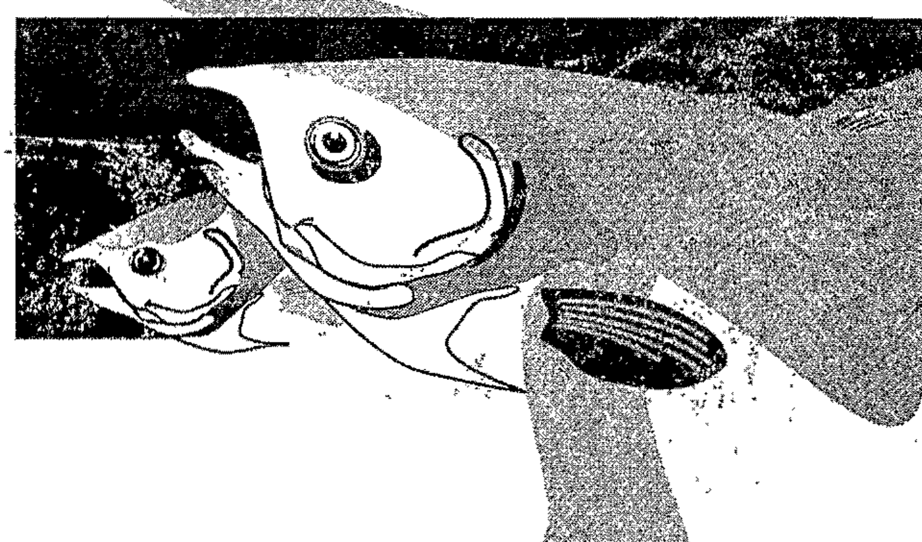
City of Bellingham

Watershed Master Plan

September, 1995



DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

Submitted to

CITY OF BELLINGHAM
Department of Public Works
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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The purpose of this plan is to provide a comprehensive watershed management plan for the city of Bellingham urban/suburban fringe areas. Acting under Chapter 90 RCW, the City of Bellingham authorized HDR Engineering, Inc. to prepare this plan.

The goals of this plan were to:

Analyze existing facilities and environmental resources

Identify existing and projected problems

Analyze alternative solutions and make recommendations

Prepare a management plan to implement recommendations

In addition to this plan, a Design Criteria Handbook has been prepared to guide the use of the Washington Department of Ecology's Stormwater Management Manual for the Puget Sound Basin (The Technical Manual). This handbook has been prepared as a separate document.

Recommendations include both structural and nonstructural solutions to flooding and water quality problems. The goal is to provide practical and environmentally sensitive solutions to allow responsible growth and yet maintain valuable natural resources.

ES.2 STUDY AREA DESCRIPTION

The City of Bellingham is the major urban area in Whatcom County. Whatcom County lies on the border between Washington and British Columbia between the Georgia Straight and the Cascade Mountains. The study area includes primarily Bellingham's urban fringe and was selected for the potential for urban growth and the lack of inventoried facilities. The study area includes portions of Whatcom Creek, Padden Creek, Padden Lake, Chuckanut Creek, and Baker Creek watersheds. Most of the areas are drained by open streams and have valued wetlands, habitat, and aesthetics.

The study area exhibits an array of storm and surface water characteristics including: wetlands, streams, ponds, ravines, ditches, and piped systems. Land use varies from forested land to industrial areas and includes agriculture, residential and commercial uses.

Existing land uses were established utilizing aerial photography from 1988, supplemented by field work. Land use projections were based on full build out at densities derived from current zoning designations.

ES.3 HYDROLOGY

The climate in Bellingham is typical of much of the maritime Pacific Northwest. It is typically mild and moist with most of the 35 inches of average annual precipitation falling from September through May.

The design storm selected for water quality facilities has a 6 month return frequency distributed over a 24 hour period. 90 percent of total rainfall volume occurs in storm events equal to or less than this event.

Channel and ditch erosion was evaluated based on a design storm having a 2 year return frequency. Facility capacity for trunk conveyance facilities was based on a 25 year return frequency event.

Land use characteristics for estimating runoff were based on pervious areas being wet from previous rainfall. This was done to characterize the typical winter soil conditions found in the study area.

ES.4 ENVIRONMENTAL EVALUATION

Environmental resources, such as wetlands and streams, were assessed based on vegetation species, vegetation diversity, impacts of current development, habitat potential, and erosion. They were then evaluated for general impacts of increased or decreased runoff and pollutant loadings from upstream development. Typically decreased base flows are a larger problem to the wetland hydrology than increased flows from specific storm events.

ES.5 WATER QUALITY

Annual pollutant loadings of 11 constituents were established for each basin outfall. Loadings were determined based on findings from similar land uses taken from recent studies in western Washington and National Urban Runoff Program (NURP) data from around the county.

ES.6 OPERATIONS AND MAINTENANCE

the 1992 Puget Sound Water Quality Plan requires each city and county within its jurisdiction to establish operations and maintenance programs and ordinances for new and existing public and private stormwater systems. The City of Bellingham has an organized program for accomplishing maintenance tasks through the Street Division of the Public Works Operations Department.

Recommended Maintenance schedules are discussed in Chapter 12.

ES.7 RECOMMENDED PLAN

Chapter 14 outlines the elements of the recommended Capital Improvement Program (CIP). The CIP includes projects to provide conveyance along the main drainage system for the 25 year design storm and to protect against erosion for the 2 year design storm. Where feasible, regional detention facilities have been recommended to reduce peak flows to downstream facilities. Some areas will still require local detention facilities to mitigate against downstream flooding. This program is projected to cost approximately five million dollars based on 1992 costs.

It is the intent of this plan to require all new development to implement onsite water quality measures to mitigate the pollutant concentration and loadings anticipated to be generated by proposed specific site activities.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

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1. INTRODUCTION

1.1 PURPOSE AND AUTHORITY

The purpose of this plan is to provide a comprehensive watershed management plan for the urban/suburban fringe areas of the Whatcom Creek, Silver Beach, Padden Creek, Padden Lake, Chuckanut Creek, and Squalicum Creek watersheds. While aspects of this management plan will apply to the central urban areas, those areas have not been included within the scope of this plan.

Acting under Chapter 90 RCW, the City of Bellingham authorized HDR Engineering Inc. to prepare this plan in an agreement dated July 9, 1991.

1.2 GOALS AND OBJECTIVES

The goals and objectives of the Watershed Master Plan include:

- Analysis of existing facilities and environmental resources
- Identification of existing and projected problems
- Analysis of alternatives leading to recommendations
- Preparation of a management plan to implement recommendations

In addition to preparing the Watershed Master Plan, the project goals include developing a Design Criteria Handbook to guide the use of the Washington Department of Ecology's (DOE) "Stormwater Management Manual for the Puget Sound Basin (The Technical Manual)" in the areas under the City of Bellingham's jurisdiction. This handbook is prepared as a separate document.

1.3 REPORT OVERVIEW

The study areas exhibit an array of storm and surface water characteristics. Features found at various locations through out these basins include wetlands, spring fed streams, ponds, ravines, open ditch collection systems, and piped systems. The land use has varied from forested or agriculture to high density residential and industrial areas.

Recommendations for stormwater management within the study areas include both structural and nonstructural solutions to provide practical and environmentally sensitive solutions to allow responsible growth and yet maintain valuable natural resources.

1.4 AGENCY COORDINATION

The project team has utilized experience working with other jurisdictions and agencies to obtain data or input on alternatives and recommendations. Contacts include:

Western Washington University (W.W.U.)
University of Washington
The Center for Urban Water Resources Management

Coordination has taken place with Whatcom County to inventory existing facilities.

The following organizations have been invited to comment on the plan:

Department of Ecology
Department of Fisheries
Department of Wildlife
Puget Sound Water Quality Authority
Whatcom County

2. STUDY AREA DESCRIPTION

2.1 GENERAL

The City of Bellingham is situated within Whatcom County. Whatcom County lies between the Georgia Strait to the west, the Cascade Range to the east, British Columbia to the north and Skagit County to the south. The study area for this plan includes portions of five watersheds which flow through the City of Bellingham. These watersheds include: Whatcom Creek, Lake Padden, Padden Creek, Chuckanut Creek, and Squalicum Creek.

The study areas within each watershed were selected because of their potential for urban growth and their lack of inventoried facilities. Most of the areas are drained by streams valued for wetlands and habitat as well as aesthetics.

The terrain within the study areas ranges from flat to steep and the streams flow through deep ravines in several locations.

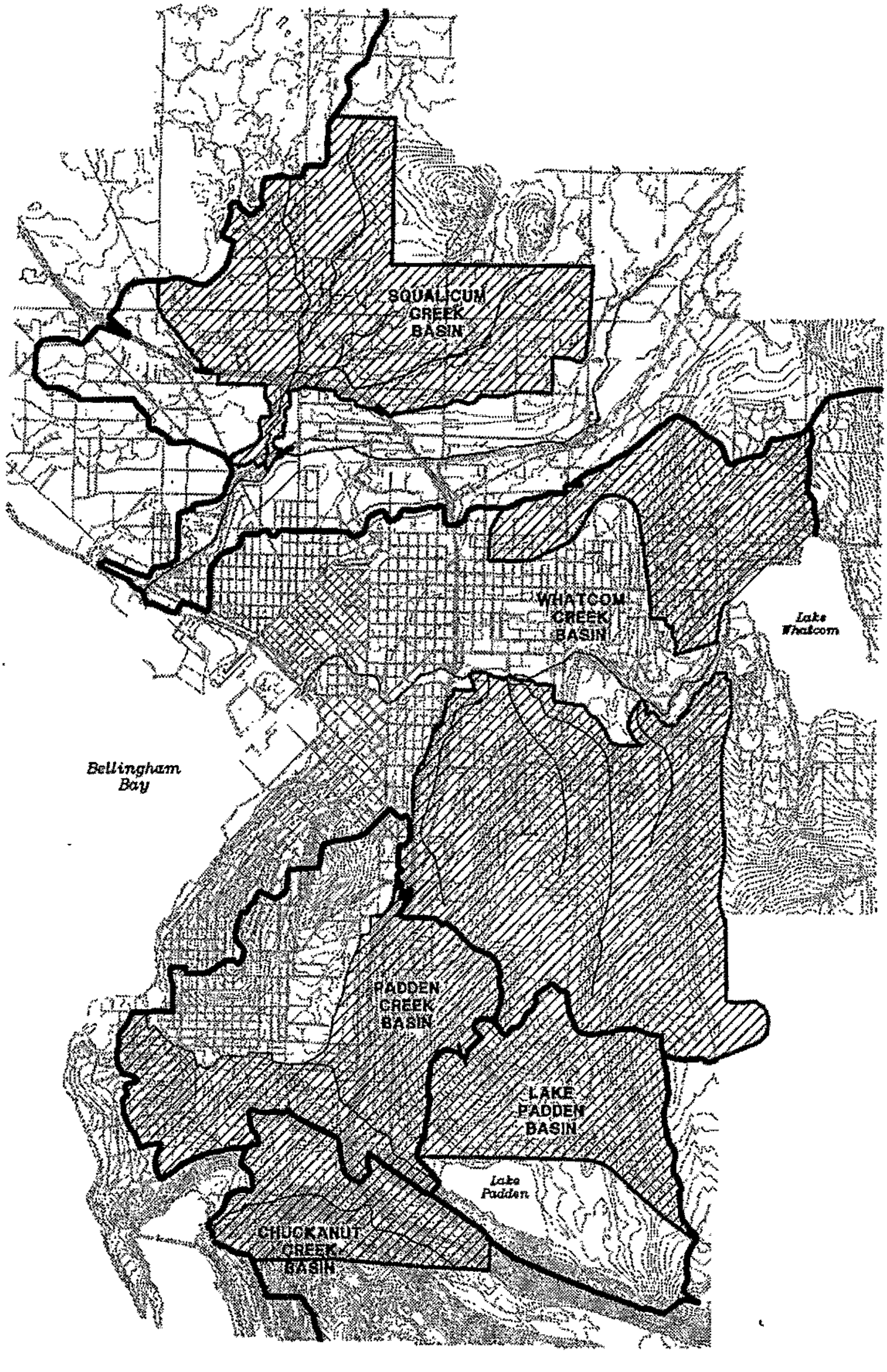
2.2 LOCATION AND BOUNDARIES

Figure 2.2 shows each watershed and the study area limits. The Whatcom Creek watershed extends from Lake Whatcom westward to Bellingham Bay. It includes most of downtown Bellingham and the coastline region. The study area portion of this basin consists of five basins, located inland from downtown. The basins include Fever Creek, Silver Beach, Lincoln Creek, Cemetery Creek, and Hannah Creek.

The Lake Padden watershed lies to the south of the Whatcom Creek basin. The study area includes the portion of the watershed north of Wilkin Street and Samish Way. The majority of the basin is located outside of the city limits. The non-study area consists of Lake Padden Golf Course and Park.

The Padden Creek watershed is composed of two basins, the Padden Creek basin and the Connelly Creek basin. The Connelly Creek basin is to the northwest of Lake Padden, whereas the Padden Creek basin extends from the lake outlet westward to Bellingham Bay.

The Chuckanut Creek watershed is south and east of Lake Padden. The study area includes an area parallel to Lake Padden, extending westward toward Chuckanut Bay, within the city limits.



CITY OF BELLINGHAM
WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE 22

STUDY AREA

The Squalicum Creek watershed is located to the north of downtown Bellingham. Two basins were studied within this basin, including the southerly portions of Spring Creek and Baker Creek. The main stem of Squalicum Creek, below Baker Creek, was included in the hydraulic analysis.

2.3 CLIMATE

The climate in the Bellingham area is typical of much of the maritime Pacific Northwest. It is usually mild and moist producing abundant precipitation from September through May. Spring, Winter and Fall are typically cool and breezy. In Winter occasional arctic air masses converge with the moist maritime air resulting in snowfall, even in the lowland areas. During the Summer a warm Pacific high pressure typically dominates weather patterns, bringing clear skies and warm temperatures. Average annual rainfall is 35 inches in the study area.

2.4 EXISTING LAND USE

The Whatcom Creek study area includes parts of seven Bellingham neighborhoods. The Puget, Whatcom Falls, Samish, York, Sunnyland, Roosevelt, and Alabama Hill neighborhoods all lie within the Whatcom Creek drainage basin. From initial development, the York and Sunnyland neighborhoods were developed at relatively high, suburban density. Historically, Alabama Hill, Roosevelt, Puget, Whatcom Falls, and Samish were developed in a low density, rural style. However, in recent years higher density suburban development has occurred in these areas.

Most of the Lake Padden drainage basin is forested or developed at a relatively low density for residential or recreational use. Development within the drainage basin is concentrated primarily to the north of Samish Way.

Portions of eight neighborhoods lie within the Padden Creek drainage basin. These neighborhoods include South Hill, W.W.U., Sehome, Fairhaven, Happy Valley, Samish, Edgemoor, and South. At present, the northern and western portions of the Padden Creek basin have been relatively highly developed with a mix of commercial, industrial, residential single and residential multi-family home usage. The study area, comprising the eastern and southern portions of the basin, is currently less developed, with the upper parts of the watersheds often dominated by steep, forested land. However, relatively dense residential and commercial development exists at the north end of the Connelly Creek subbasin, including large parking areas associated with a shopping center in the headwaters of Connelly Creek.

Most of the Chuckanut Creek Basin is located outside the study area. Portions of three neighborhoods, Edgemoor, South, and Samish, are in the study area. At present much of the basin is undeveloped forested lands and the neighborhoods are sparsely developed with rural residential housing along the major roads. Opportunities for additional development exist in all neighborhoods.

Parts of five Bellingham neighborhoods lie within the Squalicum Creek drainage basin. Lands within the study area consist of roughly 20 percent of the basin's drainage area. Much of the watershed is forested or rural, however relatively high density development has occurred north of Interstate-5 and along parts of Guide Meridian.

2.5 LAND USE PROJECTIONS

Within the Whatcom Creek drainage basin, the central and southern portions of the Puget and Whatcom Falls and the northern portions of Samish neighborhoods are areas where extensive development is likely to occur in the future. In addition some portions of the Fever Creek area are designated as industrial zoning. This growth will include increased amounts of pavement and the associated vehicle traffic.

Anticipated development within the Lake Padden study area is likely to be single-family residences, following the current trend. The more densely developed areas may consist of trailer parks. Future development pressure will likely occur north of Wilken Road and Samish Way.

Future development within the Padden Creek study area will most likely occur in the Happy Valley, Samish, Edgemoor and South neighborhoods. This development is anticipated to be a mix consisting predominantly of residential multi-family and single family homes. Most of the growth anticipated for the Connelly Creek portion of the study area will be a mix of residential and commercial.

Development within the Chuckanut Creek study area will most likely occur on the lower elevation slopes within the basin. This anticipated development will most likely be residential single family housing, following the current trend. Most of this basin is anticipated to remain forested because of steep slopes and limited access.

Anticipated land use in the Squalicum Creek study area is expected to consist of primarily single-family residential development. Higher density single-family residential and some multi-family residential development is anticipated along the main transportation corridors. Development along the Guide Meridian is expected to be primarily commercial and light industrial land use.

3. HYDROLOGY

3.1 GENERAL

This chapter presents an overview of the approach to the hydrologic and hydraulic system analysis performed in the study area. The methodology and criteria used in the system analysis are also included in the chapter.

3.2 MODEL DEVELOPMENT

Hydrologic analysis of the study area was performed using a computer model called "WaterWorks", which is based on the Soil Conservation Service's (SCS) TR-20 Model. The model is capable of modeling existing basin conditions and modifications to reflect future anticipated land use. Table 3.1 tabulates criteria used for the hydrologic/hydraulic analysis.

TABLE 3.1
CRITERIA FOR HYDROLOGIC/HYDRAULIC ANALYSIS

Aspect of Analysis	Criteria	Value(s)
System Capacity	Design Storm	
	■ Frequency	2-, 25-, and 100-year/24-hour events
	■ Total Precipitation	1.8, 3.1, and 3.8 inches total rainfall, respectively (NOAA).
Runoff	Hydraulic Capacity	System Inventory
	Land Use	Current land use established by aerial photography. Ultimate land use, assumed as full build-out of development as currently zoned.
	SCS Curve Numbers	
	■ Pervious Areas	Variable, see Table D.1 (Appendix D)
	■ Impervious Areas	CN=98

The design storms were selected for system analysis at 2-year, 25-year, and 100-year return intervals for the purpose of channel erosion control, facility capacity and improvement recommendations, and system responses, respectively.

Basin, subbasins, and their boundaries in each study area were verified using USGS quadrangle maps and contours found in the Bellingham Drainage Atlas (Drainage Atlas). Facilities were identified utilizing information from the Drainage Atlas. Subbasins were delineated to reflect tributary area to modeled facilities. Critical locations in the basin were identified for hydrograph generation based on existing facility capacity, anticipated expansion and future growth. The identified basins, subbasins, their boundaries, characteristics, and critical locations were verified through field examinations. Differences in these characteristics, (maps and drainage atlas versus field examinations) were reconciled to match field conditions and supplemented by further information provided by the City of Bellingham.

Given the design storm and its distribution, the computer model, "WaterWorks" was used to generate runoff hydrographs in terms of peak rates and total volumes from subbasins based on approximated runoff characteristics. The program was also used to combine and route those hydrographs through each basin's drainage system. The following subbasin characteristics have been approximated for use in the model to generate runoff hydrographs for each subbasin:

- Design storm (inches and distribution)
- Time increment of storm distribution (minutes)
- Total area, impervious and pervious areas (acres)
- SCS curve numbers (CN) for impervious and pervious area
- Time of concentration (minutes)
- Physical configuration of drainage facilities

The above information was taken from the Drainage Atlas, aerial photography, field examinations, and land use forecasts. The hydrograph computation method used in the model is the SCS Curvilinear Unit Hydrograph Method. Appendix D, Table D.1 shows the curve numbers used for land uses in western Washington. Table D.2 shows values used to determine time of concentration, travel time, and Manning's "n".

The SCS type 1A storm distribution was selected for drainage system analysis. The storm distribution selection was based upon an anaylsis of local rain gage data, rainfall distribution, and SCS established storm distribution for western Washington. The SCS distribution is based on a long record of measured storms. The following precipitation events were selected as design storm events for system analysis:

Return Period 24-Hour Duration	Precipitation Inches
2 Year	1.8
25 Year	3.1
100 Year	3.8

This information was obtained from isohyetal maps published by The National Oceanic and Atmospheric Administration (NOAA) Atlas 2 Precipitation - Frequency Atlas of the Western United States, Volume IX-Washington."

Given the parameters defined above, "WaterWorks" was used to generate runoff hydrographs for the pervious and impervious areas within each subbasin. These generated hydrographs were then combined and routed through the drainage network of pipes, open channels, and detention facilities. Peak flow and total volumes were estimated from the generated hydrographs at each point along the drainage system. Conveyance capacity for each modeled drainage facility was then examined based on estimated peak flows. Excessive channel velocities from the 2-year design storm are identified for erosion analysis.

The hydrologic model was applied for the following purposes:

- To provide data to analyze existing problems

- To identify other existing capacity and velocity problems and impacts of future growth

- To evaluate the effectiveness of alternative strategies proposed for managing surface and storm water in the basin

Modeled runoff peak flows and volumes were used to examine calculated capacities of model drainage facilities. These peak flows and volumes were used to identify inadequacies of the existing system under current and future land use conditions.

Volume 2 - Basin Details, appended to this document, provides hydrologic information for each study area. The following figures and tables are included:

Figure 1- "Hydrologic Flow Chart Schematic" correlates the subbasins and facilities with the routing logic used in "WaterWorks." See the correlating facility maps for location.

Tables 2 and 3 - "Flow Projections" show results of the hydrologic modelling.

Tables 6, 7, and 8 - "Curve Numbers" list a summary of curve numbers used in the hydrologic model and breaks down by land use for each basin. The curve numbers shown are weighted by land use, soil type, and area for both existing land uses and anticipated future land uses.

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4. ENVIRONMENTAL

The goals established early in the project included documentation of the presence and value of wetlands and streams in the study area. Associated with this goal was the need to predict the impacts and/or benefits to wetlands and streams resulting from watershed management options. It was also necessary to consider the presence of fisheries resources in the study area and to predict the impacts and/or benefits to fisheries resources of various watershed management options. Finally, a goal was established to identify and document nonpoint pollution problem areas in the drainage basins so this information could be used to control the problem. Generally, preservation of natural watercourses in the City's drainage basins was considered a high priority in the development of watershed management recommendations.

4.1 ENVIRONMENTAL STUDY DESCRIPTION

Whatcom Creek, Squalicum Creek, Padden Creek, and Chuckanut Creek basins, and the Lake Padden watershed were included in this study. The project limits within each basin were determined by the City. Detailed field studies did not cover the entire drainage basin areas, only inventoried were priority subbasins, priority streams within those subbasins, and priority wetlands within each of these subbasins. The priority subbasins were selected for field inventory based on their chances of being impacted by nearby development. Priority streams in selected subbasins were chosen based on their size, seasonality, and existing or pending development pressures nearby. Priority wetlands were determined to be those relatively close and hydrologically, or potentially hydrologically connected, to priority streams. Only wetlands identified in the City's existing inventory were field studied; however, previously uninventoried wetlands discovered during the field work were noted in the study.

4.2 WETLAND DESCRIPTION, EVALUATION AND IMPACT ASSESSMENT

Wetlands identified by the 1991 Bellingham Wetland Inventory and directly associated with priority streams, were examined during the Watershed Master Plan field investigation. The presence of hydrophytic vegetation, wetland hydrology and hydric soils were examined in each wetland. The dominant species in each vegetation layer were identified and density and maturity were estimated. Hydrologic information consisted of a flow rate measurement where surface inundation was present, observations of hydrologic constrictions and an assessment of the hydroperiod. Information on other important wetland parameters including shape, size, slope, and complexity of the upland/wetland boundary were also noted along with a characterization of the wetland substrate (soils).

A simplified functional values analysis was performed on the wetlands addressed by this study. This analysis consisted of evaluations of wildlife habitat, water quality benefits, flow attenuation potential, and groundwater recharge function for a given wetland. These evaluations were subjective (non-quantitative), based upon qualitative analysis performed by field biologists.

Because wildlife species ordinarily have unique requirements for food, cover, water quality and other habitat factors, the general status of wildlife habitat was evaluated by gauging three factors:

- The degree of disturbance to natural vegetation, where greater disturbance is likely to be detrimental rather than beneficial to existing wildlife.

- Proximity to development, where high density development and heavily traveled roadways generally reduce habitat quality of adjacent areas.

- The complexity of the ecosystem, where the presence of multiple wetland classes is biologically more diverse and more valuable.

The water quality benefits of wetlands were evaluated in light of the filtering potential of their vegetation and soils. Wetland geometry and vegetation density are important factors controlling the efficiency of the filtering function.

The floodwater attenuation function was evaluated by noting whether irregular wetland topography or the presence of substantial persistent hydrophytic vegetation could attenuate potentially high floodwater velocities thereby reducing erosional forces and stabilizing the existing wetland system. Although they are commonly areas of groundwater discharge, wetlands can be an important part of groundwater recharge in seasonally wet areas.

A wetland impacts assessment gauged the existing and potential effects of stormwater runoff on investigated wetlands. Stormwater runoff affects wetlands in three general ways including:

- Modifying the frequency and duration of wetland inundation which may have a direct influence on the stability of existing vegetation and wildlife communities.

- Increasing erosion (and downstream deposition) during high water flows.

- Generally reducing water quality through increased amounts of man-made pollutants and increased suspended solids from erosion.

For each wetland studied, a subjective interpretation was performed concerning impacts caused by periodic flooding from existing and future land uses, revised flows from potential future land uses, runoff water quality from existing and possible future land uses, and wetland groundwater exchange functions from future land uses. Wetlands which were most and least sensitive to stormwater impacts were listed and the anticipated impacts to these wetlands described. Wetlands with currently limited value, but with potential for improved value from enhancement were noted in the study.

4.3 STREAM DESCRIPTIONS, EVALUATIONS AND IMPACT ASSESSMENTS

The stream inventory consisted of stream characteristics including channel dimensions, riparian vegetation and other physical characteristics of streams. Channel dimensions such as bankful width and bankful depth reveal the stream's carrying capacity, regardless of the water level present at the time of the field investigation. Riparian vegetation was identified and evaluated for species diversity, habitat types, percent cover and percent shade. Other stream characteristics considered important for a comprehensive understanding of the stream environment included the identification of the stream substrate composition and degree of compactness, an estimate of slopes on land adjacent to the streams, occurrence and extent of bank erosion, water flow rate and water clarity.

Streams were qualitatively evaluated for wildlife habitat, aesthetics and water clarity. Fish are clearly the important wildlife associated with streams. Stream obstructions that appeared likely to prevent the passage of salmonid species were noted where observed. An aesthetic evaluation gauged the nature and degree of human disturbance on the local stream environment. Water clarity was noted and considered the best indicator of general water quality in the absence of laboratory testing for contaminants. Water clarity is largely a function of suspended solid content and contamination by point and/or nonpoint pollution sources. For observations made during seasonal low water levels, flow velocity is relatively slow. Consequently, erosion and suspended sediment would be low and water clarity would most likely be reduced by development-related activities. At high water flows, dilution diminishes the effect of development-related pollution and the clarity would most likely be reduced by suspended solids from elevated levels of erosion.

Because additional development in a watershed will very likely result in increased stormwater runoff, a stream impacts assessment section attempted to characterize the general effects of stormwater runoff on inventoried streams. These general effects include: (1) increased potential for stream flooding, (2) increase frequency and duration of high flow events, (3) increased erosion, (4) introduction of pollutants from nonpoint sources into the surface water system, and (5) displacement of current wildlife and vegetation communities.

Included in the analysis of stormwater impacts on streams were qualitative interpretations of potential impacts to studied streams due to periodic flooding from existing and future land use runoff, revised flows from possible future land uses, and runoff water quality from existing and future land uses. In each drainage basin, field inventoried streams were identified relative to their sensitivity to stormwater impacts. Additionally, streams were identified which were considered to be of limited value but to have potential for improved value through enhancement.

4.4 FISHERIES RESOURCE IDENTIFICATION

Fish habitat in the streams within the study area was determined through a review of existing literature and data bases listed in the bibliography. Because the available literature on local fisheries resources is scant, additional information was sought through personal communications with local fisheries experts. Fisheries resources documented in each basin are listed. Information is specific to a stream or stream reach or fish species as available.

Routine observations made while walking through each stream corridor included the identification of impediments to fish passage.

The general effects of increased or decreased stormwater runoff on fisheries habitat were subjectively assessed. In most cases, the effects of additional water volume are not likely to be a problem; however, most likely coupled with larger water volume would be increased sedimentation and pollutants which may pose a significant threat to salmon spawning habitat as well as other fisheries resources. Depending on their degree, duration and timing, decreased water flows can have a detrimental effect of fisheries resources.

5. WATER QUALITY

5.1 GENERAL

This chapter presents an overview of the approach to estimating pollutant loadings. The methodology and criteria used in the analysis are also included in this chapter.

5.2 POLLUTANT LOADINGS

Pollutant loading estimating was done utilizing a simple spreadsheet analysis. The spread sheet tracks annual wash-off rates for 11 constituents and tracks them for five different land use classifications.

The constituents tracked included:

Biochemical Oxygen Demand (BOD5)
Chemical Oxygen Demand (COD)
Total Suspended Solids (TSS)
Dissolved Solids (DS)
Total Nitrogen
Total Amonia
Total Phosphorus
Dissolved Phosphorus
Copper
Lead
Zinc

Sources for annual loadings included studies performed by the Municipality of Metropolitan Seattle Washington (METRO), WRMS Water Quality Manual, National Urban Runoff Program (NURP), and work being done for the Municipality of Anchorage, Alaska. Loadings used can be found in Appendix C, Table C.1. These loadings do not reflect potential reductions from current water quality improvement policies or implemented mitigation measures.

The land use categories included:

Commercial
Industrial
High Density Residential
Low Density Residential
Forest/Open Space

The land use areas for each basin were taken from the tables used to determine curve numbers as described in Chapter 3.

The purpose of developing these estimates is to look for trends in how land use revisions impact potential pollutant buildup and washoff. Volume 2, Tables 4 and 5 for each study area in the basin details appended to this document show the estimated buildups. Projected future loadings do not reflect the implementation of water quality Best Management Practices (BMPs). The loadings are intended to show the impacts of development without mitigation.

Further discussion on practices to mitigate the increases is presented in the Chapter 6 through Chapter 11.

6. GENERAL CONSIDERATION OF ISSUES AND RECOMMENDATIONS

6.1 GENERAL

One of the valued resources of the City of Bellingham and the adjacent area is the character of the natural streams. As development occurs, runoff increases both in peak flow and in volume of runoff from a given storm. In some cases the stream character has been lost or diminished due to channeling, piping, and armoring (rock lining) of natural stream reaches. In other cases the character has been diminished. One of the goals of this watershed management plan is to recommend ways to preserve the character of the natural streams as a valued resource.

This chapter presents known drainage and water quality issues and problems, identifies alternative solutions, and sets forth recommended actions to enhance the general surface/storm water system. It analyzes aspects of the surface/storm water system that pertain to all five watersheds.

Issues specific to individual basins are discussed in more detail in Chapters 7 through 11.

6.2 WATER QUANTITY ISSUES, PROBLEMS AND APPROACHES

Chapters 7 through 11 present known drainage problems which were identified through several sources: hydraulic modeling and analysis, flooding reports documented by City Public Works Staff, and field investigations. The alternative solutions to existing and anticipated future problems have been identified and recommended for actions to strengthen the future storm water system management.

The hydraulic capacities of the channels, culverts, and storm drains in the study areas were compared with the modeled peak flow rates from the 25-year frequency, 24-hour duration design storms under existing and future land use conditions. The future land use was based on the City's current zoning plan. Volume 2, basin details, lists a tabular comparison of capabilities of drainage facilities and modeled peak flow rates (Tables 2 and 3 for each study area).

Channel erosion problems were also identified based on the computer-modeled results. The model was used to determine channel velocities using the simulated 2-year storm in the drainage basin. Problems were identified for a channel reach if its modeled velocity exceeds the estimated scour velocity, typically 5 feet per second (fps).

The primary topic relating to quantity issues deals with regional detention compared to local site detention, bypass piping, or sizing pipes and armoring channels to convey the full design storm. These issues must be addressed on a site by site basis because every basin and subbasin is unique with special circumstances. It should also be remembered when dealing with quantity issues that water quality is an important factor as well and that water quality issues must be included in the decision process.

6.2.1 Regional versus Local Detention

In general it is better to provide for regional detention instead of relying on local detention facilities. If space is available, regional detention facilities can be worked into multiple use sites incorporating habitat enhancement, recreation, and/or open space. From an analysis perspective, they both work in about the same manner and afford the same level of protection. The main analytical difference is the routing of discharge hydrographs through various stream reaches. This difference has slight impacts on downstream flow projections.

The advantage of regional detention is that the storage volume can be more efficiently achieved in one facility as opposed to several. Reasons for this include setbacks, slope requirements, and fewer control structures. Large ponds can achieve a more efficient property area to volume ratio. Smaller detention facilities require more property area per volume of storage and therefore increased "lost opportunity" costs by using land that could have been put to other uses. Regional facilities allow additional land to be available for other uses by providing more storage per square foot of land. This can be carried over to reduced opportunity costs for development or other forms of open space use.

Another advantage of regional detention is lower maintenance costs. Fewer facilities to mobilize and demobilize for, reduces crew time. In addition, the responsibility for maintaining local facilities generally rests on the property owner or homeowners group. Often they are not aware of their responsibility, do not have the knowledge or equipment to do it properly, or do not have the funds to contract the work.

The disadvantage of regional detention facilities is that the conveyance system must be in place to convey the flows to the facility without damaging natural resources or improvements. Another disadvantage is that in some cases, development is ready to occur before the regional facilities can be funded or constructed. In these situations, local detention must be provided to protect facilities and environmentally sensitive areas.

6.2.2 Bypass Piping versus Increasing Channel Protection

Bypass piping provides a means to transport flows around sensitive stream reaches to protect them from erosion potential caused by increased peak flows or increased runoff volume. The advantage of bypass piping is its ability to protect the stream without disrupting the natural or landscaped areas with equipment and construction activities. It also generally reduces the need for easement acquisition. Bypass piping must be carefully planned to avoid utility conflicts in the street right-of-way; or to avoid environmental damage if constructed adjacent to the stream.

Protecting the channel by lining or rip-rap generally destroys or reduces the natural qualities of a stream and will dictate a fixed flow path that may further degrade the natural qualities. Once these fixtures are in place they need to be maintained and the changes to the flow regime can lead to other erosion or flooding problems. Any instream measures to protect a stream reach must also include analysis of disruption and environmental damage which will occur due to construction and maintenance. Some slope protection methods that involve bioengineering are less damaging over time. These designs utilize root mass to stabilize slopes. They must be carefully protected to prevent undercutting and monitored to be sure that the vegetation remains viable.

6.2.3 Detention Versus Increased Downstream Capacity

Both detention and increased downstream capacity solve water quantity problems for capacity and erosion issues. Detention facilities provide an opportunity for water quality improvement by providing an opportunity for sedimentation and in many cases, biofiltration. Bypass piping and channel protection measures will quickly aid to convey any water quality problems to the discharge location, where it may be difficult to treat.

6.2.4 Washington Department of Fisheries

The Washington Department of Fisheries has prepared draft revisions to the hydraulic code. These revisions would require runoff from projects including more than 5,000 square feet to detain increased runoff to the following standards:

- Runoff from a two-year design storm will be released at 50 percent of the pre-developed two-year peak discharge rate.

- Runoff from the 25-year design storm will be released at the pre-developed 25-year peak discharge rate.

6.3 ENVIRONMENTAL ISSUES, PROBLEMS AND APPROACHES

During the field work conducted in those drainage basins closely inventoried, specific existing and potential future environmental problems were identified and solutions were proposed as described in the basin-specific descriptions in Chapters 7-11. One of the general issues identified was the effect of existing and increased land development on the natural resources (streams, wetlands, fish resources and water quality) in the drainage basins. The development of land impacts the natural dynamic of pre-development environment along streams and in wetlands and can result in the presence of deleterious nonpoint chemical pollutants and sediment loads in the water of these resources. This, and the construction of physical barriers such as culverts along streams, can severely effect the ability of native fish and wildlife to survive the changes in their natural ecosystem. Associated with issues of land development related impacts are issues related to providing opportunity for development and economic viability within the City of Bellingham, while protecting the valuable, and sometimes fragile, natural ecosystem. Another issue is restoration of natural environments which have been negatively impacted in the past.

The environmental problems identified during the field work are directly related to the impacts of land development and land-use. Problems included: (1) the presence of stream reaches with severely eroded channels; (2) loss of fish habitat through the physical alteration of streams and woody riparian vegetation; (3) wetlands which have been disturbed so that many of their functions have been degraded and vegetative composition altered; and (4) degraded water quality in both streams and wetlands.

In general, solutions to the problems will largely be dependent on the successful implementation of the Watershed Master Plan, its associated land development guidelines and proposed Best Management Practices (BMPs). By identifying relatively unimpacted, high value natural resources, and by proposing basin-specific guidelines for nearby and upstream development in the future, existing valuable streams, wetlands, and fish resources can be better protected. By identifying those resources which are highly degraded or have the potential for degradation, subbasin-specific development guidelines and restoration plans can be implemented to prevent further degradation and allow for improvement of existing conditions. These solutions should protect and/or improve water quality and fish habitat in streams and wetlands.

6.4 WATER QUALITY ISSUES AND RECOMMENDATIONS

Water quality degradation typically goes hand in hand with increased development and intensified land uses. Sediments in the runoff are increased both from erosion and wash off from streets and parking lots. Many of the pollutants attach to the sediments and are transported along with them. Nutrients increase because land use practices include fertilizer applications and there is no heavy plant cover to filter or utilize them and not as much permeable soil to absorb them. In addition, the amount of oxygen demanding organics increases with intensified land uses, as do petrochemicals, metallic elements and organic compounds. Metallic elements and organic compounds can also result in toxicity, while petrochemicals also impact water quality.

Steps need to be taken as development occurs to minimize further degradation to the water quality of the streams and Bellingham Bay. Many of these steps can be retrofitted into currently developed areas to improve the quality of surface water runoff.

The Washington Department of Ecology has established the 6-month return frequency storm as the water quality facility design storm for the Puget Sound basin. It is the intent of this plan to require all new development to implement on-site water quality measures, or arrange off-site provisions, to mitigate the pollutant concentrations and loadings anticipated to be generated by the specific site activities.

Examples of BMPs to improve water quality include the use of grass filter strips, settling ponds, biofilters, construction wetlands, oil/water separators, infiltration, concentrators and filters. They can also include incorporating clearing setbacks from streams, removing livestock from streams and other sensitive areas, revising landscaping and runoff patterns, stabilizing slopes by terracing and/or bioengineering, selective clearing limits and improving ground cover.

Public environmental education can be an important element contributing to the improvement of water quality in streams. The effort should be targeted to both residential contributors and commercial/industrial contributors. Examples include water quality programs in the schools, public forums, and printed brochures describing how to dispose of (or recycle) yard and other household wastes including automobile motor oil, anti freeze, soapy water and cleaners.

Key public education points include:

- The promotion of integrated pest management
- Proper application of fertilizers
- Use of native plants in landscaping
- Proper disposal or recycling of wastes such as soapy water, oils, anti freeze, cleaners, solvents, etc.
- Reducing impervious surfaces in residential site design

6.4.1 Potential Nonpoint Source Pollution Problems along Streams

While walking along each inventoried stream corridor, observations of nonpoint pollution sources were made. Anticipated nonpoint source pollution problems included livestock as potential sources of manure runoff; adjacent residences as potential sources of wastes from failed septic systems, lawn and garden chemicals and fertilizers, automobile oils, antifreeze and gasoline; adjacent businesses as potential sources of lawn and garden chemicals, automobile related pollutants, and chemicals associated with manufacturing processes; adjacent roads as potential sources of automobile-related pollutants (zinc, lead, asbestos, antifreeze, oils, etc.), winter road salts and traction sand; and outfalls to streams or wetlands from any known or unknown source. Possible nonpoint pollution sources were observed during the field investigations and a list of the types of potential pollutants and their respective reach locations is included in the basin descriptions.

6.4.2 Regulatory Considerations

The Puget Sound Water Quality Management Plan requires implementing source control and treatment and effective treatment, using BMPs, of the six-month design storm for proposed development.

The National Pollutant Discharge Elimination System (NPDES) program will require a water quality sampling program to identify outfalls with high pollutant discharges. The program will also require corrective measures for these discharges.

Washington Department of Fisheries has prepared draft revisions to the hydraulic codes that would require BMPs to be utilized for water quality. Identified BMPs include wet detention ponds and biofiltration channels.

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7. WHATCOM CREEK BASIN

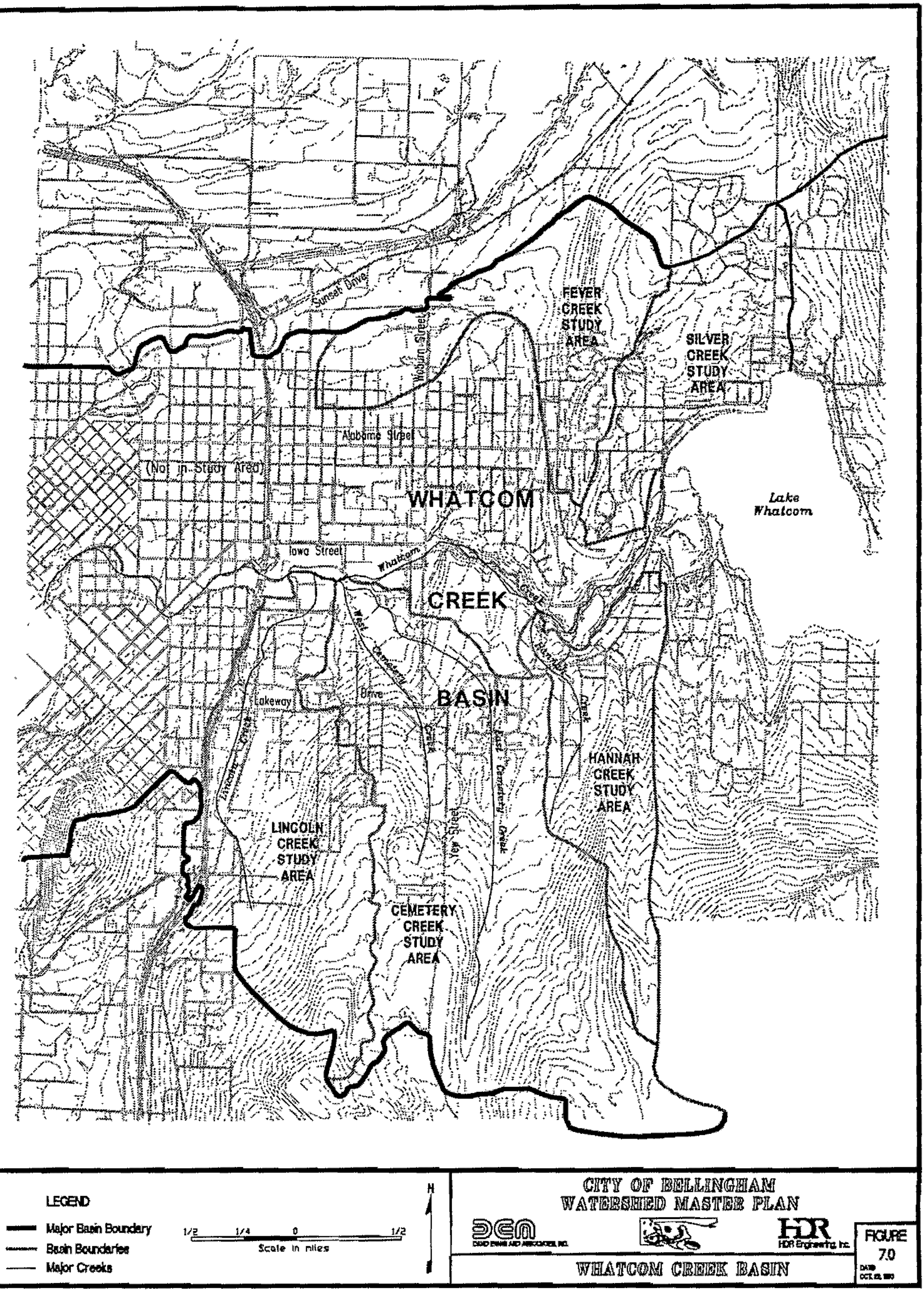
Parts of seven neighborhoods including Puget, Whatcom Falls, Samish, York, Sunnyland, Roosevelt, and Alabama Hill lie within the Whatcom Creek drainage basin. From the start, the York and Sunnyland neighborhoods were developed at a relatively high, suburban density. Historically, Alabama Hill, Roosevelt, Puget, Whatcom Falls, and Samish were developed in a low density, rural style. However, in recent years higher density suburban development has occurred in these areas. Figure 7.0 presents the subbasins within the Whatcom Creek Basin and the study areas.

Within the Whatcom Creek drainage basin, those areas where extensive development is more likely to occur in the near future include the central and southern portions of Puget and Whatcom Falls and the northern portions of Samish. East Cemetery Creek, West Cemetery Creek and Lincoln Creek are the principal drainage corridors in these areas; therefore, they were designated as priority streams to be included in the present study. Additionally, selected wetlands in the Silver Beach drainage area and in the Fever Creek drainage basin were included in the field inventory of aquatic resources.

A modified wetland functions and values assessment was performed on selected wetlands which were identified in the 1991 Bellingham Wetland Inventory and associated with East Cemetery Creek, West Cemetery Creek, Lincoln Creek, Fever Creek and the Silver Beach drainage area. Stream reaches along East and West Cemetery Creeks and Lincoln Creek were inventoried in the field.

The majority of the field investigation of the Whatcom Creek drainage basin was conducted between September 4, 1991 and October 22, 1991 during an interval of little precipitation and mild temperatures. Water levels in streams and wetlands were thought to be at, or near, their annual low at the time. Wetlands surveys in the Fever Creek and Silver Beach drainage areas were conducted on February 5, 1992, a much wetter time of the year.

Narratives summarizing all pertinent data from the field forms are presented below. For a more detailed description of individual stream reaches and wetlands, see Appendix E and Volume 2.



CITY OF BELLINGHAM
WATERSHED MASTER PLAN

HDR Engineering, Inc.

WHATCOM CREEK BASIN

FIGURE 7.0

7.1 FEVER CREEK STUDY AREA

7.1.1 Basin Characteristics

The Fever Creek Basin (Figure 7.0) has an approximate area of 580 acres. The northerly portion of the study area is zoned primarily for industrial uses and has seen some development. The easterly portion of the study area is a long narrow drainage which consists of residential land uses. The basin is mainly drained by a ditch, with intermittent flow, adjacent to a trail along the western boundary of the basin. Most of the tributary drainage facilities are pipes and ditches. Figure 7.1.1 depicts drainage facilities. Figure 7.1.2 depicts wetlands and stream reaches.

The majority of the soil types are silty loams with moderate percolation rates. The area north of St. Clair detention basin is an undeveloped area with high soil infiltration rates.

7.1.2 Wetlands

One wetland area in the Fever Creek subbasin, WH-33a, was studied during the field investigation of the Whatcom Creek drainage basin. This wetland consisted of forested and scrub-shrub wetland classes and was associated with an existing storm water detention facility. A complex combination of wetland types appears to provide excellent wildlife habitat and the combination of thick herbaceous and persistent vegetation affords moderate biofiltration and floodwater attenuation values. Existing conditions of the wetland suggested that increased storm water flows could be managed without substantial negative impacts.

7.1.3 Streams

Much of the land in the Fever Creek subbasin has been developed and in the process, the natural course of the creek has been modified through channelization. No stream inventory field work was performed on Fever Creek as part of this study.

7.1.4 Fisheries

Sources indicate no known fish utilization of Fever Creek in the study area.

7.1.5 Nonpoint Pollution

Relatively dense residential and commercial development occurred within the Fever Creek subbasin and consequently, the potential for nonpoint pollution problems is considered high. Nonpoint pollution resulting from residences, roads and commercial development within the Fever Creek basin is expected to occur (refer to "General Discussion of Identification of Possible Nonpoint Source Pollution Problems Along Streams" in Chapter 4).

7.1.6 Water Quality

Most of the growth anticipated for this portion of the Fever Creek Basin is designated to be industrial. This growth will include increased amounts of pavement and the associated vehicle traffic. Volume 2 includes tables showing existing and projected pollutant loadings from the basin based on historical data listed in Appendix C. As can be seen, most of the designated pollutants will increase over 300 percent and some of the metals are projected to increase approximately 500 percent.

Most of these pollutants readily attach themselves to suspended solids. By removing solids from the runoff, these pollutants typically are removed as well. Most of this area has been cleared and graded in anticipation of development with provisions being made for detention facilities. The detention facilities should include provisions for sediment removal as part of their design, or can be modified to include a sediment trap. Utilizing grassed swales as part of site grading and for parking lot runoff has proven to be effective in removing pollutants as well.

For the residential areas, public environmental education resulting in lifestyle modifications can be an effective way to reduce the impacts of development on water quality. Key areas include promotion of use of integrated management and proper application of fertilizers in the landscape; use of native plants in landscaping and proper disposal or recycling of household wastes such as soapy water, oils, antifreeze, cleaners, etc.; and reducing impervious surfaces in residential site design.

7.1.7 Problem Identification

Figure 7.1.1 shows the approximate location of each of the problem areas listed in Table 7.1.

TABLE 7.1
IDENTIFIED FEVER CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	P11 P12	FUT	PIPE CAP	Parkview Subdivision Bypass
2	D21 D23	FUT	CHAN VEL	Illinois Street, west of Vining Street, ditch erosion
3	P122	EX	INLET	Stream inlet east of East Alpine Drive
4	Multiple Locations	FUT	CHAN CAP WQ	West of St. Clair Street

[a]Abbreviations: EX = Existing Land Use; PIPE CAP = Pipe Capacity; CHAN VEL = Channel Velocity; INLET = Inlet Capacity; FUT = Future Growth Land Use; CHAN CAP = Channel Capacity; WQ = Water Quality

7.1.8 Alternative Analysis

Problems No. 1, No. 2, and No. 3

The pipe installed to bypass upstream flows at the Parkview subdivision will not handle the flows generated by further development in the upstream basins.

Channel velocities exceed scour velocity limits for fully developed conditions in ditches along Illinois Street, west of Vining Street.

Periodic flooding has occurred due to the installation of a small diameter pipe, constricting the stream inlet to the piped system east of Alpine Drive.

The following alternatives will provide solutions to Problems No. 1, No. 2 and No. 3.

Alternative 1 -

- Enlarge the undersized pipes in the Parkview subdivision bypass to 18- inches diameter.
- Maintain rock lining of channel sides along Illinois Street, west of Vining Street. Install rip-rap check dams as needed to flatten channel gradient.
- Replace the existing small diameter plastic pipe at the stream inlet east of Alpine Dr. with an 18-inch diameter pipe and include a rock or sand bag head wall to direct flow into pipe.

Alternative 2 - Require local detention for each site as the upstream area develops.

Alternative 3 - Divert a greater portion of the existing runoff from subbasins FC101 and FC114 into the Barkley Boulevard drainage system to offset increased flows from new development south of Barkley Boulevard. Low flows from subbasin FC114 should still be allowed to continue along its natural course because some landscaping improvements have been done along the stream. This flow should be kept to under approximately one half of a cubic foot per second so that downstream facilities will not be overtaxed after development. Channel armoring will still be necessary along Illinois Street.

The recommended solution is Alternative 3, increase utilization of Barkley Boulevard drainage system. The system as it exists has the capacity to handle existing flows. The hydrological model did not show any of the modeled pipes to be undersized for a 25- year design storm. Alternative 1 and 2 require disturbance to existing facilities and along easements and private property. Alternative 2 would provide protection by reducing peak flows but would still subject downstream ditches to increased erosion potential due to larger volumes of runoff from developed conditions. Alternative 2 would also place a burden on the downstream facilities to accept increased flows if the detention ponds were to fail from blockage or storms that exceed the design criteria.

Alternative 3 can be installed when the upstream area develops and can be constructed by the developer as part of the development project. This alternative would utilize regional water quality and detention facilities at St. Clair Pond eliminating the need for on-site detention. It would also include a means to direct overflows along the roadway to the St. Clair Detention Pond and not through the existing system. Alternative 3 should be constructed in conjunction with development and will not be included in the Capital Improvement Program.

Problem No. 3 - Stream inlet east of Alpine Drive

The third element of Alternative 1, improving the stream inlet configuration (Figure FC.1), will still be required since flooding occurs under current storm events. The small diameter pipe appears to have been installed by the property owner. Construction could be done with a small works project or by City crews.

Problem No. 4 - Downstream Capacity and Water Quality west of St. Clair Street

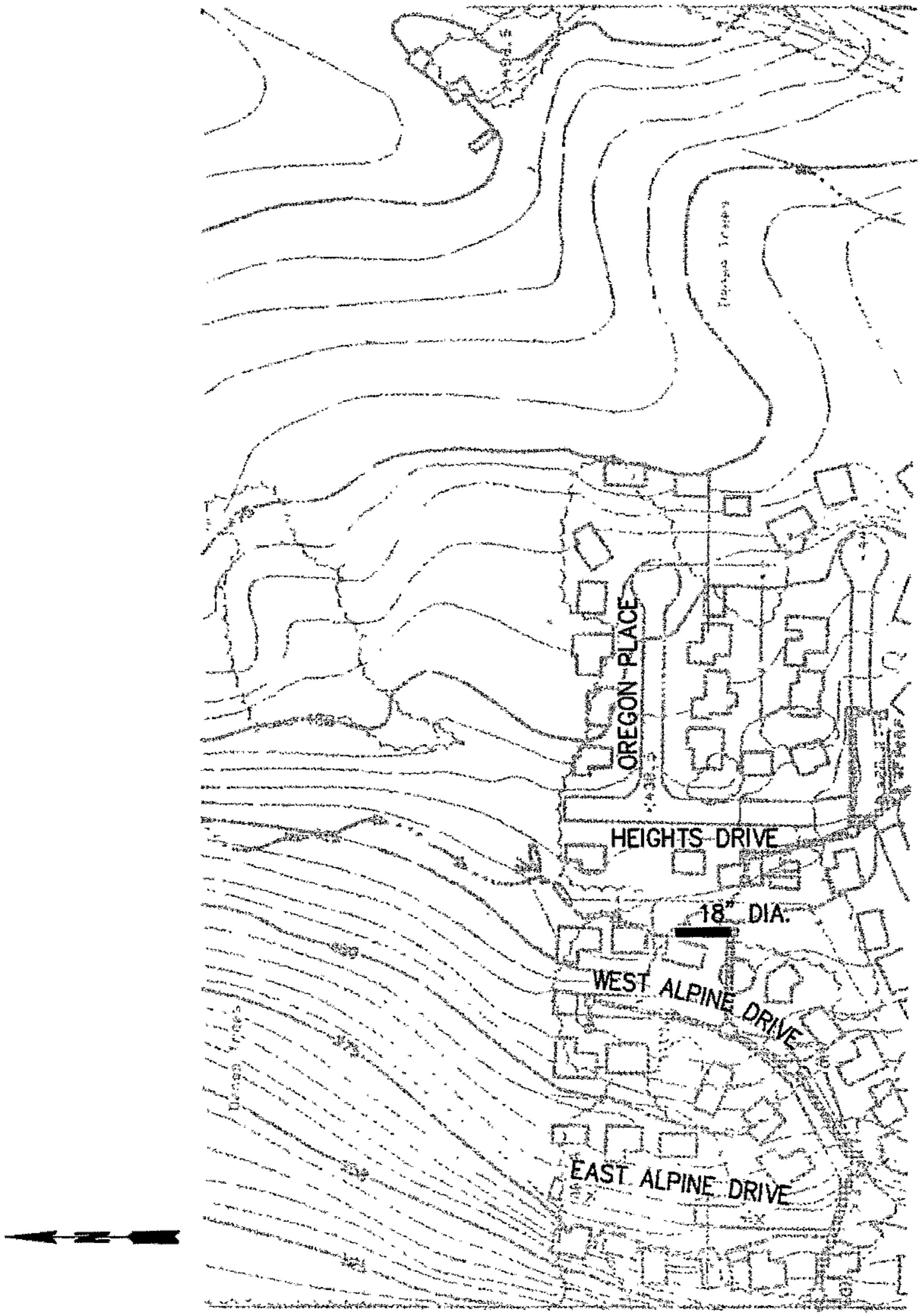
Development of this area will increase imperviousness which will increase runoff volumes and peak flows. Runoff from paved areas tends to have lower quality than from natural conditions or from vegetated areas.

The following alternatives will provide solutions to system capacity problems:

Alternative 4 - Improve downstream facilities to handle increased flows

Alternative 5 - Provide local detention facilities for each subbasin (FC201 through FC601) north of the abandoned railroad right-of-way and East Illinois Street.

The recommended solution is Alternative 5, to provide local detention facilities. Most of this area has been cleared and graded in anticipation of development. Site grading has made provisions for detention facilities. These facilities should be designed to release flows that will not overtax downstream facilities. In addition, water quality components should be included in the design such as grassed swales, wet ponds, and oil/water separators. These facilities should be constructed in conjunction with the development and will not be included in the Capital Improvement program.



SCHEMATIC
FEVER CREEK
PROBLEM NO. 3

BELLINGHAM WATERSHED MASTER PLAN	FIGURE FC.1
HDR Engineering, Inc.	10/22/93

BELL1-4.DWG

7.2 SILVER BEACH STUDY AREA

7.2.1 Basin Characteristics

Silver Beach Basin is drained primarily by storm drains and ditches to Lake Whatcom (Figure 7.0). The basin contains 464 acres and land use development in the basin is mostly residential with some commercial buildings. There are two major ponds in the basin: Big Rock Pond located near the intersection of Sylvan and Illinois Lane and Scudder Pond located south of Alabama Street, near Lake Whatcom. Figure 7.2.1 depicts drainage facilities. Figure 7.2.2 depicts wetlands and stream reaches.

Soil types are mainly silty loams with low to moderate infiltration rates.

7.2.2 Wetlands

Two wetlands, WH-82 (Scudder Pond) and WH-86 (Big Rock Pond), in the Silver Beach study area were evaluated in the field. Both of these areas consisted of open water ponds with an associated wetland fringe. Emergent vegetation in the open water and dense forest vegetation with three vegetation layers on the wetland fringe characterized these areas. Moderate to high wetland values for wildlife habitat, flood attenuation and water quality were noted, as was sensitivity to encroaching development. Both open water ponds appeared to have capacity for additional storm water flows.

7.2.3 Streams

Field investigation of streams in the Silver Beach subbasin was not undertaken as part of this study.

7.2.4 Fisheries

Silver Beach Creek, a tributary to Lake Whatcom, is reported to have cutthroat spawning and rearing habitat. This tributary is located in a residential area on the eastern boundary of this basin and flows between Britton Road and Haggin Street in the Silver Beach neighborhood.

7.2.5 Nonpoint Pollution

Residential development occurring within the Silver Beach subbasin is a potential source of nonpoint pollution. Nonpoint pollution resulting from residences, roads and commercial development within the Silver Beach basin is expected to occur (refer to "General Discussion of Identification of Possible Nonpoint Source Pollution Problems Along Streams" in Chapter 4).

7.2.6 Water Quality

Most of the growth projected for the Silver Beach study area is residential. Volume 2 includes tables showing the existing and projected pollutant loadings from the basin, based on historical data listed in Appendix C. The Silver Beach Basin is included under current water quality policies to protect the water quality of Lake Whatcom. Public environmental education can be an effective way to reduce the impacts of development on water quality. Key areas include the application of fertilizers and pesticides, and disposal or recycling of household wastes. (See Section 7.1.6 for discussion.)

7.2.7 Problem Identification

Figure 7.2.1 shows the approximate location of each of the problem areas listed in Table 7.2.

TABLE 7.2
IDENTIFIED SILVER BEACH PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	P61	EX	PIPE CAP	Britton Road outfall from Northshore Drive to Lake Whatcom
2	P63	FUT	PIPE CAP	Northshore Drive west of Britton Road

[a]Abbreviations: EX = Existing Land Use FUT = Future Growth Land Use
PIPE CAP = Pipe Capacity CHAN CAP = Channel Capacity
CHAN VEL = Channel Velocity WQ = Water Quality

7.2.8 Alternative Analysis

Problem No. 1 -Britton Road Outfall

The pipe discharging south from Northshore Drive to Lake Whatcom is undersized.

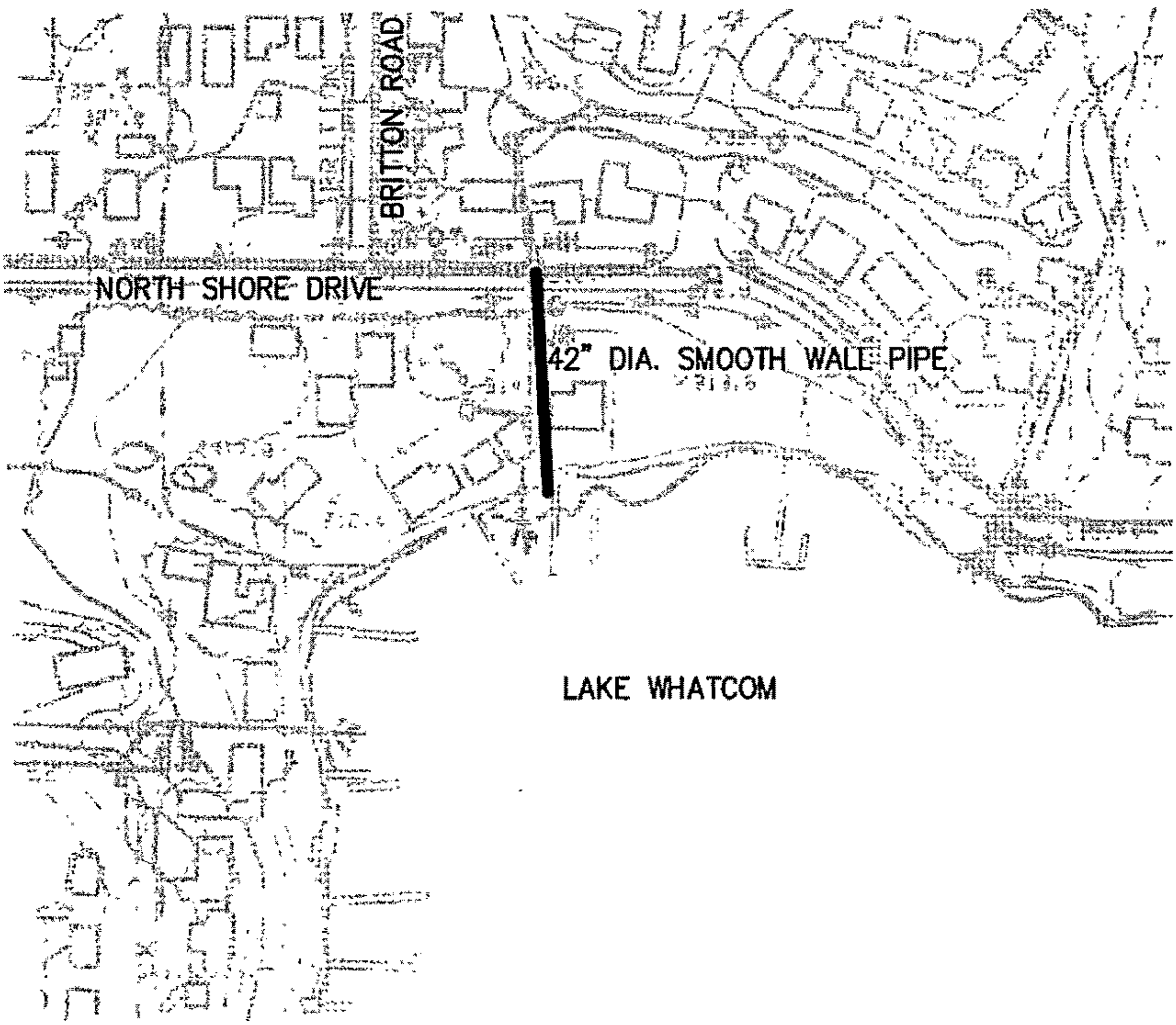
The following alternatives will provide solutions to the capacity problem:

> Alternative 1 - Replace the existing storm drain with a 42-inch diameter smooth wall pipe.
>
> Alternative 2 - Install a parallel 36-inch diameter smooth wall pipe.
>
> Alternative 3 - Create a high flow overflow route to Lake Whatcom to prevent damage to adjacent property and infrastructure.

The recommended alternative is Alternative 1, to replace the existing pipe with a 42-inch diameter smooth wall pipe south of Northshore Drive (Figure SB.1). Whenever possible, overflow routes should be incorporated into designs.

Problem No. 2 - Storm drain under Northshore Drive, west of Britton Road

The capacity of the 21-inch diameter concrete pipe is inadequate for projected flows. The reduced capacity appears to have occurred because the slope was flattened to clear a sewer line.



SCHEMATIC
SILVER BEACH
PROBLEM NO. 1

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE SB.1 10/22/93

BELL5-8.DWG

The following alternatives will provide solutions to Problem No. 2:

Alternative 4 - Replace the line with a 24-inch diameter smooth wall pipe.

Alternative 5 - Allow pipe to surcharge and utilize pressure flow.

Alternative 6 - Provide detention upstream.

The recommended solution to Problem No. 2 is Alternative 5, to allow the pipe to surcharge. If the sewer line is removed or abandoned, the drain line should be replaced at the steeper grade. The projected 25-year flow produces a hydraulic grade line slightly below the street surface. The projected flows are based on undeveloped land being fully built out at current zoning and land use projections. Establishment of a proposed park in the upper reaches of the basin should reduce flow projections, and the hydraulic grade line, at the identified pipe. No feasible location was found for regional detention facilities upstream of P63. Some opportunity may exist to incorporate detention into new development of the upper hillsides. Pipe joints and manholes should be tested for water tightness, and grouted if necessary, to prevent damage to roadway subgrade.

7.3 LINCOLN CREEK STUDY AREA

7.3.1 Basin Characteristics

Lincoln Creek Basin is drained by Lincoln Creek which discharges to Whatcom Creek (Figure 7.0). The basin has a drainage area of 804 acres, adjacent to and primarily east of Highway I-5. The southern and westerly portions of the basin are generally commercial land uses. The easterly and northerly portions are primarily residential. The upper reaches have only seen minimal development at this time. The drainage system is a mix of creeks, ditches, and pipes. The creek discharges to Whatcom Creek through a 43-inch by 63-inch arch pipe below Fraser Street and an open ditch.

The soil types in the basin are primarily silty loams with moderate infiltration rates. Most of southeast area in the basin is covered by dense forests and brush. Figure 7.3.1 depicts the basin boundaries and drainage facilities. Figure 7.3.2 depicts wetlands and stream reaches.

7.3.2 Wetlands

In general, inventoried wetlands located in the lower reaches (Reaches 1-6) of Lincoln Creek are characterized by moderate to high degrees of disturbance resulting from adjacent, relatively extensive, residential and commercial development. Wetland plant communities had low species diversity, culverts and channelization modified the natural course of the water source, adjacent land was commonly developed, and the potential for nonpoint source pollution problems appeared to be high. Only minor wetland impacts would be anticipated from local manipulation of water volumes or additional development in the area, due to the already degraded wetland functions and values.

Development intensity in the vicinity of inventoried wetlands in the upper reaches (Reaches 7-9) of Lincoln Creek was relatively low and adverse wetland impacts were minor compared to development-related wetland impacts observed in the lower reaches. Upper-reach inventoried wetlands had a combination of emergent, shrub-dominated and forested vegetation classes. Wetland values were rated moderate overall and some wetland impacts can be expected should surrounding lands be developed.

7.3.3 Streams

Based on general stream attributes and the character of adjacent development, Lincoln Creek can be divided into three sections, grouping reaches with like features:

> Section 1: a moderately to highly disturbed, predominantly developed, lower section. Reaches 1, 2, 3 and 4 are characterized by a low stream gradient, immature/even-aged forest and landscaped (lawns/shrubs) vegetation, moderate to high disturbance consisting of extensive channelization and nearby moderate-density residential and commercial development. A culvert under Lakeway Drive marks the upstream end of this section.

> Section 2: a moderately to highly disturbed, road development-dominated middle section. Reaches 5 and 6 are characterized by a moderate stream gradient, and nearby commercial

and residential development. Immature/even-aged forest occurs in Reach 5, and Reach 6 has only sparse herbaceous vegetation.

Section 3: a minimally to moderately disturbed, low development density upper section. Reaches 7, 8 and 9 have a low to moderate stream gradient, mature forest vegetation and relatively minor adjacent development.

7.3.4 Fisheries

Despite the degraded character of the lower reaches of Lincoln Creek, these areas are considered important for cutthroat trout, coho and chinook salmon. Salmon do not occupy the upper reaches of Lincoln Creek because the culvert at the break between Reach 3 and Reach 4 (at Lincoln Street) is impassable to salmon. Reaches 5, 7, 8 and 9 are sea-run cutthroat spawning and juvenile rearing areas.

7.3.5 Nonpoint Pollution

Due to the proximity of residential and commercial development to the lower reaches of Lincoln Creek, the potential for nonpoint pollution was considered high. Automobile-related pollutants from roads and parking areas as well as fertilizers and herbicides associated with lawn maintenance are the most likely nonpoint source pollutants entering Lincoln Creek in this area. Abundant iron-rich bacteria colonies and thick algae growing on the stream substrate were interpreted as evidence of degraded water quality; however, growth of these materials may be exacerbated by the low flow rates and warm temperatures prevalent at the time of the field investigation. Above Reach 5, (near the intersection of Lincoln Street and Ashley Avenue) the occurrence of nonpoint pollution appeared to be minimal.

7.3.6 Water Quality

Lincoln Creek will see a mix of growth including both commercial/industrial and residential. Volume 2 includes tables showing existing and projected pollutant loadings from the basin based on historical data listed in Appendix C. The lower reaches of Lincoln Creek appear to be impacted by nonpoint pollution and the problem is expected to get worse. The pollutant loading projections show an increase of 20 to 50 percent. Because of the likelihood of pollutants being introduced into the stream from existing and anticipated land uses, runoff control methods that incorporate detention are preferable to those that advocate bypassing the higher flows. Bypassing flows, or stabilizing channels to handle higher flows, tend to push the problem downstream. Detention provides opportunities for sedimentation, filtration, and biological uptake.

Constructing an interceptor swale at the north end of the ball fields adjacent to Fraser Avenue will reduce the amount of fertilizer that enters the stream. The swale should be shallow and incorporate a wide grassy bottom. The runoff would be discharged to the stream in the vicinity of the trunk pipe under Fraser Street.

For the residential areas, public environmental education can be an effective way to reduce the impacts of development on water quality (see Section 7.1.6 for discussion). Key areas include the application of fertilizers and pesticides, and disposal of household wastes such as soapy water, oils, and cleaners.

7.3.7 Problem Identification

Figure 7.3.1 shows the approximate location of each of the problem areas listed in table 7.3.

TABLE 7.3
IDENTIFIED LINCOLN CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	D11, D13, D14, D16	EX	WQ	Lower reaches of Lincoln Creek
2	P12	FUT	PIPE CAP	Moore Street outfall pipe, north of Fraser Street
3	P14A, P14B, P14C, D13, D14	FUT	PIPE CAP CHAN VEL	Lincoln Creek from Lincoln Street and Fraser Street
4	P19A	FUT	PIPE CAP	West of Lincoln Street north of Ashley Avenue
5	P21A	FUT	PIPE CAP	Lincoln Creek at Ashley Avenue
6	D23	EX	WQ	Lincoln Creek between Byron Avenue and Dumas Avenue
7	P171 P174	FUT	PIPE CAP	Lakeway Drive east of Lincoln Avenue
8	P203	FUT	PIPE CAP	North of Byron Avenue between I-5 and Lincoln Street

[a]Abbreviations: EX = Existing Land Use FUT = Future Growth Land Use
PIPE CAP = Pipe Capacity CHAN CAP = Channel Capacity
CHAN VEL = Channel Velocity WQ = Water Quality

7.3.8 Alternative Analysis

Problem No. 1 - Nonpoint Pollution

The suspected low water quality in the lower reaches of Lincoln Creek appears to be a consequence of nonpoint pollution resulting from sediment and nutrient loading and from chemicals released to the aquatic ecosystem from roads, lawns, and businesses in the basin. The lower reaches of Lincoln Creek were among the most impacted, apparently polluted stream reaches field inventoried in the Whatcom Creek basin.

Recommendation. Nonpoint pollution can be mitigated in several ways which are discussed elsewhere in this document. Lincoln Creek can be improved by upgrading existing storm drains with grease and oil traps and increase public education programs regarding water quality maintenance. Some amount of stream-side restoration and plantings would be desirable to enhance degraded fish and wildlife habitat and general aesthetics. A biofiltration swale between the athletic fields (south of, and adjacent to, Fraser Street) and Lincoln Creek as it parallels Fraser Street could help reduce the potential for turf fertilizers and pesticides (if used) entering the creek. Implemented BMPs guiding future development in the basin could help to reduce the potential for additional water quality impacts.

Problems No. 2 and 3 - Pipe Capacities and Channel Velocities

The existing outfall 65" x 40" pipe arch on Moore Street, north of Fraser Street is too small to convey the future 25-year design storm. This problem will be further exacerbated by development in the upper reaches of the basin.

There are four culverts along Lincoln Creek, from Lincoln Street to Fraser Street that lack the capacity to convey flows projected from the fully developed condition of the upstream basin. The projected flows from future development will also result in channel velocities in excess of 6 feet per second. Velocities this high can create additional erosion problems along the stream bed and banks.

The following alternatives will provide solutions to Problems No. 2 and No. 3:

Alternative 1 -

- Install a 48-inch diameter pipe parallel to the Moore Street outfall pipe and improve the inlet configuration to reduce turbulent flow.

- Replace the culverts along Lincoln Creek from Lincoln Avenue to Fraser with 60-inch diameter culverts or hydraulically equivalent structures.

- Armor the stream channel with rip-rap to prevent erosion. The channel will need to be widened to allow the rip-rap to be placed without sacrificing channel cross section.

Alternative 2 - Construct local detention facilities as sites develop upstream.

Alternative 3 - Install bypass piping along Lincoln Street to convey all but base flows to Whatcom Creek.

Alternative 4 - Construct a regional detention facility along Lincoln Creek, north of Ashley Avenue, between Lincoln Street and I-5.

The recommended solution is Alternative 4, construct a regional detention facility (Figure LC.1). Alternative 1 would destroy the remaining natural appearing reaches of Lincoln Creek and disrupt adjacent improvements. Alternative 2 would require the installation of many smaller detention facilities which would have increased maintenance impacts as well as land use impacts by utilizing area with development potential. Alternative 3 may solve capacity problems but is expensive, would require tearing up a "new" roadway, and would provide no water quality benefits.

Alternative 4 would help preserve the natural appearance of the lower reaches of Lincoln creek and provide an opportunity for passive water quality treatment. The site selected is difficult to develop because of wetlands next to the stream, and is in an area where the stream has already been disrupted and re-channeled. The wetland assessment for this site states that additional water would only have minor effects on this disturbed wetland. This alternative can be implemented in several phases. The first phase would be for the city to purchase the property to reserve it. The second would be to construct the improvements in conjunction with upstream development work, possibly by having the developers construct the pond as a mitigation measure.

The area needed to provide the recommended detention volume will impact the development potential of the remaining site. Access will be difficult to the area west of the proposed pond. Development of the easterly portion will be limited to a strip along Lincoln Street.

26 acre-feet of detention storage is required to mitigate down stream problems projected for future land uses. The proposed pond will cost $18,300 per acre-foot.

Problem No. 4 - Undersized culvert, main stem west of Lincoln Street

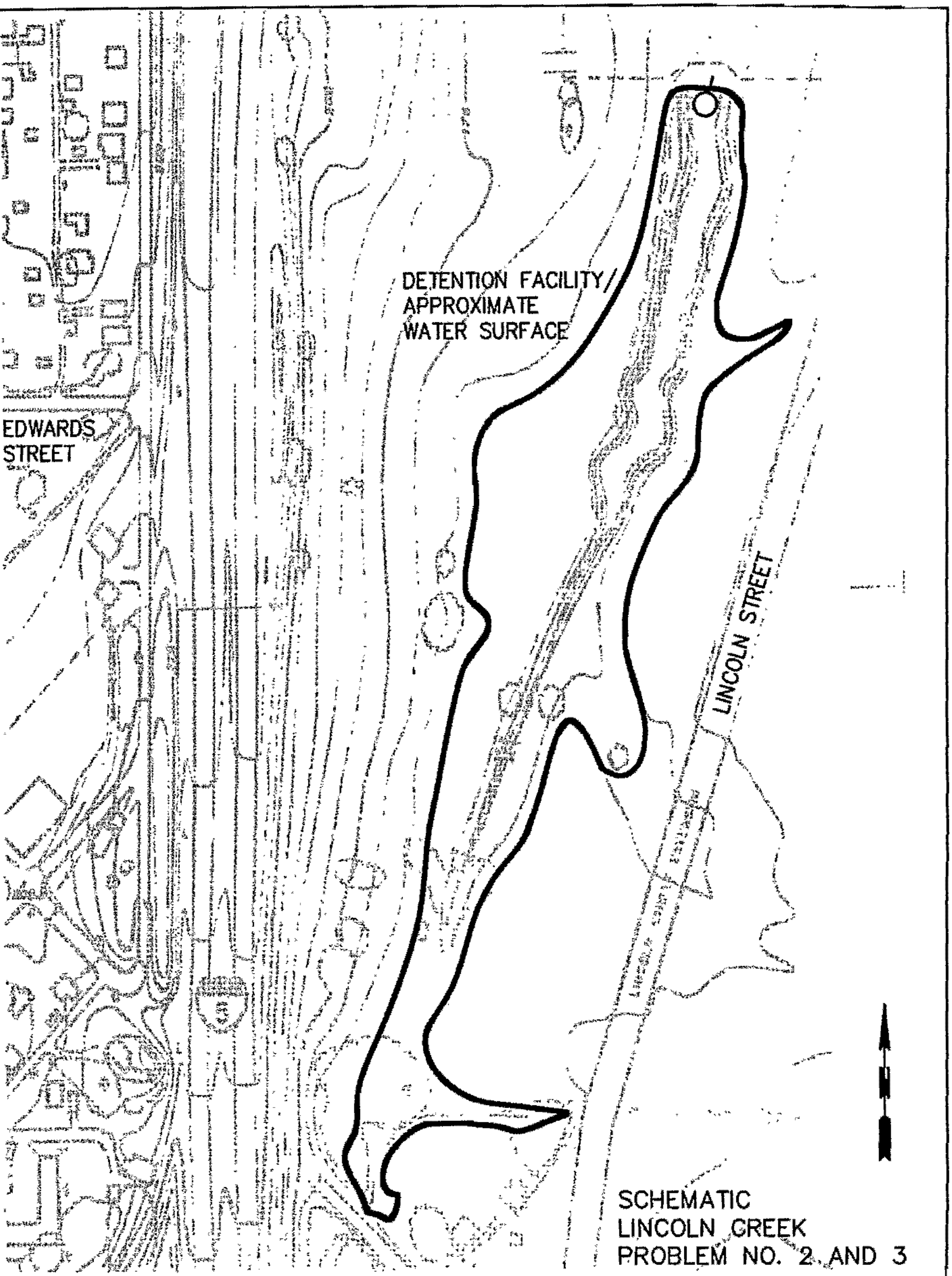
A culvert has been installed along a channelized portion of Lincoln Creek, on the north side of the Ashley Avenue extension. This culvert is inadequate to convey the projected flows from future development.

The following alternatives will provide solutions to Problem No. 4:

Alternative 2 - Construct local detention facilities as sites develop upstream.

Alternative 5 - Remove the culvert and restore the channel dimension and natural characteristics.

The recommended solution is Alternative 5, remove the culvert. The culvert does not appear to serve a current purpose so should be removed. This removal can be done under the annual maintenance budget.



BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
LC.1
10/22/93

BELL1-4.DWG

Problem No. 5 - Undersized culvert crossing under Ashley Avenue

A culvert crossing Ashley Avenue is inadequate to handle the projected flows from future development.

The following alternatives will provide solutions to Problem No. 5:

> Alternative 2 - Construct local detention facilities as sites develop upstream.
>
> Alternative 6 - Replace the pipe with a 48-inch diameter culvert.
>
> Alternative 7 - Construct a regional detention facility along Lincoln Creek south of Dumas Avenue.

The recommended solution is Alternative 2, construct local detention facilities as sites developed upstream. A potential site for regional detention exists south of Dumas Avenue. Utilization of this site would require both excavation and placement of fill in identified wetland areas, making permitting difficult. Local detention, if maintained, will also reduce erosion potential in D21, D22, and D23 by reducing peak flows and associated velocities. The goal is to maintain the remaining natural channel characteristics as a valued natural resource.

Problem No. 6 - Erosion and Sedimentation

Recently felled trees near Lincoln Creek between Byron Avenue and Dumas Avenue (Reach 8) form a large, permanent debris jam which will disrupt normal stream flow resulting in extensive bank erosion and downstream sedimentation.

The following alternatives will provide solutions to Problem No. 6:

> Alternative 8 - Remove debris from the creek and restore natural vegetation to stabilize the banks.
>
> Alternative 9 - Install bypass piping to reduce peak flows in the stream bed.

The recommended solution is Alternative 8, removing the debris and restoring the natural vegetation. This can be done under the annual maintenance budget.

Problem No. 7 - Undersized pipes along Lakeway Avenue

The existing system (model element P171 and P174) is inadequate to convey the projected flows from future development.

The following alternatives will provide solutions to Problem No. 7:

> Alternative 2 - Construct local detention facilities as sites develop upstream.

Alternative 10 - Replace the undersized pipes with a 48-inch and 30-inch diameter smooth wall pipes.

Alternative 11 - Divert flows from subbasin LC126 directly into Lincoln Creek with a 30-inch diameter smooth wall pipe.

The recommended solution is Alternative 11, flow diversion (Figures LC.2). As much of the upstream basin should be diverted to the Lincoln Avenue Detention Pond to reduce peak flows through the downstream system and portions of Lincoln Creek. Pipe elements should then be sized to handle the remaining increase. This eliminates the need for several smaller detention facilities but still reduces peak flows downstream. The construction of the flow diversion facilities should be phased to match development in the area. Flow diversion is recommended as an effort to maximize the water quality benefits and flow regulation benefits of the proposed detention facilities on the main stem of Lincoln Creek.

Construction of the diversion pipe and easement acquisition should be a condition placed on proposed development in Basin LC126. Local detention should be required if easements are unattainable.

Problem No. 8 - Undersized pipe north of Byron Avenue

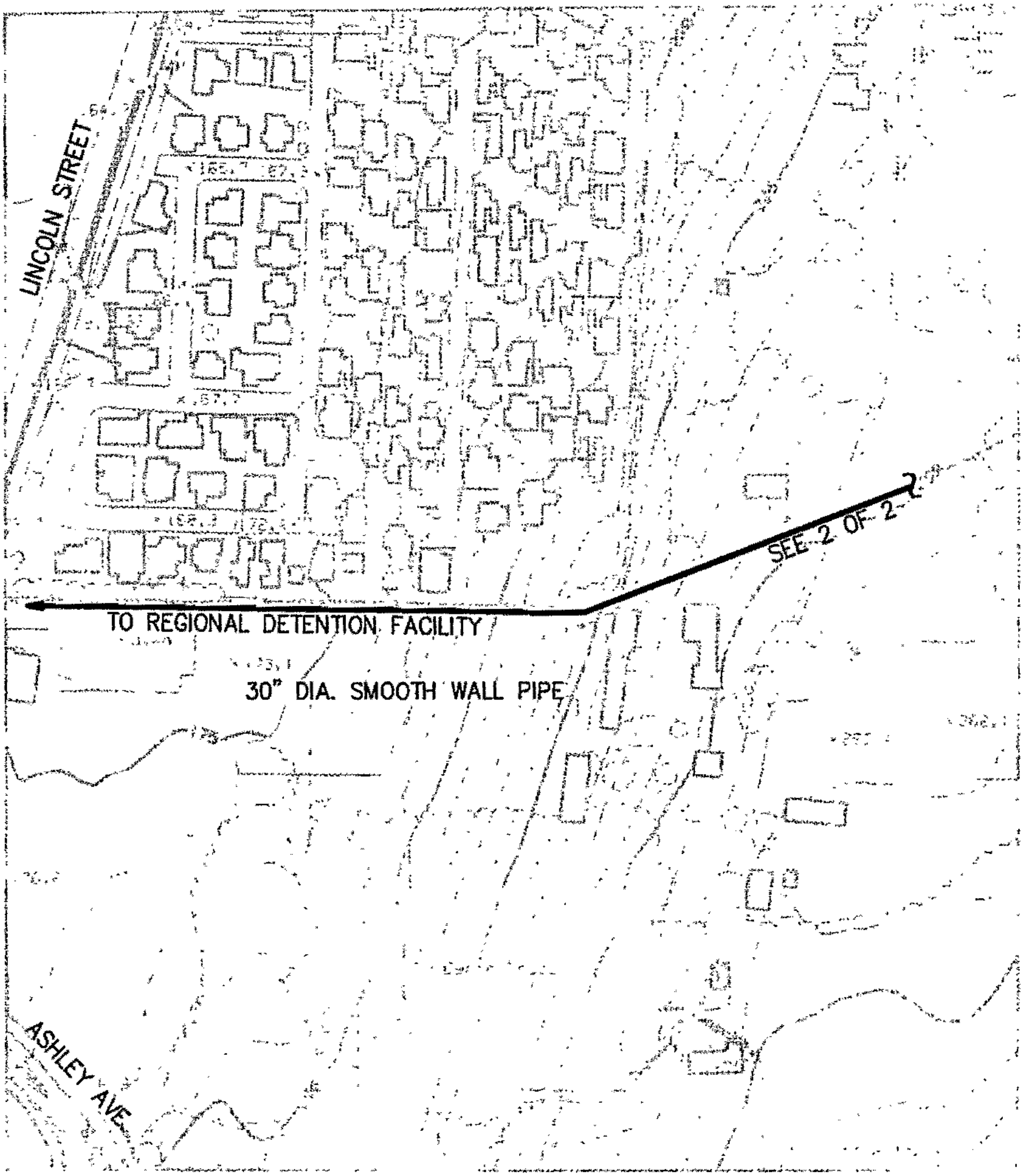
The existing pipe (model element P203) is inadequate to convey projected flows from future developments.

The following alternatives will provide solutions to Problem No. 8:

Alternative 2 - Construct local detention facilities as sites develop upstream.

Alternative 12 - Replace the pipe with a 21-inch diameter smooth wall pipe.

The recommended solution is Alternative 12, increase the pipe diameter (Figure LC.3). This can be constructed in conjunction with the development of the site, it will not be included in the Capital Improvement Program.



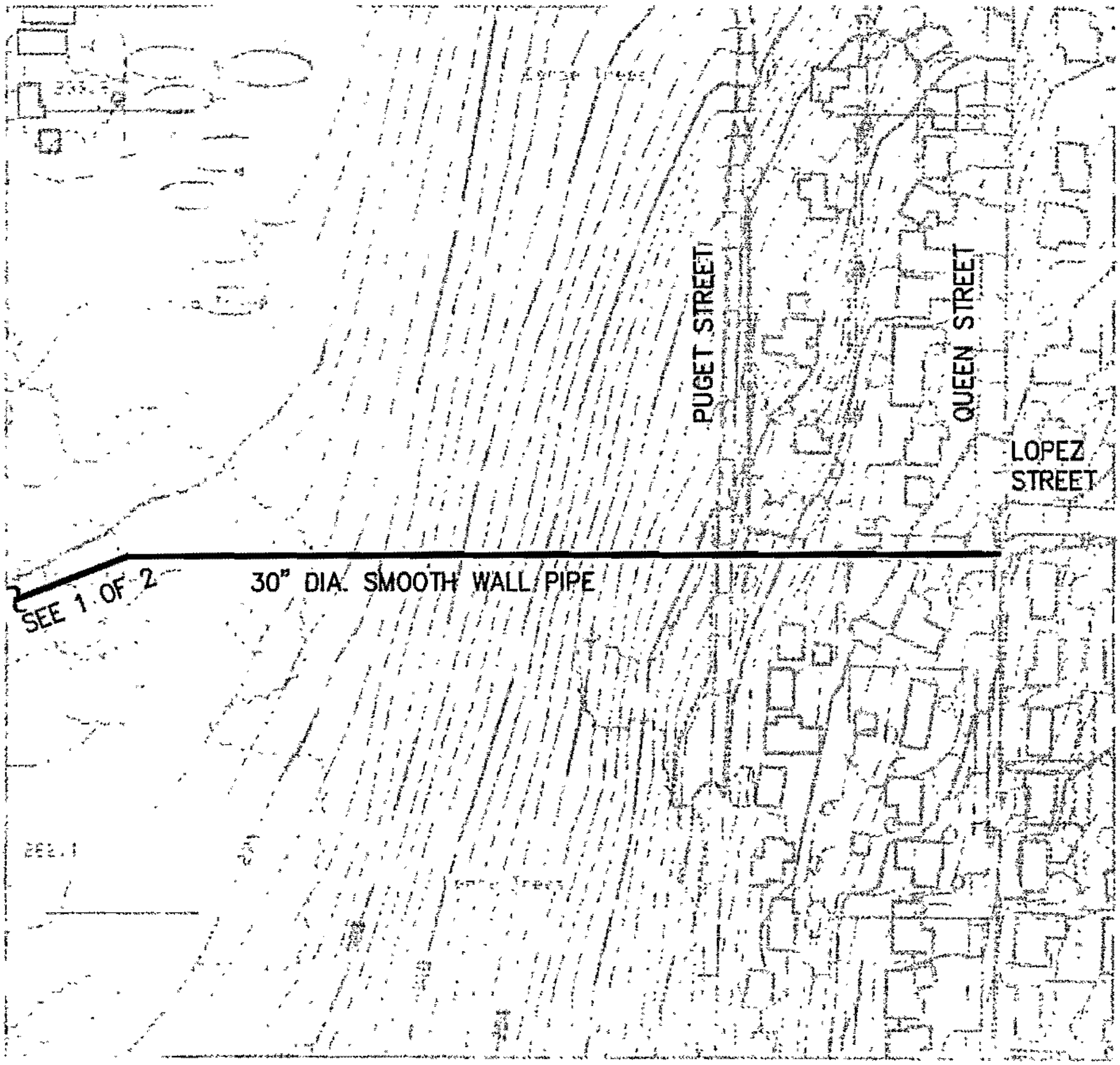
SCHEMATIC
LINCOLN CREEK
PROBLEM NO. 7

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
LC.2
1 OF 2
10/22/93

BELL5-8.DWG

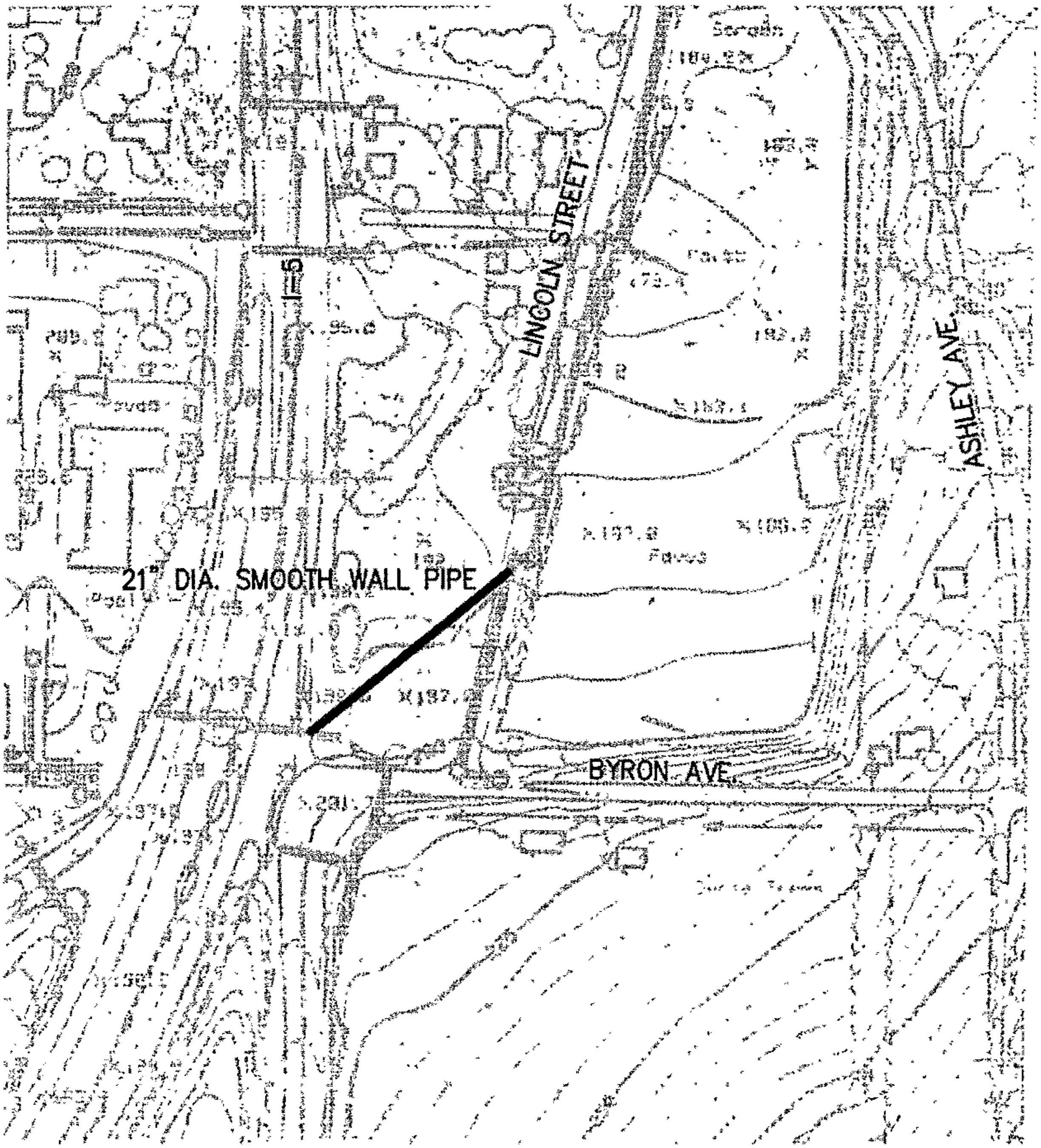


SCHEMATIC
LINCOLN CREEK
PROBLEM NO. 7

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
LC. 2
2 OF 2
10/22/93



SCHEMATIC
LINCOLN CREEK
PROBLEM NO. 8

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
LC.3
10/22/93

BELL5.8.DWG

7.4 CEMETERY CREEK STUDY AREA

7.4.1 Basin Characteristics

The Cemetery Creek Basin has been divided into an east tributary basin and west tributary basin (Figure 7.0). The basin has an approximate drainage area of 1,670 acres of which 65 percent of the basin area is undeveloped. The basin is drained by Cemetery Creek which discharges to Whatcom Creek.

The downstream portion of the basin is a combination of commercial, undeveloped, and cemetery land uses. The central portion is primarily residential and the upper reaches are mostly undeveloped wooded areas.

The soil types are mainly silty loams with slow to moderate infiltration rates. Figure 7.4.1 depicts the basin boundaries and drainage facilities. Figure 7.4.2 depicts wetlands and stream reaches.

7.4.2 Wetlands

The lower reaches of East Cemetery Creek and West Cemetery Creek flow through a large, high quality, forested wetland. Aside from trash dumped along an unimproved right-of-way that traverses the wetland in a east-to-west-direction, few detrimental development-related impacts were observed during the inventory. Wetland values including wildlife habitat, water quality and floodwater attenuation were moderate to high and impacts to wetlands would be minor for moderate increases in flow volume.

In general, other wetlands in the Cemetery Creek drainage basin were located in areas of low to moderate development density. Most of these wetlands were dominated by immature/even-aged forest vegetation with some component of emergent vegetation. Wildlife habitat, flood attenuation and water quality values were low to moderate and overall wetland impacts would be low to moderate for increased storm water flows.

7.4.3 Streams

East Cemetery Creek and West Cemetery Creek collect runoff from the eastern and central portions, respectively, of the Whatcom Creek drainage basin and merge just before entering Whatcom Creek at approximately the 1.3 milepost.

East Cemetery Creek - Streams

On the basis of general stream attributes and character of adjacent development, East Cemetery Creek can be divided into four sections:

> Section 1: a moderately disturbed, low to moderate development density lower section. Reaches 1 and 2 are characterized by a low stream gradient, mature forest vegetation, low to moderate disturbance consisting of partial channelization and nearby low-density residential and commercial development. Part of this section runs through WH-42, a

large, relatively undisturbed, palustrine forested wetland associated with the confluence of East Cemetery Creek and West Cemetery Creek. A culvert under Woburn Road marks the upstream end of this section.

Section 2: a section bounded by the Bayview cemetery. Reaches 3, 4 and 5 flow through Bayview Cemetery. Mature forest vegetation, strongly incised bedrock channel and relatively steep stream gradient typifies this section. A culvert under Lakeway Drive marks the upstream limit of this section.

Section 3: a highly disturbed and developed section south of Lakeway Drive. Reaches 6, 7, 8, 9 and 10 are characterized by a low to moderate stream gradient and substantial human disturbance from adjacent development. Vegetation in the riparian corridor was highly altered from encroachment of residential development. Water quality appeared to be poor due to nonpoint source pollution as evidenced by particularly abundant iron-rich bacteria colonies and widespread dark coatings (perhaps grease and oil) on the stream substrate.

Section 4: a relatively undisturbed, low development density, headwaters section. In general, the upper section of East Cemetery Creek, Reaches 11, 12, 13 and 14, are characterized by moderate stream gradient, mature forest vegetation, and little to no adjacent development. Evidence of human disturbance is low.

West Cemetery Creek - Streams
Based upon general stream attributes and development characteristics West Cemetery Creek can be divided into four sections including:

Section 1: a relatively undisturbed, undeveloped lower section. Reaches 1, 2, 3 and 4 flow through mature forest vegetation and were nearly undisturbed, evidence of human impact is minor as there was little adjacent development. At the upper end of this section, Reach 4 was an incised, moderate to high gradient channel that flows northward and enters a broad, low gradient area (Reaches 1, 2, and 3) of palustrine forested wetlands. Due to the low slope of the land, the lack of a strongly incised channel, and the presence of dry subsidiary channels in the wetland area, it appeared that West Cemetery Creek overflows its primary channel during high water flows and utilizes additional channels besides the one inventoried. A culvert under Lakeway Drive marked the upper limit of this section.

Section 2: a developed, highly impacted middle section. Reaches 5 and 6 were characterized by a high stream gradient, highly incised channel, and moderate to high disturbance due to the proximity of moderate density residential development. Stream bank cutting was serious in this section, and in one area could potentially threaten the structural integrity of a dwelling if unabated erosion continues. The proximity of development suggested potential nonpoint source pollution impacts from lawn fertilizers and herbicides.

Section 3: a low density developed upper section. Reaches 7, 8 and 9 were at the headwaters of West Cemetery Creek and have a low to moderate stream gradient and a combination of mature/even-aged forest vegetation and lawn areas associated with adjacent, low-density residential development. Existing lawns and horse pastures created a strong potential for nonpoint source pollution impacts from lawn fertilizers, herbicides and manure runoff.

Section 4: headwater tributaries to West Cemetery Creek. Two headwater tributaries of West Cemetery Creek were examined during the stream inventory and both join West Cemetery Creek at the junction of Reach 8 and 9. Tributary 1 was an intermittent stream corridor characterized by thick, shrub-dominated vegetation, minor evidence of human impact and moderate stream gradient. Tributary 2 was an intermittent watercourse which initially parallels Yew Street then runs through an area of residential development. Substantial human disturbance and potential for nonpoint source pollution problems from the road and adjacent development characterized this tributary. The general area around these two tributaries, and around the wetlands in the vicinity, is very wet in character. It appears that considerable surface water flows through this region.

7.4.4 Fisheries

In the reaches of East Cemetery Creek below Woburn Street and West Cemetery Creek below Lakeway Drive, coho and chinook salmon have been observed. Although suitable habitat may be present, salmon do not utilize Cemetery Creek reaches above Lakeway and Woburn because culverts beneath these roads prevent the movement of salmon upstream. The upper reaches of East and West Cemetery Creeks are considered to be habitat for sea-run cutthroat spawning and juvenile rearing; however, fish passage would need to be restored at the above mentioned culverts for the upper reaches of Cemetery Creek to be a valuable fisheries resource.

7.4.5 Nonpoint Pollution

The potential for nonpoint pollution appears to be minor in the lower reaches of East Cemetery Creek due to the low overall development density. If future development is permitted in the vicinity of this area, nonpoint pollution could be expected, unless mitigating measures are taken to control it.

Fertilizer/herbicide runoff from Bayview Cemetery lawns together with lawn maintenance chemical runoff and automobile-related pollutants associated with roads and parking areas from the Eaglewood subdivision are potential sources of nonpoint pollution in the middle reaches of East Cemetery Creek. Evidence suggesting degraded water quality in this area included abundant iron-rich bacteria colonies on the creek substrate and presence of dark coatings, possibly oil and grease, on creek gravels and cobbles. Relatively few potential nonpoint pollution problems were noted in the upper reaches of East Cemetery Creek and the middle reaches of West Cemetery Creek.

In the upper reaches and inventoried tributaries of West Cemetery Creek, residential development was a potential source of nonpoint pollution. Automobile-related pollutants from roads and parking areas, fertilizer/herbicide runoff from lawn maintenance and manure runoff from horse/donkey pastures were the most likely nonpoint source pollutants entering the upper reaches of West Cemetery Creek.

7.4.6 Water Quality

Most of the growth anticipated for Cemetery Creek will be residential, however, some industrial/commercial growth will occur near Whatcom Creek. Volume 2 includes tables presenting the existing and projected pollutant loadings based on historical data listed in Appendix C. The middle reaches of Cemetery Creek are being impacted by nonpoint pollution. Runoff control methods that incorporate detention are preferable to those that advocate bypassing the higher flows. Bypassing flows, or stabilizing channels to convey higher flows, tends to push the problem downstream. Detention provides opportunities for sedimentation, filtration, and biological uptake.

For the residential areas, public environmental education can be an effective way to reduce the impacts of development on water quality (see Section 7.1.6 for discussion). Key areas include the application of fertilizers and pesticides, and disposal of household wastes such as soapy water, oils and cleaners.

Efforts should be continued to maintain the wetlands at the mouth of Cemetery Creek and to remove the refuse that is periodically dumped there. These wetlands can provide water quality benefits to the discharges from Cemetery Creek.

7.4.7 Problem Identification

Figure 7.4.1 shows the approximate location of each of the problem areas listed in Table 7.4

TABLE 7.4
IDENTIFIED CEMETERY CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	D10, D11, D12	FUT	CHAN VEL	E. Cemetery Creek, north of Lakeway Drive
2	D13	EX	BANK	E. Cemetery Creek, south of Lakeway Drive and west of Modoc Drive
3	D15, D16, D17	FUT	CHAN VEL PIPE CAP	E. Cemetery Creek, south of Blackberry Lane
4	P151	FUT	PIPE CAP	South and east of Alvardo Drive and Kenoyer Drive
5	D21	EX	CHAN VEL	Lower reaches of W. Cemetery Creek, erosion south of Lakeway Drive
6	D32	FUT	CHAN VEL	Upper reaches of tributary to W. Cemetery Creek (SE of athletic fields)
7	P20A	FUT	PIPE CAP	W. Cemetery Creek, extended Fraser Street
8	D13	EX	WQ	Middle reaches of East Cemetery Creek

[a]Abbreviations: EX = Existing Land Use FUT = Future Growth Land Use
PIPE CAP = Pipe Capacity CHAN CAP = Channel Capacity
CHAN VEL = Channel Velocity WQ = Water Quality
BANK = Bank Erosion

7.4.8 Alternative Analysis

Problems No. 1, No.2 and No.3 - Channel velocities, bank erosion, and undersized culverts along East Cemetery Creek.

As the upper reaches of East Cemetery Creek develop, increased flows will lead to greater stream velocities and erosion potentials north of Lakeway Drive. One stream reach already reaches velocities in excess of 5 feet per second under current conditions, however the stream is already at bed rock at that reach, so additional erosion is not a problem.

Serious bank erosion has been observed along East Cemetery Creek to the south of Lakeway Drive and west of Modoc Drive. This erosion is occurring in proximity to existing residential structures. Should erosion continue unabated the structural integrity of the structures could be threatened.

As the upper reaches of East Cemetery Creek develop, increased flows will lead to increased stream velocities and erosion potentials south of Blackberry Lane. Several culverts along this reach are not adequately sized to convey the projected increased flows.

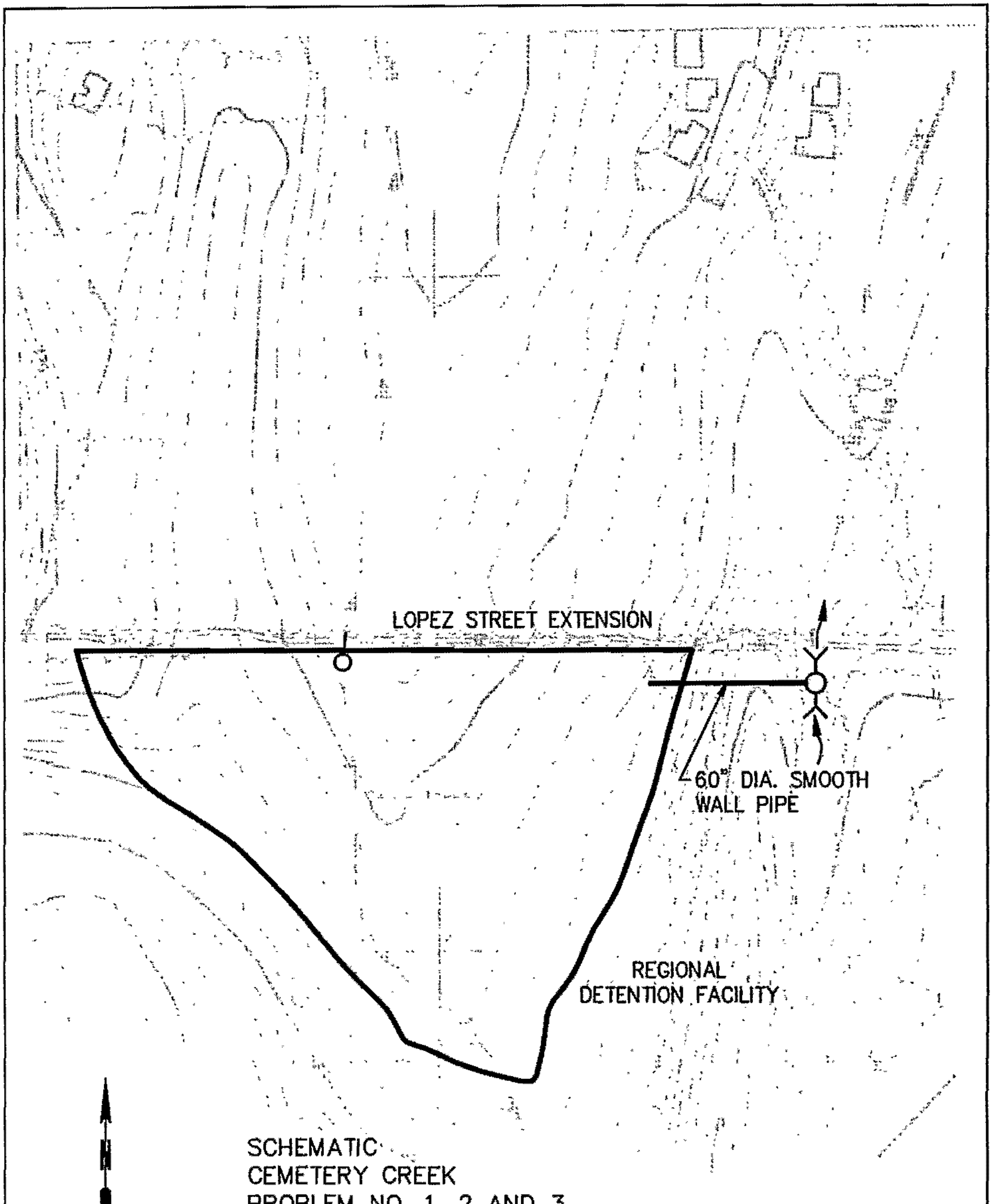
The following alternatives will provide solutions to the velocity problems:

> Alternative 1 - Install check dams to reduce stream gradients. Reducing channel gradients will result in slower velocities.
>
> Alternative 2 - Armor stream cross sections to protect soils from erosion. This would include bioengineered slope protection.
>
> Alternative 3 - Construct local detention facilities as sites develop upstream.

