14 Appendix C: Preliminary Stormwater Site Plan

STORM DRAINAGE REPORT
FOR
EAST MAPLE RIDGE PLAT

City of Blaine, WA

December 11, 2006

12-13-06

DOUGLAS N. CAMPBELL
STATE OF WASHINGTON
21794
REGISTERED
PROFESSIONAL ENGINEER

EXPIRES 10/19/07

A•P•C
INCORPORATED

ASSOCIATED PROJECT CONSULTANTS, INC., P.S.
Professional Consulting Engineers
1401 Astor Street, Bellingham, WA 98225

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I. INTRODUCTION

PURPOSE AND OBJECTIVES

This report has been prepared to address the impacts to stormwater runoff resulting from the proposed East Maple Ridge Plat and PUD. The conditions of development require that a preliminary drainage study be prepared to establish a basis for storm water routing, treatment, and storage for the project. The project is still in the pre-design stage at this point, so items concerning detailed design, such as conveyance sizing, control structure design, and detailed pond design are not discussed here. An in-depth final drainage study and design report will be prepared and submitted during the coming design process for each phase of development.

The purpose of this study is to estimate and discuss the impacts of the stormwater runoff from the proposed East Maple Ridge Subdivision, so that stormwater detention and treatment needs can be adequately accommodated in the overall project design. This analysis will provide a preliminary basis for storm water routing, treatment, and storage design for this site, allowing the project to smoothly incorporate stormwater controls within the design process to protect downstream areas from increased streambank erosion and to provide water quality treatment of the runoff prior to discharge from the subdivision.

PRINCIPAL FINDINGS AND RECOMMENDATIONS

Stormwater runoff from the proposed development will be detained and treated on-site to limit potential downstream impacts. The topography of the site, and existing drainage system patterns dictate that the project will require multiple stormwater facilities. The Final Stormwater Control Plan proposes to construct three combined detention and water quality pond facilities, located in the lowest topographic areas on the site. The ponds will discharge treated runoff in accordance with the 2005 Department of Ecology Stormwater Manual for Western Washington (SWMM).

Water quality treatment of runoff from the site will be provided in created stormwater treatment wetlands within each detention pond. Stormwater treatment wetlands provide Basic and Enhanced Treatment of runoff utilizing mechanical dissipation and uptake of pollutants by the aquatic vegetation and associated microbiological community.

A qualitative analysis of the downstream drainage elements identified several existing and potential problems that could be impacted by this development. Additional analysis will be required to assess the existing conditions and the recommended measures to mitigate potential impacts.

Careful planning of proposed infrastructure at the time of construction of each phase is recommended, so that each pond is functional at the appropriate stage of construction, and to protect the ponds from impacts from successive phases. Implementation of an effective Erosion Control Plan will be required for each phase of construction, to protect pond facilities and the downstream drainage system.

II. PROJECT OVERVIEW

The East Maple Ridge project area is located within the City of Blaine in Section 32, Township 41, Range 1E, W.M., as shown in Figure 1. The study area for this project includes approximately 88.4-acres of currently undeveloped forested land.

East Maple Ridge will be a residential subdivision, consisting of 353 dwelling units, including single-family attached, single-family detached, and cottage units, and some neighborhood retail commercial uses, as shown in Figure 2. The property is zoned to allow up to 4 lots per gross acre, under the City of Blaine's Planned Unit Development zone. A minimum of 20% of the site must be reserved as open space, and this study assumes that the stormwater facility areas will be included in the open space areas.

Infrastructure including roadways, sanitary sewer system, water main distribution system, drainage conveyance system, and other utilities will be constructed to serve each lot. The average single-family detached lot size for this project is approximately 5,926 square feet. The project will also include single-family attached housing and cottage housing areas to provide more clustered densities and provide for greater amounts of open space in the development.

The project will incorporate a storm drainage system that will provide storm runoff treatment and detention as required by both City and State standards.

