing microorganisms have the potential to affect human and livestock health and generally enter surface waters in runoff containing animal or human wastes. Municipal discharges of sewage can also deliver bacteria and other organisms to surface waters.

Field and laboratory testing will be performed on the water samples collected. Parameters selected will characterize general water quality conditions. Field-testing using *in situ* methods will be performed for temperature, dissolved oxygen, and pH during each sampling effort using a hand-held YSI meter and probe.

Surface and stormwater water samples will be collected by directly filling pre-labeled bottles containing the Environmental Protection Agency (EPA) recommended preservative for each parameter to be tested. Where possible, samples will be collected at a depth of approximately one foot.

Edge Analytical, an EPA accredited laboratory, will perform the sample testing using EPA approved methods (Table 1). All laboratory costs shall be the responsibility of the City.

2.2 Sampling Locations

A total of nine water quality stations will be established at locations within the City of Burlington (Figure 1). These locations have been selected because they meet the study objectives of characterizing existing surface and stormwater conditions as well as identifying existing point and non-point source pollution to Gages Slough and the Skagit River. Stations will be located in the following areas:

1. Gages Slough at the N.E. corner of the City's property boundary
2. Gages Slough at intersection of Skagit and Rio Vista Roads
3. Gages Slough at Gilkey Road under Burlington Northern trestle
4. Gages Slough off Goldenrod Road downstream of I-5
5. Gages Slough at Pulver Road Pump Station
6. Joe Leary ditch
7. City of Burlington Wastewater treatment plant storm drain
8. Storm drain at Cascade Mall Drive
9. Whitmarsh Road pump station discharge to Skagit River

Surface and stormwater water samples will be collected by directly filling pre-labeled bottles containing the Environmental Protection Agency (EPA) recommended preservative for each parameter to be tested. Where possible, samples will be collected at a depth of approximately one foot.

Edge Analytical, an EPA accredited laboratory, will perform the sample testing using EPA approved methods (Table 1). All laboratory costs shall be the responsibility of the City.

Table 1. Parameters and EPA methods for analysis of water quality samples.

Analyte	Sampling type	Units	Method Number	Method Reference	Instrument Detection Limit
Hardness (as CACO3)	Stormwater	mg/L	130.2	EPA	1.0
pH	Storm & Surface water	mg/L			
Ammonia Nitrogen	Surface water	mg/L	350.1	EPA	0.005
Total Nitrogen (TKN)	Surface water	mg/L	351.3	EPA	0.25
Nitrate + Nitrite	Surface water	mg/L	353.2	EPA	0.010
Total Phosphorus	Surface water	mg/L	365.2	EPA	0.005
Total Petroleum Hydrocarbon	Stormwater	mg/L	418.1	EPA	1.0
Total Dissolved Solids	Surface water	mg/L	160.1	EPA	1.0
Total Suspended Solids	Storm & Surface water	mg/L	160.2	EPA	1.0
Fecal Coliform Bacteria	Storm & Surface water	mg/L	200.7	EPA	0.002
Dissolved Copper	Stormwater	µg/L	200.7	EPA	0.002
Dissolved Lead	Stormwater	µg/L	239.2	EPA	0.001
Dissolved Zinc	Stormwater	µg/L	200.7	EPA	0.002
Carbamates	Stormwater	µg/L			
Organoclorines	Stormwater	µg/L			
Dissolved Oxygen	Surface water	mg/L	grab		

Figure 1. Surface and stormwater monitoring locations within the City of Burlington.

2.2 Sampling Locations

A total of nine water quality stations will be established at locations within the City of Burlington (Figure 1). These locations have been selected because they meet the study objectives of characterizing existing surface and stormwater conditions as well as identifying existing point and non-point source pollution to Gages Slough and the Skagit River. Stations will be located in the following areas:

10. Gages Slough at the N.E. corner of the City's property boundary
11. Gages Slough at intersection of Skagit and Rio Vista Roads
12. Gages Slough at Gilkey Road under Burlington Northern trestle
13. Gages Slough off Goldenrod Road downstream of I-5
14. Gages Slough at Pulver Road Pump Station
15. Joe Leary ditch
16. City of Burlington Wastewater treatment plant storm drain
17. Storm drain at Cascade Mall Drive
18. Whitmarsh Road pump station discharge to Skagit River

2.3 Sampling frequency

The frequency and location of water quality sampling will vary depending on the specific objective being addressed (Table 2). At the initiation of each monitoring year, samples will be tested for the complete list of analytes at all locations. Subsequently, to characterize general water quality throughout the year, samples of both physical and biological analytes as well as nutrients will be collected bi-monthly at each sampling location. For consistency these samples will be collected at 60-day intervals in January, March, May, July, September, and November. Following the analysis of the first year of data, the frequency and location of the sampling protocol may be altered.

2.4 Stormwater Sampling

Stormwater will be sampled twice annually following Ecology sampling guidance (Ecology 2002). Stormwater shall be sampled once during a spring storm and once during a fall storm. In each case there must be a minimum of at least 24-hours of no measurable precipitation prior to the sampling effort. The storm to be sampled must have an intensity of at least 0.1inches of rainfall (depth) in a 24-hour period (Ecology 2002). Three stormwater sites have been selected for this protocol (Figure 1). In addition, sites 1 and 5 will also be sampled during the stormwater sampling to provide information about into and outflow conditions from the City Limits.

In addition to the parameters tested bi-monthly in surface water samples, trace metals and pesticides concentration will be analyzed in stormwater samples (Table 1). The concentration of copper, lead, and zinc as well as organochlorine and carbamate pesticides will be evaluated from filtered storm water samples using the Washington State Water Quality Standards for Surface Waters (Washington Administrative Code [WAC] 173-201A).

Table 2. City of Burlington surface and stormwater sampling schedule.

Month	Parameters	Locations
January	All	All
March	Surface Water	1,2,3,4,5,6
Spring Storm	Stormwater	1,5,7,8,9
May	Surface Water	1,2,3,4,5,6
July	Surface Water	1,2,3,4,5,6
September	Surface Water	1,2,3,4,5,6
Fall Storm	Stormwater	1,5,7,8,9
November	Surface Water	1,2,3,4,5,6

3.0 QUALITY CONTROL AND QUALITY ASSURANCE

Many factors can introduce error into a monitoring program. Therefore, a quality control (QC) program will be implemented to check the quality of the data being collected. Quality assurance (QA) is an integrated system of management procedures and activities used to evaluate data quality and verify that the QC program is operating within acceptable limits (USEPA 1997). Such a program is essential for the collection of scientifically sound water quality data.

This QC/QA program specifies methods and procedures for the testing laboratory. Specifically, analysis will incorporates the collection and analysis of blank and spiked samples. Laboratory method detection limits for the selected water quality attributes have been identified to ensure the method detection limit is higher than the level required by the monitoring program. Laboratory water samples will be preserved, stored at 4°C during transport, and delivered to the laboratory within 24 hours following collection.

4.0 REFERENCES

How to do stormwater sampling; a guide for industrial facilities. 2002. Washington State Department of Ecology. Publication #02-10-071. Olympia, WA.

APPENDIX H –

Water Quality Assessment Memo for Gages Slough and the Skagit River

Sheldon & Associates, Inc.

5031 University Way NE #204 • Seattle, Washington 98105-4341
206-522-1214 • Fax 206-522-3507

Date: 2/17/05

To: Rod Garrett, Director of Public Works

Cc: Margaret Fleek, Director of Planning Department

From: Jenna Scholz, Water Quality Specialist

RE: **Preliminary Water Quality Assessment for Gages Slough and the Skagit River**

INTRODUCTION

A water quality assessment was conducted to characterize general surface water conditions and identify existing point and non-point sources of pollution to both Gages Slough and the Skagit River. Physical, chemical, and biological water quality parameters were monitored in 2004. Sampling was conducted along the length of Gages Slough within the city limits to assess current conditions and highlight any potential contaminants of concern.