The following alternatives can also provide a solution to the capacity problems:

> Alternative 4 - Construct a regional detention facility along East Cemetery Creek south of Alvarado Drive.
>
> Alternative 5 - Replace the undersized culverts with 60-inch diameter culverts. Below Alvarado Drive and 42-inch diameter culverts above Alvarado Drive.

The recommended solution Alternative 4, to construct a regional detention facility south of Alvarado Drive (Figure CC.1). Alternatives 1, 2, and 5 would reduce the natural characteristics of the main channel and would disrupt adjacent improvements. Alternative 3 requires the installation of multiple smaller detention facilities which would have increased maintenance impacts as well as lost site potential for development. See Chapter 6 for a more detailed discussion of regional versus local detention.

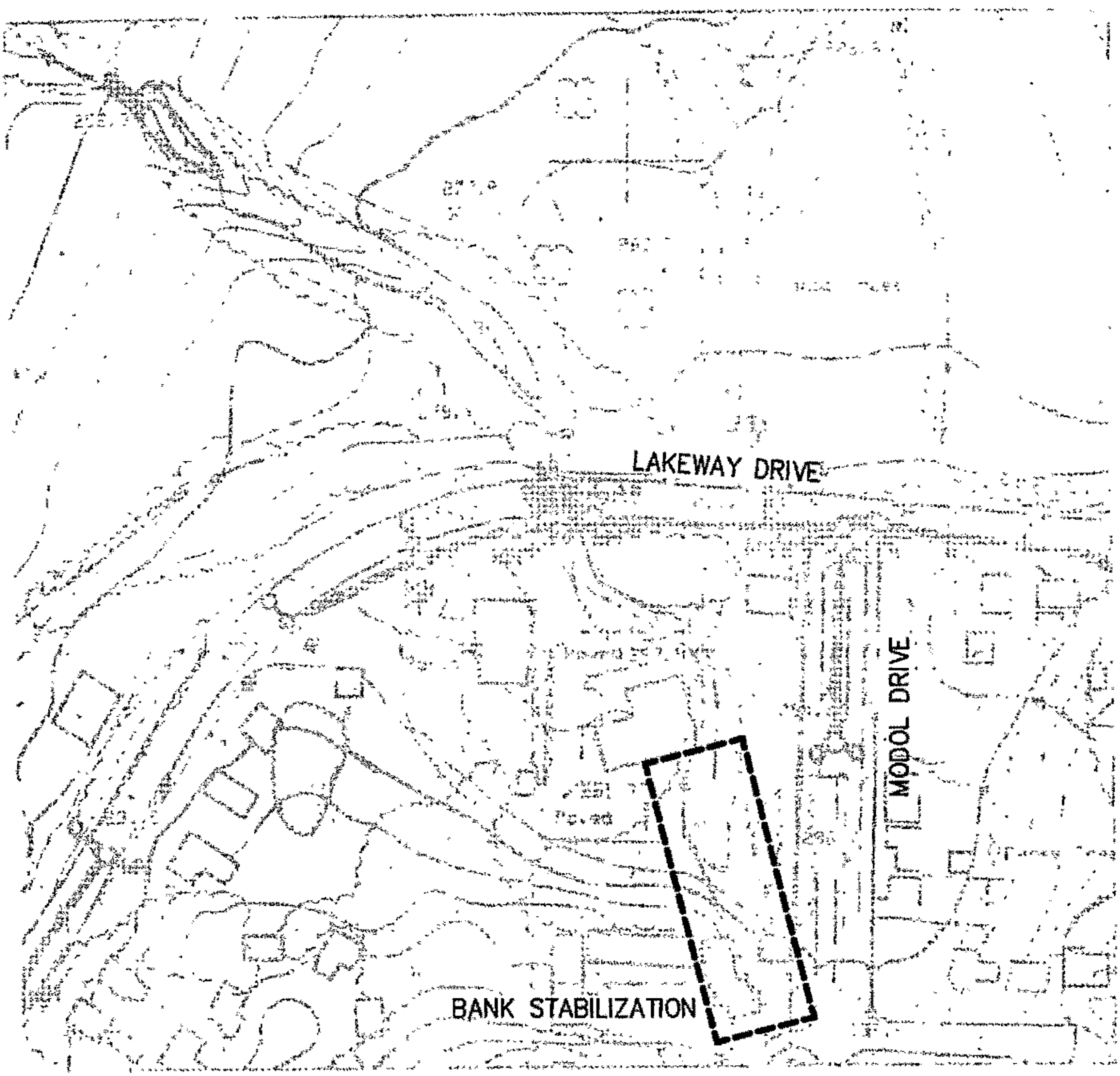


SCHEMATIC
CEMETERY CREEK
PROBLEM NO. 1, 2 AND 3

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
CC.1
1 OF 2
10/22/93



SCHEMATIC
CEMETERY CREEK
PROBLEM NO. 2

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE CC.1 2 OF 2 10/22/93

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Alternative 4 would help preserve the natural appearance of the lower reaches of West Cemetery Creek and provide an opportunity for passive water quality treatment. This alternative may be implemented in several phases to include early purchase of the property to "reserve" it and later construction in conjunction with upstream development, possibly by developers as a mitigation measure.

66 acre-feet of detention storage is required to mitigate projected downstream problems. The proposed pond will cost $10,300 per acre-foot.

Problem No. 2 would still need some additional stream bank stabilization from current erosion problems.

Problem No. 4 - Undersized collection system east of Kenoyer Drive.

A collection system serving the area south and east of Alvarado Drive and Kenoyer Drive has been installed with a detention system. While this facility is adequate to meet existing flows, it is inadequate to meet projected flows from the tributary basin.

The following alternatives will provide solutions to Problem No. 4:

> Alternative 3 - Construct local detention facilities as sites develop upstream.
>
> Alternative 6 - Upsize the facilities to handle the increased projected flows
>
> Alternative 7 - Collect the upstream flow and construct a system to bypass the existing facilities and discharge into East Cemetery Creek at the current location.
>
> Alternative 8 - Divert peak upstream flows from the tributary basin directly to the main branch of East Cemetery Creek. The bypass system would include a combination of 60-inch diameter pipe and open channel conveyance to convey all but the base flows.

The recommended solution is Alternative 8, diverting flow directly to East Cemetery Creek (Figure CC.1). The other alternatives would disrupt existing streets and other improvements and would require added costs of longer piping and restoration needs. Alternative 8 would allow more efficient use of the proposed regional detention facility and can be constructed in conjunction with upstream development as a mitigation measure, if timed after the detention facility construction. This recommendation is based on Alternative 4, already being implemented. See Chapter 6 for discussion on regional versus local detention.

Problem No. 5 - Channel velocities, West Cemetery Creek

Channel velocities exceed scour limits on the lower reaches of West Cemetery Creek

The following alternates will provide solutions to Problem No. 5:

> Alternative 1 - Install check dams to reduce stream gradients. Reducing channel gradients will result in slower velocities.

Alternative 2 - Armor stream cross sections to protect soils from erosion. This would include bioengineered slope protection.

Alternative 3 - Construct local detention facilities as sites develop upstream.

Alternative 9 - Construct a regional detention facility west of Yew Street and south of Alvarado Drive.

The recommended solution is Alternative 2 and 3, protect stream cross section (Figure CC.2) and provide local detention. Work would still be needed to stabilize stream banks from current erosion problems in the proximity of the existing residential structures south of Lakeway Drive.

Insufficient regional detention volume was available to meet storage requirements necessary to adequately reduce stream velocities. Local detention will provide some mitigation, however, steep channel gradients contribute to the high velocities. Detention will reduce the peak flow rate, but will not reduce total runoff volume. Increased runoff volume can be more damaging on unprotected steep slopes than peak flows because of the extended period of increased flow energy.

Problem No. 6 - Channel velocities, West Cemetery Creek tributary

Channel velocities on the upper reaches of a tributary to West Cemetery Creek (south east of the athletic fields) have potential for channel erosion along the steeper slopes.

The following alternatives will provide solutions to the velocity problems:

Alternative 1 - Install check dams to reduce stream gradients. Reducing channel gradients will result in slower velocities.

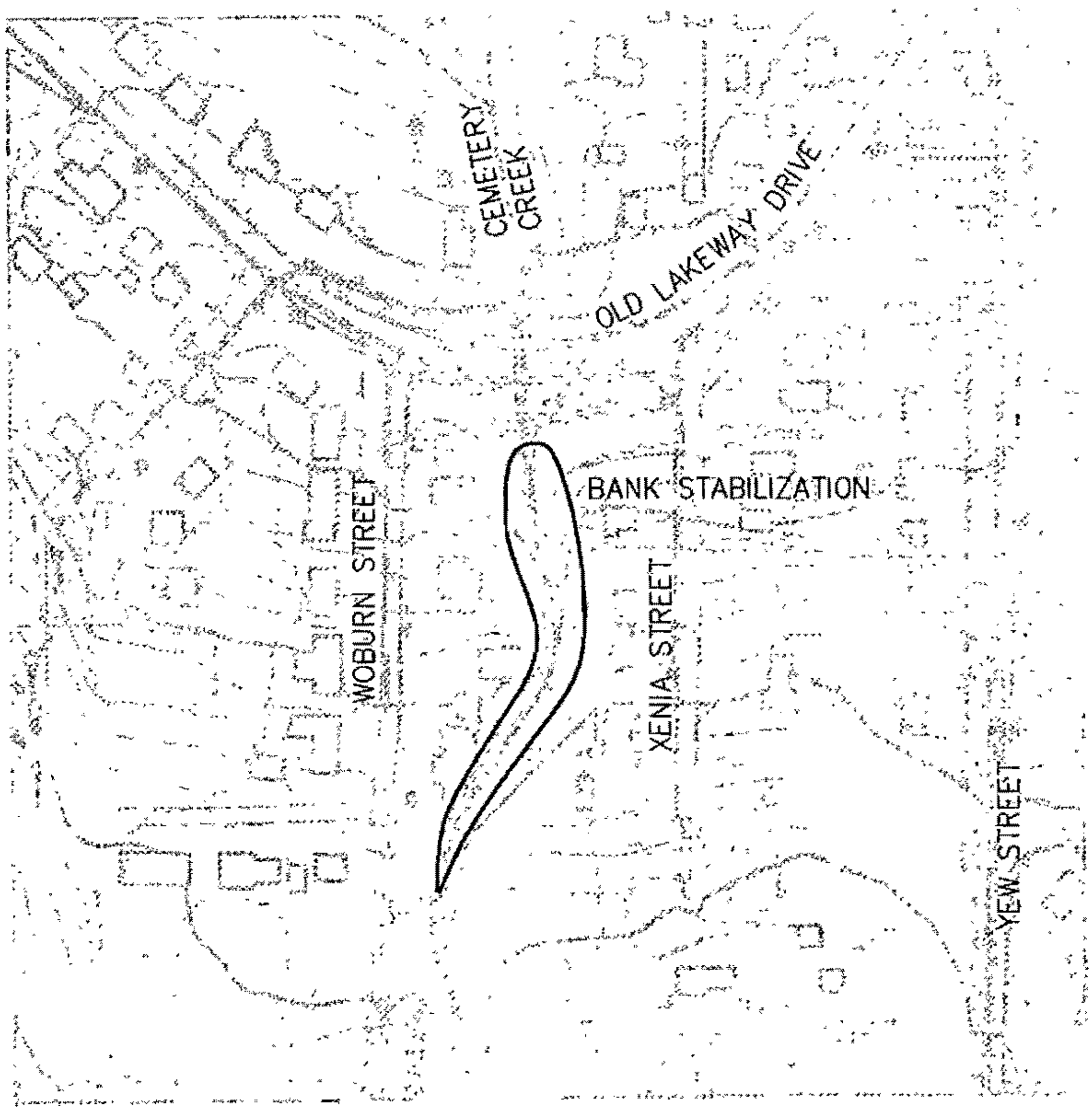
Alternative 2 - Armor stream cross sections to protect soils from erosion. This would include bioengineered slope protection.

Alternative 3 - Construct local detention facilities as sites develop upstream.

The recommended solution is a combination of Alternatives 1 and 2, install check dams and armor stream cross sections. The tributary basin is already fairly developed thus Alternative 3 is not feasible as most new development will be single lot in fill.

Problem No. 7 - Culvert capacity, West Cemetery Creek at Fraser Road extension.

Culvert P20A is too small to convey the flow projected from the fully developed tributary basin.



SCHEMATIC
CEMETERY CREEK
PROBLEM NO. 5

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE CC.2 10/22/93

REL35-36.DWG

The following alternatives will provide solutions to Problem No. 7:

Alternative 3 - Construct local detention facilities as sites develop upstream.

Alternative 10 - Construct regional detention facility identified in Alternative 9 and install a parallel 36-inch diameter culvert.

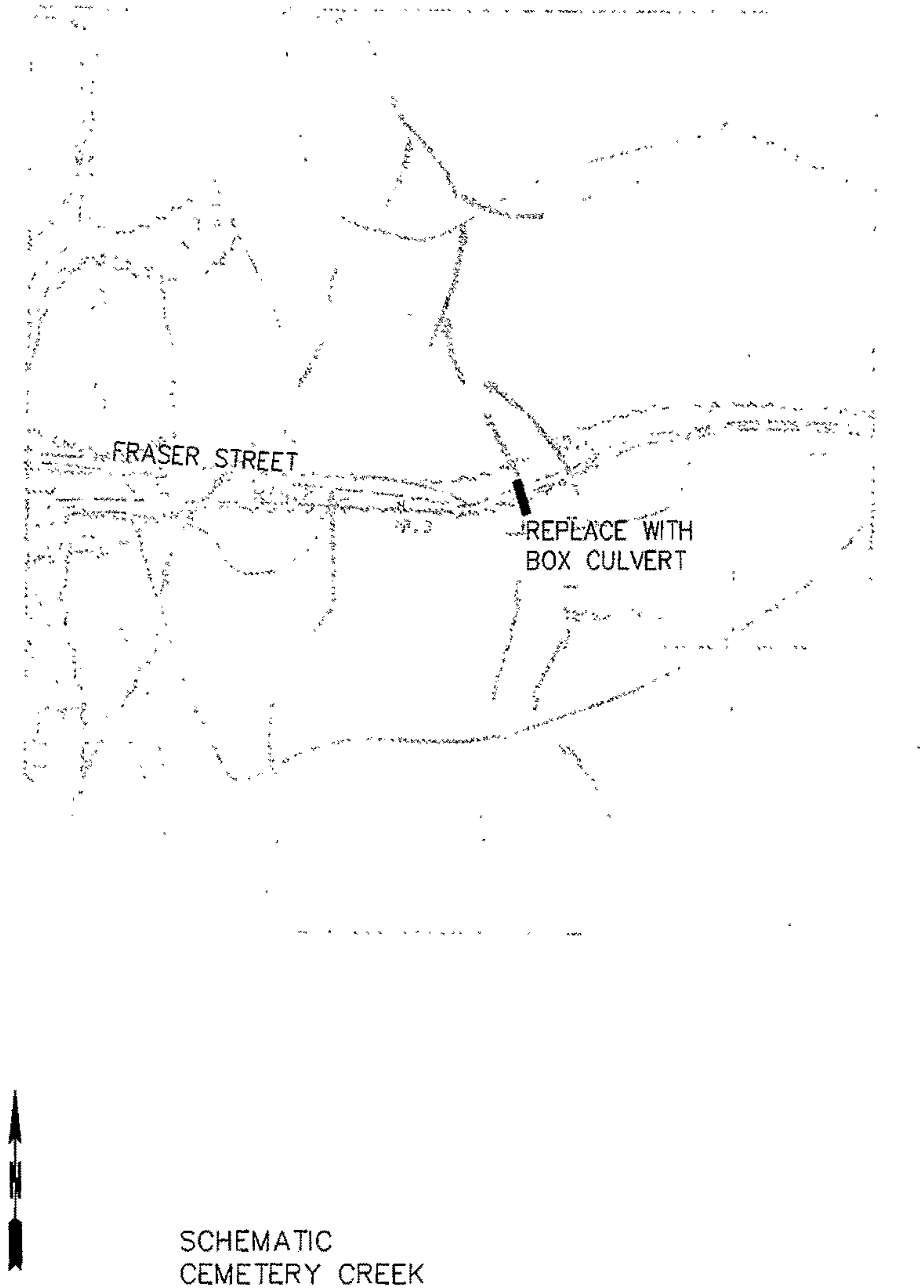
Alternative 11 - Install two parallel 36-inch diameter culverts or one precast box culvert.

The recommended solution is Alternative 11, install one precast box culvert (Figure CC.3). This work should be done in conjunction with the roadway improvements for Fraser Street. These improvements are likely to happen prior to the upstream regional detention facility. A box culvert is preferable to multiple culverts because the larger single opening is less likely to catch debris, and it can be constructed with a gravel bottom to enhance fish passage. This culvert should be sized to pass the full projected flows even though detention has been recommended in the upstream basin. The area is low and flat and susceptible to flooding if upstream facilities fail.

Problem No. 8 - Water Quality

Observations during field investigations suggest that nonpoint pollution is causing lower water quality in the middle reaches of East Cemetery Creek.

Recommendation. Nonpoint pollution can be mitigated in several ways which are discussed elsewhere in this document. Cemetery Creek can be improved by upgrading existing storm drains with grease traps and increase public education programs regarding water quality maintenance. Future development in the Cemetery Creek drainage basin should employ water purifying biofiltration swales to cleanse storm water of nonpoint pollutants prior to its entrance to natural watercourses and wetlands. Implementation of BMPs should help to reduce the potential for additional water quality impacts resulting from additional development in the basin.



SCHEMATIC
CEMETERY CREEK
PROBLEM NO. 7

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE CC.3 10/22/93

BEL23-26.DWG

7.5 HANNAH CREEK STUDY AREA

7.5.1 Basin Characteristics

The Hannah Creek Basin is a long, narrow drainage with a drainage area of 480 acres (Figure 7.0). The drainage system consists of Hannah Creek, natural ditches, and pipes. The northerly portion of the basin is highly developed as a residential area. The southerly portion is mostly undeveloped area and primarily wooded.

The soil types are mainly silty loams with moderate infiltration rates. The basin boundaries and drainage facilities are depicted in Figure 7.5.1. The wetlands and stream reaches are depicted in Figure 7.5.2.

7.5.2 Wetlands

Wetlands identified in the City of Bellingham Wetland Inventory (Shapiro, 1991) are primarily situated away from the main conveyance course of Hannah Creek. Consequently, field investigation of wetlands in the Hannah Creek subbasin was not undertaken as part of this study. Impacts to wetlands in the Hannah Creek basin should be considered relative to site specific proposals in the future.

7.5.3 Streams

Field investigation of streams in the Hannah Creek subbasin was not undertaken as part of this study.

7.5.4 Fisheries

No report of fish use was identified for Hannah Creek.

7.5.5 Nonpoint Pollution

Further residential development in the Hannah Creek subbasin could be a source of nonpoint pollution in the future. Such nonpoint pollution would result from the construction of additional residences and roads if measures are not taken to control and filter additional storm water from these developments (refer to "General Discussion of Identification of Possible Nonpoint Source Pollution Problems Along Streams" in Chapter 4).

7.5.6 Water Quality

Most of the growth projected for the Hannah Creek study area is residential. Volume 2 includes tables showing existing and projected pollutant loadings from the basin based on historical data listed in Appendix C. Public environmental education can be an effective way to reduce the impacts of development on water quality (see Section 7.1.6 for discussion). Key areas include the application of fertilizers and pesticides, and disposal of household wastes such as soapy water, oils and cleaners.

Efforts should be continued to maintain the wetlands at the mouth of Hannah Creek and to remove the refuse that is periodically dumped there. These wetlands can provide water quality benefits to the discharges from Hannah Creek.

7.5.7 Problem Identification

Figure 7.5.1 shows the approximate location of each of the problem areas listed in Table 7.5.

TABLE 7.5
IDENTIFIED HANNAH CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	D10, D101	FUT	CHAN VEL	Lower reaches of Hannah Creek
2	Not Used			
3	P203A	FUT	PIPE CAP	Raymond Street
4	P12A	EX	PIPE CAP	Arbor Street Access to Whatcom Falls Park

[a]Abbreviations: EX = Existing Land Use FUT = Future Growth Land Use
PIPE CAP = Pipe Capacity CHAN CAP = Channel Capacity
CHAN VEL = Channel Velocity WQ = Water Quality

7.5.8 Alternative Analysis

Problem No. 1 - Channel velocities, lower Hannah Creek

Projected flows from future development have the potential to result in channel erosion in the lower reaches of Hannah Creek.

The following Alternatives provide solutions to Problem No. 1:

Alternative 1 - Construct local detention facilities as sites develop upstream.

Alternative 2 - Construct a regional detention facility south of Lakeway Drive.

Alternative 3 - Armor the stream bed to protect against erosion.

Alternative 4 - Install check dams and stilling pools along the stream reach to reduce velocities and minimize erosion.

The recommended solution is a combination of Alternative 1 and 4, construct local detention facilities and install check dams and stilling pools. The Creek travels through several gradient changes and has some natural drops and pools in its course. Providing upstream detention will reduce projected peak flows and projected velocities but will not reduce the projected volume of water to pass through the stream reaches. The increased runoff volume may still contribute to erosion problems along the steeper gradients because of the prolonged period of higher flow energy. Alternative 4 allows mitigation measures where needed without disrupting the entire reach. Work can be done in the park using logs, stone check dams, or stabilized sand bags. Other creative solutions may be available utilizing natural materials.

Problem No. 2 - Not used.

Alternative 5 - Not used.

Problem No. 3 - Culvert capacity (P203A) under Raymond Street

Projected flows from future development exceed the capacity of the existing multiple culverts under Raymond Street.

The following alternatives will provide solutions to Problem No. 3:

Alternative 1 - Construct local detention facilities as sites develop upstream.

Alternative 6 - Construct a regional detention facility above Whatcom Street.

Alternative 7 - Replace the multiple culverts with a box culvert. (1.5' x 3' interior dimensions.)

<u>The recommended solution is Alternative 7</u>, replace the multiple culverts with a box culvert (Figure HC.2). This alternative was recommended for the same reasons discussed for Problem No. 2, except overflows would damage adjacent properties. This work can be done as mitigation for upstream site development.

Problem No. 4 - Pipe capacity (P12A) under the Arbor Street access to Whatcom Falls Park.

Modeled flows from existing land uses exceed the capacity of this pipe. At one time this pipe drained a local detention pond through a raised inlet.

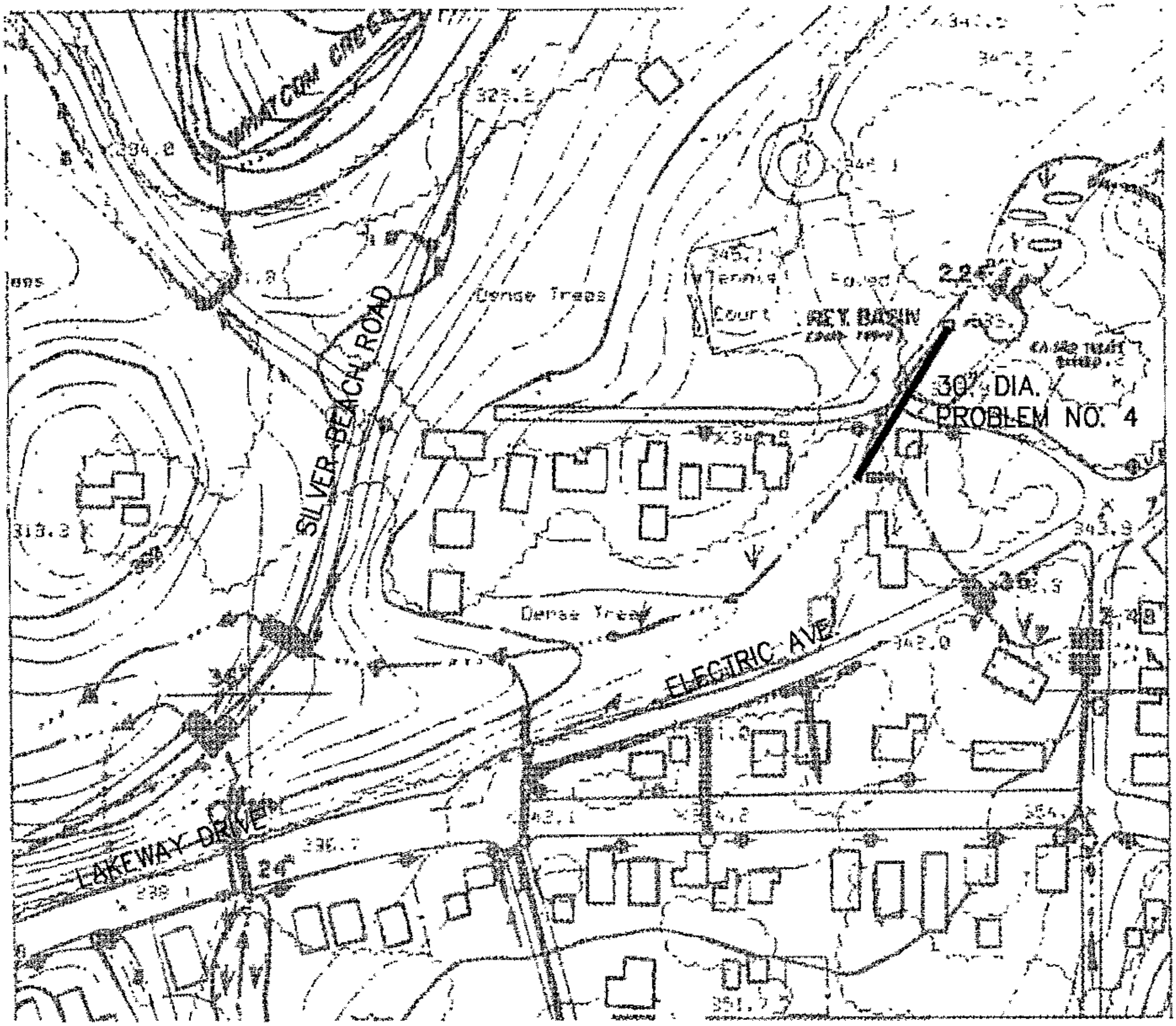
The following alternatives will provide solutions to Problem No. 4:

Alternative 1 - Construct local detention facilities as sites develop upstream.

Alternative 6 - Construct a regional detention facility above culvert P12A.

Alternative 8 - Replace the culvert with a 30-inch diameter culvert.

<u>The recommended solution is Alternative 8</u>, replace the culvert with a 30-inch diameter culvert (Figure HC.1). Regional or local detention is not feasible upstream of this culvert because most of the tributary area is already developed. Projected development will be primarily in fill.



SCHEMATIC
HANNAH CREEK
PROBLEM NO. 4

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE HC.1 9/1/95

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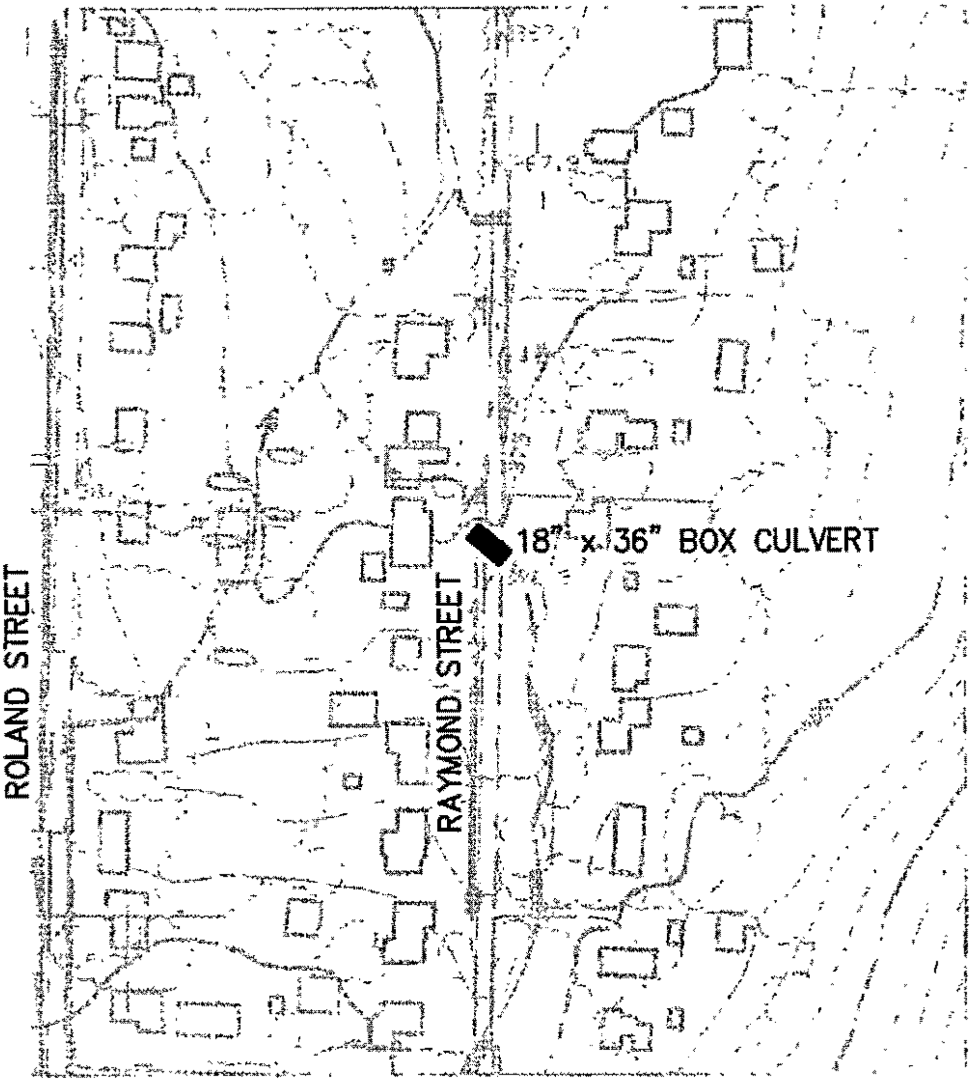

SCHEMATIC
HANNAH CREEK
PROBLEM NO. 3

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE HC.2 10/22/93

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8. LAKE PADDEN BASIN

Most of the Lake Padden drainage basin is forested or developed in relatively low density residential or recreational uses, concentrated primarily to the north of Samish Way. Future development pressure will likely occur in this area, north of Wilken Road and Samish Way.

The portion of the Lake Padden Basin that lies within the city limits is located in the Samish neighborhood. The more densely developed areas consist of trailer parks. The future development will most likely be single-family residential homes.

Most of the basin, however, lies outside of the city limits (Figure 8.0). The non-study area consists of Lake Padden Golf Course and Park.

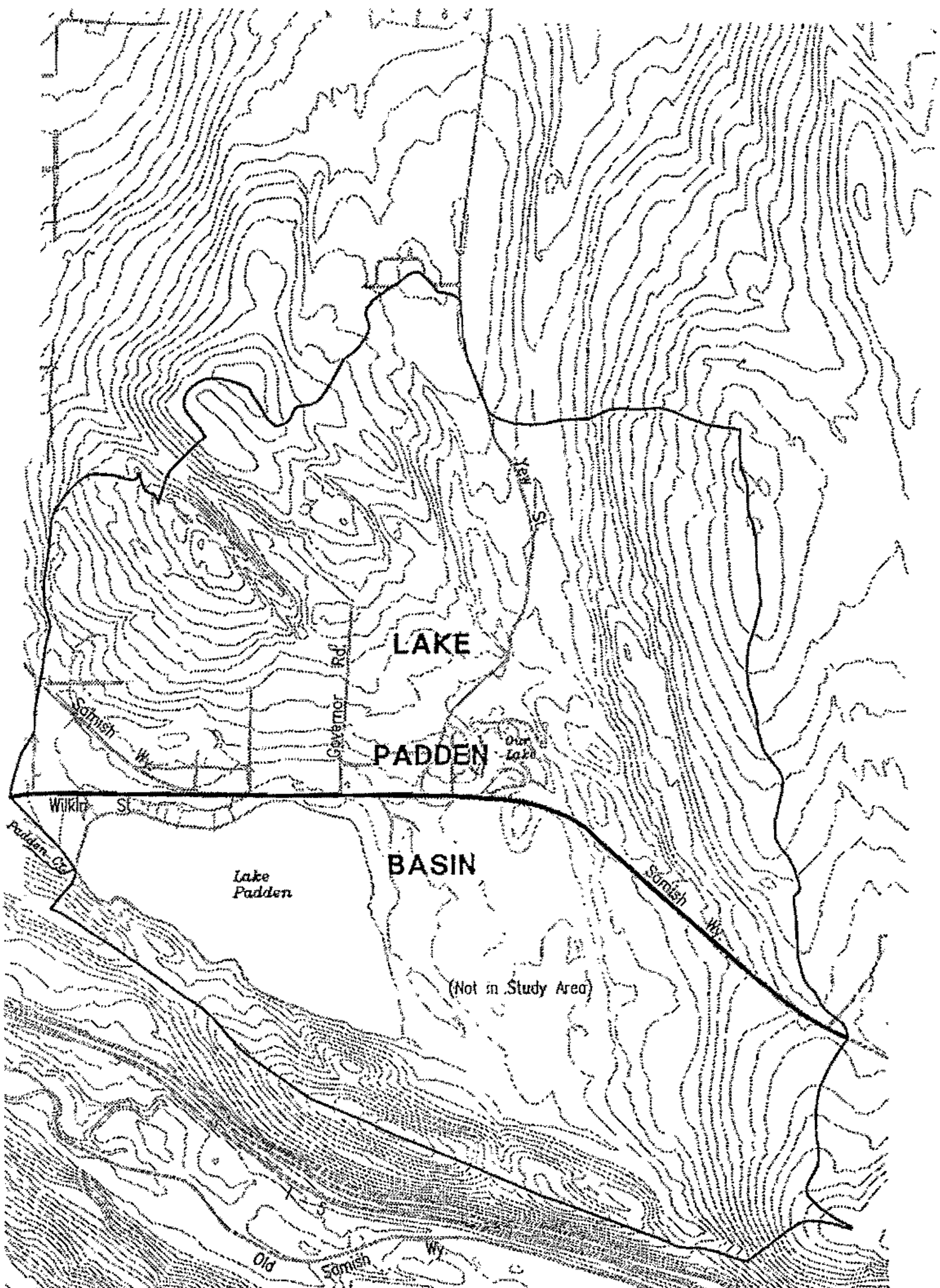
8.1 BASIN CHARACTERISTICS

The Lake Padden Basin has an approximate area of 1,770 acres of which the southernmost 756 acres were outside of the defined study area (Figure 8.1). The basin is drained primarily by intermittent creeks. Three small ponds, one larger pond (Our Lake), and Lake Padden provide storage capacity. They account for approximately 9 percent of the basin acreage, with Lake Padden covering a surface area of approximately 150 acres.

Most of the soils in the basin are gravelly or silt loam with moderate percolation rates. A small portion of the basin is overlain with soils that have very high infiltration rates and an equivalent area has soils with very slow infiltration rates.

8.2 WETLANDS

The field investigation of the Lake Padden drainage basin was conducted on March 11, 1992. Select wetlands and a single stream reach associated with an unnamed tributary of Our Lake were inventoried in the field (Figure 8.2). A simplified wetland functions and values assessment was performed on the inventoried wetlands and stream reach. Runoff from spring-season storms boosted water levels in streams and wetlands to an intermediate level at the time of the field investigation. See Volume 2 for more detailed descriptions.



LEGEND
Major Basin Boundary
Study Area Boundary
Major Creeks

1500 1000 500 0 1500
Scale in feet

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

LAKE PADDEN BASIN

FIGURE 8.0

The three wetland areas identified for field study lay outside of the city limits and therefore were not included in the 1991 Bellingham wetland inventory. Our Lake Wetland 1 (OL-1) and Governor Road Wetland are open water wetlands (ponds) and Our Lake Wetland 2 (OL-2) is a palustrine forested wetland. OL-1 is characterized by a high level of disturbance, substantial adjacent development, low vegetation species diversity, and strong potential for nonpoint source pollution problems. The proximity of relatively dense residential development to OL-1 further compromises its functions and values and tightly constrains the potential for increasing flow of stormwater runoff into this wetland. Governor Road Wetland and OL-2 wetlands are characterized by low levels of disturbance, low density adjacent development, good vegetation species diversity, and generally low potential for nonpoint source pollution. Governor Road Wetland has a greater capacity to take increased runoff because it lacks nearby development and most of its detrimental impacts. Additional stormwater may have a deleterious effect on existing vegetation and wildlife habitat.

8.3 STREAMS

A section of an unnamed tributary, D-65, (see Figure 8.2) to Our Lake was inventoried for this study. This relatively undisturbed reach is characterized by a low stream gradient, mature forest vegetation and minor adjacent development. With increased stormwater flows, additional erosion in this reach is probable. The reach traverses OL-2, a high value, forested wetland.

8.4 FISHERIES

Cutthroat, rainbow trout and landlocked sockeye salmon (also known as *kokanee*) are found in Lake Padden. Cutthroat and kokanee spawning habitat is provided by two unnamed tributaries of Lake Padden. The stream (including stream reach D-62 described in Section 8.3) which subsequently flows through "Our Lake" and the golf course before entering Lake Padden is one, the other is the stream that flows into the southeastern end of Lake Padden.

8.5 NONPOINT POLLUTION

The most likely sources of nonpoint pollution are from chemicals used in lawn or garden maintenance and from automobiles using the roads. No nonpoint pollution problems were observed during the field investigation. The potential for nonpoint pollution in this area is considered low to moderate. Outside of the study area, herbicides and pesticides from lawn maintenance at the golf course are another potentially significant source of nonpoint pollutants to Lake Padden.

8.6 WATER QUALITY

Most of the growth anticipated for the Lake Padden Basin will be residential, with some commercial sites. Volume 2 includes tables showing existing and projected pollutant loadings from the basin based on the historical data listed in Appendix C. Pollutant loading projections show loadings that are two to four times higher than existing land use estimates. Efforts should be made to treat runoff before it enters Lake Padden, Our Lake, and the pond off of Governor Road. Biofiltration should be incorporated into all new development. Flow should be routed through grass-lined swales before entering the identified drainage course, and water quality ponds should be incorporated wherever possible. One good location would be on the west side of Yew Street along the tributary to Our Lake. Runoff control methods that incorporate detention provide water quality benefits through sedimentation, filtration, and biological uptake.

Public environmental education can be an effective way to reduce the impacts of development on water quality from residential areas. (See discussion in Section 6.4.)

Efforts should be continued to maintain the wetlands at Our Lake, adjacent to Yew Avenue, and at Governor Road. These wetlands can improve the quality of water discharging into Our Lake and Lake Padden.

8.7 PROBLEM IDENTIFICATION

Figure 8.1 shows the approximate location of each of the problem areas listed in Table 8.7.

TABLE 8.7
IDENTIFIED LAKE PADDEN PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	P71	EX	PIPE CAP	Yew Street at Tacoma Avenue
2	D72	FUT	CHAN CAP	Ditch D72, east of Yew Street, north of Tacoma Avenue
3	P66	FUT	PIPE CAP	Culvert under Yew Street
4	D65	FUT	CHAN VEL	Upstream of Our Lake
5	D31	FUT	CHAN VEL	West of Governor Road
6	P12	FUT	PIPE CAP	Under Samish Way, south of Harrison

[a]Abbreviations: EX = Existing Land Use; FUT = Future Growth Land Use; PIPE CAP = Pipe Capacity; CHAN CAP = Channel Capacity; CHAN VEL = Channel Velocity; WQ = Water Quality

8.8 ALTERNATIVE ANALYSIS AND RECOMMENDATIONS

Problem No. 1 - Undersized culvert P71, Yew Street at Tacoma Avenue

The 15" diameter driveway culvert east of Yew Street is too small to handle the runoff generated in the tributary basin, at the current land uses.

The following alternatives will provide solutions for existing capacity problems:

Alternative 1 - Replace the existing 15" diameter culvert with a 30" diameter concrete culvert.

Alternative 2 - Install a parallel 24" diameter culvert to the existing culvert.

Alternative 3 - Provide detention facilities upstream of the culvert.

The following alternatives will provide solutions for anticipated capacity problems caused by projected flows:

Alternative 4 - Replace the existing 15" diameter culvert with a 48" diameter concrete culvert or equivalent arch pipe.

Alternative 5 - Install a precast concrete three-sided box with approximately 8 square feet of opening.

Alternative 6 - Provide detention facilities upstream of the culvert sized to handle the developed land uses.

<u>The recommended solution is Alternative No. 5.</u> (Figure LP.1) Culvert inlet backwater elevations are a problem at this location because the roadway low spot, the overflow location, is located east of the culvert site. Larger diameter culverts would not be as effective since the depth of flow is limited. Sizing the culvert for existing conditions would be a short sighted solution. Providing upstream detention would provide a solution but would be more expensive, as would multiple culverts.

Problem No. 2 - Ditch D72 Capacity Problems, east of Yew Street and north of Tacoma Avenue

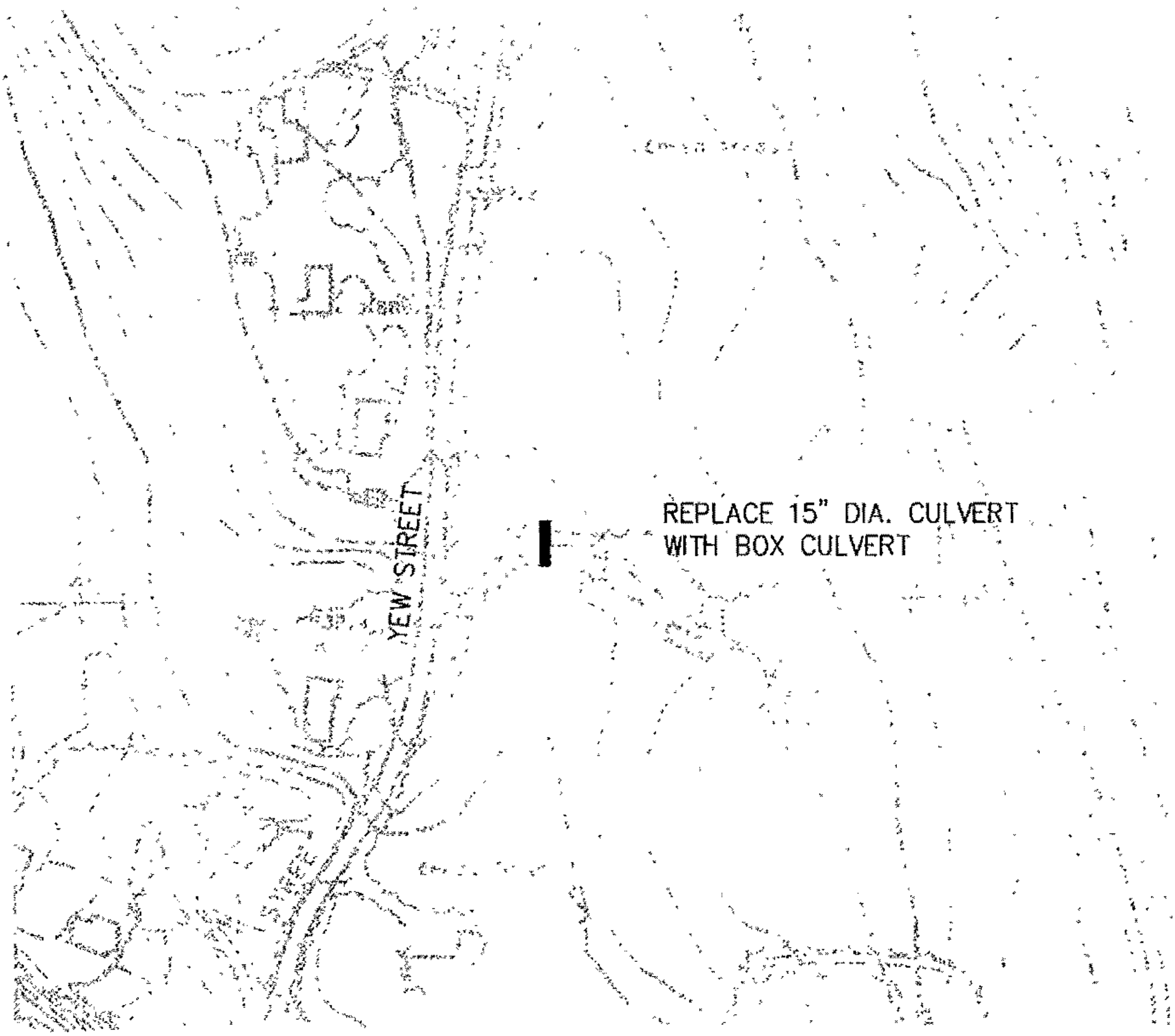
The projected flow depth (2.2 ft) for ditch D72 from a fully developed basin, exceeds the observed bank depth of 2 ft.

Alternative 7 - Provide detention facilities upstream.

Alternative 8 - Widen channel cross section by 3 feet to handle projected flows.

Alternative 9 - Require developers of upstream property to obtain a flooding easement from the impacted properties along this reach for the 6" of over bank flow.

<u>The recommended solution is Alternative No. 9.</u> The depth of flow is projected to be 0.2 feet over the top of bank at several locations. This projected flow depth may cause minimal damage. The problem could be alleviated by minor landscaping at critical locations.



SCHEMATIC
LAKE PADDEN
PROBLEM NO. 1

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
LP.1

10/22/93

BEL13-16.DWG

Problem No. 3 - Culvert P66 Capacity Crossing Yew Street

The 24" diameter culvert under Yew Street lacks adequate capacity to handle runoff from a fully developed basin.

Alternative 10 - Provide detention in the low area west of Yew Street.

Alternative 11 - Replace the existing 24" diameter culvert with a 48" diameter culvert.

Alternative 12 - Install a parallel 36" diameter culvert.

<u>The recommended solution is a combination of Alternatives 10 and 11.</u> (Figure LP.2) The low area west of Yew Avenue provides a good location for a regional detention facility and water quality enhancement facility. The culvert should still be upsized to handle overflow requirements for impoundments to prevent overtopping the road.

Problem No. 4 - Ditch D65 Channel Velocities, Upstream of Our Lake

The channel velocities projected for a fully developed basin (5.3 fps) exceed scour velocity limits.

The recommended solution for Problem No. 3 should also correct Problem No. 4. Check dams reduce velocities and energy dissipators will also reduce velocities.

Problem No. 5 - Ditch D31 Channel Velocities, west of Governor Road

The channel velocities projected for a fully developed basin (6.4 fps) exceed scour velocity limits.

Alternative 13 - Modify the pond discharge structure upstream to reduce flows.

Alternative 14 - Armor the channel to protect against erosion. The channel will need to be widened to allow the riprap to be placed without sacrificing channel cross section.

Alternative 15 - Install check dams and energy dissipators to reduce velocities.

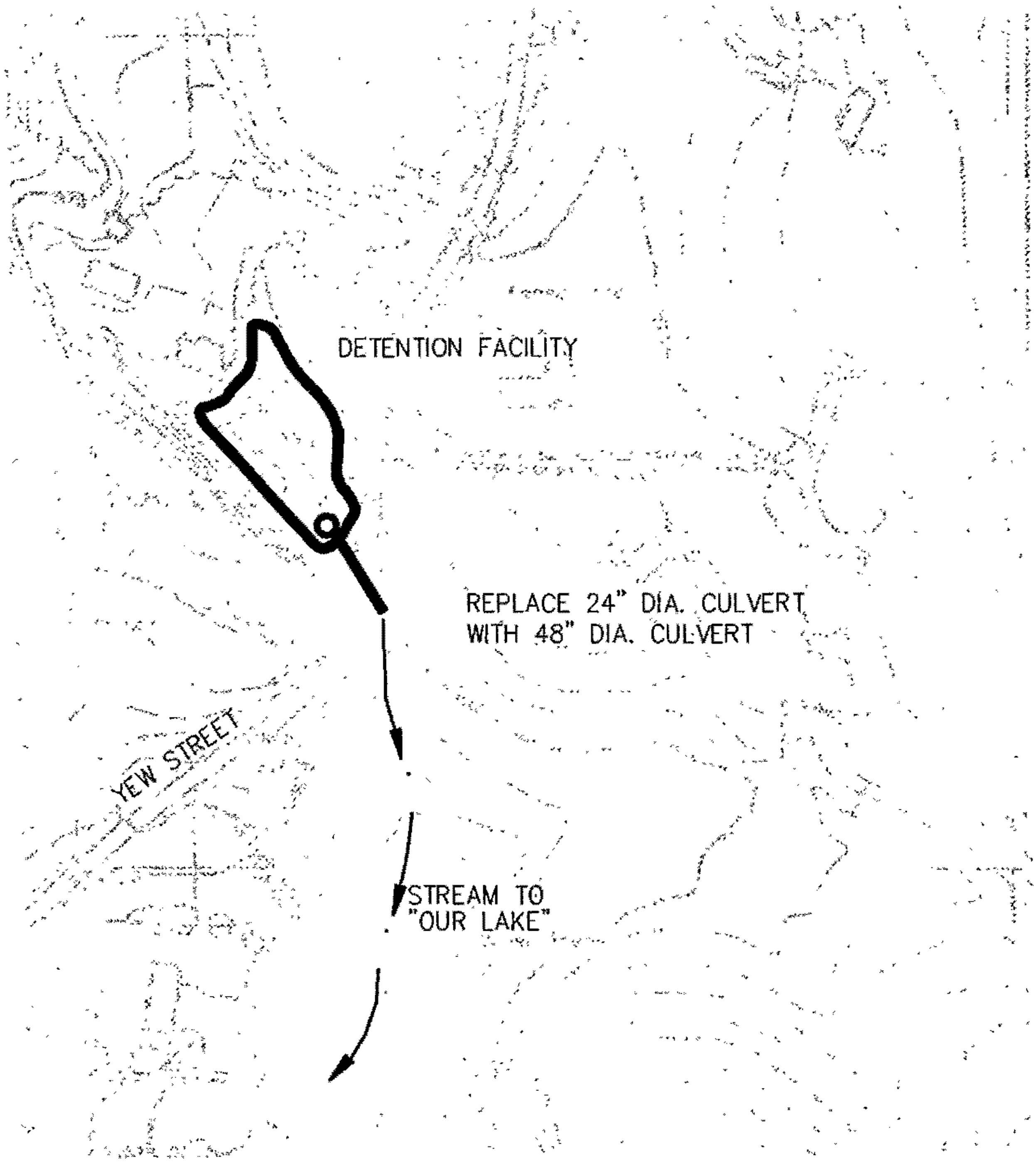
<u>The recommended solution is Alternative No. 15</u> since the velocities are slightly above 5 fps. Energy dissipators should be installed as problem areas develop.

Problem No. 6 - Pipe P12 Capacity under Samish Way south of Harrison

The 24" diameter pipe under Samish Way lacks adequate capacity to handle runoff from a fully developed basin.

Alternative 16 - Provide detention facilities upstream.

Alternative 17 - Replace the existing 24" diameter pipe with a 30" diameter pipe.



SCHEMATIC
LAKE PADDEN
PROBLEM NO. 3

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE LP.2 10/22/93

BEL13-16.DWG

The recommended solution is Alternative No. 16. Provide local detention facilities upstream. Preliminary plans are being prepared to develop the upstream hillside. Local detention should be made a condition of plant approval.

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9. PADDEN CREEK BASIN

Portions of eight neighborhoods lie within the Padden Creek drainage basin (Figure 9.0). These neighborhoods include South Hill, W.W.U., Sehome, Fairhaven, Happy Valley, Samish, Edgemoor, and South. The Happy Valley, Edgemoor and South neighborhoods were defined as the study area because future development pressure will most likely occur in these neighborhoods.

The northern and western portions of the basin have been developed at a relatively high density, with a mix of commercial, industrial, residential single and residential multiple usage. The study area consists of the lesser developed eastern and southern portions of the basin (Figure 9.1). The upper parts of the watersheds are dominated by forested land. Future development will most likely be mixed, consisting predominantly of multi- and single-family residential. Two subbasins that were identified in this study: Connelly Creek (the 200 series basins) and Padden Creek (the 100 series basins).

9.1 PADDEN CREEK STUDY AREA

9.1.1 Basin Characteristics

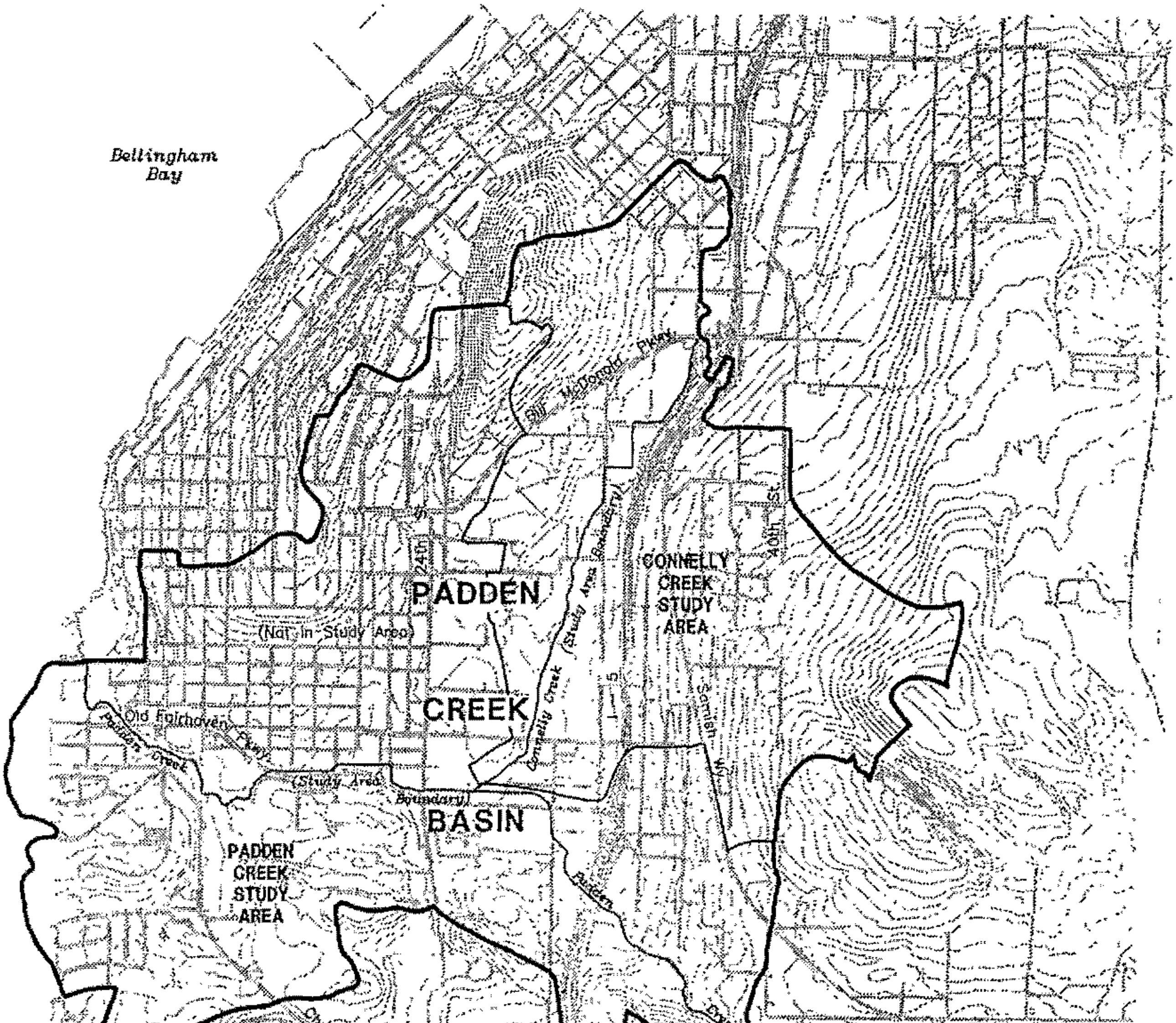
The Padden Creek study area is approximately 850 acres of the entire Padden Creek Basin area of 2,600 acres (Figures 9.1a and 9.1b). The basin is drained primarily by the mainstem of Padden Creek. For the most part, the tributaries are intermittent, and include pipes and ditches as facilities. A few depression wetlands and a small detention pond off of Chuckanut Drive serve to store and attenuate storm runoff from the area.

Most of the soil types found in this basin are silt loam with moderate percolation rates, a small portion of the basin is overlain with soils with very slow infiltration rates.

9.1.2 Wetlands

Four wetland areas were studied during the field investigation of the Padden Creek subbasin (Figures 9.2a and 9.2b). Included are areas of estuarine intertidal wetlands and palustrine forested, scrub-shrub and emergent wetlands.

A diverse range of characteristics are present in the studied wetlands. The intertidal environment of PA-1 provides unique wildlife habitat and important tidal flood control functions. PA-2 and PA-4 are relatively undisturbed palustrine scrub/shrub and forested wetlands. PA-2 has moderate to high wildlife habitat value, water quality benefits and floodwater attenuation potential.



LEGEND

- Major Basin Boundary
- Basin Boundaries
- Major Creeks

2000 1000 0 2000
Scale in Feet

N

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

DEA David Evans and Associates, Inc.

HDR HDR Engineering, Inc.

PADDEN CREEK BASIN

FIGURE 9.0

DATE OCT 22 1993

PA-4 is characterized as a 12.4-acre forested swamp in the Bellingham Wetland Inventory; however, the field investigation for the Watershed Master Plan found only a few minor areas of wetlands (approximately 0.25 acres in size) in this area along the creek. These small areas were associated with seeps in the upper bank of Padden Creek. This finding is a major discrepancy between the 1991 Wetland Inventory and this inventory. The general quality of PA-4 was moderate to high, but its small size substantially reduced the overall importance of its functions and values. A high level of human disturbance characterized PA-26 along Old Fairhaven Parkway, and the wetland had low wildlife habitat value but moderate to high biofiltration and floodwater attenuation values. Existing conditions of all the studied wetlands suggested that increased stormwater flows could be managed without substantial negative impacts.

9.1.3 Streams

The inventory of Padden Creek was conducted from its outlet in Bellingham Bay to Interstate Highway 5 (Figures 9.2a and 9.2b). Based on general stream characteristics and the nature of adjacent development, this portion of Padden Creek can be divided into three sections:

Section 1: a moderately disturbed lower segment having moderate density commercial and residential development. Reaches PC-1, and PC-2 have a low stream gradient, immature/even-aged forest vegetation, and substantial commercial and residential development nearby.

Section 2: a minimally to moderately disturbed, middle segment running primarily through Fairhaven Park. Reaches PC-3, PC-4 and PC-5 have a low to moderate stream gradient, predominantly mature forest vegetation and only minor adjacent development. Reaches PC-4 and PC-5 are part of Fairhaven Park. Separating Sections 2 and 3, Padden Creek flows through an approximately 2,100-foot long drainage conveyance (shown as the "Brick Tunnel" on Figure 9.1b, also referred to as P18 on Figures 9.1a and 9.1b) beneath Old Fairhaven Parkway. The tunnel physically separates the upstream extremity of PC-5 and the downstream extremity of PC-6.

Section 3: a moderate to highly disturbed, moderately densely developed upper segment. Reaches PC-6, PC-7, PC-8, PC-9 and PC-10 are characterized by a low to moderate stream gradient, a mixture of mature and immature/even-aged forest and pasture vegetation, and residential and commercial development.

9.1.4 Fisheries

Coho and chum salmon have been observed in the lower reaches of Padden Creek. Fish ladders beneath the Chuckanut Drive Bridge and at the east end of Fairhaven Park permit passage of anadromous fish from Bellingham Bay through Padden Creek to the east end of the Brick Tunnel; however, the tunnel is reported to be impassable to upstream fish migration.

The Bellingham Maritime Fisheries project plants salmon eggs and releases salmon fry at several locations in the Padden Creek watershed. A piece of PVC pipe approximately four inches in diameter and several hundred feet long was observed in the creek bed of stream reach PC-10. It is reportedly related to fish stocking of the waterway. Coho, chum, and chinook are placed in this portion of Padden Creek west of I-5, and east of 30th Street. Planted salmon can migrate out to sea but cannot return to the upper reaches because of the Brick Tunnel. Steelhead trout utilize the lower reaches of Padden Creek. Resident cutthroat trout are reported to occur in the reaches between I-5 and Lake Padden.

9.1.5 Nonpoint Pollution

A significant amount of residential, and some commercial development, is already present within the Padden Creek subbasin. Marine service establishments adjacent to wetland PA-1 may contribute nonpoint pollutants to this intertidal habitat. The potential for nonpoint pollution problems is considered moderate to high along Padden Creek. No obvious evidence of nonpoint pollution problems were observed during the field investigation.

9.1.6 Water Quality

Most of the potential for growth in the Padden Creek Basin will be single- and multi-family residential development. Some industrial/commercial growth may occur near the mouth of Padden Creek. Volume 2 includes tables showing existing and projected pollutant loadings based on historical data listed in Appendix C.

The pollutant loading projections show increases of 30 to 70 percent. The lower reaches of the basin have greater potential for pollutant washoff. Padden Creek will also be impacted by pollutant loadings being discharged from Lake Padden and Connelly Creek. Because pollutants are likely to wash into the creek from existing and anticipated land uses, runoff control methods that incorporate detention are preferable to those that advocate bypassing higher flows. Biofilter swales and/or water quality ponds should be incorporated into all new development.

Heavy algal growth was observed on the rocks in reach D14, which usually indicates high nutrient loading. In addition, bank under cutting and sloughing was observed in many of the lower reaches. Increased runoff from upstream development will increase this activity, which increases the amount of sediments in the water column.

For the residential areas, public environmental education can be an effective way to reduce the impacts of development on water quality. (See Section 6.4 for discussion.)

9.1.7 Problem Identification

Figures 9.1a and 9.1b show the approximate location of the problem areas listed in Table 9.1.

TABLE 9.1
IDENTIFIED PADDEN CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
1	P18, D19	FUT	PIPE CAP CHAN CAP	Brick Tunnel and Padden Creek west of 24th Street
2	P162 & D163	FUT	PIPE, CHAN CAP	Fairhaven Park and South
3	D11 D12 D17	EX	BANK, CHAN VEL	Padden Creek below Old Fairhaven Parkway
4	D355	FUT	CHAN VEL	Connelly Avenue and 34th Street

[a]Abbreviations: EX = Existing Land Use; FUT = Future Growth Land Use; PIPE CAP = Pipe Capacity; CHAN CAP = Channel Capacity; CHAN VEL = Channel Velocity; WQ = Water Quality; BANK = Bank Erosion

9.1.8 Alternative Analysis and Recommendations

Problem No. 1 - P18 and D19 Capacity, Brick Tunnel and Padden Creek west of 24th Street.

The channel cross section, 8 feet wide by 6 feet deep at the lower end transitioning to 12 feet wide by 5 feet deep at the upper end, is inadequate to handle flows projected from the fully developed basin (ditch overflows).

The following alternatives will provide solutions to the ditch capacity problem:

Alternative 1 - Maintain existing overflow patterns to route overflows around the brick tunnel.

Alternative 2 - Landscape the adjacent properties to add two to three more feet of free board to the bank for a total channel depth of 8 feet.

Alternative 3 - Modify the Happy Valley Detention facility on Connelly Creek to release a maximum of 96 cfs.

Alternative 4 - Provide local detention for upstream development

The recommended solution is Alternative 4, to provide local detention for upstream development. Alternative 1 should also be enforced to minimize overflow damage from system clogging or major storm events.

Landscaping the adjacent properties to create additional freeboard would require building a levee along the creek and modifying local drainage patterns and facilities.

Adjusting the Happy Valley detention facility to release a minimum of 96 cfs would require raising the existing facility berm by 3 feet. The flows calculated utilizing existing land uses are below the calculated capacity of both the brick tunnel and the channel. Providing local, on-site, detention for development in the upper subbasins would keep peak flows at current levels for those subbasins. Subbasins closer to the brick tunnel should not detain for storms larger than the water quality storm event, to allow peak flows to pass before the tributary basin hydrograph peak reaches the brick tunnel. Subbasins for detention include: PC106, PC107, PC108, PC161, PC162, PC232, PC233, PC234 and PC252.

The inlet to the brick tunnel should be monitored regularly and debris removed from the trash rack when found. Debris on the trash rack will reduce the hydraulic capacity of the inlet and increase the likelihood of overflow conditions.

Problem No. 2 - P162 and D163 Capacity, Fairhaven Park

These facilities (P162 - 24" diameter and D163 - 2 feet by 2 feet ditch) are inadequate to handle the flows projected for the fully developed tributary basin.

The following alternatives will provide solutions to the identified capacity problems for P162 and D163:

Alternative 4 - Provide local detention for upstream development.

Alternative 5 - Replace the existing 24" diameter concrete pipe with a 36" diameter concrete pipe. Widen the ditch from 2 to 4 feet.

The recommended solution is Alternative 5, provide detention for upstream development. This is the approach agreed upon during the permitting process for pipe P162.

Problem No. 3 - Channel Erosion in Padden Creek

Field observation indicated large amounts of mass wasting and significant amounts of bank undercutting. Hydrologic modeling indicates excessive channel velocities in reaches D11, D12 and D17.

The following alternatives will provide solutions to erosion problems along Padden Creek:

Alternative 6 - Construct a high flow by-pass to carry peak flows directly to the mouth of Padden Creek. This pipe would be a 72" diameter smooth wall pipe.

Alternative 7 - Increase detention volumes along the creek and tributaries to minimize peak flows.

Alternative 8 - Install bioengineered slope stabilization for bank protection and notched check dams to reduce channel velocities.

The recommended solution is Alternative 8, to install bioengineered slopes and notched check dams (Figure PC.1). Providing detention would only eliminate peak flows and would not reduce flow volumes. The continued wetting would increase the sloughing problem and prolonged flows would also continue bank undercutting. Constructing a 72" diameter diversion pipe would be disruptive and more extensive by at least one order of magnitude.

Problem No. 4 - D355 Channel Velocities, Connelly Avenue at 34th Street.

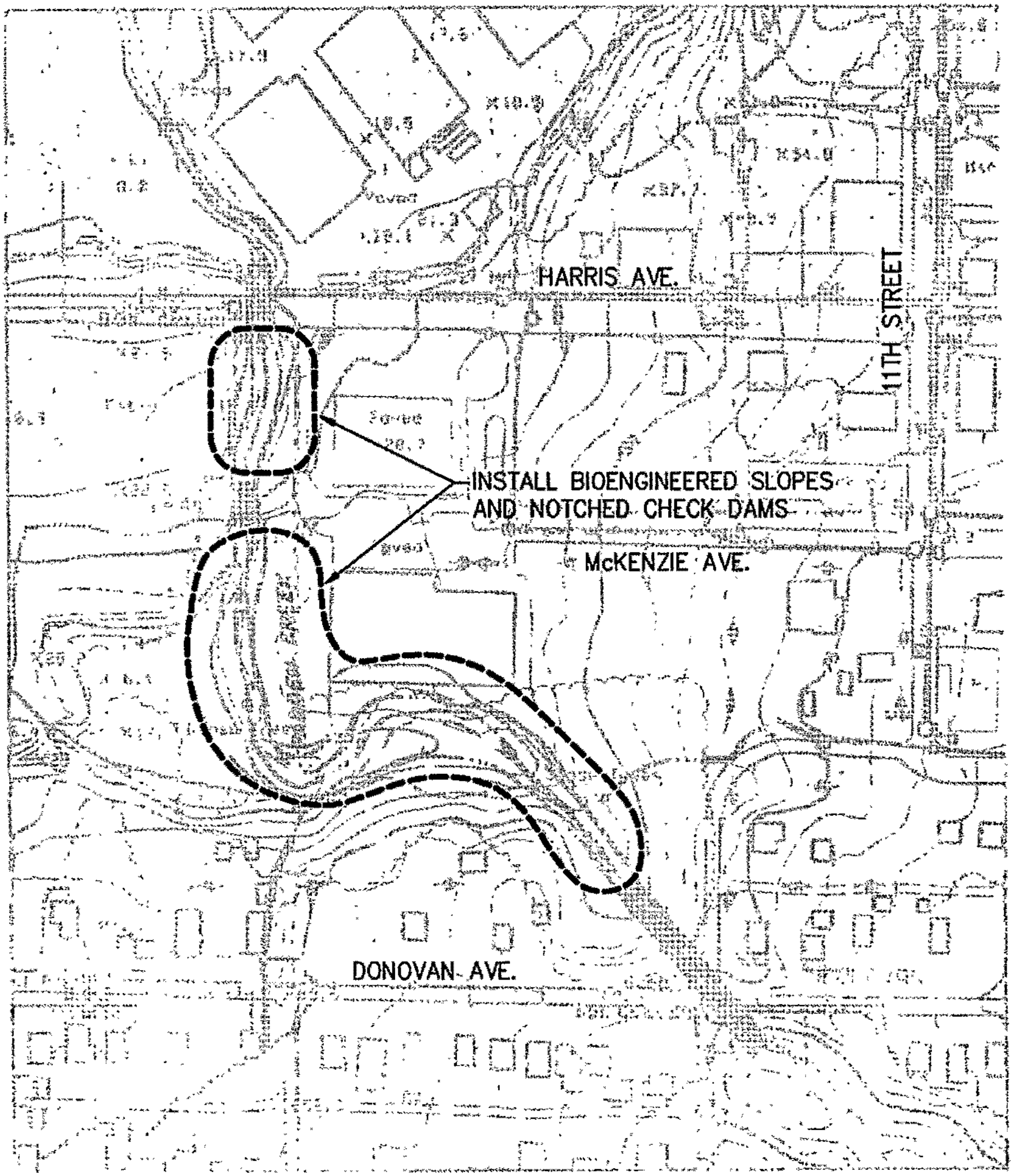
The hydrologic model indicates excessive velocities of 6.9 fps in the ditch.

The following alternatives will provide solutions to channel velocity problems identified for D355:

Alternative 9 - Armor the ditch to protect against erosion. The channel cross section will need to be widened to maintain existing flow area.

Alternative 10 - Require detention for new developments that contribute runoff to this reach to maintain flows and velocities within acceptable limits for the reach facilities.

The recommended solution is Alternative 9, to armor the ditch with riprap (Figure PC.2). Providing local detention will reduce erosion problems by reducing peak flow velocities. It will not reduce increased flow volumes and will result in extended periods of higher flow energy in the channel.



SCHEMATIC
PADDEN CREEK
PROBLEM NO. 3

N

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
PC.1
1 OF 2
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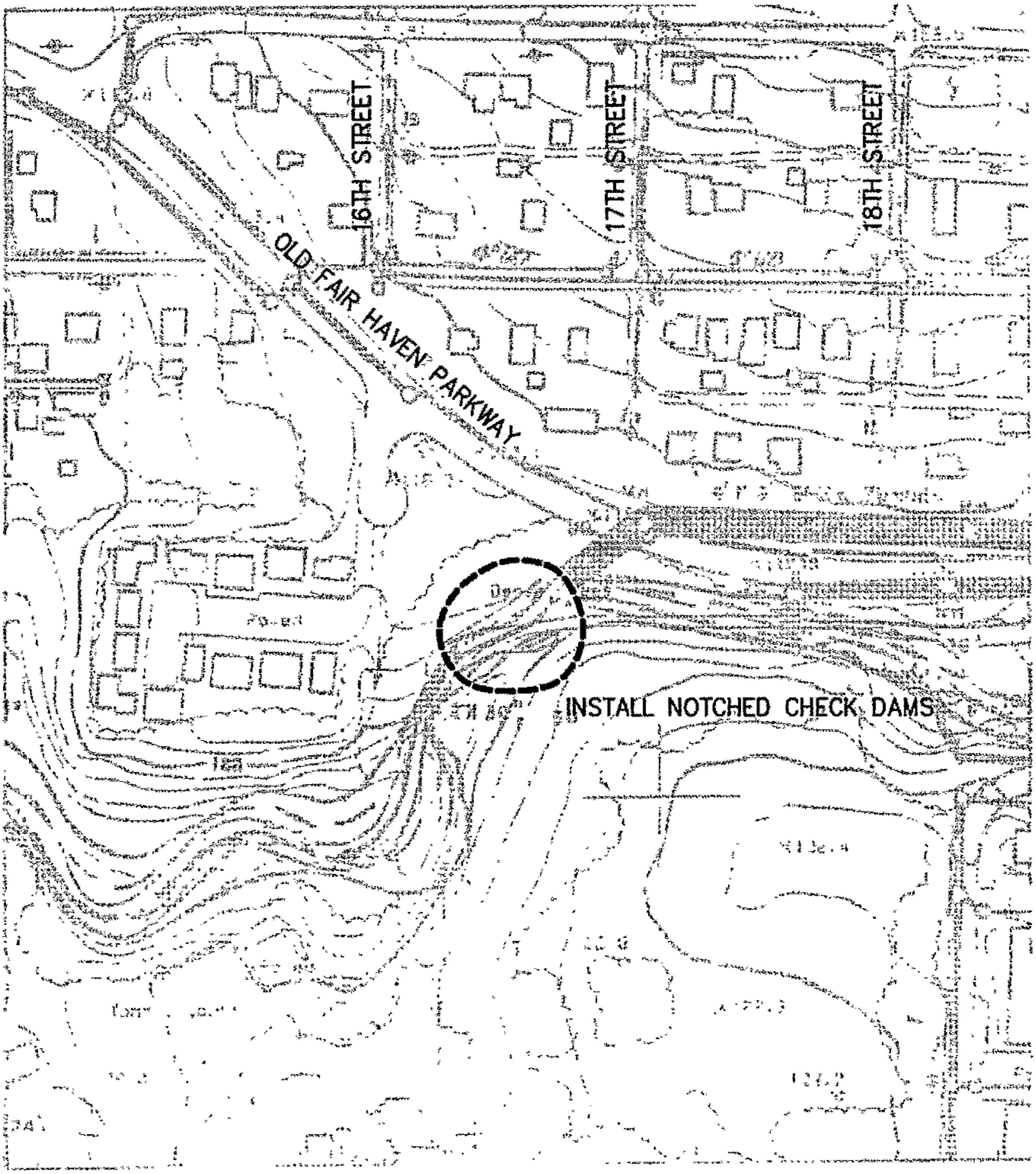

SCHEMATIC
PADDEN CREEK
PROBLEM NO. 3

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
PC.1
2 OF 2
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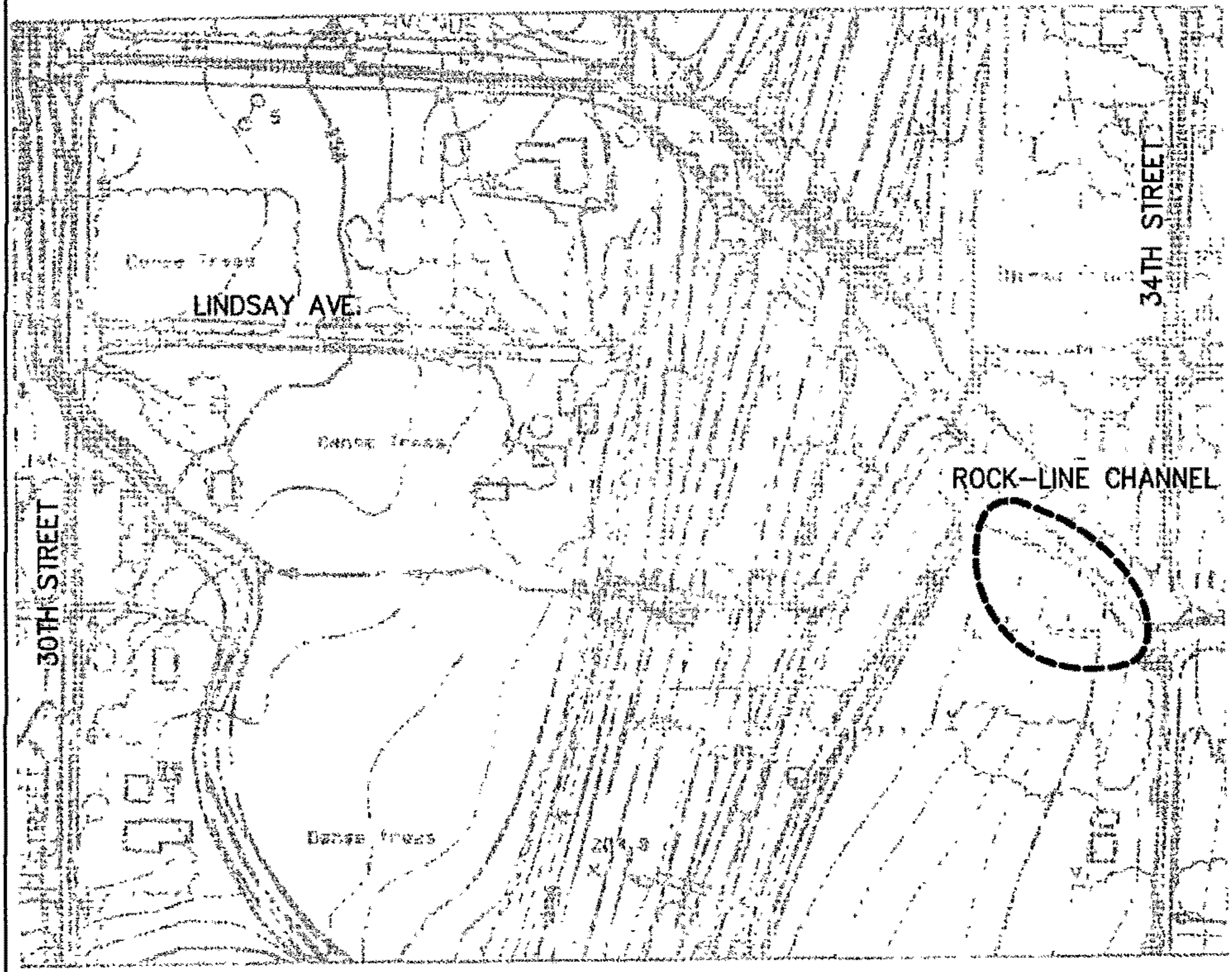
BEL17-20.DWG



SCHEMATIC
PADDEN CREEK
PROBLEM NO. 4

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE PC.2 10/22/93

BEL17-20.DWG

9.2 CONNELLY CREEK STUDY AREA

9.2.1 Basin Characteristics

The Connelly Creek study area is approximately 620 acres of the entire Padden Creek Basin's 2,600 acres (Figures 9.1a and 9.1b). The basin is drained primarily by the mainstem of Connelly Creek. For the most part, the tributaries are intermittent in nature incorporating pipes and ditches as facilities. The Connelly Creek detention pond provides some storage and attenuation of storm runoff.

Most of the soil types found in this basin are silt loam with moderate percolation rates, a small portion of the basin was overlain with soils with very slow infiltration rates.

9.2.2 Wetlands

The natural resources field investigation of the Padden Creek drainage basin was conducted on March 3 through 11, 1992. A simplified wetland functions and values assessment was performed on selected wetlands. Stream reaches along part of Padden Creek and Connelly Creek were inventoried for this study. Runoff from spring storm activity boosted water levels in streams and wetlands to an intermediate level during the field investigation. A more detailed description of wetlands is contained in Volume 2.

Four wetland areas associated with Connelly Creek were studied during the field investigation of the subbasin (Figure 9.2a). Wetlands PA-27 and PA-28 associated with the lower reaches of Connelly Creek consist of predominantly emergent and scrub-shrub wetland classes. Generally good water quality benefits are provided by the thick emergent vegetation of this wetland. Because they are disturbed, the effect of decreased/increased water flows on these wetland is small.

Wetlands PA-29 and PA-33 in the upper reaches of Connelly Creek are characterized by mature forest vegetation, providing excellent wildlife habitat and good water quality benefits. One of these relatively high quality wetlands (Wetland PA-33) is already part of an existing stormwater detention facility (the dam lies between PA-29 and PA-33). Thus, it was assumed that increased stormwater flows could be managed within the existing detention facility without substantial negative impacts to the downstream wetlands.

9.2.3 Streams

Connelly Creek was inventoried from its confluence with Padden Creek upstream to the culvert at Taylor Avenue (Figure 9.2a). Based on its general vegetation characteristics, this portion of Connelly Creek can be divided into two sections:

> Section 1: a shrub and grass dominated lower portion of the stream. Reaches CC-1, CC-2 and CC-3 are characterized by a low stream gradient, shrub- and herbaceous-dominated vegetation and some nearby residential development.

Section 2: a forested dominated upper portion of the stream. Reaches CC-4 and CC-5 have a low gradient, mature forest vegetation and relatively little closely adjacent development except for the detention facility dam which lies between reaches CC-4 and CC-5.

A more detailed description of wetlands is contained in Volume 2.

9.2.4 Fisheries

The "Brick Tunnel" through which Padden Creek flows under Old Fairhaven Parkway is a barrier to the passage of salmon returning to Connelly Creek from Bellingham Bay. However, coho are planted annually in Padden and Connelly Creeks (above the tunnel) by the Maritime Heritage Hatchery. Additionally, cutthroat and steelhead have been observed in Connelly Creek.

9.2.5 Nonpoint Pollution

Relatively dense residential and commercial development exists at the north end of the Connelly Creek subbasin. Although no nonpoint pollution was observed in the field, the potential for nonpoint pollution problems in this area was considered moderate to high. Large parking areas associated with the shopping center in the headwaters of Connelly Creek may contribute non-point pollutants to the creek's waters.

9.2.6 Water Quality

Most of the growth anticipated for the Connelly Creek study area will be residential and commercial. Some multi-family residential development may occur. Volume 2 includes tables showing existing and projected pollutant loadings from the basin based on historical data listed in Appendix C. Field observations during the field investigations revealed some water quality problems in the form of murky water, probably from erosion and land disturbances.

The pollutant loading projections predict increases of 20 to 50 percent above current pollutant loading estimates. The upper reaches of the basin have great potential for pollutant washoff. Modifications to the operation of the Happy Valley Detention Facility should be considered to include a dead storage volume to improve sediment removal. New development in the basin should incorporate biofilter swales prior for water discharging into Connelly Creek. Collection systems above I-5 should incorporate grass-lined swales traversing the hillside to improve pollutant removal rates.

The wetlands along Connelly Creek provide for sedimentation, filtration and biological uptake. Efforts should be made to preserve these areas and the Happy Valley Detention Facility and their quality functions.

Public environmental education can be an effective way to reduce the impacts of development on water quality from residential areas. (See the discussion in Section 6.4.)

9.2.7 Problem Identification

Figure 9.1a shows the locations of problem areas in the Connelly Creek Basin listed in Table 9.2. The problem numbers for the Connelly Creek Basin start with Number 21. This is to avoid confusion with the Padden Creek Basin problem numbers which are shown on the same figure.

TABLE 9.2
IDENTIFIED CONNELLY CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem[a]		Location
21	P27A, P27B, P29	FUT	PIPE CAP	Connelly Creek south of Bill McDonald Parkway
22	D243, D244, D245, D247, D248	EX	CHAN VEL	Mill Avenue tributary
23	P261B-P269, D261A, D261C, D269A	FUT	PIPE CAP CHAN CAP	Ridgemont Way and Bennett Avenue
24	D252, D254	EX	CHAN VEL	Taylor Avenue
25	P281	FUT	PIPE CAP	Fielding and Samish Way

[a]Abbreviations: EX = Existing Land Use; FUT = Future Growth Land Use; PIPE CAP = Pipe Capacity; CHAN CAP = Channel Capacity; CHAN VEL = Channel Velocity; WQ = Water Quality; BANK = Bank Erosion

9.2.8 Alternative Analysis and Recommendations

Problem No. 21 - Pipes P27A, P27B, and P29 Capacity, Connelly Creek south of Bill McDonald Parkway

Many of the pipes within these reaches are undersized to convey the runoff generated from the fully developed tributary basin.

The following alternatives will provide solutions for the identified capacity problems:

Alternative 1 - Replace identified pipes (24" and 30" diameter CMP) with 48" diameter concrete pipe.

Alternative 2 - Install parallel 36" diameter smooth wall pipes.

Alternative 3 - Provide detention upstream to limit flows to the system capacity.

The recommended solution is Alternative No. 1, replace the pipes with 48" diameter concrete pipes (Figure CON.1). There is no practical area upstream to provide the detention volumes needed to reduce flows, most development will be in fill. Installing parallel pipe would require extra space within the existing right-of-ways making future utility work more difficult. Implementing this recommendation will require fisheries approval.

Problem No. 22 - Ditches D243, D244, D245, D247, and D248 Channel Velocity

The estimated channel velocities of 5.2 fps and 6.7 fps, exceed scour velocity limits.

The following alternatives will provide solutions to the identified velocity problems:

Alternative 3 - Provide detention upstream.

Alternative 4 - Armor the channel to protect against erosion.

Alternative 5 - Install check dams and energy dissipators to reduce velocities.

The recommended solution is Alternative 4, armoring the channel. The hillside is steep enough through this area to make check dams or energy dissipators less effective. Channel armoring can be done at reported trouble spots through the annual maintenance budget.

Detention is unlikely to solve the erosion problem because steepness of ditch gradient is the primary cause of the high velocity. Providing upstream detention will reduce peak flows and velocities, but will not reduce the projected volume of water to pass through the ditch reaches. Increased volume, over an extended time, increases the period of higher flow energy.

Problem No. 23 - Pipes P261B-P269 and Ditches D261A, D261C, and D269A at Ridgemont Way and Bennett Avenue.

These 15" and 18" diameter pipes are undersized to convey the runoff generated from the fully developed tributary basin. The estimated channel velocities of 7.3 fps and 7.5 fps exceed scour velocity limits.

The following alternatives will provide solutions to the identified velocity problems:

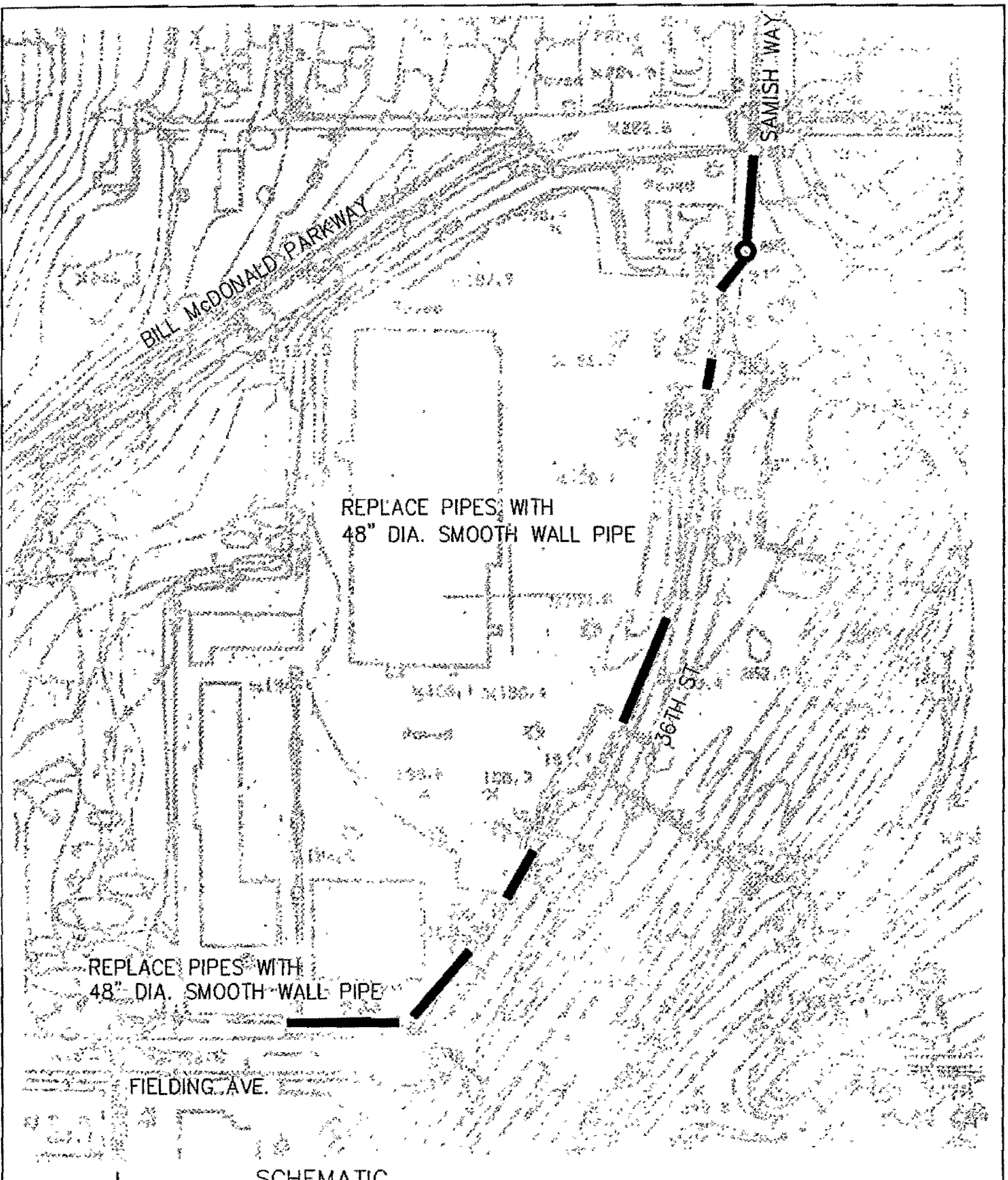
Alternative 4 - Armor the channel to protect against erosion.

Alternative 5 - Install check dams and energy dissipators to reduce velocities.

The following alternatives will provide solutions to the identified capacity problems:

Alternative 6 - Replace the identified pipes (ranging from 15" to 18" diameter cmp) with 24" diameter smooth wall pipes.

Alternative 7 - Utilize the existing system and allow the gutter to accommodate overflow.



SCHEMATIC
CONNELLY CREEK
PROBLEM NO. 21

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FIGURE
CON.1

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Alternative 8 - Redirect flows back to their original flow pattern through subbasin PC261.

Alternative 9 - Provide detention for development east of 40th Street.

The recommended solution is Alternatives 4 and 9, armoring the channel and providing detention for development. Replacing the pipes with 24" diameter concrete pipes would be expensive and disruptive. Redirecting the flow back to PC261 would exacerbate Problem No. 21. It is generally not recommended to plan overflow in a traveled street for safety reasons.

Problem No. 24 - Ditches D252 and D254 Channel Velocities

The projected channel velocities of 5.1 fps and 5.6 fps, estimated for existing land uses, exceed scour velocity limits.

The following alternatives will provide solutions to the identified velocity problems:

Alternative 3 - Provide detention upstream.

Alternative 4 - Armor the channel to protect against erosion.

Alternative 5 - Install check dams and energy dissipators to reduce velocities.

The recommended solution is Alternative 4, armoring the channel. Channel armoring would be done at reported trouble spots through the annual maintenance budget. Detention is unlikely to solve the erosion problems because steepness of ditch gradient is the primary cause of the high velocity. See discussion for Problem No. 22.

Problem No. 25 - P281 Capacity, Fielding and Samish Way

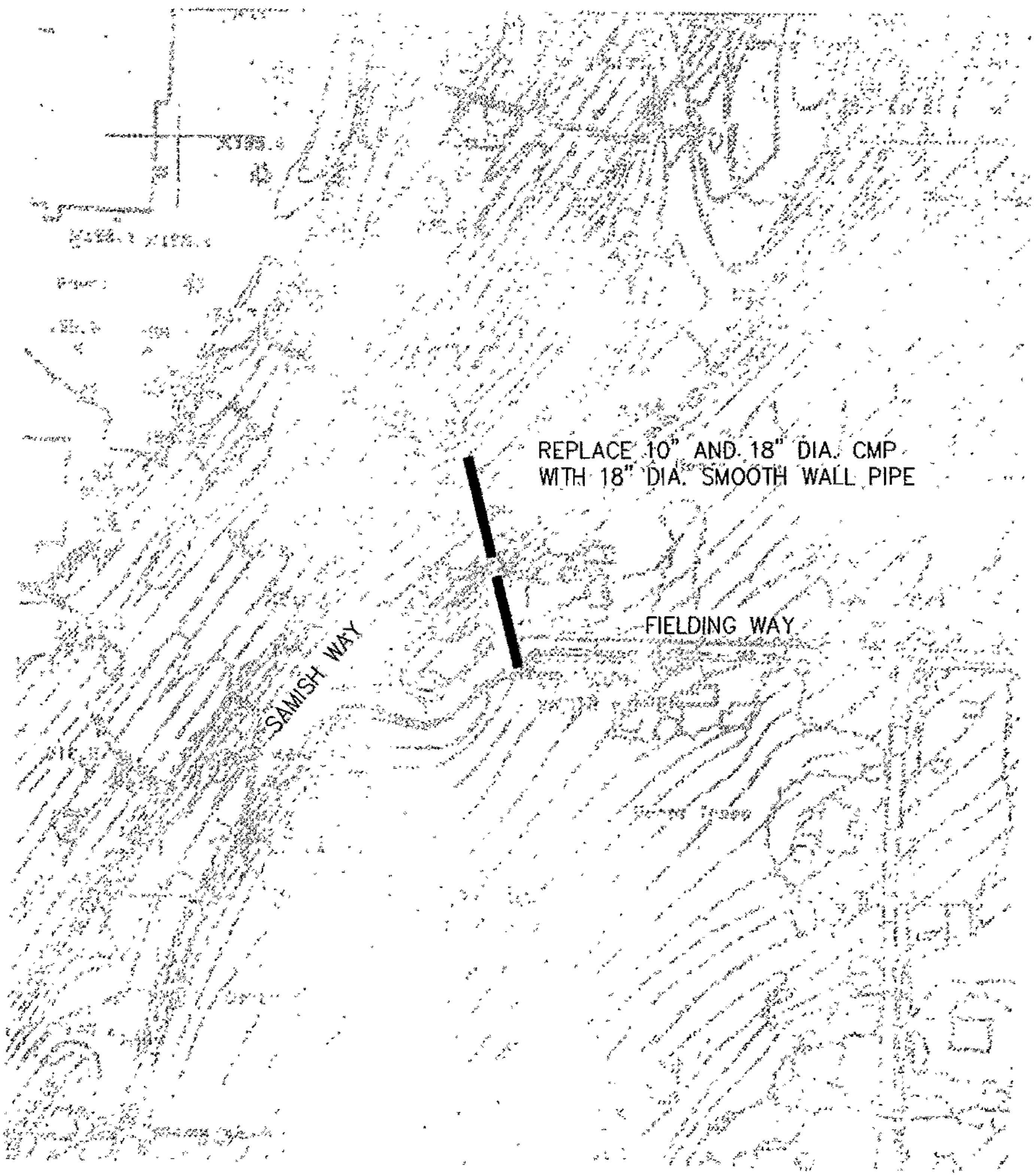
This 10" diameter pipe is inadequate to convey the projected runoff from a fully developed basin.

The following alternatives will provide solutions to the identified capacity problem:

Alternative 12 - Replace existing CMP pipe with an 18" diameter smooth wall pipe.

Alternative 13 - Provide detention as upstream properties develop.

The recommended solution is Alternative 12, to replace the pipe with an 18" diameter concrete pipe (Figure CON.2). Most upstream development will be single lot development. Requiring on-site detention would increase the number of small facilities that would either need to be inspected or maintained by the City.



SCHEMATIC
CONNELLY CREEK
PROBLEM NO. 25

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE CON.2 10/22/93

BEL13-16.DWG

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10. CHUCKANUT CREEK BASIN

Most of the Chuckanut Creek Basin is located outside the city limits (Figure 10.0). That area within the Bellingham city limits was studied for this project. Portions of three neighborhoods; Edgemoor, South, and Samish lie within the study area.

At present, much of the basin is undeveloped forested lands. Rural density single-family residential development has occurred along the major roads. The more densely developed areas consist of trailer parks. Opportunities for additional development still exist in all of the neighborhoods because of the current relatively low-density residential development. Future development will most likely be single-family residential housing in the northwest corner of the basin and east of Lake Padden, near I-5.

The development will most likely occur on the lower elevation slopes within the basin. County development plans should be monitored to assure adequate protection of downstream City facilities.

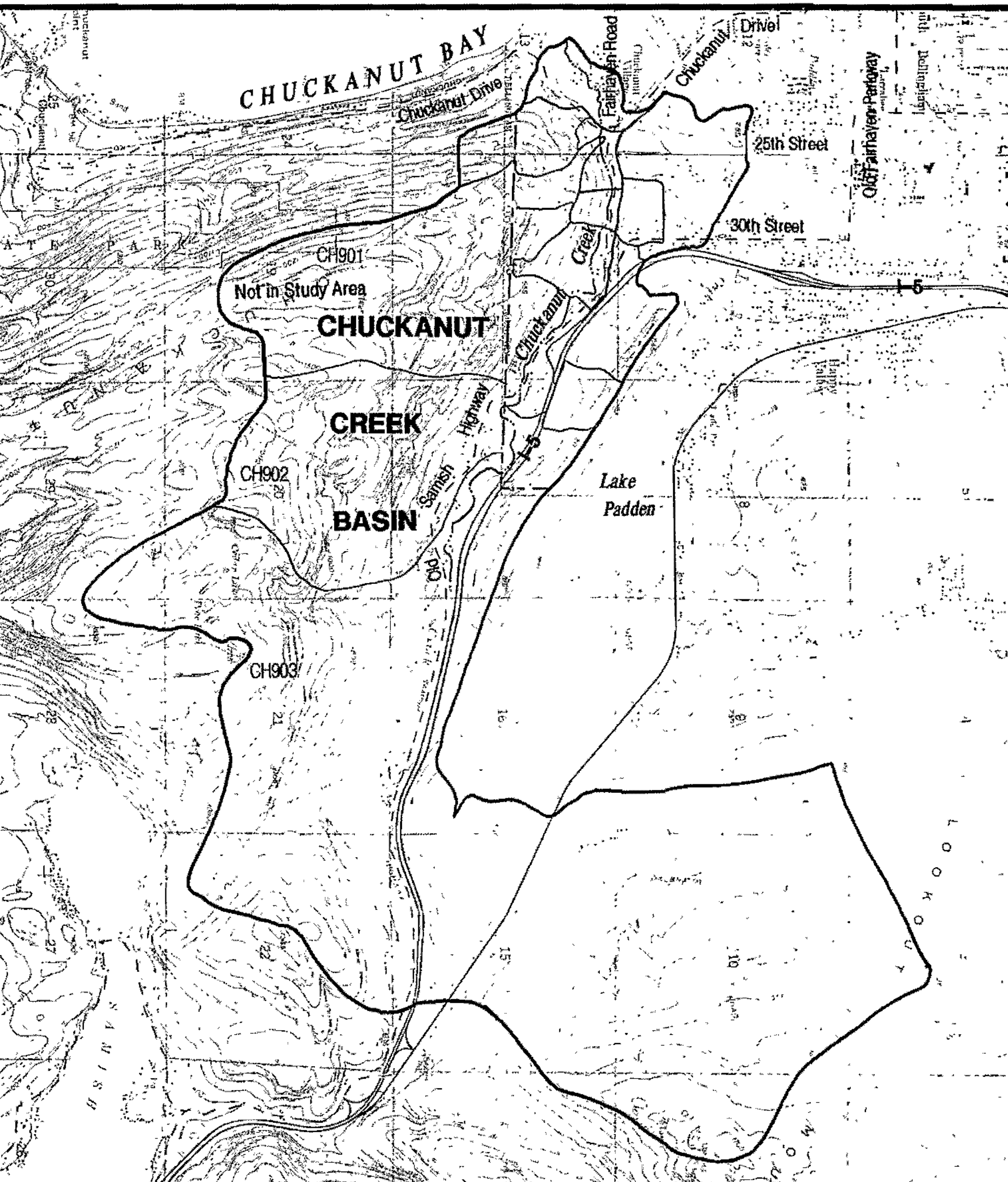
10.1 BASIN CHARACTERISTICS

The Chuckanut Creek Basin has an approximate area of 4,834 acres of which 4,062 acres are outside of the defined study area. The basin is drained primarily by the mainstem of Chuckanut Creek. Although a few perennial streams drain the non-study area, most tributaries are intermittent in nature. Hoag pond and a large wetland around the interurban trail provide some storage and attenuation of storm runoff for the northwestern portion of the basin. Most drainage facilities are streams and culverts, with some pipes and ditches are found in the northwest portion.

While the majority of soils types found in this basin are silt loam with moderate percolation rates, a small portion of the basin is overlain with soils with very slow infiltration rates.

10.2 WETLANDS

Six wetlands associated with Chuckanut Creek were studied during the field investigation (see Figure 10.2). In general, these wetlands (CH-1, CH-10, CH-27, CH-26, CH-31, and CH-47) are characterized by a relatively low level of human disturbance, forest vegetation, moderate wildlife habitat value, moderate water quality benefits and only minor anticipated effects from increases in stormwater flows. A more detailed description of these wetlands is contained in Volume 2.



LEGEND

- Major Basin Boundary
- Basin Boundaries
- Study Area Boundary
- Major Creeks

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE 10.0

CHUCKANUT CREEK BASIN

DATE OCT. 22 1993

10.3 STREAMS

The inventory of Chuckanut Creek was conducted from its outlet in Chuckanut Bay to the Bellingham city limits roughly two miles to the east (Figure 10.2). Overall, Chuckanut Creek presented some of the least obviously disturbed stream corridor habitat of all the streams inventoried within the city limits. Stream characteristics and the nature of adjacent development are generally uniform over the entire length of the study area. Mature or immature/even-aged forest was the dominant vegetation type and the stream gradient was low to moderate. Human disturbance of Chuckanut Creek was low, except for the lowermost reach where residential development was most common and closely adjacent to the creek in its floodplain. Although Reach CH-1 has several residential properties that sustained flood damage over the last two years, the other reaches appeared to have the potential to handle additional stormwater flows without significant adverse effects. A more detailed description is found in Volume 2.

10.4 FISHERIES

Within the city limits, Chuckanut Creek is free of barriers to the passage for salmon. Coho and chum salmon utilize Chuckanut Creek from Chuckanut Bay to a short distance upstream of the city limit, where the creek flows over steep rock outcrops that form an impassable barrier. According to conversations with staff from the Washington State Department of Fisheries, if plans for a fish ladder at the steep rock outcrops are implemented, extensive spawning and rearing habitat will be made accessible to salmon.

The Bellingham Maritime Heritage Hatchery plants salmon eggs in fish boxes located in the Chuckanut Creek watershed. Chum eggs are placed in a tributary of Chuckanut Creek (near the Chuckanut Drive culvert for Chuckanut Creek) and coho eggs are placed in the upper reaches of Chuckanut Creek east of I-5 (outside of the study area). Planted salmon can reach the sea, but those planted east of the freeway cannot return to their origination point.

Cutthroat trout utilize most of Chuckanut Creek and steelhead trout may be able to surmount the steep rocks just outside of the city limits.

10.5 NONPOINT POLLUTION

Failures of private septic systems could potentially contribute nonpoint pollution to reach CH-1 of Chuckanut Creek. The residential neighborhood within the drainage basin of this reach is serviced by older septic systems, and is periodically flooded because it lies within the creek's floodplain.

A potential nonpoint pollution problem was observed in reach CH-4 where a stormwater pipe from I-5 discharges into wetland CH-31. The wetland could be impacted by providing biofiltration treatment before discharging to Chuckanut Creek. Another potential problem was possible sediment and manure laden runoff from a small creekside animal pasture in reach CH-6. No other instances of nonpoint pollution were observed during the field investigation.

In general, residential development near Chuckanut Creek is a potential source of nonpoint pollution from lawn and garden herbicides and pesticides as well as septic wastes from potential failing septic systems.

10.6 WATER QUALITY

Most of the potential for growth in the Chuckanut Creek Basin will be single-family residential. Some spot commercial growth may occur for convenience shopping. Volume 2 includes tables showing existing and projected pollutant loadings based on historical data listed in Appendix C. The pollutant loading projections show a wide range of increases, mainly due to the relatively undeveloped existing land use. Development standards in this basin should incorporate as much biofiltration as possible. Collection systems should incorporate grass-lined swales traversing slopes in place of pipes or rock-lined chutes perpendicular to the slope.

Bank under cutting and sloughing has been observed in many of the lower reaches. Increased runoff from upstream development will increase this activity, which will, in turn, increase the amount of sediments in the water column.

Because septic tanks have failed near the mouth of the creek a growth moratorium has been put in place. Other potential water quality concerns include a horse pasture adjacent to the stream (see Section 10.5).

For the residential areas, public environmental education can be an effective way to reduce the impacts of development on water quality. (See Section 6.4)

10.7 PROBLEM IDENTIFICATION

Figure 10.1 shows the approximate location of each of the problem areas listed in Table 10.7.

TABLE 10.7
IDENTIFIED CHUCKANUT CREEK PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem*		Location
1	P114	FUT	PIPE CAP	Lake Samish Road
2	D10	EX	CHAN VEL BANK	Chuckanut Creek Main Stem
3	D101	FUT	CHAN VEL	Chuckanut Creek Tributary
4	D121, D123	FUT	CHAN VEL	Chuckanut Creek Tributary
5	D141	FUT	CHAN VEL	Chuckanut Creek Tributary
6	D151, D153	FUT	CHAN VEL	Chuckanut Creek Tributary
7		FUT	WQ	Chuckanut Basin

*Abbreviations: EX = Existing Land Use; FUT = Future Growth Land Use; PIPE CAP = Pipe Capacity; CHAN CAP = Channel Capacity; CHAN VEL = Channel Velocity; WQ = Water Quality

10.8 ALTERNATIVE ANALYSIS AND RECOMMENDATIONS

Problem No. 1 - P114 Capacity, Lake Samish Road

This 18" diameter pipe is inadequate to convey projected flows from a fully developed tributary basin.

The following alternatives will provide solutions to the capacity of pipe P114:

Alternative 1 - Replace the 18" diameter pipe with a 24" diameter smooth wall pipe.

Alternative 2 - Provide upstream detention for future development

The recommended solution is Alternative 1. Replace the pipe with a 24" diameter smooth wall pipe. This can be placed as a requirement of future development (Figure CH.1). Replacing the pipe is preferred to providing detention beyond the water quality design storm event because this area is near the mouth of the watershed. Detention will detain the runoff discharge and increase the peak flows in the main stem, aggravating existing and projected erosion problems.

Problem No. 2 - Chuckanut Creek Main Stem Channel Velocities

Field investigations indicated segments of sloughing and bank undercutting. The hydrologic model also projects high channel velocities for the fully developed basin. In addition the lower reach is prone to flooding.