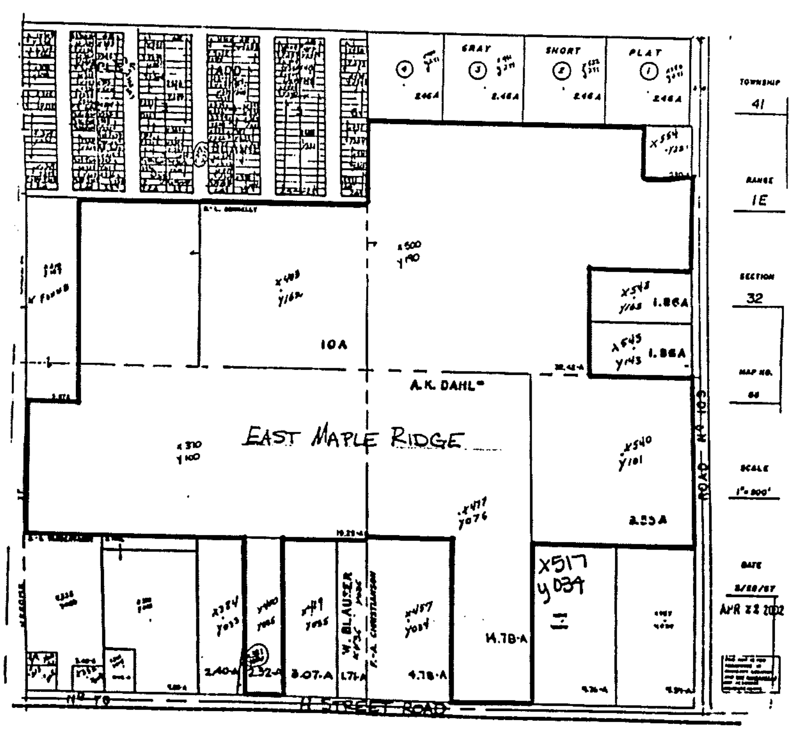


Figure 1 - Vicinity Map

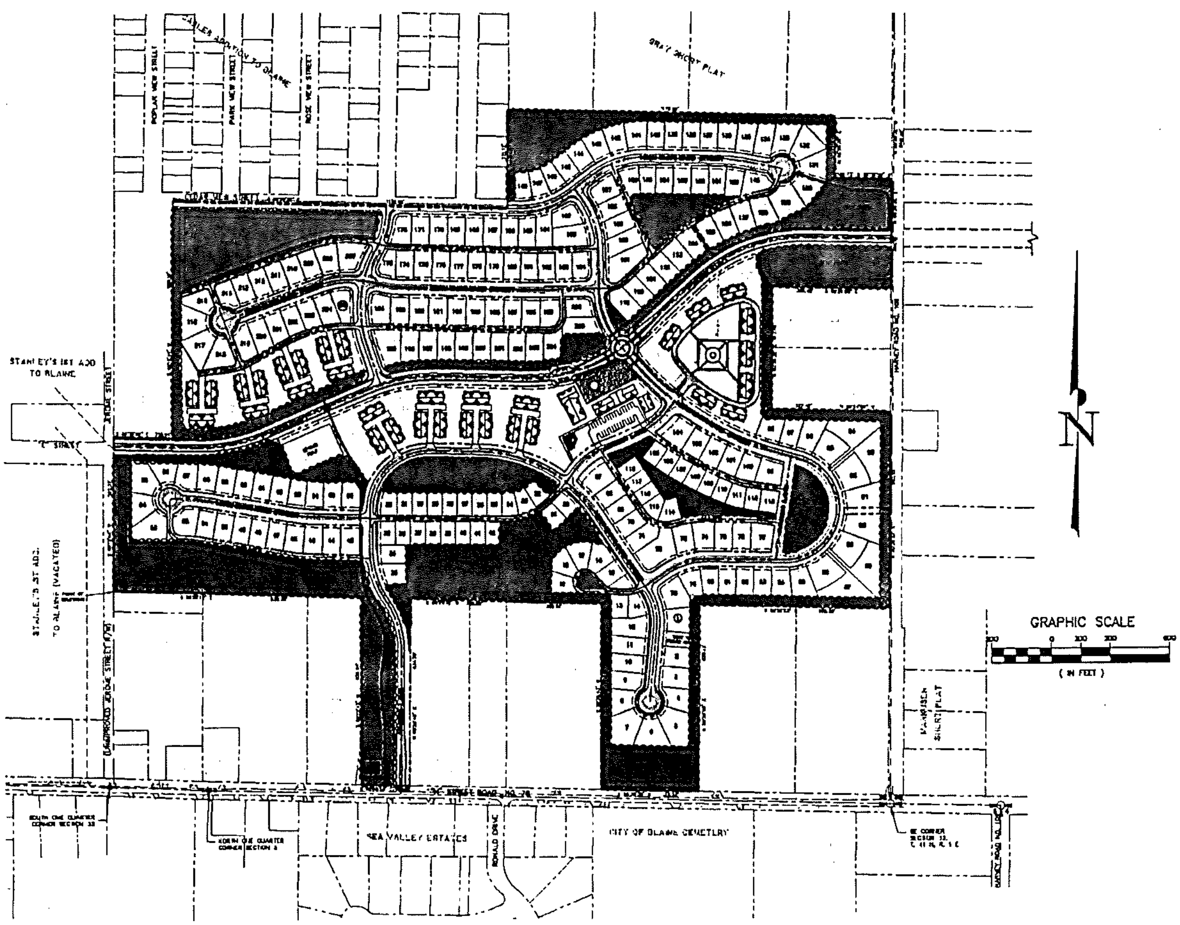


Figure 2 - Proposed Preliminary Plat Site Plan

III. DESIGN STANDARDS

Design standards for this project are in accordance with the Department of Ecology 2005 Stormwater Management Manual for Western Washington (SWMM).

DOE MINIMUM REQUIREMENTS

The SWMM requires that projects that create 5,000-sf or more new impervious area must meet the following 10 minimum requirements:

Minimum Requirement #1: Preparation of Stormwater Site Plans

This report has been prepared in compliance with the DOE SWMM requirements for preparation of stormwater site plans.

Minimum Requirement #2: Construction Stormwater Pollution Prevention

A Stormwater Pollution Prevention Plan (SWPPP) will be prepared and submitted for approval with each phase of the development, along with plans and specifications for grading and construction of the site infrastructure.

Minimum Requirement #3: Source Control Pollution Prevention

This requirement is intended to prevent the occurrence of stormwater coming into contact with pollutants. The proposed site design will limit the exposure of stormwater to pollutants by separating unpolluted runoff from runoff from pollution generating areas until after treatment, where possible. Additionally it is recommended that the use of pesticides and fertilizers be minimized in the long-term maintenance of the pervious site areas, to avoid pollution of runoff from the site.

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

The proposed stormwater control plan will preserve the existing natural drainage system, flow pattern, and outfalls.

Minimum Requirement #5: On-Site Stormwater Management

The intent of this requirement is to reduce the amount of disruption of the natural hydrologic characteristics of the site to prevent flooding or erosion impacts. This site will manage stormwater runoff on-site by providing conveyance, treatment, and flow control management in the permanent stormwater control facilities described in this plan.

Minimum Requirement #6: Runoff Treatment

Basic Treatment of stormwater runoff is required for projects that create 5,000-sf or more new pollution generating impervious surfaces (PGIS), or 0.75-acres or more new pollution generating pervious surfaces (PGPS).

Enhanced Treatment of stormwater runoff is required for pollution generating areas of industrial, commercial, and multi-family developments, which drain directly or indirectly to fish-bearing streams or lakes.

This site will include some areas subject to Basic Treatment, and some areas subject to Enhanced Treatment requirements.

Minimum Requirement #7: Flow Control

This requirement applies to projects that discharge stormwater directly or indirectly through a conveyance system into a fresh water body, and which create 10,000-sf or greater of new plus replaced impervious surfaces, or cause a 0.10-cfs increase in the peak flow rate at the 100-year storm. The requirements for flow control proposed for this project are based on the 2005 SWMM duration standard, as required by the City of Blaine.

The project design included consideration of the feasibility of constructing stormwater infiltration facilities on this site; however the soils and hydrogeologic investigation and analysis of the site determined that infiltration facilities would not be likely to succeed on this site, because of the glacial till aquitard layer underlying the site at typical depths of 3 to 5-feet, as discussed in the Soil Infiltration Evaluation memorandum prepared by Kleinfelder, dated December 11, 2006, included in Appendix A.

The development will incorporate three open detention ponds to provide storage of runoff during storm events.

Minimum Requirement #8: Wetlands Protection

There is an identified wetland area near the south property line, which has been described in the wetland delineation report prepared by MRM Consulting, dated July 2004. The project site has been designed to avoid impacts to the wetlands and wetland buffer areas.

Minimum Requirement #9: Basin Watershed Planning

The proposed stormwater system for this project has been designed in general conformance with the 1998 East Blaine Stormwater Drainage Pre-Design Study, prepared by Associated Project Consultants, Inc. The project is located within Predevelopment Basins B and C, and Post-development Basin B, C, and D in that study. As recommended, the proposed project is designed to maintain the existing drainage pattern, and provide on-site detention and treatment of runoff.

Minimum Requirement #10: Operation and Maintenance

The stormwater ponds and facilities must include provision for maintenance in their design and construction, as required by the DOE SWMM requirements for each BMP, and by the City of Blaine Public Works Department. A Stormwater Facilities Maintenance Plan must be prepared with the Stormwater Site Plan and construction documents for each phase of the development.

IV. SITE CONDITIONS

SOILS

The project area is situated within the Everett Gravelly Sandy Loam soil unit (USDA/SCS, 1992). The soil unit is deep and described as somewhat excessively drained. This soil is categorized as hydrologic soil group 'B.' However, for the purposes of hydrologic analysis and runoff estimation, the site soils were modeled as group 'C' soils, due to the perched groundwater table and hard glacial till soils at a depth of approximately 5-feet. For a more comprehensive description of the site's soil properties see the Soil Survey of Whatcom County, US Department of Agriculture, Soil Conservation Service map, soil descriptions, and water features table, as well as the site soils report prepared by Klienfelder, included in Appendix A.