This memo provides a summary of the water quality monitoring effort and a brief discussion of findings. Water quality data are compared with state and federal criteria as well as ambient data from other wetlands in the Puget Sound lowlands. Using these criteria, parameters of specific concern are identified and a brief discussion of their potential impact to wetland water quality is given.

METHODS

Standard techniques to assess water quality were used to monitor water quality within Gages Slough. A complete discussion of the methods used for this assessment can be found in the City of Burlington Surface Water Monitoring Plan (S&A 2004). Methodologies were developed to ensure a consistent and accurate sampling approach over a five-year monitoring period (S&A 2004).

Both comparison and compliance monitoring were conducted. Comparison monitoring was conducted by collecting samples in key wetland habitats within the slough and comparing them to other highly urbanized wetland systems in Puget Sound. Compliance monitoring was conducted by collecting samples from the upper- and lower-most stations within the slough. In addition samples were taken at specific stormwater outfalls. Sampling data were then compared with water quality criteria established by the Washington State Department of Ecology (Ecology 2003) and Environmental Protection Agency (EPA).

Analytes Evaluated

Physical parameters measured included temperature, total dissolved solids, total suspended solids, dissolved oxygen, and pH. Chemical parameters included nutrients such as nitrogen and phosphorus which are essential components of plant and animal diets; metals such as copper, lead, and zinc and total petroleum hydrocarbons associated with roadways and vehicles; and pesticides (e.g. insecticides) used on crops and gardens. Biological parameters included microorganisms such as fecal coliform bacteria from human sewage or animal manure. These disease-causing microorganisms have the potential to affect human and livestock health and generally enter surface waters in runoff containing animal or human wastes. Municipal discharges of sewage can also deliver bacteria and other organisms to surface waters.

Sampling Methods

Surface water samples were collected as grab samples by directly filling pre-labeled bottles containing the EPA recommended preservative for each parameter to be tested. During the storm sampling, composite water samples were collected and combined. Each stormwater sampling location was sampled three times during a storm event and combined into a single composite sample allowing for a 10% duplicate sampling for quality control and quality assurance protocol. Edge Analytical (an EPA accredited laboratory) performed the sample testing using EPA approved methods.

All samples were tested for the complete list of analytes at the beginning of the monitoring program in March 2004. Subsequently, the frequency of water quality sampling varied depending on the specific objective being addressed and the availability of City staff to conduct the sampling. For example, to characterize general water quality throughout the year, samples of physical, chemical, and biological analytes were collected every other month at select sampling locations. Stormwater samples were collected once in November 2004. In addition to the parameters tested in monthly samples, trace metals and pesticides were also analyzed in stormwater samples. The concentration of parameters from filtered storm water samples was evaluated using the Washington State Water Quality Standards for Surface Waters (Ecology 2003).

Sampling location

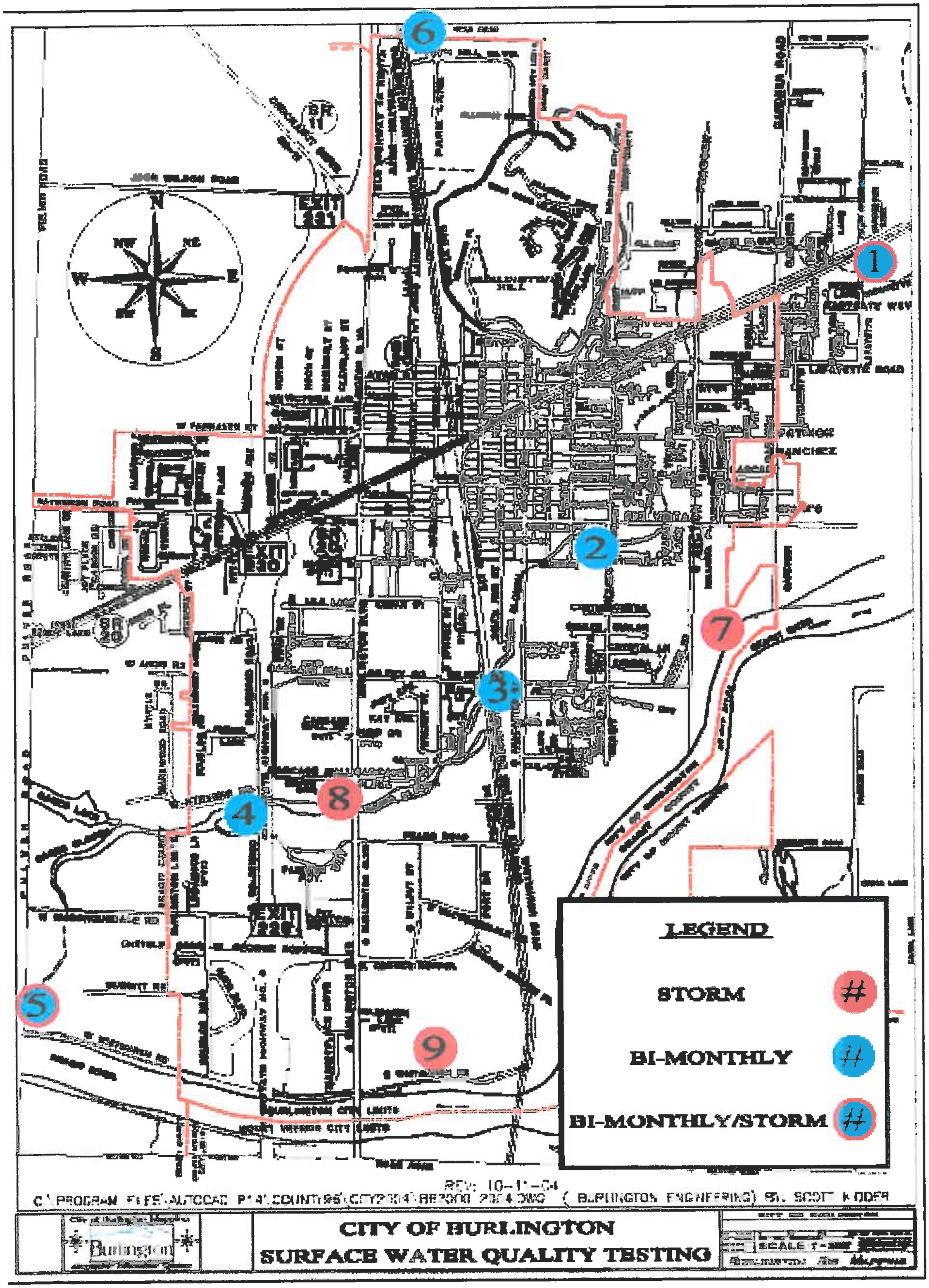
Nine water quality stations were established at locations along the slough within the City of Burlington (Figure 1). These locations were selected because they meet the study objectives of characterizing existing surface and stormwater conditions as well as identifying existing point and non-point source pollution to Gages Slough and the Skagit River. Stations were located in the following areas:

1. In Gages Slough at the upper most end at the City boundary off Gardner Road
2. In Gages Slough at the intersection of Skagit Road and Rio vista Avenue
3. In Gages Slough along Gilkey Road below the Burlington Northern Railroad Bridge
4. In Gages Slough at the intersection of Interstate 5 and Goldenrod Road
5. In Gages Slough just upstream of the pump station discharging to the Skagit River
6. At the outfall at the intersection with Old Highway 99 (northern most site)
7. At the outfall for the City of Burlington Wastewater Treatment Facility
8. In Gages Slough along Burlington Boulevard near the Cascade Mall
9. At the outfall to the Skagit River along East Whitmarsh Road

Evaluation Criteria

The Federal Clean Water Act (CWA) requires states to set standards for pollution and to enforce violations. The goals of the CWA include maintaining surface water that does not threaten the health of fish, shellfish, or wildlife. These goals establish standards for the specific chemical criteria set by the State of Washington Department of Ecology (Ecology).