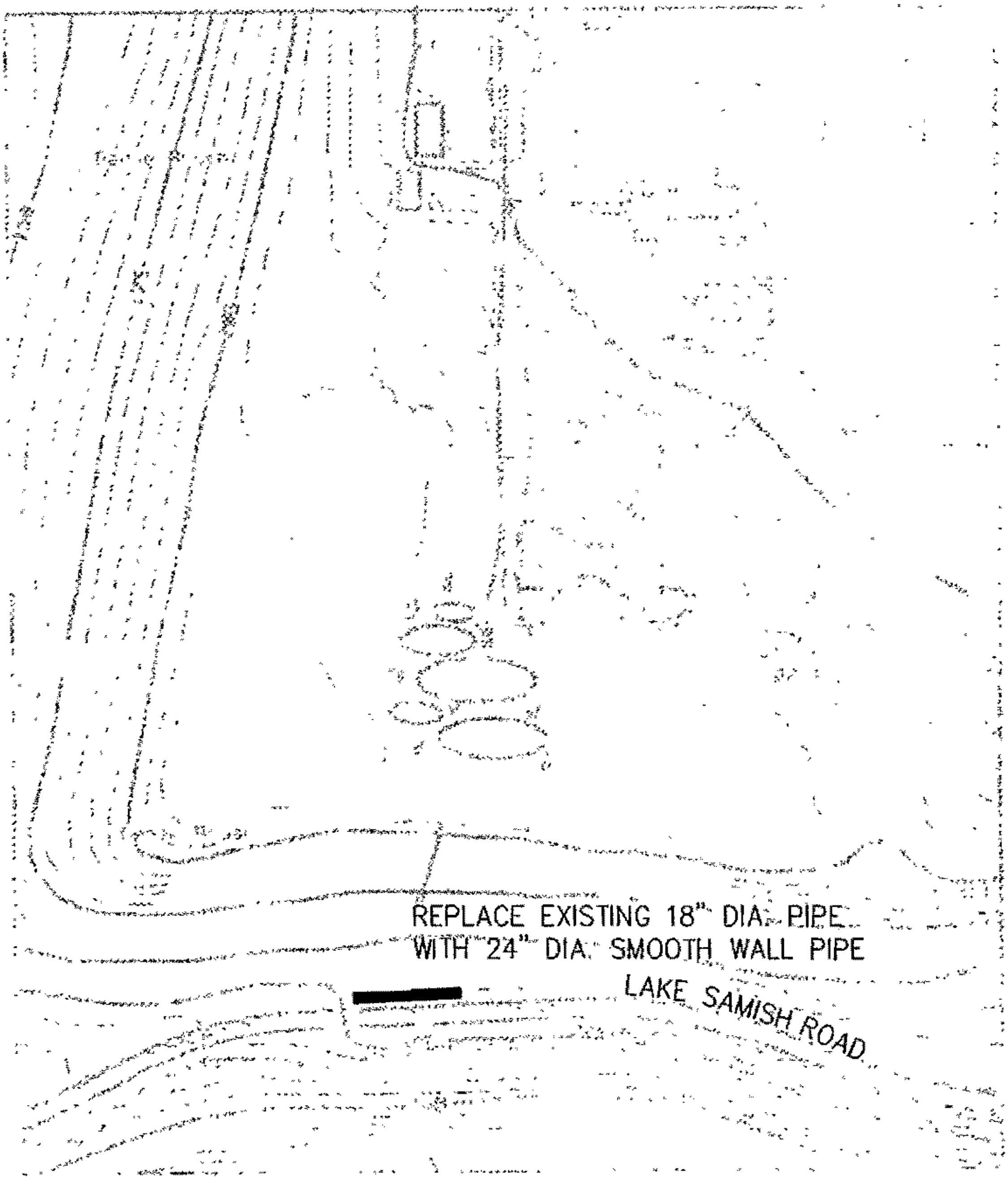
The following alternatives will provide solutions to the channel velocity problem:

Alternative 3 - Provide regional detention upstream to reduce peak flows.

Alternative 4 - Stabilize the eroding and sloughing slopes with plantings and bioengineering.

Alternative 5 - Install energy dissipators or check dams to reduce stream velocities.

The recommended solution is a combination of Alternatives 3 and 4. Plantings to stabilize slopes can be effective on gentler slopes and must include toe protection when undercutting could occur. Bioengineering can be effective for stabilization of steeper slopes. A bio-engineered slope would include "soft" gabions with toe protection. The "soft" gabions are constructed out of layered, decomposable, matting material (such as coconut fabric) and willow shoots. Check dams and other energy dissipators can be disruptive to fish migration and can lead to other types of erosion problems. They should be used cautiously in main streams. Culvert crossings at Chuckanut Drive (P11) and Old Samish Highway (P16) can be restricted to utilize stream storage to buffer flows at the mouth of the creek. Restrictions must be designed to maintain fish passage and to pass extreme flood events without impairing the roadway embankments. This can be done utilizing a large diameter manhole configuration similar to detention facilities. The manhole would not have a control gate. Roadway



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SCHEMATIC
CHUCKANUT CREEK
PROBLEM NO. 1

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
CH.1
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embankment stabilization may be required. Plans for growth upstream of the city limits should include regional detention facilities.

Problems No. 3 Through 6 - Channel Velocities on Chuckanut Creek Tributaries

The hydrologic model projects excessive channel velocities for tributaries D101, D121, D123, D141, D151, and D153 for the fully developed tributary basins.

Alternate 6 - Armor ditches to protect against erosion.

Alternate 7 - Provide upstream detention for future development.

Any combination of armoring, planting, check dams, energy dissipators, and detention can solve velocity problems. These mitigating procedures should be enforced as part of the requirements for future development.

Detention facilities are less appropriate for the study area portion of the Chuckanut Basin. Because the total basin is relatively long compared to width, efforts to detain flow in the lower reaches, near the creek, will have a cumulative effect of increasing peak flows. These flows should be allowed to drain out of the system before the peak flows from upstream areas reach the lower creek segments. Increasing peak flows would aggravate existing and projected erosion problems in this basin.

Problem No. 7 - Water Quality Degradation from Development

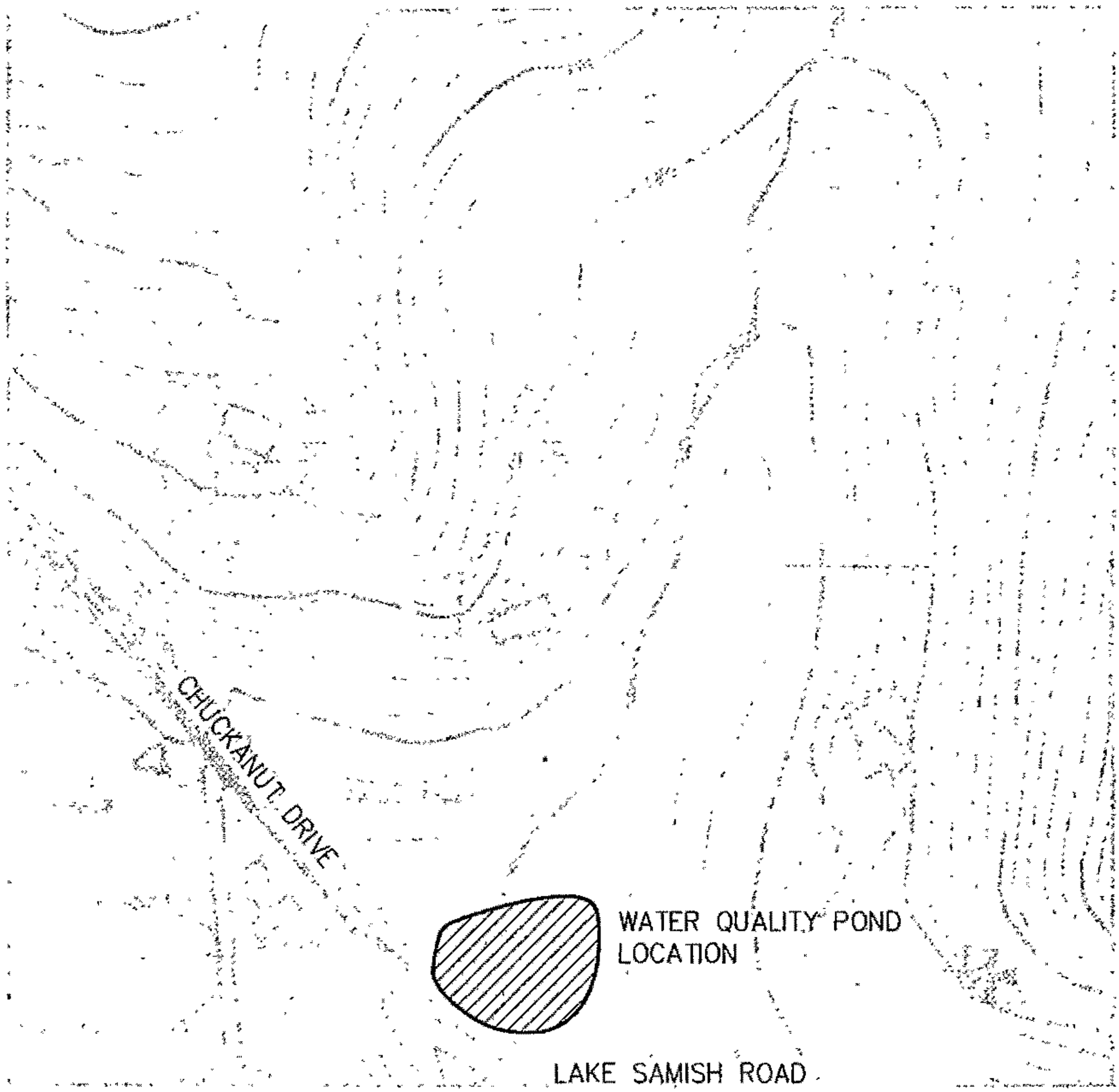
The Chuckanut Basin is currently one of the least disturbed streams in the project area. Human disturbance will undoubtedly have an impact on water quality. Some impacts are currently seen at the mouth where the lots are not served by sewers and from horse pastures adjacent to the stream.

Alternate 8 - Develop a public education/awareness program to educate residents about their impacts on the stream, its water quality and habitat potential.

Alternate 9 - Construct a water quality pond in the ravine southeasterly of the intersection of Chuckanut Drive and Lake Samish Road.

The recommended alternatives is to develop a public education/awareness program to educate residents about their impacts on the stream. The later can be facilitated by an "Adopt A Stream" type program.

Basin CH112 has the most potential for development and as such would have the largest impact on water quality. If this basin is found to be contributing to the water quality degradation of Chuckanut Creek, a water quality pond can be constructed in the ravine southeasterly of the intersection of Chuckanut Drive and Lake Samish Road (Figure CH-2).



SCHEMATIC
CHUCKANUT CREEK
PROBLEM NO. 7

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE CH.2 10/22/93

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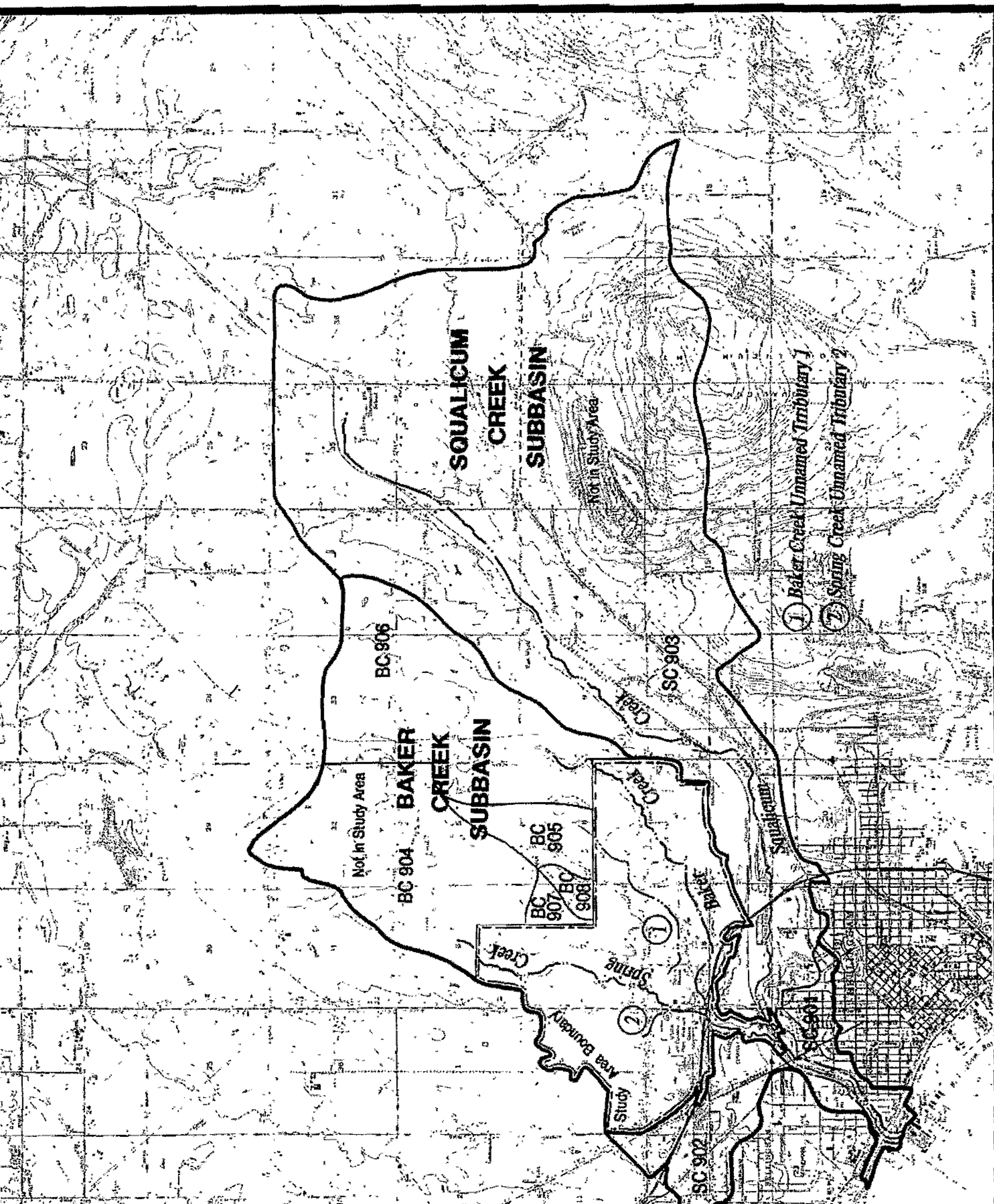
11. SQUALICUM CREEK BASIN

Parts of five Bellingham neighborhoods; Columbia, Cornwall Park, Birchwood, Mount Baker, and Guide Meridian, lie within the Squalicum Creek drainage basin. Lands within the city limits constitute roughly 20% of the basin's drainage area; the remaining 80% lie within unincorporated land in Whatcom County. Most of the drainage basin is forested or developed in low density residential or agricultural use; however, significant, relatively high-density development occurs west of I-5 and along parts of the Guide Meridian. Future development is anticipated to consist of primarily single-family residential development, with higher densities and multifamily residential development along the main transportation corridors. Development along the Guide Meridian is anticipated to be primarily commercial and light industrial type land uses. Figure 11.0 illustrates the subbasins within the Squalicum Creek Basin and the areas covered by this study.

Natural resources in the Squalicum Creek drainage basin were investigated from June 15 through 30, 1992. The portion of the Squalicum Creek Basin that lies within the study area was divided into three 3 sub-basins: Baker Creek, Spring Creek, and the Lower Squalicum Creek Corridor (Figures 11.1.1 and 11.2.1). Simplified functional values analyses were performed on selected wetlands associated with priority streams, including selected wetlands outside of Bellingham's city limits in the urban growth area. Priority streams inventoried included: Squalicum Creek downstream from its confluence with Baker Creek, Baker Creek, Baker Creek Unnamed Tributary 1, Spring Creek, and Spring Creek Unnamed Tributary 1 (see Figure 11.0).

A more detailed description of stream reaches and wetlands is contained in Volume 2. Squalicum Creek, from Guide Meridian Street to Hannegan Street, was the subject of an investigation described in the report, *"Squalicum Creek Floodplain Management Plan"* by R. W. Beck, 1992.

Information from that study has been incorporated into the Watershed Master Plan.



LEGEND

Major Basin Boundary
Basin Boundaries
Study Area Boundary
Major Creeks

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WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
11.0

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OCT 22 1993

11.1 BAKER CREEK STUDY AREA

11.1.1 Basin Characteristics

The Baker Creek study area includes approximately 1,185 acres (Figure 11.1.1). This area represents over one-third of the entire Baker Creek basin, a basin of approximately 3,150 acres. Baker Creek Basin is drained primarily by the main stem of Baker Creek and an unnamed tributary. Other tributaries are intermittent in nature. The Telegraph Road detention pond (PD-65) provides some storm water storage and attenuation of flow as do several riparian wetlands and some undersized culverts under roadway embankments.

Most soil types found in this basin are clay loams and shallow sandy loams with moderate percolation rates. Wetlands located along the main stream reaches and tributaries function to attenuate flow and have been incorporated into the basin model as detention facilities. Efforts should be made to preserve these areas for their hydrologic value as well as their water quality and habitat benefits.

11.1.2 Wetlands

During the field investigation, nine wetlands associated with Baker Creek and its major tributary (Baker Creek Tributary 1) were examined:

- Bellingham Inventory wetland SQ-8.
- Previously inventoried urban growth area wetlands 18-1, 17-3a, 17-3b, 18-5a, 7-1, and 8-9.
- Previously uninventoried (unnamed) urban growth area wetlands named for this study, "Deemer Road Wetland" and "Cougar Road Wetland".

These wetlands are shown on Figure 11.1.2.

In general, the wetlands were situated in low, seasonally saturated bottomland and were hydrologically connected with Baker Creek and its tributary. Most of the wetlands were characterized by mixtures of forest and scrub-shrub vegetation and other areas had wet meadow/pasture grass assemblages.

In the Baker Creek study area, overall wetland functional values were moderate. Wetland values were typically rated higher in forested wetlands and lower in wetlands disturbed by agriculture or nearby development. Since much of the investigated area lay in the urban fringe of Bellingham, where development has been scattered and of low density, the degree of past wetland disturbance was generally low, making wetland functional values correspondingly moderate to high. The existing conditions of most of the wetlands suggested that moderate increases in stormwater flows may not cause substantial negative impacts to existing stream banks.

Considering its large size and substantial area of wet meadow associated with scrub-shrub and forested wetlands, Wetland 18-1 (located north of McLeod Road, west of James Street, and south of Telegraph Road) had outstanding potential for use in "wetland mitigation banking." Portions of the wet meadow could be readily enhanced to mitigate for wetland impacts occurring elsewhere in the drainage basin. By combining relatively small, scattered mitigation efforts, a larger and more diverse wetland area could be created in the mitigation bank. That wetland could have functions and values greater than the sum of disassociated smaller wetland mitigation areas.

11.1.3 Streams

Based on the degree of disturbance and the character of adjacent land use, Baker Creek can be divided into three sections:

Section 1: a low to moderately disturbed, sparsely developed lower section. Reaches 1 through 7 were characterized by low stream gradient, moderate level of disturbance, and vegetation consisting of immature forest and lawn areas. Most of this section is within the Bellingham Golf and Country Club. A culvert at I-5 marks the upstream end of this section.

Section 2: a highly disturbed and relatively high-density developed middle section. Reaches 8 and 9 were highly disturbed from the construction of I-5, the Guide Meridian and adjacent, relatively high-density, commercial development. Portions of the reach were channelized and highly degraded. A change in the predominant land use from commercial to residential/agricultural marked the upstream end of this section.

Section 3: a low to moderately disturbed, low-development density upper section. Reaches 10 through 13 were characterized by low to moderate levels of disturbance, mature or immature forest and pasture vegetation, and low-density residential and agricultural land uses.

Baker Creek Unnamed Tributary 1 (which flows behind the Home Base store located east of Guide Meridian, between East Bakerview Road and Telegraph Road) was inventoried as part of this study. The tributary extended into the urban growth fringe of Bellingham and will likely be impacted by the substantial development anticipated for this region. All tributary reaches inventoried during this study were characterized by low stream gradient, a mixture of forest and pasture vegetation, and low density residential development.

11.1.4 Fisheries

A short distance upstream from its confluence with Squalicum Creek, Baker Creek passes through a culvert beneath Birchwood Avenue which prevents the return of salmon upstream. Bellingham's Maritime Heritage Hatchery plants coho and chum salmon eggs in Baker Creek near the intersection of James Street and Telegraph Road. Cutthroat trout have been observed in the Baker Creek system and steelhead may be present.

11.1.5 Nonpoint Pollution

Associated with the low-density residential and agricultural uses commonly occurring within the Baker Creek drainage area, nonpoint pollutants could include herbicides, pesticides and fertilizers used in farm, lawn or garden maintenance. Manure runoff from agricultural operations is another significant nonpoint pollution source affecting the streams. Stormwater runoff from impervious surfaces associated with commercial development along McLeod, East Bakerview, and Telegraph Roads typically contributes a substantial amount of nonpoint pollution. Automobile-related chemicals are the most likely pollutants emanating from the developed areas within the basin.

11.1.6 Water Quality

The Baker Creek study area will see a diversity of growth including commercial, industrial, single-family residential, and multiple-family residential. Volume 2 includes tables showing existing and projected pollutant loadings from the basin, based on historical data listed in Appendix C.

Observations during the field investigations revealed some water quality problems in several forms. Bank erosion was noted in the lower reaches, adjacent to the golf course fairways. Paints, solvents, junked cars, and livestock were noted in the stream along both Baker Creek and Baker Creek Tributary No.1. There was also evidence of a failed septic system along Baker Creek Tributary No. 1.

Operation of the Telegraph Road Detention Facility should be modified to include a dead storage volume to improve sediment removal. New development should route stormwater through biofilter swales before stormwater is discharged to the streams. To improve pollutant removal rates, collection systems on the steeper hillsides to the north, should incorporate grass-lined swales traversing the hillside.

The wetlands in the study area provide natural opportunities for sedimentation, filtration, and biological uptake. Efforts should be made to preserve these areas and their water quality enhancement functions.

Public environmental education can be an effective way to reduce the impacts of development on water quality from residential areas.

11.1.7 Problem Identification

Table 11.1 lists the identified drainage problems in the Baker Creek portion of the study area. The approximate locations of these problems are shown on Figure 11.1.1.

TABLE 11-1 IDENTIFIED BAKER CREEK PROBLEM AREAS				
Problem Number	Facility Identifier	Type of Problem*		Location
1	D12 D14	FUT	CHAN VEL CAP WQ	Stream reach between Squalicum Creek and I-5.
2	D16	EX	CHAN CAP	Baker Creek at I-5 and Guide Meridian/I-5 Underpass.
3	P17 D18 D20	EX	CHAN CAP	Stream reach east of Guide Meridian and south of Telegraph Road.
4	P21	EX	PIPE CAP	48-inch culvert south of Telegraph Road, upstream of Confluence with Tributary No. 1.
5	P235 P236 P237 P239	EX	PIPE CAP	Pipe west of Irongate Road at Division Street
6	P241	FUT	PIPE CAP	Culvert along Telegraph Road, east of Irongate Road.
7	P26	EX	PIPE CAP	Culvert under Telegraph Road, east of James Street.
8	P67	FUT	PIPE CAP	Baker Creek Tributary No. 1 at East Bakerview Road, west of James St.
9	P69 D70	EX	PIPE CHAN CAP	Baker Creek Tributary No. 1 at James St.
10	P635 P636 P638 P640	FUT	PIPE CAP	Pipe Network north of East Bakerview Road at Landon Ave.
11	D29	EX	WQ	Baker Creek, north of East Bakerview Road.
12	D66	EX	WQ	Baker Creek Tributary No. 1, east of Telegraph Road Detention Pond.
13	D701	EX	WQ	Baker Creek Tributary No. 1, south of James St.

*abbreviations:
EX = Existing Land Use
FUT = Future Growth Land Use
PIPE CAP = Pipe Capacity
CHAN CAP = Channel Capacity
CHAN VEL = Channel Velocity
WQ = Water Quality
BANK = Bank Erosion

11.1.8 Alternative Analysis

Problem No. 1 - Ditches D12 and D14 Channel Velocity and Water Quality

The channel velocities of 6.7 and 5.8 fps, estimated for future land use conditions exceed scour velocity limits. In addition, minor erosion and high algal concentrations have been observed adjacent to golf course fairways. The algae concentrations may be the result of excessive turf fertilizer applications both at the golf course and further upstream in the basin.

The following alternatives will mitigate the identified velocity problems:

Alternative 1 - Armor the Channel to protect against erosion.

Alternative 2 - Monitor channel flows and install check dams and energy dissipators to reduce velocities as appropriate.

The following alternatives will mitigate the observed erosion problems:

Alternative 3 - Plant erosion resistant vegetation along the channel side slopes.

Alternative 4 - Armor frequent stream access locations along the golf course fairways.

The following alternatives will mitigate the observed water quality problems:

Alternative 5 - Inplement public education programs specifically geared toward the impacts of nutrient loadings and excessive fertilizer application.

The recommended solution is Alternative 2, monitor the channel velocities and install check dams and energy dissipators. Alternatives 3 and 4 should be considered as well for spot locations. Work along stream reaches within the golf course should either be coordinated or conducted by the golf course. Alternative 5 should be part of an overall public awareness program with some materials targeted toward known heavy fertilizer applicators.

Problem No. 2 - Ditch D16 Water Surface and Guide Meridian/I-5 Underpass, Flooding

Pipe P15 is the 11'-5" by 7'-3" pipe arch culvert that conveys Baker Creek under Interstate I-5. The culvert itself appears to be adequate to convey projected future flows of 720 cfs with the upstream water surface approximately 9.5 feet above the invert. However, the Guide Meridian underpass has a low area (elevation 106+/-) that drains northerly to Baker Creek at ditch D16. This low area currently floods. The flooding is likely caused by backwater conditions of the culvert inlet configuration and conveyance requirements for D16. Under current land use conditions, the flow from a 25-year design storm, is 476 cfs. The headwater requirement at the pipe arch (elevation 100+/-) is approximately 7 feet. The water surface elevation for flow in D16 will include the headwater requirement for the culvert. The hydraulic grade line is high enough to back water through the 18-inch diameter pipe to flood the underpass and run southerly along Guide Meridian to Squalicum Creek.

The following alternatives will provide solutions to the identified flooding problem:

Alternative 6 - Place a back flow preventor on the underpass discharge line and install a pump to discharge drain water to D16.

Alternative 7 - Plug and abandon the existing northerly discharge from the I-5 underpass and install a new 18-inch diameter discharge drain westerly along the south side of I-5 to discharge to Baker Creek downstream of the I-5 crossing.

Alternative 8 - Plug and abandon the existing northerly discharge and discharge southerly along Guide Meridian.

<u>The recommended solution is Alternative No. 7</u>, plug the existing discharge and install a new discharge drain. Under Alternative 7, an 18-inch diameter drain line to Baker Creek would be installed downstream of the I-5 crossing (Figure BC.1). The key is to prevent water from backing up into the low area at the underpass. Routing the discharge to the west provides a shorter, although deeper, solution than going south. Routing the flow to the south may also require upgrading the existing facilities downstream to handle the increased flow.

Problem No. 3 - Ditches D18 and D20 Channel Capacity
Pipe P17 Tailwater Elevation

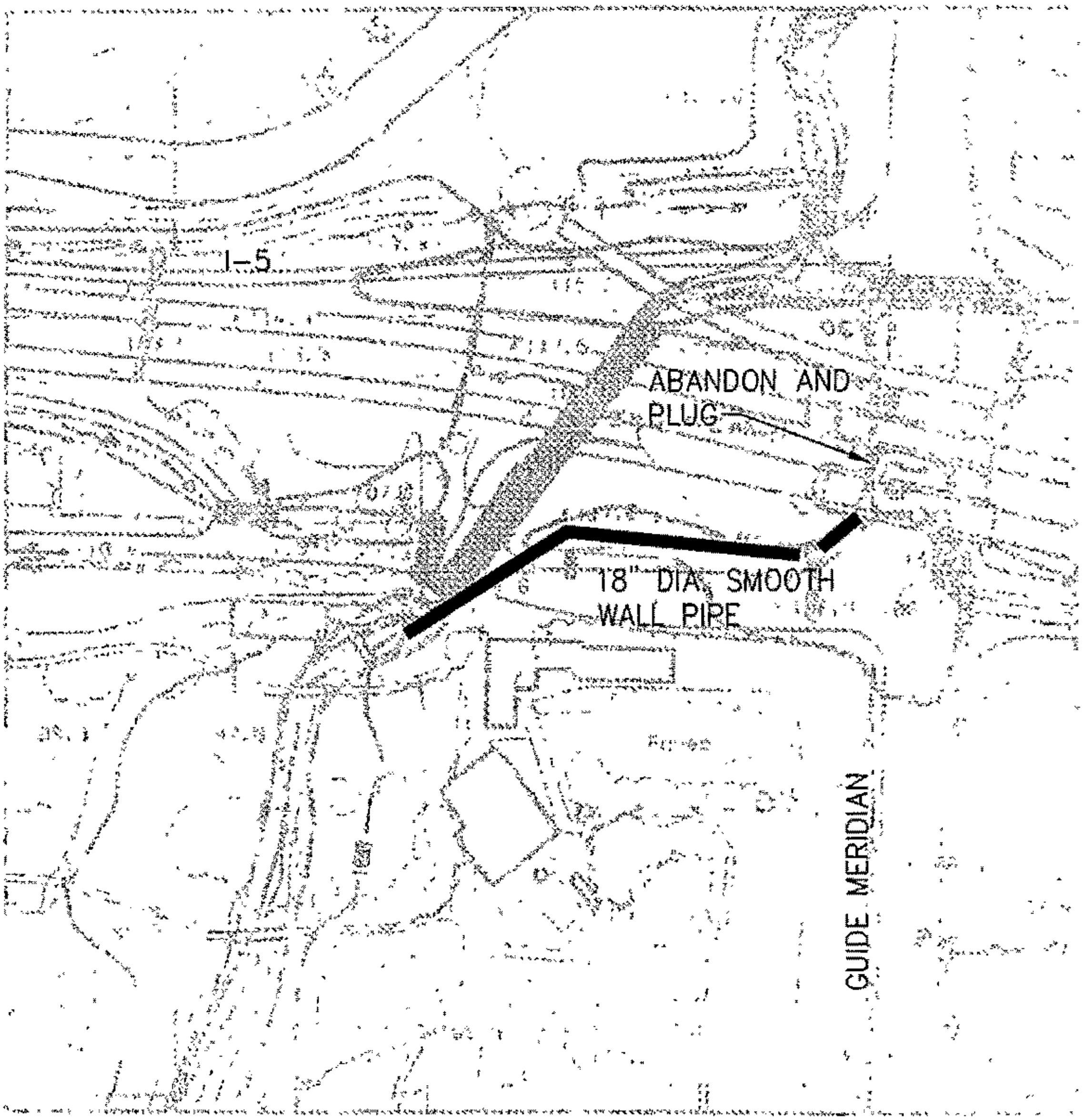
Problem No. 4 - Pipe P21 Capacity

Ditches D18 and D20 are located on the main stem of Baker Creek, east of Guide Meridian and south of Telegraph Road. They run through a landscaped commercial area with development in close proximity to the stream. Flooding has been reported in this area. The flow from a 25-year design storm is approximately 240 cfs under current land use conditions. The 25-year design storm flow from future developed conditions is estimated to be approximately 350 cfs. This problem is compounded by the water surface in Ditch D16, described in Problem No. 2. The high tailwater for Pipe P17 (water surface in Ditch D16) limits its capacity to convey flow. This causes water to back up in Ditches D18 and D20. The backwater depth in D20 is approximately 4.3 feet compared to an overflow depth of 4 feet at a pedestrian bridge.

Pipe P21 is a 48-inch diameter pipe located east of ditches D18 and D20 along the main stem of Baker Creek. It is upstream of the confluence with Baker Creek Tributary No.1. The calculated capacity of the pipe is less than the estimated flow from the 25-year design storm using existing land use conditions.

The following alternatives will provide solutions to the identified flooding problem:

Alternative 9 - Improve the channel cross section to hold the projected water surface by raising adjacent berms and eliminating berm penetrations such as walkways.



SCHEMATIC
BAKER CREEK
PROBLEM NO. 2

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
BC.1
10/22/93

RFL23-26.DWG

Alternative 10 - Modify the proposed Hannegan Road detention facility to accommodate 110 acre-feet of controlled storage. This raises the controlled water surface from elevation 190 to approximately elevation 196. The currently proposed top of berm is elevation 195.

Alternative 11 - Accept flooding of the lower areas along these channels.

Alternative 12 - Replace the culvert P21 with a 60-inch diameter culvert.

The recommended solution is Alternative No. 10. Alternative 10 would develop adequate detention facilities up stream. The proposed Baker Creek Detention Facility #2 at Hannegan Road can attenuate flows to mitigate this problem. Replacing culvert P21 will exacerbate problem No. 3 unless that problem is also remedied. Alternative 10 mitigates both problems. Solving problem No. 4 will require greater flow reductions than solving problem No. 3.

Problem No. 5 - Pipes P235, P236, P237, P239 Capacity

These pipes are inadequate to handle the 25-year design storm under existing land use conditions. P235 is 24-inch diameter Corrugated Metal Pipe (CMP), P236 is 15-inch diameter concrete, P237 is 18-inch diameter PVC, and P239 is 15-inch diameter CMP. P235 is able to marginally pass the design flows when the inlet is surcharged 8 feet.

The following alternatives will provide solutions to the identified capacity problem:

Alternative 13 - Replace Pipes P235, P236, P237, and P239 with 30-inch diameter smooth wall pipe.

Alternative 14 - Divert flow from basin BC156 along Telegraph Road to Baker Creek.

Alternative 15 - Provide detention volume to restrict flows to match existing pipe capacities.

The recommended solution is Alternative No. 15, provide local detention volume. Although diverting flows will reduce the problem, enough flow is generated by basin BC155 to overtax the pipes even with complete diversion of basin BC156. Detention should be utilized. This area is zoned for light industrial and has a higher risk than residential land uses for pollutant build-up and wash off, and for pollutant spills. Local detention facilities provide an opportunity to collect and treat the runoff. This should be done in conjunction with site development as a condition of development. The dampening effect of the wetland north of Telegraph Road must continue to be maintained.

Problem No. 6 - Pipe 241 Capacity

The 15-inch diameter CMP culvert along Telegraph road is inadequate to convey flows from the 25-year design storm under projected land use conditions.

The following alternatives will provide solutions to the identified capacity problem:

Alternative 16 - Provide local detention upstream.

Alternative 17 - Replace the culvert with a 24-inch diameter culvert.

The recommended solution is Alternative No. 16. The dampening effect of the wetland north of Telegraph Road must continue to maintained. There does not appear to be enough capacity in the wetland to restrict the flow enough to match the culvert capacity, so detention should be provided for upstream development.

Problem No. 7 - Pipe 26 Capacity

The 48-inch diameter culvert under Telegraph Road is inadequate to convey flows from the 25-year design storm modeled for existing land use conditions.

The following alternatives will provide solutions to the identified capacity problem:

Alternative 18 - Replace the culvert with a 4 by 17 foot box culvert.

Alternative 19 - Add four additional 48-inch diameter culverts.

Alternative 20 - Replace the culvert with two 60-inch diameter culverts and fill the sag in the roadway to provide adequate pipe cover.

Alternative 21 - Provide detention volume upstream to reduce projected peak flows by 145 cfs.

The recommended solution is Alternative No. 21, provide upstream detention volume. The recommended solution to problems 3 and 4, Alternative 10, will make enough detention volume available to mitigate this problem as well.

Problem No. 8 - Pipe P67 Capacity and
Problem No. 9 - Pipe P69 and Channel D70

The 30-inch diameter concrete culvert under East Bakerview Road is undersized to handle the estimated flows from the future land use conditions. The 24-inch diameter culvert under James Street and Channel D70 are undersized to handle the estimated flows from existing land use conditions.

The following alternatives will provide solutions to the identified problem:

Alternative 22 - Replace both culverts with 42-inch diameter culverts.

Alternative 23 - As properties develop upstream, construct a detention facility to maintain current flows. This facility would be located near Montgomery Road and would need to be approximately 20 acre feet.

Alternative 24 - Construct an 11 acre feet detention facility upstream, in the vicinity of Montgomery Road and maintain the existing P69 culvert at James Street.

The recommended solution is Alternative No. 24, construct a detention facility in the vicinity of Montgomery Road. The flows generated by the 25-year design storm utilizing existing land uses are dampened by 9 acre-feet of natural storage behind the culvert (P69) at James Street. Developing the remaining 11 acre feet of storage and controlled release can be incorporated into the development of the basin above Montgomery Road. This development could be the responsibility of the developer. Figure BC.2 shows approximately the modeled water surface for the 25-year design event.

Problem No. 10 - Pipe P635, P636, P638, and P640 Capacities

All four pipes are undersized to convey the projected flows from a 25-year design storm utilizing future land uses. P635 and P636 are 24-inch diameter CMP, Pipe P638 is an 18-inch diameter CMP, and P640 is an 18-inch diameter smooth wall pipe.

The following alternatives will provide solutions to the identified problem:

Alternative 25 - Replace all pipes with 30-inch diameter smooth wall pipes.

Alternative 26 - Construct a 10-acre-feet detention facility upstream of P640.

The recommended solution is Alternative No. 25, replace the pipes with 30-inch diameter smooth wall pipes (see Figure BC.3). The hillside upstream is not conducive to constructing detention facilities.

Problem No. 11 - Baker Creek Water Quality, north of East Bakerview Road

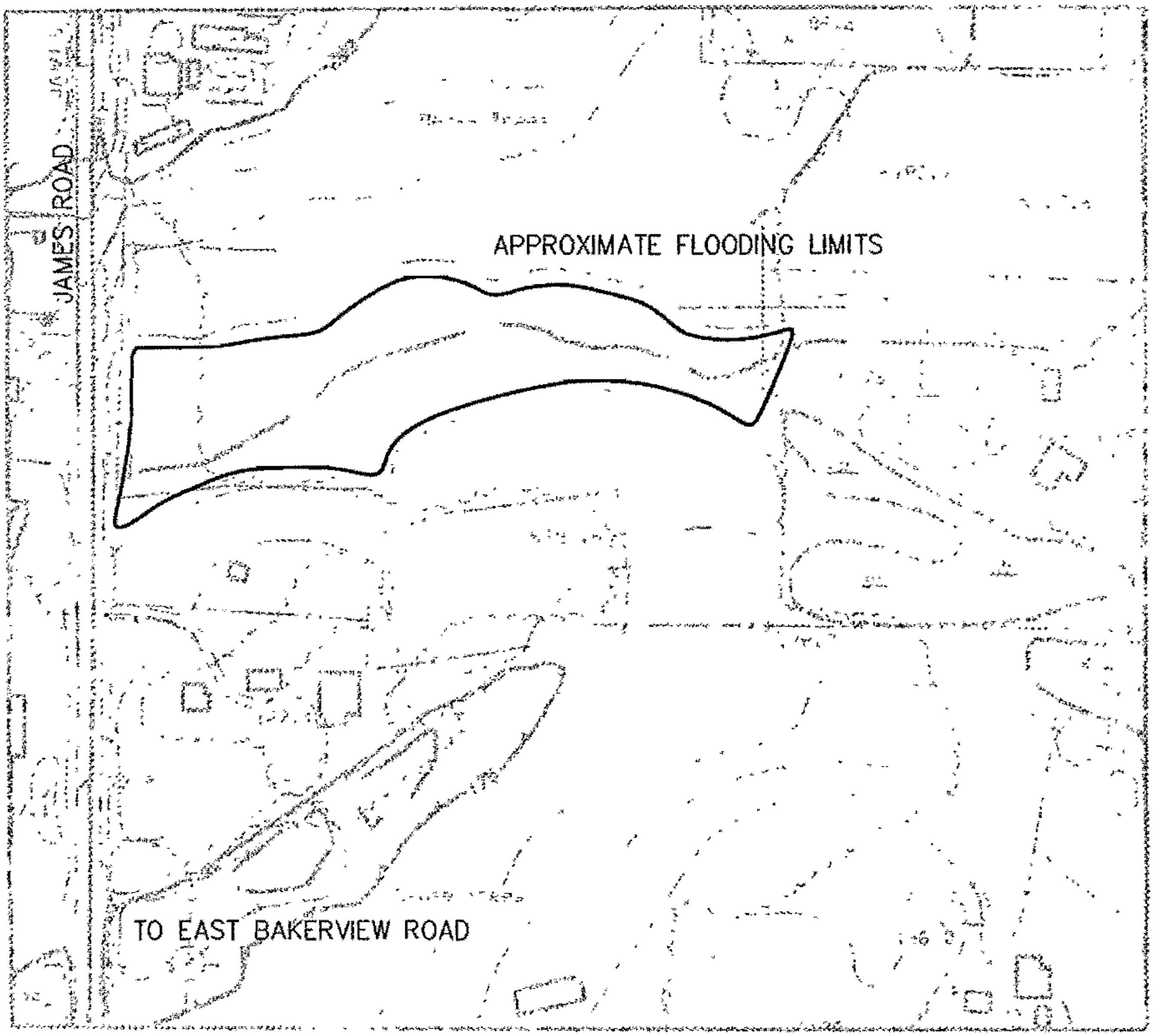
Pollutants from adjacent business along East Bakerview Road are being washed into the creek, most notably paints and solvents.

Recommendation. Control the source of these pollutants to prevent them from being washed into the creek. This can be done by utilizing best management practices to contain the pollutants during storage, use, or disposal.

Problem No. 12 - Baker Creek Tributary No. 1 Water Quality, north of Telegraph Road

Junked cars were observed in portions of the stream as well as livestock grazing areas adjacent to the stream. Junked cars allow pollutants such as petroleum products and metals to enter the stream. Livestock disturb stabilizing vegetation, kick up sediments, and pollute by defecating.

Recommendation. Control the source of these pollutants by removing them from the stream. The junked cars should be removed and disposed of in an environmentally safe method. Best management practices for livestock include fencing to prevent animals from entering the stream or remove them from areas with access to the stream.



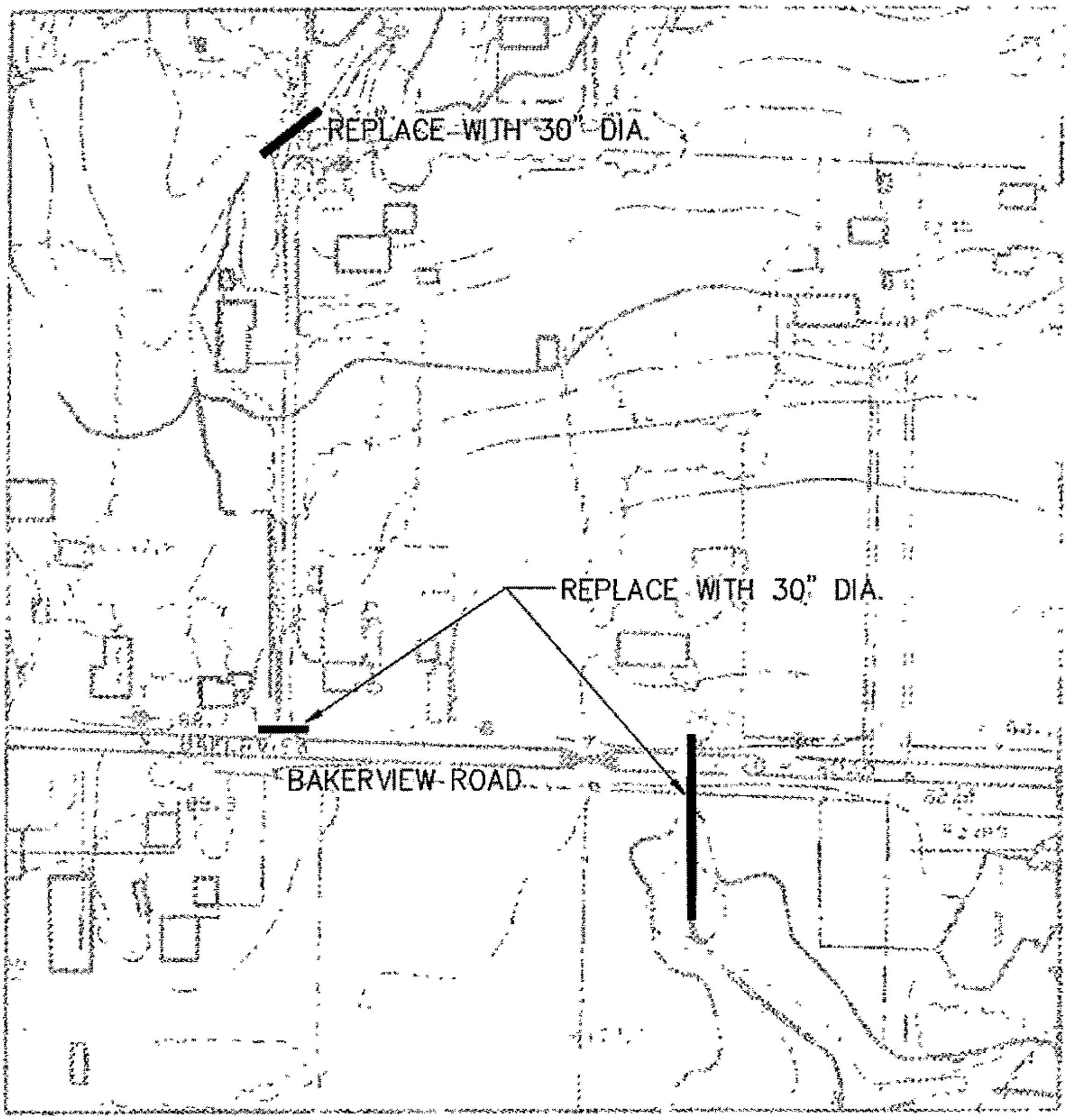
SCHEMATIC
BAKER CREEK
PROBLEM NO. 9

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
BC.2
10/22/93

BEL27-30.DWG



SCHEMATIC
BAKER CREEK
PROBLEM NO. 10

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	FIGURE BC. 3 10/22/93

BEL27-30.DWG

Problem No. 13 - Baker Creek Tributary No. 1 Water Quality, east of James Street

Livestock were observed in the stream as well as indications of a failed septic system.

Recommendation. Control the source of these pollutants by removing them from the stream. See the recommendations to problem 13 regarding the livestock. The failed septic system should be pursued by enforcing codes for septic tanks.

11.2 SPRING CREEK STUDY AREA

11.2.1 Basin Characteristics

The Spring Creek study area depicted on Figure 11.1.1 by the 200 series basins, includes approximately 920 acres. This area represents almost 40 percent of the 2,390 acre Spring Creek basin. The basin is drained primarily by the main stem of Spring Creek and an unnamed tributary. Other tributaries are intermittent in nature. A detention pond (Pd 449) has been constructed in the Cordata Business Park and will provide some storm water storage and attenuation of future flows. Several riparian wetlands and some undersized culverts also serve to attenuate flow.

Most soil types found in this basin are clay loams and shallow sandy loams with moderate percolation rates. Wetlands and undersized culverts located along the main stream reaches and tributaries attenuate flow and have been incorporated into the basin model as detention facilities. Efforts should be made to preserve these areas for their hydrological value as well as their water quality and habitat benefits. Undersized culverts should not be improved unless appropriate improvements have already been made downstream.

11.2.2 Wetlands

Five wetlands associated with Spring Creek and its major tributary (Spring Creek Tributary 1) were inventoried. These wetlands include Bellingham inventory wetlands SQ-11, SQ-13, SQ-14, SQ-16 and urban growth area wetland 7-13 (see Figure 11.1.2). In general, wetlands were situated in low, seasonally saturated bottomland and were hydrologically associated with Spring Creek and its tributary. Most of the wetlands were characterized by mixtures of forest and scrub-shrub vegetation; other areas had wet meadow/pasture grass assemblages.

Overall wetland functional values were moderate in the Spring Creek study area. Forested wetlands were considered higher in value; wetlands disturbed by agriculture or close to development were considered lower in value. Since much of the investigated area lay in the urban fringe of Bellingham, where development has been scattered and of low density, the degree of past wetland disturbance was low and functional values were considered moderate to high. Existing conditions of most wetlands studied suggested that moderate increases in stormwater flows may not cause substantial negative impacts to existing stream banks.

11.2.3 Streams

Spring Creek and one major tributary, Spring Creek Unnamed Tributary 1 (which flows along the Guide Meridian and to the west along West Bakerview Road), were inventoried. Spring Creek extends into the urban growth fringe of Bellingham and will likely be impacted by the substantial development anticipated for this region. Reaches 1 and 2 of Spring Creek were highly degraded due to their proximity to commercial development along the Guide Meridian. Reaches 3 through 6 were characterized by a gentle creek gradient, a mixture of immature forest and pasture vegetation, and low density residential development. Reaches 7, 8 and 9 had high aesthetic quality with mature forest vegetation but were physically impacted from recent, limited logging activity and adjacent land uses.

Spring Creek Unnamed Tributary 1 lies in a developed area west of the Guide Meridian and north of I-5. The watershed and lower portions of the tributary have been significantly altered in this area. Existing channelization and encroachment of development have degraded the lower portion of the tributary (along the Guide Meridian) so severely that it serves little function aside from stormwater conveyance. The upper portion of the reach flows through a relatively undisturbed steep-sided, riparian corridor south of Bakerview Road and north of Bellis Fair Mall. This corridor and its wetland have relatively high resource values.

11.2.4 Fisheries

A short distance upstream from its confluence with Squalicum Creek, Baker Creek passes through a culvert beneath Birchwood Avenue, which prevents the return of salmon upstream from Bellingham Bay to Spring Creek. Bellingham's Maritime Heritage Hatchery plants coho and chum salmon eggs in the upper reaches of Spring Creek near Division Road east of Ankar Park Drive. Cutthroat trout have been observed in the Spring Creek system, and steelhead may be present.

11.2.5 Nonpoint Pollution

Stormwater runoff from extensive areas of impervious surface associated with commercial development along the Guide Meridian probably contribute a substantial amount of nonpoint pollution to the lower sections of the Spring Creek basin. Automobile-related chemicals are the most likely pollutants contributing to nonpoint pollution problems. In addition, automobile service enterprises along the east side of the Guide Meridian and adjacent to Spring Creek probably have a significant nonpoint pollutant impact on the adjacent watercourse. Nonpoint pollutants including herbicides, pesticides and fertilizers used in farm, lawn or garden maintenance can enter Spring Creek and its tributary from low density residential and agricultural uses commonly occurring in the upper portions of the drainage area.

11.2.6 Water Quality

The Spring Creek study area is expected to see a growth consisting primarily of light industrial and multi-family land uses in the areas now forested or in meadow. There will be some fill-in of commercial areas and some loss of single-family residential uses to denser land uses. Volume 2 includes tables showing existing and projected pollutant loadings from the basin, based on historical data listed in Appendix C. Water quality is easily degraded from intense land uses such as industrial, commercial, and multiple family. Increased traffic and density of parked vehicles leads to increased discharge of petroleum products and metals. Higher percentages of impervious areas also contribute to increasing amounts of run off/wash off and reduce infiltration and biofiltration.

Observations during the field investigations of the Spring Creek area revealed some water quality problems in several forms. There were visible signs of pollutants in the water where the creek meets Guide Meridian. Batteries were observed in the creek, and oil was noticed leaking from dumpsters adjacent and draining to the creek. Further upstream, near Van Wyck Road, portions of the stream have been degraded from logging activities.

New development should include biofiltration swales to improve sediment removal and biological uptake. New and proposed detention facilities should include a dead storage volume to improve sediment removal efficiencies.

The wetlands found in the study area provide natural opportunities for sedimentation, filtration, and biological uptake. Efforts should be made to preserve these areas and their water quality enhancement functions.

Public environmental education can effectively reduce the impacts of development on water quality (see Section 6.4).

11.2.7 Problem Identification

Table 11.2 lists the identified drainage problems in the Spring Creek study area (see Figure 11.1.1).

TABLE 11.2
IDENTIFIED SPRING CREEK PROBLEM AREAS[a]

Problem Number	Facility	Type		Location
21	P44	FUT	PIPE CAP	Spring Creek at Guide Meridian.
22	P51	FUT	PIPE CAP	Spring Creek at East Bakerview Road, Prince Avenue, and Kellogg Avenue.
23	P55	FUT	PIPE CAP	Spring Creek at Horton Road.
24	P411	EX	PIPE CAP	Easterly Tributary at Guide Meridian and Telegraph Road.
25	P435A	FUT	PIPE CAP	Spring Creek Tributary 1, north of West Bakerview Road.
26	P443-P444 P4432-P4435	FUT	PIPE CAP	Collector Pipes under a Guide Meridian, north of Bakerview Road.
27	D45	EX	WQ	Spring Creek, east of Guide Meridian.
28	D52	EX	WQ	Spring Creek, vicinity of Van Wyck Road.
29	P441-P442C	FUT	PIPE CAP	Pipe under Guide Meridian south of Baker View Road.
30	P431B	EX	PIPE CAP	Spring Creek Tributary 1 at Guide Meridian.
31	P461-P468	FUT	PIPE CAP	Pipe under Guide Meridian north of Cordata Discharge.

abbreviations: EX = Existing Land Use; FUT = Future Growth Land Use; PIPE CAP = Pipe Capacity; CHAN CAP = Channel Capacity; CHAN VEL = Channel Velocity; WQ = Water Quality; BANK = Bank Erosion

11.2.8 <u>Alternative Analysis</u>

Problem No. 21 - Pipe P44 Capacity at Guide Meridian

The twin 48-inch diameter culverts conveying Spring Creek under Guide Meridian are inadequate to handle the projected flows from a 25-year design storm using future land uses.

The following alternatives will provide solutions to the identified problem:

> Alternative 1 - Replace the existing culverts with a 4 by 11 foot box culvert.
>
> Alternative 2 - Incorporate 35 acre-feet of detention facilities upstream above Kellogg Avenue.

<u>The recommended solution is Alternative No. 2,</u> incorporate detention upstream (see Figure SC.1). Construction of the recommended box culvert would be expensive and disrupt traffic flow in this congested area. The culverts are adequate for current land use, and sufficient volume is available in the reaches of Spring Creek north of Kellogg Avenue. Additional volume can be utilized, if needed, in the ravines between Kellogg Avenue and East Bakerview Road.

35 acre-feet of detention is required to mitigate downstream problems projected for future land uses. The proposed pond will cost approximately $14,900 per acre-foot.

Problem No. 22 - Pipe P51 Capacity at Kellogg Avenue

P51 (60-inch diameter concrete culvert) is undersized for the 25-year design storm modeled for future land use conditions. The depth of backwater needed behind culvert P51 is estimated to overflow Kellogg Avenue.

The following alternatives will provide solutions to the identified problem:

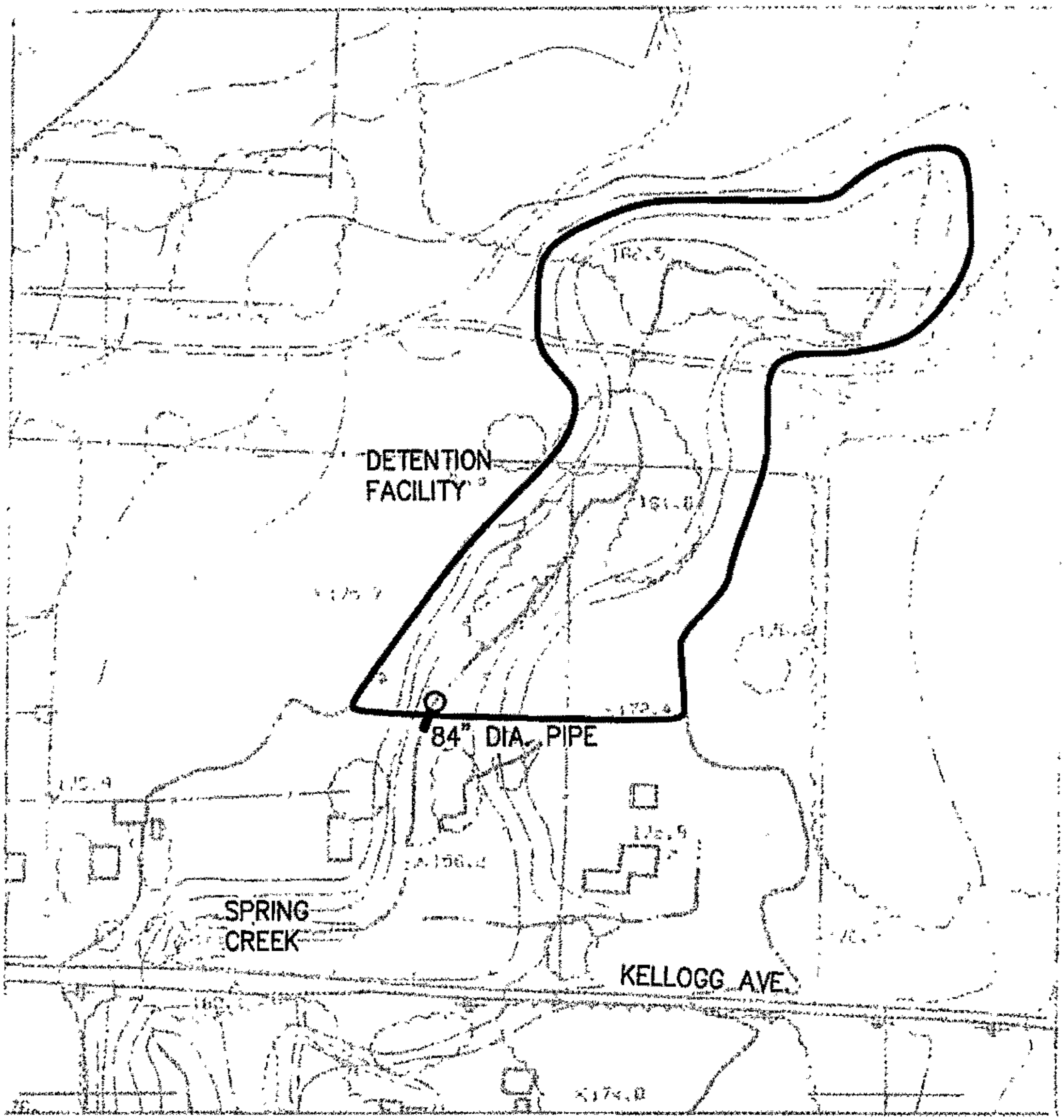
> Alternative 3 - Add a parallel 60-inch diameter culvert to P51.
>
> Alternative 4 - Incorporate detention upstream. Detention volumes for Alternative 4 are less than those needed for Alternative 2.

<u>The recommended solution is Alternative No. 2.</u> Providing detention above Kellogg Avenue to mitigate Problem 21 will also mitigate Problem 22.

Problem No. 23 - Pipe 55 Capacity at Horton Road

This 60-inch diameter CMP culvert is inadequate for the 25-year design storm under future land use. The backwater behind this culvert would overtop the road.

The following alternatives will provide solutions to the identified problem:



SCHEMATIC
SPRING CREEK
PROBLEM NO. 21 AND 22

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
SC.1
10/22/93

BEL35-36.DWG

Alternative 5 - Replace the culvert with a 72-inch diameter culvert.

Alternative 6 - Provide 35 acre-feet of detention upstream, in addition to the natural storage adjacent to Horton Road.

The recommended solution is Alternative No. 6. Provide detention north of Horton Road. Raising the grade of Horton Road would also increase the capacity of P55 by allowing more head water. This could be done in conjunction with roadway improvements and reduce detention requirements.

Problem No. 24 - Pipe P411 Capacity

This pipe is undersized to handle the flows from a 25-year design storm under the existing land use conditions.

The following alternatives will provide solutions to the identified problem:

Alternative 7 - Replace the pipe with a 24-inch diameter smooth wall pipe.

Alternative 8 - Allow pipe to surcharge

The recommended solution is Alternative No. 8, allow the pipe to surcharge. The estimated surcharge for the 25-year design storm is slightly lower than the overflow elevation. Flooding should not occur unless there is a downstream blockage or other hydraulic constraints.

Problem No. 25 - Pipe P435A Capacity Spring Creek Tributary No. 1 along West Bakerview Road.

The 42-inch diameter CMP pipe is too small to handle the flows from a 25-year design storm modeled for future land use under open channel flow conditions.

The pipe slope is flat, the modeled hydraulic grade line indicates the pipe will function under a surcharged condition without overflowing.

Problem No. 26 - Pipe P441 through P444 Capacity

These parallel pipes under the Guide Meridian are inadequate for the 25-year design storm under projected land use conditions.

The following alternatives will provide solutions to the identified problem:

Alternative 9 - Replace pipe P4432 through P4435 with a 30-inch diameter smooth wall pipe, maintain interconnecting pipes across the Guide Meridian, and allow P443 - P444 to surcharge.

Alternative 10 - Require onsite detention in the tributary basins.

The recommended solution is Alternative No. 10, require onsite detention in the tributary basins.

Problem No. 27 - Spring Creek Water Quality, east of Guide Meridian

Junked batteries were observed in portions of the stream. Petroleum products from adjacent business along Guide Meridian are being washed into the creek.

Recommendation. Control the source of these pollutants by removing them from the stream. The junked batteries should be removed and disposed of in an environmentally safe method. Best management practices to contain the pollutants during storage, use, or disposal should be utilized. Public education could reduce continuation of this problem.

Problem No. 28 - Spring Creek Water Quality, Van Wyck Road

Portions of the stream have been degraded from logging activities.

The recommended solution is to improve erosion and sediment control practices during construction or other clearing activities. Best management practices may include sediment ponds, filter fabric fencing, check dams, or flow spreaders. Many of these practices are outlined in the United States Forest Service Logging Practices materials.

Problem No. 29 - Pipes P441 through P442C Capacity

The trunk line under the Guide Meridian, north of Spring Creek and south of West Baker View Road is undersized to handle runoff from the 25-year design storm under projected land use conditions.

The following alternatives will provide solutions to the identified problem.

Alternative 11 - Incorporate additional detention upstream.

Alternative 12 - Replace the existing pipes with a 48-inch diameter smooth wall pipe.

Alternative 13 - Add a parallel 30-inch diameter smooth wall pipe north of Spring Creek Tributary No. 1 and a parallel 36-inch diameter smooth wall pipe south of Spring Creek Tributary No. 1.

The recommended solution is Alternative No. 12. Replace the existing pipes with a 48-inch diameter smooth wall pipe.

Problem No. 30 - Pipe P431B Capacity

P431B, where Spring Creek Tributary No. 1 enters the Guide Meridian system, is inadequate to convey the flows from the 25-year, 24-hour design storm event under existing land use conditions.

The following alternatives will provide solutions to the identified problem:

Alternative 14 - Improve the inlet for Spring Creek Tributary 1 by replacing the existing 18-inch diameter pipe with a 30-inch diameter smooth walled pipe.

Alternative 15 - Incorporate detention in the upstream basin.

The recommended solution is Alternative No. 14. Improve the inlet for Spring Creek Tributary 1 by replacing the existing 18-inch diameter pipe with a 30-inch diameter smooth wall pipe.

Problem No. 31 - Pipe P461 through P468 Capacity

Portions of the system for the Guide Meridian, north of the Cordata discharge are undersized to convey runoff from the 25-year, 24-hour design storm under projected land use conditions.

The following alternatives will provide solutions to the identified problem.

Alternative 10 - Require onsite detention in tributary basins.

Alternative 16 - Replace the existing pipes with 30-inch diameter to 42-inch diameter pipe.

The recommended solution is Alternative 10. Require onsite detention in the tributary basin.

11.3 SQUALICUM CREEK STUDY AREA

11.3.1 Basin Characteristics

Squalicum Creek, below the confluence with Baker Creek, was generally examined for capacity and environmental issues. The Squalicum Creek Basin, except for Baker Creek and Spring Creek, was not included within this study, however, descriptions of the portion of Squalicum Creek basin within the city limits are included in this study, from the Draft Report *"Squalicum Creek Flood Plain Management Plan"* by R.W. Beck, 1992.

Squalicum Creek flows were approximated using the hydrographs generated from Baker and Spring creeks. These flows were added to a hydrograph generated for Upper Squalicum Creek and calibrated to the FEMA 100 year flow rate. (Flood Insurance Study, City of Bellingham - Whatcom County, March 2, 1982 Federal Emergency Management Agency Community No. 530199). This portion of the report is limited to the main stem of the creek.

11.3.2 Wetlands

No inventoried wetlands were examined along the main stem portion of Squalicum Creek covered by this study. Several large wetland areas exist in Upper Squalicum Creek corridor within the city limits and are described by Beck, 1992. A summary of those descriptions is as follows:

> The portion of Squalicum Creek drainage basin between Guide Meridian Street and Hannegan Street to the east is dominated by a complex system of wetlands. Wetland habitats presently range from open water (Bug Lake and Sunset Pond) to mature forested wetlands. Emergent wetlands primarily exist in the eastern portion of this area. Due to their size, frequency, and hydrologic association with (and proximity to) Squalicum Creek and the two ponds, the numerous individual areas of wetland in the study area could be considered all parts of a single, large wetland system. Potential impacts to wetlands in this portion of the Squalicum Creek basin could result from future adjacent, land development which could affect wetland hydrologic regimes. Regulatory mechanisms currently exist to protect these wetlands from filling, and there exists good opportunity for restoration and enhancement of previously impacted, or currently grazed, wetland areas.

11.3.3 Streams

The Lower Squalicum Creek corridor was inventoried from its outlet in Bellingham Bay to its confluence with Baker Creek. Based on general stream characteristics and the nature of adjacent development, this portion of Squalicum Creek can be divided into two sections:

> Section 1: a moderately to highly disturbed lower segment having moderate density development. Reaches 1 and 2 have a low stream gradient, rip-rapped banks and substantial industrial and commercial development nearby.

Section 2: a low to moderately disturbed, low development density upper segment. Reaches 3 through 7 have low to moderate stream gradient, predominantly immature/even-aged forest vegetation and minor adjacent development.

In-city reaches in the upper Squalicum Creek between Guide Meridian and Hannegan Street were examined by Beck, 1992 and are described as follows:

> This portion of Squalicum Creek lies in a relatively flat-bottomed valley. The creek generally flows in a single contained channel for much of the distance; however, in several areas, the creek becomes heavily braided and apparently even flows underground in certain areas. It is difficult to follow the "creek" in these areas. There are at least two primary tributaries to Squalicum Creek between Guide Meridian and Hannegan to the east, and these include North Fork Squalicum Creek and Tributary "W" which flows along the north side of the railroad grade.

11.3.4 Fisheries

Coho and chum salmon can utilize Squalicum Creek from Bellingham Bay to the northern city limit near Hannegan Road. However, there are several impediments to fish passage as described in Beck, 1992, and these include (1) a footpath 265 feet upstream from Guide Meridian Street in Cornwall Park; (2) an underground flowing portion of the creek just upstream of Bug Lake; (3) a portion of the creek traversing a steep gradient covered by large rocks below the culvert which conducts water under Interstate 5; (4) heavily braided portions of the creek between Interstate 5 and Bug Lake and above Sunset Pond; and (5) a heaver dam/pond downstream of Hannegan Road.

Bellingham's Maritime Heritage Hatchery plants coho and chum salmon eggs and fry in three locations in the Squalicum Creek watershed. These are:

- Near the intersection of Lindberg Avenue and Nome Street
- Near Meridian Street
- In the pond to the north of the K-Mart store

In addition, this portion of Squalicum Creek is known to support sea-run cutthroat and steelhead.

11.3.5 Nonpoint Pollution

The presence of significant residential, commercial and industrial development within the Lower Squalicum Creek area suggests that the potential for nonpoint pollution problems is moderate to high. No obvious evidence of nonpoint pollution problems were observed during the field investigation.

11.3.6 Water Quality

There was no observed indication of water quality problems generated along the main stem. Water quality problems found within the corridor are symptomatic of problems throughout the basin and typical of those described elsewhere in this document and in Beck, 1992.

11.3.7 Problem Identification

The model results indicate erosive velocities along most of the stream reaches anticipated at projected land uses. The model also indicates box culverts P5 and P7 are undersized. Erosive velocities are found in reaches D06, D8a, and D10 using the model for existing land uses. Erosive velocities in the other reaches and the undersized box culverts were found when modeling future land use conditions.

11.3.8 Alternative Analysis

The lower Squalicum Creek Corridor is experiencing the impacts of development upstream. The stream should be monitored and erosion problems corrected through stream management practices such as flow deflectors, notched weirs, or drop structures combined with pools. The undersized box culverts should also be monitored to see if other upstream improvements or land use management mitigate the potential problem. If not, a more detailed analysis should be performed to determine replacement alternatives.

12. OPERATIONS AND MAINTENANCE

12.1 EXISTING PROGRAMS

The 1992 Puget Sound Water Quality Plan (Plan) requires the Department of Ecology to develop minimum standards and guidelines for local stormwater programs in the Puget Sound Basin. For all 111 jurisdictions in the basin, the Plan requires:

> "Each county and city shall develop and enforce, within local governments' authority, operation and maintenance programs and ordinances for new and existing public and private stormwater systems. Each county and city shall maintain records of new public and private storm drainage systems and appurtenances."

Maintenance is required for the storm water system to function properly. A regularly scheduled program of cleaning, inspection, and repair must be maintained for these facilities. The City of Bellingham has an organized program for operation and maintenance of the current storm drainage system. This program is organized through the Public Works Operations, Street Division.

The Street Division employs thirteen people who vary their activities between street operations and maintenance and the storm drainage system operations and maintenance depending upon need and season. This division is responsible for maintenance of storm drains and grates, catch basins, retention ponds, and some ditching programs, in addition to street sweeping and other street maintenance functions.

12.2 PROGRAM REQUIREMENTS

Bellingham's storm drainage utility operation and maintenance program has three primary functions:

1. Maintain the functional use (e.g., hydraulic capacity, detention storage) of the public drainage system so that it can operate to its design capability.

2. Maximize the water quality control benefits of the drainage system facilities by improving pollutant removal efficiency.

3. Provide for emergency response to flooding and water quality problems resulting from drainage system restriction (e.g. debris), or illegal dumping.

The specific operation and maintenance activities for each of these functions are described in the following sections.

12.3 MAINTENANCE OF FUNCTIONAL USE

Operation and maintenance to provide optimal functional use of the system should include the following activities:

12.3.1 Inspection and Cleaning Program

An inspection program should include inspecting catch basins, manholes, pipes, ditches, culverts, and other storm drainage system components. Inspecting, servicing, and maintaining all detention and retention basins and monitoring stations should be routine. Routine observations and monitoring of storm flow and water quality in the storm drainage system should also be conducted on a regular basis.

Cleaning catch basins and manholes is also required regularly, one cleaning per year to remove accumulated debris should be minimum. Storm drain pipelines and culverts should be inspected after large storm events and during the Fall, and sediment, debris, and roots should be removed. Streets, grates and parking lots should also be cleaned after large storm events and in the Fall to remove sediment, leaves, and debris that can plug inlets, catch basins or pipes. Especially important is Bellingham's current program to run street sweepers as often as possible during Fall to remove leaves from the streets. This prevents clogging of drainage facilities during the winter season.

12.3.2 Ditch and Swale Maintenance

Ditch and swale maintenance is important to enable the ditch and/or swale to function properly. Vegetated ditch and swale systems have several advantages over piped systems. These include a capability to filter pollutants, and a potential to allow portions of runoff to infiltrate into the ground.

Cut and remove excess vegetation from ditches and swales (see below) where hydraulic function is being diminished. A poorly maintained ditch or swale can do more damage to downstream facilities and/or water quality than an unmaintained ditch or swale. These facilities should be maintained with a native vegetative cover adapted to Bellingham's climate and soils.

Too often, in an effort to maximize the flow capacity of a ditch and/or swale, crews will strip vegetation to bare ground and destroy the root structure. Denudation increases the flow velocity because there is less resistance. While an increase in velocity increases the hydraulic capacity, it also increases erosion potential. Erosion may suspend silts and granular material or transport them downstream, leading to plugging of detention facilities, silt deposits where flows slow down, or silt plumes at discharge points. It can also lead to abrasion problems in system piping or additional erosion from abrasion to channels downstream.

Stripping the ditch or swale also prevents the vegetation from acting as a biofilter for pollutants. In ditches or swales left with good grass cover, the grass will be flattened during a storm event, providing additional capacity. After the storm event, the grass typically recovers, providing effective biofiltration of lower flows within the ditch and/or swale.

Although banks tend to stabilize over time, excessive maintenance may disrupt that equilibrium. A mowing device can be successfully employed to maintain ditches and swales without denuding them. Ditches and swales recover rapidly from this procedure, however, care should be taken not to mow the ditches and swales too late into the fall, when vegetation becomes dormant. If ditch and swale vegetation is mowed after it becomes dormant a delay in regeneration occurs which reduces the effectiveness of biofiltration on storm water pollutants. All harvested materials should be removed to prevent nutrients and trapped pollutants from returning to the system.

12.3.3 Channel Maintenance

Channel maintenance should be performed once per year. Debris should only be removed if it causes excessive flow restrictions, is an eyesore, or is in danger of dislodging and clogging facilities downstream. Debris can provide habitat and help develop a meandering pattern (by reducing flow velocities). Efforts to straighten channels should be discouraged, wherever possible and pools with short drops should be encouraged over long straight slopes.

Optimally, if natural vegetation does not succeed and bank stabilization does not occur, bioengineered protection, rip-rap, or geo-grid protected channel banks provide more benefit than concrete lined channels, and are of equal ease to maintain.

12.3.4 Culvert and Pipe Maintenance

Culvert and pipe maintenance is important to insure that these structures retain design capacities and do not cause restrictions on channels. Broken, bent, or otherwise damaged culvert inlets and pipes should be repaired or replaced to eliminate headlosses and flow capacity. Similar actions should be taken at the downstream end so that restrictions are not created inside pipes. Care should be taken to protect the ditch and swale vegetation while working on the culverts and to keep disturbances to a minimum for the reasons listed under "ditch and swale maintenance" above. A television inspection program to view for cracked pipes or broken connections is recommended every two years, in addition to regular cleaning and de-rooting programs.

12.3.5 Detention and Retention Facilities

Detention facilities should be maintained annually including inspection, repair and removal of accumulated sediments and deposits. Slide gates should be operable. If the facility restriction becomes plugged, additionally restricted or is somehow removed, the facility will fill up with dead storage and will overflow during storm events instead of providing storage volume. The overflow will impact, rather than protect, any downstream facilities. In addition to potential flooding, these impacts include increased sediments in storm flow abrading downstream facilities and a reduction of downstream water quality.

Detention and retention facilities should be monitored during storm events to verify they are functioning properly and protecting downstream facilities. The control structure should be modified if it is allowing too much flow to pass (continued downstream flooding) or not enough flow to pass (frequent overflows). Scheduled maintenance depends on the capacity and flow into the facility. Annual inspection and cleaning every two to four years may be adequate for most facilities. Sediment traps should be cleaned annually.

12.3.6 Catch Basins

Catch basins require maintenance to remove accumulated sediments and oils. A general cleaning should be performed annually. Inlets should be inspected after large storm events and debris removed.

12.4 MAINTENANCE FOR WATER QUALITY BENEFITS

The majority of the activities listed for maintaining functional use also provide water quality benefits. The degree of water quality protection is controlled, in part, by the thoroughness and frequency of system maintenance. Because these BMPs are designed to improve water quality instead of controlling flood waters, their maintenance needs also differ.

The more efficient a system is at trapping sediment, the more frequent sediment removal is necessary for the system to continue functioning properly. Likewise, the more efficient a system is at trapping other pollutants (such as metals), the more frequently these wastes should be removed.

In general, the longer wastes accumulate in a system, the more likely they are to become contaminated, either through accumulation of pollutants from runoff, or from illicit dumping. Accumulated wastes can become so contaminated, in fact, that it may become difficult to dispose of them at a landfill. Additionally, accumulated wastes can be scoured from systems during storm events, resulting in shock loads to receiving waters. Finally, inadequate maintenance of stormwater quality BMPs can result in flooding problems in the same manner as those that occur when flood control facilities are not maintained.

Frequent and regular maintenance can go a long way towards preventing these things from happening.

An additional consideration in promoting water quality improvement for storm water is public education.

12.5 RESPONSE TO EMERGENCIES

Operation and maintenance to ensure appropriate emergency response capability should include the following activities:

1. Coordination of emergency response plan with state, county, and other local agencies.

2. Developing a plan to respond to high river and stream levels, heavy precipitation, and blockages in highly susceptible and critical drainage systems.

3. Develop emergency response procedures for coordinating with County emergency services for hazardous materials spills.

4. Assembling and maintaining the equipment and materials needed to respond to emergencies.

5. Training staff to respond to emergencies, including emergency services, police and fire departments, and public works staff.

The lead agency for hazardous or toxic spills is the County Emergency Services. Coordination with this agency should be orchestrated and notification and appropriate procedures should be implemented in case of this type of spill.

12.6 MAINTENANCE SCHEDULE

Many of the above suggested maintenance activities have already been implemented by the City. A schedule of maintenance activities should be prepared and kept as a portion of the record of maintenance activities.

12.6.1 Inspection and Preventative Maintenance

Inspection and preventative maintenance should be preformed on the storm flow system on a regularly scheduled basis. Some features, such as ditches and swales, require more maintenance than other facilities such as rip-rap lined channels and thus should be scheduled accordingly.

Ditches and swales and other features which have living vegetative cover need periodic maintenance during the spring and summer growing seasons. Depending on the climatic conditions, these features may need mowing every two weeks from April through September. Thereafter one final mowing prior to the dormant period, should occur during the autumn season.

Culverts, pipelines, detention facilities and catch basins need annual inspections. These inspections may be done throughout the spring, summer or fall during the annual removal of accumulated debris. Television inspection of pipeline facilities can be scheduled independently every two years or as a need is indicated by local conditions such as unexplained flooding or trench subsidence.

In addition to these area-wide maintenance schedules, channels and other features should be checked for erosion or debris build up after a heavy rainfall. Ideally, debris should be removed as soon as possible after a major rainfall, since heavy storms and/or debris may damage conveyance systems.

Certain areas may also require additional inspection and cleaning or repair. These areas include known "problem areas", for examples, places where sedimentation has traditionally occurred, or areas with large trees and potential root problems. Frequent observations of the drainage feature in these areas should be performed to maintain the facility.

Table 12-1 lists recommended maintenance activities and schedules.

TABLE 12-1
MAINTENANCE SCHEDULE

Facility	Maintenance Activity	Frequency
Catch Basin	Inspection and cleaning	Annually
Detention Basin	Inspection and cleaning	Annually
Ditches and Swales	Inspection and repair Debris removal Mowing	Annually and after large storm events Annually Every two weeks during spring and summer
Channels and Streams	Inspection and debris removal Cleaning	After large storm events Every two years
Pipes	Inspection TV monitoring	Annually and after large storm events Annually
Culverts	Debris removal	Annually and after large storm events
Street Sweeping (Vacuum)	Downtown residential (curb and gutter)	Weekly, except as frequently as possible during autumn leaf drop and after large storm events
Training	Basic training and recordkeeping Use of equipment	Orientation Ongoing training

12.6.2 Training and Recordkeeping

To perform the tasks listed above, a drainage system maintenance crew needs to be designated and trained. This crew will assess facility performance, maintain the optimal amount of vegetative cover and repair broken or cracked equipment. The crew should be properly trained and certified on the required heavy machinery, confined area entry procedures, and traffic safety.

Maintenance records should also be maintained by the crew. These records should include notes from scheduled preventative maintenance procedures and should flag any additional problems. Record keeping is also an NPDES regulatory requirement. Although the City is not currently subject to these requirements, the records will provide the City with backup information needed to document the program when the City comes under the NPDES requirements.

12.7 PROGRAM EQUIPMENT

It is recommended that the public works maintenance program be expanded to include dedicated maintenance equipment for the storm drain system. Additional cleaning equipment and crew will be required to operate facilities dedicated to storm drain maintenance.

Recommended equipment for the use of the storm drainage system crew include:

One Vactor truck
One backhoe
Two 5-yard dump trucks
Two 10-yard dump trucks
Two 1-ton service trucks
Two pickup trucks
Two street sweepers
One grader
One chipper (borrowed from Parks Department)
One storm line TV camera (borrowed from Sewer Department)
De-Rooting Equipment (borrowed from Sewer Department)
Mower Vegetation Trimmer

Additional equipment which should be made available to the crew include maintenance shop equipment and repair kits, in addition to crew safety and public safety equipment.

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13. DEVELOPMENT AND BEST MANAGEMENT PRACTICES

Effective stormwater management begins at the conceptual stage of development projects and carries over into lifestyle issues. Individual acts may not amount to much, however, the cumulative effects can be dramatic. While planning activities, especially the handling of pollutants, thought should be given to the impact of the activity on area waters. Activities and facilities designed to reduce the impacts of stormwater on the environment are called Stormwater Best Management Practices (BMPs).

The Washington Department of Ecology has established the six-month return frequency storm as the water quality facility design storm for the Puget Sound Basin. It is the intent of this plan to require all new development to implement on-site water quality measures, or arrange off-site provisions to mitigate the pollutant concentrations and loadings anticipated to be generated by the specific site activities.

13.1 DEVELOPMENT BMPs

Development BMPs are generally facilities to mitigate the impacts of development on downstream features. Examples of BMPs include: detention ponds, wet ponds (detention ponds with a permanent pool), wet vaults, oil/water separators, and biofiltration. These BMPs are geared toward reducing peak flows and improving water quality by filtering or settling out pollutants. The DOE has prepared guidelines for the Puget Sound basin found in the Storm Water Management Manual for the Puget Sound Basin (the Technical Manual). The guideline for water quality facilities is to size them to handle the six-month design storm.

Unprotected construction activities are significant contributors of silts and sediments. BMPs have been developed to control sediments from leaving sites and can be found in the Storm Water Management Manual for the Puget Sound basin, among other reference locations. BMPs for construction typically include rock check dams, filter fabric fencing, sediment traps, straw bales, mulching, and vegetative cover. These BMPs should be maintained until all disturbed areas are stabilized and the collection and conveyance systems are approved and functioning.

Infiltration BMPs generally will not be successful for concentrated flows because of the typical soil structure found in Bellingham. Their use should only be considered on a case by case basis, and only for private facilities to be maintained by private property owners.

Dispersal methods should be utilized in residential areas to dampen the flow hydrographs generated by roofs, patios, and driveways. Directing the flow onto grassed or otherwise landscaped areas, instead of directly into the storm drain collection system can be effective in reducing peak flows from basins. This is generally only effective in residential areas because of the higher ratio of pervious to impervious areas. Dispersal of roof drains can be done utilizing splash blocks to direct flow away from foundations.

Stormwater dispersal can also be an effective BMP for preventing erosion at point discharges, such as from parking lots. This should only be used when discharging to a ditch or swale and where long-term grade control is possible.

13.2 STREAM STABILIZATION BMPs

Protection of Bellingham's valuable stream corridors is one of the goals of this Watershed Management Plan. There are several areas of bank sloughing and erosion particularly in the lower reaches of Padden Creek and Chuckanut Creek. In addition, flows projected for fully developed conditions indicate additional areas will be at risk. Two zones must be considered for erosion potential, the stream bed and the stream banks.

Erosion of the stream bed can be diminished by installing notched check dams, pools, deflectors, and energy dissipators to flatten gradients and reduce velocities. These should be designed to not hamper fish movement or spawning areas. Protection measures must consider impacts to fish habitat. Channel armoring should only be considered as a last resort if velocities can not be reduced to acceptable levels through other techniques. Methods of armoring include concrete, riprap, or shotcrete.

Bank sloughing is generally caused by soil wetting either from groundwater entering the stream or from stream water surface cycles. BMPs to mitigate sloughing include vegetative enhancements such as willow shoots or reeds. In steeper areas bioengineered slopes should be utilized. These slopes include layers of willow, or other suitable vegetative matter, and biodegradable fabric, such as coconut matting. The concept is that the willows will stabilize and the roots will reinforce the soils before the coconut matting degrades. Utilizing overhanging vegetation can also help to restore cooler water temperatures. It is important to include toe protection for these installations to prevent undercutting and collapse. Concrete, rock gabions, or riprap should only be considered as a last resort in these problem areas.

13.3 SOURCE CONTROLS

Eliminating the sources of pollution is typically less expensive than treatment practices to remove it. The DOE has established BMPs to control discharge from many different activities. NPDES has established permitting requirements for key industries based on SIC codes. Enforcement of the NPDES permitting requirements for industrial sites is being handled by the DOE.

Key aspects of source control include:

- Education for both industry and residential environments to help people understand the impacts of their actions.

- Isolate the handling and storage of potential pollutants and establish controls to contain spills.

- Provide adequate disposal or recycling opportunities to provide convenient alternatives to dumping

- Provide incentives for implementing effective BMPs such as grants or published public recognition.

These practices can apply to residential, commercial, industrial, or agricultural environments but to different degrees.

Animal management BMPs can also reduce water quality degradation. Areas of the Squalicum Creek Basin include pasturing of livestock adjacent to the stream. This causes water quality degradation problems from increased erosion and from animal wastes. Buffers should be established to restrict the access of livestock to the riparian zone. Fecal coliform counts in stormwater can also be attributed to pet waste, especially after long frozen periods or long dry periods when build up can be a problem.

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14. RECOMMENDED PLAN

In the previous chapters of this report, the study area has been examined in a variety of ways. The collection and conveyance facilities were analyzed through observation, complaint files, review of existing reports, gathering of existing facility data, and computer modeling. The analysis of natural resources supplemented previous wetland inventories with stream and fisheries assessments. Alternative solutions were developed for current and projected problems to minimize flooding, erosion, and negative impacts on natural resources such as wetlands, streams, and other water resources.

This chapter integrates the recommendations from the preceding chapters into a program to cover the entire study area.

14.1 CAPITAL IMPROVEMENT PROGRAM

The capital improvements recommended in the previous chapters have been combined and prioritized into an implementation program. Prioritization has been based on the severity of the problem, the timeliness necessary for its implementation, and budgetary impacts. The severity of the problem also considered whether the problem identification was based on field and staff reports, runoff from existing land uses, or runoff from projected land uses.

Table 14.1 lists problem areas listed as existing problems in Chapters 7 through 11.

Table 14.2 lists problem areas listed as future problems in Chapters 7 through 11.

Table 14.3 summarizes the recommended solutions for the identified problems with design and construction costs in 1992 dollars.

Figure 14.1 presents the projects needed to mitigate identified problems. In each case, the recommended solution mitigates both existing problems and projected impacts from future development in the problem reaches. Figure 14.1 also shows the proposed schedule for implementing these projects for land acquisition, design, and construction.

Table 14.4 presents the annual break down of costs considering a 5 percent annual inflation rate.

Table F.1 (Appendix F) provides the cost data utilized to generate project costs. Table F.2 provides the correlation between costs estimated for 1992 and costs projected for the implementation year. Individual project cost opinions can be found in Volume 2 as part of the information provided for each basin.

TABLE 14-1 IDENTIFIED EXISTING PROBLEM AREAS			
Problem Number	**Facility Identifier**	**Type of Problem***	**Location**
Fever Creek			
3	P122	INLET	Stream inlet east of East Alpine Drive
Silver Beach			
1	P61	PIPE CAP	Britton Road outfall from Northshore Drive to Lake Whatcom
Lincoln Creek			
1	D11, D13, D14, D16	WQ	Lower reaches of Lincoln Creek
6	D23	WQ	Lincoln Creek between Byron Avenue and Dumas Avenue
Cemetery Creek			
2	D13	BANK	E. Cemetery Creek, south of Lakeway Drive and west of Modoc Drive
5	D21	CHAN VEL	Lower reaches of W. Cemetery Creek, erosion south of Lakeway Drive
8	D13	WQ	Middle reaches of East Cemetery Creek
Hannah Creek			
4	P12A	PIPE CAP	Arbor Street Access to Whatcom Falls Park
Lake Padden			
1	P71	PIPE CAP	Yew Street at Tacoma Avenue
Padden Creek			
3	D11, D12, D17	BANK CHAN VEL	Padden Creek below Old Fairhaven Parkway
Connelly Creek			
22	D243, D244, D245, D247, D248	CHAN VEL	Mill Avenue tributary
24	D252, D254	CHAN VEL	Taylor Avenue
Chuckanut Creek			
2	D10	CHAN VEL BANK	Chuckanut Creek Mainstem

TABLE 14-1 IDENTIFIED EXISTING PROBLEM AREAS			
Problem Number	**Facility Identifier**	**Type of Problem***	**Location**
Baker Creek			
2	D16	CHAN CAP	Baker Creek at I-5 and Guide Meridian/I-5 Underpass
3	P17, D18, D20	CHAN CAP	Stream reach east of Guide Meridian and south of Telegraph Road
4	P21	PIPE CAP	48-inch culvert south of Telegraph Road, upstream of confluence with Tributary No. 1.
5	P235, P236, P237, P239	PIPE CAP	Pipe west of Irongate Road at Division Street
7	P26	PIPE CAP	Culvert under Telegraph Road, east of James Street
9	P69, D70	PIPE CHAN CAP	Baker Creek Tributary No. 1 at James St.
11	D29	WQ	Baker Creek, north of East Bakerview Road
12	D66	WQ	Baker Creek Tributary No. 1, east of Telegraph Road Detention Pond
13	D701	WQ	Baker Creek Tributary No. 1, south of James St.
Spring Creek			
24	P411	PIPE CAP	Easterly tributary at Guide Meridian and Telegraph Road
27	D45	WQ	Spring Creek, east of Guide Meridian
28	D52	WQ	Spring Creek, vicinity of Van Wyck Road
30	P431B	PIPE CAP	Spring Creek Tributary 1 at Guide Meridian

* PIPE CAP = Pipe Capacity
CHAN VEL = Channel Velocity
BANK = Bank Erosion
CHAN CAP = Channel Capacity
WQ = Water Quality

TABLE 14-2
IDENTIFIED FUTURE PROBLEM AREAS

Problem Number	Facility Identifier	Type of Problem*	Location
Fever Creek			
1	P11, P12	PIPE CAP	Parkview Subdivision Bypass
2	D21, D23	CHAN VEL	Illinois Street, west of Vining Street, ditch erosion
4	Multiple Locations	CHAN CAP WQ	West of St. Clair Street
Silver Beach			
2	P63	PIPE CAP	Northshore Drive west of Britton Road
Lincoln Creek			
2	P12	PIPE CAP	Moore Street outfall pipe, north of Fraser Street
3	P14A, P14B, P14C, D13, D14	PIPE CAP CHAN VEL	Lincoln Creek from Lincoln Street and Fraser Street
4	P19A	PIPE CAP	West of Lincoln Street north of Ashley Avenue
5	P21A	PIPE CAP	Lincoln Creek at Ashley Avenue
7	P171, P174	PIPE CAP	Lakeway Drive east of Lincoln Avenue
8	P203	PIPE CAP	North of Byron Avenue between I-5 and Lincoln Street
Cemetery Creek			
1	D10, D11, D12	CHAN VEL	E. Cemetery Creek, north of Lakeway Drive
3	D15, D16, D17	CHAN VEL PIPE CAP	E. Cemetery Creek, south of Blackberry Lane
4	P151	PIPE CAP	South and east of Alvardo Drive and Kenoyer Drive
6	D32	CHAN VEL	Upper reaches of tributary to W. Cemetery Creek (SE of athletic fields)
7	P20A	PIPE CAP	W. Cemetery Creek, extended Fraser Street
Hannah Creek			
1	D10, D101	CHAN VEL	Lower reaches of Hannah Creek
3	P203A	PIPE CAP	Raymond Street

TABLE 14-2 IDENTIFIED FUTURE PROBLEM AREAS			
Problem Number	**Facility Identifier**	**Type of Problem***	**Location**
Lake Padden			
2	D72	CHAN CAP	Ditch D72, east of Yew Street, north of Tacoma Avenue
3	P66	PIPE CAP	Culvert under Yew Street
4	D65	CHAN VEL	Upstream of Our Lake
5	D31	CHAN VEL	West of Governor Road
6	P12	PIPE CAP	Under Samish Way, south of Harrison
Padden Creek			
1	P18, D19	PIPE CAP CHAN CAP	Brick Tunnel and Padden Creek west of 24th Street
2	P162, D163	PIPE, CHAN CAP	Fairhaven Park and South
4	D355	CHAN VEL	Connelly Avenue and 34th Street
Connelly Creek			
21	P27A, P27B, P29	PIPE CAP	Connelly Creek south of Bill McDonald Parkway
23	P261B-P269, D261A, D261C, D269A	PIPE CAP CHAN CAP	Ridgemont Way and Bennett Avenue
25	P281	PIPE CAP	Fielding and Samish Way
Chuckanut Creek			
1	P114	PIPE CAP	Lake Samish Road
3	D101	CHAN VEL	Chuckanut Creek Tributary
4	D121, D123	CHAN VEL	Chuckanut Creek Tributary
5	D141	CHAN VEL	Chuckanut Creek Tributary
6	D151, D153	CHAN VEL	Chuckanut Creek Tributary
7		WQ	Chuckanut Basin

TABLE 14-2 IDENTIFIED FUTURE PROBLEM AREAS			
Problem Number	Facility Identifier	Type of Problem*	Location
Baker Creek			
1	D12, D14	CHAN VEL CAP WQ	Stream reach between Squalicum Creek and I-5
6	P241	PIPE CAP	Culvert along Telegraph Road, east of Irongate Road
8	P67	PIPE CAP	Baker Creek Tributary No. 1 at East Bakerview Road, west of James St.
10	P635, P636, P638, P640	PIPE CAP	Pipe Network north of East Bakerview Road at Landon Ave.
Spring Creek			
21	P44	PIPE CAP	Spring Creek at Guide Meridian
22	P51	PIPE CAP	Spring Creek at East Bakerview Road, Prince Avenue, and Kellogg Avenue
23	P55	PIPE CAP	Spring Creek at Horton Road
25	P435A	PIPE CAP	Spring Creek Tributary 1, north of West Bakerview Road
26	P443-P444 P4432-P4435	PIPE CAP	Collector Pipes under a Guide Meridian, north of Bakerview Road
29	P441-P442C	PIPE CAP	Pipe under Guide Meridiansouth of Baker View Road
31	P461-P468	PIPE CAP	Pipe under Guide Meridian northof Cordata Discharge

* PIPE CAP = Pipe Capacity
CHAN VEL = Channel Velocity
BANK = Bank Erosion
CHAN CAP = Channel Capacity
WQ = Water Quality

Bellingham Watershed Master Plan | Table 14.3
Capital Improvement Schedule

Cost Estimating Year: 1992
Annual Cost Escalation: 5.0%

No.	Drainage Basin	Title/Description	1992 Project Cost ($1000)	1992 Design ($1000)	1992 Constr. ($1000)	1992 Land $ ($1000)
1	Fever Creek	Problem No. 2	5.1	1.0	4.1	n/a
2	Silver Beach	Problem No. 1	47.1	9.4	37.7	n/a
3	Lincoln Creek	Problem Nos. 2, and 3	474.8	12.5	49.8	412.5
4	Lincoln Creek	Problem No. 7	694.8	139.0	555.8	n/a
5	Lincoln Creek	Problem No. 8	44.3	8.9	35.4	n/a
6	Cemetery Creek	Problem Nos. 1, 2, and 3	678.6	47.7	190.9	440.0
7	Cemetery Creek	Problem No. 4	380.7	76.1	304.6	n/a
8	Cemetery Creek	Problem No. 5	15.6	3.1	12.5	n/a
9	Hannah Creek	Problem No. 3	23.8	4.8	19.0	n/a
10	Hannah Creek	Problem No. 4	55.3	11.1	44.2	n/a
11	Lake Padden	Problem No. 1	10.4	2.1	8.3	n/a
12	Lake Padden	Problem Nos. 3, and 4 *	69.5	4.5	18.1	46.9
13	Connelly Creek	Problem No. 21	312.4	62.5	249.9	n/a
14	Connelly Creek	Problem No. 25	50.8	10.2	40.6	n/a
15	Padden Creek	Problem No. 3	448.1	89.6	358.5	n/a
16	Padden Creek	Problem No. 4	12.4	2.5	9.9	n/a
17	Chuckanut Creek	Problem No. 1	27.8	5.6	22.2	n/a
18	Chuckanut Creek	Problem No. 2	249.0	49.8	199.2	n/a
19	Baker Creek	Problem No. 2	78.5	15.7	62.8	n/a
20	Baker Creek	Problem No. 10	79.0	15.8	63.2	n/a
21	Spring Creek	Problem Nos. 21, and 22	521.8	32.4	129.4	360.0
22	Spring Creek	Problem No. 29	424.5	84.9	339.6	n/a
23	Spring Creek	Problem No. 30	8.3	1.7	6.6	n/a
		Totals:	4,712.6	863.3	2,589.9	1,259.4

* – Capital Improvement Projects not included in 5-year plan.

Bellingham Watershed Master Plan | **Table 14.4**
Capital Improvement Plan
Summary of Yearly Project Costs
($1,000)

Cost Estimating Year: 1992
Annual Cost Escalation: 5.0%

Year	Land Acq. Yr. Costs	Design Yr. Costs	Constr. Yr. Costs	Total Costs
1996	1036.2	0.0	0.0	1036.2
1997	519.3	150.3	0.0	669.6
1998	0.0	160.9	631.3	792.2
1999	0.0	131.1	675.9	807.0
2000	0.0	200.3	39.2	239.5
2001	0.0	0.0	1,378.6	1378.6

14.2 OPERATIONS AND MAINTENANCE

A proactive operations and maintenance program can be effective in reducing local flooding problems and improving receiving water quality. The City of Bellingham currently performs stormwater maintenance functions through the Public Works Operations, Street Division. At least one and preferably two crews should be dedicated to stormwater management. Crew dedication is important in order to maintain consistency and develop expertise in environmentally sound stormwater maintenance practices.

Allotments should be included annually in the budget to fund operations and maintenance costs, small projects, problem responses, and opportunity projects. Opportunity projects include items such as culvert replacements or piping under roadway improvements. Projects should be combined with other capital improvements whenever feasible to reduce costs.

The budget for annual operations and maintenance should include staff salaries and benefits as well as equipment costs. Several problems, primarily channel erosion caused by future development along tributary streams, have been recommended to be resolved through funding in this budget also. These types of problems are generally localized and are reported through citizen complaints or crew field reports.

APPENDIX A

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APPENDIX B

PUBLIC INVOLVEMENT

CITY OF BELLINGHAM WASHINGTON

DEPARTMENT OF PUBLIC WORKS, 210 Lottie St., Bellingham, Washington 98225
Telephone (206) 676-6961

March 10, 1994

To Whom It May Concern:

The Puget Sound Water Quality Authority, in conjunction with the Department of Ecology, has been working to effect new rules and regulations governing surface water management. The City of Bellingham is mandated by the Puget Sound Water Quality Authority to adopt the regulations set forth in the Department of Ecology Stormwater Technical Manual or create an equivalent substitute. This must take place before July 1, 1994. To that end, the City of Bellingham's Public Works Department with the help of HDR Engineering has been developing a Watershed Master Plan. This Master Plan is intended to provide guidance to City staff, private engineers, developers and the general public regarding surface water management strategies throughout most of the City. The plan does not replace the DOE Manual, but acts as a modifier to the Manual requirements in those situations where our study has pointed out the need for alternative or additional stormwater controls.

Presently, our draft of the Master Plan is being reviewed by DOE to judge if it is acceptable to their standards. Once this is accomplished, the Public Works Department will be working as quickly as possible toward the adoption of the Plan by the City in order to meet the prescribed deadline. Since these new rules will directly impact the way in which future projects are designed, administered and constructed, it is our desire that interested parties be cognizant of what is in store. Therefore, we wish to inform you that copies of the City of Bellingham Draft Watershed Master Plan are now available at the Bellingham Public Library as well as Western Washington University's Wilson Library.

We hope that you can find time to review these documents, and we invite your questions and comments. It is our goal that the Plan be understandable and as simple as possible to implement. Since many changes are forth coming that will effect the way we all do our business, we encourage your review and input. If you have any questions regarding the Plan, please contact me at 676-6961. Otherwise, please provide your comments in writing to me by May 15, 1994.

Sincerely,

William M. Reilly

William M. Reilly
Utility Specialist

WMR/shh
031094

cc: Mayor Douglas
Bellingham City Council
Jack Garner
Tom Rosenberg
Sarah Caron
Planning Department
Buildings and Codes

CITY OF BELLINGHAM WASHINGTON

DEPARTMENT OF PUBLIC WORKS, 210 Lottie St., Bellingham, Washington 98225
Telephone (206) 676-6961

* * * NOTICE * * *

In compliance with federal and state mandates, the Bellingham City Council is considering adoption of a stormwater management ordinance. The ordinance outlines minimum requirements for all land disturbing activities, including (but not limited to) redevelopment, single family home construction, land subdivision, and addition of impervious surface. The Department of Public Works is holding informational workshops to explain the details of the ordinance at the following times:

<u>Stormwater Management Workshop Session A</u>
Bellingham City Council Chambers
210 Lottie Street
Thursday, January 19, 1995
2:00 - 3:00 PM

<u>Stormwater Management Workshop Session B</u>
Bellingham City Council Chambers
210 Lottie Street
Tuesday, January 24, 1995
7:30 - 8:30 PM

The content of the workshops will be the same. Since council action is likely to have an impact on the community, a public hearing is anticipated in early February. The public is encouraged to attend one of the workshops in preparation for the hearing. If you are unable to attend a workshop but would like to learn more, please contact Bill Reilly at (360) 676-6961.

Engineering Division staff will be available to answer questions after the workshops or during normal work hours at (360) 676-6961.

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APPENDIX C

POLLUTANT LOADING ESTIMATES

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TABLE OF POLLUTANT WASH-OFF RATES (lb/acre/yr) TABLE C.1

BELLINGHAM WATERSHED MASTER PLAN

DATE: 6-30-93

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH-DENSITY RESIDENTIAL	LOW-DENSITY RESIDENTIAL	FOREST
BOD5	139	173	108	27	3.65
COD	955	56	297	25	N/A
TSS	964	50	390	15	76
DS	383	3.2	201	100	36.5
TOTAL NITROGEN	1.5	0.639	0.55	0.274	0.0365
TOTAL AMMONIA	2.7	2.7	3.3	1.278	0.055
TOTAL PHOSPHORUS	46.9	19.2	27.7	3.906	0.256
DISSOLVED PHOSPHORUS	14.6	11	7.3	1.533	0.0088
COPPER	1.9	0.6	0.3	0.03	0.025
LEAD	6.3	4.1	0.6	0.1	0.02
ZINC	2.7	7.1	0.3	0.2	0.02

NOTE

BOD5: BIOCHEMICAL

COD: CHEMICAL OXYGEN DEMAND

TSS: TOTAL SUSPENDED SOLIDS

DS: DISSOLVED SOLIDS

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APPENDIX D

HYDROLOGIC ANALYSIS

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Table III-1.3 SCS Western Washington Runoff Curve Numbers
(Published by SCS in 1982) Runoff curve numbers for selected agricultural, suburban and urban land use for Type 1A rainfall distribution, 24-hour storm duration.

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land(1):	winter condition	86	91	94	95
Mountain open areas:	low growing brush & grasslands	74	82	89	92
Meadow or pasture:		65	78	85	89
Wood or forest land:	undisturbed	42	64	76	81
Wood or forest land:	young second growth or brush	55	72	81	86
Orchard:	with cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping.					
Good condition:	grass cover on ≥75% of the area	68	80	86	90
Fair condition:	grass cover on 50-75% of the area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs etc.		98	98	98	98
Open water bodies:	lakes, wetlands, ponds etc.	100	100	100	100
Single family residential(2):					
Dwelling Unit/Gross Acre	%Impervious(3)	Separate curve number shall be selected for pervious & impervious portions of the site or basin			
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUD's, condos, apartments, commercial businesses & industrial areas	%impervious must be computed				

(1) For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Sec. 4, Hydrology, Chapter 9, August 1972.
(2) Assumes roof and driveway runoff is directed into street/storm system.
(3) The remaining pervious areas (lawn) are considered to be in good condition for these curve numbers.

Table D.1

Table III-1.4 "n" AND "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	n_s
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil) 0.011	
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover ($s \leq 0.20$ ft/ft)	0.06
Cultivated soil with residue cover ($s > 0.20$ ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	k_s
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.25)	13
7. Paved and gravel areas (n = 0.012)	27

Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	k_c
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe (n = 0.024)	21
7. Concrete pipe (0.012)	42
8. Other waterways and pipe 0.508/n	

Channel Flow (Continuous stream, R = 0.4)	k_c
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other streams, man-made channels and pipe 0.807/n**	

Table III-1.5 Values of the Roughness Coefficient, "n"

Type of Channel and Description	Manning's "n"* (Normal)
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	0.025
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as above, but some weeds	0.040
5. Same as 4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Flood plains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as above, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as above, but with flood stage reaching branches	0.120

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APPENDIX E

ENVIRONMENTAL ANALYSIS METHODOLOGY AND DOCUMENTATION

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This appendix describes the methodology employed, and the data forms used, to collect natural resource inventory data. Narratives of the data collected for specific natural resources inventoried in drainage basins, subbasins and specific streams and wetlands are included in Volume 2 - Basin Detail.

1.0 ENVIRONMENTAL ANALYSIS METHODOLOGY

The Watershed Master Plan field survey resulted in the collection of natural resources information and qualitative evaluations on selected stream and wetland environments in the major drainage basins of the City of Bellingham. To facilitate data collection, a stream reach nomenclature was developed. Streams were subdivided into segments known as *reaches* which were defined by one of three conditions: (1) the confluence of a stream tributary, (2) the presence of a man-made constriction such as a culvert or bridge, or (3) the profound change in stream characteristics. Information and evaluations recorded on a data form represent an average of multiple observations made along an entire reach. Samples of blank data forms for stream reaches and wetlands are shown in Figures E1 and E2. The data forms were developed to standardize the collection of pertinent measurements and subjective observations regarding surveyed streams and wetlands. Stream data forms previously developed for use by the U.S. Forest Service, King County Building and Land Development Division, and the Bonneville Power Authority were reviewed during the development of the Bellingham Watershed Master Plan field form. In the following description of the field form, main headings are **CAPITALIZED AND BOLDFACE**, subheadings are **<u>boldface and underscored</u>**, form items are in *italics*, and item choices are <u>underscored</u>.

1.1 DEFINITION OF TERMS

1.1.1 <u>Stream Field Form</u>

CHANNEL DIMENSIONS include physical parameters which taken together quantify the stream's capacity to carry water. *High flow width* is the maximum width of a stream under high water conditions. *Bankful width* is the distance across the channel from upper bank to upper bank. *Bankful depth* measures the vertical distance from the steam bottom to the height of a channel's upper bank. *Low water width* and *low water depth* measure channel width and depth, respectively, under low flow conditions. *Steam gradient* is the grade of the stream to the nearest percent. *Bank undercut* estimates the percentage of stream bank undercut by water flow where the complete undercutting of one stream bank would represent 50 percent undercut.

VEGETATION parameters characterize the type and amount of riparian vegetation present in a given reach and indicate the approximate amount of shade or cover. *Vegetative cover overhang (grass/forbs)* indicates the percentage of streambank supporting grass and/or forbs which are tall enough to provide overhanging cover to the steam. *Stream canopy* estimates the percentage of vegetative canopy above the stream at midstream position. *Estimated shade* is the approximate percentage of stream surface shaded as if it was one o'clock on a sunny midsummer afternoon. *Classification* refers to the type of plant community observed and *vegetation density* takes the amount of canopy, understory and herbaceous layers into account.

BELLINGHAM WATERSHED MASTERPLAN: STREAM FIELD FORM

Stream ____________ Reach ______________ Loc: T:___ R:___ S:___Observer _____ Date _____

CHANNEL DIMENSIONS

High Flow Width____ft. Bankful Width_____ft. Low Water Width_____ft.

Bankful Depth ____ft. Low Water Depth____ft. Stream Gradient____% Bank Undercut_____%

VEGETATION

Vegetative cover overhang (grass/forbs) _____% Stream Canopy: _______% Estimated Shade: _____%

Classification: Mature Forest Immature/Even age Shrub-dominated Pasture/Meadow Developed

Vegetation density: <=50% 50-70% 70-90% >=90%

STREAM CHARACTERISTICS

Upper Bank					
Landform-slope:	<10% 10-20	20-30	30-40 40-60	>60%	
Mass wasting:	None	Small	Moderate	Large	
Debris jams:	None	Small	Moderate	Large	
Lower Bank					
Channel overflow:	None	Rare	Occasional	Common	
Bank rock content:	<20%	20-40%	40-65%	>65%	
Flow obstruction:	None	Few	Moderate	Many	
Cutting:	None	Some	Frequent	Continuous	
Ht. of raw banks (in.)	<6	6-12	12-24	>24	
Bar development	None	Some	Moderate	Extensive	
Bottom					
Substrate	Bedrock	Silt/organic	Sand	Gravel(<1in.)	
	Gravel(1-3.9in.)	Cobble(3.9-10in.)	Boulder		
Particle Packing	Tight	Moderate	Loose	None	
Scouring & Deposition	<5%	5-30%	30-50%	>50%	
Aquatic Vegetation	Rare	Spotty	Common	Abundant	
Water Clarity:	Muddy	Murky	Clear		
Flow Velocity____ft/sec					

Enhancement Potential____

____

____

Effect of Increased Stormwater____

____

____

Non-point pollution____

____

____

Comments (e.g. surrounding land uses, eroding stream banks, trash, human disturbance)__

____

____

Figure E1: Stream Field Form

BELLINGHAM WATERSHED MASTERPLAN:
RIPARIAN WETLAND FIELD FORM

Wetland Inventory Designation ________

VEGETATION

Stratification:	1 layer	2 layers	3 layers
Density:	low	moderate	high
Maturity:	young	intermediate	old
Species Diversity:	low	intermediate	high

Dominant Plant Species ____

____

Vegetation: Non-persistent Persistent

HYDROLOGY

Velocity flow______ft/sec.