EXISTING DRAINAGE BASINS

The site straddles a broad hilltop that divides the site with an east-west ridge running across the center of the site. The existing study area has been divided for analysis into 2 overall drainage basins, with runoff traveling either southwest or northwest from the divide being included in Basin I and Basin II, respectively.

Basin I includes all the area onsite, south of the topographic divide. This basin has been further divided for analysis into three sub-basins I-A, I-B and I-C, based on the downstream drainage path. All of the basin areas south of the topographic divide drain generally by overland flow toward an open ditch in H Street, which is culverted in two places south to a tributary of Dakota Creek. Basins I-A and I-B are the areas that drain toward the westerly drainage course, while Basin I-C is the area that drains toward the easterly drainage course (described below under Downstream Analysis).

Basin II represents the entire on-site area north of the divide, which drains north by sheet flow toward the Cedar View Street right-of-way and Cable's Addition, and north toward the US/Canada border in an existing ditch in Jerome Street.

The site vegetation cover for the pre-development condition is assumed to be forested for all site areas, in accordance with the 2005 SWMM. Table 1 lists the Predevelopment (or existing) Condition Basin Areas.

Table 1 - Pre-development Drainage Basins

Basin ID	Pervious	Impervious	Total
Basin I-A	37.22 ac	0.00 ac	37.22 ac
Basin I-B	2.345 ac	0.00 ac	2.345 ac
Basin I-C	17.01 ac	0.00 ac	17.01 ac
Basin II	31.86 ac	0.00 ac	31.88 ac
TOTAL	88.45 ac	0.00 ac	88.45 ac

PROPOSED DRAINAGE BASINS

As stated above, the post-developed site layout will consist of 353 single-family attached, single-family detached, and cottage housing lots. Basic infrastructure improvements, consisting of roads, curbs, sidewalks, and drainage, will be constructed. Impervious surface (asphalt, sidewalk, driveways, and roofs) will replace pervious surface where natural landscape is presently located. The developed project will generally maintain the existing topography of the site area, including overall drainage basin divisions. The existing wetlands will be preserved and protected within the development process, and the use of the wetlands will be improved by preserving the wetland area as open space within the development.

The storm drainage system will be designed to convey the runoff from each basin and discharge into the neighboring drainages within established and required parameters. The drainage system in each basin will be independent of the others, so that the existing drainage patterns will be altered as little as possible. The runoff from the developed project will be conveyed to the detention ponds through storm drain systems consisting of catch basins and storm pipe. The ponds will discharge at restricted rates to meet the flow duration standard in accordance with the 2005 SWMM.

In the post-development condition, Basins I-A and I-B are modeled together, with Basin I-B configured as bypass flow. This allows the calculation of flow control facilities that can mitigate the flow impacts of the bypassed areas by providing additional storage for the on-line basin areas. Table 2 shows a summary of the proposed post-development basin areas. Maps of the Predevelopment and Proposed Basins are included in the Appendix.

Table 2 - Proposed Drainage Basins

Basin ID	Pervious	Impervious	Total
Basin I-A	21.04 ac	14.87 ac	35.91 ac
Basin I-B	1.858 ac	0.487 ac	2.345 ac
Basin I-C	10.55 ac	6.42 ac	16.97 ac
Basin II	19.27 ac	13.96 ac	33.23 ac
TOTAL	52.718 ac	35.737 ac	88.45 ac

Impervious and pervious areas were estimated from the current site plans for the development, taking into account the proposed street locations and width, and assuming and average impervious area of 2,500-sf per single-family lot. Although some areas of the project are planned to remain forested as open space and park areas, the majority of the pervious site areas were modeled as grass/landscaping, to allow flexibility in the development. Because of the conservative factors incorporated into the basin calculations, minor changes to the development site plan should not appreciably affect the drainage runoff estimates in this report.

V. FINAL STORMWATER CONTROL PLAN

The permanent stormwater control plan for East Maple Ridge will incorporate three open pond facilities to provide flow control and water quality treatment of runoff from the project prior to discharge. Pond 1 will be located in the southwest corner of the site and will provide treatment for Basins I-A and I-B. Pond 2 will be located adjacent to H Street in the southeast area of the site, and will provide treatment for Basin I-C. Pond 3 will be located in the northwest corner of the site, and will provide treatment for Basin II.

The placement of the detention ponds is important in the overall design of the development. The East Maple Ridge pond locations planned in this analysis have been based on topographic constraints, the preservation of the historic drainage patterns, and to allow integration of the ponds into the open space areas and overall subdivision design.

The following sections discuss the major design components of the ponds. Additional design requirements for access, safety, and maintenance will be in accordance with the 2005 SWMM.

WATER QUALITY DESIGN

As discussed above, under DOE Minimum Requirement #6, runoff from pollution generating areas of the site must receive Basic or Enhanced Treatment prior to discharge from the site, depending on the site use classification.

Based on the overall site drainage design configuration, we recommend that the principal stormwater treatment for all site runoff should be in the planned open stormwater ponds. The high perched water table on this site, and the relatively large surface areas required for the ponds to meet detention requirements, will facilitate the creation of Stormwater Treatment Wetlands within each pond. This BMP is approved by the DOE SWMM to provide Basic and Enhanced treatment of runoff.

The WWHM basin models include sizing estimates for water quality facilities. In accordance with the SWMM, stormwater treatment wetlands are sized based on a minimum surface area that is equal to 1/3 of the water quality design volume. The following Table lists the water quality volumes and minimum surface areas for stormwater treatment wetlands in each of the three planned detention ponds.

Table 3 - Stormwater Treatment Wetland Sizes

	WQ Design Volume (cf)	Minimum Area (sf)
Pond 1	40,698 cf	13,566 sf
Pond 2	33,990 cf	11,330 sf
Pond 3	29,076 cf	9,692 sf

FLOW CONTROL DESIGN

The detention ponds have been preliminarily sized to provide detention storage to meet the flow duration standard in accordance with the 2005 SWMM. Each pond outlet will be through a flow restricting structure consisting of several orifices and an overflow riser. For this preliminary analysis, the detention storage volumes and elevations, and the flow restrictor dimensions have been estimated to allow for planning of adequate pond areas in the site development plan. The modeled pond storage dimensions are listed in the following Tables. Detailed model parameters and results including pre- and post-development flow rates are included in the Appendix.

Table 4 - Detention Pond Sizes

	Pond Bottom Area	Active Storage Depth	Active Volume
Pond 1	63,000 sf	6 ft	8.94 acre feet
Pond 2	24,300 sf	7 ft	4.34 acre feet
Pond 3	62,500 sf	6.5 ft	8.79 acre feet

EMERGENCY OVERFLOW SPILLWAY

An emergency overflow spillway must be designed for each pond to convey the 100-year, 24-hour storm out of the pond, in case of an obstruction of the orifice and riser structures. A downstream flowpath must be designed to safely convey the peak flow rate from the pond in the case of an overflow. Spillway designs will be included in the final design for each detention pond, and considered in the overall drainage conveyance design for the subdivision.