Ecology has established water quality criteria for the protection of fresh waters of the state (Ecology 2003). These surface water criteria are used to highlight discrepancies between the quality of the water body being analyzed and the quality of water needed to support a healthy aquatic ecosystem. Water bodies not meeting state criteria are placed on Ecology's 303 (d) list for non-compliance. Section 303 (d) of the federal Clean Water Act (CWA) mandates that the state establish the Total Maximum Daily Load (TMDL) of pollutants for surface waters that do not meet standards after application of technology-based pollution controls. The TMDL


LEGEND
STORM
BI-MONTHLY
BI-MONTHLY/STORM
CITY OF BURLINGTON
SURFACE WATER QUALITY TESTING
EXIT 231
EXIT 230
EXIT 229
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determines the amount of a given pollutant that can be discharged to the water body and still meet water quality standards. In the case of non-point source wetland analysis, these surface water criteria are not used to determine exceedances in a regulatory context, as there are currently no specific water quality criteria for wetlands. Rather, the standards are used in an ecological context to highlight the pollutants of concern within a given water body. Ecology has developed criteria for fecal coliform bacteria, dissolved oxygen, temperature, and pH (Table 1).

Table 1. Surface water quality criteria for the designated uses of salmon and trout spawning, core rearing and migration; and extraordinary primary contact recreation (Ecology 2003).

Fecal coliform bacteria	Dissolved oxygen	Temperature	pH
Not > 50 colonies/100 mL	9.5 mg/L	16.0 °C (60.8 °F)	6.5 to 8.5

Ecology criteria are also provided for trace metals such as copper, lead and zinc (Ecology 2003). Unlike other criteria, which are adjusted by designated use, criteria for trace metals are based on the specific hardness of the water sampled; the harder the water the less toxic the metal. In order to determine the correct criteria, it is important to use a hardness value, which reflects ambient conditions because the higher the hardness value the higher the criteria will be. Criteria for this assessment is based on a hardness of 30.0 mg/L (Table 2), which is the mean value reported within samples collected in the study area.

Table 2. Ecology criteria for total trace metals.

Total copper criteria	**Total lead criteria**	**Total zinc criteria**
5.3 (µg/L)	14.5 (µg/L)	8.5 (µg/L)

In 1998, Gages Slough was placed on Ecology's 303(d) list for violations of fecal coliform standard. The Skagit River has a TMDL for dissolved oxygen and fecal coliform bacteria. This TMDL was prepared to address impairments to contact recreation in the Lower Skagit River Basin, and all the tributaries in the lower Skagit River basin to their headwaters (Ecology 2000). Gages Slough is a tributary to the Skagit River and stormwater from the City of Burlington is discharged either to Gages Slough or directly to the Skagit River. Therefore, concentrations of both fecal coliform bacteria and dissolved oxygen are of specific concern to this assessment.

In addition of Ecology criteria, the EPA has recommended section 304(a) water quality criteria for nutrients (Table 3). These criteria were developed with the aim of reducing and preventing eutrophication on a national scale. Criteria are recommended for both causal (total nitrogen and total phosphorus) and response (chlorophyll a) variables. Different criteria apply to different ecoregions across the United States. The criteria that apply to Washington State fall under Ecoregion II, Western Mountain Regions. Results from the sampling effort are compared against these criteria to determine the potential of nutrients to increase the rate of eutrophication in Gages Slough.

Table 3. EPA recommended regional criteria for nutrients.

Water body type	Total nitrogen (mg/L)	Total phosphorus (mg/L)
Rivers and Streams	0.31	0.05

Regional Wetland Comparisons

Wetlands have received increased attention in recent years as a result of continuing wetland losses and impacts resulting from development. In urbanizing areas, the quantity and quality of stormwater can change significantly as a result of land-use conversion in a watershed. Increases in the quantity of stormwater may result from new impervious surfaces (e.g., roads, buildings), installation of storm sewer piping systems, and removal of trees and other vegetation. On the other hand, decreased inflow of water can result from modifications in surface and groundwater flows. For cases where wetlands are the primary receiving water for urban stormwater from new developments, it is hypothesized that the effects of watershed changes will be manifested through changes in the hydrology of wetlands (Booth 1991).

Agricultural practices such as those from crops as well as small hobby farms and large farms can also affect wetland water quality. Improper agricultural practices can lead to physical erosion of pasture areas or stream banks by the animals as well as increased inputs of nutrients and bacteria from the animals. They can further affect water quality through the loss of riparian vegetation and subsequent increase in water temperatures. Increased inputs of organic materials and lower water temperatures lead to high bacterial counts and a decrease dissolved oxygen concentrations. Failing on-site septic systems can also allow bacteria and other disease causing organisms to enter surfaces waters. Additions of nutrients may also be associated with organic chemicals that enter the water following the failure.

To evaluate the relative quality of water within Gages Slough, data collected in other wetlands (Azous and Horner 1997) located in the Puget Sounds Lowlands were used to establish ambient conditions (Table 4). These data were used to provide a relative understanding of pollutant concentrations and identify sites that require further analyses. In this study, ambient water quality was established for wetlands with different levels of urbanization. The nonurbanized category had both < 4% impervious land cover and > 40% forest and highly urbanized sites had watersheds that were both > 20% impervious and < 7% forest by area.

The data for nonurbanized wetlands paint a water quality portrait of Puget Sound Basin lowland palustrine wetlands relatively unaffected by humans (Table 4). They are slightly acidic (median pH = 6.4) systems with dissolved oxygen levels often well below saturation. Suspended solids are routinely low but quite variable, reflecting the strong influence of storm runoff events on total suspended solids. Total dissolved nitrogen concentrations are higher than dissolved phosphorus, suggesting general limitation of plant and algal growth by phosphorus. Fecal coliform concentrations are low (< 10 colonies/100 mL), and heavy metals concentrations are in the low parts per billion range.

Table 4. Ambient values of water quality variables for wetlands with varying degrees of urbanization (adopted from Azous and Horner 1997).

Variable	Non-urbanized	Highly Urbanized
pH	6.4	6.9
Dissolved oxygen (mg/L)	5.9	6.3
Total suspended solids (mg/L)	2.0	4.0
Ammonia (mg/L)	0.021	0.032
Nitrate+nitrite-nitrogen (mg/L)	0.112	0.376
Total phosphorus (mg/L)	0.029	0.069
Fecal coliform bacteria (CFU/100 mL)	9.0	61.0
Zinc (ug/L)	5.0	20.0

RESULTS AND DISSCUSSION

Results from the water quality monitoring are presented for each of the 13 parameters analyzed. Data are compared against state and federal criteria and recommended standards as well as the ambient water quality data for wetlands at different levels of urbanization. Seasonal patterns are identified and, where possible, site-specific information is analyzed. Finally, specific parameters of concern are identified and their potential impacts to aquatic ecosystems are discussed.

This is the first year of water quality monitoring and, for a variety of reasons, not all data are available during each sampling effort. As a result, data interpretation for certain parameters (pH and metals) is limited. Despite this inconsistency, information for each parameter can be assessed to the degree necessary to determine if it is of concern. This monitoring program will be expanded in 2005, avoiding this difficulty in the future. A complete list of monitoring program improvements and changes is provided in the update to the Surface Water Management Plan.

Physical Parameters

pH:
A limited sampling of pH provides data for July through December (Figure 2). The pH levels were highest in July and lowest in December at most sites. Values were generally below both the Ecology criteria (6.5-8.5) and ambient values for wetlands in the Puget Sound lowlands (nonurbanized = 6.4; highly urbanized = 6.9), with the exception of site 2 which had the highest pH value reported (7.4). Site 4 consistently had the lowest pH values for all months sampled.