Percentage of wetland basin filled during low water: _____%

Potential for expanded water surface: low medium high

Hydroperiod:	seasonally saturated	permanently saturated
	seasonally flooded	permanently flooded
Constricted outlet	yes	no

PHYSICAL PARAMETERS

Wetland Substrate: peat, clay, fine mineral soils, cobble-gravel, bedrock,

Slope: ______%

Sinuosity of wetland/upland edge: low medium high

biofiltration ____

____

enhancement pot.____

____

water-quality benefits____

____

habitat value____

____

floodwater attenuation____

____

effect of decreased/increased flows____

____

effect of adjacent land uses____

____

Figure E2: Riparian Wetland Field Form

STREAM CHARACTERISTICS describe attributes of the **upper bank**, **lower bank**, and **channel bottom** upon which an evaluation of a stream channel's resistive capacity to detachment of bed and bank materials and the capacity of a stream to adjust and recover from potential changes in flow can be made.

The **upper bank** is the land area immediately adjacent to the stream channel. An estimate of the grade of land adjacent to the stream channel is the *landform slope*, which determines the lateral extent and ease to which banks can be eroded and the potential volume of slough which can enter the water. *Mass wasting* rates existing or potential detachment from the soil mantle and downslope movement into waterways of relatively large pieces of ground. *Debris jams* are comprised of floatable objects deposited on stream banks including man-made materials and natural products of the forest.

The **lower bank** is located between the normal high water and low water lines. *Channel overflow* occurs when channel capacity is exceeded and deposits of soil and organic debris are found on the banks or on bank vegetation. *Bank rock content* is the primary determinant for resistance of channel banks to flow forces since bank vegetation is generally minimal. Objects in the stream channel, such as large rocks and embedded logs are *flow obstructions* which commonly modify the direction and velocity of stream flow. *Cutting height of raw banks* and *bar development* are concomitant processes, since erosion in one area is always coupled with deposition elsewhere; however, it is possible for each to be taking place in different reaches of the same stream at the same time. *Cutting height* refers to the loss of vegetation by scouring and uprooting or an increase in the steepness of the channel banks where they are naturally devoid of plants. *Bar development* refers to accumulations of sand and gravel that form where flow drops below the sediment suspension velocity.

The **channel bottom** lies between the low water lines of the lower banks. *Substrate* refers to the type of material dominating the channel bottom. *Particle packing* evaluates the resistance of bottom materials to flow forces. *Scouring and deposition* is an estimate of the area affected by these processes. The occurrence and abundance of *aquatic vegetation* is a qualitative measure of soil-rock stabilization in the stream bed, where the absence of vegetation indicates the least stable conditions. *Water clarity* describes the degree of transparency (and therefore the relative amount of suspended solids) of stream water. Muddy refers to water rendered opaque by suspended solids, clear to perfectly transparent water, and murky describes the wide range of cloudy water conditions in between. *Flow velocity* is estimated by timing the movement of a floating object over a known distance.

For each reach, evaluations and comments regarding potential, effect of increased stormwater, nonpoint pollution, and general comments were recorded. *Enhancement potential* of a reach qualitatively evaluates whether a stream environment can be improved and is roughly proportional to the degree of human disturbance of a given reach. Because additional development in a watershed will likely result in increased stormwater runoff, a qualitative assessment of the *effect of increased stormwater* on a each reach was noted. Comments regarding the ability of the existing channel to contain additional flows and potential threat of accelerated bank erosion to existing development were among the concerns registered under the stormwater comment. Where observed, potential sources of *nonpoint pollution* such as animal pasture, adjacent residences and businesses, adjacent roads, and identified and unidentified culverts were recorded. Pertinent information not already covered in the form was recorded on the comment line.

1.1.2 Riparian Wetland Field Form

Wetlands are defined by the presence of hydrophytic vegetation, wetland hydrology and hydric soils. For each wetland examined during the field investigation, information on **VEGETATION**, **HYDROLOGY**, and **PHYSICAL PARAMETERS** was collected and a simplified functional values analysis was performed. Wetlands examined during the field study were directly associated with inventoried streams and were identified by the 1991 Bellingham Wetland Inventory. *Wetland Inventory Designation* refers to index number assigned to wetlands by the 1991 Bellingham Wetland Inventory.

The **VEGETATION** section of the field form was where general information about the distribution and composition of the observed plant community was recorded. The plant community is subdivided into layers, where trees greater than 20 feet in height form the canopy, shrubs and trees less than 20 feet constitute the understory, and non-woody plants comprise the herbaceous layer. *Stratification* refers to the number of vegetation layers observed and a response of three would indicate the presence of canopy, understory and herbaceous species. *Density* is a qualitative measure of plant abundance that accounts for vegetation from all layers. *Maturity* indicates the roughly estimated age of the plant community, where young would be less than 20 years old, intermediate approximately 20-50 years in age, and old being greater than 50 years. If the plant community is not young, the response ordinarily refers to the age of the tree species and not the shrubs or herbaceous plants. A subjective measure of the variety of plant species observed in a wetland was reported under *species diversity*. Plants with an areal abundance greater than 20 percent of a given vegetation layer were listed under *dominant plant species*. *Persistent* vegetation is woody and *non-persistent* is herbaceous.

The spatial and temporal characteristics of water in the wetlands are addressed in the **HYDROLOGY** section. For wetlands which were inundated at the time of observation, *flow velocity* was estimated from observations of a floating object moving over a known distance. *Hydroperiod* refers to the degree and duration of wetland hydrology over an average year. When wetlands are narrowed by some topographic feature or physical barrier, they have a *constricted outlet*.

PHYSICAL PARAMETERS include other important wetland characteristics unrelated to vegetation and hydrology. *Wetland substrate* characterizes the material upon which wetlands formed and in most cases it is fine mineral soils. *Slope* refers to the grade of the wetland ground surface to the nearest degree. *Sinuosity* is a qualitative assessment of the complexity of the wetland/upland boundary.

Information on several items related to wetland functional values were collected in comment form. The presence or absence of vegetation thought to be capable of filtering pollutants from stormwater runoff was noted in the *biofiltration* comment line. The ability to increase wetland functional values through augmentation of vegetation and/or alteration of hydrologic characteristics was qualitatively assessed in *enhancement potential.* In general, the enhancement potential was proportional to the degree of human disturbance observed. *Water quality benefit* of wetlands is the subjectively perceived ability to reduce surface water contamination as water flows through vegetation and soils. *Habitat value* refers to the presence and condition of wildlife habitat in wetlands. In general, the wildlife habitat potential is inversely proportional to the degree of human disturbance. Additionally, wetlands with two or more vegetated strata are though to be higher in habitat value than emergent wetlands without an open-water class present. The distribution and type of wetland vegetation were evaluated for their ability to reduce overland flow velocity under *floodwater attenuation.* Since future development in the vicinity of wetlands would have the potential to modify local hydrology, the ramifications of hydrologic changes were considered under the *effect of decrease/increased flows.* Decreased flows are potentially problematic for fisheries resources and increased flows are potentially hazardous in terms of increased and accelerated erosion. Proximity of human activity is ordinarily the most important factor affecting the overall quality of the wetland environment and an evaluation of man's activities on a wetland is addressed in the *effect of adjacent land uses.*

For consistency and continuity, two out of three field staff conducted stream and wetland inventory information. Field groups investigated each creek, walking upstream and visiting each field station only once. All data were collected at that time. As part of the Watershed Master Plan study, selected streams and wetlands in the major drainage basins of Bellingham were inventoried. In addition, qualitative evaluations and impact assessments were performed on inventoried streams. Information for the stream inventory was collected in the field by two-person teams during a single pass along a given stream.

2.0 ENVIRONMENTAL DOCUMENTATION

Refer to Volume 2 - Basin Detail for more detailed documentation for individual basins.

APPENDIX F

CAPITAL IMPROVEMENT COST ESTIMATES

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WATERSHED MASTER PLAN — Table F.1
CITY OF BELLINGHAM, WASHINGTON
"BLANK"
Problem No. 7

Item	Quantity	Unit	Unit Cost
Storm Sewer, Concrete Pipe			
12–inch	1	LF	$50
15–inch	1	LF	$55
18–inch	1	LF	$60
24–inch	1	LF	$75
30–inch	1	LF	$100
36–inch	1	LF	$120
42–inch	1	LF	$140
48–inch	1	LF	$165
Storm Sewer, CMP			
24–inch	1	LF	$65
30–inch	1	LF	$90
36–inch	1	LF	$110
42–inch	1	LF	$130
48–inch	1	LF	$150
54–inch	1	LF	$190
60–inch	1	LF	$220
66–inch	1	LF	$250
72–inch	1	LF	$280
78–inch	1	LF	$330
Structures			
Manholes, 48–inch (8–feet deep max.)	1	EA	$1,200
Manholes, 48–inch (over 8–feet deep)	1	VLF	$160
Manholes, 54–inch (8–feet deep max.)	1	EA	$1,875
Manholes, 54–inch (over 8–feet deep)	1	VLF	$250
Manholes, 72–inch (8–feet deep max.)	1	EA	$2,600
Manholes, 72–inch (over 8–feet deep)	1	VLF	$330
Manholes, 84–inch (8–feet deep max.)	1	EA	$3,500
Manholes, 84–inch (over 8–feet deep)	1	VLF	$390
Manholes, 96–inch (8–feet deep max.)	1	EA	$4,625
Manholes, 96–inch (over 8–feet deep)	1	VLF	$475
Manholes, 102–inch (8–feet deep max.)	1	EA	$5,750
Manholes, 102–inch (over 8–feet deep)	1	VLF	$625
Catch Basin	1	EA	$940
Catch Basin Inlet	1	EA	$500
Connect to Existing	1	EA	$200
Concrete Headwall	1	EA	$3,000
Flow Control Device	1	EA	$1,000
Special Structures	1	LS	$0
Special Junctions	1	LS	$0
Surface Restoration			
Asphalt Pavement	1	SY	$15
Curbing	1	LF	$3
Concrete Pavement	1	LF	$18
Crushed Surfacing	1	TON	$15
Asphalt Concrete Overlay	1	TON	$35
Landscaping	1	SY	$10
Earthwork			
Regrade Channel (Significant Excavation)	1	CY	$12
Regrade Channel (Clean–Up)	1	LF	$4
Bioengineered Slope	1	SF	$14
Embankment	1	CY	$5
Excavation	1	CY	$5
Drain Rock	1	CY	$30
Rip Rap	1	CY	$28
Miscellaneous			
6–inch Underdrain	1	LF	$9
Bank Stabilization	1	SY	$10
Hydroseeding	1	SY	$2
Riparian Vegetation	1	SY	$10
Habitat Structure	1	EA	$650
Streambed Gravel	1	LF	$4
Subtotal:			
Mobilization: 10%			
Contingency: 20%			
Sales Tax: 7.8%			
Subtotal – Construction:			
Real Estate Acquisition			
Purchase	1	EA	$0
Easement – Residential	1	SF	$1.25
Easement – Commercial	1	SF	$1.50
Easement – Agricultural	1	SF	$1.00
Subtotal – Real Estate:			
Engineering Design and Construction: 25%			
TOTAL PROJECT COST:			

Bellingham Watershed Master Plan
Capital Improvement Schedule

Table F.2

Cost Estimating Year: 1992
Annual Cost Escalation: 5.0%

No.	Drainage Basin	Title/Description	1992 Project Cost ($1000)	1992 Design ($1000)	1992 Constr. ($1000)	1992 Land $ ($1000)	Land Acq. Year	Land Acq. Cost	Design Year	Design Year $	Constr. Year	Constr. Year $
1	Fever Creek	Problem No. 2	5.1	1.0	4.1	n/a			1999	1.4	2000	6.0
2	Silver Beach	Problem No. 1	47.1	9.4	37.7	n/a			1998	12.6	1999	53.0
3	Lincoln Creek	Problem Nos. 2, and 3	474.8	12.5	49.8	412.5	1996	501.4	1997	15.9	1998	66.7
4	Lincoln Creek	Problem No. 7	694.8	139.0	555.8	n/a			*	*	*	*
5	Lincoln Creek	Problem No. 8	44.3	8.9	35.4	n/a			*	*	*	*
6	Cemetery Creek	Problem Nos. 1, 2, and 3	678.6	47.7	190.9	440.0	1996	534.8	1998	64.0	1999	268.6
7	Cemetery Creek	Problem No. 4	380.7	76.1	304.6	n/a			*	*	*	*
8	Cemetery Creek	Problem No. 5	15.6	3.1	12.5	n/a			1999	4.4	2000	18.5
9	Hannah Creek	Problem No. 3	23.8	4.8	19.0	n/a			2000	7.0	2001	29.5
10	Hannah Creek	Problem No. 4	55.3	11.1	44.2	n/a			1998	14.8	1999	62.3
11	Lake Padden	Problem No. 1	10.4	2.1	8.3	n/a			1998	2.8	1999	11.7
12	Lake Padden	Problem Nos. 3, and 4	69.5	4.5	18.1	46.9	1997	59.8	2000	6.7	2001	28.0
13	Connelly Creek	Problem No. 21	312.4	62.5	249.9	n/a			2000	92.3	2001	387.7
14	Connelly Creek	Problem No. 25	50.8	10.2	40.6	n/a			2000	15.0	2001	63.0
15	Padden Creek	Problem No. 3	448.1	89.6	358.5	n/a			1997	114.4	1998	480.4
16	Padden Creek	Problem No. 4	12.4	2.5	9.9	n/a			1999	3.5	2000	14.7
17	Chuckanut Creek	Problem No. 1	27.8	5.6	22.2	n/a			2000	8.2	2001	34.5
18	Chuckanut Creek	Problem No. 2	249.0	49.8	199.2	n/a			1998	66.7	1999	280.3
19	Baker Creek	Problem No. 2	78.5	15.7	62.8	n/a			1997	20.0	1998	84.2
20	Baker Creek	Problem No. 10	79.0	15.8	63.2	n/a			2000	23.3	2001	98.0
21	Spring Creek	Problem Nos. 21, and 22	521.8	32.4	129.4	360.0	1997	459.5	2000	47.8	2001	200.8
22	Spring Creek	Problem No. 29	424.5	84.9	339.6	n/a			1999	119.5	2001	526.8
23	Spring Creek	Problem No. 30	8.3	1.7	6.6	n/a			1999	2.3	2001	10.3
		Totals:	4,712.6	863.3	2,589.9	1,259.4						

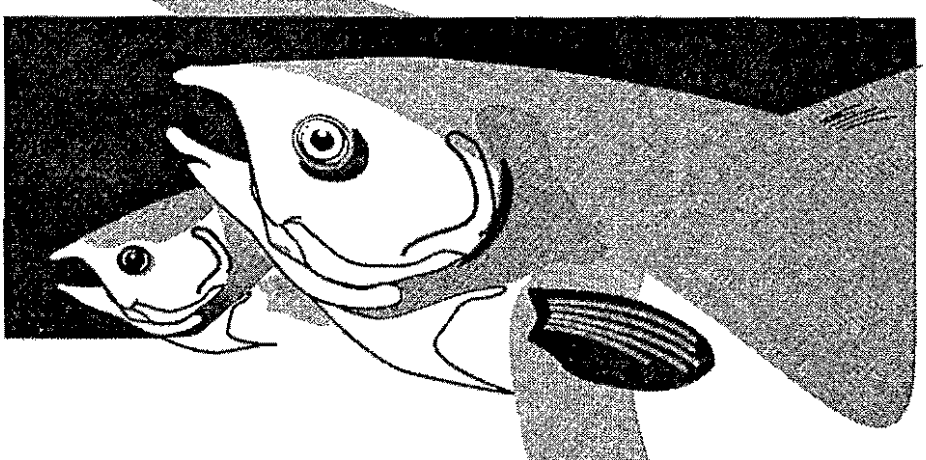
* – Capital Improvement Projects not included in 5–year plan.

City of Bellingham

Watershed Master Plan

September, 1995

Volume 2
Basin Detail



DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

Submitted to

CITY OF BELLINGHAM
Department of Public Works
210 Lottie Street
Bellingham, Washington 98225

Prepared by

HDR ENGINEERING, INC.
500-108th Avenue N.E.
Bellevue, Washington 98004-5538

JOHN R. GENSKOW
STATE OF WASHINGTON
20694
REGISTERED
PROFESSIONAL ENGINEER

9/18/95

EXPIRES 3/21/1996

September, 1995

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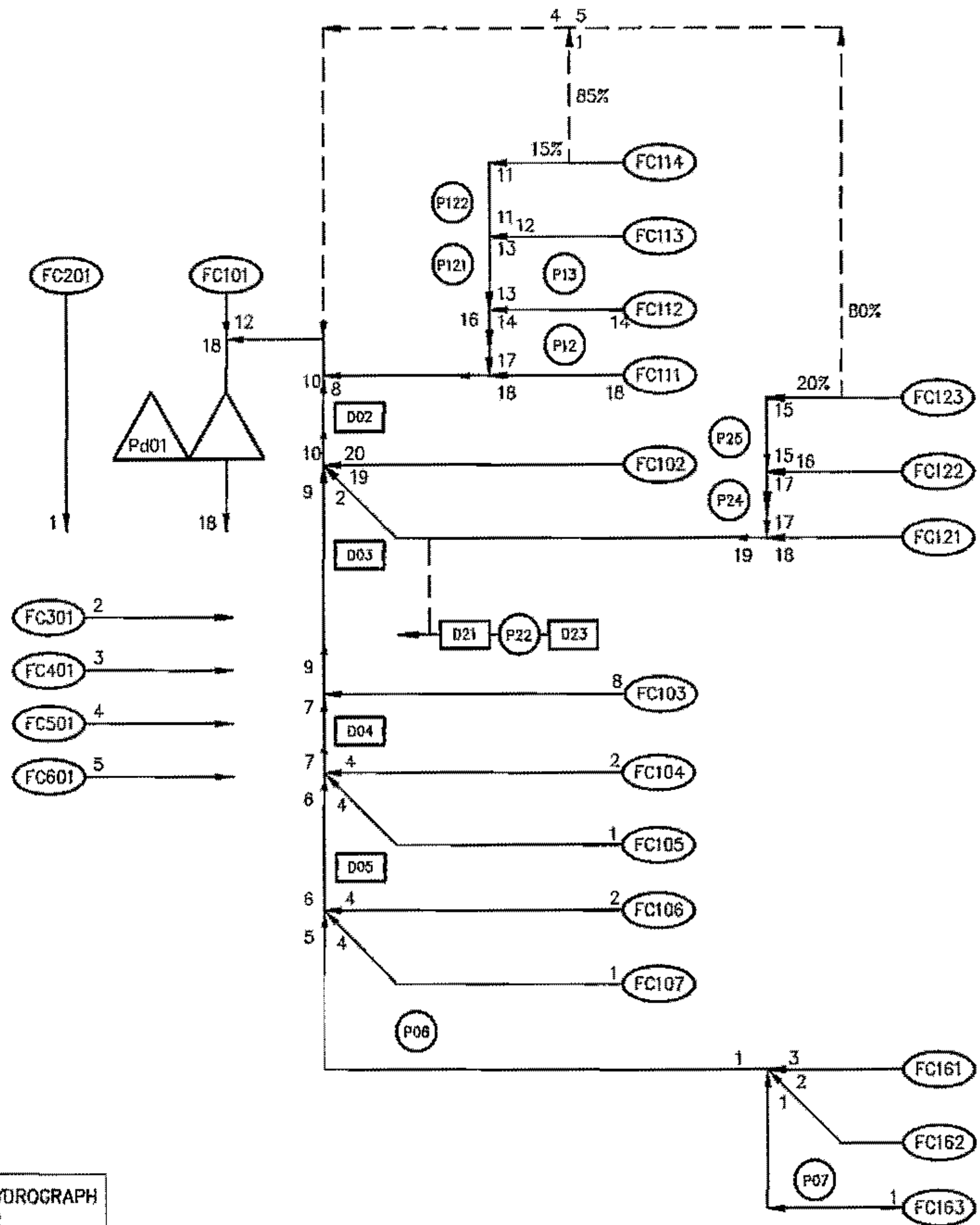
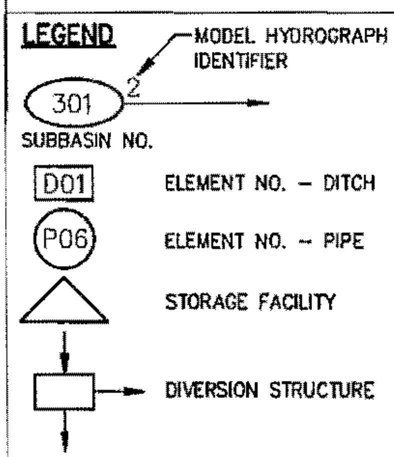
VOLUME 2 - BASIN DETAIL

Note: Subsections .1 through .10 are typical sections to be found in Chapter 1 through 12 in Volume 2 - Basin Detail.

FEVER CREEK STUDY AREA





HYDROLOGIC MODEL SCHEMATIC FOR FEVER CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	VOLUME 2 FIGURE 1.1 9/1/95

Bellingham Watershed Master Plan Flow Table

Basin Name : Fever Creek - Existing Condition

Sep-95

Volume 2

Table 1.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D02				3.0			15.2	4.5	1.3	38.9	5.6	2.2	52.4	6.0	2.6
D03				3.0			9.2	3.6	1.0	23.7	4.5	1.8	32.9	4.9	2.2
D04				3.0			7.5	2.6	0.7	19.2	3.3	1.1	26.7	3.7	1.3
D05				3.0			5.1	2.3	0.5	13.5	3.0	0.9	18.8	3.3	1.1
D06	1.25	19.4	15.8				4.9	13.2	0.4	13.1	17.0	0.8	18.4	18.0	1.0
D07	1.25	11.1	9.0				2.2	7.0	0.4	5.9	9.2	0.7	8.2	9.9	0.8
P11	1.00	9.4	12.0				4.4	11.8	0.5	10.4	13.3	full	14.3	18.2	full
P12	1.00	5.0	6.4				1.7	5.7	0.4	4.2	7.1	0.7	6.1	7.8	full
P13	1.00	3.8	4.8				1.0	4.1	0.4	2.6	5.2	0.6	3.5	5.5	0.8
D21				2.0			5.1	4.9	0.4	12.3	6.4	0.7	16.9	7.0	0.9
P22	1.50	21.6	12.2		3.0	9.5	5.1	10.0	0.5	12.3	12.6	0.8	16.9	13.5	1.0
D23				3.0			5.0	6.3	0.4	12.2	8.2	0.7	16.7	8.9	0.9
P24	1.25	14.5	11.8				3.9	10.0	0.4	9.4	12.6	0.7	12.9	13.3	0.9
P25	1.00	10.1	12.9				0.2	5.1	0.1	0.9	7.8	0.2	1.7	9.6	0.3
P121	1.25	26.7	21.8				0.6	9.0	0.1	1.6	12.0	0.2	2.8	14.1	0.3
P122	1.25	18.9	15.4		1.0	2.6	0.3	5.4	0.1	1.1	8.5	0.2	2.1	10.2	0.3

Bellingham Watershed Master Plan Flow Table Basin Name : Fever Creek - Future Condition Sep-95														Volume 2 Table 1.3	
REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D02				3.0			24.4	5.0	1.7	57.9	6.2	2.8	76.3	6.6	3.2
D03				3.0			19.5	4.3	1.6	41.3	5.2	2.5	53.9	5.5	2.9
D04				3.0			16.5	3.2	1.0	34.8	3.9	1.5	45.2	4.2	1.7
D05				3.0			11.6	2.9	0.9	24.6	3.6	1.3	32.0	3.8	1.4
D06	1.25	19.4	15.8				10.1	16.0	0.6	21.6	17.6	full	28.3	23.1	full
D07	1.25	11.1	9.0				4.4	8.5	0.6	9.3	10.1	0.9	12.1	9.9	full
P11	1.00	9.4	12.0				5.8	12.7	0.6	12.9	16.4	full	17.5	22.2	full
P12	1.00	5.0	6.4				2.5	6.4	0.5	6.0	7.6	full	8.5	10.8	full
P13	1.00	3.8	4.8				1.4	4.5	0.4	3.1	5.4	0.7	4.0	5.1	full
D21				2.0			7.1	5.4	0.5	15.8	6.8	0.8	21.2	7.4	1.0
P22	1.50	21.6	12.2		3.0	9.5	7.1	11.0	0.6	15.8	13.3	1.0	21.2	13.9	1.2
D23				3.0			7.1	7.0	0.5	15.7	8.8	0.9	21.0	9.4	1.1
P24	1.25	14.5	11.8				5.5	11.0	0.5	12.2	13.2	0.9	16.4	18.1	full
P25	1.00	10.1	12.9				0.3	6.0	0.1	1.1	8.4	0.2	1.8	9.7	0.3
P121	1.25	26.7	21.8				1.1	10.6	0.2	2.9	14.2	0.3	4.5	16.1	0.3
P122	1.25	18.9	15.4		1.0	2.6	0.3	5.5	0.1	1.1	8.5	0.2	2.1	10.2	0.3

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Fever Creek – Existing
Oct–93

VOLUME 2
TABLE 1.4

LAND USE / CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	4619.1	6404.4	3215.7	1365.5	15604.7
COD	0.0	1495.2	17612.1	2977.5	0.0	22084.8
TSS	0.0	1335.0	23127.0	1786.5	28431.6	54680.1
DS	0.0	85.4	11919.3	11910.0	13654.7	37569.4
TOTAL NITROGEN	0.0	17.1	32.6	32.6	13.7	96.0
TOTAL AMMONIA	0.0	72.1	195.7	152.2	20.6	440.6
TOTAL PHOSPHORUS	0.0	512.6	1642.6	465.2	95.8	2716.2
DISSOLVED PHOSPHORUS	0.0	293.7	432.9	182.6	3.3	912.5
COPPER	0.0	16.0	17.8	3.6	9.4	46.7
LEAD	0.0	109.5	35.6	11.9	7.5	164.4
ZINC	0.0	189.6	17.8	23.8	7.5	238.7
LAND USE (ACRES)	0.0	26.7	59.3	119.1	374.1	579.2

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Fever Creek – Future
Oct–93

VOLUME 2
TABLE 1.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	29306.2	24364.8	4973.4	0.0	58644.4
COD	0.0	9486.4	67003.2	4605.0	0.0	81094.6
TSS	0.0	8470.0	87984.0	2763.0	0.0	99217.0
DS	0.0	542.1	45345.6	18420.0	0.0	64307.7
TOTAL NITROGEN	0.0	108.2	124.1	50.5	0.0	282.8
TOTAL AMMONIA	0.0	457.4	744.5	235.4	0.0	1437.3
TOTAL PHOSPHORUS	0.0	3252.5	6249.1	719.5	0.0	10221.1
DISSOLVED PHOSPHORUS	0.0	1863.4	1646.9	282.4	0.0	3792.7
COPPER	0.0	101.6	67.7	5.5	0.0	174.8
LEAD	0.0	694.5	135.4	18.4	0.0	848.3
ZINC	0.0	1202.7	67.7	36.8	0.0	1307.3
LAND USE (ACRES)	0.0	169.4	225.6	184.2	0.0	579.2

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Fever Creek Basin
Oct–93

VOLUME 2
TABLE 10.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	172.0	0.0	98	172.0	72	97.0	98	75.0	80
102	9.5	2.9	98	6.6	90	4.9	98	4.6	90
103	15.6	5.0	98	10.6	80	8.1	98	7.5	80
104	6.0	0.9	98	5.1	69	3.1	98	2.9	80
105	17.8	6.0	98	11.8	80	9.3	98	8.5	80
106	3.1	0.3	98	2.8	72	1.6	98	1.5	80
107	4.1	0.8	98	3.3	75	2.1	98	2.0	80
111	12.8	4.4	98	8.4	87	6.7	98	6.1	86
112	6.4	2.2	98	4.2	80	3.3	98	3.1	80
113	3.7	1.3	98	2.4	80	1.9	98	1.8	80
114	34.4	0.0	98	34.4	64	15.8	98	18.6	81
121	7.6	2.6	98	5.0	80	4.0	98	3.6	80
122	23.9	8.1	98	15.8	80	12.0	98	11.9	80
123	23.7	0.8	98	22.9	64	9.5	98	14.2	80
161	20.6	5.4	98	15.2	75	10.7	98	9.9	80
162	5.4	1.4	98	4.0	78	2.8	98	2.6	80
163	20.1	5.0	98	15.1	78	10.5	98	9.6	80
201	33.5	0.0	98	33.5	87	24.1	98	9.4	86
301	104.0	0.0	98	104.0	88	70.1	98	33.9	88
401	25.2	5.4	98	19.8	87	13.1	98	12.1	90
501	14.6	2.8	98	11.8	86	7.6	98	7.0	90
601	15.2	2.5	98	12.7	84	8.0	98	7.2	90
TOTAL	579.2	57.8		521.4		326.2		253.0	
%	100.0%	10.0%		90.0%		56.3%		43.7%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Fever Creek Basin – Existing
Oct–93

VOLUME 2
TABLE 10.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	172.0	0.0	98	172.0	72							172.0	72
102	9.5	2.9	98	6.6	90	6.6	90						
103	15.6	5.0	98	10.6	80	10.6	80						
104	6.0	0.9	98	5.1	69	1.7	80					3.4	64
105	17.8	6.0	98	11.8	80	11.8	80						
106	3.1	0.3	98	2.8	72	1.4	80					1.4	64
107	4.1	0.8	98	3.3	75	2.2	80					1.1	64
111	12.8	4.4	98	8.4	87	8.4	87						
112	6.4	2.2	98	4.2	80	4.2	80						
113	3.7	1.3	98	2.4	80	2.4	80						
114	34.4	0.0	98	34.4	64							34.4	64
121	7.6	2.6	98	5.0	80	5.0	80						
122	23.9	8.1	98	15.8	80	15.8	80						
123	23.7	0.8	98	22.9	64							22.9	64
161	20.6	5.4	98	15.2	75	10.4	80					4.8	64
162	5.4	1.4	98	4.0	78	3.5	80					0.5	64
163	20.1	5.0	98	15.1	78	13.6	80					1.5	64
201	33.5	0.0	98	33.5	87					26.8	89	6.7	81
301	104.0	0.0	98	104.0	88							104.0	88
401	25.2	5.4	98	19.8	87	12.7	90					7.1	81
501	14.6	2.8	98	11.8	86	6.4	90					5.4	81
601	15.2	2.5	98	12.7	84	3.8	90					8.9	81
TOTAL	579.2	57.8		521.4		120.5				26.8		374.1	
%	100.0%	10.0%		90.0%		20.8%				4.6%		64.6%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Fever Creek Basin – Future
Oct–93

VOLUME 2
TABLE 10.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	172.0	97.0	98	75.0	80	57.2	81	5.6	85	12.2	74		
102	9.5	4.9	98	4.6	90	4.6	90						
103	15.6	8.1	98	7.5	80	7.5	80						
104	6.0	3.1	98	2.9	80	2.9	80						
105	17.8	9.3	98	8.5	80	8.5	80						
106	3.1	1.6	98	1.5	80	1.5	80						
107	4.1	2.1	98	2.0	80	2.0	80						
111	12.8	6.7	98	6.1	86	6.1	86						
112	6.4	3.3	98	3.1	80	3.1	80						
113	3.7	1.9	98	1.8	80	1.8	80						
114	34.4	15.8	98	18.6	81	14.9	80	3.7	85				
121	7.6	4.0	98	3.6	80	3.6	80						
122	23.9	12.0	98	11.9	80	11.9	80						
123	23.7	9.5	98	14.2	80	13.6	80	0.6	80				
161	20.6	10.7	98	9.9	80	9.9	80						
162	5.4	2.8	98	2.6	80	2.6	80						
163	20.1	10.5	98	9.6	80	9.6	80						
201	33.5	24.1	98	9.4	86					9.4	86		
301	104.0	70.1	98	33.9	88	16.0	90			17.9	86		
401	25.2	13.1	98	12.1	90	12.1	90						
501	14.6	7.6	98	7.0	90	7.0	90						
601	15.2	8.0	98	7.2	90	7.2	90						
TOTAL	579.2	326.2		253.0		203.6		9.9		39.5			
%	100.0%	56.3%		43.7%		35.1%		1.7%		6.8%			

1.9 FEVER CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 7.0 and 7.1.2 in the Watershed Master Plan.

One wetland (WH-33a, the St. Clair Detention Pond) was field inventoried in the Fever Creek basin and is described below. No portion of Fever Creek was inventoried during the field work in this basin.

1.9.1 Fever Creek Wetland Descriptions

WH-33a (St. Clair Detention Pond)

Wetland Description: This structurally complex wetland exhibited three wetland types including forested wetland, emergent wetland in the detention basin, and scrub/shrub wetland. A detention basin formed the southern limit of the wetland and during peak runoff flows, it may have open water. A single vegetative layer of weedy grasses dominated the detention area. Forested wetland with three layers of vegetation stratification and a canopy dominated by wester red cedar (*Thuja plicata*) comprised the central portions of the wetland. The northern part of WH-33a was a scrub-shrub and emergent wetland dominated by roses and Douglas' spirea (*Spiraea douglasii*). Diversity of plant species was high and persistent vegetation was present. The hydroperiod was classified as seasonally flooded and seasonally saturated. The percentage of the wetland basin filled during low water was estimated at less than 5 percent and the potential for expanded surface water is high. Fever Creek flows southward through the wetland area, and a water control structure at the south end of the detention basin forms a constricted outlet through which Fever Creek flows. Fine mineral soils constituted the wetland substrate. Landform slope was approximately three percent, and the sinuosity of the wetland/upland edge was medium with somewhat irregular wetland boundaries. This wetland measures approximately 37 acres in size.

Wetland Values: The interspersion of wetland types warranted a high wildlife habitat value rating. Biofiltration was evaluated as good due to the presence of mineral soils and complex herbaceous and woody vegetation. The wetland area would be effective at floodwater attenuation due to its large size and capability for expanded surface water between high and low water levels.

Wetland Impacts: Current impacts were minimal; however, residential development in the Alabama Hill area may encroach on wetlands and cause detrimental impacts.

1.9.2 (Not used)

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Fever Creek – Alternative No. 3" Problem No. 2			Revised: HDR Engineering, Inc.	Nov-93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Earthwork				
Regrade Channel (Significant Excavation)	**10**	**CY**	**$12**	**$120**
Excavation	**5**	**CY**	**$5**	**$25**
Rip Rap	**100**	**CY**	**$28**	**$2,800**
Subtotal:				**$2,900**
Mobilization: 10%				**$300**
Contingency: 20%				**$600**
Sales Tax: 7.8%				**$300**
Subtotal – Construction:				**$4,100**
Engineering Design and Construction:	25%			**$1,000**
TOTAL PROJECT COST:				**$5,100**

SILVER BEACH STUDY AREA

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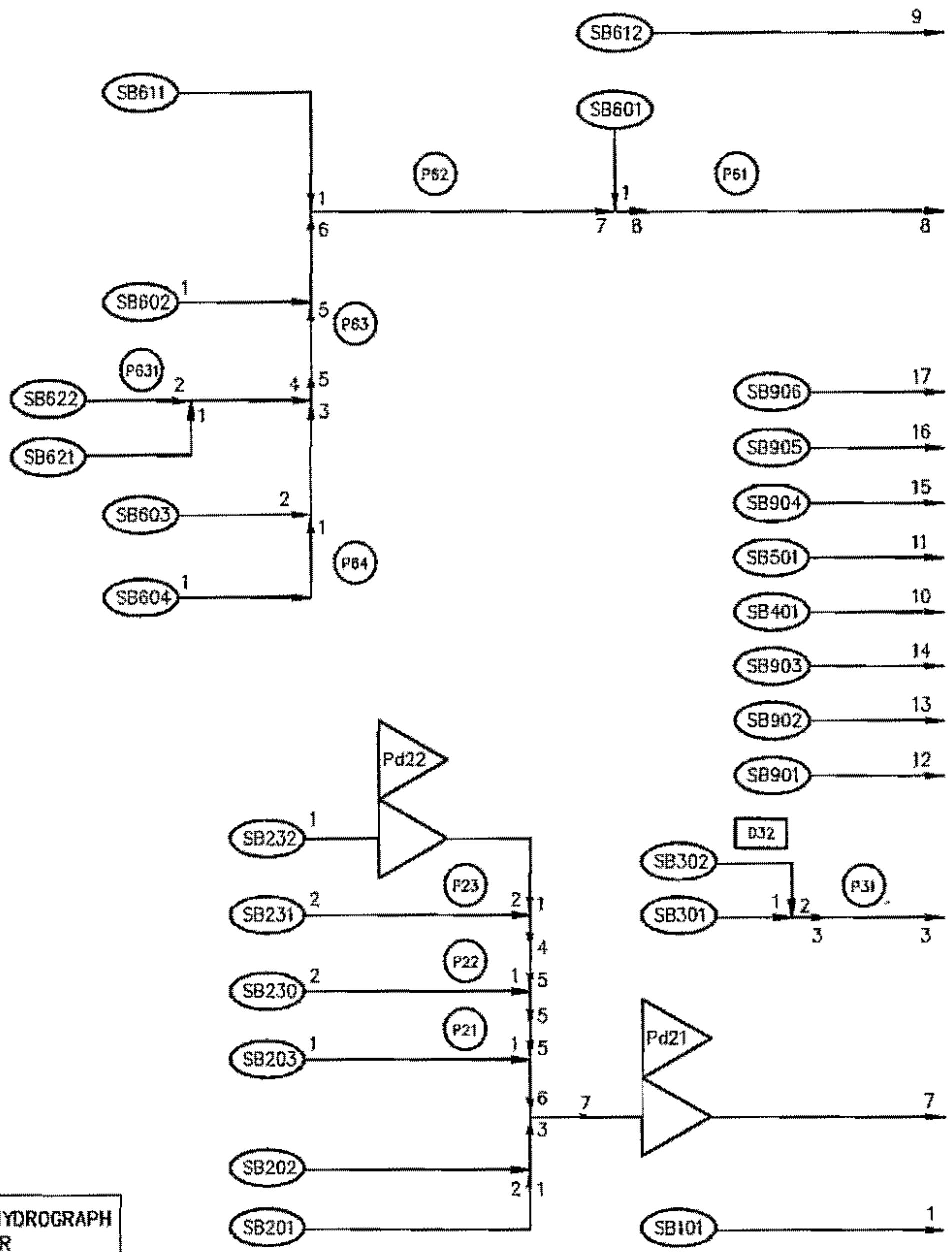

LEGEND

MODEL HYDROGRAPH IDENTIFIER

2

301

SUBBASIN NO.

D01 ELEMENT NO. – DITCH

P06 ELEMENT NO. – PIPE

STORAGE FACILITY

DIVERSION STRUCTURE

HYDROLOGIC MODEL SCHEMATIC FOR SILVER BEACH BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE 2.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Silver Beach - Existing Condition
Sep-95

Volume 2
Table 2.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P21	1.75	46.9	12.7				5.0	12.7	0.4	13.7	16.9	0.7	19.3	18.5	0.8
P22	1.75	32.2	13.4				2.2	7.7	0.3	6.0	10.2	0.5	8.4	11.3	0.6
P23	1.00	9.9	12.5				0.2	4.9	0.1	0.8	7.6	0.2	1.3	8.7	0.2
P31	1.25	15.3	12.5		3.0	6.5	1.6	8.1	0.8	3.9	10.4	0.4	5.5	11.5	0.5
D32				3.0			0.1	1.4	0.1	0.3	2.1	0.2	0.7	2.5	0.3
P61	2.00	16.0	5.1				6.6	4.9	0.9	15.5	5.8	1.6	23.3	7.4	full
P62	3.00	66.9	9.5				5.7	5.8	0.6	13.2	7.4	0.9	20.3	8.3	1.1
P63	1.75	23.6	9.8				2.2	6.1	0.4	4.4	7.5	0.5	7.9	8.8	0.7
P64	1.00	8.5	10.9				0.1	3.7	0.1	0.5	5.8	0.2	0.9	7.1	0.2
P631	1.75	33.3	13.9				0.3	4.4	0.1	1.5	6.9	0.3	3.0	8.6	0.4

Bellingham Watershed Master Plan Flow Table
Basin Name : Silver Beach - Future Condition
Sep-95

Volume 2
Table 2.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P21	1.75	46.9	12.7				10.7	15.8	0.6	24.6	19.7	0.9	32.8	21.1	1.1
P22	1.75	32.2	13.4				6.0	10.2	0.5	13.8	12.9	0.8	18.5	13.9	1.0
P23	1.00	9.9	12.5				1.1	8.3	0.2	2.8	10.8	0.4	4.8	12.5	0.5
P31	1.25	15.3	12.5		3.0	6.5	3.2	9.9	0.4	8.3	12.8	0.7	11.2	13.6	0.8
D32				3.0			0.9	2.7	0.3	2.6	3.5	0.5	3.6	3.8	0.6
P61	2.00	16.0	5.1				22.4	7.1	full	54.0	17.2	full	72.8	23.1	full
P62	3.00	66.9	9.5				20.6	8.3	1.1	50.2	0.4	1.9	67.6	9.6	full
P63	1.75	23.6	9.8				10.6	9.5	0.8	28.2	11.7	full	38.5	16.0	full
P64	1.00	8.5	10.9				2.2	9.1	0.3	5.5	11.6	0.6	7.5	12.2	0.7
P631	1.75	33.3	13.9				5.0	10.0	0.6	13.8	13.2	0.8	18.9	14.3	0.9

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Silver Beach – Existing
Oct–93

VOLUME 2
TABLE 2.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	1014.7	0.0	3380.4	5899.5	756.3	11050.9
COD	6971.5	0.0	9296.1	5462.5	0.0	21730.1
TSS	7037.2	0.0	12207.0	3277.5	15747.2	38268.9
DS	2795.9	0.0	6291.3	21850.0	7562.8	38500.0
TOTAL NITROGEN	11.0	0.0	17.2	59.9	7.6	95.6
TOTAL AMMONIA	19.7	0.0	103.3	279.2	11.4	413.6
TOTAL PHOSPHORUS	342.4	0.0	867.0	853.5	53.0	2115.9
DISSOLVED PHOSPHORUS	106.6	0.0	228.5	335.0	1.8	671.9
COPPER	13.9	0.0	9.4	6.6	5.2	35.0
LEAD	46.0	0.0	18.8	21.9	4.1	90.8
ZINC	19.7	0.0	9.4	43.7	4.1	76.9
LAND USE (ACRES)	7.3	0.0	31.3	218.5	207.2	464.3

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Silver Beach -- Future
Oct-93

VOLUME 2
TABLE 2.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH-DENSITY RESIDENTIAL	LOW-DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	1459.5	0.0	5788.8	10643.4	21.9	17913.6
COD	10027.5	0.0	15919.2	9855.0	0.0	35801.7
TSS	10122.0	0.0	20904.0	5913.0	456.0	37395.0
DS	4021.5	0.0	10773.6	39420.0	219.0	54434.1
TOTAL NITROGEN	15.8	0.0	29.5	108.0	0.2	153.5
TOTAL AMMONIA	28.4	0.0	176.9	503.8	0.3	709.3
TOTAL PHOSPHORUS	492.5	0.0	1484.7	1539.7	1.5	3518.5
DISSOLVED PHOSPHORUS	153.3	0.0	391.3	604.3	0.1	1148.9
COPPER	20.0	0.0	16.1	11.8	0.2	48.0
LEAD	66.2	0.0	32.2	39.4	0.1	137.9
ZINC	28.4	0.0	16.1	78.8	0.1	123.4
LAND USE (ACRES)	10.5	0.0	53.6	394.2	6.0	464.3

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Silver Beach
Oct–93

VOLUME 2
TABLE 2.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	34.5	11.5	98	23.0	72	16.0	98	18.5	77
201	11.8	2.5	98	9.3	78	6.1	98	5.7	80
202	11.7	2.5	98	9.2	77	6.1	98	5.6	80
203	9.6	2.4	98	7.2	64	5.0	98	4.6	81
230	24.0	6.0	98	18.0	78	10.8	98	13.2	80
231	33.5	5.0	98	28.5	81	13.4	98	20.1	80
232	24.8	1.3	98	23.5	64	10.5	98	14.3	81
301	14.4	4.0	98	10.4	78	5.5	98	8.9	80
302	6.6	0.6	98	6.0	64	2.8	98	3.8	80
401	25.6	5.9	98	19.7	75	11.3	98	14.3	80
501	14.8	6.7	98	8.1	80	8.8	98	6.0	80
601	8.0	2.0	98	6.0	80	4.1	98	3.9	80
602	7.3	2.0	98	5.3	87	3.8	98	3.5	80
603	16.2	5.6	98	10.6	72	6.9	98	9.3	78
604	13.7	0.0	98	13.7	64	6.2	98	7.5	82
611	44.3	5.6	98	38.7	69	19.9	98	24.4	80
612	76.9	22.0	98	54.9	72	29.2	98	47.7	80
621	16.7	0.0	98	16.7	64	8.0	98	8.7	80
622	44.3	0.0	98	44.3	64	19.4	98	24.9	80
901	4.6	1.6	98	3.0	80	2.6	98	2.0	80
902	3.6	1.2	98	2.4	80	2.0	98	1.6	80
903	9.2	3.1	98	6.1	80	5.8	98	3.4	80
904	2.9	1.0	98	1.9	80	1.5	98	1.4	80
905	1.3	0.3	98	1.0	80	0.7	98	0.6	80
906	4.0	0.6	98	3.4	71	2.1	98	1.9	80
TOTAL	464.3	93.4		370.9		208.5		255.8	
%	100.0%	20.1%		79.9%		44.9%		55.1%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Silver Beach – Existing
Oct–93

VOLUME 2
TABLE 2.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	34.5	11.5	98	23.0	72	7.6	80	3.9	80			11.5	64
201	11.8	2.5	98	9.3	78	8.0	80					1.3	64
202	11.7	2.5	98	9.2	77	7.4	80					1.8	64
203	9.6	2.4	98	7.2	64							7.2	64
230	24.0	6.0	98	18.0	78	14.7	81					3.3	64
231	33.5	5.0	98	28.5	81	19.3	82					9.2	77
232	24.8	1.3	98	23.5	64							23.5	64
301	14.4	4.0	98	10.4	78	6.7	85					3.7	64
302	6.6	0.6	98	6.0	64							6.0	64
401	25.6	5.9	98	19.7	75	13.8	80					5.9	64
501	14.8	6.7	98	8.1	80	8.1	80						
601	8.0	2.0	98	6.0	80	6.0	80						
602	7.3	2.0	98	5.3	87	5.3	87						
603	16.2	5.6	98	10.6	72	5.3	80					5.3	64
604	13.7	0.0	98	13.7	64							13.7	64
611	44.3	5.6	98	38.7	69	12.4	80					26.3	64
612	76.9	22.0	98	54.9	72	27.4	80					27.5	64
621	16.7	0.0	98	16.7	64							16.7	64
622	44.3	0.0	98	44.3	64							44.3	64
901	4.6	1.6	98	3.0	80	3.0	80						
902	3.6	1.2	98	2.4	80	2.4	80						
903	9.2	3.1	98	6.1	80	6.1	80						
904	2.9	1.0	98	1.9	80	1.9	80						
905	1.3	0.3	98	1.0	80	1.0	80						
906	4.0	0.6	98	3.4	71			3.4	71				
TOTAL	464.3	93.4		370.9		156.4		7.3		0.0		207.2	
%	100.0%	20.1%		79.9%		33.7%		1.6%		0.0%		44.6%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Silver Beach – Future
Oct–93

VOLUME 2
TABLE 2.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	34.5	16.0	98	18.5	77	12.4	80					6.0	72
201	11.8	6.1	98	5.7	80	5.7	80						
202	11.7	6.1	98	5.6	80	5.6	80						
203	9.6	5.0	98	4.6	81	3.5	80	1.2	85				
230	24.0	10.8	98	13.2	80	13.2	80						
231	33.5	13.4	98	20.1	80	20.1	80						
232	24.8	10.5	98	14.3	81	12.5	80	1.8	85				
301	14.4	5.5	98	8.9	80	8.9	80						
302	6.6	2.8	98	3.8	80	3.8	80						
401	25.6	11.3	98	14.3	80	14.3	80						
501	14.8	8.8	98	6.0	80	5.7	80			0.3	85		
601	8.0	4.1	98	3.9	80	3.9	80						
602	7.3	3.8	98	3.5	80	3.5	80						
603	16.2	6.9	98	9.3	78	6.2	80	0.8	85	2.3	72		
604	13.7	6.2	98	7.5	82	5.7	85	0.4	85	1.3	72		
611	44.3	19.9	98	24.4	80	24.0	80	0.4	85				
612	76.9	29.2	98	47.7	80	47.7	80						
621	16.7	8.0	98	8.7	80	8.8	80						
622	44.3	19.4	98	24.9	80	23.6	80	1.3	85				
901	4.6	2.6	98	2.0	80	2.0	80						
902	3.6	2.0	98	1.6	80	1.6	80						
903	9.2	5.8	98	3.4	80	2.0	80	1.1	80	0.3	85		
904	2.9	1.5	98	1.4	80	1.4	80						
905	1.3	0.7	98	0.6	80	0.6	80						
906	4.0	2.1	98	1.9	80	1.9	80						
TOTAL	464.3	208.5		255.8		238.5		6.9		4.1		6.0	
%	100.0%	44.9%		55.1%		51.4%		1.5%		0.9%		1.3%	

2.9 SILVER BEACH STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 7.0 and 7.2.2 in the Watershed Master Plan.

Two wetlands (WH-82, Scudder Pond; and WH-86, Big Rock Pond) in the Silver Beach drainage area were field inventoried and are described below. No streams in this subbasin were inventoried.

2.9.1 Silver Beach Wetland Descriptions

WH-82 (Scudder Pond)

Wetland Description: This wetland had one layer of vegetation growing in open water and three layers of vegetation growing around portions of the wetland margins. The dominant open water plant species was broad-leaf cattail (*Typha latifolia*). The margins of the pond was inhabited by dense woody vegetation including: red alder (*Alnus rubra*), willows (*Salix sp.*), red-osier dogwood (*Cornus stolonifera*) as well as various emergent herbaceous species. Vegetation in both open water and marginal areas was persistent. Surface water flow was not evident throughout most of the wetland area, however, low flow (approximately 0.3 ft/sec) was noted near the pond water's exit where double 24-inch culverts form a constricted outlet on the southern wetland boundary. The percentage of the basin filled during low water was estimated at 80 percent. There was little area for expanded water surface; however, due to well defined 3-foot high pond banks, the wetland could handle additional water volume. The hydroperiod was assumed to be permanently flooded. Peat soils formed the substrate, and the wetland basin was level without discernable slope. The sinuosity of the wetland edge was low and regular in form. This wetland measures approximately 2.8 acres in size.

Wetland Values: Wildlife habitat was rated as high, and species observed during the field investigation included seven red-winged blackbirds, eight mallard, a pair of hooded mergansers, and four to five coot. In addition, evidence of a beaver lodge was noted. Water quality benefits rate high for sediment and toxicant retention, and nutrient removal.
Wetland Impacts: Adjacent residential development has impacted wetland buffer areas to the north.

WH-86 (Big Rock Pond)

Wetland Description: Open water characterized this permanently flooded wetland. Velocity flow was not evident. A horizontally placed intake culvert forms a constricted outlet at the pond's southern end. Potential for surface water area expansion was low due to well defined banks, however, there was moderate potential for increased water volume. Approximately 90 percent of the basin was estimated to be full during low water periods. Dense woody vegetation inhabits the banks and pond margins with three layers of stratification. Species diversity was intermediate with red alder and willows dominating the vegetation. Aquatic macrophytes and some cattails were observed as well. The shallow pond substrate was peat. The slope was level and the sinuosity of the wetland/upland edge was low. This wetland measures approximately 0.3 acres in size.

Wetland Values: Wildlife habitat was rated high. The pond provided aquatic habitat for amphibians and invertebrates. Two pairs of bufflehead ducks were observed along with mallard ducks. A moderate to high rating was given for floodwater attenuation, and the pond provides water quality benefits such as sediment and toxicant retention and nutrient retention.

Wetland Impacts: Road and new development to the west impacts wetland buffers and may increase sediment loading into the shallow pond. Enhancement potential was low. Biofiltration should be maintained for waters entering the pond and buffers should be preserved to the north. Proposed extension of Barkley Boulevard to the north of the pond may have a negative effect on the supply and quality of the water in Big Rock Pond unless care is taken to mitigate for these potential effects.

2.9.2 <u>(Not used)</u>

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Silver Beach – Alternative No. 1" Problem No. 1			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
42–inch	**130**	**LF**	**$140**	**$18,200**
Structures				
Manholes, 72–inch (8–feet deep max.)	**1**	**EA**	**$2,600**	**$2,600**
Connect to Existing	**3**	**EA**	**$200**	**$600**
Surface Restoration				
Asphalt Pavement	**130**	**SY**	**$15**	**$1,950**
Curbing	**260**	**LF**	**$3**	**$780**
Crushed Surfacing	**30**	**TON**	**$15**	**$450**
Earthwork				
Regrade Channel (Clean–Up)	**5**	**LF**	**$4**	**$20**
Excavation	**330**	**CY**	**$5**	**$1,650**
Rip Rap	**10**	**CY**	**$28**	**$280**
Subtotal:				**$26,500**
Mobilization: 10%				**$2,700**
Contingency: 20%				**$5,800**
Sales Tax: 7.8%				**$2,700**
Subtotal – Construction:				**$37,700**
Engineering Design and Construction:	**25%**			**$9,400**
TOTAL PROJECT COST:				**$47,100**

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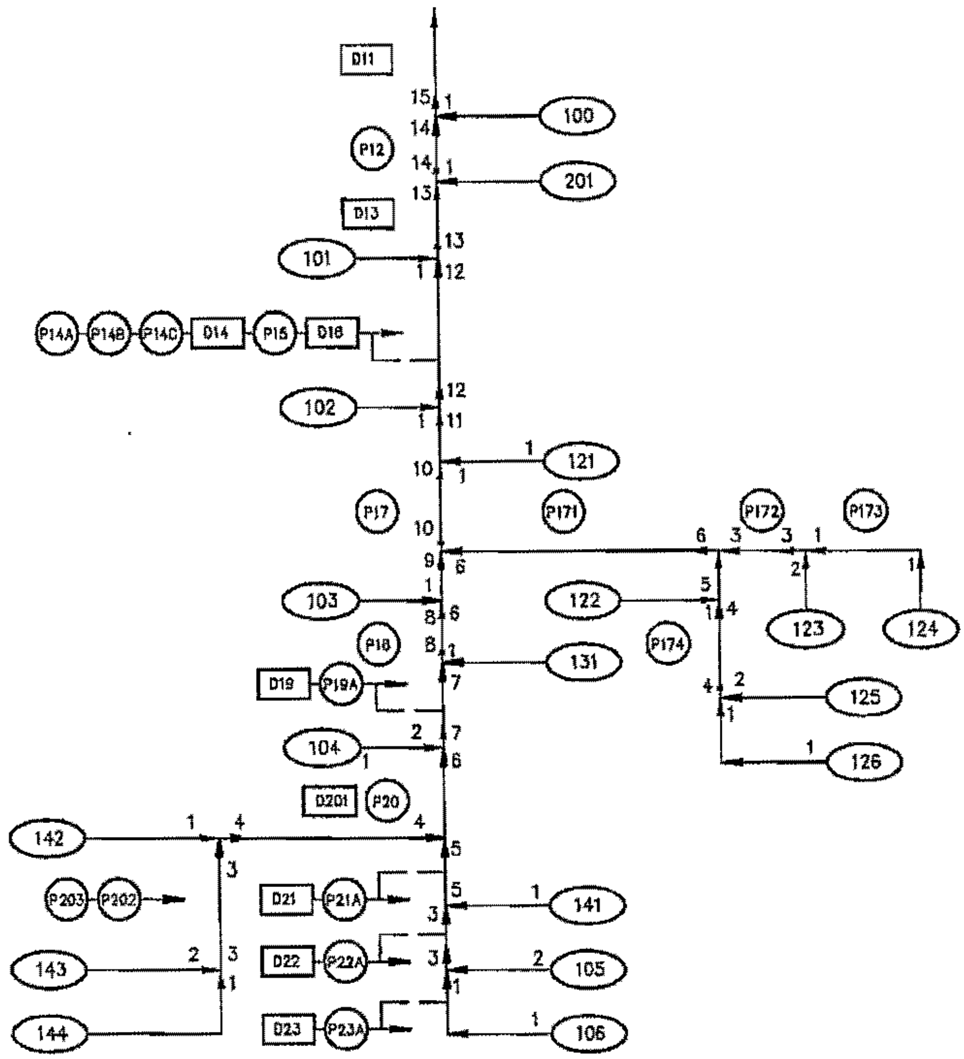
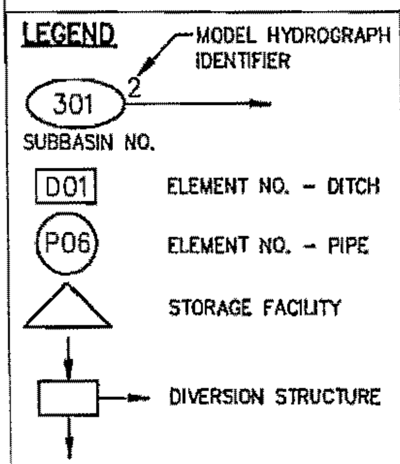
LINCOLN CREEK STUDY AREA





HYDROLOGIC MODEL SCHEMATIC
FOR LINCOLN CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE
3.1

9/1/95

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Bellingham Watershed Master Plan Flow Table
Basin Name : Lincoln Creek - Future Condition
Sep-95

Volume 2
Table 3.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D11				2.5			110.4	6.2	4.5	233.1	6.9	8.5	298.4	7.0	10.6
P12	4.27	112.3	7.9		6.5	120.0	105.2	9.0	3.3	223.6	15.8	full	287.8	20.3	full
D13				4.0			98.3	6.6	2.4	208.1	8.0	3.5	262.8	8.5	3.9
D14				2.0			94.5	6.6	2.3	198.0	7.9	3.4	247.8	8.4	3.8
P14A	4.30	136.6	9.3		3.5	70.0	94.5	10.0	2.7	198.0	13.4	full	247.8	16.8	full
P14B	4.00	55.2	4.4		6.0	115.0	94.5	7.5	full	198.0	15.8	full	247.8	19.7	full
P14C	4.30	136.6	9.3		6.0	110.0	94.5	10.0	2.7	198.0	13.4	full	247.8	16.8	full
P15	5.00	141.5	7.2		10.0	225.0	98.9	7.8	3.1	207.2	10.6	full	255.1	13.0	full
D16				4.0			98.9	5.7	1.6	207.2	7.1	2.3	255.1	7.5	2.6
P17	4.00	327.3	26.1		18.0	220.0	91.6	22.3	1.5	193.4	27.1	2.2	233.4	28.3	2.5
P171	3.00	51.2	7.3				44.1	8.2	2.2	89.0	12.6	full	114.4	16.2	full
P172	3.00	51.2	7.3				21.5	6.9	1.4	44.3	8.2	2.2	57.5	8.1	full
P173	2.30	46.4	11.7				18.1	11.0	1.0	37.8	13.0	1.5	49.3	12.4	full
P174	2.00	28.0	8.9				18.3	9.5	1.2	36.2	11.5	full	46.3	14.7	full
P175	2.00	53.8	17.1				12.9	14.1	0.7	25.2	16.9	1.0	32.0	17.9	1.1
P18	4.00	110.3	8.8				43.3	8.3	1.7	100.7	10.0	3.0	131.7	10.5	full
D19				2.0			34.7	2.6	1.4	87.8	3.4	2.3	116.5	3.6	2.6
P19A	3.00	51.2	7.3				37.4	7.9	1.9	88.1	12.5	full	116.9	16.5	full
P20	3.50	77.3	7.3		3.7	56.0	27.3	7.3	1.4	74.6	9.2	2.8	100.2	10.4	full
D201				3.0			19.9	5.1	1.3	39.1	6.0	2.2	49.6	6.3	2.6
P202	2.00	34.8	11.1				13.2	10.3	0.9	26.7	12.2	1.3	34.2	12.6	1.6
P203	1.50	21.6	12.2		2.0	9.0	13.2	12.8	0.9	26.7	15.1	full	34.2	19.4	full
D21				2.0			20.2	4.8	0.4	59.3	7.1	0.8	81.0	7.9	0.9
P21A	4.00	31.5	6.4				20.3	6.8	1.5	59.4	12.1	full	81.1	16.5	full
D22				2.0			16.9	4.5	0.4	49.6	6.7	0.7	68.0	7.5	0.8
P22A	3.00	162.0	22.9		18.0	140.0	16.9	14.8	0.7	49.6	20.2	1.1	68.2	21.9	1.4
D23				2.0			12.5	3.7	0.4	37.6	5.4	0.7	52.5	6.0	0.9
P23A	2.00	49.2	15.6		8.0	40.0	12.6	13.1	0.7	37.6	17.2	1.3	52.7	16.8	full

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Lincoln Creek – Future
Oct–93

VOLUME 2
TABLE 3.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	26159.8	7283.3	17863.2	10435.5	79.2	61821.0
COD	179731.0	2357.6	49123.8	9662.5	0.0	240874.9
TSS	181424.8	2105.0	64506.0	5797.5	1649.2	255482.5
DS	72080.6	134.7	33245.4	38650.0	792.1	144902.8
TOTAL NITROGEN	282.3	26.9	91.0	105.9	0.8	506.9
TOTAL AMMONIA	508.1	113.7	545.8	493.9	1.2	1662.8
TOTAL PHOSPHORUS	8826.6	808.3	4581.6	1509.7	5.6	15731.7
DISSOLVED PHOSPHORUS	2747.7	463.1	1207.4	592.5	0.2	5010.9
COPPER	357.6	25.3	49.6	11.6	0.5	444.6
LEAD	1185.7	172.6	99.2	38.7	0.4	1496.6
ZINC	508.1	298.9	49.6	77.3	0.4	934.4
LAND USE (ACRES)	188.2	42.1	165.4	386.5	21.7	803.9

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Lincoln Creek – Existing Conditions
Oct–93

VOLUME 2
TABLE 3.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN
100	27.8	12.4	98	15.4	87			2.2	90	13.2	86		
101	41.4	13.2	98	28.2	87	14.4	90	0.8	90	4.0	90	9.0	81
102	19.5	11.9	98	7.6	74			0.7	85	3.4	72	3.5	74
103	27.4	22.5	98	4.9	75			1.2	83	3.7	72		
104	48.8	10.5	98	38.3	76			0.8	90	19.5	86	18.0	64
105	44.8	4.0	98	40.8	70	5.0	85					35.6	68
106	168.0	1.0	98	167.0	69	10.0	87					157.0	68
121	14.2	6.7	98	7.5	90	1.0	90			6.5	90		
122	14.1	8.4	98	5.7	90	5.3	90	0.4	90				
123	10.8	8.5	98	2.3	82	1.9	80	0.4	90				
124	102.0	22.9	98	79.1	75	53.5	80					25.6	64
125	22.9	5.5	98	17.4	68	3.3	84	0.4	90			13.7	64
126	54.9	0.8	98	54.1	70	1.2	90					52.9	70
131	54.7	17.1	98	37.6	82	12.4	90			5.2	90	20.0	75
141	37.8	0.0	98	37.8	67							37.8	67
142	19.6	10.5	98	9.1	78			0.1	90	4.0	86	5.0	72
143	26.8	15.3	98	11.5	76			0.8	90	5.2	86	5.5	64
144	22.9	2.3	98	20.6	72	5.0	85					15.6	68
201	45.5	6.7	98	38.8	82			0.1	90	6.5	86	32.2	81
TOTAL	803.9	180.2		623.7		113.0		7.9		71.2		431.4	
%	100.0%	22.4%		77.6%		14.1%		1.0%		8.9%		53.7%	

3.9 LINCOLN CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 7.0 and 7.3.2 in the Watershed Master Plan.

Six wetlands (WH-2, WH-4, WH-8, WH-9, WH-11 and WH-14) in the Lincoln Creek drainage basin were field inventoried and are described below. Lincoln Creek stream reaches are described subsequently.

3.9.1 <u>Lincoln Creek Wetland Descriptions</u>

WH-2 (Lincoln Creek, Reach 1)

Wetland Description: This wetland had one vegetation layer characterized as having low density with young plant community maturity and low species diversity. The dominant plant species was reed canarygrass (*Phalaris arundinacea*) with a few specimens of red alder (*Alnus rubra*) and willow (Salix sp.). Persistent vegetation was noted. No surface water was observed, therefore no flow rate could be measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an approximate slope of one percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 1.6 acres in size.

Wetland Values: The habitat value was rated as minimal and the presence of substantial herbaceous vegetation merited a good water quality benefits rating. Low to moderate flow attenuation would be provided by abundant herbaceous vegetation.

Wetland Impacts: This nearly monotypic stand of reed canarygrass probably resulted from disturbance associated with the construction of adjacent athletic fields. Few impacts would degrade this relatively low value wetland.

WH-4 (Lincoln Creek, Reach 4)

Wetland Description: This wetland had three layers of vegetation characterized as low to moderately dense with intermediate plant community maturity and intermediate species diversity. The dominant plant species included black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), himalayan blackberry (*Rubus discolor*), and nightshade (*Circaea* sp.). Persistent vegetation dominated this wetland area. Since no surface water was observed, flow rate could not be measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered low due to the steep slope of riparian corridor sides. The wetlands are fed by seeps and the hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an approximate slope of 30 percent. The sinuosity of the wetland/upland boundary was low. This wetland measures approximately 1.1 acres in size.

constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 1 percent. The sinuosity of the wetland/upland boundary was rated medium. This wetland measures approximately 0.7 acres in size.

Wetland Values of Area A: The wildlife habitat value was rated as moderate based on the presence of a forest vegetation community. Since only sparse herbaceous vegetation for biofiltration was observed, a low to moderate water quality benefits rating was recorded. Good flow attenuation would be provided by abundant persistent vegetation.

Wetland Impacts on Area A: The potential adverse affects of increased stormwater in this wetland appear to be low due to the currently degraded condition of the wetland.

Wetland Description of Area B: This wetland is characterized by one layer of vegetation with low to moderate density, young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*) bentgrasses (*Agrostis* spp.) and soft rush (*Juncus effusus*). Vegetation was dominantly non-persistent. During the February 1992 field investigation, scattered areas of shallow inundation were observed; however, no flowing water was observed. Approximately 2 percent of the wetland basin was filled and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was noted. Fine mineral soils formed the wetland substrate which had a slope of less than 1 percent. The sinuosity of the wetland/upland boundary was rated low. This wetland measures approximately 0.5 acres in size.

Wetland Values of Area B: The wildlife habitat value was rated as low because the vegetation is dominated by reed canarygrass. Although this herbaceous vegetation was not considered particularly good wildlife habitat, it can provide an important biofiltration function, therefore a moderate water quality benefits rating was recorded. In addition, good flow attenuation would be furnished by the abundant reed canarygrass.

Wetland Impacts for Area B: This wetland area is highly disturbed. Grade changes have altered the natural hydrology of the area and the natural vegetation has been removed and succeeded by an invasive herbaceous plant assemblage. Consequently, the potential adverse affects of increased stormwater in this wetland appear to be relatively minor.

WH-11 (Lincoln Creek, Reach 6)

Wetland Description: This area is a highly disturbed, section of paving adjacent to a channelized portion of Lincoln Creek, yet it satisfies the technical criteria for wetlands. There was one sparse layer of vegetation with young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), and American speedwell (*Veronica americana*). No surface water was observed, and no flow rate was measured. Fine mineral soils formed the wetland substrate between the cracks in the pavement. This wetland measures approximately 0.5 acres in size.

Wetland Values: The wildlife habitat value was rated as non-existent and the presence of minor herbaceous vegetation and essentially nonexistent infiltration capacity merited a poor

Stream Characteristics: Above the upper bank, the landform slope was approximately 30 to 40 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was common and the water clarity was murky. A flow rate of approximately 0.2 feet/second was observed.

Stream Evaluations: Stream aesthetics were poor due to the highly disturbed nature of the stream area. Stream environment appeared to be poor fish habitat. Murky water clarity suggested poor water quality which may be due to the proximity of athletic fields (and their associated fertilizers and herbicides), roadway and commercial development.

Stream Impacts Assessment: Increased flows may aid this reach by flushing system of pollutants.

Lincoln Creek, Reach 2 (D14)

Reach Locators: Downstream limit, culvert at York Street; Upstream limit, culvert under private drive.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth 0.4 feet; Stream Gradient, 3 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and developed (lawn areas) with an overall vegetation density of less than 50 percent. The stream canopy was estimated at 10 percent cover and the estimated shade was 30 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was spotty and the water clarity was murky. A flow velocity of approximately 0.5 feet/second was observed.

Stream Evaluations: Murky water indicated potentially poor water quality and extensive residential development and roadways around stream are the likely source of pollutants. Stream aesthetics were poor due to the highly disturbed nature of the stream environment.
Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. Additional flows could cause flooding of apartments located near stream.

observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a bedrock, coarse gravel, and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow velocity of 0.25 feet/second was observed.

Stream Evaluations: Stream aesthetics were poor due to the extensive human disturbance, surrounding commercial development and presence of abundant litter. Piping which drains runoff from adjoining parking areas dumps stormwater here, suggesting that water quality may be compromised by nonpoint pollution.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Lincoln Creek, Reach 5 (D19)

Reach Locators: Downstream limit, culvert at Fred Meyer parking lot; Upstream limit, culvert at Lincoln Street; Associated with wetlands WH-8 and WH-9.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 6 feet; Low Water Width, 4 feet; Bankful Depth, 2 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 80 percent.

Riparian Vegetation: The vegetation was characterized as immature/even aged forest and developed (Fred Meyer) with an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 85 percent and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 to 20 percent. No mass wasting was noted and a small amount of debris jams were observed on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic substrate with essentially no particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was spotty and the water clarity was slightly murky. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good except that substantial litter was strewn along the northern half of the reach. Slightly murky water suggests a potential problem with water quality. Pollutant-laden runoff from impervious coverage associated with adjacent commercial development and Lincoln Street are the most likely contributors of nonpoint source pollution to the reach.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 8 feet; Low Water Width, 2 feet; Bankful Depth, 1.5 feet; Low Water Depth 0.2 feet; Stream Gradient, 4 percent; Bank Undercut, 80 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with shrub-dominated and developed areas and an overall vegetation density of 50 to 70 percent. The stream canopy was estimated at 50 percent and the estimated shade was 70 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 30 percent. Small amounts of mass wasting were noted and moderate to large debris jams were observed on the upper bank. Channel overflow was estimated as rare. Bank rock content was 40 to 65 percent and there were many flow obstructions on the lower bank. Frequent to continuous cutting of the creek banks was observed and the height of the raw banks was greater than 24 inches in some instances. The creek bottom had a silt/organic and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Stream aesthetics were compromised at the south end of the reach by the cutting of mature trees adjacent to the creek. Fallen trees in channel will form a major debris jam during high water flows. Stream aesthetics were excellent except at the reach ends where man's detrimental influence is strong. Clear water suggested that overall water quality was good although proximity of residential development to stream may be source of nonpoint source pollution.

Stream Impacts Assessment: Substantial evidence of current erosion problems in this reach indicated that increased stormwater flows are not advisable.

Lincoln Creek, Reach 9

Reach Locators: Downstream limit, culvert at Dumas Avenue; Upstream limit, end of stream; Associated with wetland WH-14.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 5 feet; Bankful Depth, 1 feet; Stream Gradient, 2 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as mature and even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 70 percent and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare to occasional. Bank rock content was less than 20 percent and there were a moderate number of flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare. This reach was dry therefore water clarity could not be evaluated and no flow was observed.

WATERSHED MASTER PLAN			Revised:	Nov–93
CITY OF BELLINGHAM, WASHINGTON			HDR Engineering, Inc.	
"Lincoln Creek – Alternative No. 4"				
Problem No. 2, and 3				
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
48–inch	50	LF	$165	$8,250
Structures				
Manholes, 84–inch (8–feet deep max.)	1	EA	$3,500	$3,500
Manholes, 84–inch (over 8–feet deep)	6	VLF	$390	$2,340
Flow Control Device	1	EA	$1,000	$1,000
Surface Restoration				
Landscaping	1,950	SY	$10	$19,500
Earthwork				
Regrade Channel (Significant Excavation)	10	CY	$12	$120
Rip Rap	10	CY	$28	$280
Subtotal:				$35,000
Mobilization: 10%				$3,500
Contingency: 20%				$7,700
Sales Tax: 7.8%				$3,600
Subtotal – Construction:				$49,800
Real Estate Acquisition				
Easement – Commercial	275,000	SF	$1.50	$412,500
Subtotal – Real Estate:				$412,500
Engineering Design and Construction:	25%			$12,500
TOTAL PROJECT COST:				$474,800

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LINCOLN CREEK STUDY AREA

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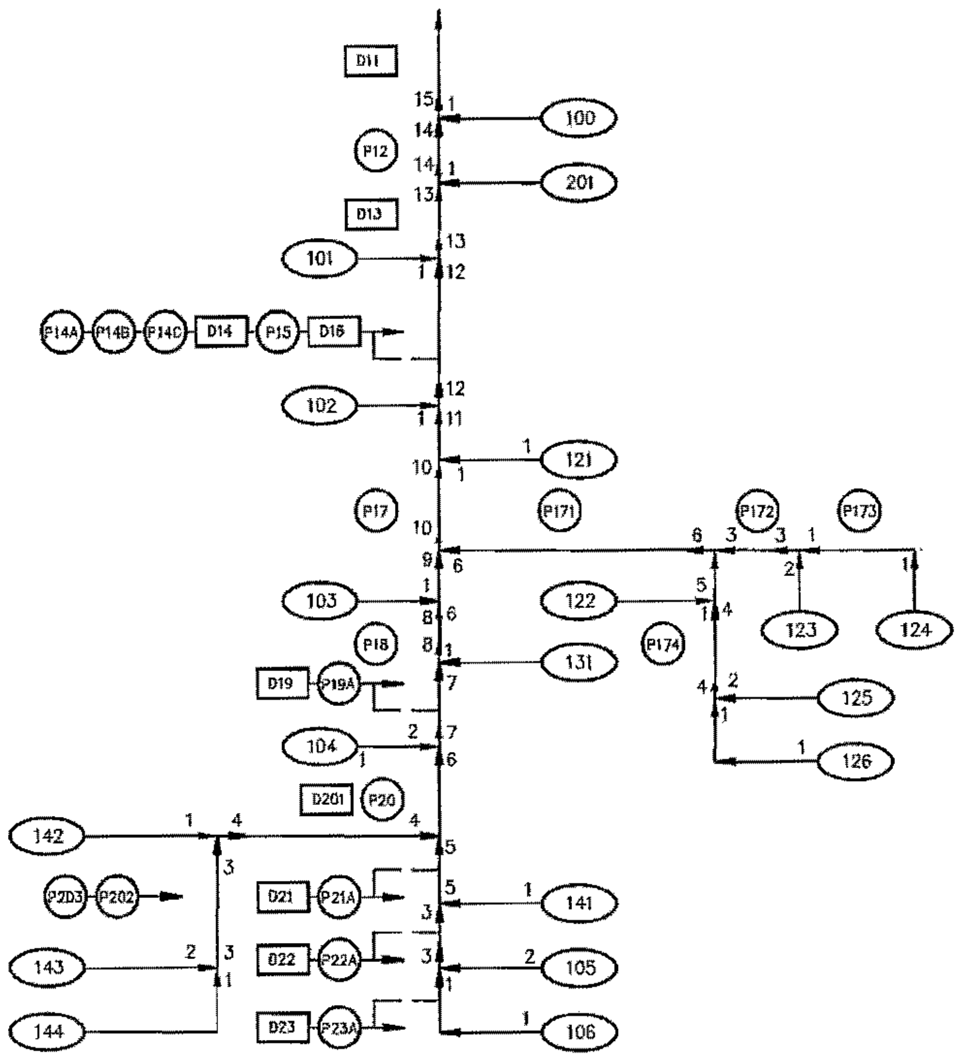

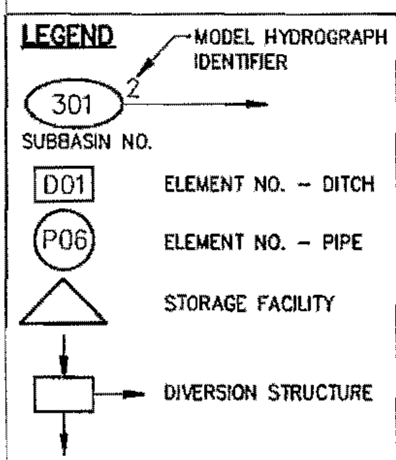

HYDROLOGIC MODEL SCHEMATIC FOR LINCOLN CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE 3.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Lincoln Creek - Existing Condition
Sep-95

Volume 2
Table 3.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D11				2.5			57.9	5.4	2.7	124.7	6.3	5.0	172.8	6.6	6.6
P12	4.27	112.3	7.9		6.5	120.0	54.7	7.9	2.1	118.0	8.3	full	161.8	11.4	full
D13				4.0			50.3	5.5	1.6	104.7	6.7	2.4	145.2	7.3	2.9
D14				2.0			46.0	5.4	1.6	93.2	6.5	2.3	128.8	7.1	2.7
P14A	4.30	136.6	9.3		3.5	70.0	46.1	8.4	1.7	94.0	10.0	2.6	128.8	10.5	3.4
P14B	4.00	55.2	4.4		6.0	115.0	46.1	4.9	2.8	94.0	7.5	full	128.8	10.3	full
P14C	4.30	136.6	9.3		6.0	110.0	46.1	8.4	1.7	94.0	10.0	2.6	128.8	10.5	3.4
P15	5.00	141.5	7.2		10.0	225.0	47.7	6.5	2.0	97.5	7.8	3.1	135.8	8.2	3.9
D16				4.0			47.4	4.5	1.0	96.9	5.7	1.5	135.8	6.3	1.9
P17	4.00	327.3	26.1		18.0	220.0	39.6	17.6	0.9	81.7	21.6	1.4	118.5	24.0	1.7
P171	3.00	51.2	7.3				18.3	6.7	1.2	38.0	7.9	1.9	51.3	7.3	full
P172	3.00	51.2	7.3				12.2	5.9	1.0	25.5	7.2	1.5	34.2	7.8	1.8
P173	2.30	46.4	11.7				8.9	9.0	0.7	19.3	11.1	1.0	26.4	12.0	1.2
P174	2.00	28.0	8.9				2.4	5.5	0.4	5.2	6.8	0.6	8.8	7.9	0.8
P175	2.00	53.8	17.1				0.7	6.0	0.2	3.2	9.4	0.3	5.8	11.2	0.4
P18	4.00	110.3	8.8				16.5	6.3	1.1	39.6	8.1	1.7	54.3	8.8	2.0
D19				2.0			12.0	1.9	0.8	28.1	2.5	1.3	40.7	2.7	1.5
P19A	3.00	51.2	7.3				13.3	6.1	1.0	30.4	7.6	1.7	42.9	8.1	2.1
P20	3.50	77.3	7.3		3.7	56.0	10.2	5.6	0.9	22.2	6.9	1.3	33.5	7.7	1.6
D201				3.0			10.2	4.2	0.8	21.7	5.2	1.4	28.9	5.6	1.7
P202	2.00	34.8	11.1				5.9	8.3	0.6	12.8	10.2	0.8	17.2	11.0	1.0
P203	1.50	21.6	12.2		2.0	9.0	5.9	10.4	0.5	12.8	12.7	0.8	17.2	13.6	1.0
D21				2.0			3.1	2.3	0.1	12.9	4.0	0.3	23.4	5.1	0.4
P21A	4.00	31.5	6.4				3.1	4.1	0.5	12.9	6.1	1.1	23.5	7.0	1.6
D22				2.0			2.7	2.2	0.1	11.3	3.8	0.3	20.5	4.8	0.4
P22A	3.00	162.0	22.9		18.0	140.0	2.7	8.6	0.3	11.4	13.2	0.5	20.6	15.7	0.7
D23				2.0			2.0	1.9	0.1	8.4	3.2	0.3	15.5	4.0	0.4
P23A	2.00	49.2	15.6		8.0	40.0	2.0	7.7	0.3	8.4	11.7	0.6	15.5	13.9	0.8

Bellingham Watershed Master Plan Flow Table
Basin Name : Lincoln Creek - Future Condition
Sep-95

Volume 2
Table 3.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D11				2.5			110.4	6.2	4.5	233.1	6.9	8.5	298.4	7.0	10.6
P12	4.27	112.3	7.9		6.5	120.0	105.2	9.0	3.3	223.6	15.8	full	287.8	20.3	full
D13				4.0			98.3	6.6	2.4	208.1	8.0	3.5	262.8	8.5	3.9
D14				2.0			94.5	6.5	2.3	198.0	7.9	3.4	247.8	8.4	3.8
P14A	4.30	136.6	9.3		3.5	70.0	94.5	10.0	2.7	198.0	13.4	full	247.8	16.8	full
P14B	4.00	55.2	4.4		6.0	115.0	94.5	7.5	full	198.0	15.8	full	247.8	19.7	full
P14C	4.30	136.6	9.3		6.0	110.0	94.5	10.0	2.7	198.0	13.4	full	247.8	16.8	full
P15	5.00	141.5	7.2		10.0	225.0	98.9	7.8	3.1	207.2	10.6	full	255.1	13.0	full
D16				4.0			98.9	5.7	1.6	207.2	7.1	2.3	255.1	7.5	2.6
P17	4.00	327.3	26.1		18.0	220.0	91.6	22.3	1.5	193.4	27.1	2.2	233.4	28.3	2.5
P171	3.00	51.2	7.3				44.1	8.2	2.2	89.0	12.6	full	114.4	16.2	full
P172	3.00	51.2	7.3				21.5	6.9	1.4	44.3	8.2	2.2	57.5	8.1	full
P173	2.30	46.4	11.7				18.1	11.0	1.0	37.8	13.0	1.5	49.3	12.4	full
P174	2.00	28.0	8.9				18.3	9.5	1.2	36.2	11.5	full	46.3	14.7	full
P175	2.00	53.8	17.1				12.9	14.1	0.7	25.2	16.9	1.0	32.0	17.9	1.1
P18	4.00	110.3	8.8				43.3	8.3	1.7	100.7	10.0	3.0	131.7	10.5	full
D19				2.0			34.7	2.6	1.4	87.8	3.4	2.3	116.5	3.6	2.6
P19A	3.00	51.2	7.3				37.4	7.9	1.9	88.1	12.5	full	116.9	16.5	full
P20	3.50	77.3	7.3		3.7	56.0	27.3	7.3	1.4	74.6	9.2	2.8	100.2	10.4	full
D201				3.0			19.9	5.1	1.3	39.1	6.0	2.2	49.6	6.3	2.6
P202	2.00	34.8	11.1				13.2	10.3	0.9	26.7	12.2	1.3	34.2	12.8	1.6
P203	1.50	21.6	12.2		2.0	9.0	13.2	12.8	0.9	26.7	15.1	full	34.2	19.4	full
D21				2.0			20.2	4.8	0.4	59.3	7.1	0.8	81.0	7.9	0.9
P21A	4.00	31.5	6.4				20.3	6.8	1.5	59.4	12.1	full	81.1	16.5	full
D22				2.0			16.9	4.5	0.4	49.6	6.7	0.7	68.0	7.5	0.8
P22A	3.00	162.0	22.9		18.0	140.0	16.9	14.8	0.7	49.6	20.2	1.1	68.2	21.9	1.4
D23				2.0			12.5	3.7	0.4	37.6	5.4	0.7	52.5	6.0	0.9
P23A	2.00	49.2	15.6		8.0	40.0	12.6	13.1	0.7	37.6	17.2	1.3	52.7	16.8	full

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Lincoln Creek – Existing
Oct–93

VOLUME 2
TABLE 3.4

CONSTITUENTS \ LAND USE	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	18862.3	7075.7	14418.0	1684.8	1574.6	43615.4
COD	129593.5	2290.4	39649.5	1560.0	0.0	173093.4
TSS	130814.8	2045.0	52065.0	936.0	32786.4	218647.2
DS	51973.1	130.9	26833.5	6240.0	15746.1	100923.6
TOTAL NITROGEN	203.6	26.1	73.4	17.1	15.7	336.0
TOTAL AMMONIA	366.4	110.4	440.6	79.7	23.7	1020.8
TOTAL PHOSPHORUS	6364.3	785.3	3698.0	243.7	110.4	11201.7
DISSOLVED PHOSPHORUS	1981.2	449.9	974.6	95.7	3.8	3505.1
COPPER	257.8	24.5	40.1	1.9	10.8	335.1
LEAD	854.9	167.7	80.1	6.2	8.6	1117.6
ZINC	366.4	290.4	40.1	12.5	8.6	717.9
LAND USE (ACRES)	135.7	40.9	133.5	62.4	431.4	803.9

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Lincoln Creek – Future
Oct–93

VOLUME 2
TABLE 3.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	26159.8	7283.3	17863.2	10435.5	79.2	61821.0
COD	179731.0	2357.6	49123.8	9662.5	0.0	240874.9
TSS	181424.8	2105.0	64506.0	5797.5	1649.2	255482.5
DS	72080.6	134.7	33245.4	38650.0	792.1	144902.8
TOTAL NITROGEN	282.3	26.9	91.0	105.9	0.8	506.9
TOTAL AMMONIA	508.1	113.7	545.8	493.9	1.2	1662.8
TOTAL PHOSPHORUS	8826.6	808.3	4581.6	1509.7	5.6	15731.7
DISSOLVED PHOSPHORUS	2747.7	463.1	1207.4	592.5	0.2	5010.9
COPPER	357.6	25.3	49.6	11.6	0.5	444.6
LEAD	1185.7	172.6	99.2	38.7	0.4	1496.6
ZINC	508.1	298.9	49.6	77.3	0.4	934.4
LAND USE (ACRES)	188.2	42.1	165.4	386.5	21.7	803.9

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Lincoln Creek
Oct-93

VOLUME 2
TABLE 3.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC	AC	CN	AC	CN	AC	CN	AC	CN
100	27.8	12.4	98	15.4	87	20.0	98	7.8	90
101	41.4	13.2	98	28.2	87	20.7	98	20.7	87
102	19.5	11.9	98	7.6	74	16.0	98	3.5	84
103	27.4	22.5	98	4.9	75	23.3	98	4.1	79
104	48.8	10.5	98	38.3	76	41.5	98	7.3	76
105	44.8	4.0	98	40.8	70	19.5	98	25.3	83
106	168.0	1.0	98	167.0	69	48.6	98	119.4	81
121	14.2	6.7	98	7.5	90	4.9	98	9.3	90
122	14.1	8.4	98	5.7	90	8.9	98	5.2	90
123	10.8	8.5	98	2.3	82	7.7	98	3.1	87
124	102.0	22.9	98	79.1	75	44.8	98	57.2	80
125	22.9	5.5	98	17.4	68	11.6	98	11.3	85
126	54.9	0.8	98	54.1	70	32.0	98	22.9	83
131	54.7	17.1	98	37.6	82	32.8	98	21.9	89
141	37.8	0.0	98	37.8	67	15.2	98	22.6	80
142	19.6	10.5	98	9.1	78	16.7	98	2.9	86
143	26.8	15.3	98	11.5	76	22.8	98	4.0	84
144	22.9	2.3	98	20.6	72	11.9	98	11.0	83
201	45.5	6.7	98	38.8	82	18.9	98	26.6	86
TOTAL	803.9	180.2		623.7		417.8		386.1	
%	100.0%	22.4%		77.6%		52.0%		48.0%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Lincoln Creek – Existing Conditions
Oct–93

VOLUME 2
TABLE 3.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN
100	27.8	12.4	98	15.4	87			2.2	90	13.2	86		
101	41.4	13.2	98	28.2	87	14.4	90	0.8	90	4.0	90	9.0	81
102	19.5	11.9	98	7.6	74			0.7	85	3.4	72	3.5	74
103	27.4	22.5	98	4.9	75			1.2	83	3.7	72		
104	48.8	10.5	98	38.3	76			0.8	90	19.5	86	18.0	64
105	44.8	4.0	98	40.8	70	5.0	85					35.6	68
106	168.0	1.0	98	167.0	69	10.0	87					157.0	68
121	14.2	6.7	98	7.5	90	1.0	90			6.5	90		
122	14.1	8.4	98	5.7	90	5.3	90	0.4	90				
123	10.8	8.5	98	2.3	82	1.9	80	0.4	90				
124	102.0	22.9	98	79.1	75	53.5	80					25.6	64
125	22.9	5.5	98	17.4	68	3.3	84	0.4	90			13.7	64
126	54.9	0.8	98	54.1	70	1.2	90					52.9	70
131	54.7	17.1	98	37.6	82	12.4	90			5.2	90	20.0	75
141	37.8	0.0	98	37.8	67							37.8	67
142	19.6	10.5	98	9.1	78			0.1	90	4.0	86	5.0	72
143	26.8	15.3	98	11.5	76			0.8	90	5.2	86	5.5	64
144	22.9	2.3	98	20.6	72	5.0	85					15.6	68
201	45.5	6.7	98	38.8	82			0.1	90	6.5	86	32.2	81
TOTAL	803.9	180.2		623.7		113.0		7.9		71.2		431.4	
%	100.0%	22.4%		77.6%		14.1%		1.0%		8.9%		53.7%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Lincoln Creek – Future Conditions
Oct–93

VOLUME 2
TABLE 3.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN	AC	CN
100	27.8	20.0	98	7.8	90	6.2	90	1.6	90				
101	41.4	20.7	98	20.7	87	7.4	90	2.4	90	4.1	86	7.0	81
102	19.5	16.0	98	3.5	84	2.3	85	0.7	83	0.5	77		
103	27.4	23.3	98	4.1	79			2.5	83	1.6	72		
104	48.8	41.5	98	7.3	76	0.9	90	0.8	88	0.9	72	4.7	72
105	44.8	19.5	98	25.3	83	20.2	83	4.2	83	0.9	79		
106	168.0	48.6	98	119.4	81	95.6	81	23.9	81				
121	14.2	4.9	98	9.3	90	7.4	90	1.9	90				
122	14.1	8.9	98	5.2	90	4.4	90			0.9	86		
123	10.8	7.7	98	3.1	87	2.5	89			0.6	83		
124	102.0	44.8	98	57.2	80	45.8	80	11.4	80				
125	22.9	11.6	98	11.3	85	10.7	85			0.6	80		
126	54.9	32.0	98	22.9	83	19.2	85			3.7	76		
131	54.7	32.8	98	21.9	89	17.5	89	2.2	90	2.2	86		
141	37.8	15.2	98	22.6	80	21.8	80			0.8	80		
142	19.6	16.7	98	2.9	86	1.7	88			1.2	83		
143	26.8	22.8	98	4.0	84	2.4	86			1.6	80		
144	22.9	11.9	98	11.0	83	6.8	84	2.0	85	2.2	78		
201	45.5	18.9	98	26.6	86	1.5	90	15.1	89			10.0	81
TOTAL	803.9	417.8		386.1		274.3		68.6		21.7		21.7	
%	100.0%	52.0%		48.0%		34.1%		8.5%		2.7%		2.7%	

3.9 LINCOLN CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 7.0 and 7.3.2 in the Watershed Master Plan.

Six wetlands (WH-2, WH-4, WH-8, WH-9, WH-11 and WH-14) in the Lincoln Creek drainage basin were field inventoried and are described below. Lincoln Creek stream reaches are described subsequently.

3.9.1 Lincoln Creek Wetland Descriptions

WH-2 (Lincoln Creek, Reach 1)

Wetland Description: This wetland had one vegetation layer characterized as having low density with young plant community maturity and low species diversity. The dominant plant species was reed canarygrass (*Phalaris arundinacea*) with a few specimens of red alder (*Alnus rubra*) and willow (Salix sp.). Persistent vegetation was noted. No surface water was observed, therefore no flow rate could be measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an approximate slope of one percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 1.6 acres in size.

Wetland Values: The habitat value was rated as minimal and the presence of substantial herbaceous vegetation merited a good water quality benefits rating. Low to moderate flow attenuation would be provided by abundant herbaceous vegetation.

Wetland Impacts: This nearly monotypic stand of reed canarygrass probably resulted from disturbance associated with the construction of adjacent athletic fields. Few impacts would degrade this relatively low value wetland.

WH-4 (Lincoln Creek, Reach 4)

Wetland Description: This wetland had three layers of vegetation characterized as low to moderately dense with intermediate plant community maturity and intermediate species diversity. The dominant plant species included black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), himalayan blackberry (*Rubus discolor*), and nightshade (*Circaea* sp.). Persistent vegetation dominated this wetland area. Since no surface water was observed, flow rate could not be measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered low due to the steep slope of riparian corridor sides. The wetlands are fed by seeps and the hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an approximate slope of 30 percent. The sinuosity of the wetland/upland boundary was low. This wetland measures approximately 1.1 acres in size.

Wetland Values: The wildlife habitat value was rated as low due to the presence of the adjacent Lincoln Street and commercial development; however, the riparian corridor does provide a limited wildlife refuge in this general area. With virtually no herbaceous vegetation and steep sloping sides, this wetland had a very low water quality benefits rating. Minimal flow attenuation would be provided by existing vegetation.

Wetland Impacts: Additional stormwater flows would not greatly harm this highly disturbed wetland.

WH-8 (Lincoln Creek, Reach 5)

Wetland Description: This wetland was dominated by one layer of vegetation which was characterized as dense with a young plant community and low species diversity. The dominant plant species included red fescue (*Festuca rubra*) and bentgrasses (*Agrostis* spp.). The associated riparian corridor has three vegetation layers dominated by willow (*Salix* sp.), red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), creeping buttercup (*Ranunculus repens*) and skunk cabbage (*Lysichitum americanum*). Non-persistent vegetation dominated the wetland area and persistent vegetation dominated the riparian corridor. Surface water flowed slowly, approximately 0.5 feet/second. Although less than one percent of the wetland basin was filled at low water, the potential for an expanded water surface was considered low due to the relatively steep side slopes. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The sinuosity of the wetland/upland boundary was low. This wetland measures approximately 18.5 acres in size.

Wetland Values: The wildlife habitat value was rated as low to moderate. The wetland area is topographically elevated with respect to the stream and does not perform significant water quality benefits. Moderate low attenuation could be provided by the long, low stream corridor; slope sides have low attenuation potential.

Wetland Impacts: Additional water would have only minor effects on this disturbed wetland.

WH-9 (Lincoln Creek, Reach 5)

Near the intersection of Lincoln and Ashley Streets, the City of Bellingham's Wetland Inventory identified two nearby but separate wetlands as WH-9. In the discussion to follow, the northern wetland is called Area A and the southern wetland is called Area B.

Wetland Description of Area A: This wetland is characterized by three layers of moderate to high density vegetation with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), creeping buttercup (*Ranunculus repens*) and reed canarygrass (*Phalaris arundinacea*). Vegetation was dominantly persistent. During the February 1992 field investigation, scattered areas of shallow inundation were observed and a flow rate of less that 0.1 feet/second was observed. Approximately 10 percent of the wetland basin was filled and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and seasonally flooded and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 1 percent. The sinuosity of the wetland/upland boundary was rated medium. This wetland measures approximately 0.7 acres in size.

Wetland Values of Area A: The wildlife habitat value was rated as moderate based on the presence of a forest vegetation community. Since only sparse herbaceous vegetation for biofiltration was observed, a low to moderate water quality benefits rating was recorded. Good flow attenuation would be provided by abundant persistent vegetation.

Wetland Impacts on Area A: The potential adverse affects of increased stormwater in this wetland appear to be low due to the currently degraded condition of the wetland.

Wetland Description of Area B: This wetland is characterized by one layer of vegetation with low to moderate density, young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*) bentgrasses (*Agrostis* spp.) and soft rush (*Juncus effusus*). Vegetation was dominantly non-persistent. During the February 1992 field investigation, scattered areas of shallow inundation were observed; however, no flowing water was observed. Approximately 2 percent of the wetland basin was filled and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was noted. Fine mineral soils formed the wetland substrate which had a slope of less than 1 percent. The sinuosity of the wetland/upland boundary was rated low. This wetland measures approximately 0.5 acres in size.

Wetland Values of Area B: The wildlife habitat value was rated as low because the vegetation is dominated by reed canarygrass. Although this herbaceous vegetation was not considered particularly good wildlife habitat, it can provide an important biofiltration function, therefore a moderate water quality benefits rating was recorded. In addition, good flow attenuation would be furnished by the abundant reed canarygrass.

Wetland Impacts for Area B: This wetland area is highly disturbed. Grade changes have altered the natural hydrology of the area and the natural vegetation has been removed and succeeded by an invasive herbaceous plant assemblage. Consequently, the potential adverse affects of increased stormwater in this wetland appear to be relatively minor.

WH-11 (Lincoln Creek, Reach 6)

Wetland Description: This area is a highly disturbed, section of paving adjacent to a channelized portion of Lincoln Creek, yet it satisfies the technical criteria for wetlands. There was one sparse layer of vegetation with young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), and American speedwell (*Veronica americana*). No surface water was observed, and no flow rate was measured. Fine mineral soils formed the wetland substrate between the cracks in the pavement. This wetland measures approximately 0.5 acres in size.

Wetland Values: The wildlife habitat value was rated as non-existent and the presence of minor herbaceous vegetation and essentially nonexistent infiltration capacity merited a poor water quality benefits rating. Flow attenuation provided by existing vegetation would be negligible.

Wetland Impacts: This wetland has essentially no value due to the surrounding highly degraded adjacent land use and extensive paving.

WH-14 (Lincoln Creek, Reach 9)

Wetland Description: Emergent vegetation dominated the north end of this wetland, shrub and emergent vegetation occurred at the south end, and a forest vegetation community was located along the riparian corridor running through the wetland. Most of the wetland vegetation had two layers characterized as moderately dense with young plant community maturity and intermediate species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), red-osier dogwood (*Cornus stolonifera*), salmonberry (*Rubus spectabilis*), soft rush (*Juncus effusus*), bentgrass (*Agrostis* sp.) and creeping buttercup (*Ranunculus repens*). Both persistent and non-persistent vegetation were noted. No flow rate was measured because surface water was not observed in the wetland. Less than one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately two percent. The sinuosity of the wetland/upland boundary was medium. This wetland measures approximately 31.8 acres in size.

Wetland Values: The wildlife habitat value was rated as moderate. The herbaceous layer could provide browsing habitat for deer. The presence of moderately dense herbaceous vegetation provides low to moderate water quality benefits. High flow attenuation would be provided by abundant herbaceous vegetation in this large basin.

Wetland Impacts: This wetland has little adjacent development; however, part of the wetland area was clearcut in the past few years. This disturbed area has potential for enhancement and stormwater detention and/or treatment.

3.9.2 Lincoln Creek Stream Reach Descriptions

Lincoln Creek, Reach 1 (D13)

Reach Locators: Downstream limit, culvert at Fraser Street; Upstream limit, culvert at York Street; Associated with wetland WH-2.

Channel Dimensions: High Flow Width, 4 feet; Bankful Width, 5 feet; Low Water Width, 1.5 feet; Bankful Depth, 2 feet; Low Water Depth 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 0 percent and the estimated shade was 30 percent.

Stream Characteristics: Above the upper bank, the landform slope was approximately 30 to 40 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was common and the water clarity was murky. A flow rate of approximately 0.2 feet/second was observed.

Stream Evaluations: Stream aesthetics were poor due to the highly disturbed nature of the stream area. Stream environment appeared to be poor fish habitat. Murky water clarity suggested poor water quality which may be due to the proximity of athletic fields (and their associated fertilizers and herbicides), roadway and commercial development.

Stream Impacts Assessment: Increased flows may aid this reach by flushing system of pollutants.

Lincoln Creek, Reach 2 (D14)

Reach Locators: Downstream limit, culvert at York Street; Upstream limit, culvert under private drive.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth 0.4 feet; Stream Gradient, 3 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and developed (lawn areas) with an overall vegetation density of less than 50 percent. The stream canopy was estimated at 10 percent cover and the estimated shade was 30 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was spotty and the water clarity was murky. A flow velocity of approximately 0.5 feet/second was observed.

Stream Evaluations: Murky water indicated potentially poor water quality and extensive residential development and roadways around stream are the likely source of pollutants. Stream aesthetics were poor due to the highly disturbed nature of the stream environment.
Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. Additional flows could cause flooding of apartments located near stream.

Lincoln Creek, Reach 3 (D14)

Reach Locators: Downstream limit, culvert under private drive; Upstream limit, culvert at Lincoln Street.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 14 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth 0.25 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall vegetation density of 50 to 70 percent. The stream canopy was estimated at 50 percent cover and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 60 percent. A small amount of mass wasting was observed and no debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a silt/organic and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was murky. A flow rate of 0.25 feet/second was observed.

Stream Evaluations: Murky water suggested poor water quality which may be due to the highly developed nature of land surrounding this reach. Stream aesthetics were poor due to residential development and yard areas encroaching upon the stream banks.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. A upper portion of this reach is a concrete channel which may exacerbate downstream erosion problems if peak flows were to increase.

Lincoln Creek, Reach 4 (D16)

Reach Locators: Downstream limit, culvert at Lincoln Street; Upstream limit, culvert at Potter Street, Associated with wetland WH-4.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 7 feet; Low Water Width, 4 feet; Bankful Depth, 1.5 feet; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even aged forest with an overall vegetation density of 50 to 70 percent. The stream canopy was estimated at 50 percent cover and the estimated shade was 60 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. Small amounts of mass wasting and moderate debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a bedrock, coarse gravel, and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow velocity of 0.25 feet/second was observed.

Stream Evaluations: Stream aesthetics were poor due to the extensive human disturbance, surrounding commercial development and presence of abundant litter. Piping which drains runoff from adjoining parking areas dumps stormwater here, suggesting that water quality may be compromised by nonpoint pollution.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Lincoln Creek, Reach 5 (D19)

Reach Locators: Downstream limit, culvert at Fred Meyer parking lot; Upstream limit, culvert at Lincoln Street; Associated with wetlands WH-8 and WH-9.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 6 feet; Low Water Width, 4 feet; Bankful Depth, 2 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 80 percent.

Riparian Vegetation: The vegetation was characterized as immature/even aged forest and developed (Fred Meyer) with an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 85 percent and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 to 20 percent. No mass wasting was noted and a small amount of debris jams were observed on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic substrate with essentially no particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was spotty and the water clarity was slightly murky. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good except that substantial litter was strewn along the northern half of the reach. Slightly murky water suggests a potential problem with water quality. Pollutant-laden runoff from impervious coverage associated with adjacent commercial development and Lincoln Street are the most likely contributors of nonpoint source pollution to the reach.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Lincoln Creek, Reach 6 (D21)

Reach Locators: Downstream limit, culvert at Lincoln Street; Upstream limit, culvert at Ashley Avenue; Associated with wetland WH-11.

Reach 6 is a portion of Lincoln Creek which has been directed into an artificial concrete channel.

Lincoln Creek, Reach 7 (D22)

Reach Locators: Downstream limit, culvert at Ashley Avenue; Upstream limit, culvert at Byron Avenue.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 8 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth 0.3 feet; Stream Gradient, 6 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. No mass wasting was observed and small amount of debris jams were noted on the upper bank. No channel overflow was noted. Bank rock content was approximately 20 to 40 percent and there were few flow obstructions on the lower bank. Some to frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a fine gravel, cobble and boulder substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent; this is a relatively undisturbed reach on Lincoln Creek. Clear water and lack of obvious sources of nonpoint pollution suggested that overall water quality was good. The south end (upstream) of the reach has abundant iron-rich bacteria in water, and a culvert at the reach break is eroding out.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Lincoln Creek, Reach 8 (D23)

Reach Locators: Downstream limit, culvert at Byron Avenue; Upstream limit, culvert at Dumas Avenue.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 8 feet; Low Water Width, 2 feet; Bankful Depth, 1.5 feet; Low Water Depth 0.2 feet; Stream Gradient, 4 percent; Bank Undercut, 80 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with shrub-dominated and developed areas and an overall vegetation density of 50 to 70 percent. The stream canopy was estimated at 50 percent and the estimated shade was 70 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 30 percent. Small amounts of mass wasting were noted and moderate to large debris jams were observed on the upper bank. Channel overflow was estimated as rare. Bank rock content was 40 to 65 percent and there were many flow obstructions on the lower bank. Frequent to continuous cutting of the creek banks was observed and the height of the raw banks was greater than 24 inches in some instances. The creek bottom had a silt/organic and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Stream aesthetics were compromised at the south end of the reach by the cutting of mature trees adjacent to the creek. Fallen trees in channel will form a major debris jam during high water flows. Stream aesthetics were excellent except at the reach ends where man's detrimental influence is strong. Clear water suggested that overall water quality was good although proximity of residential development to stream may be source of nonpoint source pollution.

Stream Impacts Assessment: Substantial evidence of current erosion problems in this reach indicated that increased stormwater flows are not advisable.

Lincoln Creek, Reach 9

Reach Locators: Downstream limit, culvert at Dumas Avenue; Upstream limit, end of stream; Associated with wetland WH-14.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 5 feet; Bankful Depth, 1 feet; Stream Gradient, 2 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as mature and even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 70 percent and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare to occasional. Bank rock content was less than 20 percent and there were a moderate number of flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare. This reach was dry therefore water clarity could not be evaluated and no flow was observed.

Stream Evaluations: Stream aesthetics were generally excellent except for some disturbed areas (pasture and orchard).

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Lincoln Creek – Alternative No. 4" Problem No. 2, and 3			Revised: HDR Engineering, Inc.	Nov–93
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
48–inch	50	LF	$165	$8,250
Structures				
Manholes, 84–inch (8–feet deep max.)	1	EA	$3,500	$3,500
Manholes, 84–inch (over 8–feet deep)	6	VLF	$390	$2,340
Flow Control Device	1	EA	$1,000	$1,000
Surface Restoration				
Landscaping	1,950	SY	$10	$19,500
Earthwork				
Regrade Channel (Significant Excavation)	10	CY	$12	$120
Rip Rap	10	CY	$28	$280
Subtotal:				$35,000
Mobilization: 10%				$3,500
Contingency: 20%				$7,700
Sales Tax: 7.8%				$3,600
Subtotal – Construction:				$49,800
Real Estate Acquisition				
Easement – Commercial	275,000	SF	$1.50	$412,500
Subtotal – Real Estate:				$412,500
Engineering Design and Construction:	25%			$12,500
TOTAL PROJECT COST:				$474,800

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Lincoln Creek – Alternative No. 11" Problem No. 7			Revised: Nov–93 HDR Engineering, Inc.	
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
30–inch	3,000	LF	$100	$300,000
Structures				
Manholes, 72–inch (8–feet deep max.)	11	EA	$2,600	$28,600
Connect to Existing	3	EA	$200	$600
Surface Restoration				
Asphalt Pavement	50	SY	$15	$750
Crushed Surfacing	15	TON	$15	$225
Earthwork				
Excavation	5,735	CY	$5	$28,675
Subtotal:				$358,900
Mobilization: 10%				$35,900
Contingency: 20%				$79,000
Sales Tax: 7.8%				$37,000
Subtotal – Construction:				$510,800
Real Estate Acquisition				
Easement – Residential	45,000	SF	$1.25	$56,250
Subtotal – Real Estate:				$56,250
Engineering Design and Construction:	25%			$127,700
TOTAL PROJECT COST:				$694,800

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Lincoln Creek – Alternative No. 12" Problem No. 8			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
21–inch	300	LF	$75	$22,500
Earthwork				
Regrade Channel (Clean–Up)	10	LF	$4	$40
Excavation	390	CY	$5	$1,950
Rip Rap	10	CY	$28	$280
Subtotal:				$24,800
Mobilization: 10%				$2,500
Contingency: 20%				$5,500
Sales Tax: 7.8%				$2,600
Subtotal – Construction:				$35,400
Engineering Design and Construction:	25%			$8,900
TOTAL PROJECT COST:				$44,300

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CEMETERY CREEK STUDY AREA

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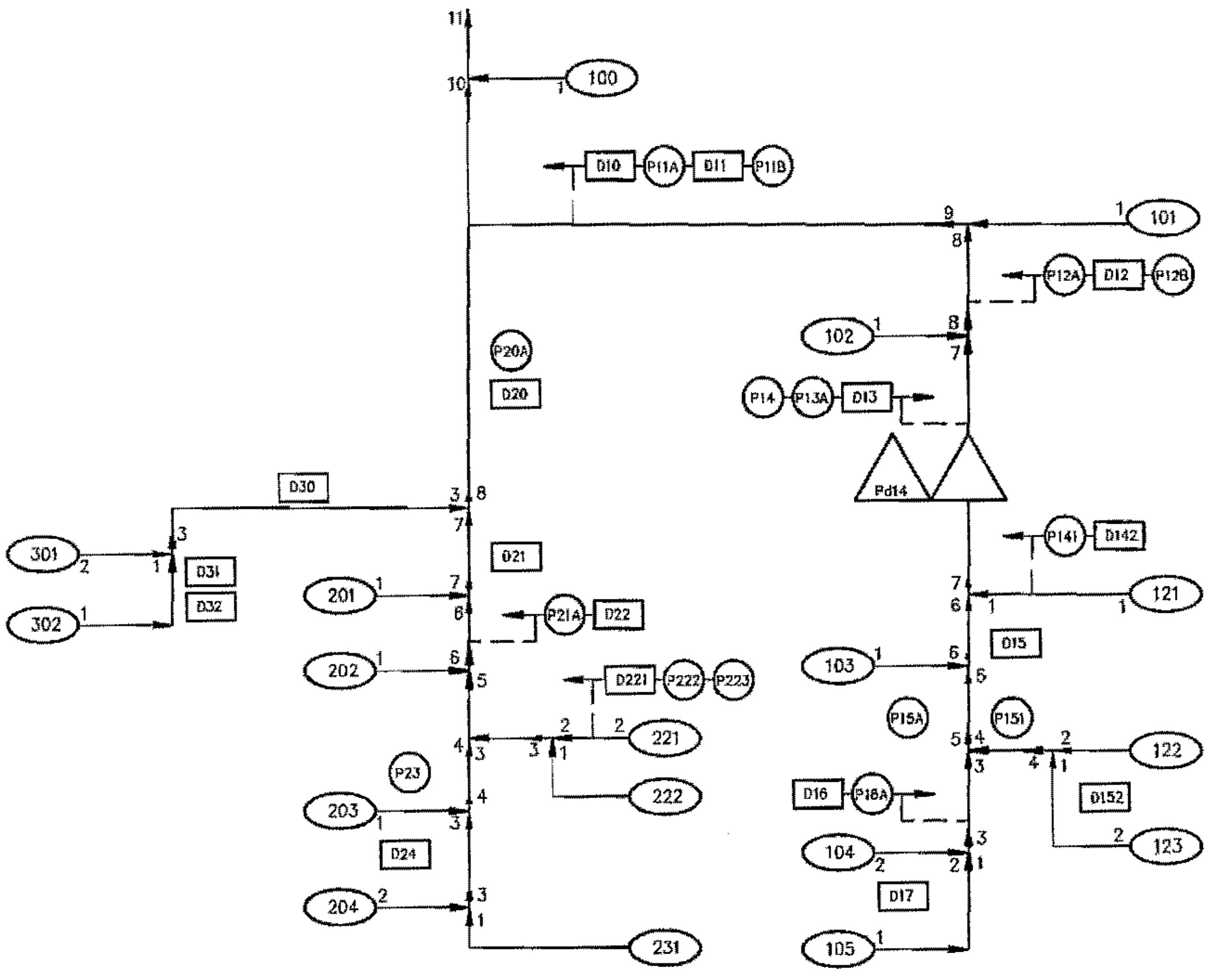

LEGEND

MODEL HYDROGRAPH IDENTIFIER

SUBBASIN NO.