In the event of an emergency overflow from the pond facilities, the conveyance system downstream of the ponds must be adequate to safely convey the peak flows. The peak emergency flows listed below assume that the design does not need to consider simultaneous pond overflow events.

Emergency Overflow Peak Discharges (100 year MRI)

Pond 1:	23.75 cfs
Pond 2:	10.90 cfs
Pond 3:	21.38 cfs

AESTHETICS

Because the stormwater pond facilities are an important component of the open space design for East Maple Ridge, specific design factors must be considered to ensure the aesthetic integration of the ponds as desirable features in the landscape. Such factors will include:

- Locating ponds where possible adjacent to other open space features, such as footpaths and park areas.

- Minimizing pond slopes along pedestrian trails and abutting lots and other open space areas to reduce the need for fencing around the ponds, allowing the ponds to be visually and physically connected to the open space.

- Appropriately landscaping around and within each detention pond to present a consistent and attractive appearance.

- Providing benches and picnic tables where appropriate to increase the use of the ponds as an attractive feature of the landscape.

Design factors for aesthetics and open space use will be included in the plans and details for construction of each pond.

MAINTENANCE

Maintenance of detention ponds is an important design feature of a storm drainage system. To allow the drainage structures to function correctly, proper maintenance schedules and practices must be followed. An important part of the maintenance of the detention pond is access. Each detention pond will provided with an access road to the outlet structure for maintenance, and access ramps built into the bottom of the pond for sediment removal where appropriate.

Some common maintenance practices will include upkeep of spillways, clearing debris from all discharge and inlet points, mowing ground cover, removing dead vegetation, periodic testing and disposal of sediment, cleaning of the outlet structure sump and surface oils, and upkeep of gravel access ways.

The Final Stormwater Design Report for each detention pond must include a Maintenance Manual and checklist and schedule of specific maintenance requirements.

EROSION CONTROL

It is of paramount importance to provide erosion control for the project area during the construction phase. Some of the Best Management Practices (BMP's) which will be implemented onsite to provide sedimentation control are silt fence, gravel check dams, sedimentation pools, and vegetated filter strips. BMP's that will provide for erosion control are hydroseeding, mulching, and rock check dams. Reference the DOE Stormwater Manual Volume II, Chapters 2, 3, and 5 for a more comprehensive list of possible erosion and sediment control BMPs. These items will be subject to ongoing inspection during the construction phases to ensure their purpose is being served properly. These preventive measures are not specifically designed into the plan at this time; however, a Stormwater Pollution Prevention Plan will be prepared for each phase of construction, and the construction plans for each phase will have a specific erosion and sedimentation control plan included.

VI. DOWNSTREAM ANALYSIS

SOUTH BASIN

Runoff from the development area south of the topographic divide will be discharged from the pond facilities into the existing open ditches along the north side of H Street. Runoff from this area is conveyed south from H Street in two separate drainages, which meet at Boblett Street, approximately 1/4-mile south of the development. The two culverts under H Street serve as conveyance for basins sized approximately 70.8-acres and 32.6-acres.

The drainage paths were mapped and examined in the field by APC Engineers on November 11, 2003. The main components of the two drainage paths are labeled in Figure 3, and identified and described in Table 5, below. Pictures of the drainage elements are included in the Appendix.

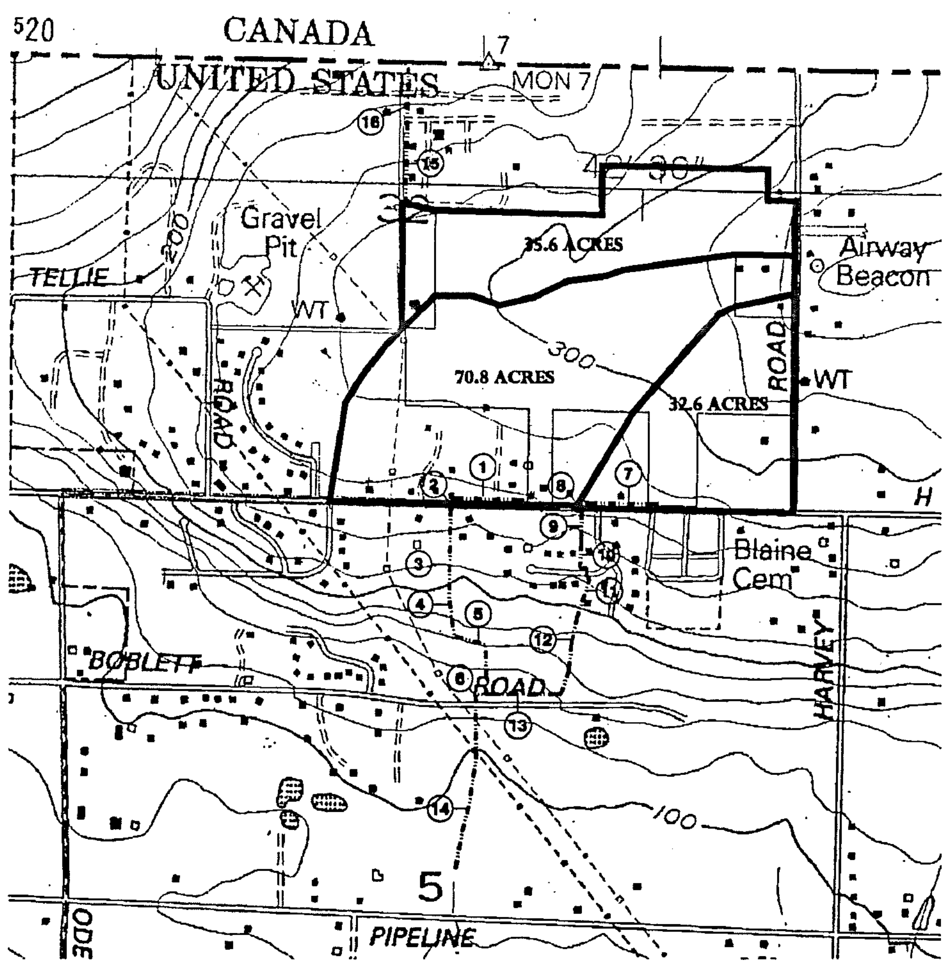


Figure 3 - Downstream Conveyance Map

Table 5 - Downstream Conveyance Segments

#	Description	Notes
1	Open ditch segment along north side of H Street	
2	12-inch CPP culvert under H Street	Inadequate capacity
3	Open ditch flowing south, moderately flat slope	May be inadequate capacity
4	Open channel or sheet flow down steep slope	Erosion potential
5	Man-made pond behind residence, to open ditch	
6	Culvert under Boblett Street	
7	Open ditch segment along north side of H Street	
8	18-inch CPP culvert under H Street	
9	Open ditch flowing south, in easement	High erosion potential
10	Storm pipe in easement, to Lee Lane	History of flooding in Lee Lane
11	Storm pipe south of Lee Lane, discharges into woods	
12	Open channel or sheet flow through woods	
13	Open ditch segment along Boblett Street, to #5	
14	Open drainage to south, tributary to Dakota Creek	
15	Open drainage ditch to north along Jerome Street	
16	Drainage discharge to US/Canada International Border	

IDENTIFIED PROBLEMS

Segment #2

The existing 12-inch culvert may be undersized for the 70.8-acre area that drains toward it. The northern portion of Segment #3 south of H Street appears to also have a possibly inadequate slope and cross section.