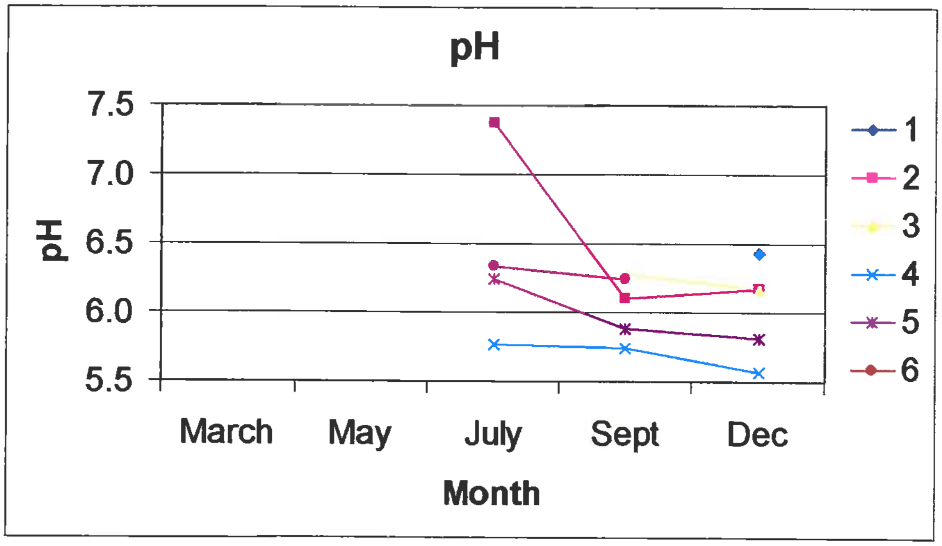

Figure 2. Levels of pH measured at study sites from July through December 2004.

The wetlands in Gages Slough are generally more acidic than most other wetlands in the Puget Sound lowlands. However, in some of their study wetlands, pH was less than 6 and generally, this water quality variables did not appear to depend on urbanization. Wetlands tended strongly to be more acidic than streams, and some more than others. Conversely, streams tended just as strongly to be slightly alkaline (and streams are the primary focus of Ecology's standards). This difference is very likely the result of organic acid production by plants that are virtually absent in lotic systems. Therefore, pH is not considered a parameter of concern in Gages Slough.

Dissolved oxygen:
Dissolved oxygen (DO) concentrations were collected from March through December (Figure 3). The DO levels were generally highest in March and lowest in July. With the exception of DO reported in March, values generally fell below the Ecology criteria (9.5 mg/L). Compared to the ambient criteria, study samples were generally below values for other wetlands in Puget Sound (nonurbanized = 5.9; highly urbanized = 6.3) during the warmer months.

Flowing streams are typically better oxygenated than wetlands. This is due to the constant mixing that occurs when water is moving. This is in contrast to the slow moving, shallow water in a wetland. DO is also inversely correlated to temperature. It is not unexpected to see the lowest levels of DO occur at the time of year with the highest water temperatures.

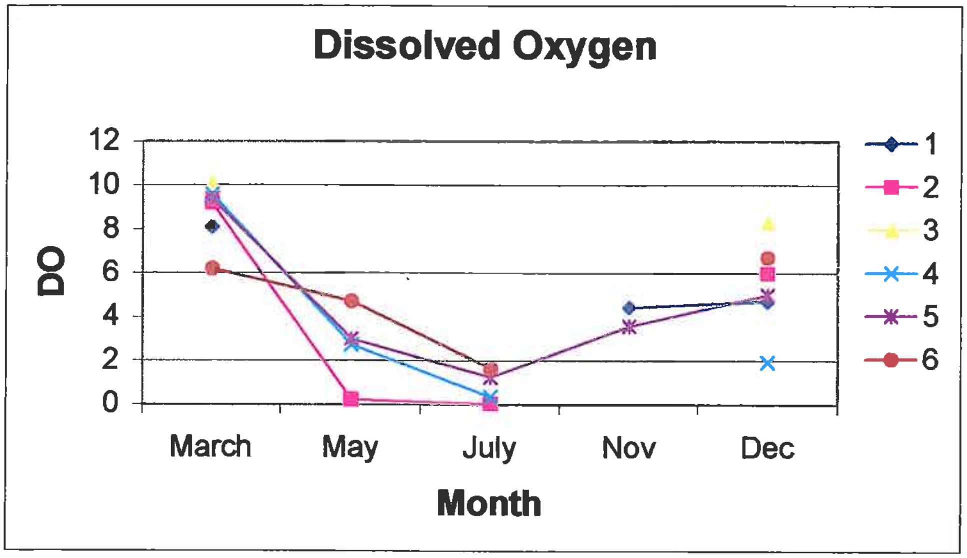

Figure 3. Dissolved oxygen concentrations at study sites from March through December 2004.

Because of the obvious seasonality of concentrations and the increase of this parameter to at or near ambient values for all sites during some or all months, DO is not considered a parameter of concern. Furthermore, concentrations of DO in water discharging to the Skagit River are not a concern, as water is well mixed in the pump house before release to the river.

Water temperature:

Water temperature data also appear to be seasonally dependent with the highest recorded values in July (Figure 4). Values exceeding the Ecology criteria (> 16.0 °C) were reported in July at sites 2 and 4. Increased water temperatures typically occur during the summer months when air temperatures are highest and low water volumes and slow velocities are present (Brown 1969). In fact, summer flows were so low, that sample collection was not possible at site 1 or site 3 in July.

Although values at some sites do exceed Ecology standards during the summer months, they are not a typical for lowland wetlands, and may in fact be lower than some lowland streams. Furthermore, water temperatures return to values below standards at the discharge point to the Skagit River (Site 5). Therefore, water temperatures are not considered a parameter of concern for Gages Slough.

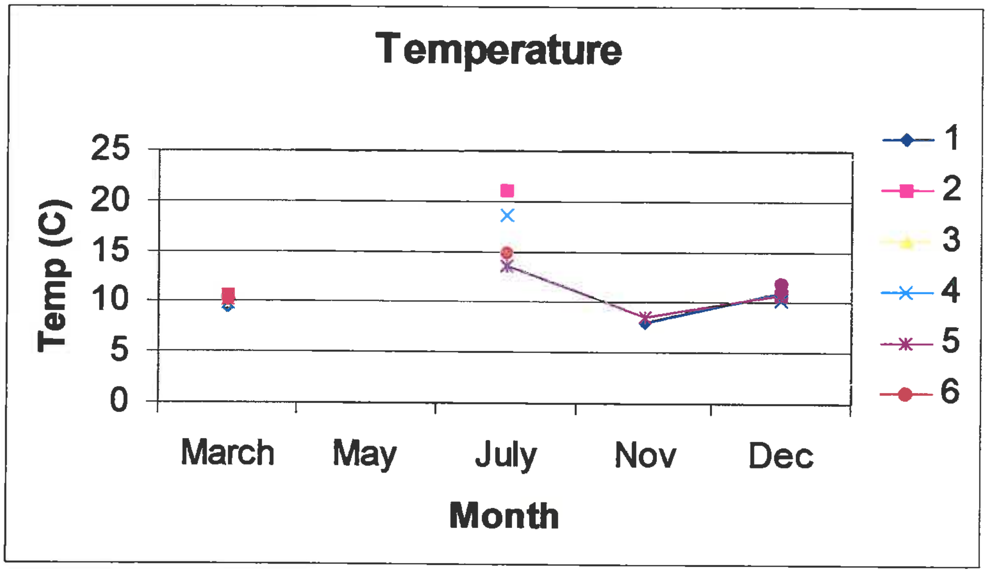

Figure 4. Water temperatures at study sites from March through December 2004.

Total suspended solids:
Concentrations of total suspended solids (TSS) varied seasonally and were generally above those observed in both nonurbanized (2.0 mg/L) and highly urbanized (4.0 mg/L) wetlands (Figure 5). Of the samples collected, 87 percent were 4 mg/L or higher. The highest concentrations were reported for March and May. These values were greater than 10 times that observed in highly urbanized wetlands. The lowest concentrations of TSS were observed in September and December.