D01 ELEMENT NO. - DITCH

P06 ELEMENT NO. - PIPE

STORAGE FACILITY

DIVERSION STRUCTURE

HYDROLOGIC MODEL SCHEMATIC
FOR CEMETERY CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN HDR Engineering, Inc.	VOLUME 2 FIGURE 4.1 9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Cemetery Creek - Existing Condition
Sep-95

Voume 2
Table 4.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10				2.0			12.1	3.7	0.5	45.8	5.8	1.1	78.8	6.9	1.5
D11				1.5			12.1	4.2	0.2	45.8	7.0	0.5	78.9	8.5	0.7
P11A	2.50	140.9	28.7				12.1	17.6	0.5	45.8	25.7	1.0	78.9	29.5	1.3
P11B	2.80	139.1	22.1		20.0	100.0	12.1	13.6	0.6	45.8	19.8	1.1	78.9	22.8	1.5
D12				1.0			10.9	3.7	0.2	41.6	6.2	0.5	72.5	7.6	0.8
P12A	3.00	204.9	29.0		11.0	105.0	10.9	15.4	0.5	41.6	22.7	0.9	72.5	26.5	1.2
P12B	4.30	410.2	28.9		14.0	230.0	10.9	12.5	0.5	41.6	18.6	0.9	72.5	21.8	1.2
D13				2.0			10.0	3.0	0.2	38.8	5.1	0.5	68.1	6.3	0.7
P13A	4.00	55.2	4.4		8.0	150.0	10.0	3.3	1.2	38.8	4.8	2.5	68.1	5.4	full
P14	2.50	15.8	3.2				10.0	3.4	1.4	38.8	7.9	full	68.1	13.9	full
P141	2.00	55.0	17.5				3.4	9.7	0.3	7.7	12.3	0.5	10.4	13.5	0.6
D142				2.0			3.4	2.8	0.2	7.7	3.8	0.3	10.4	4.3	0.4
D15				2.0			9.0	4.5	0.5	35.8	7.0	1.0	62.5	8.3	1.4
P15A	3.50	38.6	4.0				8.7	3.2	1.1	35.0	4.6	2.6	61.1	6.4	full
P151	1.25	12.2	9.9		20.0	200.0	4.7	9.3	0.5	18.7	15.3	full	32.2	26.2	full
D152				2.0			4.2	3.0	0.2	17.5	5.1	0.5	30.0	6.2	0.7
D16				1.0			4.1	2.7	0.2	16.3	4.3	0.5	29.2	5.3	0.7
P16A	2.00	17.4	5.5		3.0	20.0	4.1	4.5	0.7	16.3	6.3	1.5	29.2	9.3	full
D17				2.0			3.8	2.6	0.2	15.4	4.3	0.6	27.7	5.2	0.8
D20				2.0			24.6	4.4	1.0	60.2	5.6	1.5	83.0	6.1	1.7
P20A	3.00	51.2	7.3		4.0	50.0	24.6	7.2	1.5	60.2	8.5	full	83.0	11.7	full
D21				2.0			11.7	6.0	0.5	29.7	7.9	0.7	44.7	8.8	0.9
P21A	4.00	562.6	44.8				10.2	17.2	0.4	25.2	22.6	0.6	40.0	25.9	0.7
D22				2.0			10.2	4.5	0.3	25.2	6.3	0.5	40.0	7.4	0.6
D221				2.0			1.6	2.3	0.1	4.5	3.5	0.2	6.8	4.0	0.2
P222	1.50	28.0	15.8				1.7	8.7	0.3	4.8	11.8	0.4	7.1	13.2	0.5
P223	2.00	49.2	15.6				1.7	7.3	0.3	4.8	9.9	0.4	7.1	11.1	0.5
P23	2.30	64.2	15.0				7.3	10.0	0.5	16.8	12.6	0.8	29.0	14.6	1.1
D24				2.0			7.0	4.1	0.2	14.8	5.4	0.3	25.2	6.6	0.5
D30				2.0			14.3	1.8	0.5	32.7	2.4	0.9	44.5	2.7	1.0
D31				2.0			10.7	2.8	0.5	24.2	3.7	0.9	32.5	4.0	1.0
D32				1.0			11.4	5.8	0.3	26.0	7.7	0.5	34.7	8.5	0.6

Bellingham Watershed Master Plan Flow Table
Basin Name : Cemetery Creek - Future Condition
Sep-95

Voume 2
Table 4.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10				2.0			71.8	6.7	1.4	197.2	9.0	2.6	273.1	9.9	3.1
D11				1.5			71.8	8.2	0.7	197.4	11.8	1.3	273.7	13.2	1.5
P11A	2.50	140.9	28.7				71.8	28.8	1.3	197.4	40.2	full	273.7	55.8	full
P11B	2.80	139.1	22.1		20.0	100.0	71.8	22.2	1.5	197.4	31.3	full	273.8	43.4	full
D12				1.0			70.3	7.8	0.7	192.3	10.8	1.3	266.1	12.0	1.6
P12A	3.00	204.9	29.0		11.0	105.0	70.3	26.3	1.2	192.3	33.0	2.3	266.1	37.6	full
P12B	4.30	410.2	28.9		14.0	230.0	70.5	21.6	1.2	192.7	28.5	2.1	266.3	30.8	2.5
D13				2.0			68.7	6.4	0.7	188.4	9.2	1.3	260.6	10.3	1.6
P13A	4.00	55.2	4.4		8.0	150.0	68.8	5.5	full	188.5	15.0	full	260.7	20.7	full
P14	2.50	15.8	3.2				68.8	14.0	full	188.8	38.5	full	260.7	53.1	full
P141	2.00	55.0	17.5				7.0	12.0	0.5	15.2	15.0	0.7	19.9	16.1	0.8
D142				2.0			7.0	3.7	0.3	15.2	4.9	0.5	19.9	5.3	0.6
D15				2.0			66.6	8.5	1.5	183.3	11.2	2.5	253.6	12.1	3.0
P15A	3.50	38.6	4.0				66.1	6.9	full	182.6	19.0	full	252.1	26.2	full
P151	1.25	12.2	9.9		20.0	200.0	34.5	28.1	full	95.2	77.6	full	131.3	107.0	full
D152				2.0			33.4	6.4	0.8	92.6	8.9	1.1	127.9	9.8	1.7
D16				1.0			31.9	5.4	0.8	88.2	7.3	1.4	121.5	8.0	1.6
P16A	2.00	17.4	5.5		3.0	20.0	31.9	10.2	full	88.2	28.1	full	121.5	38.7	full
D17				2.0			30.5	5.4	0.8	85.1	7.5	1.5	117.4	8.3	1.8
D20				2.0			51.1	5.4	1.4	121.1	6.7	2.0	162.8	7.2	2.3
P20A	3.00	51.2	7.3		4.0	50.0	51.1	8.3	2.6	121.1	17.1	full	162.8	23.0	full
D21				2.0			35.1	8.3	0.8	89.3	10.6	1.3	118.1	11.4	1.4
P21A	4.00	562.6	44.8				32.2	24.3	0.7	82.6	32.0	1.0	110.7	34.8	1.2
D22				2.0			32.1	6.8	0.5	82.6	9.4	0.9	110.7	10.4	1.1
D221				2.0			4.2	3.4	0.2	10.6	4.8	0.3	14.3	5.3	0.3
P222	1.50	28.0	15.8				4.5	11.6	0.4	11.0	14.9	0.7	14.8	16.1	0.8
P223	2.00	49.2	15.6				4.5	9.7	0.4	11.0	12.6	0.6	14.8	13.7	0.8
P23	2.30	64.2	15.0				23.0	13.8	1.0	60.9	17.1	1.8	83.9	19.6	full
D24				2.0			15.2	5.5	0.3	46.0	8.2	0.7	66.1	9.3	0.8
D30				2.0			18.8	2.0	0.6	41.4	2.7	1.0	53.5	2.9	1.1
D31				2.0			12.7	3.0	0.6	27.4	3.8	0.9	35.5	4.2	1.1
D32				1.0			13.3	6.1	0.3	28.6	8.0	0.5	37.2	8.7	0.6

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Cemetery Creek – Existing
Oct–93

VOLUME 2
TABLE 4.4

LAND USE / CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	18820.6	0.0	27820.8	5089.5	3971.2	55702.1
COD	129307.0	0.0	76507.2	4712.5	0.0	210526.7
TSS	130525.6	0.0	100464.0	2827.5	82688.0	316505.1
DS	51858.2	0.0	51777.6	18850.0	39712.0	162197.8
TOTAL NITROGEN	203.1	0.0	141.7	51.6	39.7	436.1
TOTAL AMMONIA	365.6	0.0	850.1	240.9	59.8	1516.4
TOTAL PHOSPHORUS	6350.3	0.0	7135.5	736.3	278.5	14500.6
DISSOLVED PHOSPHORUS	1976.8	0.0	1880.5	289.0	9.6	4155.9
COPPER	257.3	0.0	77.3	5.7	27.2	367.4
LEAD	853.0	0.0	154.6	18.9	21.8	1048.2
ZINC	365.6	0.0	77.3	37.7	21.8	502.3
LAND USE (ACRES)	135.4	0.0	257.6	188.5	1088.0	1669.5

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Cemetery Creek – Future
Oct–93

VOLUME 2
TABLE 4.5

LAND USE / CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	11703.8	11798.6	17938.8	35156.7	178.5	76776.4
COD	80411.0	3819.2	49331.7	32552.5	0.0	166114.4
TSS	81168.8	3410.0	64779.0	19531.5	3716.4	172605.7
DS	32248.6	218.2	33386.1	130210.0	1784.9	197847.8
TOTAL NITROGEN	126.3	43.6	91.4	356.8	1.8	619.8
TOTAL AMMONIA	227.3	184.1	548.1	1664.1	2.7	2626.4
TOTAL PHOSPHORUS	3949.0	1309.4	4601.0	5086.0	12.5	14957.9
DISSOLVED PHOSPHORUS	1229.3	750.2	1212.5	1996.1	0.4	5188.6
COPPER	160.0	40.9	49.8	39.1	1.2	291.0
LEAD	530.5	279.6	99.7	130.2	1.0	1040.9
ZINC	227.3	484.2	49.8	260.4	1.0	1022.8
LAND USE (ACRES)	84.2	68.2	166.1	1302.1	48.9	1669.5

Bellingham Watershed Master Plan Curve Number Summary VOLUME 2
Basin Name: Cemetery Creek TABLE 4.6
Oct-93

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	133.8	3.0	98	130.8	75	87.8	98	46.0	82
101	66.7	3.7	98	63.0	74	4.7	98	62.0	76
102	35.8	9.5	98	26.3	80	12.6	98	23.2	81
103	10.0	6.0	98	4.0	82	4.6	98	5.4	82
104	23.1	1.5	98	21.6	65	10.6	98	12.5	80
105	400.9	6.3	98	394.6	66	184.4	98	216.5	78
121	41.5	8.4	98	33.1	79	16.5	98	25.0	81
122	19.8	8.1	98	11.7	69	9.1	98	10.7	79
123	469.7	0.0	98	469.7	66	216.1	98	253.6	78
201	23.4	2.3	98	21.1	82	10.8	98	12.6	82
202	38.4	5.6	98	32.8	79	17.7	98	20.7	82
203	49.7	1.5	98	48.2	65	22.9	98	26.8	77
204	127.9	0.0	98	127.9	66	34.7	98	93.2	78
221	12.5	3.8	98	8.7	78	5.8	98	6.7	82
222	15.3	1.2	98	14.1	67	7.0	98	8.3	79
231	111.2	20.5	98	90.7	74	32.5	98	78.7	78
301	30.4	12.1	98	18.3	74	16.4	98	14.1	85
302	59.4	20.8	98	38.6	85	27.3	98	32.1	85
TOTAL	1669.5	114.3		1555.2		721.4		948.1	
%	100.0%	6.8%		93.2%		43.2%		56.8%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Cemetery Creek – Existing
Oct–93

VOLUME 2
TABLE 4.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	133.8	3.0	98	130.8	75	1.5	83			5.5	81	123.8	75
101	66.7	3.7	98	63.0	74	1.2	83			13.3	90	48.5	70
102	35.8	9.5	98	26.3	80	8.5	84	8.3	87			9.5	70
103	10.0	6.0	98	4.0	82	2.2	80	1.8	85				
104	23.1	1.5	98	21.6	65	0.4	80			2.0	72	19.2	64
105	400.9	6.3	98	394.6	66	3.2	80			98.5	72	292.9	64
121	41.5	8.4	98	33.1	79	3.5	80	8.9	85			20.7	76
122	19.8	8.1	98	11.7	69	0.5	80	2.4	85			8.8	64
123	469.7	0.0	98	469.7	66					141.0	72	328.7	64
201	23.4	2.3	98	21.1	82	0.8	84	13.5	88			6.8	70
202	38.4	5.6	98	32.8	79	3.2	83	16.2	87			13.4	68
203	49.7	1.5	98	48.2	65	3.1	80					45.1	64
204	127.9	0.0	98	127.9	66					26.0	72	101.9	64
221	12.5	3.8	98	8.7	78	6.3	80			2.4	72		
222	15.3	1.2	98	14.1	67	2.1	85					12	64
231	111.2	20.5	98	90.7	74	35.2	85	8	85			47.5	64
301	30.4	12.1	98	18.3	74	6.1	85	3	85			9.2	64
302	59.4	20.8	98	38.6	85	32.5	85	6.1	85				
TOTAL	1669.5	114.3		1555.2		110.3		68.2		288.7		1088.0	
%	100.0%	6.8%		93.2%		6.6%		4.1%		17.3%		65.2%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Cemetery Creek – Future
Oct–93

VOLUME 2
TABLE 4.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	133.8	87.8	98	46.0	82	16.5	83			20.6	82	9.0	81
101	66.7	4.7	98	62.0	76	6.9	86	1.0	86	14.3	79	39.9	73
102	35.8	12.6	98	23.2	81	13.8	84			9.4	77		
103	10.0	4.6	98	5.4	82	5.4	82						
104	23.1	10.6	98	12.5	80	12.5	80						
105	400.9	184.4	98	216.5	78	173.2	80			43.3	72		
121	41.5	16.5	98	25.0	81	15.9	83	3.4	83	5.7	77.5		
122	19.8	9.1	98	10.7	79	8.6	80	1.3	80	0.9	72		
123	469.7	216.1	98	253.6	78	177.5	80			76.1	72		
201	23.4	10.8	98	12.6	82	8.8	84			3.8	76		
202	38.4	17.7	98	20.7	82	14.5	84			6.2	77		
203	49.7	22.9	98	26.8	77	16.1	80			10.7	72		
204	127.9	34.7	98	93.2	78	65.2	80			28.0	72		
221	12.5	5.8	98	6.7	82	5.4	82	1.3	82				
222	15.3	7.0	98	8.3	79	5.8	80	1.2	80	1.2	72		
231	111.2	32.5	98	78.7	78	56.3	80			22.4	72		
301	30.4	16.4	98	14.1	85	9.0	85	0.6	90	4.4	85		
302	59.4	27.3	98	32.1	85	25.7	85	6.4	85				
TOTAL	1669.5	721.4		948.1		636.8		15.2		247.0		48.9	
%	100.0%	43.2%		56.8%		38.1%		0.9%		14.8%		2.9%	

4.9 CEMETERY CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 7.0 and 7.4.2 in the Watershed Master Plan.

The Cemetery Creek drainage basin is composed of two main tributaries, East and West Cemetery Creeks. Three wetlands (WH-60, WH-61 and a previously uninventoried wetland) were field inventoried along East Cemetery Creek and are described below. Six wetlands (WH-42, WH-45, WH-48, WH-55, WH-53 and WH-54) along West Cemetery Creek were field inventoried and are also described below. The stream reaches of East and West Cemetery Creeks are described below following the wetland descriptions.

4.9.1.1 East Cemetery Creek Wetland Descriptions

WH-60 (East Cemetery Creek, Reach 10)

Wetland Description: This wetland had two layers of vegetation characterized as low to moderate density with young to intermediate plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), reed canarygrass (*Phalaris arundinacea*), and creeping buttercup (*Ranunculus repens*). Vegetation was dominantly non-persistent. No surface water was observed, consequently, no flow rate was measured. None of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally flooded and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of less than 1 percent. The sinuosity of the wetland/upland boundary was rated low to medium. This wetland measures approximately 0.2 acres in size.

Wetland Values: The wildlife habitat value was rated as low and based on the presence of thick reed canarygrass, a moderate water quality benefits rating was recorded. Good flow attenuation would be provided by abundant reed canarygrass and persistent vegetation.

Wetland Impacts: This wetland has significant human disturbance (littered with trash). Due to its degraded condition and opportunistic plant assemblage, the potential adverse affects of increased stormwater in this wetland appear to be minor.

Uninventoried Wetland (East Cemetery Creek, Reach 11)

Wetland Description: This wetland had three vegetation layers characterized as moderately dense with young plant community maturity and intermediate species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), skunk cabbage (*Lysichitum americanum*) and American speedwell (*Veronica americana*). Persistent and non-persistent vegetation was present. No surface water was observed, consequently, no flow rate was measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as seasonally flooded and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of less than 1 percent. The sinuosity of the wetland/upland boundary was rated low to medium.

Wetland Values: The wildlife habitat value was rated as medium to high based on the presence of the forest vegetation community in a sparsely developed area. A low to moderate water quality benefits rating was based on the lack of thick herbaceous vegetation. A braided system of shallow channels and persistent vegetation provide moderate flow attenuation values.

Wetland Impacts: Due to its relatively undisturbed condition, additional erosion and sedimentation would opportunistic plant assemblage, the potential adverse affects of increased stormwater in this wetland appear to be minor.

WH-61 (East Cemetery Creek, Reach 13)

Wetland Description: This wetland had three layers of vegetation characterized as dense with intermediate to old plant community maturity and low to intermediate species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), piggy-back plant (*Tolmiea menziesii*), and skunk cabbage (*Lysichitum americanum*). Both persistent and non-persistent vegetation were observed. No surface water was present at the time of the investigation, therefore flow rate could not be measured. None of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an slope of approximately 2 percent. The sinuosity of the wetland/upland boundary was medium. This wetland measures approximately 1.6 acres in size.

Wetland Values: The wildlife habitat value was rated as moderate and the presence of substantial herbaceous vegetation merited a moderate water quality benefits rating. Reasonably effective flow attenuation would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland has little adjacent land use and therefore only minor impact from human use. The addition of significant volumes of stormwater could disturb the existing vegetation and wildlife communities.

4.9.1.2 West Cemetery Creek Wetland Descriptions

WH-42 (West Cemetery Creek, Reaches 1-4; East Cemetery Creek, Reaches 1 & 2)

Wetland Description: This wetland had three layers of vegetation characterized as dense with old plant community maturity and high species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), and piggy-back plant (*Tolmiea menziesii*). Persistent vegetation dominated this wetland area. No surface water was observed, therefore no flow rate was measured. Approximately 1 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and seasonally flooded. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was high. This wetland measures 84.2 acres in size.

Wetland Values: The wildlife habitat potential was rated as high and the water quality benefits rating was high as this was a large, relatively undisturbed wetland. Moderate flow attenuation would be provided by persistent vegetation.

Wetland Impacts: This wetland has minor adjacent land use and only minor degradation from human use. Moderate increases in floodwater would have little impact.

WH-45 (West Cemetery Creek, Reach 6)

Wetland Description: Three vegetation layers were present in this wetland until recently when many of the trees were felled due to their interference with overhead utility lines. The remaining vegetation varied from low to high density with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), Douglas' spirea (*Spiraea douglasii*), and creeping buttercup (*Ranunculus repens*). Persistent and non-persistent vegetation were present. During the February 1992 field investigation, small areas of surface water were observed, however, no flow rate was observed. Approximately one percent of the wetland basin was filled and the potential for an expanded water surface was rated as low. The hydroperiod was evaluated as seasonally saturated and a non-constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The sinuosity of the wetland/upland boundary was rated low. This wetland measures approximately 0.7 acres in size.

Wetland Values: The wildlife habitat value was rated as medium to high based on the presence of two habitats, dense wetland vegetation and a connected riparian corridor. A low to moderate water quality benefits rating was based on the scattered presence of thick herbaceous vegetation. Thick persistent shrub vegetation would provide moderate flow attenuation values.

Wetland Impacts: The potential adverse affects of increased stormwater in this wetland would appear to be minor due to the relatively disturbed condition of this wetland.Wetland Description:

WH-48 (West Cemetery Creek, Reach 7)

Wetland Description: This wetland had three layers of vegetation characterized as dense with intermediate to old plant community maturity and intermediate to high species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), piggy-back plant (*Tolmiea menziesii*), and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated this wetland. No surface water was observed, consequently no flow rate was measured. Less than 1 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered medium to high. The hydroperiod was evaluated as seasonally saturated and seasonally flooded. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was high. This wetland measures approximately 12.9 acres in size.

Wetland Values: The wildlife habitat potential was rated as high and the presence of substantial herbaceous vegetation merited a high water quality benefits rating. High flow attenuation potential would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland has little adjacent land use and therefore only minor impact from human use. Increased stormwater flow may enhance this wetland because wetland hydrology was observed to be only marginally present.

WH-55 (West Cemetery Creek, Reach 8)

Wetland Description: This wetland had three layers of vegetation characterized as dense with intermediate plant community maturity and low to intermediate species diversity. The dominant plant species included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), and creeping buttercup (*Ranunculus repens*. Persistent vegetation dominated this area. Surface water was estimated to flow roughly 0.1 feet/second. Less than 5 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as permanently saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 1.0 acres in size.

Wetland Values: The wildlife habitat value was rated as moderate and the presence of substantial herbaceous vegetation merited a moderate water quality benefits rating. Flow attenuation would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland has little adjacent land use and therefore only minor degradation from human use.

WH-53 (West Cemetery Creek, Tributary 1, Reach 1)

Wetland Description: This wetland had three vegetation layers of high density with intermediate plant community maturity and intermediate species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), salmonberry (*Rubus spectabilis*), red-osier dogwood (*Cornus stolonifera*), manna grass (*Glyceria elata*) and piggy-back plant (*Tolmiea menziesii*). Persistent vegetation dominated this wetland. No surface water was observed, consequently no flow rate was measured. Approximately one percent of the wetland basin was filled at low water and the potential for an expanded water surface was rated as medium. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately one (1) acre in size.

Wetland Values: Because this wetland was dominated by dense shrubs, the wildlife habitat potential was rated as moderate and the presence of ample herbaceous vegetation merited a moderate water quality benefits rating. Moderate to high flow attenuation potential would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland has little adjacent land use; however, nearby residential development under construction will probably lead to an increase in wetland impacts. Increased stormwater flow may enhance this wetland because observed hydrologic indicators suggested marginal wetland hydrology.

WH-57 (West Cemetery Creek Tributary 2, Reach 1)

Wetland Description: This wetland had two layers of vegetation characterized as low to moderately dense with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), bentgrass (*Agrostis* sp.) and creeping buttercup (*Ranunculus repens*). Non-persistent vegetation dominated the area. Surface water flowed slowly at less than 0.1 feet/second. Less than 5 percent of the wetland basin was filled at low water and the potential for an expanded water surface was rated low to medium. The hydroperiod was evaluated as permanently saturated and seasonally flooded. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of roughly 7 percent. The complexity of the wetland/upland boundary was medium. This wetland measures approximately 0.4 acres in size.

Wetland Values: The wildlife habitat value was rated as low. Some areas of dense vegetation deserve a moderate to high water quality benefits rating. A low flow attenuation rating was given to the spotty persistent vegetation.

Wetland Impacts: Adjacent residential development has degraded this wetland. Additional stormwater runoff will increase erosion in this area.

4.9.2.1 East Cemetery Creek Stream Reach Descriptions

East Cemetery Creek, Reach 1

Reach Locators: Downstream limit, confluence of East and West Cemetery Creeks; Upstream limit, unimproved right-of-way for Fraser Street; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 6.5 feet; Bankful Width, 8 feet; Low Water Width, 2 feet; Bankful Depth, 2 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 38 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 69 percent and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. A small amount of mass wasting and debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks exceeded 24 inches. The creek bottom had a coarse gravel substrate with loose particle packing. Scouring and deposition was rated at greater than

50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent except at the lower reach end where stream has been channelized. Clear water suggests that overall water quality is good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. Substantial additions of stormwater could alter plant and wildlife community stability.

East Cemetery Creek, Reach 2 (D10)

Reach Locators: Downstream limit, unimproved right-of-way for Fraser Street; Upstream limit, culvert at Woburn Street; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 8 feet; Low Water Width, 6 feet; Bankful Depth, 1.5 feet; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 100 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with some developed areas and an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 80 percent cover and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. Moderate to large amounts of mass wasting and moderate to large number of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were many flow obstructions on the lower bank. There was continuous cutting of the creek banks and the height of the raw banks exceeded 24 inches in some instances. The creek bottom had a clay and cobble substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow velocity of less than 0.1 feet/second was observed.

Stream Evaluations: Numerous 2 to 3 inch fish were observed in a 1.5 foot deep pool below the culvert at Woburn. Stream aesthetics were poor to moderate due to the channelized character of a portion of the reach and the proximity of residential development. Clear water suggests that overall water quality is good; however the occurrence of a horse pasture adjacent to the reach may be detrimental to water quality.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 3 (D11)

Reach Locators: Downstream limit, culvert at Woburn Street; Upstream limit, culvert at Bayview Cemetery internal access road.

Channel Dimensions: High Flow Width, 14 feet; Bankful Width, 14 feet; Bankful Depth, 1 feet; Stream Gradient, 7 percent; Bank Undercut, 17 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. Small to moderate amounts of mass wasting and a small number of debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was greater than 65 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a bedrock and boulder substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare. No water was observed therefore water clarity was not evaluated and no flow was observed.

Stream Evaluations: Stream aesthetics were generally excellent. Water quality was not evaluated; however, proximity of reach to the cemetery (and lawn herbicides and fertilizers) may adversely affect water quality.

Stream Impacts Assessment: Due to the bedrock and boulder creek bottom and rocky sideslopes, increased stormwater flows would have relatively little affect on this reach.

East Cemetery Creek, Reach 4 (D12)

Reach Locators: Downstream limit, culvert at Bayview Cemetery internal access road; Upstream limit, culvert at Bayview Cemetery internal access road.

Channel Dimensions: High Flow Width, 13 feet; Bankful Width, 13 feet; Bankful Depth, 0.8 feet; Stream Gradient, 4 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 85 percent and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. No mass wasting and only small debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was greater than 65 percent and there were few flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom was bedrock with no particle packing. Scouring and deposition was rated at greater than 50 percent. The occurrence of aquatic vegetation was rare. No water was observed therefore water clarity was not evaluated and no flow was observed.

Stream Evaluations: Stream aesthetics were excellent except at reach ends where human disturbance (trash and deteriorating culverts) was evident. Fertilizers and herbicides from cemetery operations may degrade water quality in this reach.

Stream Impacts Assessment: Coarse bedrock channel could probably take considerably more runoff than assumed present flows.

East Cemetery Creek, Reach 5 (D12)

Reach Locators: Downstream limit, culvert at Bayview Cemetery internal access road; Upstream limit, culvert at Lakeway Drive.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 9 feet; Low Water Width, 3 feet; Bankful Depth, 1 foot; Low Water Depth, 0.25 feet; Stream Gradient, 3 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 80 percent and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. Small amounts of mass wasting and small number of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks exceeded 24 inches in some places. The creek bottom substrate consisted of bedrock, cobbles and silt/organic material with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of 0.25 feet/second was observed.

Stream Evaluations: Stream aesthetics were good. Clear water suggested that overall water quality is good although runoff from cemetery may carry lawn herbicides and fertilizers.

Stream Impacts Assessment: This reach is susceptible to additional erosion and undercutting with increased stormwater flows.

East Cemetery Creek, Reach 6 (D13)

Reach Locators: Downstream limit, culvert at Lakeway Drive; Upstream limit, culvert under a private drive.

Channel Dimensions: High Flow Width, 1.7 feet; Bankful Width, 2.5 feet; Low Water Width, 1.5 feet; Bankful Depth, 1 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as developed and virtually no woody vegetation adjacent to the stream. The overall vegetation density was less than 50 percent. The stream canopy was estimated at 10 percent and the estimated shade was 10 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare to occasional. Bank rock content was approximately 20 to 40 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water clarity was murky. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were poor due to the highly modified nature of this reach. Abundant brown bacterial colonies and proximity to Lakeway and moderate density development suggested that overall water quality is suspect.

Stream Impacts Assessment: This reach is susceptible to additional erosion, cutting and flooding with increased stormwater flows.

East Cemetery Creek, Reach 7 (D13)

Reach Locators: Downstream limit, culvert under private drive; Upstream limit, culvert at West Clearbrook Drive.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 6 feet; Low Water Width, 4 feet; Bankful Depth, 2 feet; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 5 percent.

Riparian Vegetation: The vegetation was characterized as developed with an overall vegetation density of 50 to 70 percent. The stream canopy was estimated at 40 percent and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 60 percent. A small amount of mass wasting and moderate amounts of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was greater than 65 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a cobble and boulder substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty and the water clarity was murky. A flow rate of less than 0.01 feet/second was observed.

Stream Evaluations: Stream aesthetics were poor due to the high degree of adjacent development. Murky water with abundant iron-rich bacteria suggested that overall water quality is suspect. Erosion problems were noted.

Stream Impacts Assessment: Increased stormwater flows may cause additional erosion which could potentially threaten some existing structures at risk.

East Cemetery Creek, Reach 8 (D15)

Reach Locators: Downstream limit, culvert at West Clearbrook Drive; Upstream limit, culvert at Likely Place.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 9 feet; Low Water Width, 4 feet; Bankful Depth, 0.8 feet; Low Water Depth 0.25 feet; Stream Gradient, 2 percent; Bank Undercut, 1 percent.

Riparian Vegetation: The vegetation was characterized as mature and immature/even aged forest with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent and the estimated shade was 87 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. A small amount of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as occasional to common. Bank rock content was less than 20 percent and there were few to moderate flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a sand, fine gravel and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream reach is part of a stormwater management system and is closely bounded by roads on both sides. Consequently, stream aesthetics were poor. Clear water suggested that overall water quality is good, however proximity of development and road may be sources of nonpoint source pollution.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 9 (D15)

Reach Locators: Downstream limit, culvert at Likely Place; Upstream limit, culvert at the unimproved right-of-way for Alvarado Drive.

Channel Dimensions: High Flow Width, 7 feet; Bankful Width, 9 feet; Low Water Width, 4 feet; Bankful Depth, 1.3 feet; Low Water Depth 0.4 feet; Stream Gradient, 3 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 88 percent cover and the estimated shade was 92 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. Moderate amounts of mass wasting and small amounts of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of 0.2 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were poor to moderate due to human disturbance, trash, and nearby development. Clear water suggested that overall water quality is good, however nearby residential development may be source of nonpoint source pollution.

Stream Impacts Assessment: Increased stormwater flows may accelerate mass wasting and threaten nearby homes.

East Cemetery Creek, Reach 10 (D16)

Reach Locators: Downstream limit, culvert at the unimproved right-of-way for Alvarado Drive; Upstream limit, abrupt decrease in stream gradient; Associated with wetland WH-60.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 13 feet; Low Water Width, 6 feet; Bankful Depth, 1.8 feet; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 38 percent.

Riparian Vegetation: The vegetation was characterized as mature forest, immature/even aged forest, and developed. Overall vegetation density was 70 to 90 percent. The stream canopy was estimated at 76 percent and the estimated shade was 83 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. Small to moderate amounts of mass wasting and small amounts of debris jams were noted on the upper bank. Channel overflow was estimated as occasional to common. Bank rock content was 20 to 40 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel, cobble and boulder substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was spotty and the water clarity was clear. A flow rate of 0.2 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were moderate due to some human disturbance and adjacent development. Although nearby residential development could potentially cause adverse effects, clear water suggests that overall water quality is good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 11 (D16)

Reach Locators: Downstream limit, abrupt decrease in stream gradient; Upstream limit, abrupt increase in stream gradient; Associated with an uninventoried wetland.

Channel Dimensions: High Flow Width, 4 feet; Bankful Width, 4.5 feet; Low Water Width, 2 feet; Bankful Depth, 0.75 feet; Low Water Depth 0.2 feet; Stream Gradient, < 1 percent; Bank Undercut, 25 percent.

Riparian Vegetation: The vegetation was characterized as immature/even aged forest and shrub-dominated with an overall density of greater than 70 to 90 percent. The stream canopy was estimated at 80 percent and the estimated shade was 60 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and sand substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Stream aesthetics were good and little evidence of human disturbance was noted. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 12 (D16)

Reach Locators: Downstream limit, abrupt increase in stream gradient; Upstream limit, culvert at an unimproved road/powerline easement.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 6 feet; Low Water Width, 1 feet; Bankful Depth, 0.75 feet; Low Water Depth 0.25 feet; Stream Gradient, 4 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as mature and immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 70 percent and the estimated shade was 72 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 30 percent. No mass wasting was noted but moderate to large debris jams were observed on the upper bank. Channel overflow was estimated as occasional. Bank rock content was 20 to 40 percent and there were many flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was spotty and the water clarity was clear. A flow rate of 0.2 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were good except for logged areas adjacent to the reach. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 13 (D17)

Reach Locators: Downstream limit, culvert at an unimproved road/powerline easement; Upstream limit, abrupt increase in stream gradient; Associated with wetland WH-61.

Channel Dimensions: High Flow Width, 9 feet; Bankful Width, 11 feet; Low Water Width, 1.5 feet; Bankful Depth, 1.4 feet; Low Water Depth 0.1 feet; Stream Gradient, 2 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 92 percent and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small amount of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a cobble substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of 0.2 feet/second was observed.

Stream Evaluations: Stream aesthetics were excellent. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 14

Reach Locators: Downstream limit, abrupt increase in stream gradient; Upstream limit, decrease in stream gradient.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 3 feet; Bankful Depth, 1 foot; Low Water Depth 0.2 feet; Stream Gradient, 4 percent; Bank Undercut, 32 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 68 percent and the estimated shade was 79 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. A small amount of mass wasting and moderate amount of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was 40 to 65 percent and there were a moderate number of flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a fine and coarse gravel, cobble, and bolder substrate with moderate to loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of 0.4 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Due to the relatively undisturbed condition of the reach, aesthetics were excellent. Clear water suggested that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

East Cemetery Creek, Reach 15

Reach Locators: Downstream limit, decrease in stream gradient; Upstream limit, end of stream.

Channel Dimensions: High Flow Width, 4.5 feet; Bankful Width, 5.5 feet; Low Water Width, 2.5 feet; Bankful Depth, 1 foot; Low Water Depth 0.25 feet; Stream Gradient, 2 percent; Bank Undercut, 25 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent and the estimated shade was 92 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. A small amount of mass wasting and debris jams were noted on the upper bank. Channel overflow was estimated as rare to occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a sand and fine gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow rate of less than 0.1 feet/second was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were noted. Stream aesthetics were excellent. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

4.9.2.2 West Cemetery Creek Stream Reach Descriptions

The principal channel of West Cemetery Creek was inventoried; however, the lower reaches (1, 2, and 3) of this watercourse flow across a broad, flat, forested wetland, and higher water flows probably flood wetland areas and utilize uninventoried secondary channels. Consequently, the observed channel dimensions on the lower stream reaches are not likely to reflect the highest total flow rate for the West Cemetery Creek watershed. Two relatively short tributaries to West Cemetery Creek were observed in its headwaters and are described as Tributaries 1 and 2 at the end of the stream reach descriptions for West Cemetery Creek.

West Cemetery Creek, Reach 1

Reach Locators: Downstream limit, confluence of West and East Cemetery Creeks; Upstream limit, culvert at the unimproved right-of-way for Fraser Street; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 5.5 feet; Bankful Width, 7 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth 0.5 feet; Stream Gradient, <1 percent; Bank Undercut, 34 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 98 percent cover and the estimated shade was 82 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare to occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a sand and gravel substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent except at the reach ends where man's detrimental influence is obvious. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

West Cemetery Creek, Reach 2 (D20)

Reach Locators: Downstream limit, culvert at unimproved right-of-way for Fraser Street; Upstream limit, abrupt increase in stream gradient; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 2.5 feet; Bankful Width, 3 feet; Low Water Width, 1.5 feet; Bankful Depth, 1 foot; Low Water Depth 0.4 feet; Stream Gradient, 1.5 percent; Bank Undercut, <1 percent.

Riparian Vegetation: The vegetation was characterized as mature and immature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 72 percent cover and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom was variable with silt/organic material, sand, and gravel substrate occurring interspersed with one another. The stream bottom substrate had loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was spotty and the water clarity was clear. A flow velocity of approximately 0.2 feet/second was observed.

Stream Evaluations: Some loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent except at the downstream reach end where unauthorized dumping has occurred. Clear water suggests that overall water quality was good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

West Cemetery Creek, Reach 3 (D21)

Reach Locators: Downstream limit, abrupt increase in stream gradient; Upstream limit, decrease in stream gradient; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 13 feet; Low Water Width, 3 feet; Bankful Depth, 0.6 feet; Low Water Depth 0.25 feet; Stream Gradient, 7.5 percent; Bank Undercut, 35 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent cover and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent due to the very low level of human impacts on this reach. Clear water suggests that overall water quality is good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

West Cemetery Creek, Reach 4 (D21)

Reach Locators: Downstream limit, decrease in stream gradient; Upstream limit, culvert at Lakeway Drive; Associated with wetland WH-42.

Channel Dimensions: High Flow Width, 16 feet; Bankful Width, 24 feet; Low Water Width, 2 feet; Bankful Depth, 1.7 feet; Low Water Depth 0.2 feet; Stream Gradient, 4 percent; Bank Undercut, 13 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 68 percent cover and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. A small amount of mass wasting and a moderate amount of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was approximately 20 to 40 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at as 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Loose gravels, which may be suitable salmon spawning habitat, were observed. Stream aesthetics were excellent. Clear water suggests that overall water quality is good.

Stream Impacts Assessment: This reach currently handles relatively high flow rates, and although evidence of bank erosion is present in some areas, the general condition of the reach suggests capacity for additional runoff flows.

West Cemetery Creek, Reach 5 (D22)

Reach Locators: Downstream limit, culvert at Lakeway Drive; Upstream limit, culvert at Old Lakeway Drive.

Channel Dimensions: High Flow Width, 7 feet; Bankful Width, 7 feet; Low Water Width, 3.5 feet; Bankful Depth, 2 feet; Low Water Depth 0.5 feet; Stream Gradient, 7 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as mature forest having an overall density of 70 to 90 percent. Some residential development occurs near the stream. The stream canopy was estimated at 40 percent cover and the estimated shade was 60 percent.

Stream Characteristics: Above the upper bank, the landform slope was steep, roughly 40 to 60 percent. Small amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content ranged from 40 to 64 percent and there were no flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw bank exceeded 2 feet in some areas. The creek bottom had a cobble and boulder substrate with loose packing. Scouring and deposition were rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. No flow was observed.

Stream Evaluations: Stream aesthetics were compromised by the proximity of residential development which has strongly modified the stream bank environment. Clear water suggests that overall water quality is good despite proximity of development.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. The capacity for additional stormwater flows was considered low due to the presence of bank cutting which was severe enough to potentially threaten nearby residences if it continues unabated.

West Cemetery Creek, Reach 6 (D24)

Reach Locators: Downstream limit, culvert at Old Lakeway Drive; Upstream limit, abrupt decrease in stream gradient; Associated with wetland WH-45.

Channel Dimensions: High Flow Width, 4 feet; Bankful Width, 7 feet; Low Water Width, 4 feet; Bankful Depth, 1.5 feet; Low Water Depth 0.3 feet; Stream Gradient, 7 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an The overall vegetation density was 70 to 90 percent, the stream canopy was estimated at 60 percent cover and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. Moderate to large amounts of mass wasting and moderate debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was estimated at 20 to 40 percent and there were a moderate number of flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a cobble and boulder substrate with loose packing. Scouring and deposition occurred over roughly 30 to 50 percent of the reach. The occurrence of aquatic vegetation was rare and the water clarity was clear. Flow velocity was less than 0.1 feet/second.

Stream Evaluations: Stream aesthetics were low due to significant human disturbance and abundant trash. Slope stabilization and augmentation of existing vegetation would enhance reach. Clear water suggests that overall water quality is good.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. Additional erosion could jeopardize nearby residential development.

West Cemetery Creek, Reach 7 (D24)

Reach Locators: Downstream limit, abrupt decrease in stream gradient; Upstream limit, confluence of West Cemetery Creek and West Cemetery Creek-Tributaries 1 and 2; Associated with wetland WH-48.

Channel Dimensions: High Flow Width, 4 feet; Bankful Width, 4 feet; Low Water Width, 4 feet; Bankful Depth, 1.5 feet; Low Water Depth, 0.4 feet; Stream Gradient, 2 percent; Bank Undercut, 60 percent.

Riparian Vegetation: The vegetation was characterized as mature and even aged forest with an overall density of greater than 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt and organic material substrate with essentially no particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. Flow velocity was estimated as less than 0.1 feet/second.

Stream Evaluations: The silty stream substrate is not suitable salmon spawning habitat. Stream aesthetics were good except for a few areas of human disturbance. Clear water suggests that overall water quality is good; however, nearby horse pasture maybe nonpoint pollution source.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Tributary 2 of West Cemetery Creek is also a small, intermittent watercourse and consequently, no low water channel dimensions were collected.

West Cemetery Creek, Reach 8

Reach Locators: Downstream limit, confluence of West Cemetery Creek and West Cemetery Creek-Tributaries 1 and 2; Upstream limit, culvert at San Juan Boulevard; Associated with wetland WH-55.

Channel Dimensions: High Flow Width, 2.5 feet; Bankful Width, 3 feet; Bankful Depth, 0.5 feet; Stream Gradient, 3 percent; Bank Undercut, 5 percent.

Riparian Vegetation: The vegetation was characterized as developed with an overall density of less than 50 percent. The stream canopy was estimated at 40 percent cover and the estimated shade was 30 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare. No flow was observed.

Stream Evaluations: Stream runs through landscaped yard areas of several residences, consequently, the natural vegetation has been removed and stream aesthetics were rated as low. Although no water was observed in this intermittent watercourse, water quality was evaluated as potentially low due to the likelihood of fertilizers, herbicides, pesticides and other types of residential pollutants possibly entering the surface waters in this reach.

Stream Impacts Assessment: This reach is susceptible to additional erosion, cutting and potential residential flooding with increased stormwater flows.

West Cemetery Creek, Reach 9

Reach Locators: Downstream limit, culvert at San Juan Boulevard; Upstream limit, end of stream.

Channel Dimensions: High Flow Width, 2 feet; Bankful Width, 3 feet; Bankful Depth, 0.7 feet; Stream Gradient, 4 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare. Water clarity was not evaluated because the creekbed was dry.

Stream Evaluations: Stream aesthetics were excellent. Substantial nearby development may impact water quality.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

West Cemetery Creek, Tributary 1 Reach Description

Tributary 1 of West Cemetery Creek is a small, intermittent, headwater watercourse. No flow was observed during the investigation, therefore, low water channel dimensions were not collected.

Reach 1

Reach Locators: Downstream limit, confluence of West Cemetery Creek and West Cemetery Creek-Tributaries 1 and 2; Upstream limit, end of tributary; Associated with WH-53.

Channel Dimensions: High Flow Width, 1.5 feet; Bankful Width, 2 feet; Bankful Depth, 0.7 feet; Stream Gradient, 3 percent; Bank Undercut, 2 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated with an overall density of greater than 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 100 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare. No ponded or flowing water was observed.

Stream Evaluations: Stream aesthetics were excellent, although nearby residential development could have detrimental effects. No water quality evaluation was made due to lack of observable water.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

West Cemetery Creek, Tributary 2 Reach Description

Reach 1

Reach Locators: Downstream limit, confluence of West Cemetery Creek and West Cemetery Creek-Tributaries 1 and 2; Upstream limit, end of tributary; Associated with wetland WH-57.

Channel Dimensions: High Flow Width, 4 feet; Bankful Width, 4 feet; Low Water Width, 1.5 feet; Bankful Depth, 1 foot; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, <1 percent.

Riparian Vegetation: The vegetation was characterized as mature forest, immature forest areas and developed areas with an overall vegetation density of less than 50 percent. The stream canopy was estimated at 38 percent and the estimated shade was 22 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. A small amount of mass wasting and no debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water clarity was clear. A flow of 0.25 feet/second was observed.

Stream Evaluations: Stream aesthetics were low due to high degree of human impact on the reach. The proximity to Yew Street, presence of unvegetated areas of disturbed soil, existing development and the presence of horse and donkey pasture near the stream suggests that overall water quality could be low.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Cemetery Creek – Alternative No. 4" Problem No. 1, 2, and 3			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
36–inch	140	LF	$120	$16,800
Structures				
Manholes, 72–inch (8–feet deep max.)	1	EA	$2,600	$2,600
Manholes, 72–inch (over 8–feet deep)	12	VLF	$330	$3,960
Flow Control Device	1	EA	$1,000	$1,000
Surface Restoration				
Landscaping	7,560	SY	$10	$75,600
Earthwork				
Regrade Channel (Significant Excavation)	20	CY	$12	$240
Bioengineered Slope	740	SF	$14	$10,360
Embankment	*	CY	$5	*
Rip Rap	50	CY	$28	$1,400
Miscellaneous				
Bank Stabilization	2,220	SY	$10	$22,200
Subtotal:				$134,200
Mobilization: 10%				$13,400
Contingency: 20%				$29,500
Sales Tax: 7.8%				$13,800
Subtotal – Construction:				$190,900
Real Estate Acquisition				
Easement – Residential	352,000	SF	$1.25	$440,000
Subtotal – Real Estate:				$440,000
Engineering Design and Construction:	25%			$47,700
TOTAL PROJECT COST:				$678,600

* Embankment to be constructed in conjunction with proposed roadway.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Cemetery Creek – Alternative No. 8" Problem No. 4			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
60–inch	**650**	**LF**	**$300**	**$195,000**
Structures				
Manholes, 96–inch (8–feet deep max.)	**1**	**EA**	**$4,625**	**$4,625**
Earthwork				
Excavation	**2,300**	**CY**	**$5**	**$11,500**
Rip Rap	**10**	**CY**	**$28**	**$280**
Subtotal:				**$211,400**
Mobilization: 10%				**$21,100**
Contingency: 20%				**$46,500**
Sales Tax: 7.8%				**$21,800**
Subtotal – Construction:				**$300,800**
Real Estate Acquisition				
Easement – Residential	**3,750**	**SF**	**$1.25**	**$4,688**
Subtotal – Real Estate:				**$4,700**
Engineering Design and Construction:	**25%**			**$75,200**
TOTAL PROJECT COST:				**$380,700**

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Cemetery Creek -- Alternative No. 2" Problem No. 5				Revised: Nov-93 HDR Engineering, Inc.
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Earthwork				
Bioengineered Slope	630	SF	$14	$8,820
Subtotal:				$8,800
Mobilization: 10%				$900
Contingency: 20%				$1,900
Sales Tax: 7.8%				$900
Subtotal -- Construction:				$12,500
Engineering Design and Construction: 25%				$3,125
TOTAL PROJECT COST:				$15,625

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HANNAH CREEK STUDY AREA

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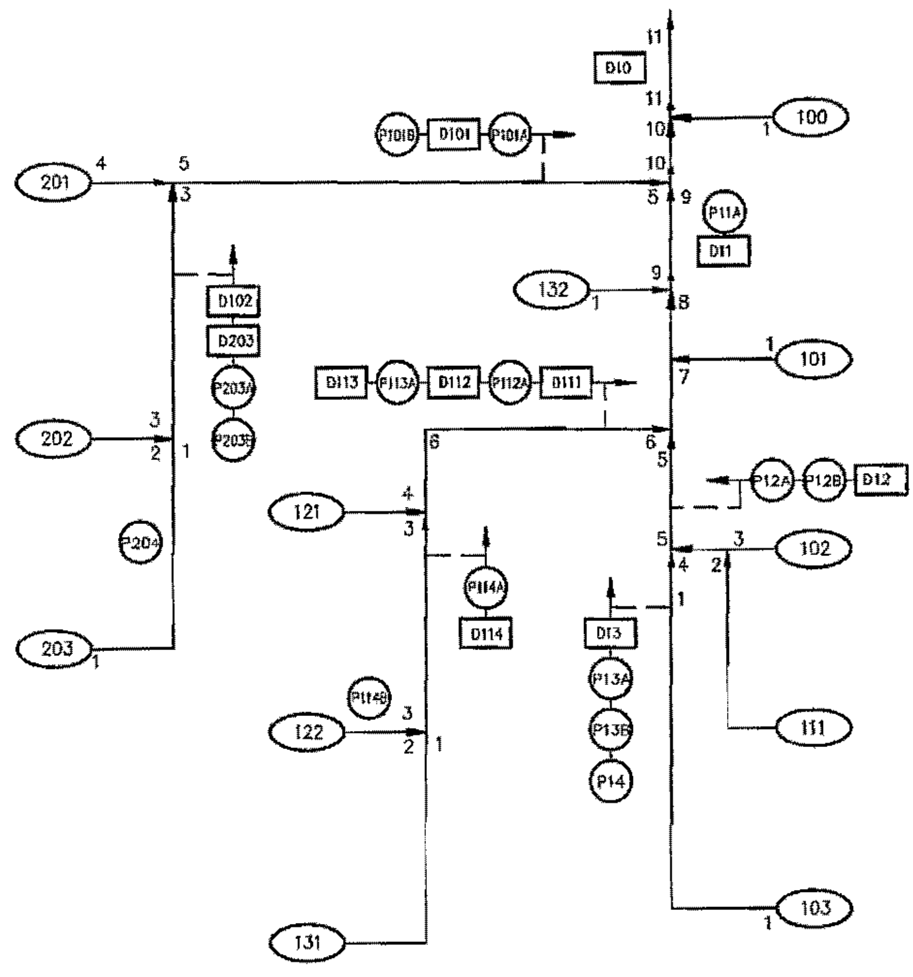

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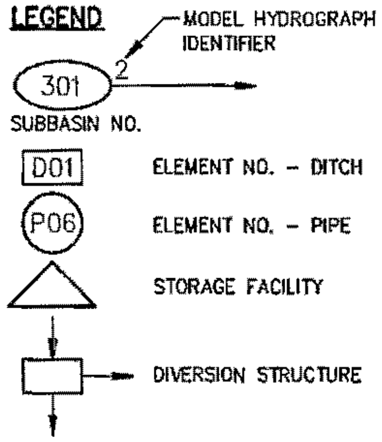

HYDROLOGIC MODEL SCHEMATIC FOR HANNAH CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE 5.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Hannah Creek - Existing Condition
Sep-95

Volume 2
Table 5.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10							14.2	4.2	0.5	42.0	6.0	1.0	61.9	6.8	1.3
D101							5.7	6.6	0.1	16.5	9.8	0.3	24.2	11.3	0.3
D102							0.8	0.9	0.1	3.5	1.5	0.2	6.9	2.0	0.3
P101A	3.00	51.2	7.3				5.7	4.8	0.7	16.5	6.5	1.2	24.2	7.2	1.5
P101B	2.00	77.7	24.7				5.7	14.4	0.4	16.5	19.7	0.6	24.3	21.9	0.8
D11							8.7	3.7	0.4	25.2	5.0	0.8	36.4	5.6	1.0
P11A	3.00	51.2	7.3		10.0	85.0	8.7	5.4	0.8	25.2	7.2	1.5	36.4	7.9	1.9
D111							1.7	2.0	0.2	7.3	3.2	0.4	11.8	3.7	0.6
D112							1.7	2.1	0.1	7.3	3.7	0.3	11.8	4.3	0.4
D113							1.7	1.9	0.2	7.3	3.2	0.5	11.8	3.7	0.7
D114				3.0			1.5	1.9	0.2	6.5	3.3	0.4	10.6	3.9	0.5
P112A	3.00	51.2	7.3		5.0	55.0	1.7	3.4	0.4	7.3	5.1	0.8	11.8	5.9	1.0
P113A	5.50	257.9	10.9		6.5	230.0	1.7	3.1	0.3	7.3	4.8	0.6	11.8	5.5	0.8
P114A	3.50	77.3	8.0		8.0	110.0	1.5	3.1	0.3	6.5	4.9	0.7	10.6	5.6	0.9
P114B	1.50	30.2	17.1		1.5	5.5	0.4	6.0	0.1	1.8	9.3	0.3	3.1	11.0	0.3
D12				2.0			5.1	1.9	0.5	15.2	2.7	0.9	21.9	2.9	1.0
P12A	1.50	8.1	4.6				5.1	4.8	0.9	15.2	8.6	full	21.9	12.4	full
P12B	2.80	44.0	7.0				5.1	4.7	0.7	15.2	6.3	1.2	21.9	7.0	1.4
D13				2.0			2.1	1.2	0.3	5.8	1.7	0.6	8.3	1.9	0.7
P13A	2.00	17.4	5.5				2.4	3.9	0.5	6.2	5.1	0.8	8.8	5.6	1.0
P13B	2.00	17.4	5.5				2.4	3.9	0.5	6.2	5.1	0.8	8.8	5.6	1.0
P14	2.00	24.6	7.8				2.4	5.0	0.4	6.2	6.5	0.7	8.8	5.6	0.8
D203				1.5			0.8	1.7	0.2	3.5	2.9	0.4	7.0	3.6	0.5
P203A	2.00	19.4	5.7		2.0	12.0	0.8	2.8	0.3	3.5	4.3	0.6	7.0	5.2	0.9
P203B	2.00	49.2	15.6		2.0	12.0	0.8	5.9	0.2	3.5	9.1	0.4	7.0	11.1	0.5
P204	2.00	42.6	13.6		15.0	40.0	0.6	4.8	0.2	2.6	7.5	0.3	5.2	9.2	0.5

Bellingham Watershed Master Plan Flow Table
Basin Name : Hannah Creek - Future Condition
Sep-95

Volume 2
Table 5.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10							36.8	5.8	0.9	91.4	7.7	1.6	119.0	8.3	1.8
D101							17.3	10.0	0.3	39.5	13.5	0.5	52.7	15.0	0.5
D102							8.4	2.1	0.4	20.5	3.0	0.7	27.9	3.3	0.8
P101A	3.00	51.2	7.3				17.3	6.5	1.2	39.5	8.0	2.0	52.7	7.5	full
P101B	2.00	77.7	24.7				17.3	19.9	0.6	39.5	24.8	1.0	52.7	26.6	1.2
D11							20.8	4.8	0.7	51.6	6.2	1.1	66.4	6.6	1.3
P11A	3.00	51.2	7.3		10.0	85.0	20.8	6.9	1.3	51.6	7.3	full	66.4	9.4	full
D111							9.1	3.4	0.5	31.6	4.9	1.0	46.2	5.4	1.2
D112							9.1	4.0	0.4	31.7	6.1	0.8	46.3	7.0	1.0
D113							9.1	3.4	0.6	31.7	4.9	1.1	46.3	5.4	1.4
D114				3.0			8.4	3.6	0.5	30.0	5.5	1.1	44.0	6.2	1.4
P112A	3.00	51.2	7.3		5.0	55.0	9.1	5.5	0.9	31.7	7.6	1.7	46.3	8.2	2.2
P113A	5.50	257.9	10.9		6.5	230.0	9.1	5.1	0.7	31.7	7.4	1.3	46.3	8.2	1.6
P114A	3.50	77.3	8.0		8.0	110.0	8.4	5.3	0.8	30.0	7.5	1.5	44.0	8.3	1.9
P114B	1.50	30.2	17.1		1.5	5.5	2.8	10.7	0.3	10.0	15.3	0.6	14.6	17.0	0.7
D12				2.0			12.4	2.5	0.8	26.1	3.1	1.1	33.9	3.3	1.3
P12A	1.50	8.1	4.6				12.4	7.0	full	26.1	14.8	full	33.9	19.2	full
P12B	2.80	44.0	7.0				12.4	6.0	1.0	26.1	7.3	1.6	33.9	7.7	1.9
D13				2.0			4.1	1.5	0.5	9.1	1.9	0.8	12.0	2.1	0.9
P13A	2.00	17.4	5.5				4.6	4.7	0.7	9.8	5.7	1.1	12.8	6.1	1.3
P13B	2.00	17.4	5.5				4.6	4.7	0.7	9.8	5.7	1.1	12.8	6.1	1.3
P14	2.00	24.6	7.8				4.6	6.0	0.6	9.8	7.4	0.9	12.8	7.9	1.0
D203				1.5			8.5	3.9	0.6	20.8	5.1	1.0	28.3	5.5	1.2
P203A	2.00	19.4	5.7		2.0	12.0	8.7	5.5	1.0	21.0	6.1	full	28.5	8.4	full
P203B	2.00	49.2	15.6		2.0	12.0	8.7	11.8	0.6	21.0	15.0	0.9	28.5	16.2	1.1
P204	2.00	42.6	13.6		15.0	40.0	7.0	10.0		17.1	12.8	0.9	23.2	13.9	1.1

Bellingham Watershed Master Plan Curve Number Summary — VOLUME 2
Basin Name: Hannah Creek — TABLE 5.6
Oct–93

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	28.9	1.5	98	27.4	64	5.5	98	23.4	69
101	13.0	2.0	98	11.0	79	6.0	98	7.0	80
102	17.8	3.6	98	14.2	78	9.3	98	8.5	80
103	20.5	6.1	98	14.4	74	10.7	98	9.8	80
111	30.0	8.2	98	21.8	74	14.4	98	15.6	78
121	12.6	2.5	98	10.1	76	5.3	98	7.3	80
122	53.3	0.0	98	53.3	64	13.4	98	40.1	77
131	141.0	2.0	98	139.0	64	35.3	98	105.7	77
132	22.9	4.8	98	18.1	81	10.5	98	12.4	85
201	58.3	12.1	98	46.2	80	26.8	98	31.5	84
202	18.2	0.5	98	17.7	69	7.2	98	11.0	78
203	63.8	0.5	98	63.3	66	22.7	98	41.1	79
TOTAL	480.3	43.8		436.5		167.1		313.4	
%	100.0%	9.1%		90.9%		34.8%		65.3%	

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Hannah Creek – Existing
Oct–93

VOLUME 2
TABLE 5.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	736.7	0.0	3013.2	2967.3	1230.8	7948.0
COD	5061.5	0.0	8286.3	2747.5	0.0	16095.3
TSS	5109.2	0.0	10881.0	1648.5	25627.2	43265.9
DS	2029.9	0.0	5607.9	10990.0	12307.8	30935.6
TOTAL NITROGEN	8.0	0.0	15.3	30.1	12.3	65.7
TOTAL AMMONIA	14.3	0.0	92.1	140.5	18.5	265.4
TOTAL PHOSPHORUS	248.6	0.0	772.8	429.3	86.3	1537.0
DISSOLVED PHOSPHORUS	77.4	0.0	203.7	168.5	3.0	452.5
COPPER	10.1	0.0	8.4	3.3	8.4	30.2
LEAD	33.4	0.0	16.7	11.0	6.7	67.9
ZINC	14.3	0.0	8.4	22.0	6.7	51.4
LAND USE (ACRES)	5.3	0.0	27.9	109.9	337.2	480.3

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Hannah Creek – Future
Oct–93

VOLUME 2
TABLE 5.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	1098.1	0.0	4276.8	11269.8	56.2	16700.9
COD	7544.5	0.0	11761.2	10435.0	0.0	29740.7
TSS	7615.6	0.0	15444.0	6261.0	1170.4	30491.0
DS	3025.7	0.0	7959.6	41740.0	562.1	53287.4
TOTAL NITROGEN	11.9	0.0	21.8	114.4	0.6	148.6
TOTAL AMMONIA	21.3	0.0	130.7	533.4	0.8	686.3
TOTAL PHOSPHORUS	370.5	0.0	1096.9	1630.4	3.9	3101.7
DISSOLVED PHOSPHORUS	115.3	0.0	289.1	639.9	0.1	1044.4
COPPER	15.0	0.0	11.9	12.5	0.4	39.8
LEAD	49.8	0.0	23.8	41.7	0.3	115.6
ZINC	21.3	0.0	11.9	83.5	0.3	117.0
LAND USE (ACRES)	7.9	0.0	39.6	417.4	15.4	480.3

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Hannah Creek – Existing
Oct–93

VOLUME 2
TABLE 5.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	28.9	1.5	98	27.4	64							27.4	64
101	13.0	2.0	98	11.0	79	7.5	80					3.5	78
102	17.8	3.6	98	14.2	78	7.4	80	1.5	72			5.3	78
103	20.5	6.1	98	14.4	74	3.0	80			6.2	80	5.2	64
111	30.0	8.2	98	21.8	74	11.6	80			2.0	85	8.2	64
121	12.6	2.5	98	10.1	76	5.1	80			5.0	72		
122	53.3	0.0	98	53.3	64							53.3	64
131	141.0	2.0	98	139.0	64	0.5	80					138.5	64
132	22.9	4.8	98	18.1	81	3.4	86	2.0	87	5.8	90	6.9	70
201	58.3	12.1	98	46.2	80	8.2	85			19.6	89	18.4	69
202	18.2	0.5	98	17.7	69	0.3	80			3.2	88	14.2	64
203	63.8	0.5	98	63.3	66	1.0	83			6.0	77	56.3	65
TOTAL	480.3	43.8		436.5		48.0		3.5		47.8		337.2	
%	100.0%	9.1%		90.9%		10.0%		0.7%		10.0%		70.2%	

Bellingham Watershed Master Plan Curve Number Detail

Basin Name: Hannah Creek – Future

Oct–93

VOLUME 2

TABLE 5.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	28.9	5.5	98	23.4	69	3.4	80	0.8	80	3.8	72	15.4	65
101	13.0	6.0	98	7.0	80	7.0	80						
102	17.8	9.3	98	8.5	80	6.8	80	1.7	80				
103	20.5	10.7	98	9.8	80	9.8	80						
111	30.0	14.4	98	15.6	78	11.1	80			4.5	72		
121	12.6	5.3	98	7.3	80	7.3	80						
122	53.5	13.4	98	40.1	77	28.1	80			12.0	71		
131	141.0	35.3	98	105.7	77	74.0	80			31.7	71		
132	22.9	10.5	98	12.4	85	9.9	86			2.5	81		
201	58.3	26.8	98	31.5	84	25.2	85			6.3	80		
202	18.2	7.2	98	11.0	78	8.8	80			2.2	72		
203	63.8	22.7	98	41.1	79	32.9	80			8.2	73		
TOTAL	480.5	167.1		313.4		224.3		2.5		71.3		15.4	
%	100.0%	34.8%		65.2%		46.7%		0.5%		14.8%		3.2%	

5.9 HANNAH CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

There were no significant wetlands identified in the Hannah Creek study area.

Hannah Creek was not identified in the project scope of work for a stream inventory.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Hannah Creek – Alternative No. 7" Problem No. 3			Revised: Nov–93 HDR Engineering, Inc.	
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
18" x 36" Box Culvert	50	LF	$250	$12,500
Surface Restoration				
Asphalt Pavement	5	SY	$15	$75
Crushed Surfacing	5	TON	$15	$75
Earthwork				
Regrade Channel (Clean–Up)	10	LF	$4	$40
Rip Rap	10	CY	$28	$280
Excavation	80	CY	$5	$400
Subtotal:				$13,400
Mobilization: 10%				$1,300
Contingency: 20%				$2,900
Sales Tax: 7.8%				$1,400
Subtotal – Construction:				$19,000
Engineering Design and Construction:	25%			$4,800
TOTAL PROJECT COST:				$23,800

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Hannah Creek – Alternative No. 8" Problem No. 4			Revised: HDR Engineering, Inc.	Nov–93
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
30–inch	230	LF	$100	$23,000
Structures				
Manholes, 54–inch (8–feet deep max.)	2	EA	$1,875	$3,750
Trash Rack	1	LS	$500	$500
Surface Restoration				
Asphalt Pavement	25	SY	$15	$375
Crushed Surfacing	5	TON	$15	$75
Landscaping	110	SY	$10	$1,100
Earthwork				
Regrade Channel (Clean–Up)	10	LF	$4	$40
Excavation	400	CY	$5	$2,000
Rip Rap	10	CY	$28	$280
Subtotal:				$31,100
Mobilization: 10%				$3,100
Contingency: 20%				$6,800
Sales Tax: 7.8%				$3,200
Subtotal – Construction:				$44,200
Engineering Design and Construction:	25%			$11,100
TOTAL PROJECT COST:				$55,300

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LAKE PADDEN STUDY AREA

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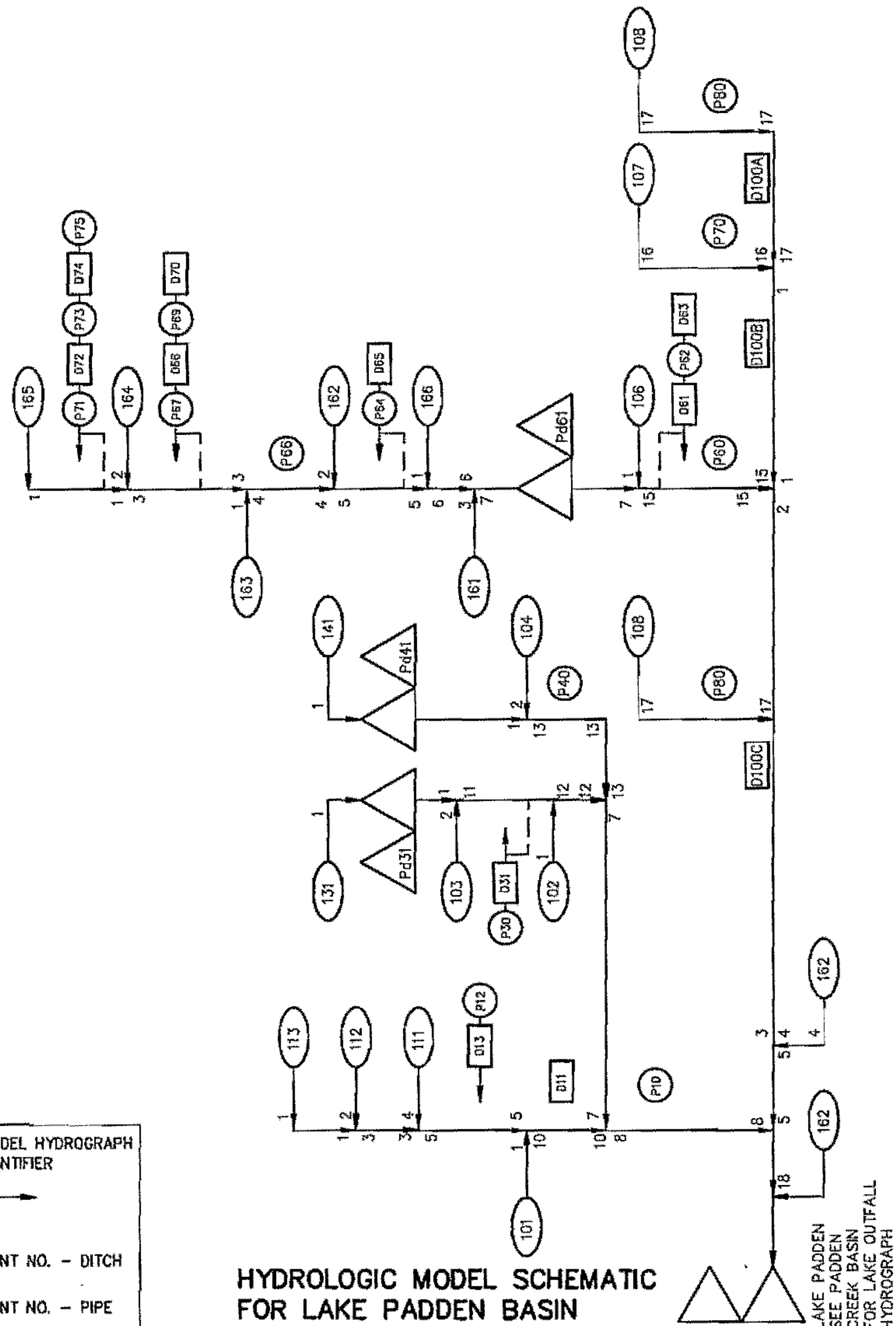
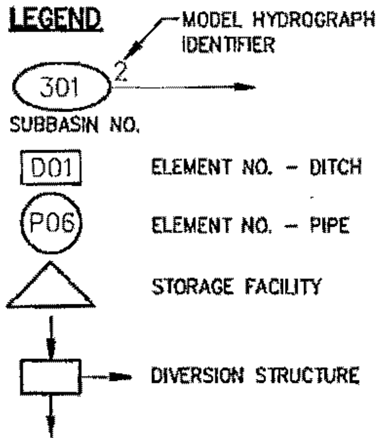


HYDROLOGIC MODEL SCHEMATIC
FOR LAKE PADDEN BASIN

LEGEND



BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE
6.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Lake Padden - Existing Condition
Sep-95

Volume 2
Table 6.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P10	3.33	135.7	15.6		8.0	104.0	5.6	7.7	0.5	13.9	10.0	0.7	20.9	11.3	0.9
D11				5.0			5.6	2.7	0.5	13.9	3.6	0.8	20.9	4.0	1.0
P12	2.00	42.6	13.6		4.0	26.0	1.3	6.1	0.2	5.8	9.5	0.5	11.7	11.6	0.7
D13				3.0			1.3	0.8	0.7	5.8	1.2	1.5	11.7	1.5	2.2
P14	2.00	65.1	20.7		10.0	35.0	1.2	4.9	0.3	4.3	7.2	0.5	8.7	8.8	0.7
P30	2.00	55.0	17.5		10.0	35.0	3.0	9.3	0.3	12.0	14.0	0.6	21.7	16.5	0.9
D31				3.0			2.3	3.9	0.3	9.4	6.1	0.6	17.3	7.3	0.8
P40	2.00	31.7	10.1		15.0	>52.0	2.0	5.7	0.3	4.3	7.1	0.5	5.9	7.7	0.6
P50	1.00	8.7	11.0		2.0	5.0	1.0	7.4	0.2	2.2	9.2	0.4	3.1	10.1	0.4
P60	5.00	338.1	17.2		15.0	350.0	11.5	8.0	0.6	51.9	12.5	1.3	85.3	14.4	1.7
D61				6.0			11.5	3.1	0.8	51.9	4.7	1.7	85.3	5.3	2.2
P62	4.24	117.8	8.3		4.5	84.0	11.5	5.3	0.9	52.0	8.1	2.0	85.3	9.1	2.7
D63				3.0			11.5	2.9	0.6	52.0	4.3	1.5	85.3	4.9	1.9
P64	4.24	207.3	14.7		4.0	74.0	8.5	7.5	0.6	41.5	11.9	1.3	66.9	13.6	1.6
D65				3.0			8.5	3.3	0.5	41.5	5.2	1.2	66.9	5.9	1.5
P66	2.00	89.1	18.2		25.0	120.0	7.1	10.9	0.5	35.5	17.1	1.1	57.2	19.3	1.5
P67	2.00	69.5	22.1		25.0	120.0	4.6	12.5	0.4	22.5	19.8	0.8	35.8	22.3	1.0
D68				8.0			4.6	2.5	0.5	22.5	4.0	1.2	35.8	4.6	1.5
P69	3.00	142.0	20.1		7.0	79.0	4.6	5.6	0.5	22.6	8.9	1.1	35.9	10.1	1.5
D70				5.0			4.6	0.7	1.2	22.6	1.1	2.3	35.9	1.2	2.8
P70	1.5	7.4	4.2		8.0	21.0	0.8	2.7	0.3	1.8	3.4	0.5	2.4	3.7	0.6
P71	1.25	13.3	10.8		5.5	10.6	4.3	9.7	0.5	21.5	17.5	full	34.0	27.7	full
D72				2.0			4.3	3.0	0.6	21.5	4.7	1.4	34.0	5.3	1.7
P73	1.50	21.6	12.2		2.0	7.4	4.3	9.5	0.5	21.6	12.2	full	34.2	19.4	full
D74				3.0			4.3	3.1	0.6	21.6	4.9	1.3	34.2	5.5	1.7
P75	1.50	14.7	8.3		3.5	8.9	4.4	8.3	0.6	21.7	12.3	full	34.3	19.4	full
P80	3.00	7.4	4.2		20.0	25.0	1.9	5.7	0.4	5.1	7.6	0.6	7.4	8.3	0.8
D100A				5.0			1.8	2.9	0.2	4.5	3.8	0.4	6.9	4.3	0.5
D100B				5.0			0.7	1.0	0.3	0.0	0.3	0.03	2.0	1.4	0.4
D100C				4.0			12.7	3.4	0.8	55.5	5.10	1.6	91.5	5.8	2.1

Bellingham Watershed Master Plan Flow Table
Basin Name : Lake Padden - Future Condition
Sep-95

Volume 2
Table 6.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P10	3.33	135.7	15.6		8.0	104.0	16.6	10.6	0.8	47.7	14.2	1.4	66.8	15.5	1.7
D11				5.0			16.6	3.8	0.8	47.7	5.1	1.5	66.8	5.6	1.8
P12	2.00	42.6	13.6		4.0	26.0	12.1	11.7	0.7	37.0	15.3	1.4	52.3	16.6	full
D13				3.0			12.1	1.5	2.2	37.0	2.0	3.7	52.3	2.1	4.3
P14	2.00	65.1	20.7		10.0	35.0	7.4	8.4	0.7	24.2	11.3	1.3	34.8	11.1	full
P30	2.00	55.0	17.5		10.0	35.0	17.3	15.5	0.8	50.3	19.8	1.5	71.2	22.7	full
D31				3.0			14.1	6.9	0.6	41.6	9.3	1.3	58.8	10.1	1.6
P40	2.00	31.7	10.1		15.0	>52.0	3.3	6.5	0.4	6.4	7.9	0.6	8.2	8.5	0.7
P50	1.00	8.7	11.0		2.0	5.0	1.1	7.6	0.2	3.0	9.8	0.4	3.8	10.7	0.5
P60	5.00	338.1	17.2		15.0	350.0	45.4	12.0	1.2	123.6	15.9	2.1	174.3	17.4	2.5
D61				6.0			45.4	4.5	1.6	123.6	5.9	2.6	174.3	6.4	2.4
P62	4.24	117.8	8.3		4.5	84.0	45.4	7.8	1.8	123.7	8.8	full	174.4	12.3	3.1
D63				3.0			45.4	4.2	1.4	123.7	5.4	2.2	174.4	5.9	2.1
P64	4.24	207.3	14.7		4.0	74.0	42.2	11.9	1.3	108.0	15.4	2.1	149.2	16.6	2.5
D65				3.0			42.2	5.3	1.2	108.0	6.7	1.9	149.2	7.3	2.2
P66	2.00	89.1	18.2		25.0	120.0	34.8	17.0	1.1	89.8	18.3	full	124.6	25.4	full
P67	2.00	69.5	22.1		25.0	120.0	20.4	19.2	0.8	54.5	24.5	1.3	75.8	24.1	full
D68				8.0			20.4	3.9	1.1	54.5	5.1	1.8	75.8	5.6	2.2
P69	3.00	142.0	20.1		7.0	79.0	21.0	8.8	1.1	56.1	11.1	2.0	78.0	11.0	full
D70				5.0			21.0	1.1	2.3	56.1	1.4	3.4	78.0	1.5	3.9
P70	1.5	7.4	4.2		8.0	21.0	0.9	2.8	0.4	2.2	3.6	0.6	3.0	4.0	0.7
P71	1.25	13.3	10.8		5.5	10.6	21.1	17.2	full	56.2	45.8	full	77.8	63.4	full
D72				2.0			21.1	4.7	1.4	56.2	6.0	2.2	77.8	6.5	2.6
P73	1.50	21.6	12.2		2.0	7.4	22.1	12.5	full	57.6	32.6	full	79.4	44.9	full
D74				3.0			22.1	4.9	1.4	57.6	6.2	2.2	79.4	6.8	2.6
P75	1.50	14.7	8.3		3.5	8.9	22.9	13.0	full	59.5	33.7	full	81.9	46.4	full
P80	3.00	7.4	4.2		20.0	25.0	4.5	7.3	0.6	11.7	9.3	1.0	16.1	9.1	full
D100A				5.0			4.2	3.9	0.4	10.6	5.2	0.6	14.5	5.6	0.7
D100B				5.0			0.8	1.1	0.3	1.1	1.2	0.3	2.6	1.5	0.5
D100C				4.0			47.8	4.9	1.5	129.9	6.3	2.5	184.5	6.9	2.9

Bellingham Watershed Master Plan Pollutant Loadings Basin Name: Lake Padden – Existing Oct–93					VOLUME 2 TABLE 6.4	
LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	0.0	10627.2	6382.8	4675.3	21685.3
COD	0.0	0.0	29224.8	5910.0	0.0	35134.8
TSS	0.0	0.0	38376.0	3546.0	97348.4	139270.4
DS	0.0	0.0	19778.4	23640.0	46752.9	90171.3
TOTAL NITROGEN	0.0	0.0	54.1	64.8	46.8	165.6
TOTAL AMMONIA	0.0	0.0	324.7	302.1	70.4	697.3
TOTAL PHOSPHORUS	0.0	0.0	2725.7	923.4	327.9	3977.0
DISSOLVED PHOSPHORUS	0.0	0.0	718.3	362.4	11.3	1092.0
COPPER	0.0	0.0	29.5	7.1	32.0	68.6
LEAD	0.0	0.0	59.0	23.6	25.6	108.3
ZINC	0.0	0.0	29.5	47.3	25.6	102.4
LAND USE (ACRES)	0.0	0.0	98.4	236.4	1280.9	1615.7

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Lake Padden – Future
Oct–93

VOLUME 2
TABLE 6.5

LAND USE / CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	0.0	12452.4	25461.0	2034.5	39947.9
COD	0.0	0.0	34244.1	23575.0	0.0	57819.1
TSS	0.0	0.0	44967.0	14145.0	42362.4	101474.4
DS	0.0	0.0	23175.3	94300.0	20345.1	137820.4
TOTAL NITROGEN	0.0	0.0	63.4	258.4	20.3	342.1
TOTAL AMMONIA	0.0	0.0	380.5	1205.2	30.7	1616.3
TOTAL PHOSPHORUS	0.0	0.0	3193.8	3683.4	142.7	7019.9
DISSOLVED PHOSPHORUS	0.0	0.0	841.7	1445.6	4.9	2292.2
COPPER	0.0	0.0	34.6	28.3	13.9	76.8
LEAD	0.0	0.0	69.2	94.3	11.1	174.6
ZINC	0.0	0.0	34.6	188.6	11.1	234.3
LAND USE (ACRES)	0.0	0.0	115.30	943.00	557.4	1615.7

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Lake Padden
Oct−93

VOLUME 2
TABLE 6.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
100	605.9	7.9	98	598.0	70	7.9	98	598.0	70
101	29.2	10.8	98	18.4	80	10.8	98	18.4	83
102	26.5	5.3	98	21.2	77	7.1	98	19.4	80
103	80.3	4.2	98	76.1	66	21.5	98	58.8	80
104	7.7	1.6	98	6.1	81	2.1	98	5.7	84
105	7.8	2.7	98	5.1	71	2.7	98	5.1	76
106	11.3	5.3	98	6.0	67	5.3	98	6.0	69
107	5.7	1.8	98	3.9	80	1.8	98	3.9	80
108	32.3	4.6	98	27.8	77	8.7	98	23.7	81
111	35.5	1.5	98	34.0	65	9.5	98	26.0	80
112	38.1	3.1	98	35.0	67	10.2	98	27.9	80
113	49.9	0.0	98	49.9	66	13.4	98	36.6	81
131	72.7	0.3	98	72.4	76	19.5	98	53.2	86
141	32.5	4.2	98	28.3	73	8.7	98	23.8	82
161	48.2	1.0	98	47.2	76	12.9	98	35.3	86
162	71.3	7.7	98	63.6	73	19.1	98	52.2	82
163	176.1	4.4	98	171.7	72	47.2	98	128.9	84
164	15.5	0.5	98	15.0	73	4.2	98	11.4	80
165	181.8	5.6	98	176.2	77	48.7	98	133.1	80
166	92.6	0.0	98	92.6	75	24.82	98	67.8	85
200	149.9	0.0	98	149.9	100	0	98	149.93	100
TOTAL	1771.0	72.5		1698.4		286.1		1484.9	
%	100.0%	4.1%		95.9%		16.2%		83.8%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Lake Padden – Existing
Oct–93

VOLUME 2
TABLE 6.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		MEADOW		OPEN SPACE		FORESTED		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	AC.	CN	AC.	CN	AC.	AC.	CN
100	605.9	7.9	98	598.0	70					113.2	75	484.7	69		
101	29.2	10.8	98	18.4	80	6.1	80	6.1	89			6.1	72		
102	26.5	5.3	98	21.2	77	13.8	80					7.4	72		
103	80.3	4.2	98	76.1	66	3.8	80					72.3	65		
104	7.7	1.6	98	6.1	81	3.4	83					2.7	79		
105	7.8	2.7	98	5.1	70	2.0	75					3.1	68		
106	11.3	5.3	98	6.0	67	4.8	68					1.2	63		
107	5.7	1.8	98	3.9	80	3.9	80								
108	32.3	4.6	98	27.8	78	14.2	80					13.6	75		
111	35.5	1.5	98	34.0	65	3.4	78					30.6	64		
112	38.1	3.1	98	35.0	67	7.0	80					28.0	64		
113	49.9	0.0	98	49.9	66							49.9	66		
131	72.7	0.3	98	72.4	76							72.1	76	0.3	100
141	32.5	4.2	98	28.3	74	7.1	81					21.2	71		
161	48.2	1.0	98	47.2	76							47.2	76		
162	71.3	7.7	98	63.6	75	11.5	83					47.0	71	5.1	100
163	176.1	4.4	98	171.7	72							171.7	72		
164	15.5	0.5	98	15.0	73							15.0	73		
165	181.8	5.6	98	176.2	77	61.7	79					114.5	76		
166	92.6	0.0	98	92.6	75							92.6	75		
200	149.9	0.0	98	149.9	100									149.9	100
TOTAL	1771.0	72.5		1698.4		142.6		6.1		113.2		1280.9		155.3	
%	100.0%	4.1%		95.9%		8.1%		0.3%		6.4%		72.3%		8.8%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Lake Padden – Future
Oct–93

VOLUME 2
TABLE 6.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		MEADOW		OPEN SPACE		FORESTED		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	AC.	CN	AC.	CN	AC.	AC.	CN
100	605.9	7.9	98	598.0	70					113.2	75	484.7	69		
101	29.2	10.8	98	18.4	83	18.4	83								
102	26.5	7.1	98	19.4	80	19.4	80								
103	80.3	21.5	98	58.8	80	58.8	80								
104	7.7	2.1	98	5.7	84	5.7	84								
105	7.8	2.7	98	5.1	76	5.1	76								
106	11.3	5.3	98	6.0	69	6.0	69								
107	5.7	1.8	98	3.9	80	3.9	80								
108	32.3	8.7	98	23.7	81	23.7	81								
111	35.5	9.5	98	26.0	80	26.0	80								
112	38.1	10.2	98	27.9	80	27.9	80								
113	49.9	13.4	98	36.6	81	36.6	81								
131	72.7	19.5	98	53.2	86	52.9	86							0.3	100
141	32.5	8.7	98	23.8	82	23.8	82								
161	48.2	12.9	98	35.3	86	35.3	86								
162	71.3	19.1	98	52.2	82	47.1	83							5.1	100
163	176.1	47.2	98	128.9	84	128.9	84								
164	15.5	4.2	98	11.4	80	11.4	80								
165	181.8	48.7	98	133.1	80	60.4	84					72.7	76		
166	92.6	24.8	98	67.8	85	67.8	85								
200	149.9	0.0	98	149.9	100									149.9	100
TOTAL	1771.0	286.1		1485.1		659.1				113.2		557.4		155.3	
%	100.0%	16.2%		83.9%		37.2%				6.4%		31.5%		8.8%	

6.9 LAKE PADDEN STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 8.0 and 8.2 in the Watershed Master Plan.

Three wetlands in the Lake Padden drainage basin were field inventoried and are described below. For this study, a limited field area was inventoried for creeks and wetlands in the basin.

A single stream reach description for the tributary flowing into "Our Lake" in the Lake Padden drainage basin follows the wetland descriptions. The area south of Wilkin Street and Samish Way was not included in the study area.

6.9.1 Lake Padden Wetland Descriptions

OUR LAKE - 1

"Our Lake" lies to the north of Lake Padden. Our Lake is an approximately 5.5-acre pond surrounded by a mobile-home/"double-wide" residential development just east of the Bellingham City limits. This pond and its wetlands were not inventoried in the City of Bellingham's wetland inventory. The shores of Our Lake are maintained as lawn, and a bridge across the central portion of the pond provides local residents a place from which to fish and view the pond.

Wetland Description: The majority of the pond is open-water with peripheral wetlands dominated by one layer of vegetation characterized as low in density with young plant community maturity and low species diversity. The dominant plant species was common cattail (*Typha latifolia*). Persistent vegetation dominated the vegetated portion of this wetland. Open-water comprises the majority of Our Lake, and the flow velocity was essentially zero. Roughly 99 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as permanently flooded and a constricted outlet was observed. Peat formed the wetland substrate which had a slope of less than 1 percent. The complexity of the wetland/upland boundary was low.
Wetland Values: The wildlife habitat potential was rated as moderate for waterfowl (potential for resting, feeding and rearing of young in the cattails). Circulation of water through a shallow pond such as this one was considered to provide a moderate water quality benefit. High flow attenuation potential would be provided by the wide, available flood basin. Vegetation surrounding the pond could benefit from enhancement with shrub and tree plantings. Nearby roads and residences may contribute nonpoint pollutants.

Wetland Impacts: This wetland is surrounded by residential development and has been manipulated extensively to create the open water. Increased stormwater flow could cause problems due to the small elevational differences between the pond and adjacent roads and dwellings.

Our Lake - 2

To the north of Our Lake, an area of forested wetland east of the Bellingham City limits was field inventoried for this study. This wetland was not inventoried in the City of Bellingham's wetland inventory. The tributary feeding Our Lake flows through this forested wetland. The northern limit of the forested wetland is a culvert under Yew Street on the wetland's northern boundary.

Wetland Description: This wetland had three layers of vegetation characterized as moderate in density with an old plant community maturity and high species diversity. The dominant plant species were red alder (*Alnus rubra*), W. red cedar (*Thuja plicata*), salmonberry (*Rubus spectabilis*) and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated the vegetated portion of this wetland. Surface water existed in the wetland, and the flow velocity was essentially zero except in the stream itself. Little or none of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and no constricted outlet was observed. Fine mineral soils comprised the wetland substrate, and there was a slope of two percent within the wetland. The complexity of the wetland/upland boundary was rated as "medium sinuosity". This wetland measures approximately one acre in size.

Wetland Values: The wildlife habitat potential was rated as high due to the presence of forested wetland habitat. The water quality benefit was rated as good because of the periodic dispersed flow through the wetland of the water generally flowing along the creek toward Our Lake. Good flow attenuation potential would be provided by the wetland and its associated woody vegetation which could slow floodwaters, should they occur. Vegetation in, and surrounding, the wetland was mature and well developed and would probably not be well served by any enhancement with additional shrub and tree plantings. Nearby roads and residences may contribute nonpoint pollutants; however, this was not directly observed.

Wetland Impacts: Increased stormwater flow could cause potential problems resulting from erosion of the substrate in the wetland which now exists above the existing creek channel. Such erosion would result in silt deposition in Our Lake downstream.

Governor Road Wetland

North of Samish Way and west of Governor Road, outside the Bellingham city, a small pond was field inventoried. This wetland was not inventoried in the city of Bellingham's wetland inventory. The pond is surrounded by second growth forest to the west of single-family residences along Governor Road.

Wetland Description: This wetland had three layers of vegetation characterized as moderate in density with an intermediate-aged plant community with intermediate species diversity. The dominant plant species were red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*) and emergent species. Persistent vegetation dominated the vegetated portion of this wetland. Open water in the pond covered the majority of the area. The flow velocity was essentially zero in the pond. Much of the wetland basin (specifically, the pond) was filled at low water and the potential for an expanded water surface was considered moderate. The hydroperiod was evaluated as permanently flooded and no constricted outlet was observed. Fine mineral soils comprised the wetland substrate, and there was a slope of three percent on the side slopes of the wetland. The complexity of the wetland/upland boundary was rated as having low sinuosity. This wetland measures approximately one-half acre in size.

Wetland Values: The wildlife habitat potential was rated as high due to the presence of forested wetland habitat adjacent to open water. The water quality benefit was rated as low to moderate, not higher because of the relative lack of herbaceous vegetation in the areas of standing water. Good floodwater attenuation potential would be provided by the portion of the wetland where additional water detention capacity existed. Vegetation in, and surrounding, the wetland was mature and well developed and would probably not be well served by any enhancement with additional shrub and tree plantings. Nearby residences may contribute nonpoint pollutants; however, this was not directly observed.

Wetland Impacts: Increased stormwater flow could cause potential problems resulting from flooding of undeveloped low areas within private yards to the east of the wetland.

6.9.2 Lake Padden Stream Reach Description

D-65 (Northern tributary to Our Lake)

Reach Locators: Downstream limit, Our Lake; Upstream limit, culvert at Yew Street.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 15 feet; Low Water Width, 1 feet; Bankful Depth, 2 feet; Low Water Depth 0.0 feet (most likely intermittent); Stream Gradient, 2 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting or large debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there was a moderate amount of flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a silt/organic and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of 0.5 feet/second was observed.

Stream Evaluations: Stream aesthetics were excellent and wildlife habitat value was high. Clear water in this reach suggested that overall water quality was good. No obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: This reach is susceptible to increased erosion and cutting with increased stormwater flows.

Stream reach descriptions cover Padden Creek from its outlet at Bellingham Bay to the culvert under Interstate Highway 5. The portion of the Padden Creek basin lying both to the north of Padden Creek and to the west of Connelly Creek was not included in the study area.

WATERSHED MASTER PLAN			Revised:	Nov-93
CITY OF BELLINGHAM, WASHINGTON			HDR Engineering, Inc.	
"Lake Padden -- Alternative No. 5"				
Problem No. 1				
Item	Quantity	Unit	Unit Cost	Total Cost
Structures				
Special Structures	1	LS	$5,000	$5,000
Surface Restoration				
Crushed Surfacing	10	TON	$15	$150
Landscaping	10	SY	$10	$100
Earthwork				
Regrade Channel (Clean-Up)	10	LF	$4	$40
Excavation	40	CY	$5	$200
Rip Rap	10	CY	$28	$280
Subtotal:				$5,800
Mobilization: 10%				$600
Contingency: 20%				$1,300
Sales Tax: 7.8%				$600
Subtotal -- Construction:				$8,300
Engineering Design and Construction:	25%			$2,100
TOTAL PROJECT COST:				$10,400

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Lake Padden – Alternative No. 11" Problem Nos. 3 and 4			Revised: HDR Engineering, Inc.	Nov–93
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
48–inch	70	LF	$150	$10,500
Surface Restoration				
Asphalt Pavement	35	SY	$15	$525
Crushed Surfacing	20	TON	$15	$300
Landscaping	15	SY	$10	$150
Earthwork				
Regrade Channel (Clean–Up)	20	LF	$4	$80
Excavation	180	CY	$5	$900
Rip Rap	10	CY	$28	$280
Subtotal:				$12,700
Mobilization: 10%				$1,300
Contingency: 20%				$2,800
Sales Tax: 7.8%				$1,300
Subtotal – Construction:				$18,100
Real Estate Acquisition				
Easement – Residential	37,500	SF	$1.25	$46,875
Subtotal – Real Estate:				$46,900
Engineering Design and Construction:	25%			$4,500
TOTAL PROJECT COST:				$69,500

CONNELLY CREEK STUDY AREA

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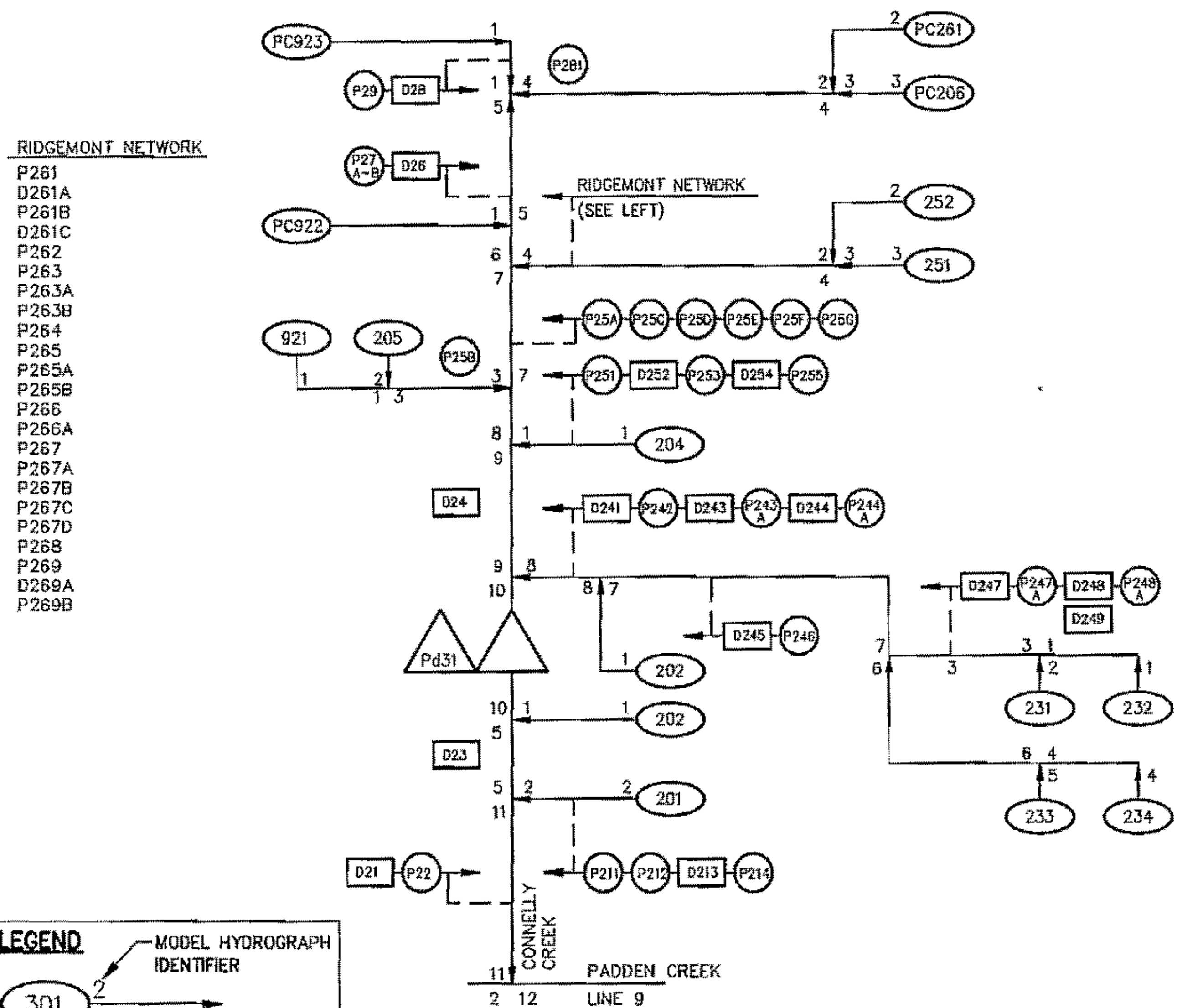

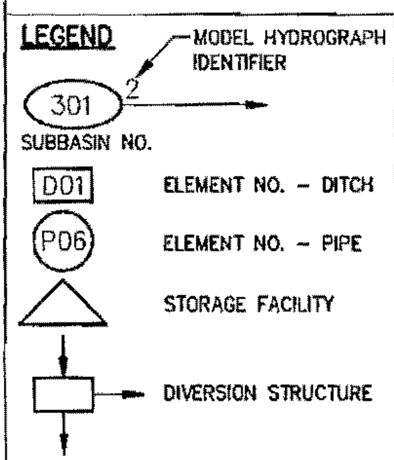

HYDROLOGIC MODEL SCHEMATIC FOR CONNELLY CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE 7.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name: Connelly Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D21				5.0			40.7	2.9	1.2	65.4	3.3	1.6	154.5	4.2	2.4
P22	3.00	72.5	10.3		6.0	71.0	40.8	10.6	1.6	65.5	11.6	2.2	161.4	22.8	full
D23				4.0			38.2	3.3	1.3	59.7	3.7	1.6	150.4	4.7	2.5
D24				3.0			50.6	4.0	1.1	106.3	4.9	1.7	143.3	5.3	2.0
P25A	4.00	76.7	6.1		7.0	170.0	42.7	9.5	1.5	84.5	11.4	2.3	116.4	12.1	2.9
P25B	2.83	105.7	16.8		5.0	55.0	11.3	11.0	0.6	26.1	14.0	1.0	36.8	15.3	1.2
P25C	3.50	136.1	14.2				42.7	12.5	1.4	84.5	14.9	2.0	116.4	15.9	2.5
P25D	3.50	175.6	15.7				42.7	15.1	1.2	84.5	18.1	1.7	116.4	19.5	2.1
P25E	3.50	163.0	16.9				42.7	14.3	1.2	84.5	17.1	1.8	116.4	18.4	2.2
P25F	4.00	146.2	11.6				42.7	10.1	1.5	84.5	12.1	2.2	116.4	12.9	2.7
P25G	4.00	109.7	8.7				42.7	8.2	1.7	84.5	9.6	2.6	116.4	9.3	full
D26				4.0			19.2	3.3	0.8	38.2	4.0	1.1	53.6	4.4	1.4
P27A	2.50	19.9	4.1				20.2	4.1	full	39.7	8.1	full	54.3	11.1	full
P27B	2.00	20.2	6.4		6.0	35.0	20.2	6.4	full	39.7	12.6	full	54.3	17.3	full
D28				5.0			13.8	1.9	0.7	26.2	2.3	1.0	36.6	2.5	1.3
P29	2.00	14.0	4.5		6.0	35.0	14.1	4.5	full	28.3	9.0	full	39.1	12.4	full
P211	2.00	52.1	16.6				5.5	10.7	0.4	15.2	14.4	0.7	22.2	15.9	0.9
P212	1.50*	13.0	7.4		4.5	16.0	5.5	8.4	0.6	15.2	10.7	1.1	22.2	12.6	full
D213				3.0			5.5	6.1	0.4	15.2	8.0	0.7	22.2	8.8	0.8
P214	1.50	29.0	16.4		4.0	15.0	5.5	12.6	0.4	15.5	16.7	0.8	22.7	18.2	1.0
D241				3.0			10.7	4.7	0.3	27.5	6.5	0.6	45.9	7.7	0.8
P242	3.54	224.6	22.9		4.0	58.0	11.0	11.8	0.5	27.7	15.5	0.8	45.9	18.0	1.1
D243	3.50			5.0			11.0	5.3	0.3	27.7	7.3	0.5	45.9	8.6	0.7
P243A	3.50	380.5	39.6		15.0	170.0	11.1	17.6	0.4	27.9	23.1	0.6	46.2	26.8	0.8
D244	4.00			5.0			11.1	5.8	0.2	27.9	8.2	0.4	46.2	9.8	0.6
P244A	4.00	312.1	24.8		10.0	170.0	11.2	11.7	0.5	28.0	15.3	0.8	46.5	17.8	1.0
D245				5.0			10.3	5.7	0.3	23.8	7.8	0.5	40.1	9.3	0.7
P246	4.00	263.7	21.0		7.0	130.0	10.7	10.3	0.5	24.3	13.1	0.8	40.7	15.2	1.1
D247				3.0			4.5	6.7	0.3	10.7	8.8	0.4	15.1	9.7	0.5
P247A	1.50	29.5	16.7		5.5	19.0	4.5	12.1	0.4	10.9	15.4	0.6	15.5	16.9	0.8
D248				2.0			4.5	4.8	0.4	10.9	6.2	0.6	15.5	6.8	0.8
P248A	2.00	96.4	30.7		5.0	30.0	4.5	15.7	0.3	11.2	20.5	0.5	15.9	22.7	0.6
D249				2.0			0.2	2.0	0.1	1.0	3.2	0.2	2.1	4.0	0.2

Bellingham Watershed Master Plan Flow Table
Basin Name: Connelly Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P251	1.50	26.8	15.1		4.0	15.0	1.4	7.9	0.2	3.6	10.5	0.4	5.5	11.9	0.5
D252				2.5			1.4	5.1	0.2	3.6	6.7	0.3	5.5	7.6	0.4
P253	1.50	26.8	15.1		5.5	19.0	1.4	6.7	0.3	3.6	8.8	0.4	5.6	10.0	0.5
D254				2.5			1.4	5.6	0.2	3.6	7.4	0.3	5.6	8.3	0.4
P255	1.50	32.3	18.3		2.0	9.0	1.4	9.1	0.2	3.6	12.1	0.3	5.6	13.7	0.4
P261	1.50	15.6	10.3				7.3	11.3	0.5	19.7	15.1	0.7	28.0	16.7	0.9
D261A				2.5			7.3	5.5	0.5	19.7	7.2	0.8	28.0	8.0	0.9
P261B	1.50	30.6	17.3				7.5	14.3	0.5	19.9	18.5	0.9	28.4	19.7	1.1
D261C				2.5			7.5	5.4	0.3	19.9	7.5	0.5	28.4	8.4	0.6
P262	1.50	36.5	4.6		3.0	13.0	7.5	16.3	0.5	20.7	21.3	0.8	29.6	23.0	1.0
P263	1.50	25.5	14.4				7.5	12.6	0.6	20.7	16.1	1.0	29.6	16.8	full
P263A	1.50	43.8	24.8				7.5	18.5	0.4	20.7	24.4	0.7	29.6	26.6	0.9
P263B	1.50	30.9	17.5				7.5	14.4	0.5	20.7	18.8	0.9	29.6	19.9	1.2
P264	2.00	24.5	17.5		5.0	30.0	7.5	14.0	0.5	20.7	18.1	0.9	29.6	16.8	full
P265	1.50	40.5	22.9				7.5	17.5	0.4	20.7	23.1	0.8	29.6	25.1	1.0
P265A	1.50	36.9	20.9				7.5	16.4	0.5	20.7	21.5	0.8	29.6	23.2	1.0
P265B	1.50	27.2	15.4				7.5	13.2	0.5	20.7	17.0	1.0	29.6	16.8	full
P266	1.50	20.3	11.5				7.5	10.6	0.6	20.7	11.7	full	29.6	16.8	full
P266A	1.50	25.9	14.7				7.5	12.7	0.6	20.7	16.3	1.0	29.6	16.8	full
P267	1.50	14.8	8.4				7.5	8.4	0.8	20.7	11.7	full	29.6	16.8	full
P267A	1.50	14.9	8.4				7.5	8.5	0.8	20.7	11.7	full	29.6	16.8	full
P267B	1.50	27.0	15.3				7.5	13.1	0.5	20.7	16.8	1.0	29.6	16.8	full
P267C	1.50	14.1	8.0				7.5	8.1	0.8	20.7	11.7	full	29.6	16.8	full
P267D	1.30	3.8	3.1				7.5	6.1	full	20.7	16.9	full	29.6	24.2	full
P268	1.50	14.5	8.2				7.5	8.3	0.8	20.7	11.7	full	29.6	16.8	full
P269	2.00	34.8	11.1		2.3		7.5	8.8	0.6	20.7	11.5	1.1	29.6	12.4	1.4
D269A				2.5			7.5	7.2	0.6	20.7	9.4	1.1	29.6	10.3	1.3
P269B	1.80	24.3	10.1				7.5	8.9	0.7	20.7	11.4	1.2	29.7	12.3	full
P281	1.50	17.8	10.0		5.0	18.0	6.4	9.2	0.6	13.5	11.1	1.0	18.1	10.3	full
D282				2.0			4.5	4.4	0.6	10.5	5.5	1.0	14.3	5.9	1.1
P283	1.95	62.8	20.9		6.0	32.0	4.6	12.2	0.4	10.8	15.7	0.6	14.6	17.1	0.6

Bellingham Watershed Master Plan Flow Table
Basin Name: Connelly Creek - Future Condition
Sep-95

Volume 2
Table 7.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D21				5.0			54.5	3.2	1.4	191.4	4.5	2.7	305.4	5.1	3.4
P22	3.00	72.5	10.3		6.0	71.0	54.6	11.3	1.9	205.3	29.0	Full	313.3	44.3	full
D23				4.0			49.5	3.5	1.5	192.1	5.0	2.9	289.8	5.5	3.4
D24				3.0			63.0	4.2	1.3	143.2	5.3	2.0	193.2	5.8	2.3
P25A	4.00	76.7	6.1		7.0	170.0	50.0	10.0	1.7	114.7	12.1	2.8	154.4	12.3	full
P25B	2.83	105.7	16.8		5.0	55.0	15.1	11.9	0.7	36.1	15.3	1.1	48.9	16.5	1.4
P25C	3.50	136.1	14.2				50.0	13.1	1.5	114.7	15.9	2.5	154.4	16.1	full
P25D	3.50	175.6	15.7				50.0	15.7	1.3	114.7	19.5	2.1	154.4	20.6	2.6
P25E	3.50	163.0	16.9				50.0	14.9	1.3	114.7	18.4	2.2	154.4	19.3	2.7
P25F	4.00	146.2	11.6				50.0	10.5	1.6	114.7	12.9	2.7	154.4	12.3	full
P25G	4.00	109.7	8.7				50.0	8.5	1.9	114.7	9.1	full	154.4	12.3	full
D26				4.0			26.0	3.6	0.1	60.2	4.5	1.4	80.7	4.9	1.7
P27A	2.50	19.9	4.1				26.6	5.4	full	61.6	12.6	full	82.3	16.8	full
P27B	2.00	20.2	6.4		6.0	35.0	26.6	8.5	full	61.6	19.6	full	82.3	26.2	full
D28				5.0			19.5	2.1	0.9	39.4	2.6	1.3	53.2	2.8	1.5
P29	2.00	14.0	4.5		6.0	35.0	19.9	6.3	full	41.7	13.3	full	55.6	17.7	full
P211	2.00	52.1	16.6				14.0	14.1	0.7	30.4	17.2	1.1	40.1	18.3	1.3
P212	1.50	13.0	7.4		4.5	16.0	14.0	10.5	1.1	30.4	17.2	full	40.1	22.7	full
D213				3.0			14.0	7.8	0.6	30.4	9.5	0.9	40.1	10.2	1.0
P214	1.50	29.0	16.4		4.0	15.0	14.2	16.4	0.7	30.8	17.5	full	40.5	22.9	full
D241				3.0			31.6	6.8	0.6	76.2	9.0	1.0	104.2	9.8	1.3
P242	3.54	224.6	22.9		4.0	58.0	32.2	16.0	0.9	77.8	20.8	1.4	106.7	22.6	1.7
D243	3.50			5.0			32.2	7.7	0.6	77.8	10.1	1.0	106.7	11.2	1.1
P243A	3.50	380.5	39.6		15.0	170.0	32.5	24.1	0.7	78.6	31.2	1.1	107.9	34.0	1.3
D244	4.00			5.0			32.5	8.7	0.4	78.6	11.9	0.8	107.9	13.2	0.9
P244A	4.00	312.1	24.8		10.0	170.0	32.7	16.1	0.9	79.0	20.7	1.4	108.5	22.6	1.6
D245				5.0			29.7	8.4	0.5	69.9	11.3	0.9	95.6	12.5	1.1
P246	4.00	263.7	21.0		7.0	130.0	30.3	14.0	0.9	71.4	17.8	1.4	97.3	19.4	1.6
D247				3.0			8.6	8.2	0.4	18.0	10.2	0.6	25.7	11.2	0.7
P247A	1.50	29.5	16.7		5.5	19.0	8.8	14.5	0.6	18.2	17.6	0.9	26.0	18.8	1.1
D248				2.0			8.8	5.8	0.6	18.2	7.1	0.8	26.0	7.8	1.0
P248A	2.00	96.4	30.7		5.0	30.0	8.9	19.2	0.4	18.5	23.7	0.6	26.4	26.1	0.7
D249				2.0			2.7	4.3	0.3	7.1	5.6	0.5	10.0	6.2	0.5

Bellingham Watershed Master Plan Flow Table
Basin Name: Connelly Creek - Future Condition
Sep-95

Volume 2
Table 7.3
Page 2 of 2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P251	1.50	26.8	15.1		4.0	15.0	3.1	10.1	0.4	7.6	13.0	0.6	10.4	14.2	0.6
D252				2.5			3.1	6.5	0.3	7.6	8.2	0.5	10.4	8.5	0.4
P253	1.50	26.8	15.1		5.5	19.0	3.2	8.5	0.4	7.6	10.9	0.6	10.4	11.8	0.7
D254				2.5			3.2	7.1	0.3	7.6	9.1	0.5	10.4	8.7	0.3
P255	1.50	32.3	18.3		2.0	9.0	3.2	11.6	0.3	7.7	15.0	0.5	10.4	16.3	0.6
P261	1.50	15.6	10.3				23.5	15.9	0.8	44.8	19.0	1.1	58.2	20.4	1.3
D261A				2.5			24.1	7.6	0.8	44.8	9.0	1.2	58.2	9.7	full
P261B	1.50	30.6	17.3				27.1	19.2	1.0	45.9	25.6	full	59.1	33.4	full
D261C				2.5			27.1	8.0	0.6	45.9	9.7	full	59.1	10.4	full
P262	1.50	36.5	4.6		3.0	13.0	27.1	22.6	1.0	50.0	28.3	full	62.5	35.4	full
P263	1.50	25.5	14.4				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P263A	1.50	43.8	24.8				27.1	26.1	0.9	50.0	28.3	full	62.5	35.4	full
P263B	1.50	30.9	17.5				27.1	19.7	1.1	50.0	28.3	full	62.5	35.4	full
P264	2.00	24.5	17.5		5.0	30.0	27.1	18.9	1.1	50.0	28.3	full	62.5	35.4	full
P265	1.50	40.5	22.9				27.1	24.6	0.9	50.0	28.3	full	62.5	35.4	full
P265A	1.50	36.9	20.9				27.1	22.8	1.0	50.0	28.3	full	62.5	35.4	full
P265B	1.50	27.2	15.4				27.1	17.6	1.2	50.0	28.3	full	62.5	35.4	full
P266	1.50	20.3	11.5				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P266A	1.50	25.9	14.7				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P267	1.50	14.8	8.4				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P267A	1.50	14.9	8.4				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P267B	1.50	27.0	15.3				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P267C	1.50	14.1	8.0				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P267D	1.30	3.8	3.1				27.1	22.0	full	50.0	40.8	full	62.5	51.0	full
P268	1.50	14.5	8.2				27.1	15.3	full	50.0	28.3	full	62.5	35.4	full
P269	2.00	34.8	11.1		2.3		27.1	12.2	1.3	50.0	15.9	full	62.5	19.9	full
D269A				2.5			27.1	10.0	1.2	50.0	11.7	1.6	62.5	12.3	1.8
P269B	1.80	24.3	10.1				27.1	11.3	full	50.1	20.8	full	62.6	26.0	full
P281	1.50	17.8	10.0		5.0	18.0	10.1	10.4	0.8	23.5	13.3	full	30.5	17.2	full
D282				2.0			7.5	5.0	0.8	15.3	6.0	1.2	19.8	6.4	1.3
P283	1.95	62.8	20.9		6.0	32.0	7.6	14.2	0.5	15.6	17.4	0.7	20.1	18.6	0.8

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Connelly Creek – Existing
Oct–93

VOLUME 2
TABLE 7.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	2627.1	0.0	0.0	7136.1	1265.1	11028.3
COD	18049.5	0.0	0.0	6607.5	0.0	24657.0
TSS	18219.6	0.0	0.0	3964.5	26341.6	48525.7
DS	7238.7	0.0	0.0	26430.0	12650.9	46319.6
TOTAL NITROGEN	28.4	0.0	0.0	72.4	12.7	113.4
TOTAL AMMONIA	51.0	0.0	0.0	337.8	19.1	407.9
TOTAL PHOSPHORUS	886.4	0.0	0.0	1032.4	88.7	2007.5
DISSOLVED PHOSPHORUS	275.9	0.0	0.0	405.2	3.1	684.2
COPPER	35.9	0.0	0.0	7.9	8.7	52.5
LEAD	119.1	0.0	0.0	26.4	6.9	152.4
ZINC	51.0	0.0	0.0	52.9	6.9	110.8
LAND USE (ACRES)	18.9	0.0	0.0	264.3	346.6	629.8

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Connelly Creek – Future
Oct–93

VOLUME 2
TABLE 7.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	2557.6	0.0	6966.0	14658.3	14.6	24196.5
COD	17572.0	0.0	19156.5	13572.5	0.0	50301.0
TSS	17737.6	0.0	25155.0	8143.5	304.0	51340.1
DS	7047.2	0.0	12964.5	54290.0	146.0	74447.7
TOTAL NITROGEN	27.6	0.0	35.5	148.8	0.1	212.0
TOTAL AMMONIA	49.7	0.0	212.9	693.8	0.2	956.6
TOTAL PHOSPHORUS	863.0	0.0	1786.7	2120.6	1.0	4771.2
DISSOLVED PHOSPHORUS	268.6	0.0	470.9	832.3	0.0	1571.8
COPPER	35.0	0.0	19.4	16.3	0.1	70.7
LEAD	115.9	0.0	38.7	54.3	0.1	209.0
ZINC	49.7	0.0	19.4	108.6	0.1	177.7
LAND USE (ACRES)	18.4	0.0	64.5	542.9	4.0	629.8

Bellingham Watershed Master Plan Curve Number Summary VOLUME 2
Basin Name: Connelly Creek TABLE 7.6
Oct-93

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	78.2	14.1	98	64.1	74	33.6	98	44.6	81
202	30.6	3.5	98	27.2	78	8.2	98	22.4	84
203	34.7	4.4	98	30.4	72	9.0	98	25.7	80
231	43.6	11.2	98	32.4	76	17.0	98	26.6	80
232	28.1	0.5	98	27.7	64	7.5	98	20.6	80
233	134.4	17.3	98	117.1	67	39.2	98	95.2	80
234	50.7	0.8	98	50.0	71	13.6	98	37.1	83
204	19.9	3.6	98	16.3	70	6.9	98	13.0	80
205	32.8	10.8	98	22.0	75	14.5	98	18.3	84
251	63.6	18.5	98	45.2	76	23.7	98	39.9	80
252	49.9	0.0	98	49.9	64	13.4	98	36.5	80
206	32.1	11.2	98	20.9	77	17.6	98	14.5	83
261	31.2	5.6	98	25.6	66	11.0	98	20.2	80
921	74.3	18.5	98	55.8	71	18.5	98	55.8	79
922	88.2	50.7	98	37.5	83	50.7	98	37.5	83
923	145.2	36.7	98	108.5	70	51.6	98	93.6	75
TOTAL	937.5	207.3		730.2		336.0		601.5	
%	100.0%	22.1%		77.9%		35.8%		64.2%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Connelly Creek – Existing
Oct–93

VOLUME 2
TABLE 7.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW		CULTIVATED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	78.2	14.1	98	64.1	74	9.1	83					21.5	64			33.5	78		
202	30.6	3.5	98	27.2	78							12.2	74			14.9	81		
203	34.7	4.4	98	30.4	72	2.1	80					23.9	71			4.2	78		
231	43.6	11.2	98	32.4	76	24.3	80					8.1	64						
232	28.1	0.5	98	27.7	64							27.6	64						
233	134.4	17.3	98	117.1	67	23.5	80					93.6	64						
234	50.7	0.8	98	50.0	71							50.0	71						
204	19.9	3.6	98	16.3	70	3.3	80					9.8	63			3.3	78		
205	32.8	10.8	98	22.0	75	6.4	88					12.9	64					2.7	95
251	63.6	18.5	98	45.2	76	38.4	78					6.8	64						
252	49.9	0.0	98	49.9	64							49.9	64						
206	32.1	11.2	98	20.9	77					13.5	85	7.3	64						
261	31.2	5.6	98	25.6	66	2.6	80					23.0	64						
921	74.3	18.5	98	55.8	71	11.7	82					41.3	66					2.8	95
922	88.2	50.7	98	37.5	83	10.4	81					17.8	74	9.4	100				
923	145.2	36.7	98	108.5	70							108.5	70						
TOTAL	937.5	207.3		730.2		131.8				13.5		514.2		9.4		55.9		5.5	
	100.0%	22.1%		77.9%		14.1%				1.4%		54.8%		1.0%		6.0%		0.6%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Connelly Creek -- Future
Oct-93

VOLUME 2
TABLE 7.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW		CULTIVATED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	78.2	33.6	98	44.6	81	44.6	81												
202	30.6	8.2	98	22.4	84	22.4	84												
203	34.7	9.0	98	25.7	80	17.5	83					4.0	70			4.2	78		
231	43.6	17.0	98	26.6	80	26.6	80												
232	28.1	7.5	98	20.6	80	20.6	80												
233	134.4	39.2	98	95.2	80	95.2	80												
234	50.7	13.6	98	37.1	83	37.1	83												
204	19.9	6.9	98	13.0	80	13.0	80												
205	32.8	14.5	98	18.3	84	18.3	84												
251	63.6	23.7	98	39.9	80	39.9	80												
252	49.9	13.4	98	36.5	80	36.5	80												
206	32.1	17.6	98	14.5	83	14.5	83												
261	31.2	11.0	98	20.2	80	20.2	80												
921	74.3	18.5	98	55.8	79	34.1	82			11.7	82	10.0	66					2.8	95
922	88.2	50.7	98	37.5	83	10.4	81					17.8	73	9.4	100				
923	145.2	51.6	98	93.6	75	39.3	83					54.3	70						
TOTAL	937.5	336.0		601.5		490.2				11.7		86.1		9.4		4.2		2.8	
	100.0%	35.8%		64.2%		52.3%				1.2%		9.2%		1.0%		0.4%		0.3%	

7.9. CONNELLY CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 9.0, 9.2a, and 9.2b in the Watershed Master Plan.

Connelly Creek was investigated from its confluence with Padden Creek to the culvert at Taylor Avenue. The area to the west of Connelly Creek was not included in the study area.