It is recommended that hydraulic analysis and possible replacement of the culvert with a larger diameter pipe, and improvement of the ditch south of H Street should be required with the infrastructure improvements for the development phases in Basin I-A.

Segment #4

The steep slope in this area presents a risk of erosion during high flow events.

Segments #9, #10, and #11

This open ditch section was recently reconstructed to shift the drainage path approximately 20-feet east of the old drainage course, forcing the water to make two 90-degree bends within the H Street right-of-way. The ditch runs along the top of a fill area, down a steep bank, and then through a flat section to the inlet to pipe segment #10. At the time of the field inspection, the ditch had little armoring, and erosion was apparent on the steep bank area.

The pipes in and south of Lee Lane (#10 and #11) are evidently inadequately sized, as there is a history of backwater flooding in this area during large storm events.

It is recommended that pipe segment #11, south of Lee Lane should be replaced with a larger diameter pipe, to eliminate the backwater flooding. Because of the proximity of existing residences and developed lot features, it is recommended that a new enclosed pipe system should be installed to route runoff around segments #9 and #10. The new pipe would intercept the discharge from culvert #8 and route the runoff east along H Street, south along Ronald Drive, and west on Lee Lane to rejoin with the existing drainage within the Lee Lane right-of-way north of segment #11.

This proposed combination of new and upgraded storm drain pipe would reduce the existing problem conditions of erosion potential and conveyance capacity. The new and replaced pipes should be sized by a hydraulic analysis that includes likely future development of the entire tributary basin. These drainage improvements should be required with the infrastructure improvements for the development phases in Basin I-C.

NORTH BASIN

Runoff from the development area north of the topographic divide will be discharged from the pond facilities into the existing open ditch along the east side of Jerome Street, which drains north within the right-of-way to Canada View Street and discharges north to the US/Canada Border. Because current discharge from the East Maple Ridge Site to the north is by sheet flow into the Cable's Addition neighborhood, construction of the final stormwater control plan should alleviate some of the existing drainage problems in that area.

We recommend that the capacity of the existing ditch and outfall segments #15 and #16 should be analyzed by hydraulic analysis to see if adequate capacity is provided, along with development of a detailed design and construction plan for Pond 3 and the site infrastructure for that phase of the development.

REFERENCES

United States Department of Agriculture, Soil Conservation Service, 1992, Soil Survey of Whatcom County Area, Washington.

Washington State Department of Ecology, 2005, Stormwater Management Manual for Western Washington.

APPENDIX A: HYDROGEOLOGIC DATA

KLEINFELDER
2405 140th Avenue NE Suite A101 Bellevue, WA 98005 (425) 562-4200 (425) 562-4201 fax

MEMORANDUM

DATE: December 11, 2006 Job/Project Number: 75739

TO: Mr. Doug Connelly and Mr. Doug Campbell

FROM: Jim Bailey

SUBJ: **East Maple Ridge Subdivision Soil Infiltration Evaluation**

This memorandum presents Kleinfelder's infiltration evaluation for the proposed East Maple Ridge subdivision development and provides an assessment of the infiltration considerations related to the project.

The objective of this study is to analyze subsurface soil and ground water conditions beneath the proposed site and evaluate the potential for infiltrating storm water. It also addresses the City of Blaine comments regarding aquifer recharge areas in their letter of February 21, 2006 to Mr. Doug Connelly.

1.0 INTRODUCTION

The East Maple Ridge Project is a Planned Unit Development (355 units) within the East Blaine Annexation area in Blaine, Washington. The approximately 88 acre project site is located north of H Street in Blaine (Whatcom, County), Washington, as shown on the Vicinity Map, Figure 1. In general, the site slopes from about elevation 300 to 340 feet on the east side to a low of about elevation 260 feet on the southwest side. A high voltage transmission line is located along the western site boundary. The north site boundary borders Cedar View street and Harvey street borders the eastern side of the site. The vegetation encountered on-site consisted of third growth Douglas firs, Big Leaf Maples, Alders and Western Red Cedars. Underbrush in many areas had been thinned out.

2.0 FIELD EXPLORATIONS

Kleinfelder explored subsurface conditions at the site by means of 9 test pits, designated TP- XY with X corresponding to closest survey marker and Y designating one of multiple test pits at location X. Use of test pits provided more suitable data for evaluation of infiltration characteristics and bearing capacity of the site soils at a considerably lower cost than would be required for complete the same number of borings.

Survey control was available at the time of our explorations only in the vicinity of test pit locations TP-8B, Tp-10A and TP-15A. Accordingly, test pit locations shown on Figure 2 should be considered approximate. The test pits generally extended to depth of about 5 feet below the existing ground surface or until glacial till was encountered. The approximate locations were as follows:

- TP-8A,B, & C located within the footprint of the proposed storm water pond on the south side of the property across from the City cemetery,
- TP-10A located on the small strip of property touching H Street and west of TP-8;
- TP-15A was south of the water line right-of-way road;
- TP-15B and TP-15C was north of the water line right-of-way road in a cleared area (TP-15B) and close to the north property line (TP-15C);
- TP-22A was located in the northeast corner of the site.