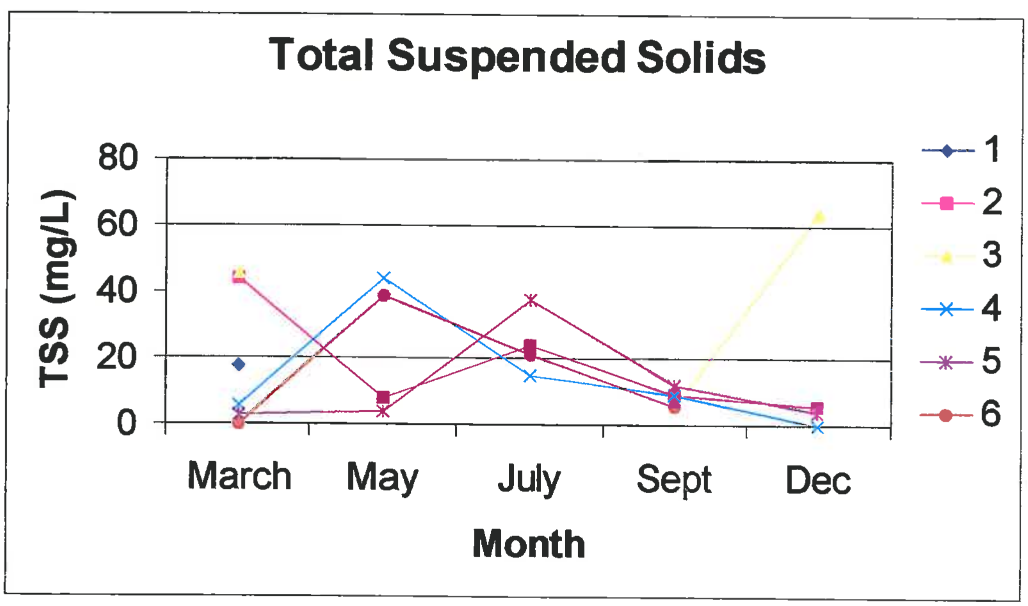

Figure 5. Total suspended solids concentrations at study sites from March through December 2004.

Suspended matter has a strong tendency to absorb and adsorb other pollutants (Stockdale 1991). Sedimentation, therefore, is a major mechanism of pollutant removal in wetlands (Chan et al. 1981; Silverman 1983). Accordingly, sites furthest downstream in Gages Slough should have the lowest concentrations of sediment. This is not the case, which indicates that the high degree of sedimentation in Gages slough may be overwhelming the ability of wetland plants to otherwise remove this parameter. Suspended sediment is a parameter of concern in this system.

<u>Chemical Parameters</u>

Nutrients:

Results for ammonia, nitrate+nitrite-nitrogen (N+N), and the sum of the two nutrient forms as total nitrogen (TN) are examined below. Data for these nutrients was collected from March through December (Figures 6,7, and 8). In general, concentrations of ammonia were highest in July (Figures 6). During the 2004 monitoring period, 100 percent of the ammonia samples collected (Figures 6) were above ambient values (nonurbanized = 0.021 mg/L; highly urbanized = 0.032 mg/L) or EPA criteria (0.31 mg/L).

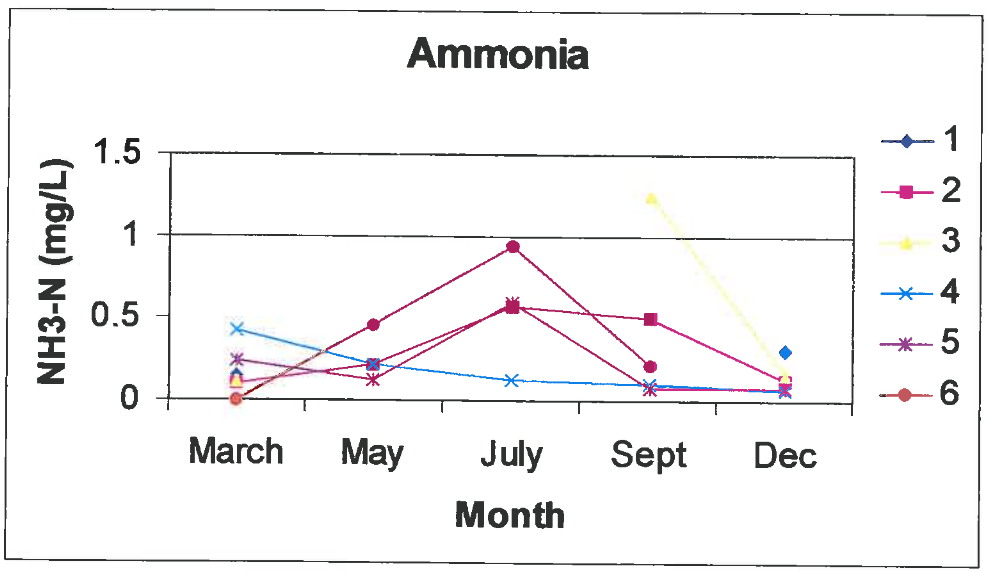

Figure 6. Ammonia concentrations at study sites from March through December 2004.

Wetlands produce ammonia in decomposing the abundant organic matter internally produced (Mitsch and Gosselink 1993). High concentrations of ammonia in July are possibly a result of greater fertilizer applications and lower water levels that concentrate nutrients at this time of year.

In contrast to the high degree of fluctuation in ammonia, N+N remained relatively constant across seasons and within each site, with the exception of Site 1 (Figure 7). Site 1 had the highest concentration of N+N and was as much a six times higher than values observed at other sites during the March sampling effort. About 62 percent of the samples analyzed for N+N were below the ambient criteria for nonurbanized wetlands (0.112 mg/L), and only 13 percent were above the ambient value for highly urbanized wetlands (0.376 mg/L).

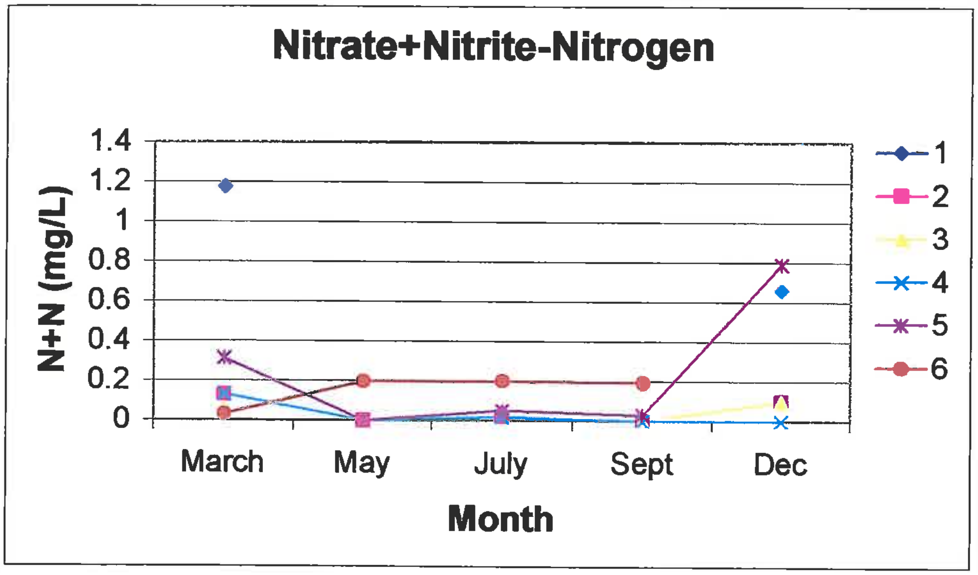

Figure 7. Nitrate+nitrite-nitrogen concentrations at study sites from March through December 2004.

The lower values of N+N may be due to localized nitrification. This process is influenced by seasonal changes in dissolved oxygen concentrations and water level, which determine on how much N+N will be found in the wetland water column.

Data for TN was collected from March through December (Figures 8). TN was high in July, particularly so at site 2, where concentrations were more than seven times those measured in May or at any of the other sites (Figure 8). For TN, 100 percent of the samples collected during the 2004 monitoring period (Figures 8) were above ambient values (nonurbanized = 0.021 mg/L; highly urbanized = 0.032 mg/L) or EPA criteria (0.31 mg/L in rivers).