Four wetlands (PA-27, PA-28, PA-29, PA-33) along Connelly Creek were field inventoried and are described below. Stream reach descriptions for Connelly Creek are described in Section 2.3.1.2 following the wetland descriptions. The Connelly Creek detention dam in the northern portion of the creek should prevent deleterious effects of heavy precipitation storm events on the creek south of the dam. The dam is located at the interface between stream reaches CC-4 and CC-5.

7.9.1 Connelly Creek Wetland Descriptions

PA-27 (Connelly Creek, Reach 1)

Wetland Description: This wetland had two layers of vegetation characterized as moderately dense with a young plant community and low species diversity. The dominant plant species included willow (*Salix* sp.), red alder (*Alnus rubra*), Scot's broom (*Cytisus scoparius*), reed canarygrass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and creeping buttercup (*Ranunculus repens*). Persistent and nonpersistent vegetation occurred in this wetland. No surface water was observed, other than in the creek itself, consequently no flow rate was measured in the wetland. The wetland basin was essentially empty at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as being seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of less than one percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 8.8 acres in size.

Wetland Values: The wildlife habitat potential was rated as low to moderate because of low vegetation diversity. The wetland exhibits high potential for enhancement which could be accomplished through tree and shrub plantings to increase species diversity. Due to the wetlands' landscape position and the low slope of adjacent land, the wetland could be enhanced through the creation of open water habitat. Little water flows through the observed thick herbaceous vegetation, rendering the effective water quality benefits as low. Low to moderate flow attenuation potential would be provided by minor persistent vegetation and the relatively large available flood basin.

Wetland Impacts: This wetland is apparently not impacted by the adjacency of nearby homes and human activity. Increased stormwater flow would probably have only minor effects on the wetland, and could actually enhance its functions and values.

PA-28 (Connelly Creek, Reach 3)

Wetland Description: This wetland had two layers of vegetation characterized as dense with young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*) and red alder (*Alnus rubra*). Persistent vegetation dominated this wetland. No surface water was observed, other than in the creek itself, consequently no flow rate was measured in the wetland. The wetland basin was empty at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2.5 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 7.5 acres in size.

Wetland Values: Because of dense shrub vegetation along the creek, the wildlife habitat potential was rated as moderate. Thick reed canarygrass affords good biofiltration functions and contributes to a moderate to high water quality benefits rating. Moderate flow attenuation potential would be provided by abundant persistent vegetation and wide available flood basin should Connelly Creek overflow in this location.

Wetland Impacts: This wetland had little adjacent land use and minor impact from human use. Increased stormwater flows would probably have only minor effects on the wetland.

PA-29 (Connelly Creek, Reach 4)

Wetland Description: The Connelly Creek detention dam separates PA-29 from PA-33 to its north. PA-29 had three layers of vegetation with moderate to high density with old plant community maturity and high species diversity. The dominant plant species included western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), red-osier dogwood (*Cornus stolonifera*), red huckleberry (*Vaccinium parvifolium*) and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated this wetland. No surface water was observed, other than in the creek itself, consequently no flow rate was measured in the wetland. The wetland basin was empty at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was medium. This wetland measures approximately 4.1 acres in size.

Wetland Values: The wildlife habitat potential was rated as high due to the relatively undisturbed forest vegetation. The natural condition of the forest vegetation merited a moderate water quality benefits rating. Moderate flow attenuation potential would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland had little adjacent land use and minor impact from human use. Increased stormwater flow may have detrimental effects on this stable forested wetland.

PA-33 (Connelly Creek, Reach 5)

Wetland Description: The Connelly Creek detention dam separates PA-33 from PA-29 to its south. This wetland had three layers of vegetation with moderate to high density with old plant community maturity and high species diversity. The dominant plant species included western red cedar (*Thuja plicata*), black cottonwood (*Populus balsamifera*), red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), red-osier dogwood (*Cornus stolonifera*), piggy-back plant (*Tolmiea menziesii*) and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated this wetland. No surface water was observed, other than in the creek itself, consequently no flow rate was measured in the wetland. The wetland basin was empty at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was medium to high. This wetland measures approximately 5.8 acres in size.

Wetland Values: The wildlife habitat potential was rated as high due to the relatively undisturbed forest vegetation. The good condition of the forest vegetation merited a moderate water quality benefits rating. Moderate to high flow attenuation potential would be provided by abundant persistent vegetation.

Wetland Impacts: This wetland had little adjacent land use and minor impact from human use. Increased stormwater flow would probably have detrimental effects on this forested wetland particularly if undermining of tree roots were to occur.

7.9.2 Connelly Creek Stream Reach Descriptions

Connelly Creek, Reach 1 (D-21)

Reach Locators: Downstream limit, confluence with Padden Creek; Upstream limit, change in steam gradient; Associated with wetland PA-27.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 25 feet; Low Water Width, 2 feet; Bankful Depth, 5 feet; Low Water Depth 0.3 feet; Stream Gradient, 1 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with a shrub dominated component. The overall vegetation density was greater than 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 100 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting or debris jams were noted on the upper bank. No channel overflow was considered to be likely. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a silt/organic and fine gravel substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 0.5 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good although enhancement could be accomplished by increasing vegetation species diversity and removing small amounts of litter. Clear water suggested that overall water quality was good; however, nearby residential development may contribute nonpoint pollutants associated with lawn and garden maintenance and automobile parking.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. However, because this reach is below the Connelly Creek detention dam, risk of high flows should be reduced as the dam impounds high flows above the reach.

Connelly Creek, Reach 2 (D-21)

Reach Locators: Downstream limit, gradient change; Upstream limit, culvert at Donovan Avenue.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 15 feet; Low Water Width, 1.5 feet; Bankful Depth, 5 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as partly shrub-dominated, pasture/meadow, and "developed" with an overall vegetation density of less than 50 percent. The stream canopy was estimated at 60 percent cover and the estimated shade was 50 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Moderate to large amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was considered very unlikely. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Frequent cutting of the lower creek bank was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a silt/organic and gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was murky. A flow velocity of approximately 1 foot/second was observed.

Stream Evaluations: Closely adjacent residential development has caused serious stream impacts, particularly in the northern portions of the reach. Enhancement could be accomplished by creating a tree and shrub buffer between residences and the creek. Trash, garden waste, and general residential debris should be removed. Murky water indicated currently active upstream erosion. Drainage pipes entering the stream from nearby residences and vehicles and "RVs" parked close to the banks of the creek on its eastern side may contribute nonpoint pollutants.

Stream Impacts Assessment: This reach is susceptible to more serious erosion and cutting with increased stormwater flows. Adjacent residences could be impacted. However, because this reach is below the Connelly Creek detention dam, risk of high flows should be reduced as the dam will impound high flows above the reach.

Connelly Creek, Reach 3 (D-23)

Reach Locators: Downstream limit, culvert at Donovan Avenue; Upstream limit, change in wetland vegetation types; Associated with wetland PA-28 (contiguous with wetland PA-29).

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 12 feet; Low Water Width, 1 feet; Bankful Depth, 3 feet; Low Water Depth 0.3 feet; Stream Gradient, 1.5 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated with an overall density of greater than 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 100 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Small amount of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a silt/organic substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was murky. A flow velocity of approximately 0.3 feet/second was observed.

Stream Evaluations: In this reach, the creek followed a nearly straight course and may have been ditched at some time in the past. Thick shrub vegetation on both sides of the stream contributed to generally good stream aesthetics. Murky water suggested that erosion was actively occurring in this reach or upstream. No obvious indicators of nonpoint source pollution were observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. However, because this reach is below the Connelly Creek detention dam, risk of high flows should be reduced as the dam impounds high flows above the reach.

Connelly Creek, Reach 4 (D-23)

Reach Locators: Downstream limit, shrub dominated riparian corridor; Upstream limit, detention dam; Associated with wetland PA-29 (contiguous with wetland PA-28).

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 2 feet; Bankful Depth, 3 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 100 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Small amounts of mass wasting and moderate debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there was a moderate amount of flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a silt/organic substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water was murky. A flow velocity of 0.3 feet/second was observed.

Stream Evaluations: Stream aesthetics were excellent and wildlife habitat value was high. Murky water in this reach, while not present upstream, indicated that stream erosion was currently active in this reach. However, there was no obvious location at which this erosion was observed to occur. No obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. However, because this reach is directly below the Connelly Creek detention dam, risk of high flows should be reduced as the dam impounds high flows above the reach.

Connelly Creek, Reach 5 (Pd-21 and D-24)

Reach Locators: Downstream limit, detention dam; Upstream limit, culvert at Taylor Avenue; Associated with wetland PA-33.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 2 feet; Bankful Depth, 2.5 feet; Low Water Depth 0.3 feet; Stream Gradient, 2 percent; Bank Undercut, 35 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 95 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Small amounts of mass wasting and moderate debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent and there were moderate amounts of flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a silt/organic substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of 0.3 feet/second was observed.

Stream Evaluations: Stream aesthetics were excellent and wildlife habitat value was high. Clear water in this reach suggested that overall water quality was good. No obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: Because the Connelly Creek detention dam is the downstream limit of this reach, this reach may be susceptible to increased erosion and cutting with major storm events resulting in increased flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Connelly Creek – Alternative No. 1" Problem No. 21			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
48–inch	850	LF	$165	$140,250
Structures				
Manholes, 84–inch (8–feet deep max.)	2	EA	$3,500	$7,000
Connect to Existing	1	EA	$200	$200
Surface Restoration				
Asphalt Pavement	850	SY	$15	$12,750
Curbing	70	LF	$3	$210
Crushed Surfacing	170	TON	$15	$2,550
Landscaping	50	SY	$10	$500
Earthwork				
Regrade Channel (Clean–Up)	45	LF	$4	$180
Excavation	2,270	CY	$5	$11,350
Rip Rap	20	CY	$28	$560
Subtotal:				$175,600
Mobilization: 10%				$17,600
Contingency: 20%				$38,600
Sales Tax: 7.8%				$18,100
Subtotal – Construction:				$249,900
Engineering Design and Construction:	25%			$62,500
TOTAL PROJECT COST:				$312,400

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Connelly Creek – Alternative No. 12" Problem No. 25			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
18–inch	**310**	**LF**	**$60**	**$18,600**
Structures				
Manholes, 48–inch (8–feet deep max.)	**2**	**EA**	**$1,200**	**$2,400**
Connect to Existing	**1**	**EA**	**$200**	**$200**
Surface Restoration				
Asphalt Pavement	**70**	**SY**	**$15**	**$1,050**
Curbing	**20**	**LF**	**$3**	**$60**
Crushed Surfacing	**15**	**TON**	**$15**	**$225**
Landscaping	**350**	**SY**	**$10**	**$3,500**
Earthwork				
Regrade Channel (Clean–Up)	**20**	**LF**	**$4**	**$80**
Excavation	**360**	**CY**	**$5**	**$1,800**
Rip Rap	**20**	**CY**	**$28**	**$560**
Subtotal:				**$28,500**
Mobilization: 10%				**$2,900**
Contingency: 20%				**$6,300**
Sales Tax: 7.8%				**$2,900**
Subtotal – Construction:				**$40,600**
Engineering Design and Construction:	**25%**			**$10,200**
TOTAL PROJECT COST:				**$50,800**

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PADDEN CREEK STUDY AREA

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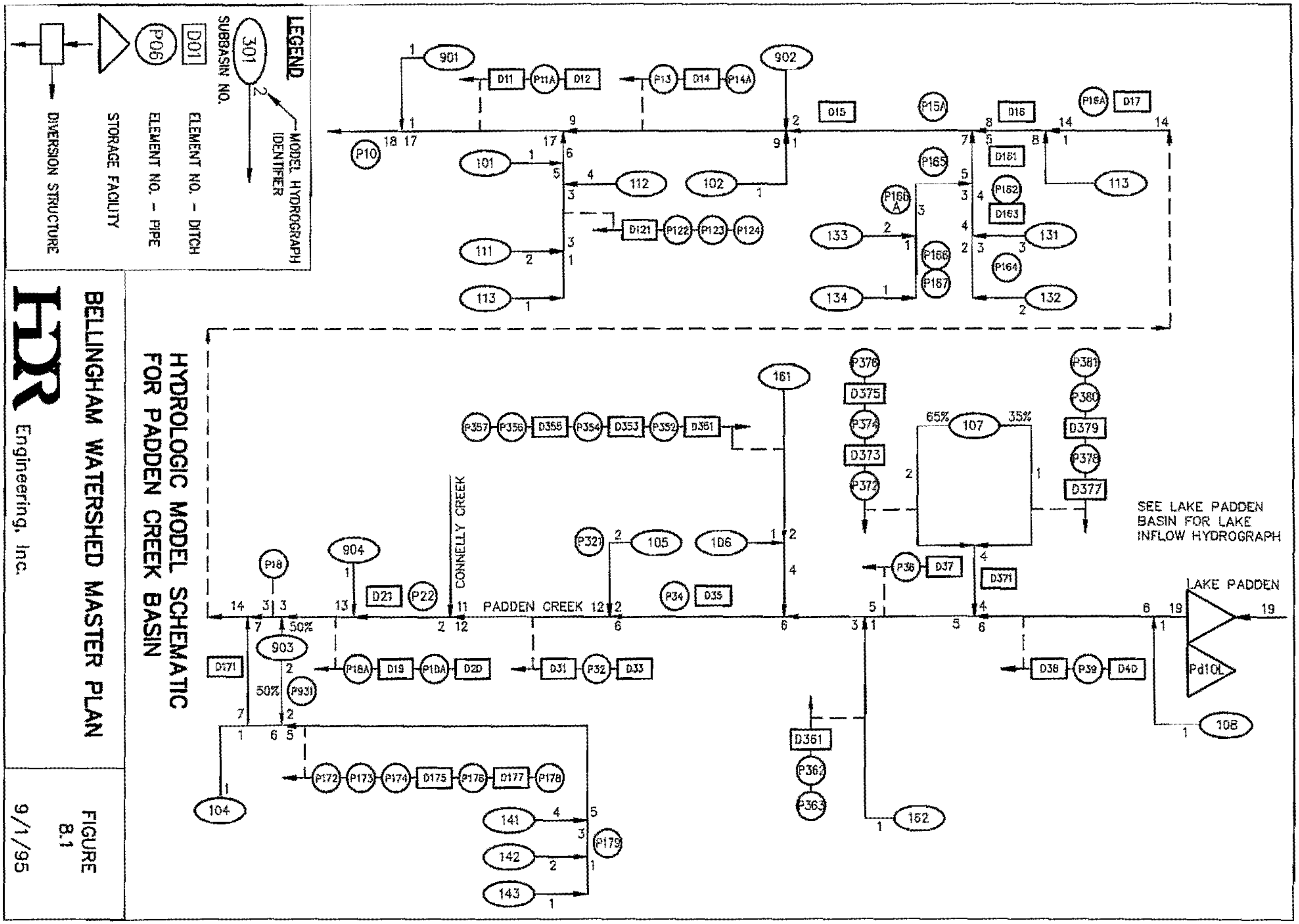

HDR Engineering, Inc.

BELLINGHAM WATERSHED MASTER PLAN

HYDROLOGIC MODEL SCHEMATIC FOR PADDEN CREEK BASIN

FIGURE 8.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Padden Creek - Existing Condition
Sep-95

Volume 2
Table 8.2
Page 1 of 3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P10	5.53	989.6	41.2		11.5	430.0	114.0	27.4	1.3	273.3	35.2	2.0	370.0	38.2	2.4
D11				4.0			104.8	4.3	1.1	246.0	5.8	1.8	335.1	6.4	2.2
P11A	6.66	858.8	24.7		15.0	610.0	105.0	16.7	1.6	246.7	21.3	2.5	335.3	23.1	2.9
D12				2.0			105.0	5.4	1.0	246.7	7.2	1.6	335.3	7.9	1.9
P13	7.82	2102.0	43.8		25.0	1080.0	98.9	22.4	1.1	232.5	28.8	1.8	323.7	31.7	2.1
D14				4.0			98.9	1.9	2.6	232.5	2.5	4.3	323.7	2.8	5.2
P14A	7.07	538.8	13.7		10.0	500.0	99.5	10.5	2.1	234.3	13.2	3.3	324.3	14.3	4.0
D15				2.0			86.7	3.5	0.9	205.8	4.8	1.5	304.7	5.5	1.9
P15A	7.07	762.0	19.4		8.0	400.0	87.4	12.9	1.7	206.2	16.5	2.5	306.4	18.3	3.1
D16				4.0			79.2	3.8	1.0	186.4	5.0	1.7	280.7	5.7	2.1
P16A	6.12	1252.2	42.6		25.0	700.0	77.0	23.6	1.0	181.7	30.3	1.6	278.4	34.3	2.0
D17				2.0			77.0	4.8	1.1	181.7	6.2	1.7	278.4	7.0	2.1
P18	5.53	262.1	10.9				61.9	7.6	2.0	130.2	9.2	3.1	227.3	9.5	full
P18A	5.00	209.4	8.7		6.5	170.0	51.9	7.3	2.0	101.3	8.6	2.9	195.5	10.0	full
D19			5.0				51.9	1.2	3.2	101.3	1.4	4.5	195.5	1.7	6.2
P19A	8.00	338.1	17.2		6.5	540.0	52.1	12.5	1.3	101.9	15.1	1.9	196.6	17.9	2.8
D20				3.0			52.1	1.5	1.9	101.9	1.8	2.7	196.6	2.2	3.8
D31				3.0			11.7	2.2	0.3	31.9	3.1	0.7	47.8	3.6	0.9
P32	6.18	629.6	21.0		6.0	200.0	11.8	8.2	0.6	32.3	11.0	1.0	48.0	12.4	1.1
D33				3.0			11.8	2.7	0.3	32.3	3.9	0.6	48.0	4.5	0.8
P34	4.24	215.1	15.2		6.0	120.0	9.0	7.5	0.6	23.9	10.0	1.0	37.3	11.4	1.2
D35				3.0			9.0	1.8	0.4	23.9	2.4	0.7	37.3	2.8	1.0
P36	4.37	429.7	28.7		25.0	360.0	1.5	6.4	0.2	7.5	10.5	0.4	13.9	12.7	0.5
D37				4.0			1.5	0.7	0.1	7.5	1.3	0.4	13.9	1.6	0.5
D38				6.0			1.0	1.4	0.1	5.0	2.7	0.1	9.3	3.4	0.2
P39	3.54	214.1	21.8		7.0	100.0	0.9	5.4	0.2	5.1	9.1	0.4	9.6	11.0	0.5
D40				6.0			0.9	1.0	0.1	5.1	2.0	0.2	9.6	2.6	0.3

Bellingham Watershed Master Plan Flow Table
Basin Name : Padden Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D121				5.0			7.1	1.1	1.2	16.4	1.3	1.7	22.2	1.4	2.0
P122	2.00	53.6	17.1				7.8	12.2	0.5	18.4	15.5	0.8	24.7	16.7	1.0
P123	1.75	28.1	11.7				7.8	10.0	0.6	18.4	12.5	1.0	24.7	13.2	1.3
P124	1.50	22.1	12.5		3.8	15.0	7.8	11.4	0.6	18.4	14.0	1.0	24.7	14.0	full
D161				2.0			14.9	2.1	1.1	31.0	2.6	1.6	42.1	2.8	1.8
P162	2.00	21.6	6.9		5.0	30.0	4.4	5.4	0.6	9.3	6.6	0.9	13.2	7.2	1.1
D163				2.0			4.4	0.9	1.0	9.3	1.0	1.4	13.2	1.1	1.7
P164	3.00	51.2	7.3		5.0	66.0	0.9	2.7	0.3	2.1	3.4	0.4	4.3	4.2	0.6
P165	4.00	120.4	9.6				10.6	5.9	0.8	22.1	7.3	1.2	29.9	8.0	1.4
P166	2.00	65.0	20.7				5.2	12.4	0.4	12.0	15.8	0.6	16.6	17.3	0.7
P166A	3.50	38.9	4.0				10.6	8.4	0.7	22.1	10.4	1.0	29.9	11.3	1.1
P167	1.50	28.0	15.8		3.5	14.0	5.2	12.1	0.4	12.0	15.2	0.7	16.6	16.5	0.8
D171				8.0			31.6	1.5	2.1	68.7	1.9	3.2	92.5	2.1	3.8
P172	3.00	81.6	11.6				4.6	6.2	0.5	15.6	8.9	0.9	24.0	10.0	1.1
P173	2.50	31.5	6.4				4.6	2.6	1.0	15.6	3.2	full	24.0	4.9	full
P174	3.50	77.3	8.0		10.0	123.0	4.6	4.0	0.6	15.6	5.7	1.1	24.0	6.4	1.4
D175				3.0			4.6	0.9	1.2	15.6	1.3	2.1	24.0	1.4	2.6
P176	3.00	59.2	8.4		8.0	45.0	4.6	5.0	0.6	15.7	7.1	1.1	24.1	8.0	1.3
D177				4.0			4.6	0.6	1.6	15.7	0.8	2.7	24.1	0.9	3.2
P178	2.50	55.3	11.3				5.5	7.2	0.5	16.6	9.9	0.9	24.8	11.0	1.2
P179	2.00	17.4	5.5		10.0	46.0	4.7	4.7	0.7	11.5	5.9	1.2	16.1	6.3	1.5

Bellingham Watershed Master Plan Flow Table
Basin Name : Padden Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P321	2.00	59.0	18.8		3.0	55.0	4.5	11.1	0.4	13.4	15.2	0.7	19.0	16.7	0.8
D351				4.0			4.0	4.4	0.3	8.9	5.6	0.5	13.3	6.3	0.6
P352	2.00	62.8	20.0		10.0	46.0	4.2	11.4	0.3	9.3	14.3	0.5	13.8	16.0	0.6
D353				3.0			4.2	1.5	0.8	9.3	1.8	1.2	13.8	2.0	1.4
P354	1.50	17.0	9.6		3.7	16.0	4.4	8.1	0.5	9.8	10.0	0.8	14.4	10.8	1.1
D355				3.0			4.4	5.5	0.3	9.8	7.0	0.5	14.4	7.8	0.6
P356	1.25	24.3	19.8				4.4	15.1	0.3	10.0	18.9	0.6	14.8	20.8	0.7
D361				2.0			4.4	4.0	0.4	10.4	5.1	0.6	14.9	5.6	0.8
P362	2.50	128.6	26.2				5.0	12.7	0.3	11.4	16.2	0.5	16.1	17.9	0.6
P363	2.00	59.4	11.5		4.0	26.0	5.0	11.5	0.4	11.4	14.6	0.6	16.1	16.1	0.7
D371				3.5			1.1	2.6	0.1	2.5	3.4	0.2	4.9	4.4	0.3
P372	1.25	11.9	9.7		3.0	10.0	0.8	5.5	0.2	1.7	6.8	0.3	3.3	8.3	0.5
D373				3.0			0.8	1.4	0.2	1.7	1.8	0.3	3.3	2.2	0.4
P374	1.25	13.5	11.0		2.6	12.0	0.8	6.0	0.2	1.7	7.5	0.3	3.3	9.1	0.4
D375				2.0			0.8	2.6	0.1	1.7	3.5	0.2	3.3	4.4	0.2
P376	1.25	15.1	12.3		3.0	9.0	0.8	6.6	0.2	1.8	8.3	0.3	3.4	9.9	0.4
D377					3.5		0.4	2.3	0.1	0.9	3.2	0.1	1.8	4.1	0.2
P378	1.50	16.1	9.1				0.4	3.9	0.2	0.9	4.9	0.2	1.8	6.0	0.3
D379					3.0		0.4	2.5	0.1	0.9	3.4	0.1	1.8	4.3	0.2
P380	1.25	9.9	8.1				0.4	4.1	0.2	0.9	5.1	0.3	1.8	6.1	0.4
P381	1.25	9.8	8.0				0.4	4.0	0.2	0.9	5.0	0.3	1.8	6.1	0.4
P931	6.93	954.8	25.3		9.0	370.0	29.6	11.4	0.8	59.7	14.1	1.2	78.7	15.3	1.4

Bellingham Watershed Master Plan Flow Table | Volume 2
Basin Name : Padden Creek - Future Condition | Table 8.3
Sep-95 |

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P10	5.53	989.6	41.2		11.5	430.0	214.4	32.9	1.8	436.5	39.9	2.5	629.6	43.6	3.2
D11				4.0			194.2	5.4	1.6	399.0	6.8	2.4	600.1	7.7	3.0
P11A	6.66	858.8	24.7		15.0	610.0	194.7	20.0	2.1	399.0	24.2	3.2	600.6	26.7	4.1
D12				2.0			194.7	6.7	1.4	399.0	8.3	2.1	600.6	9.4	2.6
P13	7.82	2102.0	43.8		25.0	1080.0	187.3	27.1	1.6	382.8	33.3	2.3	592.4	37.6	2.9
D14				4.0			187.3	2.4	3.8	382.8	2.9	5.7	592.4	3.3	7.3
P14A	7.07	538.8	13.7		10.0	500.0	189.0	12.5	2.9	384.2	14.9	4.4	594.5	15.1	full
D15				2.0			170.4	4.5	1.4	353.4	5.8	2.1	568.3	6.7	2.8
P15A	7.07	762.0	19.4		8.0	400.0	171.4	15.7	2.3	356.1	19.1	3.4	573.8	21.3	4.6
D16				4.0			145.2	4.6	1.5	326.2	5.9	2.3	525.1	6.8	3.0
P16A	6.12	1252.2	42.6		25.0	700.0	142.4	28.3	1.4	325.2	35.8	2.1	523.1	40.7	2.8
D17				2.0			142.4	5.8	1.5	325.2	7.4	2.3	523.1	8.4	3.0
P18	5.53	262.1	10.9				96.8	8.6	2.6	270.8	11.3	full	431.2	18.0	full
P18A	5.00	209.4	8.7		6.5	170.0	81.8	8.2	2.5	239.5	12.2	full	384.2	19.6	full
D19			5.0				81.8	1.3	4.1	239.5	1.8	6.8	384.2	2.0	8.5
P19A	8.00	338.1	17.2		6.5	540.0	81.9	14.2	1.7	246.3	18.8	3.2	391.7	20.0	full
D20				3.0			81.9	1.7	2.4	246.3	2.3	4.2	391.7	2.6	5.3
D31				3.0			25.3	2.9	0.6	60.1	3.8	1.0	82.7	4.3	1.2
P32	6.18	629.6	21.0		6.0	200.0	25.7	10.3	0.9	60.9	13.3	1.3	83.6	14.6	1.5
D33				3.0			25.7	3.6	0.5	60.9	4.9	0.9	83.6	5.4	1.1
P34	4.24	215.1	15.2		6.0	120.0	20.3	9.6	0.9	48.7	12.3	1.4	69.8	13.6	1.6
D35				3.0			20.3	2.3	0.7	48.7	3.1	1.1	69.8	3.4	1.4
P36	4.37	429.7	28.7		25.0	360.0	8.9	11.1	0.4	21.9	14.5	0.6	32.6	16.4	0.8
D37				4.0			8.9	1.4	0.4	21.9	1.9	0.7	32.6	2.2	0.9
D38				6.0			4.3	2.5	0.1	10.4	3.6	0.2	15.6	4.2	0.3
P39	3.54	214.1	21.8		7.0	100.0	4.5	8.8	0.4	10.7	11.4	0.5	16.0	12.8	0.6
D40				6.0			4.5	1.9	0.2	10.7	2.7	0.3	16.0	3.1	0.4

Bellingham Watershed Master Plan Flow Table
Basin Name: Padden Creek - Future Condition
Sep-95

Volume 2
Table 8.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D121				5.0			9.1	1.1	1.3	19.5	1.4	1.9	25.8	1.5	2.1
P122	2.00	53.6	17.1				9.8	13.0	0.6	21.1	16.0	0.9	27.6	17.2	1.0
P123	1.75	28.1	11.7				9.8	10.6	0.7	21.1	12.8	1.1	27.6	13.3	1.4
P124	1.50	22.1	12.5		3.8	15.0	9.8	12.1	0.7	21.1	14.2	1.2	27.6	15.6	full
D161				2.0			51.6	2.9	2.0	100.0	3.5	2.6	106.5	3.5	2.7
P162	2.00	21.6	6.9		5.0	30.0	29.0	9.2	full	53.8	17.1	full	66.7	21.2	full
D163				2.0			29.0	1.4	2.3	53.8	1.6	3.0	66.7	1.7	3.3
P164	3.00	51.2	7.3		5.0	66.0	15.2	6.0	1.2	27.7	7.0	1.7	34.7	7.4	1.9
P165	4.00	120.4	9.6				24.0	7.5	1.2	46.6	9.0	1.7	59.9	9.6	2.0
P166	2.00	65.0	20.7				10.0	15.0	0.5	20.6	18.4	0.8	26.8	19.7	0.9
P166A	3.50	38.9	4.0				24.0	10.7	1.0	46.6	12.8	1.4	59.9	13.7	1.6
P167	1.50	28.0	15.8		3.5	14.0	10.0	14.5	0.6	20.6	17.3	1.0	26.8	18.0	1.2
D171				8.0			58.2	1.8	2.9	118.0	2.2	4.3	157.8	2.4	5.0
P172	3.00	81.6	11.6				23.3	10.0	1.1	44.7	11.8	1.6	59.4	12.6	1.9
P173	2.50	31.5	6.4				23.3	4.8	full	44.7	9.1	full	59.4	12.1	full
P174	3.50	77.3	8.0		10.0	123.0	23.3	6.4	1.4	44.7	7.5	2.1	59.4	7.9	2.6
D175				3.0			23.3	1.4	2.6	44.7	1.6	3.3	59.4	1.8	3.8
P176	3.00	59.2	8.4		8.0	45.0	24.2	8.0	1.3	47.0	9.3	2.0	59.9	8.5	full
D177				4.0			24.2	0.9	3.3	47.0	1.1	4.3	59.9	1.2	4.7
P178	2.50	55.3	11.3				27.4	11.2	1.2	52.3	12.8	1.9	66.6	13.6	full
P179	2.00	17.4	5.5		10.0	46.0	15.5	6.3	1.5	29.1	9.3	full	36.7	11.7	full

Bellingham Watershed Master Plan Flow Table
Basin Name: Padden Creek - Future Condition
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Volume 2
Table 8.3
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REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P321	2.00	59.0	18.8		3.0	55.0	13.0	15.1	0.6	25.4	18.1	0.9	32.3	19.2	1.1
D351				4.0			8.1	5.5	0.4	18.3	7.0	0.7	24.6	7.6	0.8
P352	2.00	62.8	20.0		10.0	46.0	8.3	13.8	0.5	18.8	17.5	0.8	25.1	18.9	0.9
D353				3.0			8.3	1.8	1.1	18.8	2.2	1.6	25.1	2.4	1.9
P354	1.50	17.0	9.6		3.7	16.0	8.5	9.6	0.8	19.6	11.1	full	25.9	14.7	full
D355				3.0			8.5	6.7	0.4	19.6	8.5	0.7	25.9	9.2	0.8
P356	1.25	24.3	19.8				8.7	18.2	0.5	20.0	22.1	0.9	26.8	21.8	full
D361				2.0			4.9	4.1	0.4	10.6	5.1	0.6	14.5	5.6	0.7
P362	2.50	128.6	26.2				5.4	12.9	0.4	11.3	16.1	0.5	15.9	17.8	0.6
P363	2.00	59.4	11.5		4.0	26.0	5.4	11.7	0.4	11.3	14.5	0.6	15.9	16.0	0.7
D371				3.5			5.7	4.6	0.3	13.3	6.0	0.5	17.5	6.5	0.6
P372	1.25	11.9	9.7		3.0	10.0	4.1	8.8	0.5	9.0	10.6	0.8	12.1	9.7	full
D373				3.0			4.1	2.4	0.5	9.0	2.9	0.8	12.1	3.2	0.9
P374	1.25	13.5	11.0		2.6	12.0	4.2	9.7	0.5	9.4	11.9	0.8	12.4	12.5	0.9
D375				2.0			4.2	4.7	0.3	9.4	6.1	0.4	12.4	6.6	0.5
P376	1.25	15.1	12.3		3.0	9.0	4.3	10.6	0.5	9.8	13.1	0.7	13.1	13.8	0.9
D377					3.5		2.1	4.3	0.2	4.9	5.7	0.3	6.4	6.2	0.3
P378	1.50	16.1	9.1				2.2	6.4	0.4	5.0	8.1	0.6	6.5	8.7	0.7
D379					3.0		2.2	4.6	0.2	5.0	6.1	0.4	6.5	6.6	0.4
P380	1.25	9.9	8.1				2.3	6.7	0.4	5.1	8.2	0.6	6.8	8.7	0.8
P381	1.25	9.8	8.0				2.3	6.5	0.4	5.1	8.1	0.6	6.8	8.6	0.8
P931	6.93	954.8	25.3		9.0	370.0	41.7	12.7	1.0	83.0	15.5	2.0	106.6	16.7	1.5

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Padden Creek – Existing
Oct–93

VOLUME 2
TABLE 8.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	2515.9	3131.3	7819.2	6077.7	1879.0	21423.1
COD	17285.5	1013.6	21502.8	5627.5	0.0	45429.4
TSS	17448.4	905.0	28236.0	3376.5	39124.8	89090.7
DS	6932.3	57.9	14552.4	22510.0	18790.2	62842.8
TOTAL NITROGEN	27.2	11.6	39.8	61.7	18.8	159.0
TOTAL AMMONIA	48.9	48.9	238.9	287.7	28.3	652.7
TOTAL PHOSPHORUS	848.9	347.5	2005.5	879.2	131.8	4212.9
DISSOLVED PHOSPHORUS	264.3	199.1	528.5	345.1	4.5	1341.5
COPPER	34.4	10.9	21.7	6.8	12.9	86.6
LEAD	114.0	74.2	43.4	22.5	10.3	264.5
ZINC	48.9	128.5	21.7	45.0	10.3	254.4
LAND USE (ACRES)	18.1	18.1	72.4	225.1	514.8	848.5

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Padden Creek – Future
Oct–93

VOLUME 2
TABLE 8.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	2515.9	3131.3	13284.0	14642.1	536.6	34109.9
COD	17285.5	1013.6	36531.0	13557.5	0.0	68387.6
TSS	17448.4	905.0	47970.0	8134.5	11172.0	85629.9
DS	6932.3	57.9	24723.0	54230.0	5365.5	91308.7
TOTAL NITROGEN	27.2	11.6	67.7	148.6	5.4	260.3
TOTAL AMMONIA	48.9	48.9	405.9	693.1	8.1	1204.8
TOTAL PHOSPHORUS	848.9	347.5	3407.1	2118.2	37.6	6759.4
DISSOLVED PHOSPHORUS	264.3	199.1	897.9	831.3	1.3	2193.9
COPPER	34.4	10.9	36.9	16.3	3.7	102.1
LEAD	114.0	74.2	73.8	54.2	2.9	319.2
ZINC	48.9	128.5	36.9	108.5	2.9	325.7
LAND USE (ACRES)	18.1	18.1	123.0	542.3	147.0	848.5

Bellingham Watershed Master Plan Curve Number Summary　VOLUME 2
Basin Name: Padden Creek　TABLE 8.6
Oct-93

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	11.4	1.7	98	9.7	79	3.7	98	7.6	87
111	14.0	6.5	98	7.5	85	9.1	98	4.9	86.5
112	18.3	6.6	98	11.6	83	11.1	98	7.2	84.5
113	30.4	9.4	98	21.0	80	12.0	98	18.4	81.5
102	38.8	9.7	98	29.1	76	9.7	98	29.1	80
103	27.7	5.5	98	22.1	86	11.8	98	15.9	88
131	53.9	9.2	98	44.7	72	37.2	98	16.7	73
132	50.3	2.4	98	47.9	65	39.4	98	10.9	76
133	97.2	14.3	98	83.0	67	36.8	98	60.5	72
134	60.2	13.2	98	47.0	76	24.9	98	35.3	80
104	33.8	6.8	98	27.0	70	22.6	98	11.2	82
141	57.4	1.7	98	55.7	77	29.4	98	28.0	82
142	30.9	5.6	98	25.3	81	26.3	98	4.6	85
143	30.5	4.6	98	25.9	68	13.5	98	17.0	75
105	46.6	9.3	98	37.3	79	31.3	98	15.3	84
106	19.0	2.9	98	16.2	70	5.1	98	13.9	81
161	57.6	11.5	98	46.1	70	20.2	98	37.4	80
162	52.1	13.0	98	39.1	72	14.0	98	38.1	70
107	48.9	3.3	98	45.6	66	15.4	98	33.5	80.3
108	69.5	2.8	98	66.7	69	16.8	98	52.7	69
901	178.0	36.0	98	142.0	81	132.2	98	45.8	82
902	107.9	43.9	98	64.0	83	61.3	98	46.6	87.5
903	452.1	162.8	98	289.5	75	221.8	98	230.3	81
904	58.7	11.8	98	46.9	73	16.9	98	41.8	82
TOTAL	1645.2	394.3		1250.9		822.5		822.7	
%	100.0%	24.0%		76.0%		50.0%		50.0%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Padden Creek – Existing
Oct–93

VOLUME 2
TABLE 8.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW		CULTIVATED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	11.4	1.7	98	9.7	79	1.8	85			0.5	85	7.4	77						
111	14.0	6.5	98	7.5	85	6.7	87					0.8	64						
112	18.3	6.6	98	11.6	83	8.9	85					2.7	76						
113	30.4	9.4	98	21.0	80	16.6	82					4.5	72						
102	38.8	9.7	98	29.1	76	8.7	80			8.7	80	11.7	70						
103	27.7	5.5	98	22.1	86	4.4	90			13.3	90	4.4	81						
131	53.9	9.2	98	44.7	72	11.1	89					33.7	67						
132	50.3	2.4	98	47.9	65	1.0	80					43.1	64			3.8	78		
133	97.2	14.3	98	83.0	67	14.6	82					68.4	64						
134	60.2	13.2	98	47.0	76	35.3	80					11.8	64						
104	33.8	6.8	98	27.0	70	3.5	81					23.5	69						
141	57.4	1.7	98	55.7	77	2.0	88					53.7	76						
142	30.9	5.6	98	25.3	81	10.2	88					15.1	75						
143	30.5	4.6	98	25.9	68	2.6	80					23.4	67						
105	46.6	9.3	98	37.3	79	2.2	90					30.6	79			4.5	78		
106	19.0	2.9	98	16.2	70	4.4	80					11.8	66						
161	57.6	11.5	98	46.1	70	18.5	80					27.6	64						
162	52.1	13.0	98	39.1	72	6.5	80					32.6	70						
107	48.9	3.3	98	45.6	66	4.3	80					41.3	65						
108	69.5	2.8	98	66.7	69							66.7	69						
901	178.0	36.0	98	142.0	81	94.0	82	34.1	80	7.9	87	6.0	76						
902	107.9	43.9	98	64.0	83	37.8	87					26.3	79						
903	452.1	162.8	98	289.5	75	175.1	81					114.3	66						
904	58.7	11.8	98	46.9	73	5.5	88					41.4	71						
TOTAL	1645.2	394.4		1250.9		475.7		34.1		30.4		702.8				8.3			
	100.0%	24.0%		76.0%		28.9%		2.1%		1.8%		42.7%				0.5%			

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Padden Creek -- Future
Oct-93

VOLUME 2
TABLE 8.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW		CULTIVATED	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	11.4	3.7	98	7.6	87	7.1	85			0.5	85								
111	14.0	9.1	98	4.9	87	4.9	87												
112	18.3	11.1	98	7.2	85	7.2	85												
113	30.4	12.0	98	18.4	82	18.4	82												
102	38.8	9.7	98	29.1	80	20.4	80			8.7	80								
103	27.7	11.8	98	15.9	88					13.3	90	2.6	81						
131	53.9	37.2	98	16.7	73	5.9	84					10.8	67						
132	50.3	39.4	98	10.9	76	8.4	80					2.5	64						
133	97.2	36.8	98	60.5	72	31.3	80					29.2	64						
134	60.2	24.9	98	35.3	80	35.3	80												
104	33.8	22.6	98	11.2	82	11.2	82												
141	57.4	29.4	98	28.0	82	16.5	86					11.5	76						
142	30.9	26.3	98	4.6	85	4.6	85												
143	30.5	13.5	98	17.0	75	10.9	80					6.1	67						
105	46.6	31.3	98	15.3	84	15.3	84												
106	19.0	5.1	98	13.9	81	13.9	84												
161	57.6	20.2	98	37.4	80	37.4	80												
162	52.1	14.0	98	38.1	70	6.5	80					31.6	70						
107	48.9	15.4	98	33.5	80	33.5	80												
108	69.5	16.8	98	52.7	69							52.7	69						
901	178.0	132.2	98	45.8	82	38.1	82			7.7	87								
902	107.9	61.3	98	46.6	88	46.6	88												
903	452.1	221.8	98	230.3	90	172.3	90					58.0	66						
904	58.7	16.9	98	41.8	82	41.8	82												
TOTAL	1645.2	822.5		822.7		587.5				30.2		205.0							
	100.0%	50.0%		50.0%		35.7%				1.8%		12.5%							

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Padden Creek – Alternative No. 12" Problem No. 3			Revised: Nov–93 HDR Engineering, Inc.	
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Earthwork				
Bioengineered Slope	**18,000**	**SF**	**$14**	**$252,000**
Subtotal:				**$252,000**
Mobilization: 10%				**$25,200**
Contingency: 20%				**$55,400**
Sales Tax: 7.8%				**$25,900**
Subtotal – Construction:				**$358,500**
Engineering Design and Construction: 25%				**$89,600**
TOTAL PROJECT COST:				**$448,100**

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Padden Creek – Alternative No. 9" Problem No. 4			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Surface Restoration				
Landscaping	**200**	**SY**	**$10**	**$2,000**
Earthwork				
Regrade Channel (Clean–Up)	**200**	**LF**	**$4**	**$800**
Excavation	**110**	**CY**	**$5**	**$550**
Rip Rap	**130**	**CY**	**$28**	**$3,640**
Subtotal:				**$7,000**
Mobilization: 10%				**$700**
Contingency: 20%				**$1,500**
Sales Tax: 7.8%				**$700**
Subtotal – Construction:				**$9,900**
Engineering Design and Construction:	25%			**$2,500**
TOTAL PROJECT COST:				**$12,400**

8.9 PADDEN CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 9.0, 9.2a, and 9.2b in the Watershed Master Plan.

Stream reach descriptions cover Padden Creek from its outlet at Bellingham Bay to the culvert under Interstate Highway 5. The portion of Padden Creek basin lying both to the north of Padden Creek and to the west of Connelly Creek was not included in the study area.

Four wetlands (PA-1, PA-2, PA-4, PA-26) along Padden Creek were field inventoried and are described below. Stream reaches from Bellingham Bay to Interstate 5 along Padden Creek are described in Section 2.3.2.2 following the wetland descriptions.

8.9.1 Padden Creek Wetland Descriptions

PA-1 (Padden Creek, north of Reach 1)

Wetland Description: This wetland is a tidal lagoon at the mouth of Padden Creek where it meets Bellingham Bay. A constricted outlet for the lagoon exists under the railroad tracks through which Padden Creek flows into the Bay. One vegetation layer characterized as dense with young plant community maturity and low species diversity occurred along the lagoon's periphery. The dominant plant species included reed canarygrass (*Phalaris arundinacea*) and Virginia glasswort (*Salicornia virginica*). Non-persistent vegetation dominated this wetland area. No surface water was observed, therefore no flow rate was measured. Approximately 1 percent of the wetland basin was filled when the tide was out (at the time of observation) the potential for an expanded water surface was considered high and is utilized during tidal fluctuations. The hydroperiod was evaluated as permanently saturated and diurnally flooded. A cobble-gravel-muck mixture formed the wetland substrate which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 4.6 acres (not 8.2 acres as is presented in the Bellingham Wetland Inventory.

Wetland Values: The wildlife habitat potential was rated as moderate to high. The water quality benefits rating was low because PA-1 is a large, unvegetated tidal mudflat with herbaceous vegetation in a narrow rim only around the basin. Moderate flow attenuation would be provided by the wide flood basin available at low tide. Efforts to enhance the lagoon and surrounding wetlands through plantings are underway.

Wetland Impacts: Adjacent land-use including boat yards and parking areas may contribute nonpoint source pollution to this stream reach. Because the wetland is the terminus of Padden Creek, and because the creek flows through an extensively developed area (Fairhaven) prior to reaching this point, there are probably non-point pollutants entering the lagoon. Moderate increases in floodwater would have little impact on this wetland.

PA-2 (Padden Creek, Reach 2)

Wetland Description: This wetland had two layers of vegetation characterized as dense with young to intermediate plant community maturity and low species diversity. The dominant plant species included willow (*Salix* sp.), creeping buttercup (*Ranunculus repens*), reed canarygrass (*Phalaris arundinacea*), and enchanter's nightshade (*Circaea alpina*). Persistent vegetation dominated this wetland. No surface water was observed (other than in the creek), consequently no flow rate was measured. Roughly 2 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as permanently saturated and seasonally flooded. A constricted outlet was observed. Fine mineral soils with gravel and cobbles formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was rated as medium. This wetland measures approximately 1 acre in size.

Wetland Values: The wildlife habitat potential was rated as high and the presence of thick herbaceous vegetation merited a moderate to high water quality benefits rating. High flow attenuation potential would be provided by abundant persistent vegetation and a wide available flood basin.

Wetland Impacts: This wetland had low density adjacent development and therefore relatively minor impact from human use. Increased stormwater flow would probably have only minor effects.

PA-4 (Padden Creek, Reach 4)

PA-4 is characterized as a 12.4-acre forested swamp in the Bellingham Wetland Inventory; however, the field investigation for the Watershed Master Plan found only a few minor areas of wetlands (approximately 0.25 acres in size) in this area along the creek. These small areas were associated with seeps in the upper bank of Padden Creek. This is a major discrepancy between wetlands identified in this area during field work conducted for the Wetland Inventory and the Watershed Master Plan.

Wetland Description: This wetland had two layers of vegetation characterized as dense with young to intermediate plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*) and salmonberry (*Rubus spectabilis*). Persistent vegetation dominated these areas. Since no surface water was observed in the wetland exclusive of Padden Creek), no flow rate was estimated. Less than 1 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as permanently saturated and seasonally flooded. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 1 percent. The complexity of the wetland/upland boundary was low. This wetland measures roughly 0.25 acres in size.

Wetland Values: The wildlife habitat value and water quality benefits were rated as low to moderate due to the small size of the wetland areas. Flow attenuation would be low as well due to the wetland's small size.

Wetland Impacts: This wetland has little adjacent human land use and therefore only minor effects from human impact.

PA-26 (Padden Creek, Reach 8)

Wetland Description: This wetland had two layers of vegetation characterized as moderate to high density with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), willow (*Salix* sp.), and reed canarygrass (*Phalaris arundinacea*). Persistent and nonpersistent vegetation occurred in this wetland. No surface water was observed, consequently no flow rate was measured. Roughly 1 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 2.3 acres in size.

Wetland Values: The wildlife habitat potential was rated as low and the presence of thick herbaceous vegetation merited a high water quality benefits rating. Moderate flow attenuation potential would be provided by the wide available flood basin. High potential for enhancement existed and could be affected through plantings to increase species and structural diversity.

Wetland Impacts: Old Fairhaven Parkway, which is a likely source of nonpoint pollution, parallels (and is to the south of) the wetland. Additional stormwater flows would have only minor effects.

8.9.2 <u>Padden Creek Stream Reach Descriptions</u>

Padden Creek, Reach 1 (P-10 and D-11)

Reach Locators: Downstream limit, culvert at Harris Avenue; Upstream limit, culvert for Padden Creek bike trail. Wetland PA-1, a tidal basin immediately north of Harris Avenue, occurs immediately downstream.

Channel Dimensions: High Flow Width, 17 feet; Bankful Width, 22 feet; Low Water Width, 8 feet; Bankful Depth, 3.5 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged between 30 and 40 percent. Small amounts of mass wasting were observed and no debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some to frequent cutting of the lower creek bank was observed and the height of the raw banks ranged from

6 to 12 inches. The creek bottom had a coarse gravel substrate with loose particle packing. Scouring and deposition was rated at less than 5 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow rate of approximately 2.5 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good. The upper stream bank has been enhanced with supplemental shrub and tree plantings and the placement of numerous bird boxes. Clear water suggested that overall water quality was good; however, some nonpoint pollution from upstream development in Fairhaven seems likely.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 2 (D-12)

Channel Dimensions: High Flow Width, 17 feet; Bankful Width, 21 feet; Low Water Width, 8 feet; Bankful Depth, 2 feet; Low Water Depth, 0.7 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with a shrub-dominated component and an overall density of 70 to 90 percent. The stream canopy was estimated at 60 percent cover and the estimated shade was 70 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged between 10 and 20 percent. Small to moderate amounts of mass wasting were observed and small debris jams were noted on the upper bank. Occasional channel overflow was considered likely for the creek and common for the wetland area. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a silt/organic, sand, and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow rate of approximately 2 feet/second was observed.

Stream Evaluations: In general, stream aesthetics were excellent. The side slopes of the ravine were forest-covered and help to buffer the riparian corridor while providing good wildlife habitat. Wildlife habitat has been enhanced by the addition of numerous bird boxes. Clear water suggested that overall water quality was good and no obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 3 (D-14)

Reach Locators: Downstream limit, culvert at Donovan Avenue; Upstream limit, culvert and fish ladder west of Chuckanut Drive.

Channel Dimensions: High Flow Width, 20 feet; Bankful Width, 22 feet; Low Water Width, 8 feet; Bankful Depth, 4 feet; Low Water Depth 0.7 feet; Stream Gradient, 4 percent; Bank Undercut, 80 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. Large areas of mass wasting and moderate debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was estimated at 20 to 40 percent and there were few to moderate flow obstructions on the lower bank. Frequent cutting of the lower creek bank was noted and the height of the raw banks was greater than 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare, although significant accumulations of algae covered the substrate, and the water was clear. An estimated flow velocity of 2 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good. Many bird boxes enhanced the wildlife habitat. Nearby park trails facilitated human access, resulting in some disturbance and litter. Clear water suggested that overall water quality was good. No obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. An existing dwelling located at the top of the slope above a soil-slump is in potential jeopardy should erosion continue unabated.

Padden Creek, Reach 4 (D-15)

Reach Locators: Downstream limit, culvert and fish ladder west of Chuckanut Drive; Upstream limit, culvert at the north end of Fairhaven Park; Associated with wetland PA-4.

Channel Dimensions: High Flow Width, 25 feet; Bankful Width, 28 feet; Low Water Width, 18 feet; Bankful Depth, 2 feet; Low Water Depth, 0.7 feet; Stream Gradient, 2 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 40 percent. Large amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some to frequent cutting of the lower creek bank was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a coarse gravel, cobble and boulder substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare although rocks were algae covered. The water in the creek was clear. A flow velocity of 1 foot/second was observed.

Stream Evaluations: Stream aesthetics were generally good. Clear water suggested that overall water quality was good; however, a thick algal coating on the stream substrate may indicate excessive nutrient loadings from nonpoint pollution sources such as lawn fertilizers or septic system effluent. The extent of wetland PA-4 appeared to be much more limited than the depiction in the wetland inventory.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 5 (D-16)

Reach Locators: Downstream limit, culvert at the north end of Old Fairhaven Park; Upstream limit, culvert ("Brick Tunnel") at Fairhaven Parkway; Associated with wetland PA-4. This reach flows through Fairhaven Park.

Channel Dimensions: High Flow Width, 17 feet; Bankful Width, 20 feet; Low Water Width, 8 feet; Bankful Depth, 4 feet; Low Water Depth 0.7 feet; Stream Gradient, 3 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with some lawn areas associated with the park. The overall vegetation density was 50 to 70 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 30 percent. Small amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some to frequent cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel, cobble and boulder substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of 2 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good although much of the bank vegetation has been cleared and replaced with lawn areas. Clear water suggested that overall water quality was good but lawn fertilizers and pesticides, if used in park maintenance, could be nonpoint pollutants.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 6 (D-19)

Reach Locators: Downstream limit, culvert ("Brick Tunnel") near the intersection of Old Fairhaven Parkway and n Street; Upstream limit, culvert at 24th Street.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 24 feet; Low Water Width, 10 feet; Bankful Depth, 2 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Small to moderate amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some to frequent cutting of the lower creek bank was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the amount of algae coatings on submerged rocks was less than the next downstream reach (described above). The water was clear and a flow velocity of approximately 3 feet/second was observed.

Stream Evaluations: Residential development along the creek's north side has strongly modified the vegetation along this riparian corridor. Stream side plantings could stabilize eroding banks. Clear water suggested that overall water quality was good although nearby lawns may be nonpoint sources of fertilizer and herbicide pollution.

Stream Impacts Assessment: Bank erosion was noted in some areas and increased stormwater flows could accelerate the process.

Padden Creek, Reach 7 (D-20)

Reach Locators: Downstream limit, culvert at 24th Street; Upstream limit, confluence with Connelly Creek; Associated in part with wetland PA-26.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 16 feet; Low Water Width, 6 feet; Bankful Depth, 2 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 95 percent.

Riparian Vegetation: The vegetation was characterized as partly immature/even-aged forest and partly developed with an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. Small to moderate amounts of mass wasting and no debris jams were noted on the upper bank. Channel overflow was thought not to occur. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Continuous cutting of the lower creek bank was observed and the height of the raw banks exceeded 24 inches. The creek bottom had a clay substrate with tight particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 3 feet/second was observed.

Stream Evaluations: Stream aesthetics were moderate along the creek's south side and poor along the developed north side. Vegetation enhancement along the north side would help to stabilize the eroding banks as well as improve the aesthetics of the reach. Due to the proximity of residential development, some nonpoint pollution seems likely.

Stream Impacts Assessment: Substantial bank erosion is currently taking place and increased stormwater flows would only exacerbate this already serious condition.

Padden Creek, Reach 8 (D-31)

Reach Locators: Downstream limit, confluence with Connelly Creek; Upstream limit, culvert at Old Fairhaven Parkway; Associated with wetland PA-26.

Channel Dimensions: High Flow Width, 13 feet; Bankful Width, 17 feet; Low Water Width, 8 feet; Bankful Depth, 3 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small amount of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some to frequent cutting of the lower creek bank was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a fine and coarse gravel substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 3 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally good. The reach could be enhanced by removing trash and enhancing plant species diversity with tree and shrub plantings. Clear water suggested that overall water quality was good, but the nearby road (Fairhaven Parkway) could contribute nonpoint pollutants. Loose gravel, which may be suitable salmon spawning habitat, were observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 9 (D-33)

Reach Locators: Downstream limit, culvert at Old Fairhaven Parkway; Upstream limit, culvert at 30th Street.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 18 feet; Low Water Width, 6 feet; Bankful Depth, 3 feet; Low Water Depth, 0.5 feet; Stream Gradient, 3 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The immature/even-aged forest was developed with an overall density of 50 to 70 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 4 feet/second was observed.

Stream Evaluations: Stream aesthetics are low to moderate in this reach due to adjacent roads and paved parking areas. Clear water suggested that overall water quality was good although adjacent large paved surfaces could contribute automobile-related nonpoint pollutants. Loose gravel, which may be suitable salmon spawning habitat, was observed.
Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

Padden Creek, Reach 10 (D-35)

Reach Locators: Downstream limit, culvert at 30th Street; Upstream limit, culvert at I-5.

Channel Dimensions: High Flow Width, 11 feet; Bankful Width, 20 feet; Low Water Width, 6 feet; Bankful Depth, 2.5 feet; Low Water Depth, 0.5 feet; Stream Gradient, 4 percent; Bank Undercut, 25 percent.

Riparian Vegetation: The vegetation was characterized as (1) mature forest and (2) an area of maintained lawn associated with nearby residential development. The overall vegetation density was 50 to 70 percent. The stream canopy was estimated at 70 percent cover and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 3 feet/second was observed. A piece of PVC pipe approximately four inches in diameter and several hundred feet in length was located in the bed of the creek and was reported to be related to fish stocking of the waterway.

Stream Evaluations: Stream aesthetics were generally good except where maintained lawn areas replaced natural vegetation in the riparian corridor and where the white and blue PVC pipe existed. Enhancement of stream banks with native trees and shrubs would be desirable in the lawn areas; however, these areas are apparently privately owned. Clear water suggested that overall water quality was good, but fertilizers and herbicides resulting from maintenance of nearby lawns may be a source of nonpoint pollution. Loose gravel, which may be suitable salmon spawning habitat, was observed.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows.

CHUCKANUT CREEK STUDY AREA

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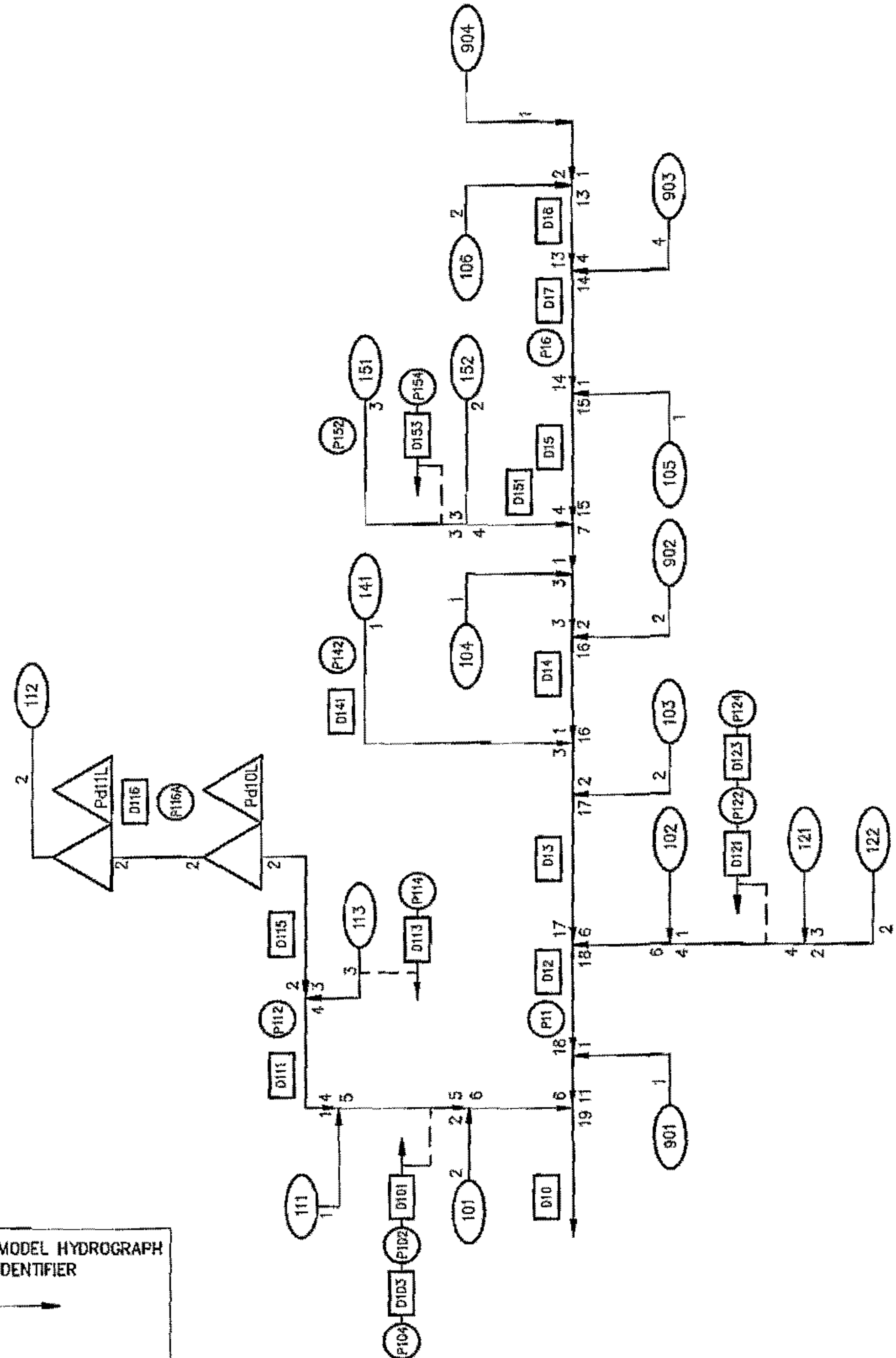

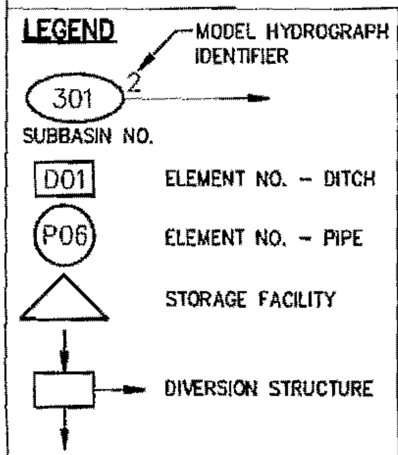

HYDROLOGIC MODEL SCHEMATIC
FOR CHUCKANUT CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE
9.1

9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Chuckanut Creek - Existing Condition
Sep-95

Volume 2
Table 9.2

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10				2.5			78.2	3.9	0.8	277.9	6.2	1.6	435.2	7.2	2.1
P11	11.28	4251.8	42.5		30.0	2300.0	74.6	16.2	1.0	267.1	23.7	1.9	419.4	27.1	2.4
D12				5.0			74.6	4.0	0.7	267.1	6.5	1.5	419.4	7.6	2.0
D13				5.0			73.1	4.1	0.7	261.9	6.5	1.5	411.7	7.6	1.9
D14				5.0			72.3	4.1	0.8	259.5	6.5	1.6	408.4	7.7	2.1
D15				4.0			59.2	3.1	0.5	215.9	5.1	1.0	344.7	6.1	1.3
P16	15.00	3745.0	21.2		25.0	3500.0	57.7	7.8	1.3	210.9	11.4	2.4	337.5	13.2	3.0
D17				4.0			57.7	2.5	0.8	210.9	3.9	1.6	337.5	4.6	2.1
D18				4.0			47.0	3.5	0.5	174.4	5.6	1.0	284.2	6.7	1.3
D101				4.0			1.0	3.5	0.1	5.9	6.7	0.3	10.2	8.0	0.4
P102	2.00	34.8	11.1		10.0	45.0	1.0	4.8	0.2	6.0	8.3	0.6	10.2	9.6	0.7
D103				8.0			1.0	1.4	0.1	6.0	2.8	0.3	10.2	3.5	0.4
P104	1.25	4.5	3.7		2.5	8.0	1.0	2.9	0.4	6.0	4.9	full	10.2	8.3	full
D111				4.0			1.4	2.6	0.2	5.5	4.2	0.4	7.4	4.7	0.5
P112	2.00	25.9	8.3		6.0	35.0	1.4	4.4	0.3	5.5	6.6	0.6	7.4	7.1	0.7
D113				4.0			1.2	3.0	0.2	2.1	3.6	0.3	2.6	3.9	0.3
P114	1.50	8.8	5.0		4.0	15.0	1.2	3.5	0.4	2.1	4.1	0.5	2.6	4.3	0.6
D115				3.5			1.4	2.1	0.2	5.4	3.4	0.5	7.3	3.7	0.6
P116A	1.25	14.2	11.6		2.0	5.0	2.0	8.1	0.3	5.7	11.0	0.5	7.7	11.8	0.6
D116				3.0			2.0	3.2	0.2	5.7	4.5	0.4	7.7	4.9	0.5
D121				4.0			1.1	4.5	0.1	7.8	9.2	0.2	13.2	11.1	0.4
P122	2.83	309.6	49.3		5.5	55.0	1.1	11.7	0.1	7.9	21.0	0.3	13.4	24.6	0.4
D123				4.0			1.1	3.5	0.1	7.9	7.0	0.3	13.4	8.4	0.5
P124	2.00	92.0	29.3		6.0	26.0	1.1	10.0	0.2	7.9	17.9	0.4	13.6	21.0	0.5
D141				3.0			1.6	5.2	0.1	4.5	7.4	0.3	6.2	8.2	0.3
P142	1.50	18.0	10.2		4.0	16.0	1.6	6.3	0.3	4.5	8.5	0.5	6.3	9.3	0.6
D151				3.0			4.2	4.8	0.3	9.7	6.2	0.5	16.8	7.2	0.7
P152	1.50	53.7	30.4		4.0	13.0	3.6	17.3	0.3	7.8	21.6	0.4	11.9	24.4	0.5
D153				3.0			1.0	2.7	0.2	3.8	4.1	0.4	6.5	4.8	0.5
P154	1.50	53.8	30.4		4.0	13.0	1.1	12.1	0.2	3.9	17.6	0.3	6.6	20.7	0.4

Bellingham Watershed Master Plan Flow Table
Basin Name : Chuckanut Creek - Future Condition
Sep-95

Volume 2
Table 9.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
D10				2.5			127.3	4.7	1.0	525.6	7.7	2.3	814.7	8.9	3.0
P11	11.28	4251.8	42.5		30.0	2300.0	120.5	18.7	1.3	506.2	28.6	2.6	784.6	32.4	3.3
D12				5.0			120.5	4.8	0.9	506.2	8.1	2.2	784.6	9.4	2.9
D13				5.0			118.5	4.9	0.9	499.2	8.2	2.2	772.8	9.5	2.8
D14				5.0			117.6	4.9	1.0	496.2	8.2	2.4	767.8	9.6	3.1
D15				4.0			102.6	3.9	0.7	440.3	6.7	1.6	678.7	7.9	2.0
P16	15.00	3745.0	21.2		25.0	3500.0	99.8	9.2	1.7	433.0	14.1	3.4	668.0	16.0	4.3
D17				4.0			99.8	3.0	1.1	433.0	5.0	2.5	668.0	5.7	3.1
D18				4.0			88.2	4.4	0.7	378.7	7.4	1.6	579.4	8.5	2.0
D101				4.0			4.3	6.0	0.2	15.2	9.0	0.4	22.3	10.2	0.5
P102	2.00	34.8	11.1		10.0	45.0	4.3	7.5	0.5	15.4	10.7	0.9	22.5	11.8	1.2
D103				8.0			4.3	2.5	0.2	15.4	4.0	0.4	22.5	4.6	0.6
P104	1.25	4.5	3.7		2.5	8.0	4.4	4.2	1.0	15.4	12.6	Full	22.6	18.4	Full
D111				4.0			5.4	4.2	0.4	10.3	5.2	0.6	14.4	5.8	0.7
P112	2.00	25.9	8.3		6.0	35.0	5.5	6.5	0.6	10.5	7.8	0.9	15.1	8.6	1.1
D113				4.0			3.7	4.4	0.4	10.2	6.0	0.6	14.6	6.7	0.8
P114	1.50	8.8	5.0		4.0	15.0	3.8	4.8	0.7	11.1	6.2	Full	15.6	8.8	Full
D115				3.5			4.6	3.2	0.4	8.5	3.9	0.6	10.1	4.1	0.7
P116A	1.25	14.2	11.6		2.0	5.0	4.8	10.4	0.5	8.7	12.1	0.7	10.1	12.6	0.8
D116				3.0			4.8	4.2	0.4	8.7	5.0	0.6	10.1	5.3	0.6
D121				4.0			3.1	5.9	0.2	14.9	10.0	0.4	23.0	11.4	0.5
P122	2.83	309.6	49.3		5.5	55.0	3.2	15.9	0.2	15.1	25.5	0.4	23.2	28.9	0.5
D123				4.0			3.2	5.1	0.2	15.1	8.7	0.5	23.2	10.0	0.6
P124	2.00	92.0	29.3		6.0	26.0	3.2	13.7	0.3	15.2	21.7	0.6	23.3	24.4	0.7
D141				3.0			2.6	6.1	0.2	6.7	8.4	0.3	9.1	9.3	0.4
P142	1.50	18.0	10.2		4.0	16.0	2.6	7.3	0.4	6.7	9.5	0.6	9.2	10.3	0.8
D151				3.0			5.4	5.2	0.4	21.7	7.7	0.8	32.1	8.5	1.0
P152	1.50	53.7	30.4		4.0	13.0	4.8	18.8	0.3	19.3	27.9	0.6	29.1	31.0	0.8
D153				3.0			0.9	2.6	0.2	5.9	4.6	0.4	10.4	5.5	0.6
P154	1.50	53.8	30.4		4.0	13.0	0.9	11.5	0.1	6.3	20.4	0.4	10.8	23.8	0.5

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Chuckanut Creek – Existing
Oct–93

VOLUME 2
TABLE 9.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	0.0	0.0	4122.9	2196.9	6319.8
COD	0.0	0.0	0.0	3817.5	0.0	3817.5
TSS	0.0	0.0	0.0	2290.5	45744.4	48034.9
DS	0.0	0.0	0.0	15270.0	21969.4	37239.4
TOTAL NITROGEN	0.0	0.0	0.0	41.8	22.0	63.8
TOTAL AMMONIA	0.0	0.0	0.0	195.2	33.1	228.3
TOTAL PHOSPHORUS	0.0	0.0	0.0	596.4	154.1	750.5
DISSOLVED PHOSPHORUS	0.0	0.0	0.0	234.1	5.3	239.4
COPPER	0.0	0.0	0.0	4.6	15.0	19.6
LEAD	0.0	0.0	0.0	15.3	12.0	27.3
ZINC	0.0	0.0	0.0	30.5	12.0	42.6
LAND USE (ACRES)	0.0	0.0	0.0	152.7	601.9	754.6

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Chuckanut Creek – Future
Oct–93

VOLUME 2
TABLE 9.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	0.0	0.0	0.0	9452.7	1476.4	10929.1
COD	0.0	0.0	0.0	8752.5	0.0	8752.5
TSS	0.0	0.0	0.0	5251.5	30742.0	35993.5
DS	0.0	0.0	0.0	35010.0	14764.3	49774.3
TOTAL NITROGEN	0.0	0.0	0.0	95.9	14.8	110.7
TOTAL AMMONIA	0.0	0.0	0.0	447.4	22.2	469.7
TOTAL PHOSPHORUS	0.0	0.0	0.0	1367.5	103.6	1471.0
DISSOLVED PHOSPHORUS	0.0	0.0	0.0	536.7	3.6	540.3
COPPER	0.0	0.0	0.0	10.5	10.1	20.6
LEAD	0.0	0.0	0.0	35.0	8.1	43.1
ZINC	0.0	0.0	0.0	70.0	8.1	78.1
LAND USE (ACRES)	0.0	0.0	0.0	350.1	404.5	754.6

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Chuckanut Creek
Oct–93

VOLUME 2
TABLE 9.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	66.8	11.4	98	55.4	71	11.4	98	55.4	71
111	53.1	1.3	98	51.8	74	7.1	98	46.0	79
112	157.8	9.3	98	148.5	71	54.0	98	103.8	79
102	29.5	0.6	98	28.9	73	0.6	98	28.9	73
121	33.0	1.1	98	31.9	74	2.7	98	30.3	78
122	28.8	0.4	98	28.4	74	2.3	98	26.5	77
103	19.5	0.6	98	18.9	71	0.6	98	18.9	71
113	34.0	2.1	98	31.9	78	7.7	98	26.3	79
104	61.7	2.1	98	59.6	74	4.1	98	57.6	72
141	17.2	3.3	98	13.9	80	4.2	98	13.0	83
105	87.6	8.0	98	79.6	72	14.1	98	73.5	78
151	80.0	9.3	98	70.7	69	10.7	98	69.3	76
152	45.5	2.8	98	42.7	72	2.4	98	43.1	73
106	58.4	5.9	98	52.5	71	4.7	98	53.7	77
901	43.8	0.5	98	43.3	76	7.1	98	36.7	85
902	498.3	6.0	98	492.3	77	6.0	98	492.3	77
903	563.6	8.3	98	555.3	76	8.3	98	555.3	76
904	2955.8	97.8	98	2858.0	72	97.8	98	2858.0	72
TOTAL	4834.4	170.8		4663.6		245.8		4588.6	
%	100.0%	3.5%		96.5%		5.1%		94.9%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Chuckanut Creek – Existing
Oct–93

VOLUME 2
TABLE 9.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	66.8	11.4	98	55.4	71	1.8	80					45.3	70			8.2	77
111	53.1	1.3	98	51.8	74							51.7	74				
112	157.8	9.3	98	148.5	71	10.6	92					109.6	64	16.1	100	12.2	78
102	29.5	0.6	98	28.9	73							28.8	73	0.1	100		
121	33.0	1.1	98	31.9	74							30.6	74			1.3	78
122	28.8	0.4	98	28.4	74							28.4	74				
103	19.5	0.6	98	18.9	71							18.9	71				
113	34.0	2.1	98	31.9	78							15.9	77			15.9	79
104	61.7	2.1	98	59.6	74							53.2	72	1.3	100	5.0	85
141	17.2	3.3	98	13.9	80							6.6	76			7.3	84
105	87.6	8.0	98	79.6	72							62.6	69			17.0	82
151	80.0	9.3	98	70.7	69							70.5	69				
152	45.5	2.8	98	42.7	72							42.5	72				
106	58.4	5.9	98	52.5	71							37.3	68	0.8	100	14.3	78
901	43.8	0.5	98	43.3	76							43.3	76				
902	498.3	6.0	98	492.3	77							492.3	77				
903	563.6	8.3	98	555.3	76							525.6	76			29.7	82
904	2955.8	97.8	98	2858.0	72							2575.1	71			282.9	80
TOTAL	4834.4	170.8		4663.6		12.4						4238.2		18.3		393.8	
%	100.0%	3.5%		96.5%		0.3%						87.7%		0.4%		8.1%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Chuckanut Creek – Future
Oct–93

VOLUME 2
TABLE 9.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN		LANDSCAPE		OPEN SPACE		FORESTED		OPEN WATER		MEADOW	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	66.8	11.4	98	55.4	71	1.8	80					45.3	70			8.2	77
111	53.1	7.1	98	46.0	79	19.4	83					26.6	76				
112	157.8	54.0	98	103.8	79	50.3	81					37.5	66	16.1	100		
102	29.5	0.6	98	28.9	73							28.8	73	0.1	100		
121	33.0	2.7	98	30.3	78	7.2	80					23.1	77				
122	28.8	2.3	98	26.5	77	6.3	81					20.2	76				
103	19.5	0.6	98	18.9	71							18.9	71				
113	34.0	7.7	98	26.3	79	21.2	82					5.1	66				
104	61.7	4.1	98	57.6	72	11.3	84					45.0	68	1.3	100		
141	17.2	4.2	98	13.0	83	11.3	86					1.7	64				
105	87.6	14.1	98	73.5	78	38.5	83					35.0	72				
151	80.0	10.7	98	69.3	76	29.3	82					40.0	72				
152	45.5	2.4	98	43.1	73	6.7	84					36.4	71				
106	58.4	4.7	98	53.7	77	12.8	80					40.9	74	0.8	100		
901	43.8	7.1	98	36.7	85											36.6	85
902	498.3	6.0	98	492.3	77							492.3	77				
903	563.6	8.3	98	555.3	76							525.6	76			29.7	82
904	2955.8	97.8	98	2858.0	72							2575.1	71			282.9	80
TOTAL	4834.4	245.8		4588.6		216.1		0.0		0.0		3997.5		18.3		357.4	
%	100.0%	5.1%		94.9%		4.5%		0.0%		0.0%		53.3%		0.4%		7.4%	

9.9 CHUCKANUT CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Refer to Figures 10.0 and 10.2 in the Watershed Master Plan.

Six wetlands (CH-1, CH-10, CH-27, CH-26, CH-31, and CH-47) in the Chuckanut Creek drainage basin were field inventoried and are described below. Stream reaches along Chuckanut Creek are described in a separate section following the wetland descriptions.

9.9.1 Chuckanut Creek Wetland Descriptions

CH-1 (Chuckanut Creek, Reach 1)

Wetland Description: This wetland is part tidal marsh and part forested wetland located at the mouth of Chuckanut Creek where it enters Chuckanut Bay. An herbaceous plant community dominated the tidal marsh and three vegetation layers characterized as dense with old plant community maturity and high species diversity occurred along the marsh's periphery. The dominant marsh plant species included Virginia glasswort (*Salicornia virginica*) and Pacific cinquefoil (*Potentilla pacifica*) and the dominant forested wetland species included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), rose (*Rosa* sp.), tall fescue (*Festuca arundinacea*). Persistent vegetation dominated the forested wetland area. No surface water was observed in the wetland except for Chuckanut Creek itself, therefore no flow rate was measured in the wetland. Approximately 2 percent of the wetland basin was filled when the tide was out and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as permanently saturated and seasonally flooded. An unconstricted outlet was observed. Fine mineral soil and muck formed the wetland substrate which had an approximate slope of 1 percent. The complexity of the wetland/upland boundary was medium. This wetland measures approximately 6.5 acres in size.

Wetland Values: The wildlife habitat potential was rated as high because of the wetland's high structural diversity and low density of adjacent development. The water quality benefits rating was moderate to high. A moderate floodwater attenuation function would be provided by abundant persistent vegetation and the wide flood basin available at low tide.

Wetland Impacts: Moderate increases in floodwater would have little impact on this wetland. Nearby septic systems may be sources of nonpoint pollution.

CH-10 (Chuckanut Creek, Reach 3)

Wetland Description: This wetland is forested with three layers of vegetation characterized as dense with moderate plant community maturity and low species diversity. The dominant plant species in this wetland included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), and pig-a-back (*Tolmiea menziesii*). Persistent vegetation dominated this wetland. No surface water was observed, therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 3 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 0.2 acres in size.

Wetland Values: Despite the relatively good condition of the wetland and surrounding forest vegetation, wildlife habitat potential was rated as moderate due to the wetland's relatively small size. A low water quality benefits rating was given because only minor volumes of water pass through this wetland. Low flow attenuation potential would be provided by sparse persistent vegetation.

Wetland Impacts: This wetland had little adjacent land use. Increased stormwater flow would probably have only minor effects.

"Pond" - Uninventoried Wetland (Chuckanut Creek, Reach 3) (not inventoried in Bellingham Wetland Inventory (BWI) - different from CH-10 in the BWI)

Wetland Description: This wetland is an open water pond identified on Figure 10.2 as "Pond". The marginally vegetated perimeter of the pond located in a woodland has one layer of vegetation (emergents) characterized as low density with young plant community maturity and low species diversity. No dominant plant species were identified as this pond was effectively free of vegetation. No flow was observed in this open water area. Roughly 100 percent of the wetland basin was filled at low water and consequently, the potential for an expanded water surface was considered low. The hydroperiod was evaluated as permanently flooded. A constricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 0 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 0.2 acres in size.

Wetland Values: The wildlife habitat potential was rated as low to moderate due to the wetland's small size and virtual absence of vegetation. Vegetation and size were also the primary considerations leading to a low to moderate water quality benefits rating. Low flow attenuation potential would be provided by essentially no available flood basin.

Wetland Impacts: This wetland had little adjacent land use. Increased stormwater flow may flood the existing wetland basin but would probably have only minor effects.

CH-26 (Chuckanut Creek, Reach 3)

Wetland Description: This wetland had three layers of vegetation characterized as dense with old plant community maturity and high species diversity. The dominant plant species included red alder (*Alnus rubra*), western red cedar (*Thuja plicata*), salmonberry (*Rubus spectabilis*) and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated in this wetland. Minor surface water was observed, and a flow rate of 0.5 feet/second was measured. Roughly 1 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as permanently saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was medium. This wetland measures approximately 0.7 acres in size.

Wetland Values: Because of the relatively undisturbed character of the wetland and the surrounding forest, the wildlife habitat potential was rated as high. The small size of the wetland combined with the presence of thick herbaceous vegetation merited a moderate water quality benefits rating. Moderate flow attenuation potential would be provided by thick persistent vegetation.

Wetland Impacts: Additional stormwater flows would have only minor effects on this wetland.

CH-27 (Chuckanut Creek, Reach 3)

Wetland Description: This wetland had three layers of vegetation characterized as dense with intermediate plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), pig-a-back plant (*Tolmiea menziesii*) and skunk cabbage (*Lysichitum americanum*). Persistent vegetation dominated this wetland. No surface water was observed, consequently no flow rate was measured. Less than 1 percent of the wetland basin was filled at the time of the investigation and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 5 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 0.3 acres in size.

Wetland Values: The wildlife habitat potential was rated as moderate and the small size of the wetland combined with the presence of thin herbaceous vegetation merited a low water quality benefits rating. Flow attenuation potential was rated low due to the small size and relatively steep grade of the wetland.

Wetland Impacts: Additional stormwater flows would have only minor effects on this wetland.

CH-31 (Chuckanut Creek, Reach 4)

Wetland Description: This wetland had three layers of vegetation characterized as moderately dense with intermediate plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*) and skunk cabbage (*Lysichitum americanum*). Persistent and nonpersistent vegetation occurred in this wetland. No flow rate was measured. Approximately 5 percent of the wetland basin was filled at low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Clay and fine mineral soils formed the wetland substrate which had a slope of approximately 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 0.4 acres in size.

Wetland Values: Wildlife habitat potential was rated as moderate. Herbaceous vegetation provides biofiltration functions and contributes to a moderate to high water quality benefits rating. Moderate to high flow attenuation potential would be provided by persistent vegetation and a sizable available flood basin.

Wetland Impacts: This wetland had little adjacent land use and minor impact from human use, except for potential nonpoint pollution from I-5 stormwater runoff. Increased stormwater flows would probably have only minor effects on the wetland.

CH-47 (Chuckanut Creek, Reach 5)

Wetland Description: This wetland had three layers of vegetation with moderate density with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), salmonberry (*Rubus spectabilis*), creeping buttercup (*Ranunculus repens*) and pig-a-back (*Tolmiea menziesii*). Persistent vegetation plant dominated this wetland. A wetland surface water flow rate of 0.5 feet/second was measured. The wetland basin was approximately 5 percent full at low water and the potential for an expanded water surface was considered low. The hydroperiod was evaluated as seasonally saturated. An unconstricted outlet was observed. Fine mineral soils formed the wetland substrate which had a slope of approximately 4 percent. The complexity of the wetland/upland boundary was low to medium. This wetland measures approximately 0.3 acres in size.

Wetland Values: The wildlife habitat potential was rated as low due to the wetlands' small size and low structural diversity. A low to moderate water quality benefits rating was assigned based on small wetland size and thin herbaceous vegetation. Low to moderate flow attenuation potential would be provided by scattered persistent vegetation.

Wetland Impacts: This wetland had little adjacent land use and minor impact from human use. Increased stormwater flow would have only slight effects on this forested wetland.

9.9.2 Chuckanut Creek Stream Reach Descriptions

Refer to Figure 10.2 in the Watershed Master Plan.

Reach descriptions cover Chuckanut Creek from its outlet at Bellingham Bay east and southeastward to the Bellingham city limits.

Chuckanut Creek, Reach 1 (D10)

Reach Locators: Downstream limit, Chuckanut Bay; Upstream limit, culvert for a private drive; Associated with wetland CH-1.

Channel Dimensions: High Flow Width, 17 feet; Bankful Width, 18 feet; Low Water Width, 10 feet; Bankful Depth, 2.5 feet; Low Water Depth, 0.3 feet; Stream Gradient, 1.5 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 50 percent cover and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Small amounts of mass wasting were observed and no debris jams were noted on the upper bank. Channel overflow was rated as occasional. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a coarse gravel substrate with moderate particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty and the water was clear. A flow rate of approximately 2.5 feet/second was observed.

Stream Evaluations: Stream aesthetics were generally excellent. Clear water suggested that overall water quality was good; however, septic systems associated with nearby residential development may be a source of nonpoint pollution.

Stream Impacts Assessment: This reach is susceptible to additional erosion and cutting with increased stormwater flows. Greater stormwater flows would increase the potential flood hazard for existing residential development adjacent to the creek.

Chuckanut Creek, Reach 2 (D10)

Reach Locators: Downstream limit, culvert for a private drive; Upstream limit, culvert under Chuckanut Drive.

Channel Dimensions: High Flow Width, 35 feet; Bankful Width, 40 feet; Low Water Width, 5 feet; Bankful Depth, 6 feet; Low Water Depth, 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 85 percent cover and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. Moderate to large amounts of mass wasting were observed and no debris jams were noted on the upper bank. Channel overflow was considered very unlikely. Bank rock content was less than 20 percent and there were no flow obstructions on the lower bank. Frequent cutting of the creek banks was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a sand, coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at greater than 50 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow rate of approximately 3 feet/second was observed.

Stream Evaluations: In general, stream aesthetics were excellent. The relatively undeveloped character of the reach made for good wildlife habitat. Clear water suggested that overall water quality was good; although, houses on septic system at the low end of the reach could contribute nonpoint pollutants.

Stream Impacts Assessment: The substantial bank erosion observed along this reach would be exacerbated with increased stormwater flows.

Chuckanut Creek, Reach 3 (D12, D13, D14)

Reach Locators: Downstream limit, culvert at Chuckanut Drive; Upstream limit, change in stream characteristics; associated with wetlands CH-10, CH-26 and CH-27.

Channel Dimensions: High Flow Width, 23 feet; Bankful Width, 28 feet; Low Water Width, 6 feet; Bankful Depth, 5 feet; Low Water Depth, 0.5 feet; Stream Gradient, 4 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 95 percent cover and the estimated shade was 100 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. Small amounts of mass wasting were observed and moderate debris jams were noted on the upper bank. Channel overflow was rated as rare. Bank rock content ranged from 40 to 65 percent and there were many flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a sand, coarse gravel, cobble, boulder and bedrock substrate with loose particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow rate of approximately 3 feet/second was observed.

Stream Evaluations: In general, this long, unusually uniform reach had excellent stream aesthetics. The presence of mature forest vegetation and the relatively undeveloped character of the reach made for good wildlife habitat. Clear water suggested that overall water quality was good. No obvious sources of nonpoint pollution were observed.

Stream Impacts Assessment: Portions of the creek which were naturally armored with bedrock and boulders could take greater stormwater flows but in areas where existing bank erosion was observed, greater flows may exacerbate the erosion problem.

Chuckanut Creek, Reach 4 (D14 and D15)

Reach Locators: Downstream limit, change in stream characteristics; Upstream limit, change in stream characteristics; Associated with wetland CH-31.

Channel Dimensions: High Flow Width, 21 feet; Bankful Width, 24 feet; Low Water Width, 6 feet; Bankful Depth, 4 feet; Low Water Depth, 0.5 feet; Stream Gradient, 4 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 80 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. No mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was greater than 65 percent and there were few flow obstructions on the lower bank. Some cutting of the creek banks was observed and the height of the raw banks was 6 to 12 inches. The creek bottom had a cobble and bedrock substrate with loose particle packing. Scouring and deposition was rated at 30 to 50 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of 3 feet/second was observed.

Stream Evaluations: Stream aesthetics were excellent. The lack of adjacent development and presence of mature forest vegetation provided good wildlife habitat. Clear water suggested that overall water quality was good; however a large stormwater drainage pipe from I-5 discharges into this reach and may contribute nonpoint pollutants.

Stream Impacts Assessment: The rocky character of this reach is resistent to erosion and could accommodate increased stormwater flows without anticipated serious erosion.

Chuckanut Creek, Reach 5 (D15)

Reach Locators: Downstream limit, change in stream characteristic; Upstream limit, culvert at Old Samish Way; Associated with wetland CH-47.

Channel Dimensions: High Flow Width, 35 feet; Bankful Width, 50 feet; Low Water Width, 8 feet; Bankful Depth, 4 feet; Low Water Depth 0.3 feet; Stream Gradient, 3 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall vegetation density of 70 to 90 percent. The stream canopy was estimated at 90 percent cover and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. No mass wasting and large debris jams were noted on the upper bank. Channel overflow was considered very unlikely. Bank rock content was less than 20 percent and there were moderate number of flow obstructions on the lower bank. No cutting of the creek banks was observed. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition was rated at greater than 50 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of 1.5 feet/second was observed.

Stream Evaluations: Stream aesthetics were good to excellent. Clear water suggested that overall water quality was good.

Stream Impacts Assessment: Absence of mass wasting and bank cutting suggested that this reach could accommodate increased stormwater flows.

Chuckanut Creek, Reach 6 (D17 and D18)

Reach Locators: Downstream limit, culvert at Old Samish Way; Upstream limit, Bellingham city limits.

Channel Dimensions: High Flow Width, 26 feet; Bankful Width, 29 feet; Low Water Width, 6 feet; Bankful Depth, 4 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature and immature/even-aged forest with an overall density of 50 to 70 percent. The stream canopy was estimated at 75 percent cover and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting was observed. Small debris jams were noted on the upper bank. Channel overflow was considered unlikely. Bank rock content was estimated at 20 to 40 percent and there were few flow obstructions on the lower bank. Some to frequent cutting of the creek banks was observed and the height of the raw banks was greater than 24 inches. The creek bottom had a gravel, cobble and boulder substrate with tight particle packing. Scouring and deposition was rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare and the water was clear. A flow velocity of approximately 2.5 feet/second was observed.

Stream Evaluations: In general, reach aesthetics were good to excellent except at the lower end where natural vegetation has been removed to create a horse pasture. Clear water suggested that overall water quality was good; however, the horse pasture is a likely nonpoint source of water pollutants (manure runoff). Additionally, denuded steep slopes associated with the horse pasture probably contribute sediment to the creek.

Stream Impacts Assessment: Bank erosion was noted in some areas and increased stormwater flows may accelerate the erosion process.