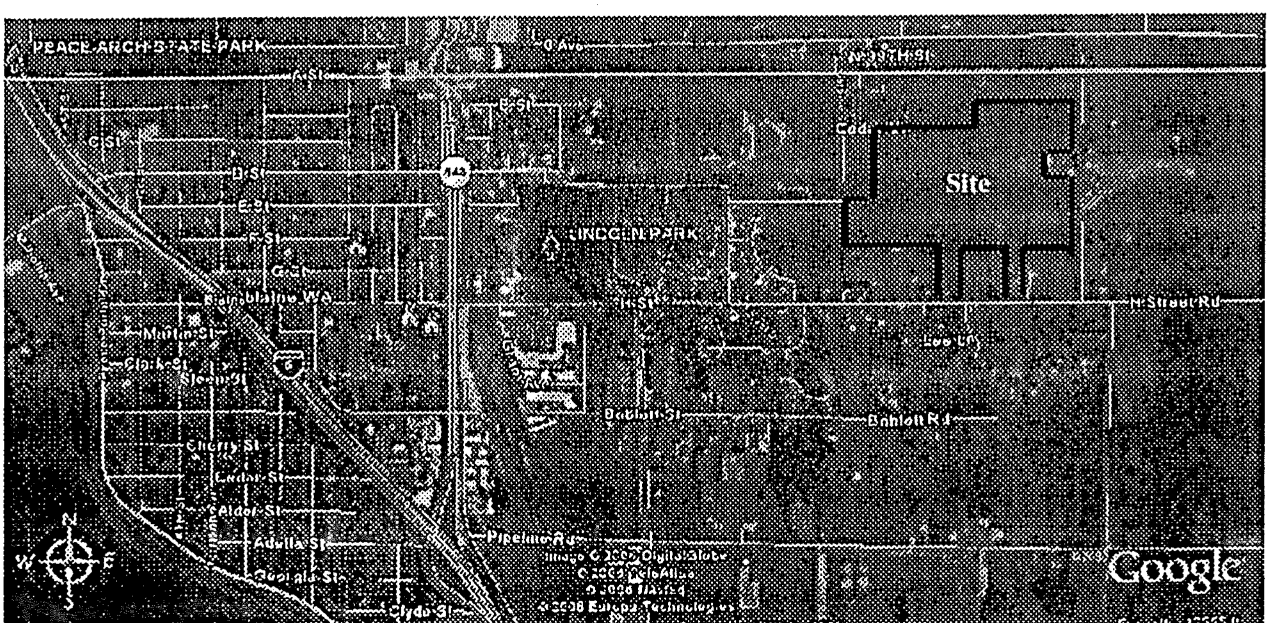


Figure 1 – Site Location

3.0 SUBSURFACE CONDITIONS

3.1 SOIL CONDITIONS

Based on our field investigations and review of previous hydrogeologic studies, Whatcom Soil Survey and our experience in the area, the proposed project site is located in an area covered by recessional glacial outwash underlain by glacial till.

Based on the previous and recent explorations, the soil conditions include a topsoil layer and weathered, disturbed outwash layer underlain by recessional outwash sand to a depth of about 3 to 5 feet below the current ground surface. In the test pits excavated on November 22, 2006, glacial till was encountered at the bottom of all the test pits. The soil types encountered are as follows:

- **Topsoil:** A layer of topsoil was encountered in all explorations and ranged from about 8 to 12 inches thick. The topsoil was composed of a loose mixture of roots, decomposed vegetation and sandy silt with varying amounts of gravel.
- **Weathered, Disturbed Outwash:** The topsoil layer was underlain by one to two feet of a loose brown silty sand with gravel and occasional roots. We believe that this zone likely represents an upper weathered zone of the underlying outwash has been partially disturbed over the years during historical logging and other activities on the site.
- **Recessional Outwash:** Recessional glacial outwash was encountered in all test pits. The outwash consisted of fine to coarse sand with varying amounts of sand and cobbles and some silt. Cobbles and boulders up to 6 inches in maximum dimension were observed in several of the test pits and boulders up to 3 feet in maximum dimension were observed on the surface in various areas of the site.
- **Glacial Till:** Glacial till was encountered in all the test pits at depths ranging from 3 to 5 feet bgs. This corresponded to an elevation of about 268 on the southwest portion of the site to an elevation of about 317 feet in the northeast portion. The glacial till extended to the maximum extent of all explorations, where encountered. It consisted of very dense cemented silty sands and gravels. Nearby well logs indicate the thickness of the till is at least 40 feet in the area.

3.2 GROUNDWATER CONDITIONS

Based on our interpretation of previous reports, and a review of well construction logs from the Washington State Department of Ecology, we conclude that the continuous (beneficial use) ground water table is relatively deep (over 100 feet), well below the depth of our explorations. However, our test pit excavations indicate there is a thin saturated zone of outwash underlain by a till aquitard layer. It appears that during the wet winter months there is a perched ground water table a few feet above the top of the till. During the dry summer months, the perched ground water may be limited or non existing.

Ground water was observed seeping into all of the test pits on the south side of the site including TP-8A, TP-B, TP-C, and TP-10A. The seepage was occurring in the courser segments of the recessional outwash deposits and rapidly filled the test pit with two to three feet of water within an hour (see Figure 3). No perched water was observed in the remaining test pits.

Figure 3 – Perched Ground Water TP-8B

4.0 STORM WATER INFILTRATION AND AQUIFER RECHARGE

For an infiltration system to perform as designed, several geotechnical conditions must be met:

- ADEQUATE INFILTRATION RATES: The soils at the base of the infiltration pond must have an adequate infiltration rate to allow the ground water to seep into the ground.

- CAPACITY OF THE GROUND TO TRANSMIT THE INFLOWS: The ground must have adequate permeability, aquifer thickness, and unsaturated aquifer thickness to transmit the design inflows away from the soils below the pond without backing up into the pond.

Based on the soil conditions and the results of the test pit excavations, the ground at the site does not have a sufficient thickness of unsaturated soil above the water table or the low permeability glacial till to be a candidate for direct storm water infiltration. Our interpretation of the soil conditions observed in the test pits indicate that for any reasonable set of assumptions the groundwater inflow rates beneath an infiltration pond would form a ground water mound which would eventually rise up into the pond preventing further infiltration.

Blaine Municipal Code (BMC) Title 17.82.060 designates the site as located in an aquifer recharge area. According to the BMC "Classification of recharge areas shall be based upon the susceptibility of the aquifer. High susceptibility shall be defined as those areas where surficial geology and soils information both indicate high recharge potential." The United States Department of Agriculture, Soil Conservation Service, Soil Survey for Whatcom County identifies the site soils as an Everett Series, which is defined as "deep and very deep, somewhat excessively drained soils formed in a mixture of volcanic ash and alluvium over glacial outwash and glacial till."

The site excavations performed for this study indicate that the although the shallow soils are in places moderately drained the presence of a thick shallow till layer and perched ground water indicate that the site is not a significant source of direct recharge to beneficial aquifers located beneath the glacial till. The Glacial till, if continuous across the site, will act as a significant impediment for infiltrating storm water. The very conditions that make the site unsuitable for an infiltration pond indicate the site does not appear to have surficial geological conditions that are highly permeable.

5.0 LIMITATIONS

This report may be used only by the client and only for the purposes stated within a reasonable time from its issuance, but in no event later than one year from the date of the report. Land or facility use, on and off-site conditions, regulations, or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized use or non-compliance.