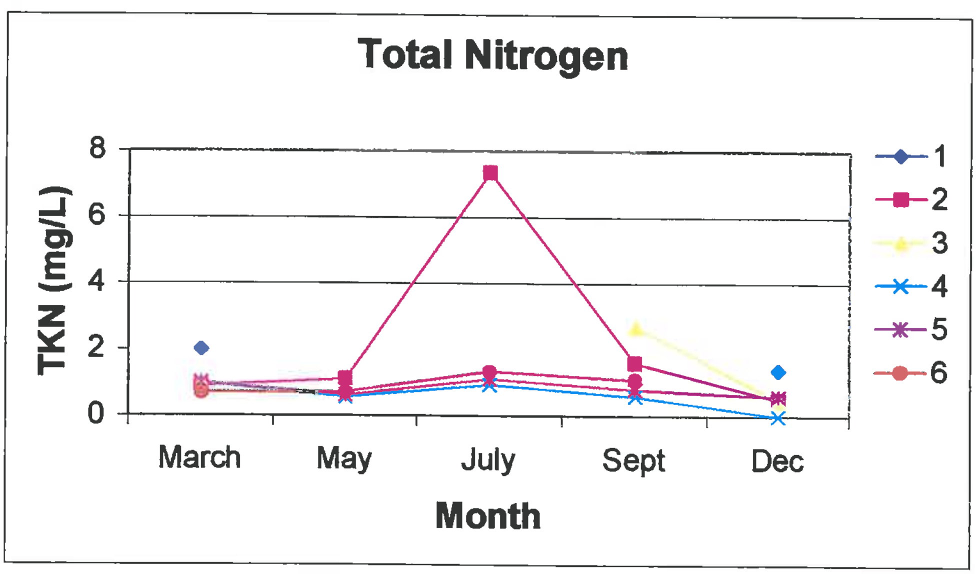

Figure 8. Total nitrogen concentrations at study sites from March through December 2004. TN measurements comprise the sum ammonia and N+N concentrations combined. Accordingly, TN concentrations naturally track those of these two nutrients. Because N+N values were relatively low, the high levels of TN are therefore most likely due to the high concentrations of ammonia present in the water column during sampling. Moreover, the concentrations of both ammonia and TN in Gages Slough are indicative of a highly eutrophic system.

Concentrations of total phosphorus (TP) were also measured from March through December (Figure 9). The seasonal patterns for this nutrient were similar to those observed for ammonia and TN, with the highest concentrations being observed in the summer. Again, the highest were values were observed at Site 2 in concentrations as much as five times higher than that observed at other stations that month (Figure 9). TP concentrations were above ambient values for Puget Sound wetlands (0.070 mg/L) in 79 percent of samples collected. They we also above the EPA criteria (0.050 mg/L) in 79 percent of samples collected.

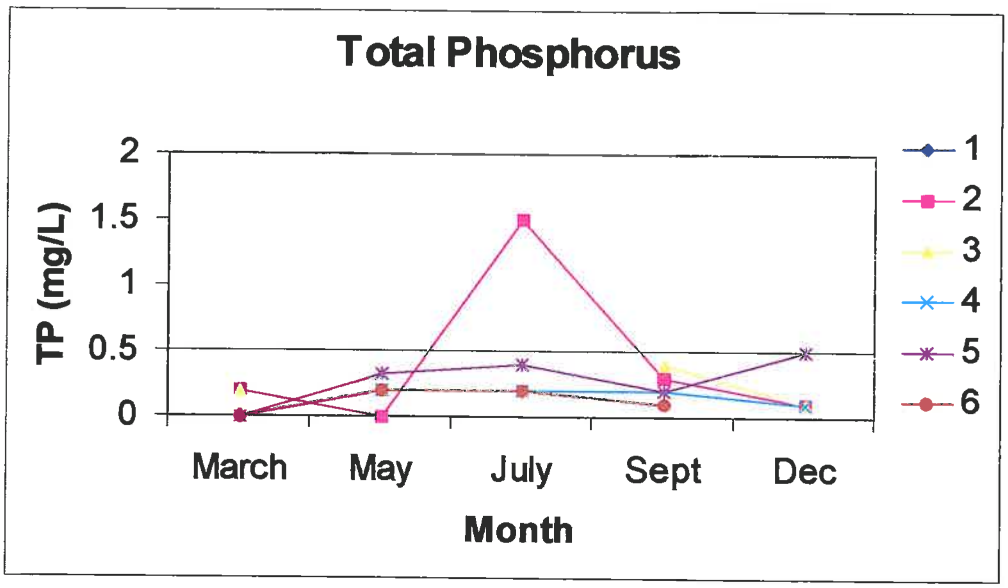

Figure 9. Total phosphorous concentrations at study sites from March through December 2004.

It is recognized that TP of greater than 0.050 mg/L is an indication of a hypertrophic state (Welch 1980). Wetlands are recognized as systems prone to eutrophication for a number of reasons including rapid nutrient cycling, and the fact that nearly their entire water column is in the photic zone. Azous and Horner 1997, also found that other wetlands in Puget Sound, even those subject to little or no urbanization, appear to have a rather high trophic state, and more urbanized systems are even higher.

Wetlands naturally intercept sediment, nutrients, and other pollutants transported from upstream and adjacent areas. They are therefore natural sinks for nutrients and have been increasingly used to remove nitrogen and phosphorus from wastewater, septic effluent, and enriched agricultural drainage (Azous and Horner 1997). However, when wetlands receive excessive nutrient loadings, ecosystem processes such as plant productivity and nutrient cycling are altered. Some of these alterations include changes in wetland structure and function (Carpenter et al. 1998) such as replacement of the slow growing native vegetation by faster growing invasive species (Davis 1991). Data from this first year of monitoring indicates that the wetlands in Gages Slough contain levels of nutrients (both TN and TP) that are above that observed in other wetland habitats in Puget Sound, even those experiencing a high degree of urbanization. Therefore, eutrophication is a concern for Gages Slough and should continue to be monitored.

Pesticides and hydrocarbons:
Analysis of both pesticides and hydrocarbons reveals that these parameters are not currently a concern in Gages Slough or in stormwater discharging to the Skagit River. Pesticides were not detected in any of the samples collected. Similarly total petroleum hydrocarbons were not detected in any of the samples collected in either March or November.

Metals:
Metals concentrations (copper, lead, and zinc) were monitored twice during the 2004 monitoring effort. The first sampling was during the initial sampling effort in March and the second was during the storm sampling in November. However, more sites were monitored in March than in November; during the March sampling effort samples were collected at nine locations, while they were only collected from five locations in November. This small and inconsistent sampling frequency limits the analysis of metals to an assessment of spring, dry conditions (March) and fall, wet conditions (November).

During March copper was only detected at sites 7 and 8 (Figure 10). In November, only site 2 had observable concentrations of copper. Eighty percent of the samples collected (including both March and November samples) contained no detectable levels of copper. However, in each of the three samples that did contain detectable amounts, concentrations exceed Ecology standards of 5.3 µg/L.

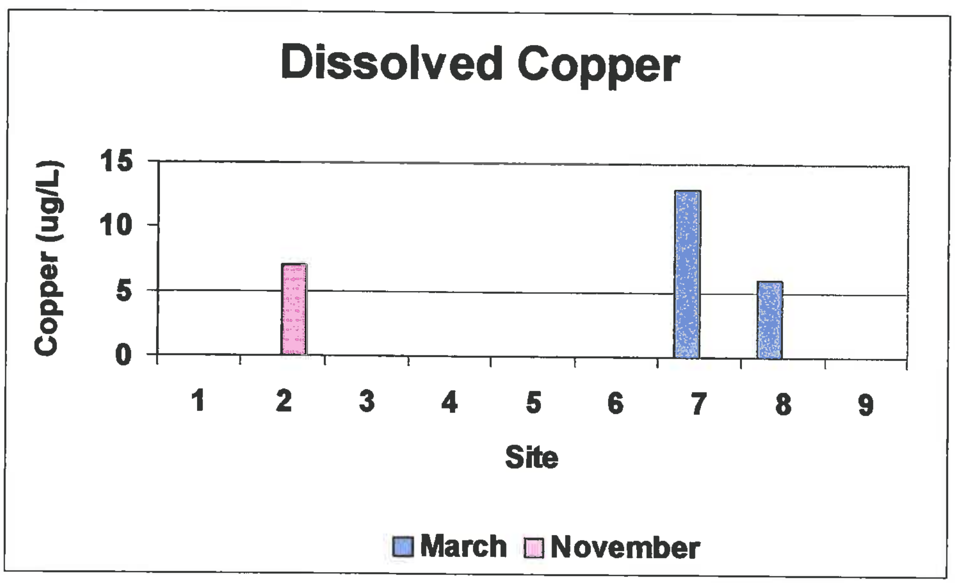

Figure 10. Concentrations of dissolved copper collected in March and November 2004.