BAKER CREEK STUDY AREA

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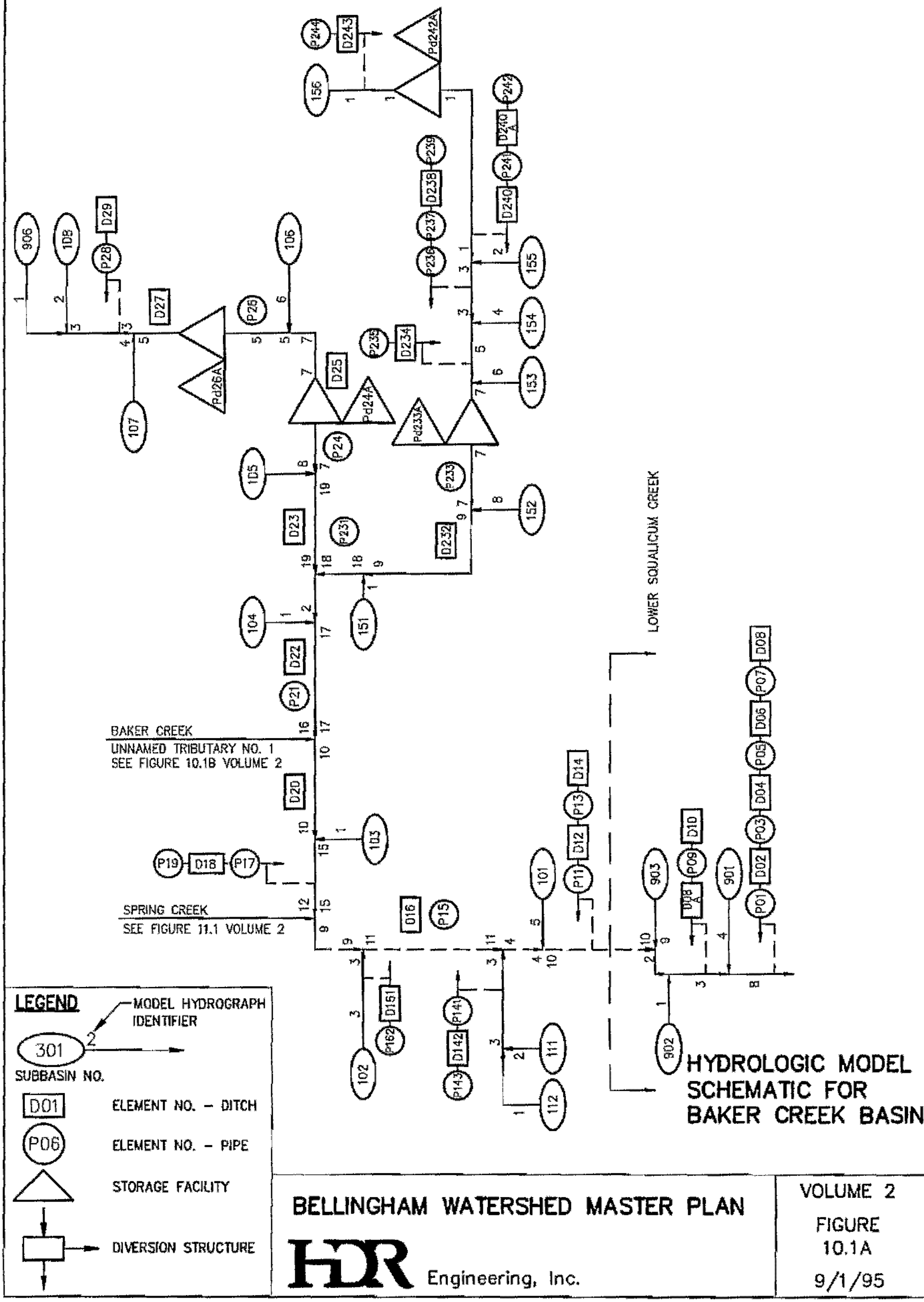
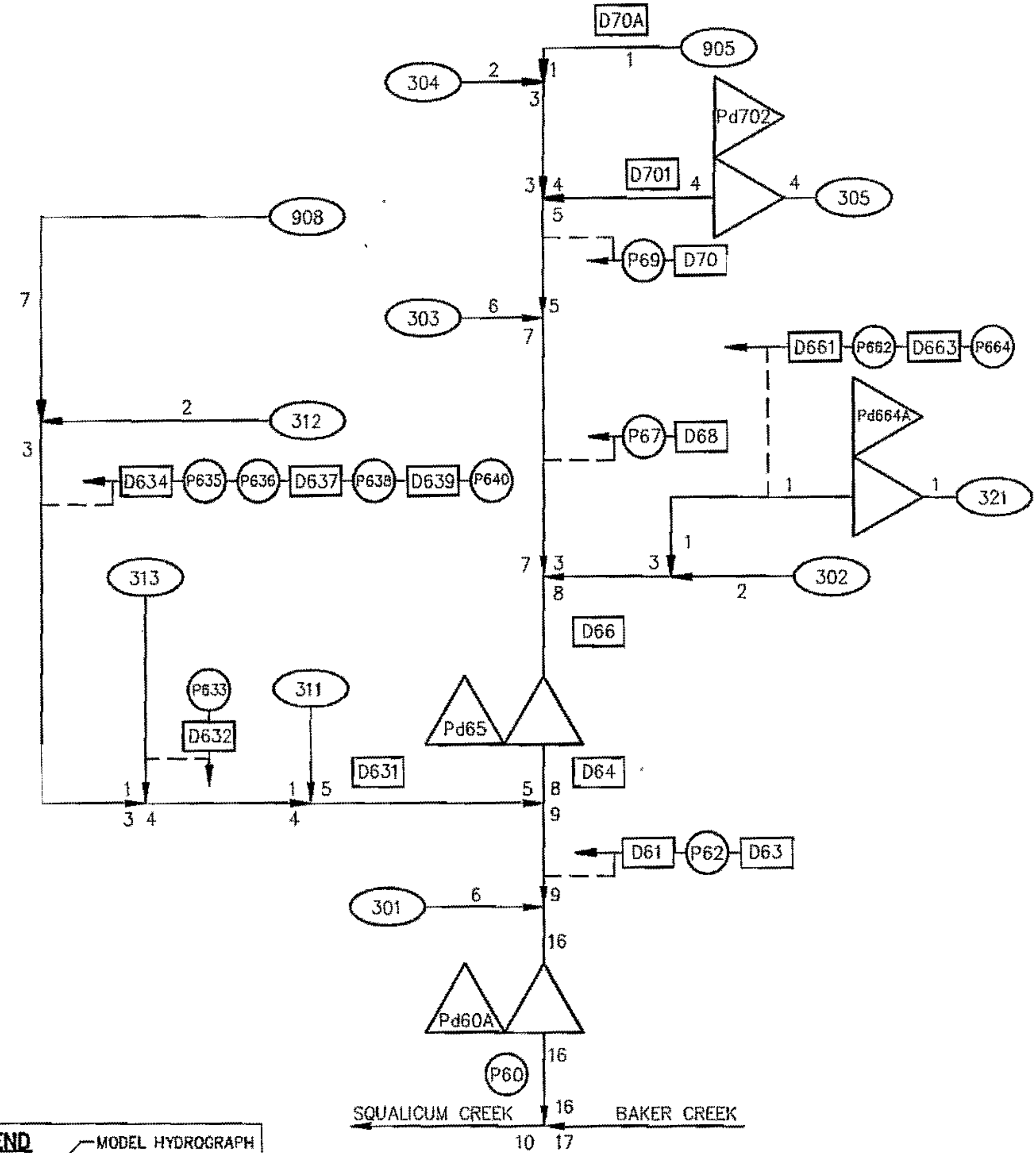
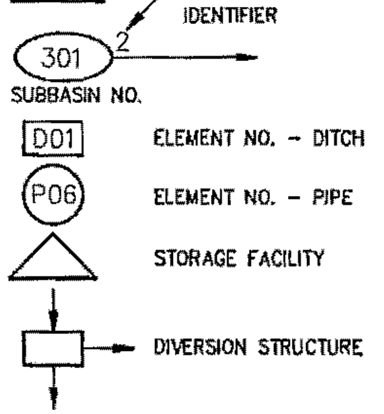


HYDROLOGIC MODEL SCHEMATIC FOR BAKER CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN	VOLUME 2
HDR Engineering, Inc.	FIGURE 10.1A 9/1/95





HYDROLOGIC MODEL SCHEMATIC FOR BAKER CREEK UNNAMED TRIBUTARY NO. 1

BELLINGHAM WATERSHED MASTER PLAN	VOLUME 2
HDR Engineering, Inc.	FIGURE 10.1B
	9/1/95

Bellingham Watershed Master Plan Flow Table
Basin Name : Baker Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P11	7.97	1856.5	37.2		10.0	480.0	171.0	23.2	1.6	489.2	31.4	2.7	647.2	33.8	3.2
D12				3.0			171.0	5.7	1.0	489.2	8.4	1.8	647.2	9.3	2.2
P13	7.00	1597.6	41.5		20.0	750.0	171.0	27.1	1.5	489.2	36.5	2.6	647.2	39.3	3.1
D14				2.5			171.0	5.1	1.7	489.2	7.0	3.0	647.2	7.5	3.4
P15	10.00	323.8	4.1		11.8	1000.0	165.0	4.1	5.0	475.6	6.0	full	629.9	8.0	full
D16				2.5			165.0	3.1	2.8	475.6	4.2	4.8	629.9	4.5	5.6
P17	8.00	431.6	8.2		9.0	475.0	86.3	6.4	2.4	241.2	8.5	4.4	333.1	9.1	5.4
D18				2.5			86.3	4.9	1.0	241.2	6.7	1.8	333.1	7.4	2.2
P19	6.00	460.0	16.3		8.0	280.0	86.3	12.5	1.8	241.2	16.5	3.1	333.1	17.7	3.8
D20				4.0			85.6	5.4	1.2	239.8	7.5	2.1	331.4	8.3	2.6
P21	4.00	87.2	6.9		7.0	140.0	63.1	7.6	2.5	178.8	14.2	full	252.0	20.0	full
D22				4.0			63.1	3.7	1.0	178.8	5.1	1.8	252.0	5.6	2.2
D23				3.0			53.5	2.6	1.5	157.4	3.6	2.7	216.9	4.0	3.2
P24	5.00	316.3	16.1		30.0	500.0	51.2	11.8	1.4	151.8	15.9	2.4	209.1	17.2	2.8
D25				3.0			53.6	2.7	1.4	157.0	3.7	2.5	245.1	4.2	3.1
P26	4.00	174.5	13.9		5.5	110.0	52.7	11.6	1.3	154.9	15.8	2.2	242.1	17.9	2.8
D27				3.0			53.6	3.4	1.5	185.9	4.8	2.9	272.8	5.3	3.5
P28	5.00	316.3	16.1		18.0	450.0	50.9	11.8	1.4	178.9	16.6	2.7	263.5	18.0	3.5
D29				3.0			50.9	2.5	1.3	178.9	3.6	2.7	263.5	4.0	3.3
P141	4.00	174.5	13.9				13.1	8.2	0.7	31.1	10.5	1.1	41.9	11.4	1.3
D142							13.1	2.8	0.7	31.1	3.7	1.1	41.9	4.0	1.2
P143	4.00	263.9	21.0				13.2	11.0	0.6	31.3	14.1	0.9	42.1	15.4	1.1
D161				10.0			21.8	4.2	0.6	40.9	5.3	0.9	51.1	5.7	1.0
P162	4.00	121.4	9.7		5.5	110.0	22.4	7.4	1.2	42.2	8.8	1.7	53.1	9.3	1.9
P231	4.00	174.5	13.9		8.0	150.0	14.9	8.5	0.8	31.8	10.6	1.2	37.9	11.1	1.3
D232				3.0			14.0	1.2	1.2	29.7	1.5	1.7	35.0	1.6	1.9
P233	2.00	31.8	10.1		20.0	140.0	13.3	9.7	0.9	26.3	11.3	1.4	30.3	11.5	1.5
D234				3.0			15.5	2.0	0.9	31.4	2.4	1.3	43.6	2.6	1.6
P235	2.00	27.5	8.8		12.0	50.0	15.7	9.0	1.1	31.9	10.2	full	44.6	14.2	full
P236	1.25	6.2	5.0		5.5	13.0	10.2	8.3	full	20.7	16.8	full	27.2	22.2	full
P237	1.50	7.9	4.5		5.5	18.0	10.2	5.8	full	20.7	11.7	full	27.2	15.4	full
D238				4.0			10.2	0.3	2.6	20.7	0.4	3.6	27.2	0.4	4.0
P239	1.25	1.3	1.0		2.5	13.0	13.0	10.6	full	24.8	20.2	full	32.1	26.2	full
D240				4.0			6.3	0.7	1.0	13.3	0.8	1.5	17.3	0.9	1.8
D240A				4.0			6.4	1.3	0.6	13.4	1.6	1.0	17.3	1.7	1.1

Bellingham Watershed Master Plan Flow Table
Basin Name : Baker Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P241	1.25	3.9	3.2		2.5	13.0	6.4	5.2	full	13.4	10.9	full	17.3	14.1	full
P242	2.33				3.0	28.0	6.4	5.7	0.7	13.5	7.0	1.1			
D243				4.0			9.1	1.3	0.8	17.5	1.6	1.2	22.5	1.7	1.3
P244	2.00	17.4	5.5		5.5	30.0	9.6	5.7	1.1	18.2	5.8	full	23.4	7.4	full
P60	4.00				25.0	350.0	24.7	10.0	1.0	67.0	13.3	1.7	86.1	14.2	2.0
D61				3.0			23.6	2.2	1.2	64.9	2.9	2.1	82.7	3.1	2.3
P62	5.00	730.6	37.2		12.0	290.0	23.6	18.1	0.7	65.1	24.1	1.2	82.8	25.7	1.4
D63				2.0			23.6	2.9	0.7	65.1	4.1	1.3	82.8	4.4	1.5
D64				1.0			16.5	2.3	0.5	42.1	3.2	0.8	53.5	3.5	0.9
D66				2.0			16.6	2.0	0.5	57.2	3.2	1.1	84.0	3.6	1.3
P67	2.50	14.1	2.9		10.5	75.0	15.1	3.1	full	51.5	10.5	full	75.2	15.3	full
D68				3.0			15.1	2.4	0.6	51.5	3.6	1.2	75.2	4.0	1.4
P69	2.00	49.2	15.6		8.0	42.0	14.4	13.6	0.7	49.5	15.7	full	72.4	23.1	full
D70				1.0			14.4	1.1	1.3	49.5	1.6	2.4	72.4	1.7	2.9
D70A							11.1	2.3	0.6	37.7	3.3	1.2	54.8	3.7	1.4
D631				3.0			8.9	2.1	0.7	31.8	3.1	1.3	46.7	3.4	1.6
D632				3.0			2.6	1.0	0.5	8.0	1.4	0.9	11.4	1.5	1.0
P633	1.25	7.9	6.4		6.5	23.0	2.7	5.8	0.5	8.2	6.6	full	11.6	9.4	full
D634				3.0			5.1	2.5	0.4	20.3	3.9	0.8	30.6	4.4	1.0
P635	2.00	22.4	7.1		4.0	28.0	5.1	5.8	0.7	20.3	8.1	1.5	30.6	9.8	full
P636	2.00	34.8	11.1		3.0	20.0	5.1	7.9	0.5	20.3	11.5	1.1	30.6	12.5	1.5
D637				3.0			5.1	1.7	0.5	20.3	2.6	1.1	30.6	2.9	1.4
P638	1.50	9.0	5.1		2.5	11.0	5.1	5.3	0.8	20.3	11.5	full	30.8	17.4	full
D639				3.0			5.1	0.9	0.9	20.3	1.3	1.8	30.8	1.4	2.2
P640	1.50	18.0	10.2		9.5	28.0	5.2	8.8	0.6	20.5	11.6	full	31.0	17.6	full
D661				3.0			0.4	0.4	0.1	1.3	0.6	0.3	2.0	0.7	0.3
P662	1.25	11.1	9.0		5.5	16.0	0.4	4.4	2.0	1.3	6.1	0.3	2.0	6.9	0.4
D663				3.0			0.4	0.8	0.1	1.3	1.2	0.2	2.0	1.4	0.2
P664	1.25	11.1	9.0		11.5	35.0	0.4	4.4	0.2	1.3	6.1	0.3	2.0	6.9	0.4
D701				1.0			2.1	0.3	1.0	8.1	0.5	1.9	12.6	0.5	2.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P11	7.97	1856.5	37.2		10.0	480.0	326.4	28.0	2.3	650.9	33.9	3.3	861.1	36.5	3.8
D12				3.0			326.4	7.3	1.4	650.9	9.3	2.2	861.1	10.3	2.6
P13	7.00	1597.6	41.5		20.0	750.0	326.4	32.6	2.1	650.9	39.4	3.1	861.1	42.3	3.6
D14				2.5			326.4	6.2	2.4	650.9	7.5	3.4	861.1	8.2	3.9
P15	10.00	323.8	4.1		11.8	1000.0	318.9	4.9	6.9	635.9	6.1	full	841.1	8.1	full
D16				2.5			318.9	3.7	3.9	635.9	4.5	5.6	841.1	4.8	6.5
P17	8.00	431.6	8.2		9.0	475.0	170.8	7.8	3.6	346.6	9.2	5.5	405.4	9.4	6.3
D18				2.5			170.8	6.1	1.5	346.6	7.5	2.2	405.4	7.9	2.4
P19	6.00	460.0	16.3		8.0	280.0	170.8	15.1	2.5	346.6	17.9	3.9	405.5	18.4	4.4
D20				4.0			169.9	6.7	1.8	345.1	8.4	2.6	403.7	8.8	2.9
P21	4.00	87.2	6.9		7.0	140.0	122.2	9.7	full	264.1	21.0	full	310.8	24.7	full
D22				4.0			122.2	4.5	1.5	264.1	5.7	2.2	310.8	6.0	2.4
D23				3.0			104.2	3.2	2.1	229.2	4.0	3.3	274.3	4.2	3.6
P24	5.00	316.3	16.1		30.0	500.0	100.2	14.3	2.1	221.7	17.4	3.1	265.5	18.1	3.5
D25				3.0			112.3	3.4	2.1	257.9	4.2	3.1	295.7	4.4	3.4
P26	4.00	174.5	13.9		5.5	110.0	110.6	14.7	2.3	254.6	20.3	full	291.7	23.2	full
D27				3.0			123.5	4.3	2.3	333.5	5.6	3.8	458.9	6.1	4.5
P28	5.00	316.3	16.1		18.0	450.0	118.3	14.9	2.1	323.0	16.5	full	444.5	22.6	full
D29				3.0			118.3	3.2	2.1	323.0	4.2	3.6	444.5	4.6	4.3
P141	4.00	174.5	13.9				21.1	9.4	0.9	43.2	11.5	1.4	55.7	12.3	1.6
D142							21.1	3.2	0.9	43.2	4.0	1.3	55.7	4.3	1.5
P143	4.00	263.9	21.0				21.6	12.7	0.8	43.6	15.5	1.1	55.9	16.7	1.3
D161				10.0			24.0	4.4	0.6	44.4	5.4	0.9	55.6	5.9	1.1
P162	4.00	121.4	9.7		5.5	110.0	24.5	12.4	0.9	45.5	14.8	1.2	56.9	15.8	1.3
P231	4.00	174.5	13.9		8.0	150.0	21.4	9.4	1.0	40.3	11.3	1.3	52.3	12.1	1.5
D232				3.0			20.4	1.4	1.5	36.3	1.6	1.9	46.1	1.7	2.2
P233	2.00	31.8	10.1		20.0	140.0	17.3	10.3	1.0	29.0	11.5	1.6	39.7	12.6	full
D234				3.0			19.6	2.1	1.0	40.3	2.6	1.5	51.7	2.8	1.7
P235	2.00	27.5	8.8		12.0	50.0	19.9	9.5	1.3	41.3	13.1	full	53.0	16.9	full
P236	1.25	6.2	5.0		5.5	13.0	12.8	10.4	full	25.1	20.5	full	32.3	26.3	full
P237	1.50	7.9	4.5		5.5	18.0	12.8	7.2	full	25.1	14.2	full	32.3	18.3	full
D238				4.0			12.8	0.3	2.9	25.1	0.4	3.9	32.3	0.4	4.4
P239	1.25	1.3	1.0		2.5	13.0	15.9	13.0	full	29.8	24.3	full	38.4	30.9	full
D240				4.0			8.7	0.7	1.2	17.3	0.9	1.8	19.5	0.9	1.9
D240A				4.0			8.7	1.4	0.8	17.4	1.7	1.1	19.5	1.8	1.2

Bellingham Watershed Master Plan Flow Table
Basin Name : Baker Creek - Future Condition
Sep-95

Volume 2
Table 10.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P241	1.25	3.9	3.2		2.5	13.0	8.7	7.1	full	17.4	14.2	full	19.5	15.9	full
P242	2.33				3.0	28.0	8.8	6.3	0.9	17.4	7.5	1.2	19.6	7.7	1.4
D243				4.0			12.0	1.4	1.0	22.7	1.7	1.3	28.9	1.8	1.5
P244	2.00	17.4	5.5		5.5	30.0	12.6	6.0	1.3	23.8	7.6	full	30.1	9.6	full
P60	4.00				25.0	350.0	54.7	12.6	1.5	99.4	14.7	2.1	119.3	15.3	2.4
D61				3.0			54.3	2.7	1.9	103.5	3.2	2.6	133.9	3.5	2.9
P62	5.00	730.6	37.2		12.0	290.0	54.4	21.8	0.9	103.6	26.3	1.3	134.1	28.4	1.5
D63				2.0			54.4	3.9	1.2	103.6	4.7	1.7	134.1	5.1	1.9
D64				1.0			35.1	3.0	0.7	55.8	3.6	0.9	62.4	3.7	1.0
D66				2.0			44.2	2.9	0.9	112.4	4.0	1.6	152.8	4.4	1.9
P67	2.50	14.1	2.9		10.5	75.0	39.7	8.1	full	100.6	20.5	full	136.8	27.9	full
D68				3.0			39.7	3.3	1.0	100.6	4.4	1.7	136.8	4.8	1.9
P69	2.00	49.2	15.6		8.0	42.0	38.3	17.3	1.3	97.3	30.9	full	131.8	41.9	full
D70				1.0			38.3	1.4	2.1	97.3	1.8	3.3	131.8	2.0	3.8
D70A							30.1	3.1	1.1	76.5	4.0	1.7	103.5	4.4	2.0
D631				3.0			26.4	2.9	1.2	65.0	3.8	1.9	86.2	4.1	2.2
D632	•			3.0			5.9	• 1.3	0.7	13.9	1.6	1.2	18.7	1.8	•1.3
P633	1.25	7.9	6.4		6.5	23.0	6.5	7.2	0.9	14.8	12.1	1.2	19.6	16.0	full
D634				3.0			18.8	3.8	0.8	47.7	5.0	1.3	64.1	5.4	1.5
P635	2.00	22.4	7.1		4.0	28.0	18.9	8.0	1.4	48.0	15.3	full	64.2	20.5	full
P636	2.00	34.8	11.1		3.0	20.0	18.9	11.3	1.1	48.0	15.3	full	64.2	20.5	full
D637				3.0			18.9	2.5	1.1	48.0	3.3	1.7	64.2	3.5	2.0
P638	1.50	9.0	5.1		2.5	11.0	19.3	10.9	full	48.9	27.7	full	65.9	37.3	full
D639				3.0			19.3	1.3	1.7	48.9	1.6	2.7	65.9	1.7	3.1
P640	1.50	18.0	10.2		9.5	28.0	20.1	11.4	full	50.1	28.4	full	67.7	38.3	full
D661				3.0			1.1	0.6	0.2	2.8	0.8	0.4	4.0	0.9	0.5
P662	1.25	11.1	9.0		5.5	16.0	1.1	5.7	0.3	2.8	7.5	0.4	4.0	8.3	0.5
D663				3.0			1.1	1.1	0.2	2.8	1.6	0.3	4.0	1.8	0.3
P664	1.25	11.1	9.0		11.5	35.0	1.1	5.7	0.3	2.8	7.5	0.4	4.0	8.3	0.5
D701				1.0			6.9	0.4	1.7	17.1	0.6	2.6	23.1	0.6	3.0

Baker Creek, Reach 2 (D-14)

Reach Locators: Downstream limit, culvert at Birchwood Avenue; Upstream limit, beginning of golf course. One of two parts of Wetland SQ-8 is associated with this reach.

Channel Dimensions: High Flow Width, 25 feet; Bankful Width, 30 feet; Low Water Width, 10 feet; Bankful Depth, 2.5 feet; Low Water Depth, 0.4 feet; Stream Gradient, 2 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 50 to 70 percent. The stream canopy was estimated at 30 percent cover, and the estimated shade was 45 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged between 40 and 60 percent. No mass wasting and a moderate number of debris jams were noted on the upper bank. The frequency of channel overflow was evaluated as rare. Bank rock content was 40 to 65 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Stream aesthetics were moderate. By adding native evergreen trees, this reach could be enhanced. Water quality appears to be worse than in the down-stream reach based on the observance of increased amounts of algae and iron-fixing bacteria colonies in the water. The upstream portion of this reach is a dry creekbed. Moderate density residential development occurs on both sides of the reach.

Stream Impacts Assessment: This reach has clay-lined stream sides, which probably could take increased stormwater flows with minimal problem.

Baker Creek, Reach 3 (D-14)

Reach Locators: Downstream limit, beginning of golf course; Upstream limit, change in stream characteristics. Two of three parts constituting Wetland SQ-9 were located in this reach.

Channel Dimensions: High Flow Width, 18 feet; Bankful Width, 18 feet; Low Water Width, 0 feet; Bankful Depth, 2 feet; Stream Gradient, 2 percent; Bank Undercut, 75 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 50 percent cover, and the estimated shade was 50 percent. Areas in this reach identified as wetlands by the Bellingham Wetland Inventory were not verified by this study.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. Small mass wasting sloughs and a lack of debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was estimated at 20 to 40 percent, and there were no flow obstructions on the lower bank. Frequent cutting of the lower creek bank was noted, and the height of the raw banks was 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at greater than 50 percent. The occurrence of aquatic vegetation was rare. Since this reach was dry, water clarity could not be evaluated and no flow was recorded.

Stream Evaluations: This reach was located within the golf course and consisted of alterating forested and maintained lawn plant assemblages. Stream aesthetics were mixed: aesthetics were low in the fairway portions of the reach where natural vegetation was absent while wooded portions were aesthetically good to excellent. Enhancement in the form of native shrub plantings along the creek where it crosses the fairway would help stabilize eroding stream banks and provide cover for wildlife. Lawn areas associated with the golf course were likely sources of nonpoint pollution including lawn fertilizers, herbicides, and pesticides. Water was present only in the upstream portion of this reach.

Stream Impacts Assessment: The existing problem of slope sloughing from fairway stream banks would be exacerbated by increased stormwater flows.

Baker Creek, Reach 4 (D-14)

Reach Locators: Downstream limit, change in stream characteristics; Upstream limit, change in stream characteristics (no significant landmarks).

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 7 feet; Bankful Depth, 3 feet; Low Water Depth, 2 feet; Stream Gradient, 1 percent; Bank Undercut, 35 percent.

Riparian Vegetation: The vegetation was characterized as pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 0 percent cover, and the estimated shade was 0 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. No mass wasting or debris jams were noted on the upper bank. The frequency of channel overflow was estimated as occasional. Bank rock content was 20 to 40 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 12 to 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty. The water clarity was murky. A flow velocity of 0.1 fps was observed.

Stream Evaluations: This reach was located within maintained lawn areas of the golf course. Reach enhancement with shrub plantings would enhance aesthetics and habitat values of the reach but might conflict with golf use. Murky water and thick algae accumulations on the stream substrate suggested high water nutrient levels that could be attributable to nonpoint pollution sources such as lawn fertilizers.

Stream Impacts Assessment: Herbaceous vegetation on the creek banks could handle some increased stormwater flows without serious adverse impacts.

Baker Creek, Reach 5 (D-14)

Reach Locators: Downstream limit, change in stream characteristics; Upstream limit, change in stream characteristics (no significant landmarks).

Channel Dimensions: High Flow Width, 18 feet; Bankful Width, 18 feet; Low Water Width, 0 feet; Bankful Depth, 2.5 feet; Stream Gradient, 2 percent; Bank Undercut, 75 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 50 percent cover, and the estimated shade was 50 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. Small mass wasting sloughs and no debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was estimated at 20 to 40 percent, and there were no flow obstructions on the lower bank. Frequent cutting of the lower creek bank was noted, and the height of the raw banks was 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at greater than 50 percent. The occurrence of aquatic vegetation was rare. Water clarity was clear, and a flow rate of approximately 0.1 fps was recorded.

Stream Evaluations: Forested and maintained lawn areas alternate along this reach. Aesthetics were low in the fairway portions of the reach where natural vegetation was absent, and wooded portions were aesthetically good to excellent. Native shrub plantings along the creek where it crosses the fairway would help stabilize eroding stream banks and enhance wildlife values. Lawn areas associated with the golf course may be sources of nonpoint pollution including lawn fertilizers, herbicides, and pesticides.

Stream Impacts Assessment: Creek bank erosion would be accelerated by increased stormwater flows.

Baker Creek, Reach 6 (D-14)

Reach Locators: Downstream limit, change in stream characteristics; Upstream limit, change in stream characteristics (no significant landmarks).

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 7 feet; Bankful Depth, 3 feet; Low Water Depth, 2 feet; Stream Gradient, 1 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 0 percent cover, and the estimated shade was 0 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was 20 to 40 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 12 to 24 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty. The water clarity was murky. A flow velocity of 0.1 fps was observed.

Stream Evaluations: This reach was located within maintained lawn areas of the golf course. Enhancement of bank vegetation with shrub plantings would benefit the reach by stabilizing the creek bank and improving wildlife habitat but might conflict with current use. Murky water and thick algae and iron-fixing bacteria accumulations on the stream substrate suggested that creek water was nutrient-rich, potentially from nonpoint pollution sources such as lawn fertilizers.

Stream Impacts Assessment: Upper creek banks are stabilized by lawn grasses and may be able to handle some increased stormwater flows without serious adverse impacts.

Baker Creek, Reach 7 (D-14)

Reach Locators: Downstream limit, change is stream characteristics; Upstream limit, culvert south of Interstate Highway 5.

Channel Dimensions: High Flow Width, 17 feet; Bankful Width, 20 feet; Low Water Width, 15 feet; Bankful Depth, 2.5 feet; Low Water Depth, 1.5 feet; Stream Gradient, 1 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as pasture/meadow and developed with an overall vegetation density of greater than 90 percent. The stream canopy was estimated at 0 percent cover, and the estimated shade was 0 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and no debris jams were noted on the upper bank. The frequency of channel overflow was evaluated as rare. Bank rock content was greater than 65 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks ranged between 6 and 12 inches. The creek bottom had a silt/organic, coarse gravel, cobble, and boulder substrate with moderate particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was common, and the water clarity was murky. A flow velocity of approximately 0.5 fps was observed.

Stream Evaluations: Stream aesthetics were poor due to lack of natural vegetation in maintained lawn areas and rip-rap along the upstream end of the reach. Due to the developed nature of the area and conflicts between enhancement goals and existing recreational utilization, the enhancement potential is low. Runoff from upstream areas including Bellis Fair and I-5 are likely sources of non-point pollution in this reach.

Stream Impacts Assessment: Moderate increases in stormwater flows are anticipated to have little impact on this reach because of its rip-rapped banks at the upstream end and well-vegetated banks at the lower end of the reach.

Baker Creek, Reach 8 (D-18, D-20)

Reach Locators: Downstream limit, culvert at I-5 exit ramp to the Guide Meridian; Upstream limit, culvert at McLeod Road.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 14 feet; Low Water Width, 6 feet; Bankful Depth, 2 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as a mixture of shrub-dominated, pasture/meadow and developed areas with an overall density of 70 to 90 percent. The stream canopy was estimated at 30 percent cover, and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. Small amounts of mass wasting and lack of debris jams were noted on the upper bank. The frequency of channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was greater than 24 inches. The creek bottom had a silt/organic, coarse gravel, and cobble substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty and the water clarity was clear. A flow velocity of approximately 0.5 fps was observed.

Stream Evaluations: This reach had three sections: a) a down-stream end, shrub-dominated disturbed area; b) a central, maintained landscape below scattered firs; and c) an upstream, dredged and partly enhanced creek channel associated with moderate-density commercial development. Creek aesthetics varied according to the section. The lower portion could be enhanced with native trees and shrubs to increase plant community diversity. The landscaped portion of the reach could be enhanced by switching to native plants for the understory and groundcovers. Native shrubs have already been planted in crevices between rip-rap blocks to enhance the otherwise highly developed upstream portion of the reach. Clear water suggested that overall water quality was good. However, nearby development and runoff from impervious coverage probably contribute nonpoint pollutants. Numerous polyvinylchloride pipes of unknown origination discharge into this reach.

Stream Impacts Assessment: Current high water flows have inundated and eroded lawn areas. Increased stormwater flows would create additional erosion and cutting problems in this area.

Baker Creek, Reach 9 (D-22)

Reach Locators: Downstream limit, culvert at McLeod Road; Upstream limit, Bellingham city limit.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 14 feet; Low Water Width, 6 feet; Bankful Depth, 4 feet; Low Water Depth, 0.8 feet; Stream Gradient, 1 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 50 percent cover, and the estimated shade was 50 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a silt/organic and gravel substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was clear. No water flow was observed.

Stream Evaluations: Stream aesthetics are moderate due to lack of natural vegetation and encroachment of development in the upper half of the reach. Here, enhancement could be accomplished by adding tree and shrub plantings. Clear water suggested that overall water quality was good. However, stormwater from I-5 was directed to this reach and may carry nonpoint pollutants.

Stream Impacts Assessment: This reach has thickly vegetated banks and could probably withstand moderate increases in stormwater flows.

Baker Creek, Reach 10 (D-23)

Reach Locators: Downstream limit, Bellingham city limit; Upstream limit, culvert at James Street; Associated with wetland 18-1.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 11 feet; Low Water Width, 6 feet; Bankful Depth, 3 feet; Low Water Depth, 0.8 feet; Stream Gradient, 1 percent; Bank Undercut, 60 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and shrub-dominated with an overall density of greater than 90 percent. The stream canopy was estimated at 90 percent cover, and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged between 20 and 30 percent. No mass wasting and no debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 12 to 24 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was rare and the water clarity was clear. No water flow was observed.

Stream Evaluations: Due to the general lack of encroachment by development, no particular enhancement was needed. Clear water suggested that overall water quality was good, although horses pastured at the lower end of the reach may contribute to nonpoint source pollution.

Stream Impacts Assessment: Additional bank cutting and erosion are the likely consequences of increased stormwater flows in this reach.

Baker Creek, Reach 11 (Pd-24A, D-25)

Reach Locators: Downstream limit, James Street; Upstream limit, Telegraph Road; Associated with Wetland 17-3a.

Channel Dimensions: High Flow Width, 8 feet; Bankful Width, 10 feet; Low Water Width, 6 feet; Bankful Depth, 3 feet; Low Water Depth, 0.5 feet; Stream Gradient, 1 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 85 percent cover, and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and small debris jams were noted on the upper bank. The frequency of channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of raw banks was 6 to 12 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was common and the water clarity was murky. A flow velocity of approximately 0.1 fps was observed.

Stream Evaluations: This riparian corridor was relatively undisturbed and aesthetically excellent. Consequently, the potential for enhancement was considered low. No obvious sources of nonpoint pollution were identified.

Stream Impacts Assessment: The effect of moderate increases in stormwater flows would be minimal.

Baker Creek, Reach 12 (Pd-26A, D-27)

Reach Locators: Downstream limit, culvert at Telegraph Road; Upstream limit, culvert at Bakerview Road; Associated with 17-3b.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 8 feet; Low Water Width, 3 feet; Bankful Depth, 3 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as mature forest, immature/even-aged forest, shrub-dominated and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent cover, and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small number of debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of raw banks was 6 to 12 inches. The creek bottom had a silt/organic and gravel substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was spotty, and the water clarity was murky. A flow velocity of approximately 0.5 fps was observed.

Stream Evaluations: This riparian corridor was relatively undisturbed, and only a small amount of encroachment by residential and commercial development was observed. Consequently, the potential for enhancement was considered low. No obvious sources of nonpoint pollution were identified.

Stream Impacts Assessment: This reach has well—vegetated banks and could probably withstand moderate increases in stormwater flows.

Baker Creek, Reach 13 (D-29)

Reach Locators: Downstream limit, culvert at Bakerview Road; Upstream limit, urban-growth boundary; Associated with a previously unmapped wetland.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 12 feet; Low Water Width, 5 feet; Bankful Depth, 3 feet; Low Water Depth, 0.6 feet; Stream Gradient, 1 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of greater than 90 percent. The stream canopy was estimated at 90 percent cover, and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and a small amount of debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of raw banks was less than 6 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was spotty, and the water clarity was clear. A flow velocity of approximately 0.1 fps was observed.

Stream Evaluations: Stream aesthetics were moderate to good because natural vegetation buffers much of the reach from any nearby human disturbance. Consequently, little opportunity for enhancement was observed. Clear water suggested that overall water quality was good. However, paint/solvent spillage from Wight Corporation may be entering the watercourse.

Stream Impacts Assessment: This reach has thickly vegetated banks and could probably withstand moderate increases in stormwater flows.

10.9.2.2 Baker Creek Unnamed Tributary 1 Stream Reach Descriptions

Baker Creek Tributary 1, Reach 1 (Pd-60A, D-61)

Reach Locators: Downstream limit, culvert beneath a large building accessed from Meridian Street; Upstream limit, culvert at Deemer Road.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 6 feet; Low Water Width, 2 feet; Bankful Depth, 3 feet; Low Water Depth, 0 feet; Stream Gradient, 1 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as partly shrub-dominated and partly pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 20 percent cover, and the estimated shade was 20 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and no debris jams were noted on the upper bank. Channel overflow was thought not to occur. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was abundant and the water clarity was murky. No water flow was observed.

Stream Evaluations: Reach could be enhanced by planting trees and shrubs at the stream edge to increase vegetation diversity and increase wildlife habitat. Murky water and thick algae growth suggested that water quality was suspect and nearby commercial and residential development may be a source of nonpoint pollutants.

Stream Impacts Assessment: Few stream impacts would be expected from moderate increases in stormwater flows.

Baker Creek Tributary 1, Reach 2 (D-63, D-64)

Reach Locators: Downstream limit, culvert at Deemer Road; Upstream limit, Telegraph Road detention basin dam; Associated with wetland 18-5A.

Channel Dimensions: High Flow Width, 6 feet; Bankful Width, 10 feet; Low Water Width, 3 feet; Bankful Depth, 2 feet; Low Water Depth, 0.1 feet; Stream Gradient, 1 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 70 percent cover, and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and a small number of debris jams were noted on the upper bank. Channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there were few flow obstructions on the lower bank. Frequent cutting of the lower creek bank was observed, and the height of the raw banks were 12 to 24 inches. The creek bottom had a coarse and fine gravel substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was clear. No water flow was observed.

Stream Evaluations: To enhance this reach, areas cleared of vegetation could be restored with native trees and shrubs. Clear water suggested that water quality was good.

Stream Impacts Assessment: The small channel may flood with moderate increases in stormwater flows.

Baker Creek Tributary 1, Reach 3 (Pd-65, D-66)

Reach Locators: Downstream limit, Telegraph Road detention dam; Upstream limit, change in stream characteristics.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 15 feet; Low Water Width, 0 feet; Bankful Depth, 1 foot; Low Water Depth, 0 feet; Stream Gradient, 1 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 25 percent cover, and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks were 6 to 12 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Because most of the natural woody vegetation has been removed and livestock graze in and around the creek reach, aesthetics were rated low. Enhancement could be accomplished by eliminating livestock disturbance and planting native trees and shrubs to create structural diversity for wildlife habitat. Murky water suggested that water quality was suspect. Farm animals grazing in and around the reach, nearby residences on septic systems, metal barrels, and numerous cars stored in and adjacent to the reach are potential sources of nonpoint source pollutants.

Stream Impacts Assessment: Some erosion and cutting could be expected from moderate increases in stormwater flows.

Baker Creek Tributary 1, Reach 4 (D-66)

Reach Locators: Downstream limit, change in gradient and vegetation type; Upstream limit, culvert at Bakerview Road; Associated with wetland 18-5A.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 15 feet; Low Water Width, 4 feet; Bankful Depth, 2 feet; Low Water Depth, 0.1 feet; Stream Gradient, 1 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and immature/even-aged forest with an overall density of greater than 90 percent. The stream canopy was estimated at 90 percent cover, and the estimated shade was 100 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks were 6 to 12 inches. The creek bottom had a silt/organic and fine gravel substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was clear. A flow rate of approximately 0.5 fps was observed.

Stream Evaluations: Excellent aesthetics were observed in this reach, and minimal enhancement opportunities are available. A small open water area combined with the riparian vegetation provide good wildlife habitat values. Clear water suggested that water quality was good. Nearby residences on septic systems may be a source of nonpoint pollutants.

Stream Impacts Assessment: Some erosion and cutting would be expected from moderate increases in stormwater flows.

Baker Creek Tributary 1, Reach 5 (D-68)

Reach Locators: Downstream limit, culvert at Bakerview Road; Upstream limit, culvert at James Street; Associated with wetland 7-1.

Channel Dimensions: High Flow Width, 7 feet; Bankful Width, 9 feet; Low Water Width, 2 feet; Bankful Depth, 3 feet; Low Water Depth, 0.1 feet; Stream Gradient, 1 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 10 percent cover, and the estimated shade was 15 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks were 6 to 12 inches. The creek bottom had a silt/organic and fine gravel substrate with tight particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was murky. No water flow was observed.

Stream Evaluations: General aesthetics were poor due to the agricultural modification of the stream reach, and to the presence of invasive weedy plant species. The planting of native trees and shrubs would enhance this reach. Murky water and thick algae growth suggested that water quality was suspect and manure wastes from livestock may be a source of nonpoint pollutants.

Stream Impacts Assessment: Existing vegetation would adequately stabilize creek banks for moderate increases in stormwater flows.

Baker Creek Tributary 1, Reach 6 (D-70, D-701)

Reach Locators: Downstream limit, culvert at James Street; Upstream limit, urban-growth boundary; Associated with 8-9 and 8-4c.

Channel Dimensions: High Flow Width, 5 feet; Bankful Width, 7 feet; Low Water Width, 0 feet; Bankful Depth, 1 foot; Low Water Depth, 0 feet; Stream Gradient, 1 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 35 cover, and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks were 6 to 12 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. No water was observed so water clarity, and flow velocity could not be evaluated.

Stream Evaluations: Reach aesthetics could be improved by augmenting existing vegetation with native tree and shrub plantings. Potential nonpoint pollution sources include nearby cattle pastures and septic systems associated with scattered residential development.

Stream Impacts Assessment: Existing vegetation roots could adequately stabilize creek banks for moderate increases in stormwater flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Baker Creek – Alternative No. 7" Problem No. 2			Revised: Nov–93 HDR Engineering, Inc.	
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
18–inch	510	LF	$60	$30,600
Structures				
Manholes, 54–inch (8–feet deep max.)	3	EA	$1,875	$5,625
Connect to Existing	2	EA	$200	$400
Surface Restoration				
Asphalt Pavement	45	SY	$15	$675
Crushed Surfacing	9	TON	$15	$135
Landscaping	350	SY	$10	$3,500
Earthwork				
Regrade Channel (Clean–Up)	10	LF	$4	$40
Excavation	590	CY	$5	$2,950
Rip Rap	10	CY	$28	$280
Subtotal:				$44,200
Mobilization: 10%				$4,400
Contingency: 20%				$9,700
Sales Tax: 7.8%				$4,500
Subtotal – Construction:				$62,800
Engineering Design and Construction:	25%			$15,700
TOTAL PROJECT COST:				$78,500

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Baker Creek – Alternative No. 25" Problem No. 10			Revised: HDR Engineering, Inc.	Nov–93
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
30–inch	370	LF	$100	$37,000
Surface Restoration				
Asphalt Pavement	47	SY	$15	$705
Crushed Surfacing	10	TON	$15	$150
Landscaping	300	SY	$10	$3,000
Earthwork				
Regrade Channel (Clean–Up)	30	LF	$4	$120
Excavation	600	CY	$5	$3,000
Rip Rap	15	CY	$28	$420
Subtotal:				$44,400
Mobilization: 10%				$4,400
Contingency: 20%				$9,800
Sales Tax: 7.8%				$4,600
Subtotal – Construction:				$63,200
Engineering Design and Construction:	25%			$15,800
TOTAL PROJECT COST:				$79,000

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Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Baker Creek – Existing
Oct–93

VOLUME 2
TABLE 10.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	16471.5	38942.3	2559.6	9595.8	1686.3	69255.5
COD	113167.5	12605.6	7038.9	8885.0	0.0	141697.0
TSS	114234.0	11255.0	9243.0	5331.0	35112.0	175175.0
DS	45385.5	720.3	4763.7	35540.0	16863.0	103272.5
TOTAL NITROGEN	177.8	143.8	13.0	97.4	16.9	448.9
TOTAL AMMONIA	320.0	607.8	78.2	454.2	25.4	1485.5
TOTAL PHOSPHORUS	5557.7	4321.9	656.5	1388.2	118.3	12042.5
DISSOLVED PHOSPHORUS	1730.1	2476.1	173.0	544.8	4.1	4928.1
COPPER	225.2	135.1	7.1	10.7	11.6	389.5
LEAD	746.6	922.9	14.2	35.5	9.2	1728.5
ZINC	320.0	1598.2	7.1	71.1	9.2	2005.6
LAND USE (ACRES)	118.5	225.1	23.7	355.4	462.0	1184.7

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Baker Creek – Future
Oct–93

VOLUME 2
TABLE 10.5

CONSTITUENTS \ LAND USE	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	16471.5	43838.2	10778.4	19251.0	0.0	90339.1
COD	113167.5	14190.4	29640.6	17825.0	0.0	174823.5
TSS	114234.0	12670.0	38922.0	10695.0	0.0	176521.0
DS	45385.5	810.9	20059.8	71300.0	0.0	137556.2
TOTAL NITROGEN	177.8	161.9	54.9	195.4	0.0	589.9
TOTAL AMMONIA	320.0	684.2	329.3	911.2	0.0	2244.7
TOTAL PHOSPHORUS	5557.7	4865.3	2764.5	2785.0	0.0	15972.4
DISSOLVED PHOSPHORUS	1730.1	2787.4	728.5	1093.0	0.0	6339.1
COPPER	225.2	152.0	29.9	21.4	0.0	428.5
LEAD	746.6	1038.9	59.9	71.3	0.0	1916.7
ZINC	320.0	1799.1	29.9	142.6	0.0	2291.6
LAND USE (ACRES)	118.5	253.4	99.8	713.0	0.0	1184.7

Bellingham Watershed Master Plan Curve Number Summary — VOLUME 2
Basin Name: Baker Creek — TABLE 10.6
Oct-93

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	60.3	5.7	98	54.6	84	5.7	98	54.6	86
111	29.8	16.4	98	13.4	84	16.4	98	13.4	86
112	81.3	16.3	98	65	81	36.8	98	44.5	86
102	71.8	54.9	98	16.9	85	60.8	98	11.0	86
103	14.9	12.3	98	2.6	88	12.3	98	2.6	88
104	28.3	6.5	98	21.8	87	22.6	98	5.7	89
105	83.3	3.9	98	79.4	81	28.8	98	54.5	88
151	15	6.6	98	8.4	82	6.6	98	8.4	86
152	47.2	2.6	98	44.6	77	25.0	98	22.2	86
153	28.1	6.4	98	21.7	84	12.8	98	15.3	86
154	44.3	25.8	98	18.5	70	30.7	98	13.6	74
155	47.5	29.1	98	18.4	70	34.2	98	13.3	72
156	55.1	30.3	98	24.8	75	39.7	98	15.4	76
106	30.2	1.3	98	28.9	81	12.7	98	17.5	88
107	82.8	12.9	98	69.9	82	48.6	98	34.2	82
108	109.5	4.5	98	105	72	38.8	98	70.7	81
301	34.2	3.9	98	30.3	86	16.5	98	17.7	86
311	34.2	2.6	98	31.6	82	14.4	98	19.8	86
312	58.2	5.4	98	52.8	80	14.2	98	44.0	87
313	40.3	2.2	98	38.1	84	10.7	98	29.6	87
302	49.8	1.8	98	48	80	19.1	98	30.7	86
321	19.2	0.9	98	18.3	80	8.1	98	11.1	87
303	21.9	0.9	98	21	81	4.9	98	17.0	86
304	29.9	1.2	98	28.7	86	6.7	98	23.2	89
305	67.6	2.7	98	64.9	82	25.9	98	41.7	88
905	294.6	5.8	98	288.8	82	25.0	98	269.6	86
906	1579.5	15.8	98	1563.7	81	47.4	98	1532.1	85
908	91.4	4.6	98	86.8	77	9.8	98	81.6	86
TOTAL	3150.2	283.3		2866.9		635.2		2515	
%	100.0%	9.0%		91.0%		20.2%		79.8%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Baker Creek – Existing
Oct–93

VOLUME 2
TABLE 10.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN/OPEN SPACE		FORESTED		MEADOW/PASTURE		CULTIVATED		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	60.3	5.7	98	54.6	84	43.7	86	10.9	76						
111	29.8	16.4	98	13.4	84	2.0	86	2.0	76	9.4	85				
112	81.3	16.3	98	65.0	81	6.5	86	32.5	76	26.0	85				
102	71.8	54.9	98	16.9	85	3.4	86			13.5	85				
103	14.9	12.3	98	2.6	88	1.6	87	0.1	86	0.9	89				
104	28.3	6.5	98	21.8	87	3.6	89	2.2	79	16.0	87				
105	83.3	3.9	98	79.4	81	4.1	86	61.5	80	13.8	86				
151	15.0	6.6	98	8.4	82	0.4	86	5.2	80	2.8	85				
152	47.2	2.6	98	44.6	77	4.5	86	40.2	76						
153	28.1	6.4	98	21.7	84	3.3	86	4.3	81	14.1	85				
154	44.3	25.8	98	18.5	70			3.2	76	15.2	69				
155	47.5	29.1	98	18.4	70			0.4	76	18.1	69				
156	55.1	30.3	98	24.8	75	1.0	86	3.1	62	21.7	73				
106	30.2	1.3	98	28.9	81	0.9	86	20.8	79	7.2	86				
107	82.8	12.9	98	69.9	82	2.6	86	35.9	77	31.4	87				
108	109.5	4.5	98	105.0	72	5.2	81	58.3	68	41.5	77				
301	34.2	3.9	98	30.3	86	1.5	86	1.5	76	22.1	85	5.2	94		
311	34.2	2.6	98	31.6	82	1.6	86	17.4	76	6.3	85	6.3	94		
312	58.2	5.4	98	52.8	80	1.7	86	40.8	78	10.3	85				
313	40.3	2.2	98	38.1	84	1.5	86	10.7	80	25.9	85				
302	49.8	1.8	98	48.0	80	1.0	86	35.0	76	5.8	85	6.2	94		
321	19.2	0.9	98	18.3	80			13.4	78	4.9	86				
303	21.9	0.9	98	21.0	81	0.9	86	13.4	77	3.8	85	2.8	94		
304	29.9	1.2	98	28.7	86	1.4	89	8.3	79	19.1	88				
305	67.6	2.7	98	64.9	82	3.3	88	40.9	78	20.8	87				
905	294.6	5.8	98	288.8	82	6.1	90	133.4	77	140.8	86			8.5	100
906	1579.5	15.8	98	1563.7	81			914.8	77	648.9	86				
908	91.4	4.6	98	86.8	77			86.8	77						
TOTAL	3150.2	283.3		2866.9		101.8		1597.0		1140.3		20.5		8.5	
%	100.0%	9.0%		91.0%		3.2%		50.7%		36.2%		0.7%		0.3%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Baker Creek – Future
Oct–93

VOLUME 2
TABLE 10.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN/OPEN SPACE		FORESTED		MEADOW/PASTURE		CULTIVATED		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
101	60.3	5.7	98	54.6	86	54.6	86								
111	29.8	16.4	98	13.4	86	13.4	86								
112	81.3	36.8	98	44.5	86	44.5	86								
102	71.8	60.8	98	11	86	11	86								
103	14.9	12.3	98	2.6	88	2.6	88								
104	28.3	22.6	98	5.7	89	5.7	89								
105	83.3	28.8	98	54.5	88	54.5	88								
151	15	6.6	98	8.4	86	8.4	86								
152	47.2	25	98	22.2	86	22.2	86								
153	28.1	12.8	98	15.3	86	15.3	86								
154	44.3	30.7	98	13.6	74	13.6	74								
155	47.5	34.2	98	13.3	72	13.3	72								
156	55.1	39.7	98	15.4	76	15.4	76								
106	30.2	12.7	98	17.5	88	17.5	88								
107	82.8	48.6	98	34.2	82	34.2	82								
108	109.5	38.8	98	70.7	81	70.7	81								
301	34.2	16.5	98	17.7	86	17.7	86								
311	34.2	14.4	98	19.8	86	19.8	86								
312	58.2	14.2	98	44.0	87	44.0	87								
313	40.3	10.7	98	29.6	87	29.6	87								
302	49.8	19.1	98	30.7	86	30.7	86								
321	19.2	8.1	98	11.1	87	11.1	87								
303	21.9	4.9	98	17	86	17	86								
304	29.9	6.7	98	23.2	89	23.2	89								
305	67.6	25.9	98	41.7	88	41.7	88								
905	294.6	25	98	269.6	86					261.1	86			8.5	100
906	1579.5	47.4	98	1532.1	85					1523.1	86				
908	91.4	9.8	98	81.6	86					81.6	86				
TOTAL	3150.2	635.2		2515.0		631.7				1865.8				8.5	
%	100.0%	20.2%		79.8%		20.1%				59.2%				0.3%	

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10.9 BAKER CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Nine wetlands including: one covered by the Bellingham Wetland Inventory (SQ-8); seven found in Bellingham's urban growth area (7-1, 8-9, 17-3a, 17-3b, 18-1, 18-5a, and Deemer Road Wetland); and one previously unmapped wetland (Couger Road Wetland) were evaluated in this study. Refer to Figure 11.1.2 in the Watershed Master Plan.

10.9.1 <u>Baker Creek Wetland Descriptions</u>

SQ-8 (Baker Creek, Reach 1)

Wetland Description: This palustrine forested wetland had three vegetation layers characterized as moderately dense with intermediate plant community maturity and low species diversity. The dominant plant species included black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), giant horsetail (*Equisetum telmateia*) and reed canarygrass (*Phalaris arundinacea*). Persistent vegetation dominated this wetland area. No surface water was observed and consequently no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was observed. Mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 0.6 acres.

Wetland Values: The wildlife habitat potential was rated as moderate, and the water quality benefits rating was low because the wetland was relatively small. Low to moderate flow attenuation would be provided by the available flood basin. Vegetation diversity could be enhanced by planting native conifers.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

SQ-9 (Baker Creek, Reaches 3&4)

This areas is described as wetland in the Bellingham Watershed Inventory; however, jurisdiction wetlands were not identified in this area during the field work conducted for the study in hand.

18-1 (Baker Creek, Reach 10)

Wetland Description: This palustrine wetland had emergent and scrub-shrub sections with three vegetation layers characterized as high density with intermediate plant community maturity and intermediate species diversity. In the emergent wetland, the dominant plant species included bentgrasses (*Agrostis* spp.), field horsetail (*Equisetum arvense*), creeping buttercup (*Ranunculus repens*), sedge (*Carex* sp.), and sweet vernalgrass (*Anthoxanthum ordoratum*) and in the scrub-shrub portion the dominant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), willow (*Salix* sp.) and Douglas' spirea (*Spiraea douglasii*). Nonpersistent vegetation dominated the emergent wetland, and persistent vegetation dominated the scrub-shrub portion of this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was not observed. Mineral soils formed the wetland substrate, which had an approximate slope of less than 1 percent. The complexity of the wetland/upland boundary was low. This wetland measured approximately 16.5 acres.

Wetland Values: The wildlife habitat potential was rated as low to moderate because of the generally low relative value of wet pastures. The water quality benefits rating was moderate to high because 18-1 was a large wetland with significant grass-dominated areas with high biofiltration potential. High floodwater storage and attenuation values would be provided by the long, wide flood basin. Enhancement potential of emergent wetland area was high due to the occurrence of large wet pasture areas adjacent to existing high-quality scrub-shrub wetlands.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland. However, decreased flow would likely impact wetlands adversely due to their currently marginal hydrology.

17-3a (Baker Creek, Reach 11)

Wetland Description: This palustrine forested wetland had three vegetation layers of high density, intermediate plant community maturity, and high species diversity. The dominant plant species included red alder (*Alnus rubra*), western red cedar (*Thuja plicata*), salmonberry (*Rubus spectabilis*), vine maple (*Acer circinatum*), creeping buttercup (*Ranunculus repens*) and slough sedge (*Carex obnupta*). Persistent vegetation dominated the wetland area. Because no surface water was observed, no flow rate was measured. Approximately 2 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated, and seasonally flooded, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 1 percent. The complexity of the wetland/upland boundary was high. This wetland measured approximately 5.6 acres.

Wetland Values: The aesthetic value of this wetland was considered high because there has been little impact from adjacent land uses. The wildlife habitat potential was rated as high, and the water quality benefits rating was high because 17-3A was a large wetland with essentially undisturbed vegetation. High flow attenuation value would be provided by the persistent vegetation, and high flood storage value would be afforded by the wide available flood basin.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

17-3b (Baker Creek, Reach 12)

Wetland Description: This palustrine forested wetland had three vegetation layers of high density, intermediate plant community maturity, and high species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), black twinberry (*Lonicera involucrata*), salmonberry (*Rubus spectabilis*), slough sedge (*Carex obnupta*), and tall mannagrass (*Glyceria elata*). Persistent vegetation dominated this wetland area. A flow rate of 0.5 fps was measured. Approximately 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was high. This wetland measured approximately 5.7 acres.

Wetland Values: The aesthetic value of this wetland was highly rated due to its structural diversity and its relatively undisturbed character. The diverse native vegetation constituted excellent wildlife habitat, and therefore was rated as high for that function. The water quality benefits rating was high. High flow attenuation and flood storage values would be provided by the persistent vegetation and wide available flood basin.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

Couger Road Wetland (Baker Creek, Reach 13)

Wetland Description: This palustrine scrub-shrub wetland had two vegetation layers of high density with intermediate plant community maturity and intermediate plant species diversity. The dominant plant species included red alder (*Alnus rubra*), hairy willow-herb (*Epilobium ciliatum*), common cattail (*Typha latifolia*), pondweed (*Potamogeton* sp.) and duckweed (*Lemna* sp.). Persistent vegetation dominated this wetland area. No flow rate was measured. Approximately 20 percent of the wetland basin was filled during low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as permanently saturated and seasonally flooded and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was medium. The wetland measured approximately 0.2 acres.

Wetland Values: This wetland had high structural diversity and relatively little disturbance from adjacent land uses; therefore, a high wildlife habitat value was assigned. Moderate to high flood storage and attenuation value would be provided by the low and relatively wide available wetland flood basin. The presence of thick herbaceous vegetation had high biofiltration potential, contributing to high water quality improvement value.

Wetland Impacts: Roadway and nearby residential development are potential minor sources of nonpoint pollutants. Moderate increases in floodwater would have little impact to this wetland.

10.9.1.2 Baker Creek Unnamed Tributary 1 Wetland Descriptions

Deemer Road Wetland (Baker Creek Tributary 1, Reach 1)

Wetland Description: This palustrine forested wetland had three vegetation layers of high density with intermediate plant community maturity and low species diversity. The dominant plant species included willow (*Salix* sp.), soft rush (*Juncus effusus*), creeping buttercup (*Ranunculus repens*), and redtop bentgrass (*Agrostis alba*). Persistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 1 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 1 acre.

Wetland Values: The wildlife habitat potential was rated as moderate to high. The water quality benefits rating was high because thick herbaceous vegetation provides good biofiltration function. Moderate to high flood storage/attenuation would be provided by the relatively wide available flood basin. Vegetation diversity could be enhanced with native species and upland buffer plantings would screen wetlands from adjacent land uses.

Wetland Impacts: Moderate increases or decreases in floodwater would have little impact to this wetland.

18-5a (Baker Creek Tributary 1, Reach 2)

Wetland Description: This palustrine forested and emergent wetland had three vegetation layers characterized as having moderate density with young plant community maturity and low species diversity. The dominant plant species in the forested portion included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), Douglas' spirea (*Spiraea douglasii*), and redtop bentgrass (*Agrostis alba*). The emergent section was dominated by common cattail (*Typha latifolia*), soft rush (*Juncus effusus*), water foxtail (*Alopecurus geniculatus*), creeping buttercup (*Ranunculus repens*), hairy willow-herb (*Epilobium ciliatum*) and sedges (*Carex* spp.). Persistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Approximately 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally flooded and seasonally saturated, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was low. This wetland measured approximately 11.6 acres.

Wetland Values: Low species and structural diversity could be enhanced with native vegetation plantings. In addition, livestock should be prevented from entering the creek area to reduce erosion and decrease the amount of manure wastes entering the creek. The wildlife habitat potential was rated as moderate. The water quality benefits rating was moderate to high because of high biofiltration function provided by the abundant grasses. Moderate flood attenuation would be provided by persistent vegetation, and flood storage is available in the relatively wide flood basin.

Wetland Impacts: Moderate increases or decreases in floodwater would have little impact to this wetland.

7-1 (Baker Creek Tributary 1, Reach 5)

Wetland Description: This palustrine emergent wetland had one vegetation layer of high density with young plant community maturity and low species diversity. The dominant plant species included reed canarygrass (*Phalaris arundinacea*), soft rush (*Juncus effusus*), and water-parsley (*Oenanthe sarmentosa*). Nonpersistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered medium. The hydroperiod was evaluated as seasonally flooded and seasonally saturated, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 3 percent. The complexity of the wetland/upland boundary was low. This wetland measured approximately 5.7 acres.

Wetland Values: Enhancement potential in this wetland was rated as high—plantings of native shrubs and trees would be beneficial. The wildlife habitat potential was rated as low due to the low structural and plant species diversity. The water quality benefits rating was moderate to high because abundant grass vegetation present has a high biofiltration function, and reed canarygrass has very high nutrient removal capability. Moderate to high flood storage function would be provided by a relatively wide flood basin.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

8-9 (Baker Creek Tributary 1, Reach 6)

Wetland Description: This palustrine forested and emergent wetland had two vegetation layers characterized as moderately dense with intermediate plant community maturity and low species diversity. The dominant plant species in the forested wetland included black cottonwood (*Populus balsamifera*), western red cedar (*Thuja plicata*), redtop bentgrass (*Agrostis alba*), and soft rush (*Juncus effusus*). Dominant plants in the emergent portion of the wetland include creeping buttercup (*Ranunculus repens*), common cattail (*Typha latifolia*), slough sedge (*Carex obnupta*), and redtop bentgrass (*Agrostis alba*). Persistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 6.9 acres.

Wetland Values: The wildlife habitat potential was rated as moderate, and the water quality benefits rating was moderate to high because the biofiltration function of thick grasses. Low to moderate flood attenuation value would be provided by the wide available flood basin. Vegetation diversity could be enhanced by native conifers and other native trees and shrubs.

Wetland Impacts: Railroad and roads contribute noise disturbance. Moderate increases in floodwater would apparently have little impact to this wetland.

10.9.2.1 Baker Creek Stream Reach Descriptions

Baker Creek, Reach 1 (D-12)

Reach Locators: Downstream limit, confluence of Baker Creek with Squalicum Creek; Upstream limit, culvert at Birchwood Avenue. One of two parts of Wetland SQ-8 is associated with this reach.

Channel Dimensions: High Flow Width, 25 feet; Bankful Width, 30 feet; Low Water Width, 10 feet; Bankful Depth, 2.5 feet; Low Water Depth, 0.4 feet; Stream Gradient, 2 percent; Bank Undercut, 40 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall density of 50 to 70 percent. The stream canopy was estimated to be 30 percent cover, and the estimated shade was 45 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged between 40 and 60 percent. No mass wasting and small debris jams were noted on the upper bank. The frequency of channel overflow was evaluated as rare. Bank rock content was 40 to 65 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks ranged from 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was clear. A flow rate of approximately 0.25 fps was observed.

Stream Evaluations: Stream aesthetics were generally good. Enhancement could be accomplished by supplementing existing vegetation with native evergreen trees. Wildlife habitat could be improved by providing birdboxes and a fish ladder to bridge the culvert, which is currently impassible to salmon. Small minnows were noted in pools. Thick algal growth on the stream substrate indicated relatively high nutrient levels in the water, which may be due to fertilizer-rich runoff associated with the upstream golf course. Surrounding land uses—including roads, railroad, and residential development—all encroached on this reach.

Stream Impacts Assessment: This reach has clay-lined stream sides and could probably take increased flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Chuckanut Creek – Alternative No. 1" Problem No. 1			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
24–inch	**170**	**LF**	**$75**	**$12,750**
Surface Restoration				
Landscaping	**140**	**SY**	**$10**	**$1,400**
Earthwork				
Regrade Channel (Clean–Up)	**10**	**LF**	**$4**	**$40**
Excavation	**230**	**CY**	**$5**	**$1,150**
Rip Rap	**10**	**CY**	**$28**	**$280**
Subtotal:				**$15,600**
Mobilization: 10%				**$1,600**
Contingency: 20%				**$3,400**
Sales Tax: 7.8%				**$1,600**
Subtotal – Construction:				**$22,200**
Engineering Design and Construction:	**25%**			**$5,600**
TOTAL PROJECT COST:				**$27,800**

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Chuckanut Creek – Alternative No. 4" Problem No. 2			Revised: Nov–93 HDR Engineering, Inc.	
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Earthwork				
Bioengineered Slope	**10,000**	**SF**	**$14**	**$140,000**
Subtotal:				**$140,000**
Mobilization: 10%				**$14,000**
Contingency: 20%				**$30,800**
Sales Tax: 7.8%				**$14,400**
Subtotal – Construction:				**$199,200**
Engineering Design and Construction: 25%				**$49,800**
TOTAL PROJECT COST:				**$249,000**

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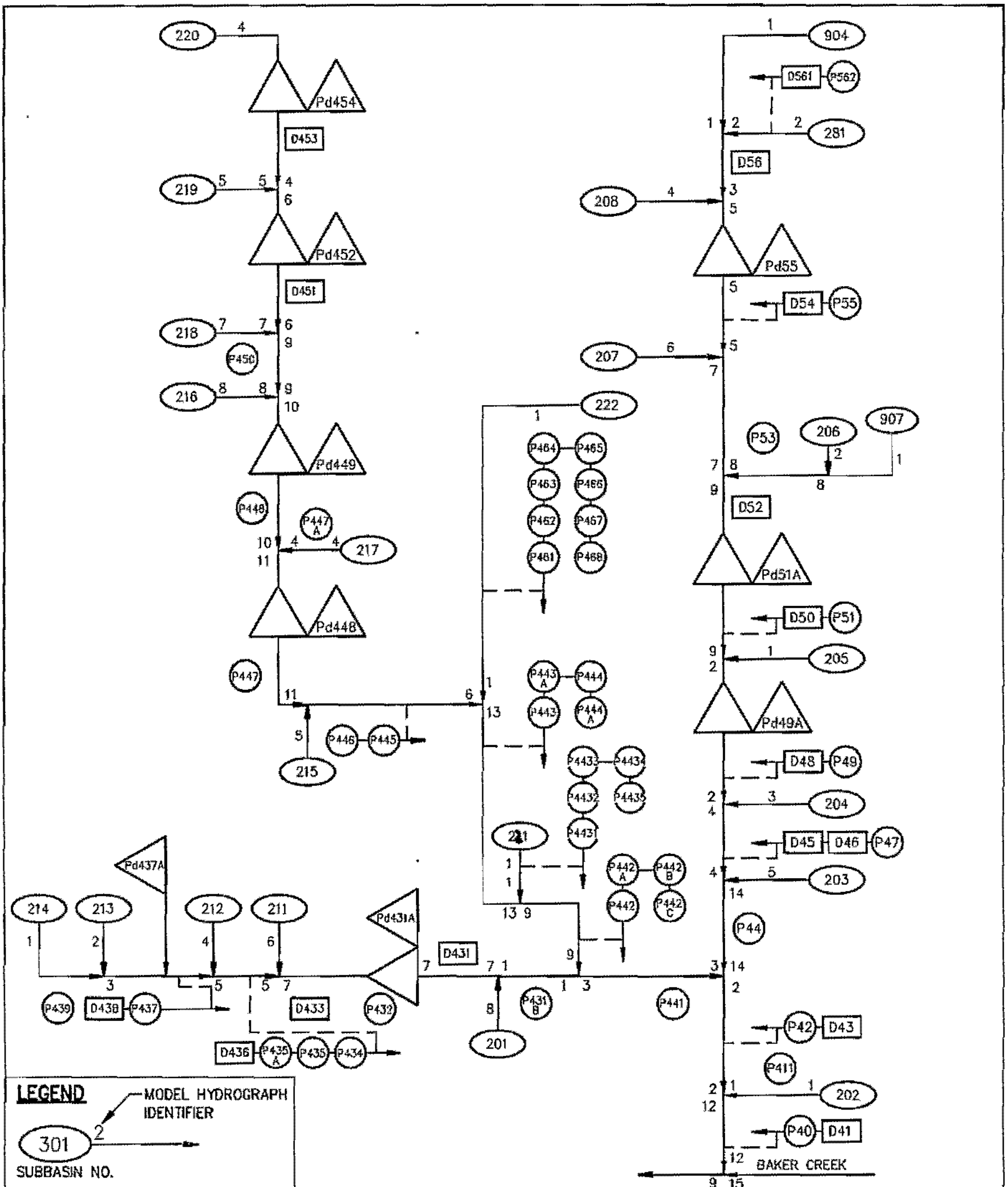
SPRING CREEK STUDY AREA



LEGEND

MODEL HYDROGRAPH IDENTIFIER

301 — 2 — SUBBASIN NO.

D01 — ELEMENT NO. – DITCH

P06 — ELEMENT NO. – PIPE

STORAGE FACILITY

DIVERSION STRUCTURE

HYDROLOGIC MODEL SCHEMATIC FOR SPRING CREEK BASIN

BELLINGHAM WATERSHED MASTER PLAN

HDR Engineering, Inc.

VOLUME 2

FIGURE 11.1

9/1/95

11.9 SPRING CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

Five wetlands including: four covered by the Bellingham Wetland Inventory (SQ-11, SQ-13, SQ-14, and SQ-16); and one in Bellingham's urban growth area (7-13) were evaluated in this study. See Figure 11.1.2 in the Watershed Master Plan.

11.9.1.1 Spring Creek Wetland Descriptions

SQ-13 (Spring Creek, Reaches 2 and 3)

Wetland Description: Most of Wetland SQ-13 had three vegetation layers of high density with intermediate plant community maturity and high species diversity. The dominant plant species included red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), willow (*Salix* sp.), salmonberry (*Rubus spectabilis*), honeysuckle (*Lonicera sp.*), skunk cabbage (*Lysichitum americanum*), mannagrass (*Glyceria* sp.), and lady fern (*Athyrium filix-femina*). Part of SQ-13 consisted of emergent wetland dominated by reed canarygrass (*Phalaris arundinacea*). Persistent vegetation dominated SQ-13. No surface water was observed; therefore no flow rate was measured. Approximately 15 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally flooded and permanently saturated. No constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 1 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 2.2 acres.

Wetland Values: On the basis of structural and species diversity, the wildlife habitat potential was rated as high in the forested portion of the wetland and low in the area dominated by reed canarygrass. The water quality benefits rating was high because SQ-13 had dense vegetation with excellent biofiltration capacity. Moderate to high flow attenuation would be provided by the available flood basin. The area dominated by reed canarygrass could be enhanced by planting native trees and shrubs.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland; however decreased flow would result in negative impacts.

SQ-14 (Spring Creek, Reach 4)

Wetland Description: Most of Wetland SQ-13 had three vegetation layers of high density with intermediate plant community maturity and high species diversity. The dominant plant species included red alder (*Alnus rubra*), willow (*Salix* sp.), soft rush (*Juncus effusus*), creeping spike-rush (*Eleocharis palustris*), and water-parsley (*Oenanthe sarmentosa*). Persistent vegetation dominated SQ-14. No flow rate was measured. Approximately 5 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally flooded, and permanently saturated and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 1 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 1.0 acre.

Wetland Values: On the basis of structural and species diversity, the wildlife habitat potential was rated as moderate. Enhancement of the wetland could be accomplished by planting native trees and shrubs to diversify the habitat while buffering the creek and wetland from existing and future development. The water quality benefits rating was high because of existing dense emergent vegetation with excellent biofiltration potential. Moderate to high floodwater storage/attenuation would be provided by the wide available flood basin.

Wetland Impacts: Moderate increases in floodwater could be tolerated without much disturbance. However decreased flow would probably result in negative impacts to the wetland.

SQ-16 (Spring Creek, Reach 5)

Wetland Description: This palustrine scrub-shrub wetland had three vegetation layers of high density with intermediate plant community maturity and high species diversity. The dominant plant species included black cottonwood (*Populus balsamifera*), soft rush (*Juncus effusus*), slough sedge (*Carex obnupta*), and redtop bentgrass (*Agrostis alba*). Persistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was observed. Mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was medium. This wetland measured approximately 2.6 acres.

Wetland Values: The wildlife habitat potential was rated as high, and the water quality benefits rating was high because SQ-16 had thick emergent vegetation with high biofiltration potential. High flood storage/attenuation values would be provided by the long and relatively wide flood basin available. Wetland vegetation is diverse and offers little potential for enhancement; however, upland buffer plantings would benefit the reach.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

7-13 (Spring Creek, Reach 6)

Wetland Description: This palustrine scrub-shrub wetland had two vegetation layers characterized as moderately dense with young plant community maturity and low species diversity. The dominant plant species included willow (*Salix* sp.), small-fruited bulrush (*Scirpus microcarpus*), soft rush (*Juncus effusus*), redtop bentgrass (*Agrostis alba*). Persistent vegetation dominated this wetland area. No surface water was observed; therefore no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water, and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated, and a constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was low. This wetland measured approximately 1.7 acres.

Wetland Values: The wildlife habitat potential was rated as low to moderate because of the low structural diversity and plant species diversity. Thick grasses present in the wetland offer good biofiltration potential; therefore, the water quality benefits rating was high. High flood attenuation value would be provided by persistent vegetation and the wide available flood basin affords high flood storage value. Areas of emergent vegetation could be enhanced by planting native trees and shrubs.

Wetland Impacts: Moderate increases or decreases in floodwater flow are anticipated to have little impact to this wetland.

11.9.1.2 Spring Creek Unnamed Tributary 1 Wetland Descriptions

SQ-11 (Spring Creek Tributary 1, Reach 1)

Wetland Description: This wetland had three layers of vegetation characterized as moderate to high density with young plant community maturity and low species diversity. The dominant plant species included red alder (*Alnus rubra*), Douglas' spirea (*Spiraea douglasii*), creeping buttercup (*Ranunculus repens*), skunk cabbage (*Lysichitum americanum*), and reed canarygrass (*Phalaris arundinacea*). Persistent and nonpersistent vegetation occurred in this wetland. No surface water flow was observed. Roughly 10 percent of the wetland basin was filled at low water, and the potential for an expanded water surface was considered medium to high. The hydroperiod was evaluated as seasonally flooded and seasonally saturated. A constricted outlet was observed. Fine mineral soils formed the wetland substrate, which had a slope of approximately 1 percent. The complexity of the wetland/upland boundary was low. This wetland measured approximately 1.6 acres.

Wetland Values: The wildlife habitat potential was rated as moderate to high due to good structural diversity and vegetation class interspersion. A moderate water quality benefit is afforded by the wetlands' thick reed canarygrass, which has strong biofiltration characteristics. Moderate flow attenuation potential would be provided by persistent vegetation in the wide available flood basin. The potential for enhancement is low, although the provision of birdboxes would be a simple way to improve the wildlife habitat.

Wetland Impacts: Additional or reduced stormwater flows would have only minor effects on this wetland.

11.9.2.1 Spring Creek Stream Reach Descriptions

Spring Creek, Reach 1 (D-43)

Reach Locators: Downstream limit, culvert at intersection of the Guide Meridian and Telegraph Road; Upstream limit, culvert under Bellis Fair accessway.

Channel Dimensions: High Flow Width, 12 feet; Bankful Width, 14 feet; Low Water Width, 10 feet; Bankful Depth, 8 feet; Low Water Depth, 1 foot; Stream Gradient, 1 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as developed with an overall density of greater than 90 percent. The stream canopy was estimated at 0 percent cover, and the estimated shade was 0 percent.

Stream Characteristics: Above the upper bank, the landform slope was greater than 60 percent. No mass wasting and no debris jams were noted on the upper bank. No channel overflow was thought to occur. Bank rock content was greater than 65 percent, and there were no flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a cobble substrate with tight particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was murky. No flow was observed.

Stream Evaluations: This reach was highly degraded due to the encroachment of roadways and dense, commercial development. Essentially no enhancement potential was present because the channel banks are covered with rip-rap. Refuse from adjacent enterprises posed a threat to water quality. Murky water indicated that water quality was generally low and that the Guide Meridian and its adjacent development were likely sources of nonpoint pollutants.

Stream Impacts Assessment: Rip-rap will protect this reach from additional erosion with moderate increases in stormwater flows.

Spring Creek, Reach 2 (D-45)

Reach Locators: Downstream limit, culvert at Bellis Fair accessway; Upstream limit, culvert at Bakerview Road.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 10 feet; Low Water Width, 10 feet; Bankful Depth, 4 feet; Low Water Depth, 2 feet; Stream Gradient, 1 percent; Bank Undercut, 75 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest, shrub-dominated and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 75 percent cover, and the estimated shade was 75 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 30 percent. No mass wasting and a moderate number of debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was less than 20 percent, and there was a moderate amount of flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a silt/organic substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Car repair facilities adjacent to the lower part of this reach are creating detrimental impacts. Discarded tires, mufflers, trash, and possibly oil from these establishments littered the banks of this reach. Enhancement could be accomplished by removing the trash, establishing environmentally sound refuse disposal practices, and planting conifers and native shrubs to provide a buffer from development as well as shading the watercourse. From the presence abundant iron-fixing bacteria and algae, poor water quality can be inferred and adjacent development is a likely source of nonpoint pollutants.

The upper portion of the reach flows through wetland SQ-13. Here, enhancement planting native species would create a good quality riparian corridor.

Stream Impacts Assessment: Additional stormwater flows would have a minor effect on this reach. Lower most portion of the reach is armored with boulders.

Spring Creek, Reach 3 (D-46)

Reach Locators: Downstream limit, change in gradient and vegetation type; Upstream limit, culvert at Bakerview Road; Associated with wetland SQ-13.

Channel Dimensions: High Flow Width, 22 feet; Bankful Width, 25 feet; Low Water Width, 12 feet; Bankful Depth, 3 feet; Low Water Depth, 1.5 feet; Stream Gradient, 1 percent; Bank Undercut, 10 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and immature/even-aged forest with an overall density of greater than 90 percent. The stream canopy was estimated at 95 percent cover, and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. Small amounts of mass wasting and a small number of debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was estimated at 20 to 40 percent, and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 6 to 12 inches. The creek bottom had a gravel, cobble, and boulder substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was murky. No water flow was observed.

Stream Evaluations: This reach was a high quality forested riparian corridor and needs no enhancement. Murky water suggested that water quality was suspect. Septic waste from failed residential septic systems may be a likely source.

Stream Impacts Assessment: There would likely be only minimal impacts to this reach from increased stormwater flows.

Spring Creek, Reach 4 (D-48)

Reach Locators: Downstream limit, culvert at Bakerview Road; Upstream limit, culvert at Prince Avenue; Associated with wetland SQ-14.

Channel Dimensions: High Flow Width, 11 feet; Bankful Width, 13 feet; Low Water Width, 7 feet; Bankful Depth, 3.5 feet; Low Water Depth, 0.5 feet; Stream Gradient, 1 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 20 percent cover, and the estimated shade was 40 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 30 percent. No mass wasting and a small number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was rated at 20 to 40 percent, and there were no flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 12 to 24 inches. The creek bottom had a silt/organic, gravel, and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant and the water clarity was murky. No water flow was observed.

Stream Evaluations: The reach could be enhanced by planting native trees and shrubs to diversify habitat and buffer stream from existing and future development. Murky water suggested that water quality was suspect and algae was abundant, indicating high water nutrient levels. No potential sources of nonpoint pollution were apparent.

Stream Impacts Assessment: Erosion and disturbance from increased stormwater flows would be minimal.

Spring Creek, Reach 5 (Pd-51A, D-50)

Reach Locators: Downstream limit, culvert at Prince Avenue; Upstream limit, culvert at Kellogg Avenue; Associated with wetland SQ-16.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 11 feet; Low Water Width, 8 feet; Bankful Depth, 3 feet; Low Water Depth, 0.5 feet; Stream Gradient, 1 percent; Bank Undercut, 20 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated with an overall density of greater than 90 percent. The stream canopy was estimated at 95 percent cover, and the estimated shade was 95 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and a moderate number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were moderate amounts of flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 6 to 12 inches. The creek bottom had a silt/organic substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was spotty, and the water clarity was murky. No water flow was observed.

Stream Evaluations: This reach was a complex vegetated habitat well worth preserving. Minimal enhancement opportunities are available along this reach as the creek banks are thickly vegetated with woody plant species. Murky water suggested that water quality was suspect; however, no obvious source of point or nonpoint pollutants was apparent.

Stream Impacts Assessment: A complex network of woody roots on the creek bank would probably resist erosion from moderate increases in stormwater flows.

Spring Creek, Reach 6 (Pd-51A, D-52)

Reach Locators: Downstream limit, culvert at Kellogg Avenue; Upstream limit, change in stream and development characteristics; Associated with wetland 7-13.

Channel Dimensions: High Flow Width, 15 feet; Bankful Width, 17 feet; Low Water Width, 5 feet; Bankful Depth, 3 feet; Low Water Depth, 1.5 feet; Stream Gradient, 1 percent; Bank Undercut, 50 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 75 percent cover, and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. The frequency of channel overflow was estimated as rare. Bank rock content was estimated at less than 20 percent, and there were no flow obstructions on the lower bank. Frequent cutting of the lower creek bank was observed, and the height of the raw banks was 12 to 24 inches. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was common, and the water clarity was murky. No water flow was observed.

Stream Evaluations: The upper portion of this reach had good aesthetic quality; however, vegetation diversity at the lower end could be enhanced by planting native shrubs and trees. Murky water can indicate suspect water quality, and nearby apartments could be a source of nonpoint pollutants.

Stream Impacts Assessment: There would likely be minimal impacts to this reach from increased stormwater flow.

Spring Creek, Reach 7 (D-52)

Reach Locators: Downstream limit, change in stream characteristics and vegetation type; Upstream limit, culvert at Van Wyck Road.

Channel Dimensions: High Flow Width, 15 feet; Bankful Width, 20 feet; Low Water Width, 7 feet; Bankful Depth, 3 feet; Low Water Depth, 0.3 feet; Stream Gradient, 1 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as mature forest with an overall density of greater than 90 percent. The stream canopy was estimated at 80 percent cover, and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and a large number of debris jams consisting of recently fallen trees were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was rated at less than 20 percent, and there were many flow obstructions in the form of blown-down trees on the lower bank. Frequent cutting of the lower creek bank was observed, and the height of the raw banks was greater than 24 inches. The creek bottom had a sand and gravel substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was rare, and the water clarity was clear. A flow velocity of 0.1 fps was observed.

Stream Evaluations: This reach was characterized by high quality riparian habitat except for areas where logging equipment has disturbed the creek bed and banks during logging in the area and removal of wind-thrown trees. Planting native trees and shrubs to stabilize disturbed areas would enhance this otherwise aesthetically excellent reach. Clear water suggested that water quality was good, and no potential sources of nonpoint pollution were observed. Wildlife habitat value was high, and abundant minnows were noted in creek pools.

Stream Impacts Assessment: Increased stormwater flows would probably cause additional erosion and habitat degradation, especially in the unvegetated areas mentioned above.

Spring Creek, Reach 8 (D-54)

Reach Locators: Downstream limit, culvert at Van Wyck Road; Upstream limit, culvert at Horton Road.

Channel Dimensions: High Flow Width, 14 feet; Bankful Width, 18 feet; Low Water Width, 4 feet; Bankful Depth, 1.5 feet; Low Water Depth, 0.1 feet; Stream Gradient, 1 percent; Bank Undercut, 25 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and shrub-dominated with an overall density of 70 to 90 percent. The stream canopy was estimated at 70 percent cover, and the estimated shade was 85 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. No mass wasting and a moderate to large number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were many flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 6 to 12 inches. The creek bottom had a gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was abundant, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Generally good aesthetics were observed in this reach, and minimal enhancement opportunities were available. Murky water and unusually thick algae growth suggested that water quality was suspect, and nearby residences on septic systems may be a source of nonpoint pollutants.

Stream Impacts Assessment: Some erosion and cutting would be expected from moderate increases in stormwater flows.

Spring Creek, Reach 9 (D-56)

Reach Locators: Downstream limit, culvert at Horton Road; Upstream limit, urban growth boundary.

Channel Dimensions: High Flow Width, 11 feet; Bankful Width, 16 feet; Low Water Width, 3 feet; Bankful Depth, 1.5 feet; Low Water Depth, 0.1 feet; Stream Gradient, 1 percent; Bank Undercut, 35 percent.

Riparian Vegetation: The vegetation was characterized as mature forest, immature forest, and shrub-dominated with an overall density of 70 to 90 percent. The stream canopy was estimated at 80 percent cover, and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and a small number of debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was less than 20 percent, and there were few to moderate number of flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was 6 to 12 inches. The creek bottom had a coarse gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was common, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Relatively few impacts from adjacent development were present in this reach, and minimal enhancement opportunities were available. Murky water and common algae growth suggested that water quality was suspect.

Stream Impacts Assessment: Some erosion and cutting would be expected from moderate increases in stormwater flows.

11.9.2.2 Spring Creek Unnamed Tributary 1 Stream Reach Descriptions

Spring Creek Unnamed Tributary 1, Reach 1 (D-431, Pd-431A, D-433)

Reach Locators: Downstream limit, culvert at accessway to Bellis Fair; Upstream limit, Bakerview Road.

Channel Dimensions: High Flow Width, 10 feet; Bankful Width, 15 feet; Low Water Width, 10 feet; Bankful Depth, 2 foot; Low Water Depth, 1.5 feet; Stream Gradient, 1 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as mature forest and pasture/meadow with an overall density of greater than 90 percent. The stream canopy was estimated at 85 percent cover, and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope was 20 to 30 percent. No mass wasting or debris jams were noted on the upper bank. The frequency of channel overflow was estimated as common. Bank rock content was less than 20 percent, and there were no flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a silt/organic substrate with no particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant, and the water clarity was murky. No water flow was observed.

Stream Evaluations: Aesthetics could be improved by augmenting existing vegetation with native tree and shrub plantings in the central, developed portion of the reach. Potential nonpoint pollution sources included nearby commercial and residential development.

Stream Impacts Assessment: Some erosion and cutting would likely occur with moderate increases in stormwater flows.

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Spring Creek – Alternative No. 2" Problem Nos. 21 and 22			Revised: HDR Engineering, Inc.	Nov–93
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, CMP				
84–inch	60	LF	$390	$23,400
Structures				
Manholes, 102–inch (8–feet deep max.)	1	EA	$5,750	$5,750
Manholes, 102–inch (over 8–feet deep)	2	VLF	$625	$1,250
Flow Control Device	2	EA	$1,000	$2,000
Surface Restoration				
Landscaping	1,230	SY	$10	$12,300
Earthwork				
Regrade Channel (Clean–Up)	30	LF	$4	$120
Embankment	4,030	CY	$5	$20,150
Excavation	15	CY	$5	$75
Rip Rap	50	CY	$28	$1,400
Miscellaneous				
Bank Stabilization	2,450	SY	$10	$24,500
Subtotal:				$90,900
Mobilization: 10%				$9,100
Contingency: 20%				$20,000
Sales Tax: 7.8%				$9,400
Subtotal – Construction:				$129,400
Real Estate Acquisition				
Easement – Commercial	240,000	SF	$1.50	$360,000
Subtotal – Real Estate:				$360,000
Engineering Design and Construction:	25%			$32,400
TOTAL PROJECT COST:				$521,800

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Spring Creek – Alternative No. 12" Problem No. 29			Revised: HDR Engineering, Inc.	Sep–95
Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Storm Sewer, Concrete Pipe				
48–inch	1,130	LF	$165	$186,450
Structures				
Manholes, 72–inch (8–feet deep max.)	5	EA	$2,600	$13,000
Manholes, 72–inch (over 8–feet deep)	12	VLF	$330	$3,960
Surface Restoration				
Asphalt Pavement	1,130	SY	$15	$16,950
Crushed Surfacing	230	TON	$15	$3,450
Landscaping	5	SY	$10	$50
Earthwork				
Excavation	2,950	CY	$5	$14,750
Subtotal:				$238,600
Mobilization: 10%				$23,900
Contingency: 20%				$52,500
Sales Tax: 7.8%				$24,600
Subtotal – Construction:				$339,600
Engineering Design and Construction:	25%			$84,900
TOTAL PROJECT COST:				$424,500

WATERSHED MASTER PLAN CITY OF BELLINGHAM, WASHINGTON "Spring Creek – Alternative No. 14" Problem No. 30			Revised: Sep–95 HDR Engineering, Inc.	
Item	Quantity	Unit	Unit Cost	Total Cost
Storm Sewer, Concrete Pipe				
30–inch	20	LF	$100	$2,000
Structures				
Manholes, 54–inch (8–feet deep max.)	1	EA	$1,875	$1,875
Surface Restoration				
Asphalt Pavement	20	SY	$15	$300
Crushed Surfacing	5	TON	$15	$75
Landscaping	5	SY	$10	$50
Earthwork				
Excavation	50	CY	$5	$250
Subtotal:				$4,600
Mobilization: 10%				$500
Contingency: 20%				$1,000
Sales Tax: 7.8%				$500
Subtotal – Construction:				$6,600
Engineering Design and Construction:	25%			$1,700
TOTAL PROJECT COST:				$8,300

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Bellingham Watershed Master Plan Flow Table
Basin Name : Spring Creek - Existing Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P40	8.00	1085.3	21.6		9.0	490.0	80.5	12.7	1.5	232.2	17.2	2.5	300.7	18.5	2.9
D41				8.0			80.5	4.1	1.3	232.2	5.9	2.4	300.7	6.4	2.8
P42	6.00	514.3	18.2		9.0	310.0	78.9	13.2	1.6	229.3	17.7	2.8	297.2	18.9	3.3
D43				8.0			78.9	4.0	1.3	229.3	5.7	2.5	297.2	6.2	2.9
P44	5.67	226.9	9.0		5.5	220.0	60.1	7.6	2.0	191.7	10.1	3.9	249.9	9.9	full
D45				4.0			58.7	4.2	1.3	189.1	6.1	2.5	246.6	6.6	2.9
D46				3.0			58.8	2.7	0.8	189.1	4.1	1.6	247.8	4.5	1.9
P47	5.00	141.5	7.2		23.0	460.0	58.8	6.9	2.2	189.1	9.6	full	251.0	12.8	full
D48				3.5			57.5	4.1	1.0	186.2	6.1	2.0	247.2	6.7	2.4
P49	5.00	238.4	12.1		15.9	350.0	57.5	10.0	1.7	186.3	13.4	3.3	249.5	12.7	full
D50				3.0			56.6	3.1	1.3	183.2	4.5	2.4	267.9	5.0	2.9
P51	5.00	236.7	12.1		8.0	210.0	56.6	9.9	1.7	183.2	13.3	3.3	295.4	15.1	1.7
D52				3.0			57.4	3.0	0.9	187.3	4.3	1.8	295.4	5.2	2.4
P53	5.00	223.7	11.4		14.0	310.0	52.7	9.3	1.6	171.1	12.6	3.3	272.9	13.9	full
D54				3.0			51.9	3.2	0.8	168.6	4.8	1.5	269.2	5.6	1.9
P55	5.00	400.1	20.4		7.5	200.0	52.0	14.1	1.2	168.8	19.5	2.3	271.1	21.9	3.0
D56				1.5			52.0	3.5	0.8	192.7	5.5	1.6	285.3	6.2	2.0
P411	1.50	11.4	6.5				9.4	7.2	1.0	17.7	10.0	full	22.2	12.6	full
D431				8.0			8.5	2.3	0.4	29.7	3.5	0.9	41.5	3.8	1.0
P431B	1.50	21.1	11.9				9.1	11.5	0.8	32.0	18.1	full	44.7	25.3	full
P432	3.00	44.4	6.3		5.0	46.0	8.6	4.9	0.9	31.2	6.8	1.8	43.7	7.2	2.4
D433				10.0			8.6	2.6	0.3	31.2	4.1	0.6	43.7	4.6	0.8
P434	3.00	70.2	9.9		7.0	80.0	5.5	10.2	0.4	20.2	15.0	0.8	28.1	16.5	0.9
P435	4.00	54.6	5.7				5.5	3.6	0.8	20.2	5.3	1.5	28.1	5.7	1.9
P435A	3.50	31.4	3.3		15.0	170.0	5.5	2.5	1.0	20.2	3.5	2.1	28.1	3.7	2.6
D436				4.0			5.5	1.9	0.3	20.2	3.0	0.7	28.1	3.3	0.8
P437	3.00	57.5	8.1		12.0	120.0	3.4	4.5	0.5	12.3	6.5	0.9	18.2	7.2	1.1
D438				3.0			3.4	0.9	0.4	12.3	1.3	0.8	18.2	1.5	1.0
P439	2.00	27.5	8.8		5.5	32.0	2.3	5.3	0.4	7.0	7.3	0.7	10.0	8.1	0.8
P441	3.00	76.0	10.8				28.0	9.9	1.3	70.3	12.2	2.3	95.6	13.5	full
P442	3.00	79.0	11.2				22.1	9.6	1.1	47.6	11.7	1.7	62.7	12.4	2.0
P442A	3.00	69.5	9.8				22.1	8.7	1.2	47.6	10.6	1.8	62.7	11.1	2.2
P442B	3.00	86.6	12.3				22.1	10.2	1.0	47.6	12.6	1.6	62.7	13.4	1.8
P442C	3.00	86.6	12.3				22.1	10.2	1.0	47.6	12.6	1.6	62.7	13.4	1.8
P443	3.00	67.6	9.6				18.1	8.1	1.1	37.1	9.8	1.6	48.2	10.4	1.8
P443A	3.00	69.5	9.8				18.1	8.3	1.1	37.1	10.0	1.5	48.2	10.6	1.8
P444	3.00	67.9	9.6				18.1	8.1	1.1	37.1	9.8	1.6	48.2	10.4	1.8
P444A	3.00	87.2	12.3				18.1	9.7	0.9	37.1	11.9	1.3	48.2	12.7	1.6

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P445	2.50	31.5	1.6		7.5	60.0	15.2	6.4	1.2	24.5	7.1	1.6	29.3	7.3	1.9
P446	2.50	24.4	5.0				6.9	4.3	0.9	24.4	4.7	1.1	12.0	5.0	1.2
P447	2.50	18.6	3.8		18.0	160.0	6.9	3.5	1.0	9.5	3.8	1.3	12.0	4.0	1.5
P447A	2.00	15.1	4.8		5.5	33.0	7.7	4.8	1.0	14.5	5.5	1.5	18.1	5.8	full
P448	2.50	20.4	4.2				5.3	3.5	0.9	8.6	4.0	1.1	12.5	4.4	1.4
P450	1.25	2.2	1.8		3.3	10.0	3.6	3.0	full	11.6	9.5	full	16.5	13.4	full
D451				2.0			3.2	0.8	0.4	9.4	1.1	0.8	13.7	1.3	1.0
D453				2.0			1.6	0.6	0.3	6.1	0.9	0.7	9.1	1.0	0.8
P461	2.00	34.1	10.8				3.1	6.7	0.4	12.7	10.0	0.8	18.8	11.1	1.1
P462	2.00	33.6	10.7				3.1	6.7	0.4	12.7	9.9	0.8	18.8	11.0	1.1
P463	2.00	34.4	11.0				3.1	6.8	0.4	12.7	10.1	0.8	18.8	11.2	1.1
P464	2.00	34.1	10.8				3.1	6.7	0.4	12.7	10.0	0.8	18.8	11.1	1.1
P465	2.50	46.1	9.4				3.1	5.3	0.4	12.7	8.0	0.9	18.8	8.9	1.1
P466	2.50	20.9	4.3				3.1	3.1	0.7	12.7	4.5	1.4	18.8	4.8	1.8
P467	2.50	20.9	4.3				3.1	3.1	0.7	12.7	4.5	1.4	18.8	4.8	1.8
P468	2.00	18.6	5.9				3.1	4.4	0.6	12.7	6.4	1.2	18.8	6.0	full
D561				2.0			2.1	0.4	0.7	8.1	0.6	1.4	12	0.7	1.7
P562	1.25	3.9	3.2		2.0	10.0	2.5	3.4	0.7	9.3	7.6	full	13.6	11.1	full
P4431	2.00	33.9	10.8				6.2	8.2	0.6	13.5	10.2	1.0	17.9	10.9	1.0
P4432	2.00	23.2	7.4				6.2	6.2	0.7	13.5	7.7	1.1	17.9	8.2	1.3
P4433	2.00	22.8	7.3				6.2	6.2	0.7	13.5	7.6	1.1	17.9	8.0	1.3
P4434	2.00	24.2	7.7				6.2	6.4	0.7	13.5	7.9	1.1	17.9	8.4	1.3
P4435	2.00	28.3	9.0				6.2	7.2	0.6	13.5	8.9	0.9	17.9	9.6	1.1

Bellingham Watershed Master Plan Flow Table
Basin Name : Spring Creek - Future Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P40	8.00	1085.3	21.6		9.0	490.0	145.3	15.0	1.9	282.3	18.2	2.8	441.4	20.5	3.5
D41				8.0			145.3	5.1	1.8	282.3	6.3	2.7	441.4	7.3	3.5
P42	6.00	514.3	18.2		9.0	310.0	143.6	15.6	2.2	279.4	18.6	3.1	437.5	20.4	4.2
D43				8.0			143.6	4.9	1.9	279.4	6.0	2.8	437.5	6.9	3.6
P44	5.67	226.9	9.0		5.5	220.0	114.7	9.1	2.9	233.5	9.3	full	362.2	14.4	full
D45				4.0			113.0	5.2	1.8	230.8	6.5	2.8	358.5	7.4	3.6
D46				3.0			113.2	3.4	1.2	230.8	4.4	1.8	358.6	5.1	2.3
P47	5.00	141.5	7.2		23.0	460.0	113.3	8.0	3.4	230.8	11.8	full	358.7	18.3	full
D48				3.5			111.2	5.1	1.5	227.4	6.5	2.3	354.2	7.6	3.0
P49	5.00	238.4	12.1		15.9	350.0	111.3	11.9	2.4	227.4	13.8	3.9	354.2	18.0	full
D50				3.0			110.8	3.9	1.8	259.3	4.9	2.9	369.8	5.4	3.5
P51	5.00	236.7	12.1		8.0	210.0	111.0	11.9	2.4	284.7	14.5	full	370.0	18.9	full
D52				3.0			113.0	3.9	1.4	284.7	5.1	2.3	433.1	5.8	2.9
P53	5.00	223.7	11.4		14.0	310.0	101.1	11.1	2.4	261.6	13.3	full	397.4	20.2	full
D54				3.0			98.7	4.0	1.1	257.2	5.5	1.9	390.8	6.3	2.4
P55	5.00	400.1	20.4		7.5	200.0	99.0	16.9	1.7	259.5	21.7	3.0	392.8	23.2	4.1
D56				1.5			99.5	4.4	1.1	282.6	6.2	2.0	392.4	6.9	2.4
P411	1.50	11.4	6.5				10.0	7.3	1.1	18.7	10.6	full	23.4	13.2	full
D431				8.0			28.3	3.4	0.8	56.7	4.2	1.2	64.5	4.4	1.3
P431B	1.50	21.1	11.9				32.6	18.4	full	64.4	36.4	full	73.5	41.6	full
P432	3.00	44.4	6.3		5.0	46.0	33.1	6.9	1.9	68.7	9.7	full	85.8	12.1	full
D433				10.0			33.1	4.2	0.7	68.7	5.3	1.0	85.8	5.7	1.1
P434	3.00	70.2	9.9		7.0	80.0	17.9	14.5	0.7	36.7	17.8	1.0	46.8	19.0	1.1
P435	4.00	54.6	5.7				17.9	5.1	1.4	36.7	6.1	2.1	46.8	6.4	2.5
P435A	3.50	31.4	3.3		15.0	170.0	17.9	3.4	1.9	36.7	3.8	full	46.8	4.9	full
D436				4.0			17.9	2.9	0.6	36.7	3.6	1.0	46.8	3.9	1.1
P437	3.00	57.5	8.1		12.0	120.0	13.7	6.7	1.0	28.8	8.1	1.5	37.8	8.7	1.8
D438				3.0			13.7	1.4	0.8	28.8	1.7	1.2	37.8	1.9	1.4
P439	2.00	27.5	8.8		5.5	32.0	7.4	7.4	0.8	15.5	9.0	1.1	20.0	9.5	1.3
P441	3.00	76.0	10.8				80.5	11.4	full	147.7	20.9	full	183.9	26.0	full
P442	3.00	79.0	11.2				56.5	12.2	1.8	99.8	14.1	full	122.8	17.4	full
P442A	3.00	69.5	9.8				56.5	11.0	2.0	99.8	14.1	full	122.8	17.4	full
P442B	3.00	86.6	12.3				56.5	13.1	1.8	99.8	14.1	full	122.8	17.4	full
P442C	3.00	86.6	12.3				56.5	13.1	1.8	99.8	14.1	full	122.8	17.4	full
P443	3.00	67.6	9.6				40.5	10.0	1.7	70.4	10.0	full	86.2	12.2	full
P443A	3.00	69.5	9.8				40.5	10.2	1.6	70.4	10.0	full	86.2	12.2	full
P444	3.00	67.9	9.6				40.5	10.0	1.7	70.4	10.0	full	86.2	12.2	full
P444A	3.00	87.2	12.3				40.5	12.1	1.4	70.4	13.7	2.0	86.2	14.1	2.4

Bellingham Watershed Master Plan Flow Table
Basin Name : Spring Creek - Future Condition
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P445	2.50	31.5	1.6		7.5	60.0	19.6	6.8	1.4	31.6	6.4	full	37.8	7.7	full
P446	2.50	24.4	5.0				8.4	4.5	1.1	12.9	5.0	1.3	22.7	5.7	1.9
P447	2.50	18.6	3.8		18.0	160.0	8.4	3.7	1.2	12.9	4.1	1.5	22.7	4.6	full
P447A	2.00	15.1	4.8		5.5	33.0	8.2	4.9	1.1	15.2	4.9	full	19.1	6.1	full
P448	2.50	20.4	4.2				7.7	3.9	1.0	15.6	4.6	1.6	25.3	5.2	full
P450	1.25	2.2	1.8		3.3	10.0	8.4	6.8	full	17.6	14.3	full	22.8	18.6	full
D451				2.0			10.3	1.2	0.8	21.3	1.4	1.3	28.0	1.6	1.5
D453				2.0			8.2	1.0	0.8	16.4	1.2	1.2	21.2	1.3	1.3
P461	2.00	34.1	10.8				20.9	11.4	1.1	38.9	12.4	full	48.6	15.5	full
P462	2.00	33.6	10.7				20.9	11.3	1.1	38.9	12.4	full	48.6	15.5	full
P463	2.00	34.4	11.0				20.9	11.5	1.1	38.9	12.4	full	48.6	15.5	full
P464	2.00	34.1	10.8				20.9	11.4	1.1	38.9	12.4	full	48.6	15.5	full
P465	2.50	46.1	9.4				20.9	9.2	1.2	38.9	10.5	1.8	48.6	9.9	full
P466	2.50	20.9	4.3				20.9	4.9	2.0	38.9	7.9	full	48.6	9.9	full
P467	2.50	20.9	4.3				20.9	4.9	2.0	38.9	7.9	full	48.6	9.9	full
P468	2.00	18.6	5.9				20.9	6.6	full	38.9	12.4	full	48.6	15.5	full
D561				2.0			3.7	0.5	1.0	11.6	0.7	1.7	16.4	0.8	2.0
P562	1.25	3.9	3.2		2.0	10.0	4.7	3.9	full	14.0	11.4	full	19.5	15.9	full
P4431	2.00	33.9	10.8				16.0	10.6	1.0	29.4	9.4	full	36.6	11.6	full
P4432	2.00	23.2	7.4				16.0	8.0	1.2	29.4	9.4	full	36.6	11.6	full
P4433	2.00	22.8	7.3				16.0	7.9	1.2	29.4	9.4	full	36.6	11.6	full
P4434	2.00	24.2	7.7				16.0	8.2	1.2	29.4	9.4	full	36.6	11.6	full
P4435	2.00	28.3	9.0				16.0	9.3	1.1	29.4	9.4	full	36.6	11.6	full

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Spring Creek – Existing
Oct–93

VOLUME 2
TABLE 11.4

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	38266.7	0.0	2970.0	5027.4	1564.8	47828.9
COD	262911.5	0.0	8167.5	4655.0	0.0	275734.0
TSS	265389.2	0.0	10725.0	2793.0	32581.2	311488.4
DS	105439.9	0.0	5527.5	18620.0	15647.6	145235.0
TOTAL NITROGEN	413.0	0.0	15.1	51.0	15.6	494.7
TOTAL AMMONIA	743.3	0.0	90.8	238.0	23.6	1095.6
TOTAL PHOSPHORUS	12911.6	0.0	761.8	727.3	109.7	14510.4
DISSOLVED PHOSPHORUS	4019.4	0.0	200.8	285.4	3.8	4509.3
COPPER	523.1	0.0	8.3	5.6	10.7	547.6
LEAD	1734.4	0.0	16.5	18.6	8.6	1778.1
ZINC	743.3	0.0	8.3	37.2	8.6	797.4
LAND USE (ACRES)	275.3	0.0	27.5	186.2	428.7	917.7

Bellingham Watershed Master Plan Pollutant Loadings
Basin Name: Spring Creek – Future
Oct–93

VOLUME 2
TABLE 11.5

LAND USE CONSTITUENTS	COMMERCIAL	INDUSTRIAL	HIGH–DENSITY RESIDENTIAL	LOW–DENSITY RESIDENTIAL	FOREST	TOTAL
BOD5	40963.3	11418.0	14536.8	11404.8	0.0	78322.9
COD	281438.5	3696.0	39976.2	10560.0	0.0	335670.7
TSS	284090.8	3300.0	52494.0	6336.0	0.0	346220.8
DS	112870.1	211.2	27054.6	42240.0	0.0	182375.9
TOTAL NITROGEN	442.1	42.2	74.0	115.7	0.0	674.0
TOTAL AMMONIA	795.7	178.2	444.2	539.8	0.0	1957.9
TOTAL PHOSPHORUS	13821.4	1267.2	3728.4	1649.9	0.0	20466.9
DISSOLVED PHOSPHORUS	4302.6	726.0	982.6	647.5	0.0	6658.7
COPPER	559.9	39.6	40.4	12.7	0.0	652.6
LEAD	1856.6	270.6	80.8	42.2	0.0	2250.2
ZINC	795.7	468.6	40.4	84.5	0.0	1389.2
LAND USE (ACRES)	294.7	66.0	134.6	422.4	0.0	917.7

Bellingham Watershed Master Plan Curve Number Summary
Basin Name: Spring Creek
Oct-93

VOLUME 2
TABLE 11.6

		EXISTING				FUTURE			
BASIN	AREA	IMPER AREA		PER AREA		IMPER AREA		PER AREA	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	23.4	1.8	98	21.6	77	19.9	98	3.5	86
211	58.3	9.4	98	48.9	82	44.8	98	13.5	86
212	53.5	2.9	98	50.6	80	26.0	98	27.5	86
213	35.8	2.3	98	33.5	77	15.1	98	20.7	86
214	37.0	5.4	98	31.7	81	15.5	98	21.5	86
215	39.9	31.8	98	8.1	85	33.9	98	6.0	86
216	17.5	1.6	98	15.9	85	7.4	98	10.1	86
217	24.2	20.3	98	3.9	85	20.3	98	3.9	86
218	41.3	0.2	98	41.1	85	18.3	98	23.0	86
219	23.4	1.0	98	22.4	83	10.6	98	12.8	86
220	47.1	3.8	98	43.4	78	35.0	98	12.1	86
202	29.7	23.2	98	6.4	85	24.6	98	5.1	86
203	28.2	18.9	98	9.3	81	24.0	98	4.2	86
221	48.1	14.8	98	33.3	81	40.8	98	7.3	86
222	65.4	4.5	98	60.9	80	51.8	98	13.6	86
204	33.9	4.0	98	29.9	84	28.0	98	5.9	87
205	54.6	13.1	98	41.5	82	39.5	98	15.1	88
206	157.1	8.3	98	148.8	76	40.7	98	116.4	86
207	34.5	0.4	98	34.1	77	20.1	98	14.4	86
208	14.9	0.9	98	14.0	76	1.5	98	13.4	86
281	49.9	0.9	98	49.0	82	1.5	98	48.4	86
904	1397.8	25.1	98	1372.7	81	57.4	98	1340.0	85
907	74.2	0.0	98	74.2	76	2.2	98	72.0	85
TOTAL	2389.7	194.6		2195.2		578.9		1810.4	
%	100.0%	8.1%		91.9%		24.2%		75.8%	

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Spring Creek – Existing
Oct–93

VOLUME 2
TABLE 11.7

BASIN	AREA	IMPER AREA		PER AREA		LAWN/OPEN SPACE		FORESTED		MEADOW/PASTURE		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	23.4	1.8	98	21.6	77	1.1	86	18.3	76	2.2	85		
211	58.3	9.4	98	48.9	82			14.7	76	34.2	85		
212	53.5	2.9	98	50.6	80	2.5	86	27.8	76	20.2	85		
213	35.8	2.3	98	33.5	77	1.7	86	28.5	76	3.4	85		
214	37.0	5.4	98	31.7	81	1.6	86	15.8	76	14.3	85		
215	39.9	31.8	98	8.1	85					8.1	85		
216	17.5	1.6	98	15.9	85					15.9	85		
217	24.2	20.3	98	3.9	85					3.9	85		
218	41.3	0.2	98	41.1	85					41.1	85		
219	23.4	1.0	98	22.4	83			4.5	76	17.9	85		
220	47.1	3.8	98	43.4	78			32.5	76	10.8	85		
202	29.7	23.2	98	6.4	85			0.4	77	6.0	85		
203	28.2	18.9	98	9.3	81	1.0	86	4.7	76	3.7	85		
221	48.1	14.8	98	33.3	81	1.7	86	15.0	76	16.6	85		
222	65.4	4.5	98	60.9	80	3.0	86	33.5	76	24.4	85		
204	33.9	4.0	98	29.9	84			7.2	79	22.7	85		
205	54.6	13.1	98	41.5	82			23.0	78	18.5	87		
206	157.1	8.3	98	148.8	76			135.1	76	13.7	87		
207	34.5	0.4	98	34.1	77			28.9	76	5.1	85		
208	14.9	0.9	98	14.0	76			13.3	76	0.7	85		
281	49.9	0.9	98	49.0	82	1.5	86	25.5	76	22.1	89		
904	1397.8	25.1	98	1372.7	81			650.7	76	722.0	85		
907	74.2	0.0	98	74.2	76			74.2	76				
TOTAL	2389.7	194.6		2195.2		14.1		1153.6		1027.5			
%	100.0%	8.1%		91.9%		0.6%		48.3%		43.0%			

Bellingham Watershed Master Plan Curve Number Detail
Basin Name: Spring Creek – Future
Oct–93

VOLUME 2
TABLE 11.8

BASIN	AREA	IMPER AREA		PER AREA		LAWN/OPEN SPACE		FORESTED		MEADOW/PASTURE		OPEN WATER	
ID	AC.	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN	AC.	CN
201	23.4	19.9	98	3.5	86	3.5	86						
211	58.3	44.8	98	13.5	86	13.5	86						
212	53.5	26	98	27.5	86	27.5	86						
213	35.8	15.1	98	20.7	86	20.7	86						
214	37	15.5	98	21.5	86	21.5	86						
215	39.9	33.9	98	6	86	6	86						
216	17.5	7.4	98	10.1	86	10.1	86						
217	24.2	20.3	98	3.9	86	3.9	86						
218	41.3	18.3	98	23	86	23	86						
219	23.4	10.6	98	12.8	86	12.8	86						
220	47.1	35	98	12.1	86	12.1	86						
202	29.7	24.6	98	5.1	86	5.1	86						
203	28.2	24	98	4.2	86	4.2	86						
221	48.1	40.8	98	7.3	86	7.3	86						
222	65.4	51.8	98	13.6	86	13.6	86						
204	33.9	28	98	5.9	87	5.9	87						
205	54.6	39.5	98	15.1	88	15.1	88						
206	157.1	40.7	98	116.4	86	116.4	86						
207	34.5	20.1	98	14.4	86	14.4	86						
208	14.9	1.5	98	13.4	86	13.4	86						
281	49.9	1.5	98	48.4	86	48.4	86						
904	1397.8	57.4	98	1340	85					1340	85		
907	74.2	2.2	98	72	85					72	85		
TOTAL	2389.7	578.9		1810.4		398.4		0.0		1412.0	170.0		
%	100.0%	24.2%		75.8%		16.7%		0.0%		59.1%	7.1%		

LOWER SQUALICUM CREEK STUDY AREA

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HYDROLOGICAL MODEL SCHEMATIC
FOR LOWER SQUALICUM CREEK

SEE FIGURE:

VOLUME 2
FIGURE 10.1 A

"HYDROLOGICAL MODEL SCHEMATIC
FOR BAKER CREEK BASIN"

Bellingham Watershed Master Plan Flow Table | Volume 2
Basin Name : Lower Squalicum Creek Corridor - Existing Condition | Table 12.2
Sep-95

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P01	11.56	3048.1	29.1		9.0	1500.0	501.9	21.5	3.2	1400.5	28.4	5.5	1908.9	30.7	6.7
D02				4.0			501.9	4.0	3.7	1400.5	5.6	6.8	1908.9	6.2	8.1
P03	11.72	3548.5	32.9		8.0	1200.0	501.9	23.2	3.0	1400.6	30.9	5.1	1909.2	33.5	6.2
D04				4.0			501.9	4.6	3.0	1400.6	6.5	5.4	1909.2	7.1	6.4
P05	10.10	1670.4	20.9		8.0	1100.0	502.0	18.2	3.8	1401.1	23.4	7.1	1910.0	23.8	full
D06				5.0			502.0	6.4	2.4	1401.1	9.2	4.4	1910.0	10.1	5.3
P07	10.10	1670.4	20.9		8.0	1100.0	502.0	18.2	3.8	1401.2	23.4	7.1	1910.2	23.8	full
D08				3.0			502.0	4.7	2.9	1401.2	6.4	5.0	1910.2	7.0	5.9
D08A				5.0			489.0	5.3	2.3	1372.1	7.4	4.2	1872.3	8.2	5.1
	10.10	1960.9	24.5		8.0	1100.0	489.0	20.3	3.4	1372.3	26.5	6.3	1872.9	27.9	7.9
D10				2.5			489.0	5.0	3.0	1372.3	7.1	5.5	1872.9	7.8	6.6

Bellingham Watershed Master Plan Flow Table
Basin Name : Lower Squalicum Creek Corridor - Future Condition
Sep-95

Volume 2
Table 12.3

REACH NAME		CAPACITY			HW CONTROL		2-YR			25-YR			100-YR		
	DIA.	Q	V	H	HW	Qhw	Q	V	H	Q	V	H	Q	V	H
ID	FT	CFS	FPS	FT	FT	CFS	CFS	FPS	FT	CFS	FPS	FT	CFS	FPS	FT
P01	11.56	3048.1	29.1		9.0	1500.0	853.9	24.9	4.2	1919.8	30.7	6.7	2576.2	32.6	8.1
D02				4.0			853.9	4.8	5.1	1919.8	6.2	8.1	2576.2	6.7	9.6
P03	11.72	3548.5	32.9		8.0	1200.0	854.0	27.0	3.9	1920.1	33.5	6.1	2576.3	35.8	7.4
D04				4.0			854.0	5.5	4.1	1920.1	7.1	6.5	2576.3	7.8	7.6
P05	10.10	1670.4	20.9		8.0	1100.0	854.6	21.0	5.1	1920.7	24.0	full	2577.3	32.2	full
D06				5.0			854.6	7.8	3.3	1920.7	10.2	5.4	2577.3	11.1	6.4
P07	10.10	1670.4	20.9		8.0	1100.0	854.7	21.0	5.1	1920.8	24.0	full	2577.4	32.2	full
D08				3.0			854.7	5.6	3.8	1920.8	7.0	5.9	2577.4	7.6	6.9
D08A				5.0			836.7	6.3	3.2	1884.9	8.2	5.1	2530.6	9.0	6.0
	10.10	1960.9	24.5		8.0	1100.0	837.0	23.5	4.6	1885.6	27.9	7.9	2531.7	31.6	full
D10				2.5			837.0	6.0	4.1	1885.6	7.8	6.6	2531.7	8.6	7.8

TABLE 12.4

POLLUTANT LOADINGS - EXISTING

AND

TABLE 12.5

POLLUTANT LOADINGS - FUTURE

NOT DEVELOPED FOR

LOWER SQUALICUM CREEK

12.9 LOWER SQUALICUM CREEK STUDY AREA ENVIRONMENTAL DOCUMENTATION

That portion of Squalicum Creek between Squalicum Harbor and the confluence with Baker Creek was examined in this study and one wetland covered by the Bellingham Wetland Inventory (SQ-1) was evaluated. Refer to Figure 11.2.2 in the Watershed Master Plan.