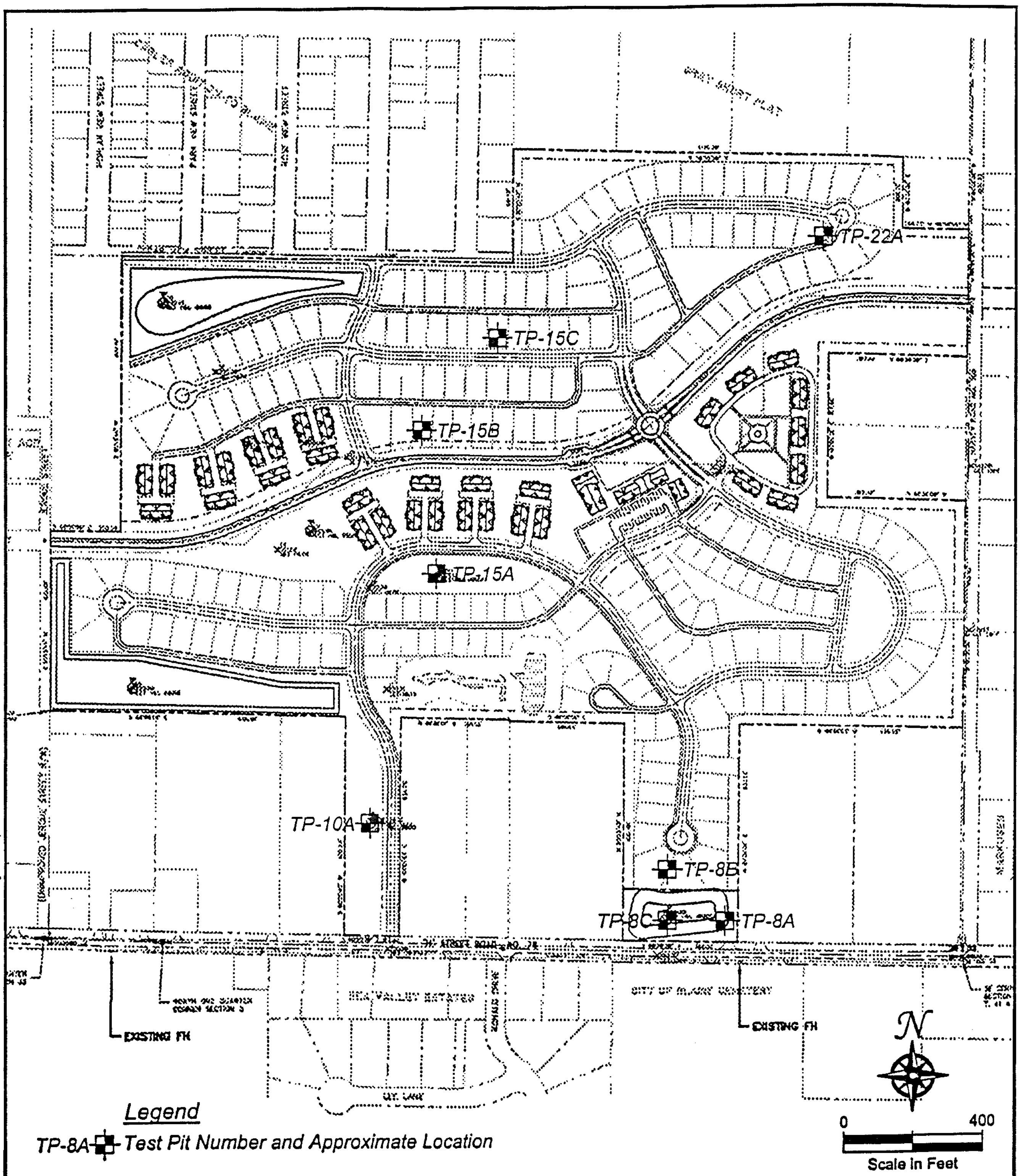
5.0 REFERENCES

City of Blaine Public Works Department, East Maple Ridge Subdivision Project Public Works Preliminary Plat Review, Letter to Mr. Doug Connelly, February 21, 2006.

Hydrogeologic Characterization Study East Blaine Annexation Area, EMCON, February 8, 1995.

Soil Survey of Whatcom County Area, Washington, United States Department of Agriculture, Soil Conservation Service, May 1992.

Evaluation of Aquifer Vulnerability Proposed East Blaine Annexation Area, EMCON Northwest, September, 1992.



ATTACHED IMAGES: Images: 120506 SURVEY STAKED TEST PITS.tif
ATTACHED XREFS:
CAD FILE: G:\75739\ LAYOUT: Layout1

KLEINFELDER

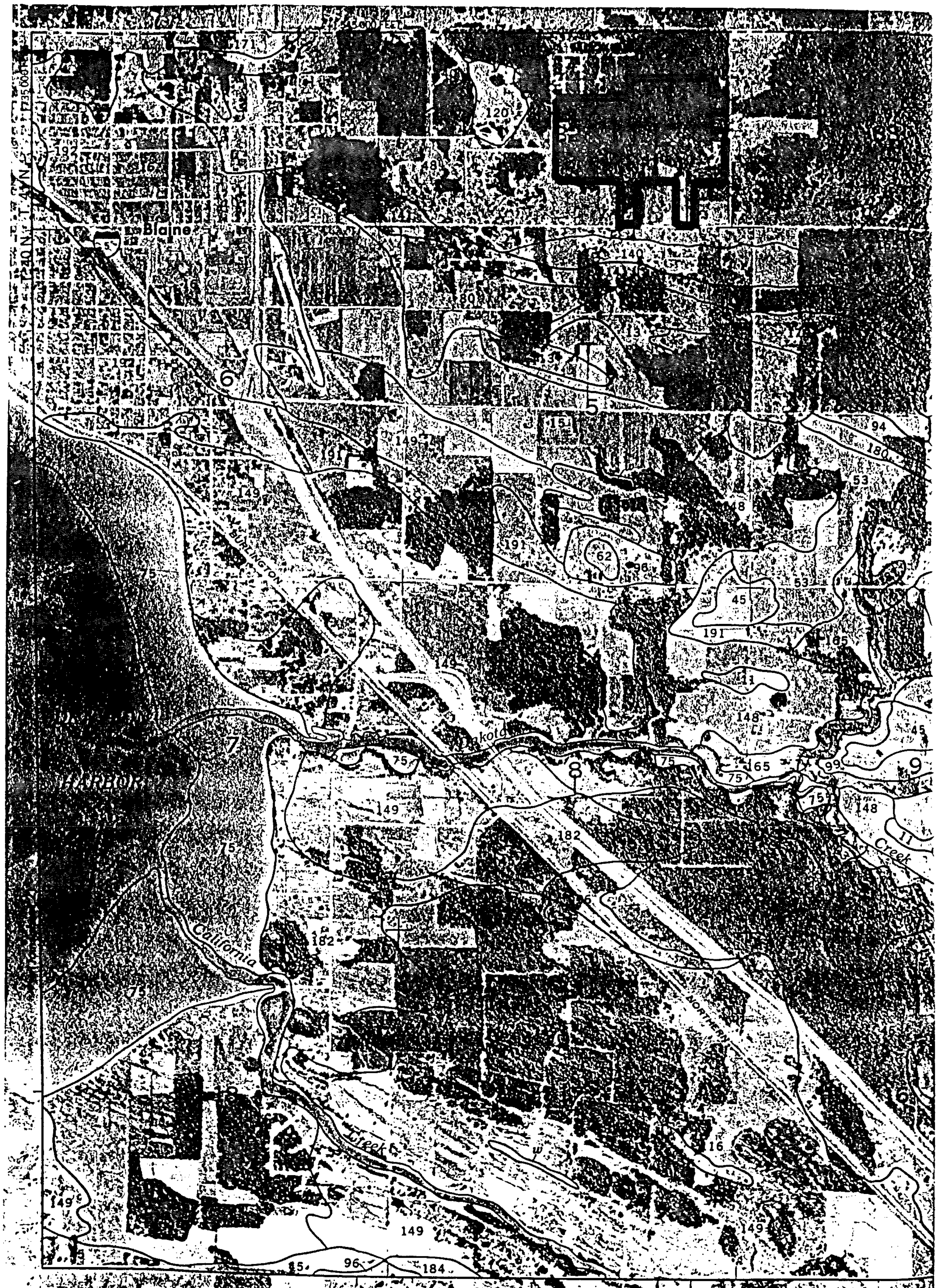
2405 140th Avenue NE, Suite A101
Bellevue, WA 98005-1877
PH: (425) 562-4200 FAX: (425) 562-4201
www.kleinfelder.com