Lead was reported in detectable concentrations at one site (Site 3) in March and two sites (Sites 7 and 8) in November (Figure 11). None of these findings overlap with the data reported for copper. Furthermore, although some sites did report values above detection limits all samples were below the Ecology criteria for this metal (14.5 µg/L).

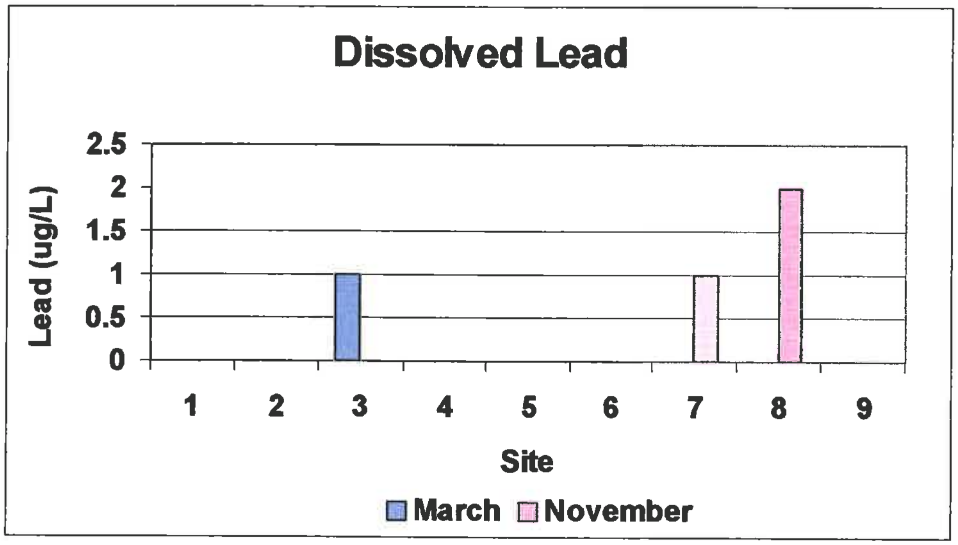

Figure 11. Concentrations of dissolved lead collected in March and November 2004.

Zinc was found in concentrations above detection limits in nearly all of the samples collected in both March and November 2004 (Figure 12). Seventy-eight percent of the sites with detectable concentrations were above the Ecology criteria of 8.5 µg/L. Furthermore, concentrations reported at site 5 in November were 28 times higher than the criteria. About 93 percent of these samples were above the ambient values (5.0) reported for nonurbanized wetlands in the Puget Sound lowlands. Finally, 33 percent of the sites sampled in March contained concentrations in excess of the 20.0 µg/L reported for highly urbanized wetlands, while eighty percent of sites were above this value in November (Figure 13).

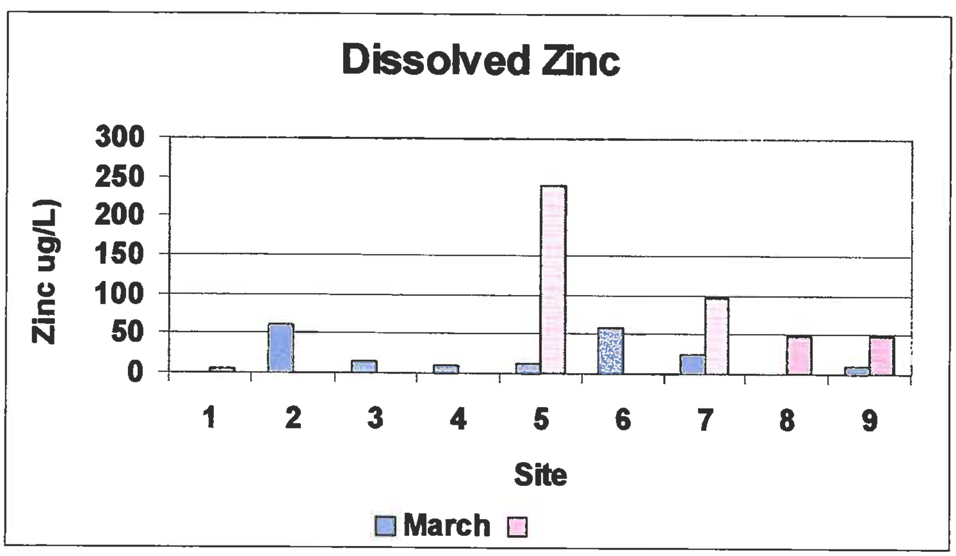

Figure 12. Concentrations of dissolved zinc collected in March and November 2004.

Zinc is typically the most frequently detected metal in wetlands (Azous and Horner 1997). Furthermore, stormwater runoff tends to contain higher concentrations than surface water, as was observed in this study. This is because zinc is collected on impervious surfaces where it accumulates over time and is then washed into receiving waters and subsequently diluted. The most likely sources of zinc detected in stormwater runoff from the study area are associated with automobiles. While break linings and clutch pads contain copper, tires contain zinc, released as they wear along the roadway. In addition to the stormwater sources, the zinc detected in the March samples could be derived from garden and lawn products. For example, zinc is a component of several moss repellents.

High concentrations of toxic materials such as zinc can interfere with the biological processes of wetland plants, resulting in impaired growth, mortality, and changes in plant communities. The degree to which plants bioaccumulate metals is highly variable. Although zinc is frequently detected in water samples, it is not often in quantities that exceed Ecology toxic criteria. For example, Azous and Horner 1997, found that criteria were only violated in one of their study wetlands, a highly urbanized one, in individual samples during the entire program. This same general situation prevailed for copper as well but not for lead, which was a found in only very low concentrations (Azous and Horner 1997). The high concentrations reported for Zinc in Gages Slough make it a parameter of concern.

<u>Biological Parameters</u>

Fecal coliform bacteria:
Fecal coliform bacteria (FC) concentrations were generally above Ecology criteria and varied seasonally (Figure 5). About 44 percent of the samples collected were above Ecology criteria (50 colonies/100 mL). Levels of bacteria observed in May and September were generally at or below the ambient values (nonurbanized = 271 CFU/100mL, highly urbanized = 969 colonies /100mL) while those observed in December were generally above ambient values and, at certain sites, were nearly 20 times these values (5000 colonies /100 mL at site 5).