12.9.1 Lower Squalicum Creek Corridor Wetland Descriptions

SQ-1 (Squalicum Creek, Reach 2)

Wetland Description: This palustrine forested, scrub-shrub and emergent wetland had three vegetation layers characterized as moderately dense with intermediate plant community maturity and low species diversity. Dominant plant species included red alder (*Alnus rubra*), willow (*Salix* sp.), common cattail (*Typha latifolia*) and reed canarygrass (*Phalaris arundinacea*). Persistent vegetation dominated this wetland area. No surface water was observed and consequently no flow rate was measured. Less than 1 percent of the wetland basin was filled during low water and the potential for an expanded water surface was considered high. The hydroperiod was evaluated as seasonally saturated and a constricted outlet was observed. Mineral soils formed the wetland substrate which had an approximate slope of 2 percent. The complexity of the wetland/upland boundary was low. This wetland measures approximately 1.5 acres.

Wetland Values: The wildlife habitat potential was rated as moderate due to existing structural diversity. Because the wetland was long and well vegetated, the water quality benefits rating was high. Moderate to high flow attenuation would be provided by the long available flood basin with abundant persistent vegetation. Vegetation diversity could be enhanced by planting native conifers.

Wetland Impacts: Moderate increases in floodwater would have little impact to this wetland.

12.9.2 Lower Squalicum Creek Corridor Stream Reach Descriptions

Squalicum Creek, Reach 1 (D-02, D-04)

Reach Locators: Downstream limit, Squalicum Harbor; Upstream limit, change in development pattern and stream gradient.

Channel Dimensions: High Flow Width, 25 feet; Bankful Width, 30 feet; Low Water Width, 20 feet; Bankful Depth, 4 feet; Low Water Depth 0.5 feet; Stream Gradient, 1 percent; Bank Undercut, 0 percent (channel lined with rip-rap).

Riparian Vegetation: The vegetation was characterized as developed. The overall vegetation density was less than 50 percent. The stream canopy was estimated at 2 percent cover and the estimated shade was 5 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting or debris jams were noted on the upper bank. Channel overflow was thought not to occur. Bank rock content was greater than 65 percent and there were no flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a sand, gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. Aquatic vegetation was abundant and the water clarity was murky. A flow velocity of approximately 1 fps was observed.

Stream Evaluations: Stream aesthetics were very low as the stream has been channelized and the natural vegetation has been removed. Because of the industrial character of the surrounding development, enhancement potential is low. Water quality may be impacted by the proximity of non-point pollution sources including roadways and parking lots.

Stream Impacts Assessment: Rip-rap on channel sides protects this reach from erosion during increased stormwater flows.

Squalicum Creek, Reach 2 (D-04)

Reach Locators: Downstream limit, change in development pattern and stream gradient; Upstream limit, change in stream gradient.

Channel Dimensions: High Flow Width, 25 feet; Bankful Width, 32 feet; Low Water Width, 18 feet; Bankful Depth, 4 feet; Low Water Depth 1.5 feet; Stream Gradient, 2 percent; Bank Undercut, 60 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest with an overall vegetation density of 70-90 percent. The stream canopy was estimated at 80 percent cover and the estimated shade was 90 percent.

Stream Characteristics: Above the upper bank, the landform slope ranged from 10 to 20 percent in the lower part and 30 to 40 percent in the upper part of the reach. No mass wasting and small debris jams were noted on the upper bank. The frequency of channel overflow was considered rare. Bank rock content was 40 to 65 percent and there were few flow obstructions on the lower bank. Frequent cutting of the lower creek bank was observed, and the height of the raw banks was 6 to 12 inches. The creek bottom had a gravel, cobble, and boulder substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. The occurrence of aquatic vegetation was common and the water clarity was murky. A flow velocity of approximately 1.5 fps was observed.

Stream Evaluations: Vegetation species diversity was low; therefore, planting additional native tree and shrub species along the creek would enhance the wildlife habitat and overall aesthetics. Trash should be removed. Abundant algae indicated high nutrient level in stream waters. Slightly murky water suggests water quality problem and the adjacent roadway and upstream development are likely sources of non-point pollution.

Stream Impacts Assessment: Rip-rap which lines the banks of this reach can probably accommodate moderately high stormwater flows.

Squalicum Creek, Reach 3 (D-04)

Reach Locators: Downstream limit, change in stream gradient; Upstream limit, change in gradient and wetland vegetation type.

Channel Dimensions: High Flow Width, 28 feet; Bankful Width, 35 feet; Low Water Width, 10 feet; Bankful Depth, 5 feet; Low Water Depth, 1 foot; Stream Gradient, 3 percent; Bank Undercut, 30 percent.

Riparian Vegetation: The vegetation was characterized as a mixture of mature and immature/even-aged forest and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 40 percent cover and the estimated shade was 50 percent.

Stream Characteristics: Above the upper bank, the landform slope was 40 to 60 percent. No mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Bank rock content was greater than 65 percent and there were few to moderate number of flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks ranged from 12 to 24 inches. The creek bottom had a gravel, cobble, and boulder substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. Aquatic vegetation was abundant and the water clarity was murky. A flow velocity of approximately 2.5 fps was observed.

Stream Evaluations: This reach could be enhanced by removing trash and debris from the creek and its banks. Abundant algae indicated high nutrient level in stream waters. Slightly murky water suggested a potential water quality problem and the adjacent roadway and upstream development are likely sources of non-point pollution.

Stream Impacts Assessment: Because the banks of this reach are armored with rip-rap, the creek can probably handle increased stormwater flows.

Squalicum Creek, Reach 4 (D-04)

Reach Locators: Downstream limit, change in stream gradient; Upstream limit, culvert at Squalicum Parkway.

Channel Dimensions: High Flow Width, 30 feet; Bankful Width, 36 feet; Low Water Width, 20 feet; Bankful Depth, 4 feet; Low Water Depth, 1 foot; Stream Gradient, 2 percent; Bank Undercut, 15 percent.

Riparian Vegetation: The vegetation was characterized as shrub-dominated and pasture/meadow with an overall density of 70 to 90 percent. The stream canopy was estimated at 10 percent cover and the estimated shade was 20 percent.

Stream Characteristics: Above the upper bank, the landform slope was 10 to 20 percent. A small number of large mass wasting sloughs and small debris jams were noted on the upper bank. Channel overflow was estimated as common. Bank rock content was less than 20 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was greater than 24 inches. The creek bottom had a gravel, cobble, and boulder substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. Aquatic vegetation was abundant and the water clarity was clear. A flow velocity of approximately 0.8 fps was observed.

Stream Evaluations: Much of this reach is dominated by reed canarygrass and therefore could be enhanced by planting native trees and shrubs along the creek banks. Although no obvious sources of nonpoint pollution were observed, abundant algae indicated high nutrient level in stream waters. Major erosion problems were observed in this reach.

Stream Impacts Assessment: Where there were relatively tight bends in the stream course, significant bank erosion was observed and increased stormwater flows would only exacerbate this existing erosion problem.

Squalicum Creek, Reach 5 (D-06)

Reach Locators: Downstream limit, culvert at Squalicum Parkway; Upstream limit, culvert at Squalicum Parkway.

Channel Dimensions: High Flow Width, 20 feet; Bankful Width, 26 feet; Low Water Width, 18 feet; Bankful Depth, 6 feet; Low Water Depth, 0.5 feet; Stream Gradient, 2 percent; Bank Undercut, 0 percent.

Riparian Vegetation: The vegetation was characterized as partly immature/even-aged forest, shrub-dominated and developed, with an overall density of 50 to 70 percent. The stream canopy was estimated at 50 percent cover and the estimated shade was 50 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. No mass wasting and no debris jams were noted on the upper bank. Because of man-made channel modifications, channel overflow was thought not to occur. Bank rock content was greater than 65 percent and there were few flow obstructions on the lower bank. No cutting of the lower creek bank was observed. The creek bottom had a gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. Aquatic vegetation was abundant and the water clarity was clear. A flow velocity of approximately 1 fps was observed.

Stream Evaluations: Enhancement potential is low due to the highly disturbed condition of this rip-rapped channel. Adjacent industrial development and roads probably contribute nonpoint source pollutants. Abundant algae indicated high nutrient level in stream waters.

Stream Impacts Assessment: Because the banks of this reach are armored with rip-rap, the creek can probably handle increased stormwater flows.

Squalicum Creek, Reach 6 (D-08, D-08A)

Reach Locators: Downstream limit, culvert at Squalicum Parkway; Upstream limit, culvert at Squalicum Parkway.

Channel Dimensions: High Flow Width, 21 feet; Bankful Width, 29 feet; Low Water Width, 17 feet; Bankful Depth, 3 feet; Low Water Depth, 0.4 feet; Stream Gradient, 2 percent; Bank Undercut, 5 percent.

Riparian Vegetation: The vegetation was characterized as mature and immature/even-aged forest with an overall density of 70 to 90 percent. The stream canopy was estimated at 75 percent cover and the estimated shade was 80 percent.

Stream Characteristics: Above the upper bank, the landform slope was less than 10 percent. A small number of large mass wasting sloughs and small debris jams were noted on the upper bank. The frequency of channel overflow was estimated as occasional. Bank rock content was estimated at 20 to 40 percent and there were few flow obstructions on the lower bank. Some cutting of the lower creek bank was observed, and the height of the raw banks was greater than 24 inches. The creek bottom had a gravel and cobble substrate with loose particle packing. Scouring and deposition were rated at 5 to 30 percent. Aquatic vegetation was abundant and the water clarity was clear. A flow velocity of approximately 1.5 fps was observed.

Stream Evaluations: This reach has moderate to good aesthetics, although some human disturbance and trash was evident. Animal habitat value is good as evidence by the presence of an active beaver dam. Additional enhancement could be accomplished by removing trash from the creek and its banks. Abundant algae indicated high nutrient level in stream waters. Slightly murky water suggested a potential water quality problem and the adjacent roadway and upstream development are likely sources of non-point pollution.

Stream Impacts Assessment: Banks of this reach are armored with rip-rap, and consequently, the creek can probably handle increased stormwater flows.

Squalicum Creek, Reach 7 (D-10)

Reach Locators: Downstream limit, culvert at Squalicum Parkway; Upstream limit, culvert at Squalicum Parkway.

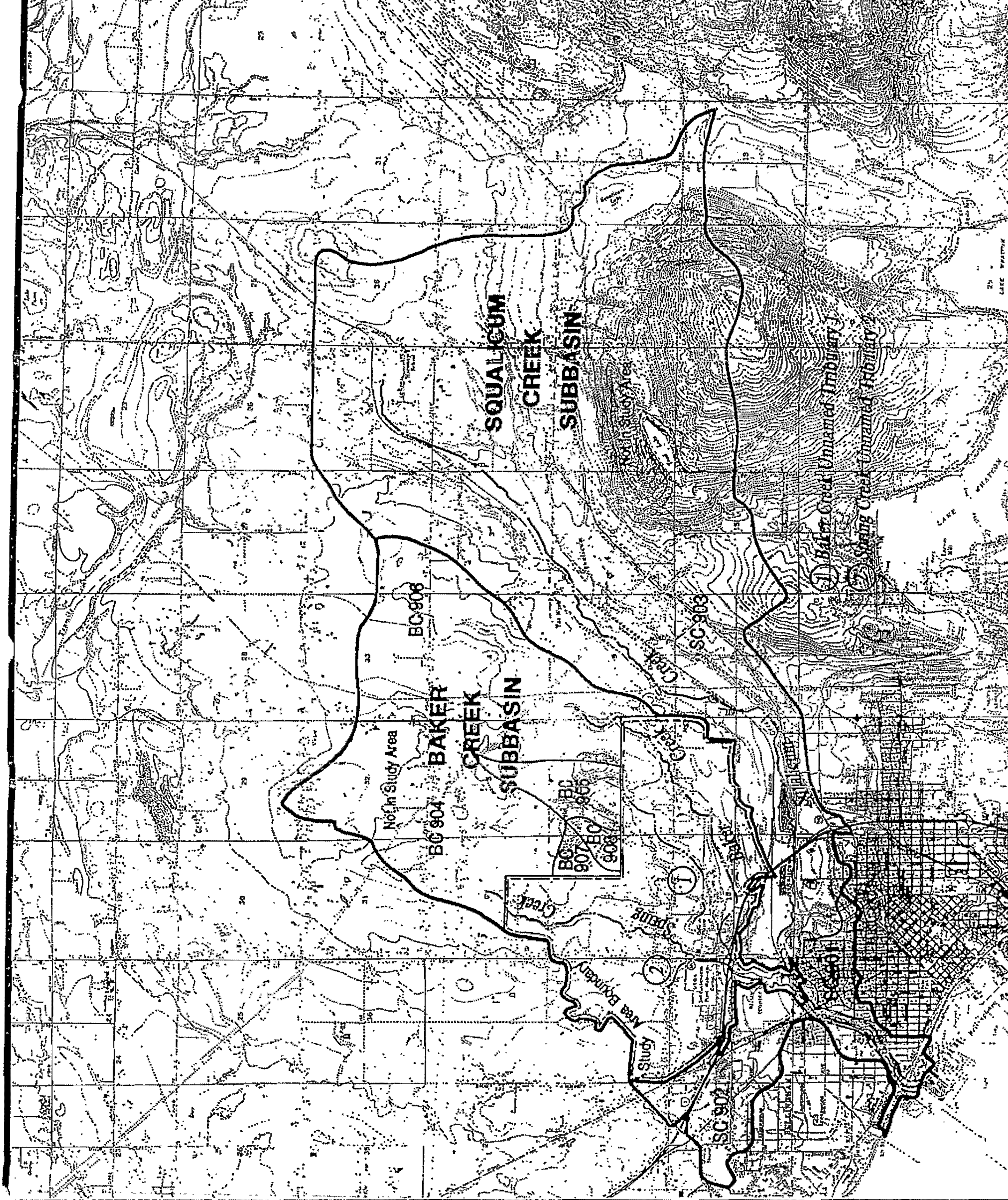
Channel Dimensions: High Flow Width, 28 feet; Bankful Width, 35 feet; Low Water Width, 15 feet; Bankful Depth, 5 feet; Low Water Depth, 0.4 feet; Stream Gradient, 2 percent; Bank Undercut, 70 percent.

Riparian Vegetation: The vegetation was characterized as immature/even-aged forest and shrub-dominated with an overall density of 70 to 90 percent. The stream canopy was estimated at 65 percent cover and the estimated shade was 70 percent.

Stream Characteristics: Above the upper bank, the landform slope was 30 to 40 percent. Small amounts of mass wasting and small debris jams were noted on the upper bank. Channel overflow was estimated as occasional. Except where gabions protect previously eroding slopes, bank rock content was less than 20 percent. There were few flow obstructions on the lower bank. Frequent cutting of the lower creek bank was observed, and the height of the raw banks was greater than 24 inches. The creek bottom had a silt/organic, gravel, cobble, and boulder substrate with loose particle packing. Scouring and deposition were rated at less than 5 percent. The occurrence of aquatic vegetation was abundant, and the water clarity was murky. A flow velocity of approximately 1 fps was observed.

Stream Evaluations: Residential development encroaches on the upper portion of this reach. Disturbed area could be enhanced by planting native trees and shrubs on creek banks. Abundant algae indicated high nutrient level in stream waters. Murky water suggested a potential water quality problem and the proximity to relatively high development densities upstream were likely sources of non-point pollution.

Stream Impacts Assessment: This reach can probably handle increased stormwater flows because the most erosion prone segments already armored with rip-rap.



LEGEND

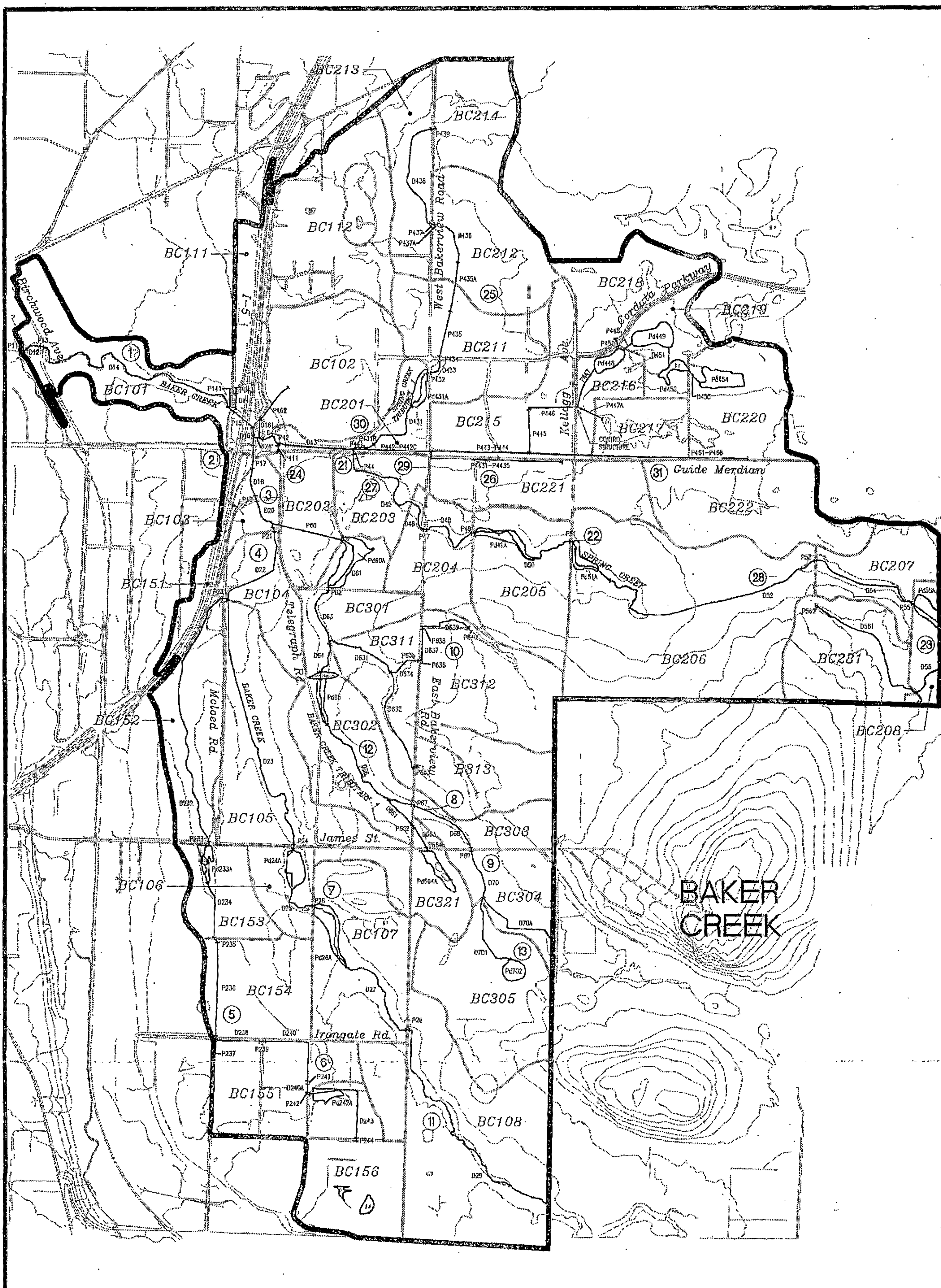
- Major Basin Boundary
- Basin Boundaries
- Study Area Boundary
- Major Creeks

1 0 1 mi.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

HDR Engineering, Inc.

FIGURE
11.0
DATE
OCT. 22 1993



LEGEND

Basin Boundary

Subbasin Boundary

SB401 Subbasin Designator

③ Problem Identifier

D32 Open Channel Reach and Number

P22 Pipe Reach and Number

N

1200 800 400 0 1200

Scale in Feet

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

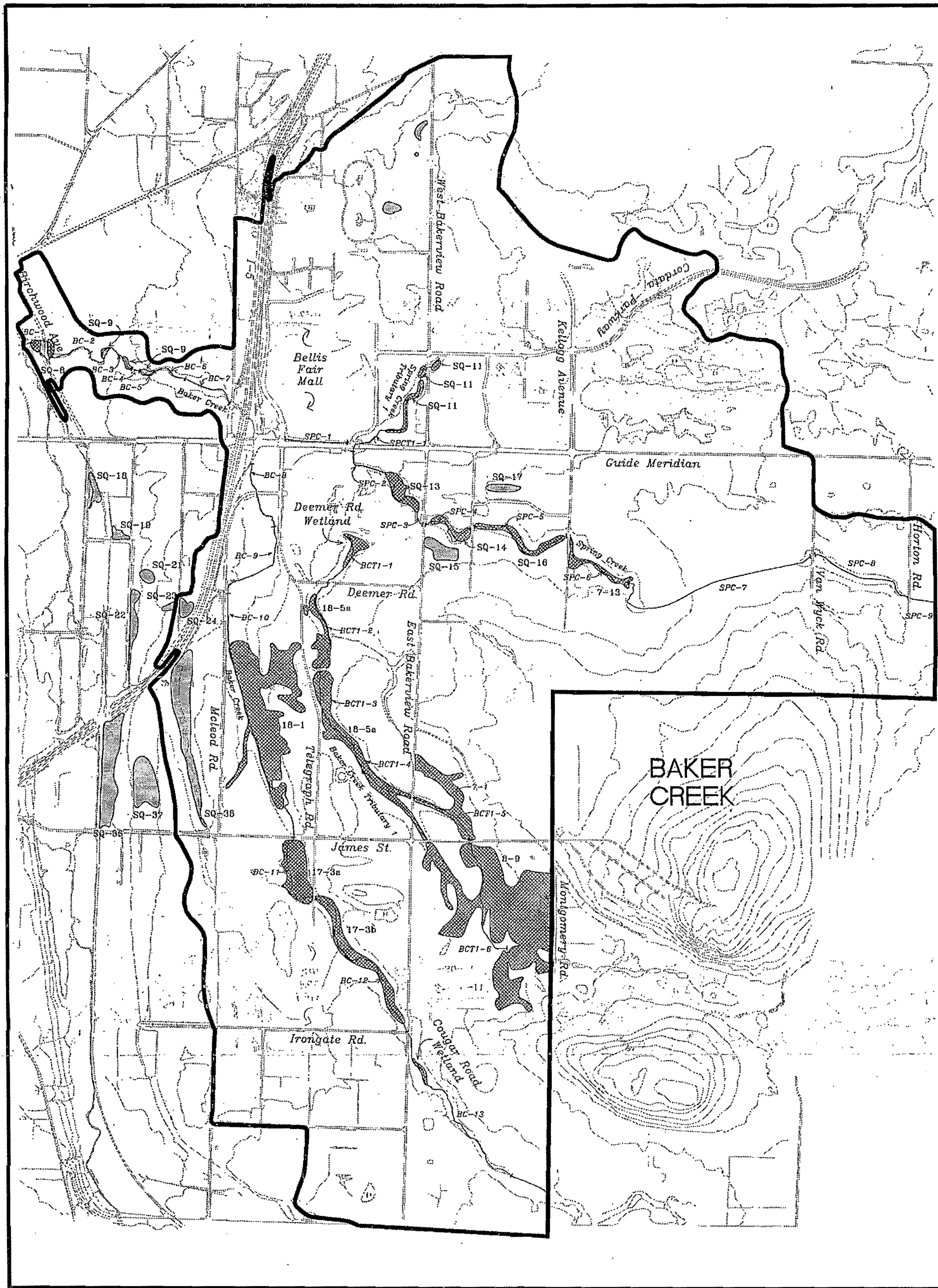
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Baker Creek Basin Facility

FIGURE
11.1.1

DATE:
SEPT.1,1995



LEGEND

- Basin Boundary
- BC-11 Stream and Reach Identifier - Field Inventoried
- Stream - Not Inventoried for this Study
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- SQ-21 Wetland Identifier

1200 800 400 0 1200

Scale in feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

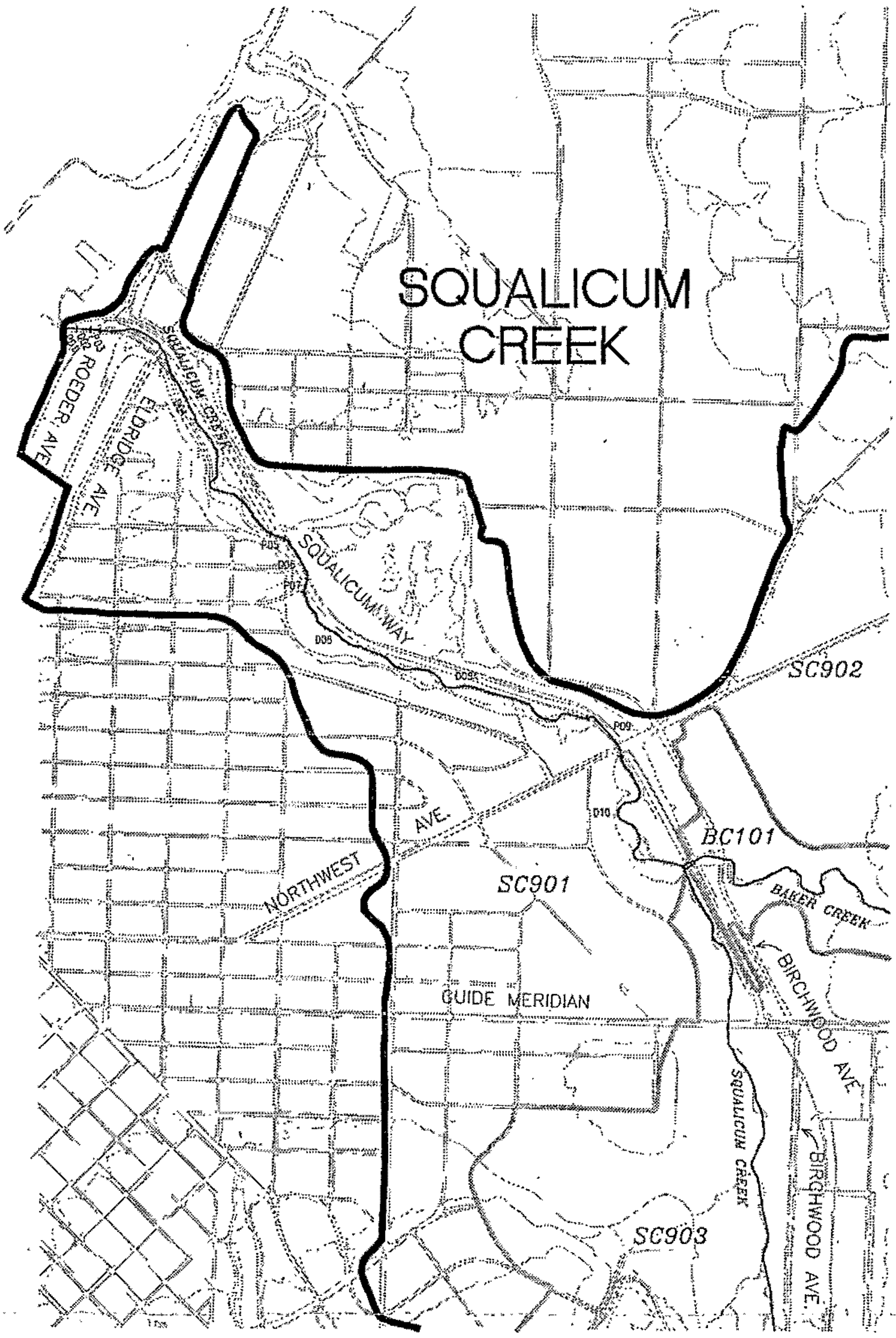
DEA DAVID EVANS AND ASSOCIATES, INC.

HDR HDR Engineering, Inc.

Baker Creek Basin Environment

FIGURE 11.1.2

DATE OCT. 22, 1993



LEGEND
- Basin Boundary
- Subbasin Boundary
- SB401 Subbasin Designator
- (3) Problem Identifier
- 032 Open Channel Reach and Number
- P22 Pipe Reach and Number

N

1200 800 400 0 1200
Scale in feet

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

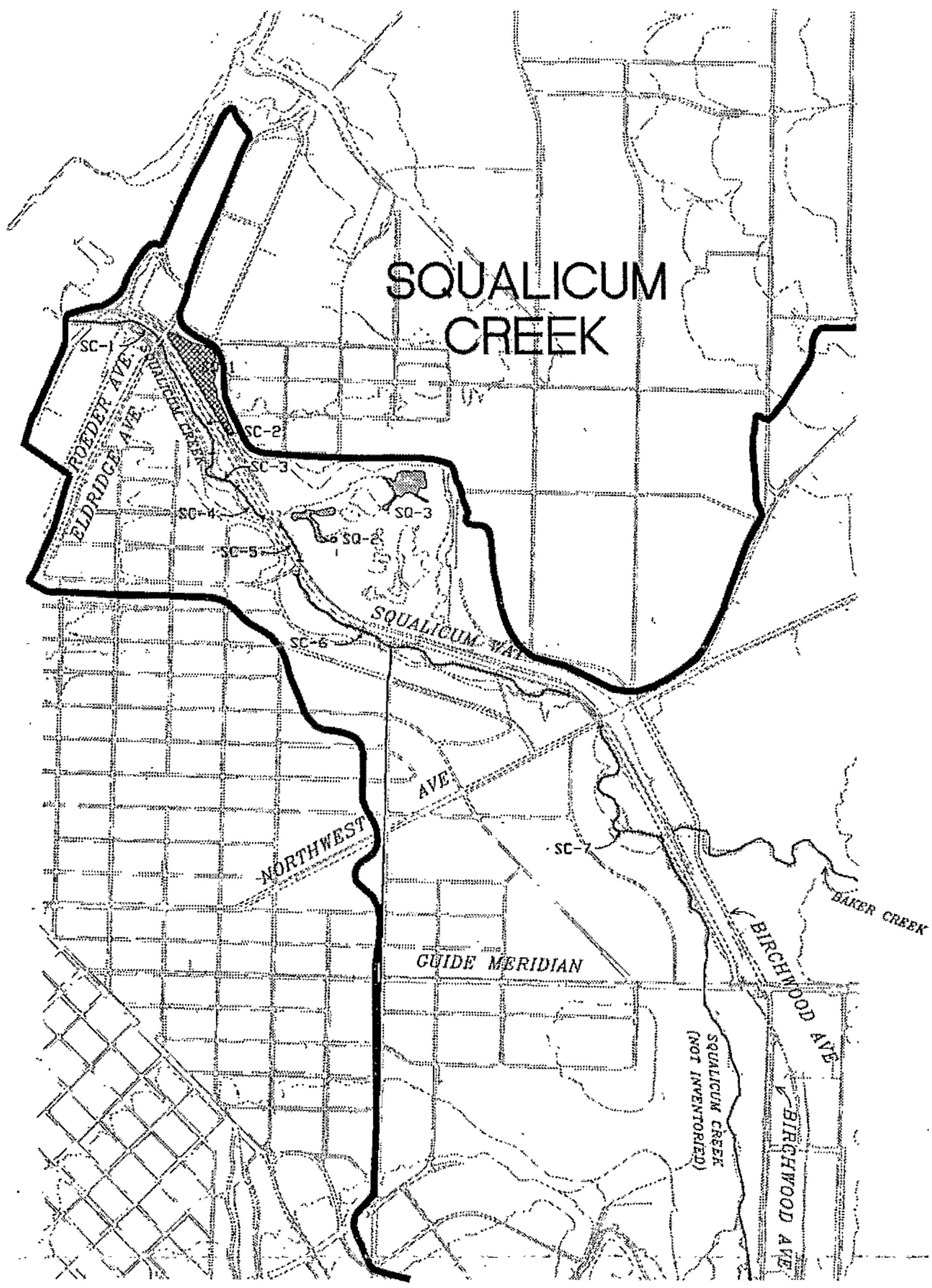
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Lower Squalicum Creek Corridor Facility

FIGURE
11.2.1

DATE
OCT. 22, 1993



LEGEND

Basin Boundary

ECC-3 Stream and Reach Identifier - Field Inventoried

Stream - Not Inventoried for this Study

Wetland - Field Inventoried

Wetland - Not Inventoried for this Study

WH-74 Wetland Identifier

1200 800 400 0 1200

Scale in feet

N

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CITY OF BELLINGHAM
WATERSHED MASTER PLAN

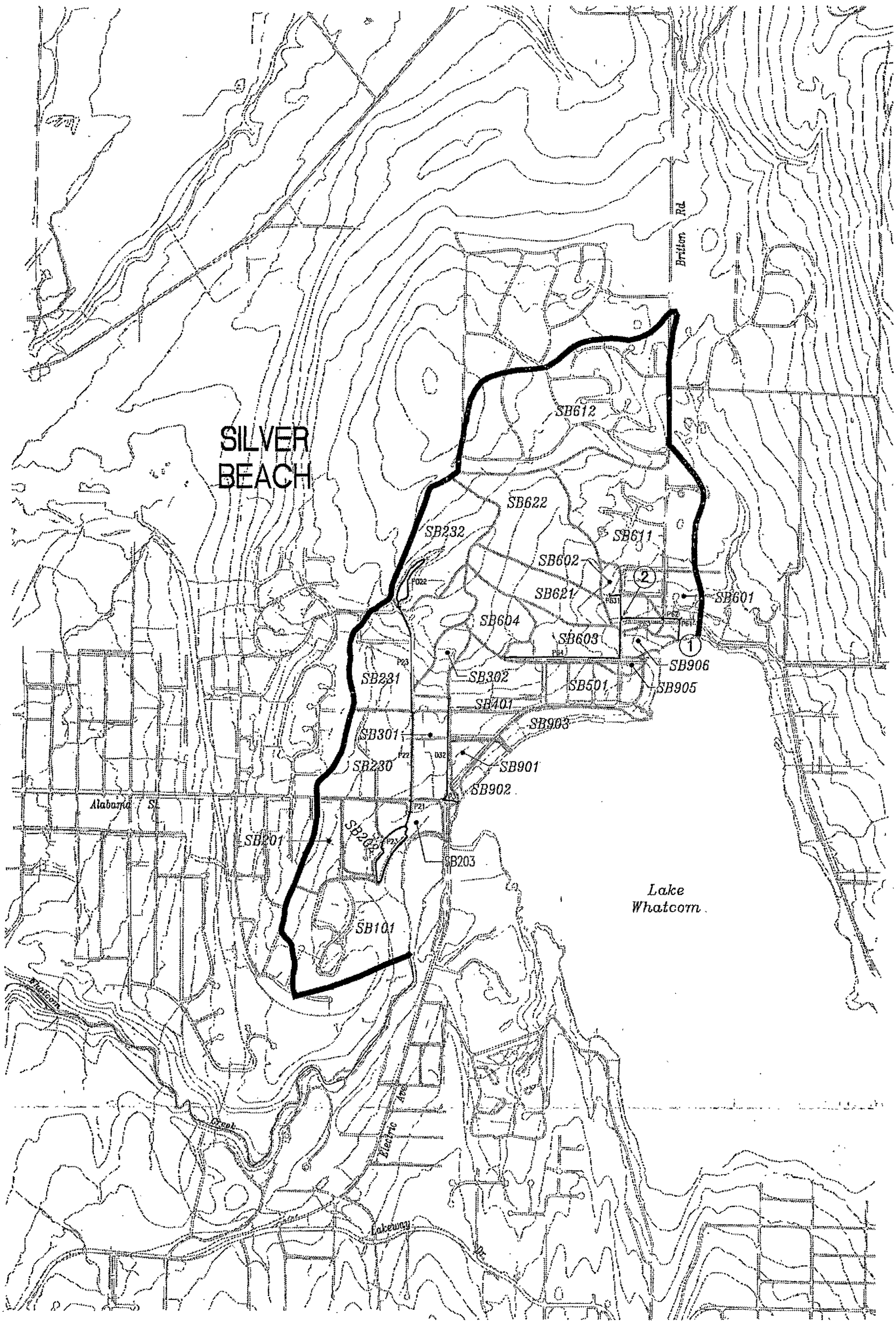
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Lower Squalicum Creek Corridor Environment

FIGURE
11.2.2

DATE:
OCT. 22, 1993



LEGEND
Basin Boundary
Subbasin Boundary
SB401 Subbasin Designator
(3) Problem Identifier
D32 Open Channel Reach and Number
P22 Pipe Reach and Number

1200 800 400 0 1200
Scale in feet

N

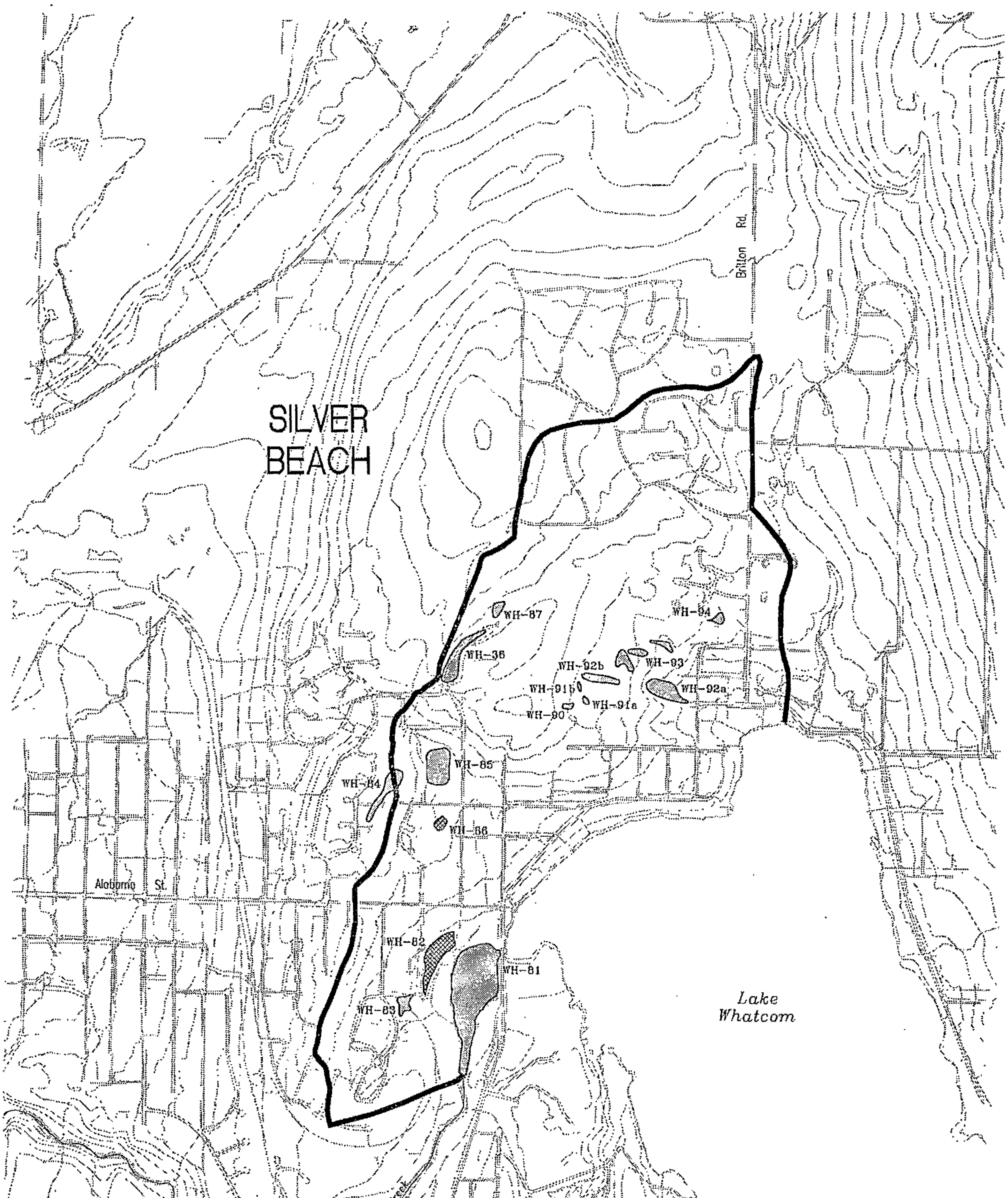
CITY OF BELLINGHAM
WATERSHED MASTER PLAN

DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Silver Beach Basin Facilities

FIGURE 7.21
DATE: SEPT. 1, 1995



LEGEND

Basin Boundary

Stream - Not Inventoried for this Study

Wetland - Field Inventoried

Wetland - Not Inventoried for this Study

WH-74 Wetland Identifier

1200 800 400 0 1200

Scale in feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

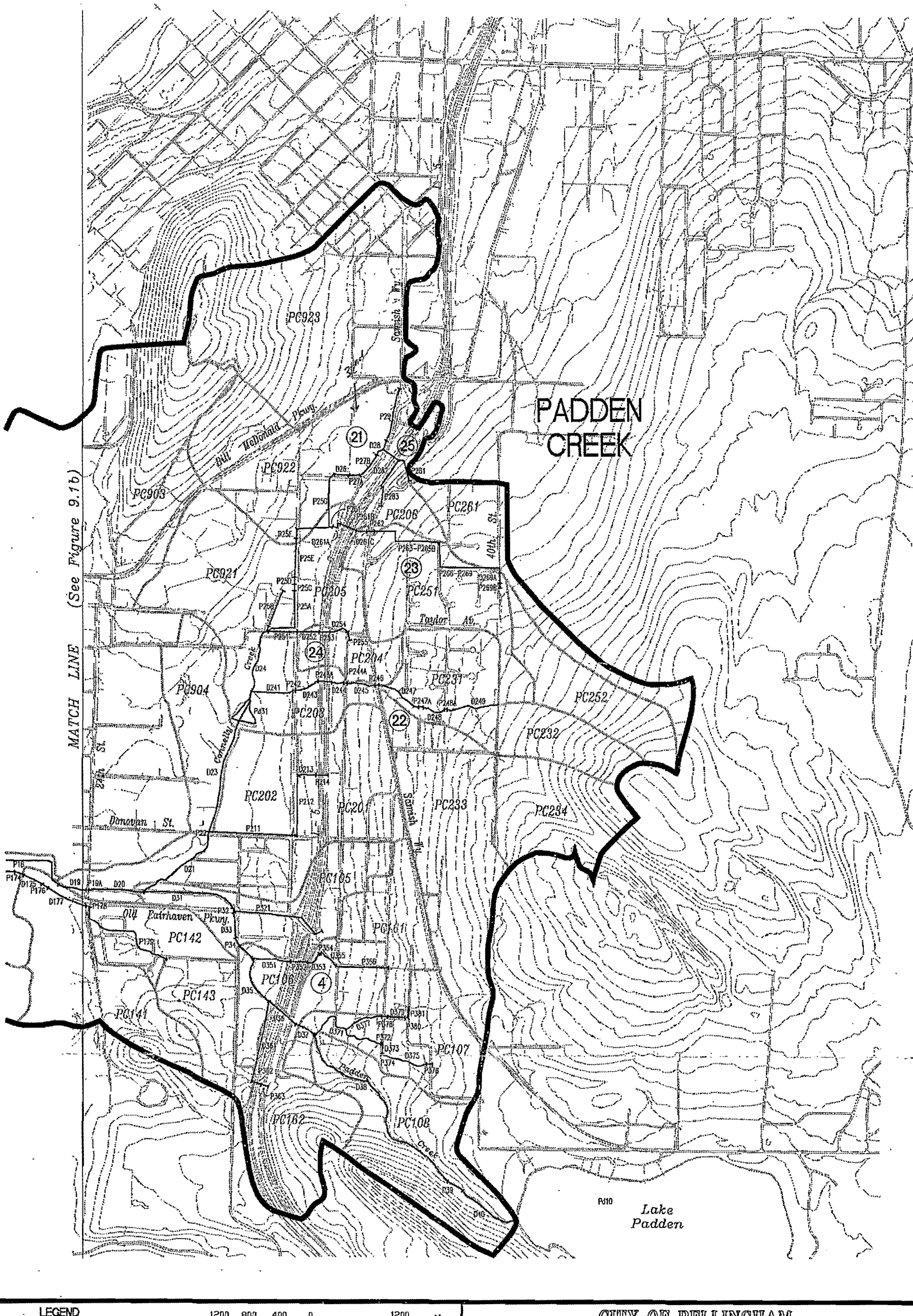
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Silver Beach Basin Environment

FIGURE
7.2.2

DATE:
OCT. 22, 1993



LEGEND

- Basin Boundary
- Subbasin Boundary
- PC 251 Subbasin Designator
- (3) Problem Identifier
- D32 Open Channel Reach and Number
- P22 Pipe Reach and Number

1200 800 400 0 1200

Scale in Feet

N

Note: Subbasin designator numbers in the 200s are within the Connelly Creek Subbasin. Those numbers in the 100s are within the Padden Creek Subbasin. Numbers in the 900s are not in the study area.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

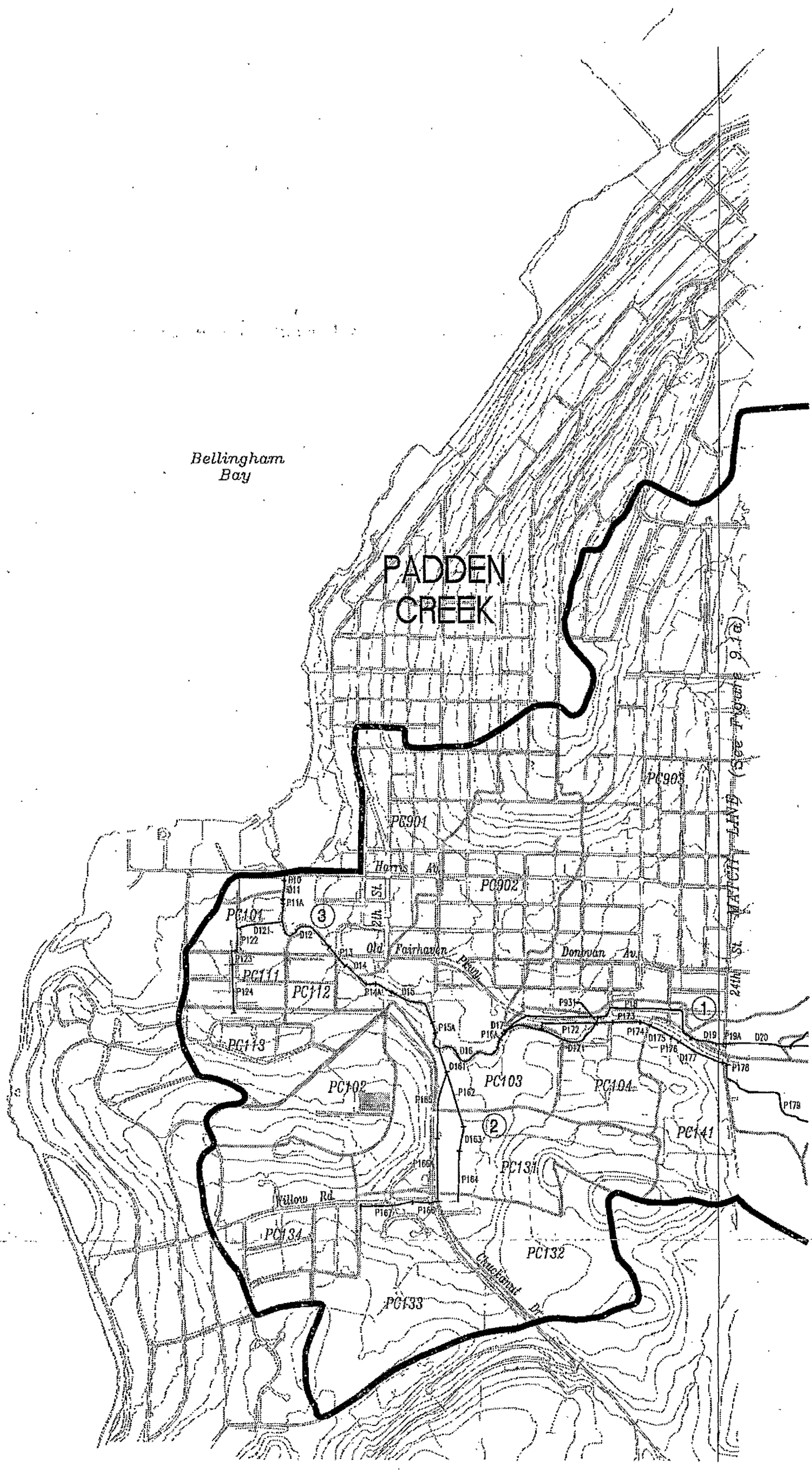
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Padden Creek Basin Facility (East Section)

FIGURE
9.1.a

DATE
SEPT. 1, 1995



LEGEND

- Basin Boundary
- Subbasin Boundary
- *SB401* Subbasin Designator
- (3) Problem Identifier
- D32 Open Channel Reach and Number
- P22 Pipe Reach and Number

1200 800 400 0 1200

Scale in feet

N

Note: Subbasin designator numbers in the 200s are within the Connelly Creek Subbasin. Those numbers in the 100s are within the Padden Creek Subbasin. Numbers in the 900s are not in the study area.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

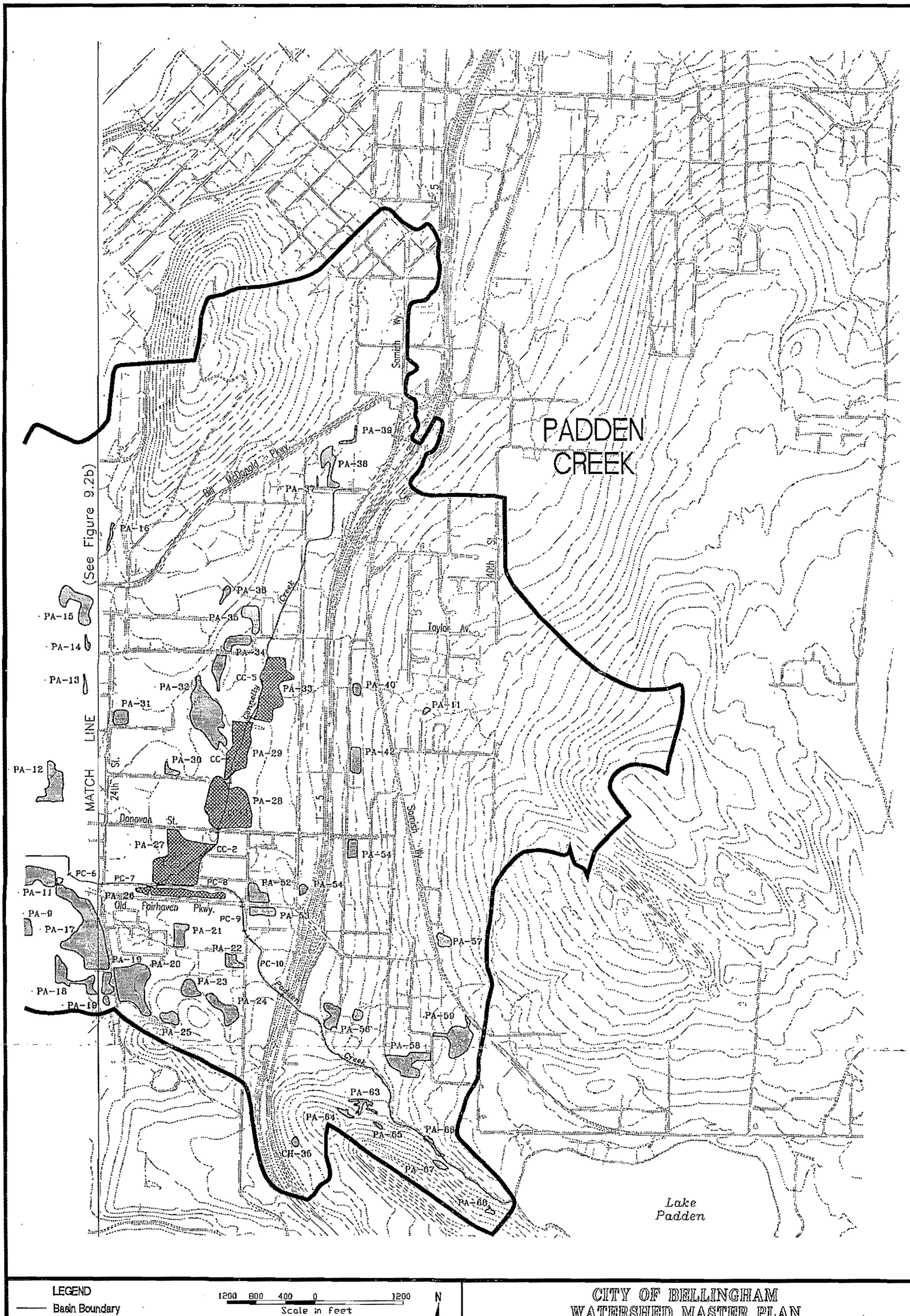
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Padden Creek Basin Facility (West Section)

FIGURE 9.1b

DATE: SEPT. 1, 1995



LEGEND

- Basin Boundary
- PC-9 Stream and Reach Identifier - Field Inventoried
- Stream - Not Inventoried for this Study
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- PA-6 Wetland Identifier

1200 800 400 0 1200

Scale in Feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

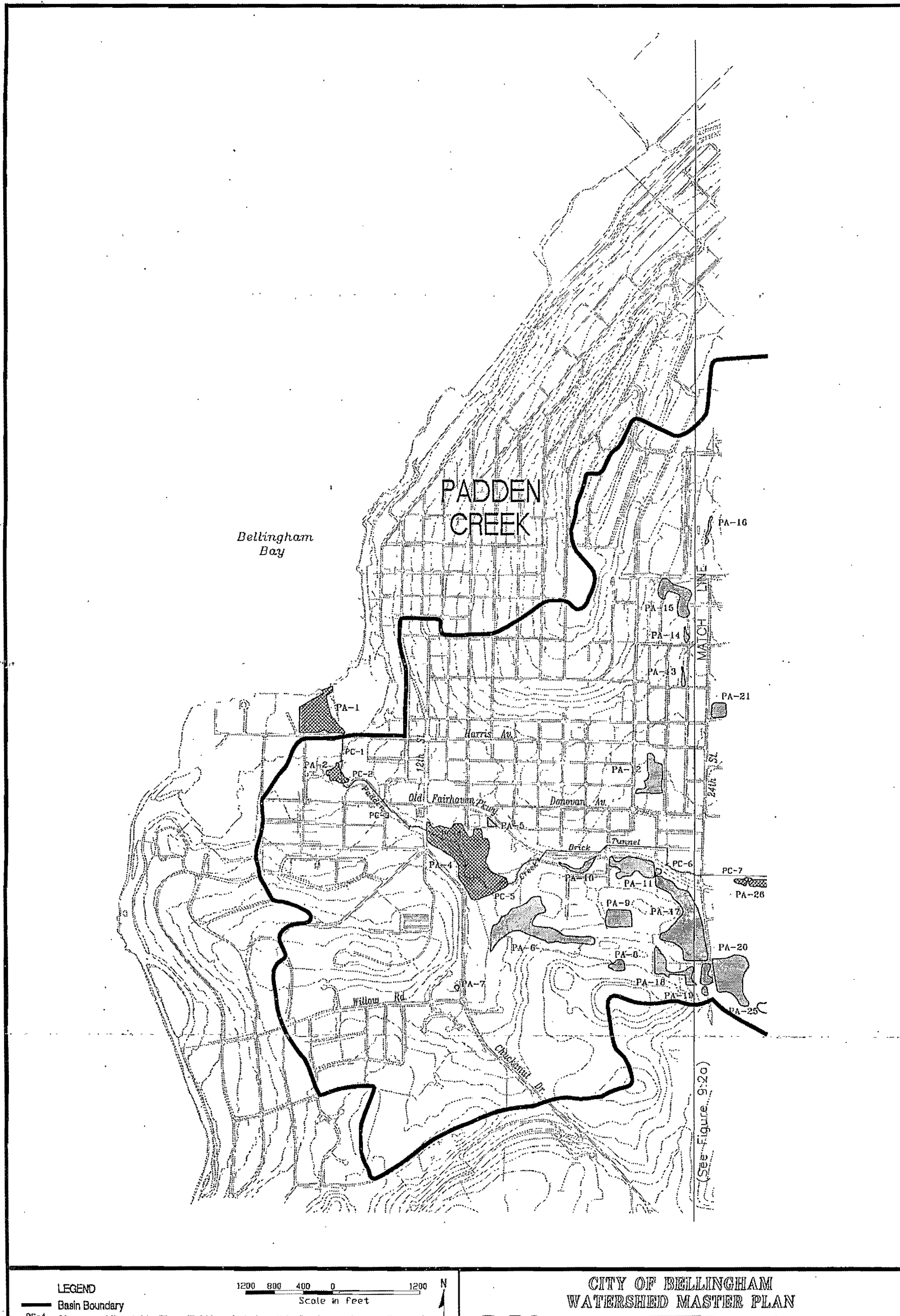
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

FIGURE 9.2a

DATE: OCT. 22, 1993

Padden Creek Basin Environment (East Section)



LEGEND

- Basin Boundary
- PC-4 Stream and Reach Identifier - Field Inventoried
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- PA-4 Wetland Identifier

1200 800 400 0 1200

Scale in feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

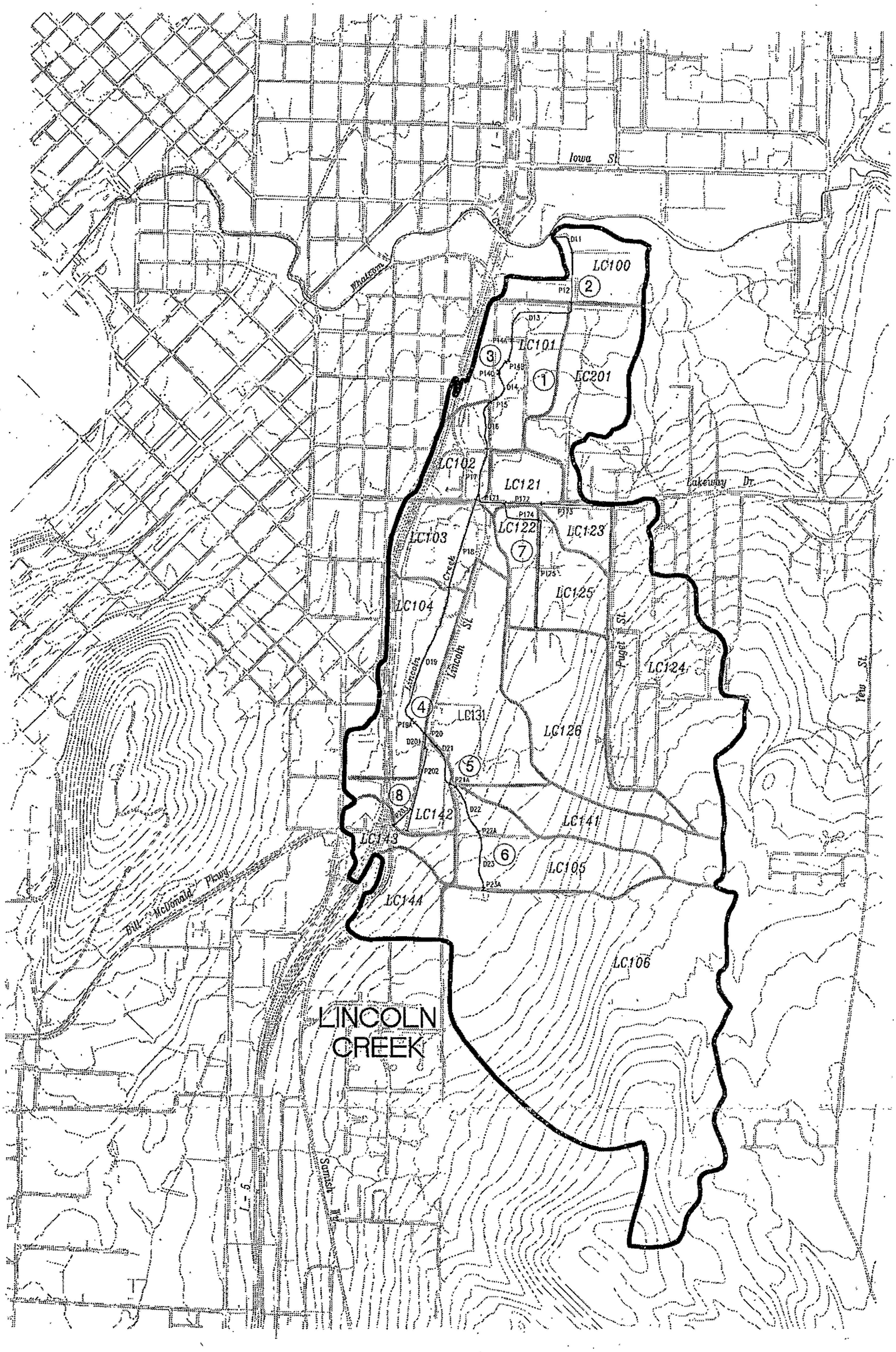
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Padden Creek Basin Environment (West Section)

FIGURE 9.2b

DATE: OCT. 22, 1993



LEGEND
Basin Boundary
Subbasin Boundary
SB401 Subbasin Designator
(3) Problem Identifier
D32 Open Channel Reach and Number
P22 Pipe Reach and Number

1200 800 400 0 1200
Scale in Feet

N

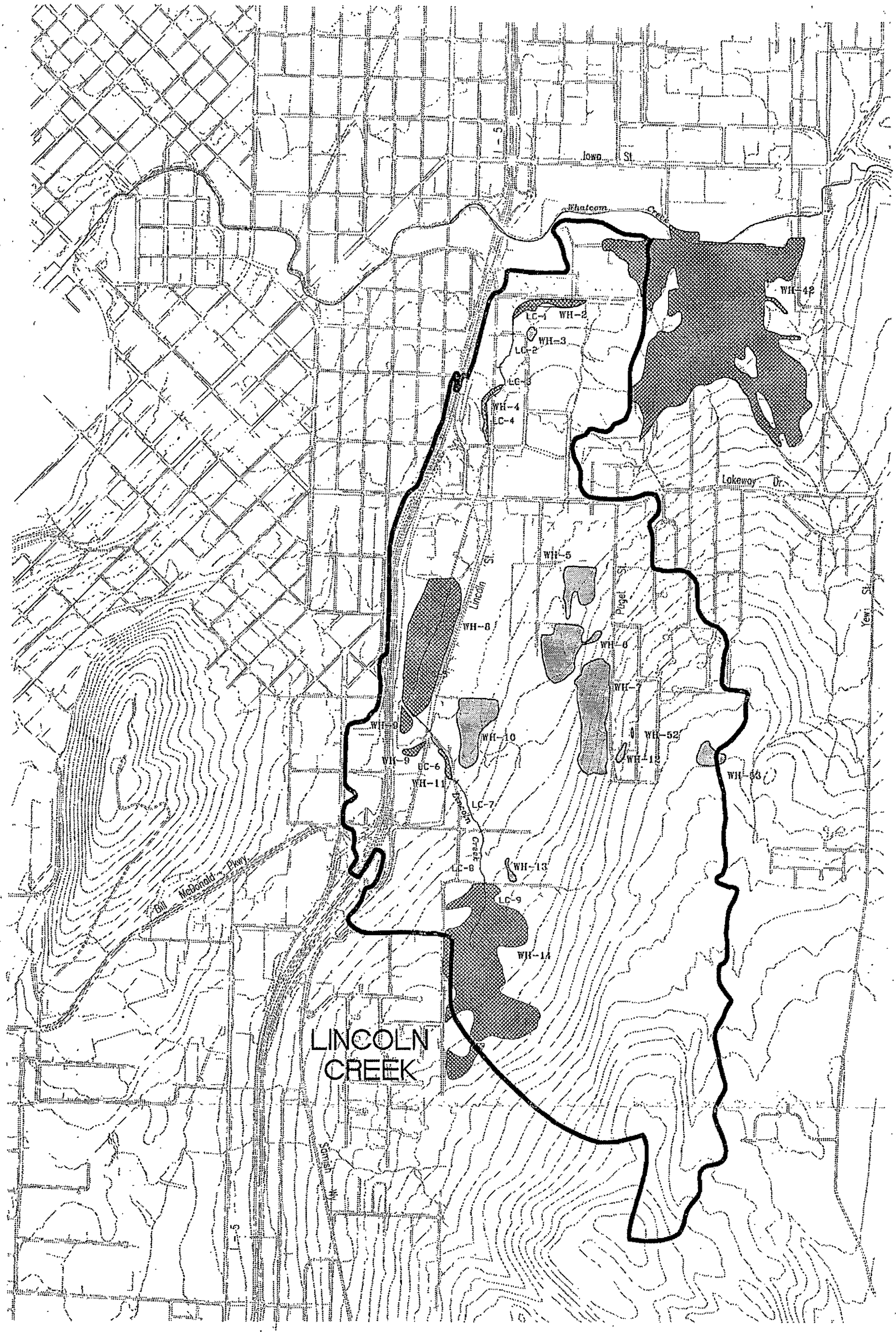
CITY OF BELLINGHAM
WATERSHED MASTER PLAN

DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Lincoln Creek Basin Facility

FIGURE
7.3.1
DATE: OCT. 22, 1993



LEGEND

- Basin Boundary
- ECC-3 Stream and Reach Identifier - Field Inventoried
- Stream - Not Inventoried for this Study
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- WH-74 Wetland Identifier

1200 800 400 0 1200
Scale in Feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

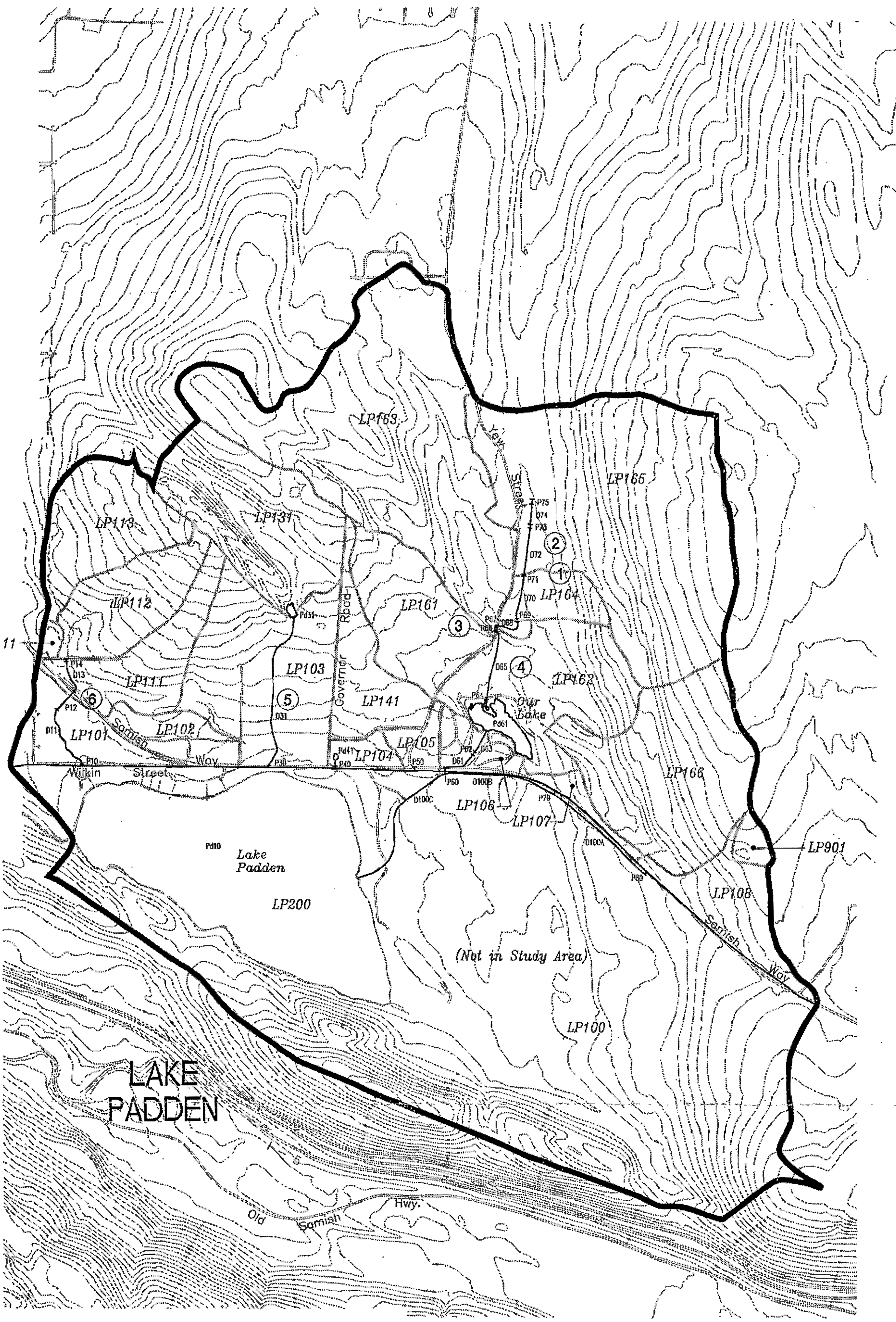
DEA DAVID EVANS AND ASSOCIATES, INC.

HDR HDR Engineering, Inc.

Lincoln Creek Basin Environment

FIGURE
7.3.2

DATE:
OCT. 22, 1993



LEGEND

Basin Boundary

Subbasin Boundary

LP162. Subbasin Designator

(3) Problem Identifier

D64 Open Channel Reach and Number

P63 Pipe Reach and Number

1200 800 400 0 1200

Scale in Feet

N

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

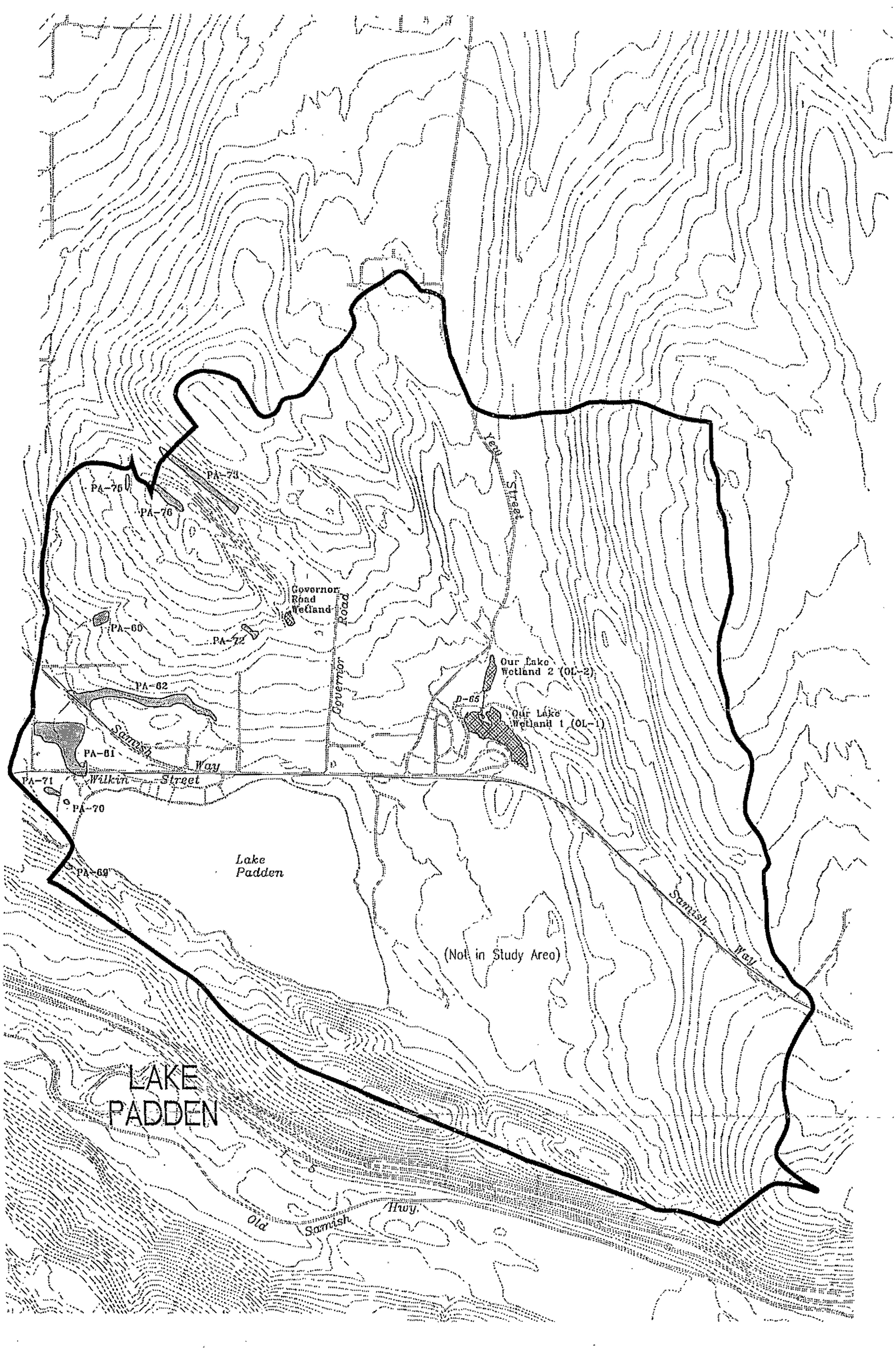
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Lake Padden Basin Facility

FIGURE 8.1

DATE: SEPT. 1, 1995



LEGEND

- Basin Boundary
- D-65 Stream and Reach Identifier - Field Inventoried
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- WH-74 Wetland Identifier

1200 800 400 0 1200

Scale in feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

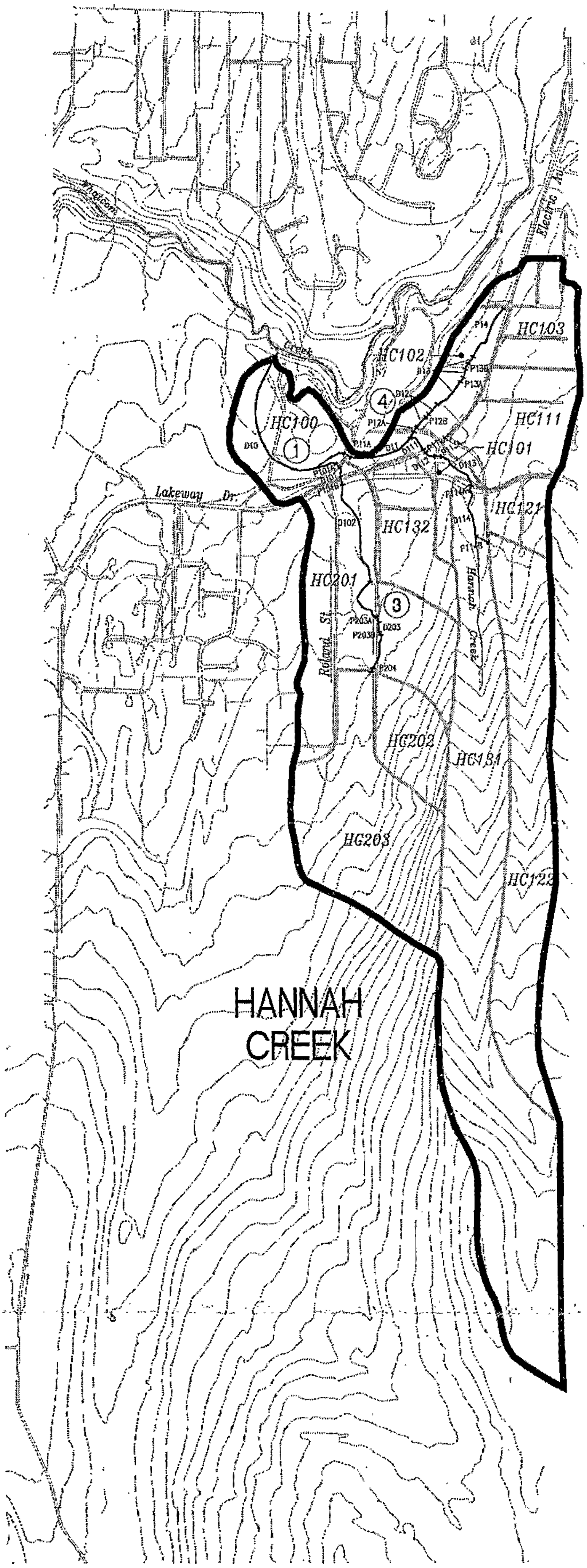
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Lake Padden Basin Environment

FIGURE 8.2

DATE: OCT. 22, 1990



LEGEND
Basin Boundary
Subbasin Boundary
SB401 Subbasin Designator
(3) Problem Identifier
D32 Open Channel Reach and Number
P22 Pipe Reach and Number

N

1200 800 400 0 1200
Scale in feet

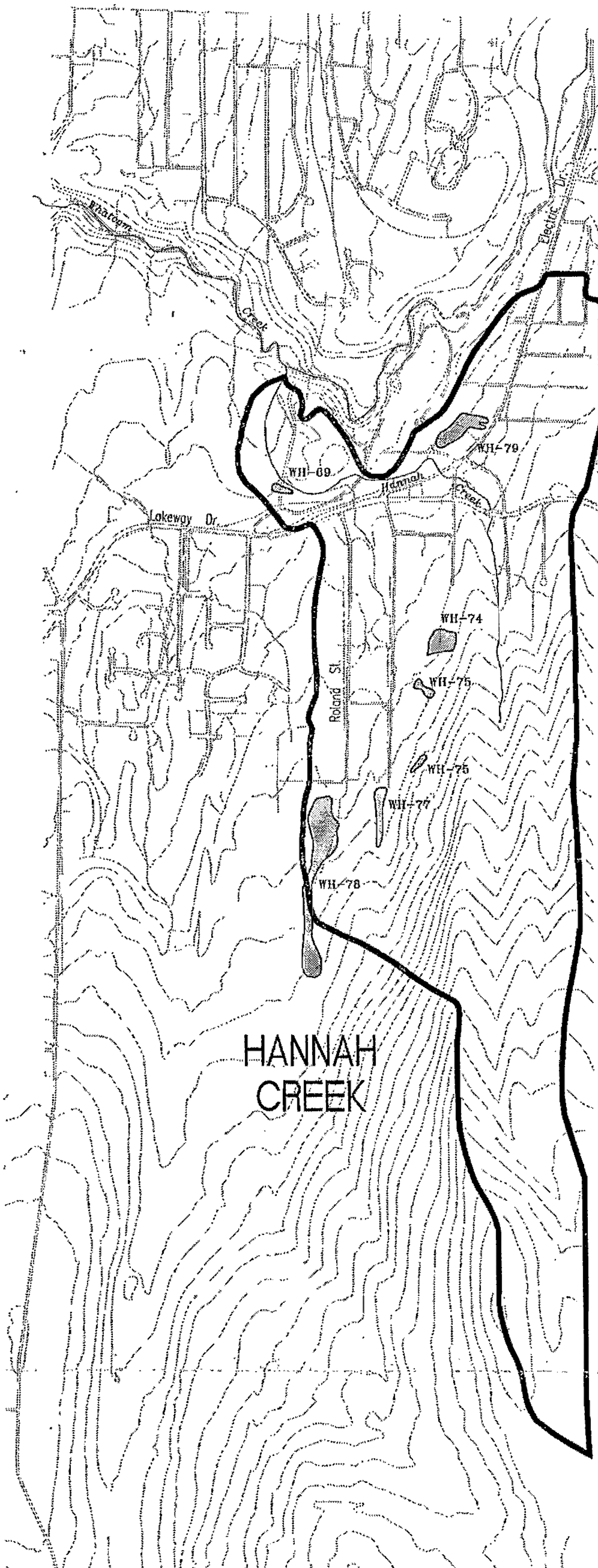
CITY OF BELLINGHAM
WATERSHED MASTER PLAN

DEA DAVID EVANS AND ASSOCIATES, INC.

HDR HDR Engineering, Inc.

Hannah Creek Basin Facility

FIGURE 7.5.1
DATE: SEPT. 1, 1995



LEGEND

Basin Boundary

Stream - Not Inventoried for this Study

Wetland - Not Inventoried for this Study

WH-74 Wetland Identifier

1200 800 400 0 1200 N

Scale in feet

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM

WATERSHED MASTER PLAN

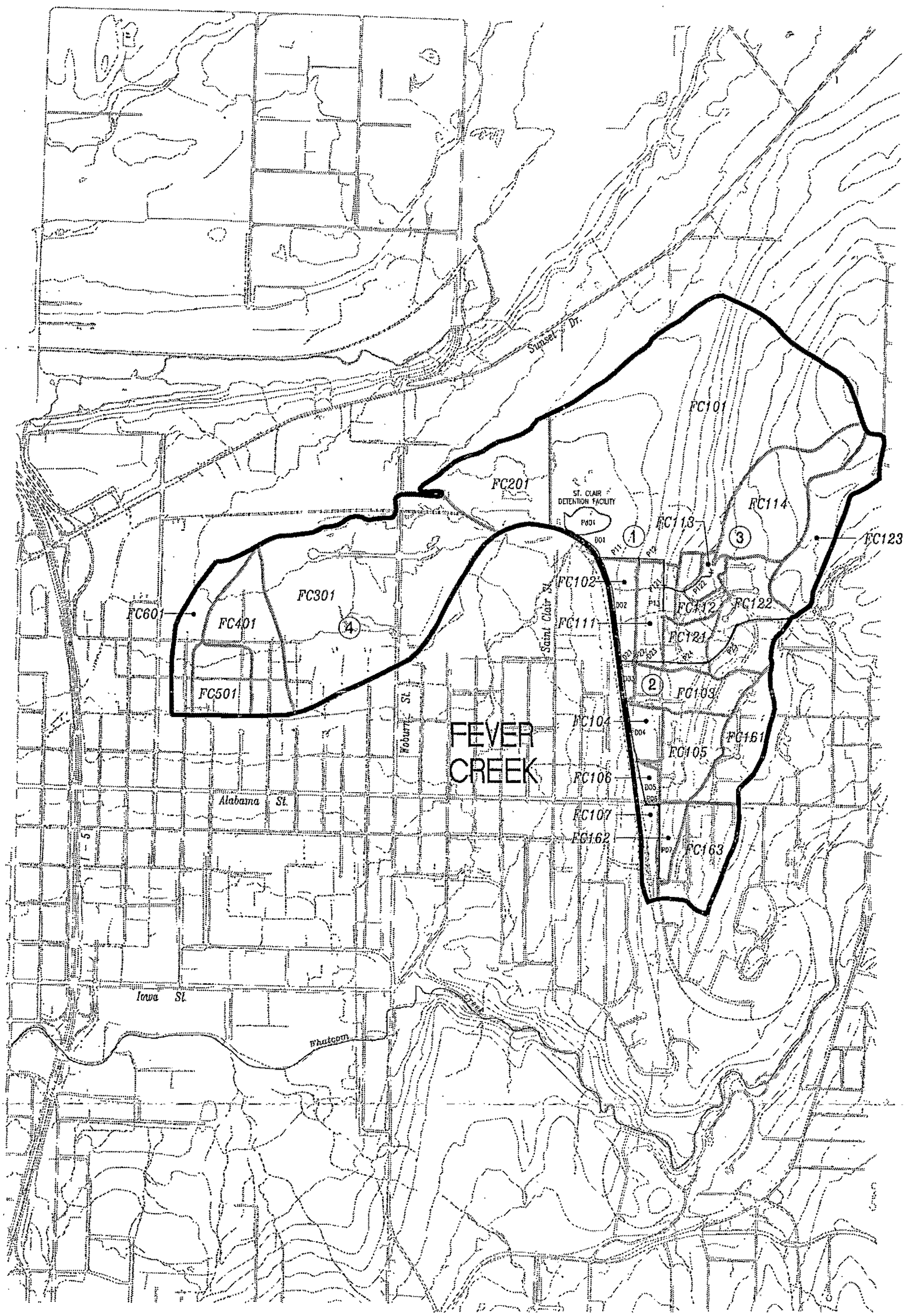
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Hannah Creek Basin Environment

FIGURE 7.5.2

DATE: OCT. 22, 1993



LEGEND
Basin Boundary (Study Area Only)
Subbasin Boundary
FC103 Subbasin Designator
(3) Problem Identifier
D12 Open Channel Reach and Number
P22 Pipe Reach and Number

1200 800 400 0 1200
Scale in Feet

N

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

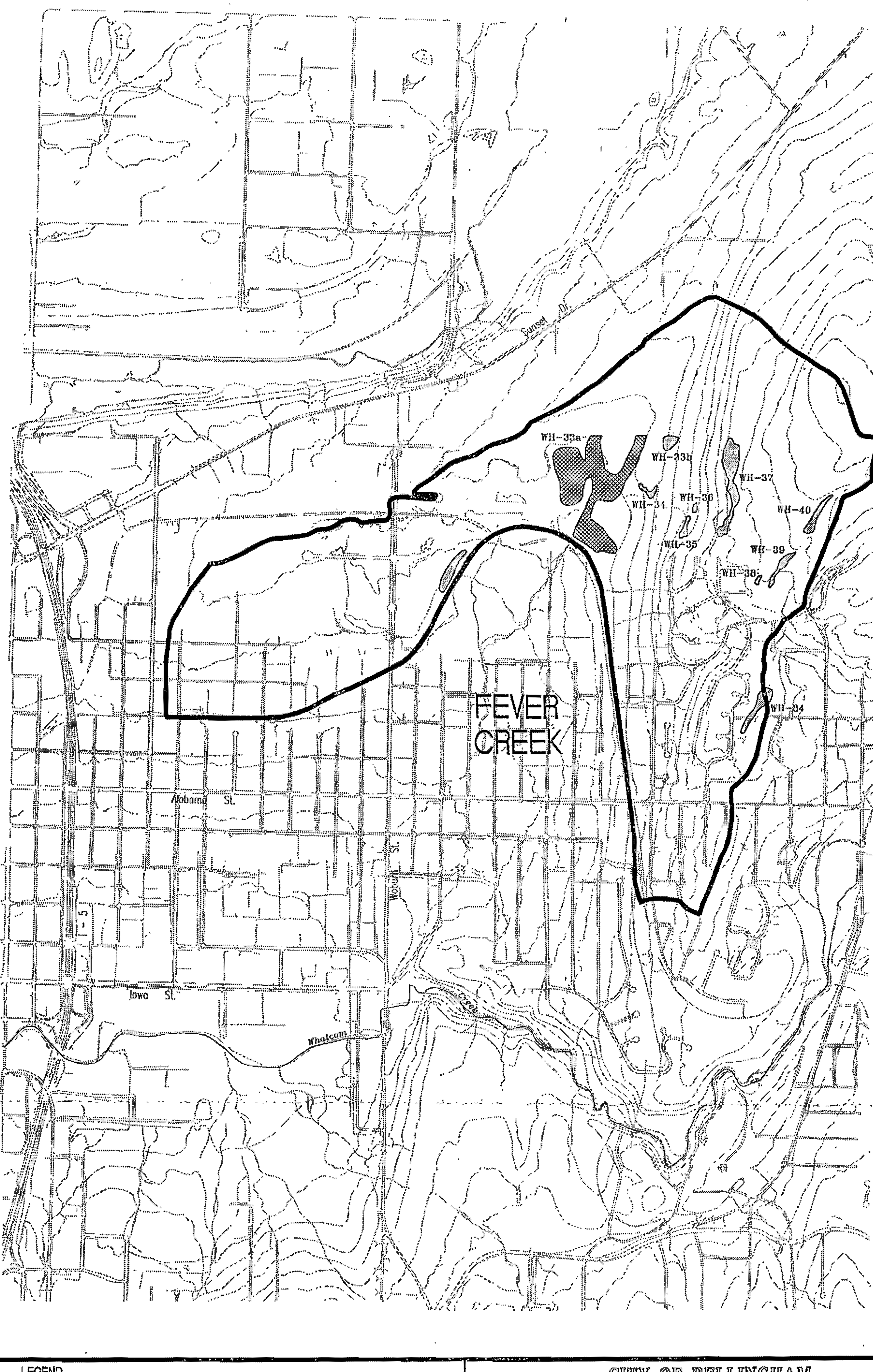
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Fever Creek Basin Facility

FIGURE 7.1.1

DATE: OCT. 22, 1993



LEGEND

Basin Boundary (Study Area Only)

WH-36 Wetland Identifier

Wetland - Not Inventoried for this Study

Wetland - Field Inventoried

1200 800 400 0 1200

Scale in Feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

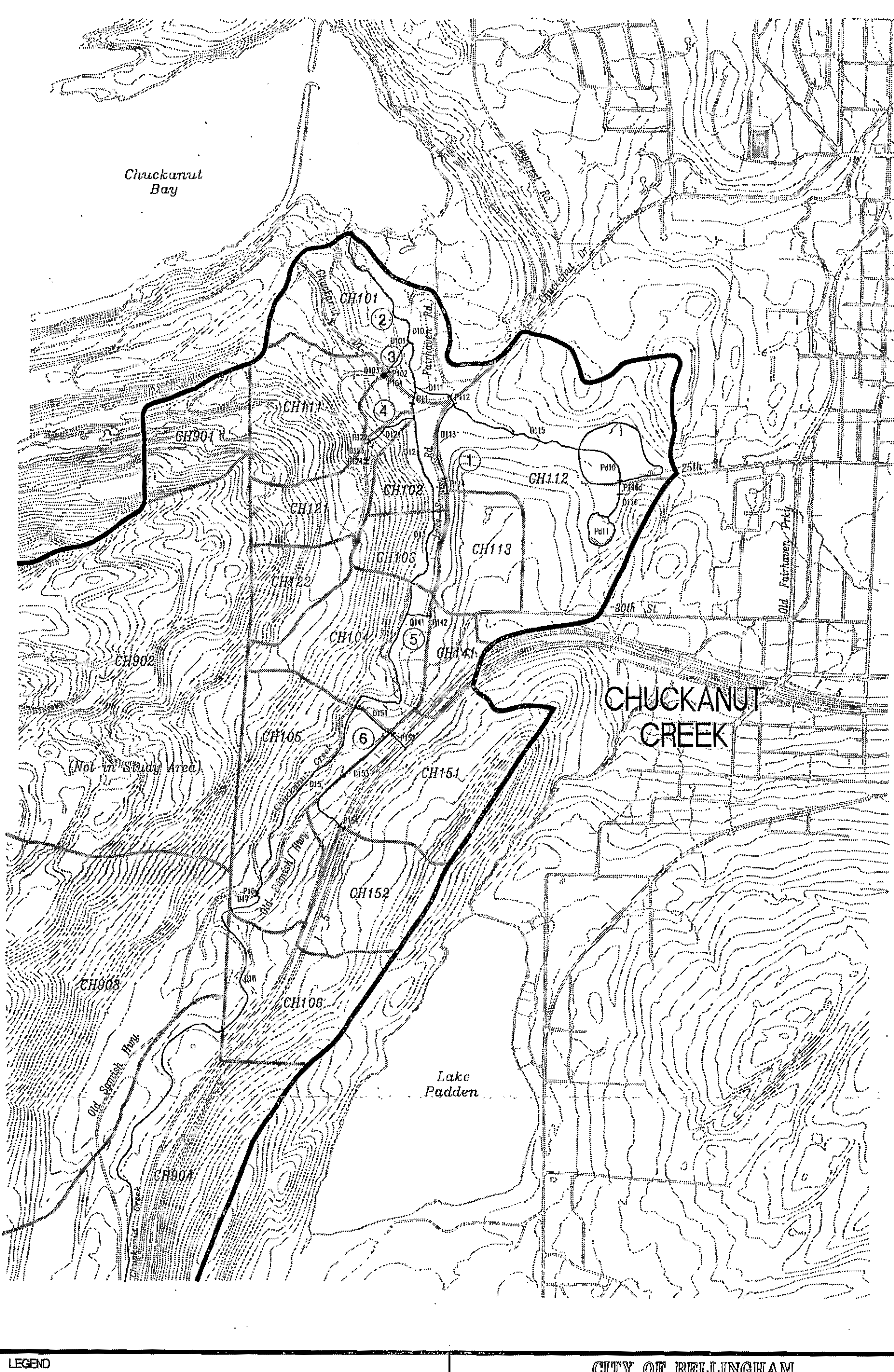
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

FIGURE 7.1.2

Fever Creek Basin Environment

DATE OCT. 22, 1993



LEGEND

Basin Boundary

Subbasin Boundary

CH141 Subbasin Designator

3 Problem Identifier

D16 Open Channel Reach and Number

P11 Pipe Reach and Number

N

1200 800 400 0 1200

Scale in Feet

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

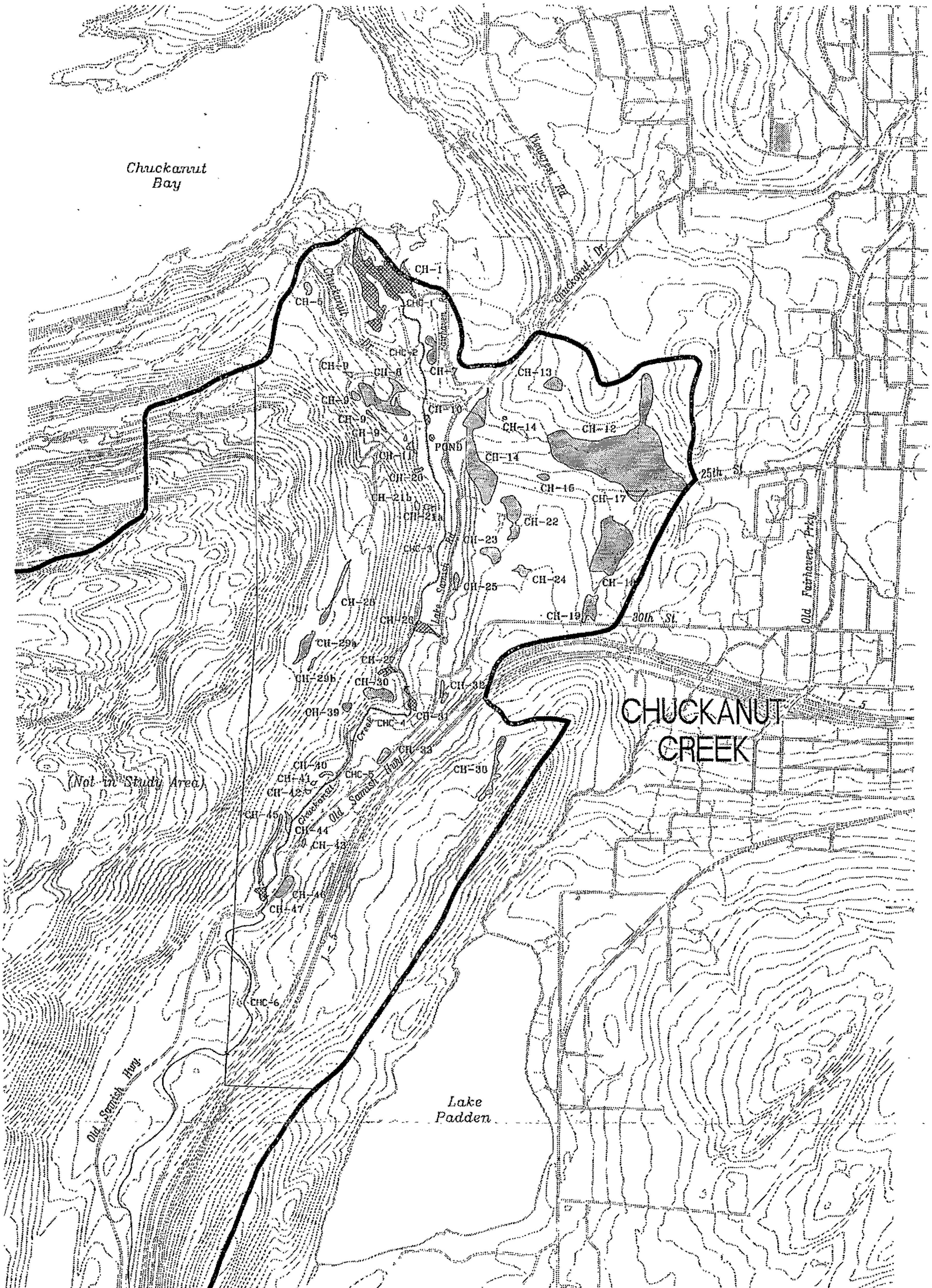
DAVID EVANS AND ASSOCIATES, INC.

HDR Engineering, Inc.

Chuckanut Creek Basin Facility

FIGURE 10.1

DATE: OCT. 22, 1993



LEGEND

- Basin Boundary
- CHC-1 Stream and Reach Identifier - Field Inventoried
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- CH-47 Wetland Identifier

N

1200 800 400 0 1200

Scale in Feet

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

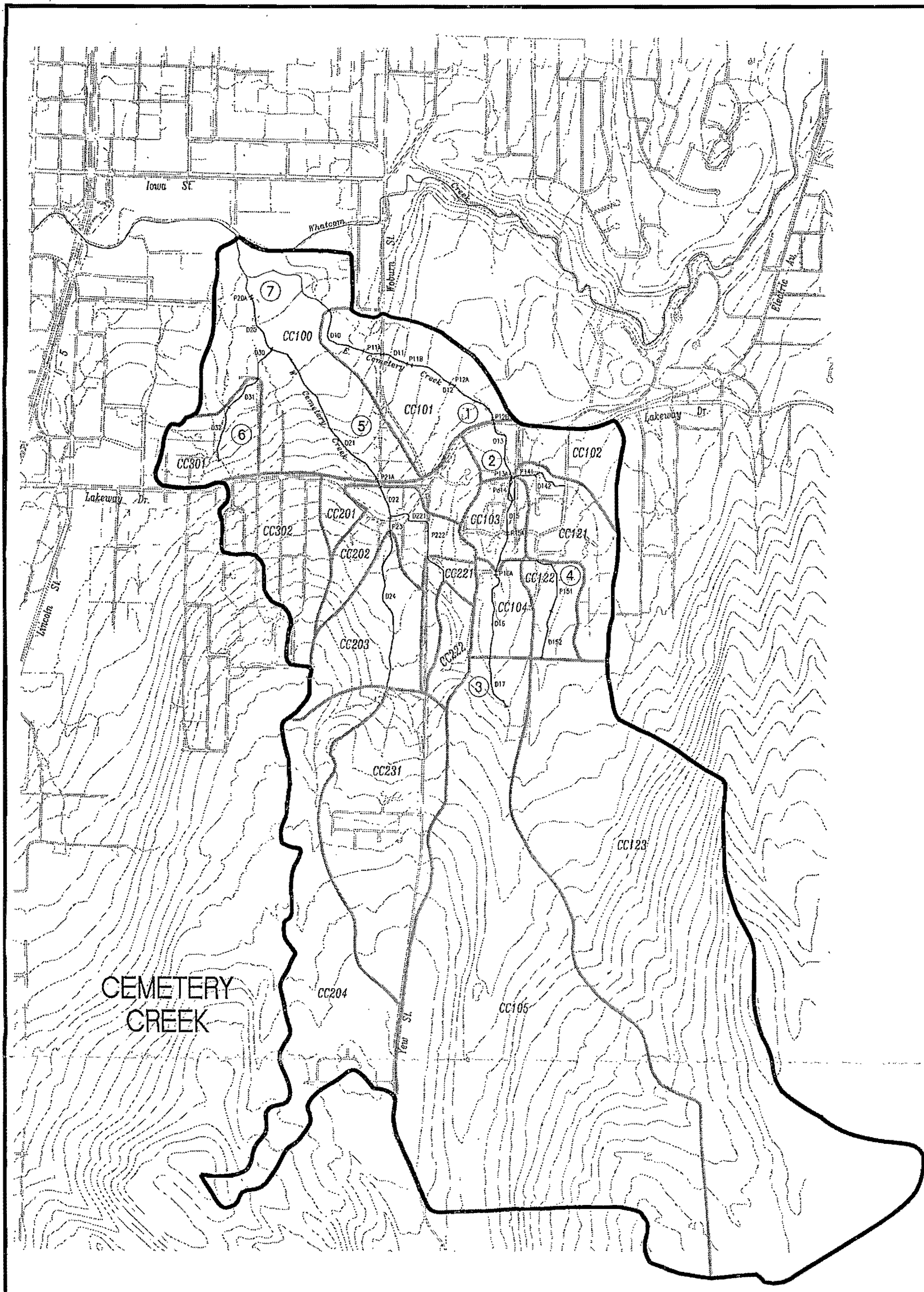
DEA DAVID EVANS AND ASSOCIATES, INC.

HDR

Chuckanut Creek Basin Environment

FIGURE 10.2

DATE: OCT. 22, 1993



LEGEND

- Basin Boundary
- Subbasin Boundary
- *SB401* Subbasin Designator
- (3) Problem Identifier
- D32 Open Channel Reach and Number
- P22 Pipe Reach and Number

1200 800 400 0 1200
Scale in Feet

N

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

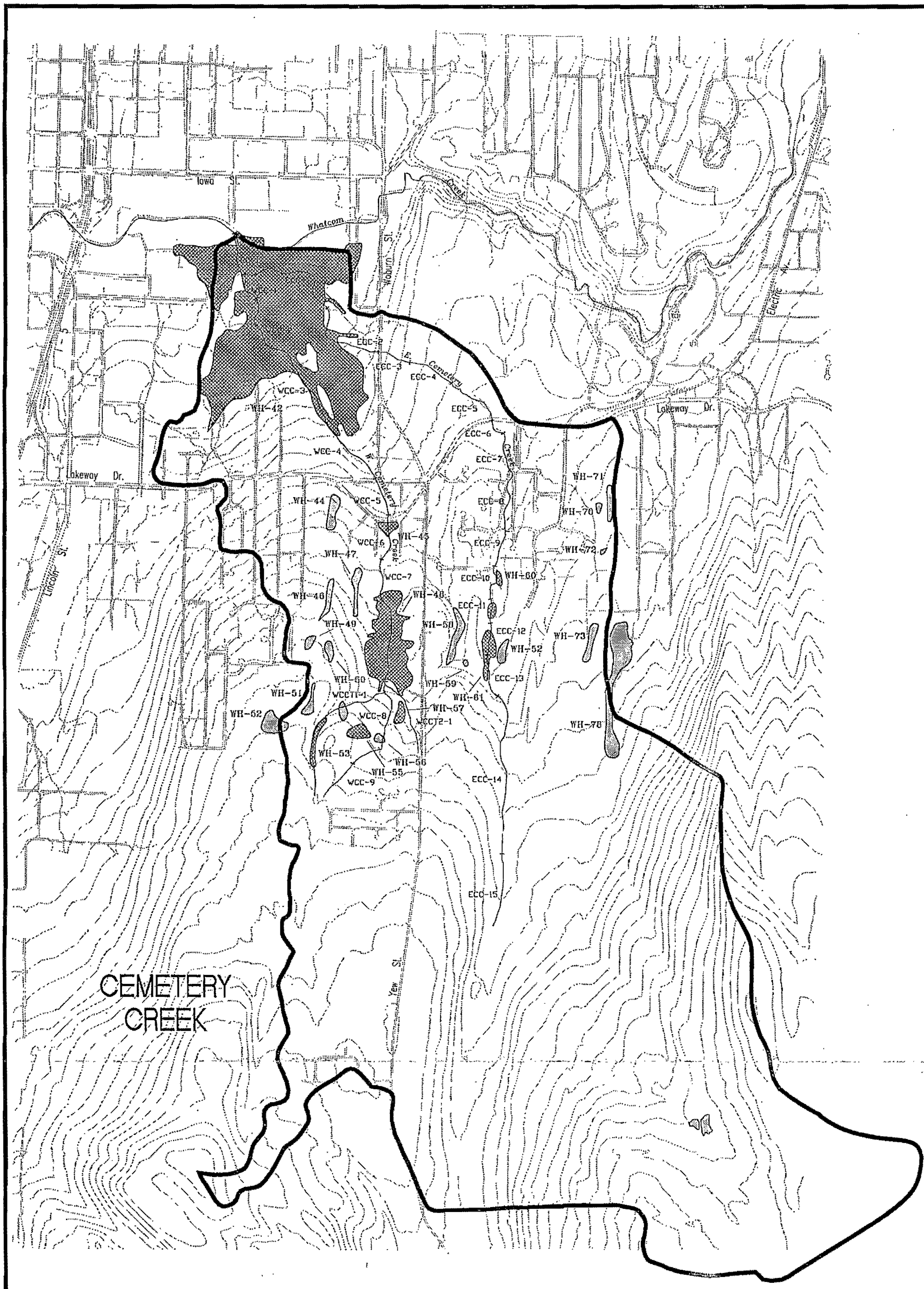
DEA DAVID EVANS AND ASSOCIATES, INC.

HDR HDR Engineering, Inc.

Cemetery Creek Basin Facility

FIGURE 7.4.1

DATE: OCT. 22, 1993



LEGEND

- Basin Boundary
- ECC-3 Stream and Reach Identifier - Field Inventoried
- Stream - Not Inventoried for this Study
- Wetland - Field Inventoried
- Wetland - Not Inventoried for this Study
- WH-74 Wetland Identifier

1200 800 400 0 1200

Scale in Feet

N

Note: Registration of some wetlands and streams shown on this map are derived from digital maps prepared by others and do not correlate with locations identified in the field or shown in the City of Bellingham Wetland Inventory.

CITY OF BELLINGHAM
WATERSHED MASTER PLAN

DEA DAVID EVANS AND ASSOCIATES, INC.

HDR HDR Engineering, Inc.

Cemetery Creek Basin Environment

FIGURE 7.4.2

DATE: OCT. 22, 1993