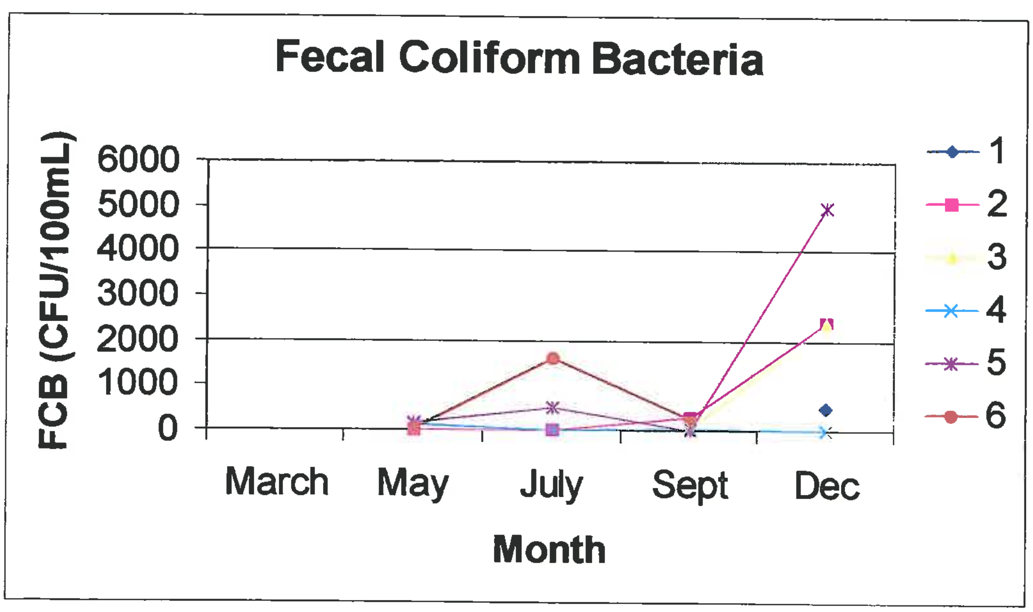

Figure 5. Fecal coliform bacteria concentrations at study sites from May through December 2004.

Fecal coliform bacteria are an indicator of pathogens from sewer and manure. FC concentrations levels have historically exceeded state standards in the Skagit River and its tributaries. As discussed earlier, a TMDL for FC was prepared (Ecology 2000) to address contamination issues and loading of this pollutant. FC can pose a public health threat with primary contact, and can degrade shellfish beds near the mouth of the river. In fact, these shellfish beds have been subject to harvest restrictions in the past. Because of these issues and the high levels of FC observed at the site of discharge to the Skagit River (site 5), FC is considered a parameter of concern for the City of Burlington.

SUMMARY

This first year of water quality monitoring has identified several parameters that may be degrading the health of the Gages Slough wetland system and water quality in the Skagit River (Table 5). These include fecal coliform bacteria, ammonia, total nitrogen, total phosphorus, and zinc. To further identify the potential non-point sources of these parameters an evaluation of contributing land uses is currently being conducted. This evaluation as well as a complete list of recommended structural and nonstructural best management practices (BMPs) will be included in the update to the City of Burlington Surface Water Management Plan.

Table 5. Gages Slough water quality parameters of concern.

Parameter of Concern	Potential Risk to Gages Slough	Water Quality Issue for Skagit River
Fecal Coliform Bacteria		X
Ammonia	X	X
Total nitrogen	X	X
Total Phosphorus	X	X
Zinc	X	X

It is recognized that wetlands are inherently dynamic systems, with annual, seasonal, and diurnal variability in water chemistry. In addition, they often have several sources of water supply, each possessing a distinctive chemical blend that varies from year to year. To better characterize the water quality in Gages Slough and to track changes in water quality over time, additional monitoring is needed. A complete list of monitoring recommendations and a plan to continue with the monitoring effort will also be provided in the update to the City of Burlington Surface Water Management Plan.

Please contact me with any questions and provide comments after March 7th, 2005. I look forward to getting your feedback on this report and completing the Surface Water Management Plan.

Sincerely,

Jenna G. Scholz, Senior Aquatic Biologist
Sheldon & Associates

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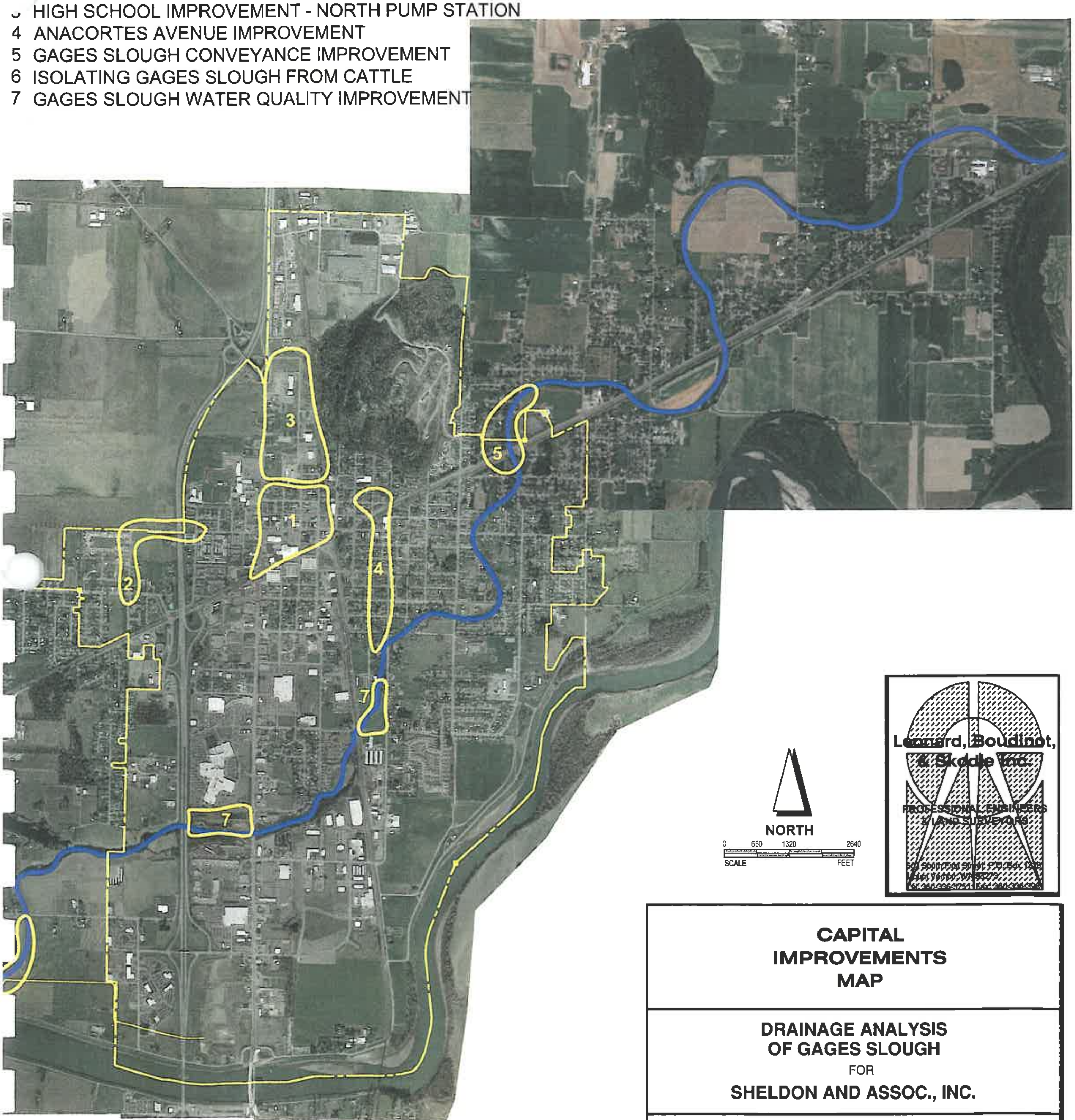
APPENDIX I –

Capital Improvements Map

PROJECT AND PROJECT TITLE

1 SPRUCE/ WALNUT STREET IMPROVEMENTS
2 WEST I-5 IMPROVEMENT - NORTH OF HW20
3 HIGH SCHOOL IMPROVEMENT - NORTH PUMP STATION
4 ANACORTES AVENUE IMPROVEMENT
5 GAGES SLOUGH CONVEYANCE IMPROVEMENT
6 ISOLATING GAGES SLOUGH FROM CATTLE
7 GAGES SLOUGH WATER QUALITY IMPROVEMENT



Leonard, Boudinot, & Skodje Inc.
PROFESSIONAL ENGINEERS & LAND SURVEYORS

CAPITAL IMPROVEMENTS MAP

DRAINAGE ANALYSIS OF GAGES SLOUGH
FOR
SHELDON AND ASSOC., INC.

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