Test Pit Locations

East Maple Ridge
Blaine, Washington

DRAWN BY: J.Stewart
REVISED BY:
CHECKED BY:
Figure
2

DRAWN December 2006 APPROVED BY:
PROJECT NO. 75739 FILE NAME: Test Pit Locations.dwg


Blaine
6
5
7
8
9
BURLINGTON
NORTHERN
Dakota
California
Creek
Creek
1
1/2
0
1
0.5
0

60 inches. In some areas the soil has sand at a depth of 30 to 60 inches.

Permeability is moderate in the Eliza soil. Available water capacity is high. The effective rooting depth is limited by a seasonal high water table, which is at or near the surface from November through April. Runoff is very slow, and there is no hazard of erosion. This soil is subject to frequent, long periods of flooding from December through April.

The Tacoma soil is very deep and very poorly drained. It formed in alluvium. Typically, the surface layer is dark grayish brown, mottled silt loam 11 inches thick. The upper 7 inches of the underlying material is dark grayish brown, mottled silt loam. The next 30 inches is dark gray, mottled silt loam. The lower part to a depth of 60 inches is dark gray, mottled fine sandy loam. In some areas the surface layer is very fine sandy loam. In other areas the soil has 18 to 35 percent clay in the upper part of the underlying material or is 30 to 40 inches deep to fine sandy loam or sand.

Permeability is moderately slow in the Tacoma soil. Available water capacity is high. The effective rooting depth is limited by a high water table, which is at or near the surface from November through April during periods of high tide. Runoff is very slow, but the hazard of water erosion is severe because of the hazards of flooding and channeling. This soil is subject to frequent, long periods of flooding from December through April. It is subject to tidal inundation unless protected. Channeling and deposition are common along streambanks.

This unit is used as woodland or for wildlife habitat. Red alder is the main woodland species. Among the trees of limited extent are western redcedar, western hemlock, black cottonwood, and Sitka spruce. The common understory plants are willow, Douglas spirea, western swordfern, western brackenfern, devilsclub, and Indian plum.

On the basis of a 50-year site curve, the mean site index for red alder is estimated to be 90. The highest average growth rate in unmanaged, even-aged stands of red alder is about 101 cubic feet per acre per year, occurring at age 40.

The main limitations affecting timber harvesting are the hazard of flooding and the muddiness caused by seasonal wetness. These limit the use of equipment to dry periods. Unsurfaced roads are soft and slippery when wet and may be impassable during rainy periods. Rock for road construction is not readily available. Extra rock is needed to maintain a stable, uniform road surface.

Equipment and logs on the surface result in a high degree of compaction when the soils are moist and a high degree of puddling when the soils are wet. Carefully laying out roads and skid trails, properly timing their use, and using low-pressure ground equipment can reduce the degree of compaction and puddling.

Seedling establishment, seedling mortality, and the hazard of windthrow are the main concerns affecting timber production. The high water table hinders root respiration and thus results in a low seedling survival rate. The seedling survival rate also may be low where flooding occurs. Reforestation can be accomplished by planting red alder or western redcedar seedlings. If seed trees are available, natural reforestation of cutover areas by red alder occurs readily. When openings are made in the canopy, the uncontrolled invasion and growth of competing plants can prevent the establishment of seedlings. Competing vegetation can be controlled by mechanical or chemical means. Because the rooting depth is restricted by the high water table, trees are frequently subject to windthrow when the soils are wet and winds are strong.

The Eliza and Tacoma soils are in capability subclass VIw.

48—Everett gravelly sandy loam, hard substratum, 2 to 8 percent slopes. This deep, somewhat excessively drained soil is on outwash terraces and moraines. It formed in a mixture of volcanic ash and alluvium over glacial outwash and glacial till. The native vegetation is mainly conifers and shrubs. Elevation is 100 to 500 feet. The average annual precipitation is about 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free period is about 180 days.

Typically, the surface is covered with a mat of undecomposed needles and twigs 2 inches thick. When mixed to a depth of 6 inches, the surface layer is dark yellowish brown gravelly sandy loam. The upper 7 inches of the subsoil is dark brown gravelly sandy loam. The lower 12 inches is strong brown very gravelly sandy loam. The substratum is dark brown very gravelly loamy sand 16 inches thick. Dense glacial till that crushes to very gravelly loamy sand is at a depth of 41 inches. The depth to very gravelly loamy sand ranges from 14 to 30 inches. The depth to dense glacial till or dense glaciomarine deposits ranges from 40 to 60 inches. The dense glacial till is similar to a cemented pan. In some areas the surface layer is very gravelly sandy loam or very gravelly loam. In other areas the soil has 15 to 35 percent rock fragments in the subsoil, is very gravelly sandy loam in the upper part of the substratum, or has dense glacial till or dense glaciomarine deposits below a depth of 60 inches.

Included in this unit are small areas of Birchbay, Clipper, Labounty, Sehome, and Squalicum soils and small areas of Everett soils that have a stony surface or have slopes of more than 8 percent or less than 2 percent. Included areas make up about 15 percent of the total acreage.

Permeability is moderate in the upper part of the Everett soil, rapid and very rapid in the substratum, and very slow in the dense glacial till. Available water capacity is low. The effective rooting depth is limited by a seasonal high water table, which is at a depth of 3.5 to 5.0 feet from December through April. Runoff is slow, and the hazard of water erosion is slight.

This unit is used mainly as woodland. It also is used as a site for homes.

Douglas fir is the main woodland species. Among the trees of limited extent are red alder, western hemlock, western redcedar, and grand fir. The common understory plants are salal, creambush oceanspray, red huckleberry, western swordfern, western brackenfern, common snowberry, and Oregongrape.

On the basis of a 100-year site curve, the mean site index for Douglas fir is 138. On the basis of a 50-year site curve, it is 106. The highest average growth rate in unmanaged, even-aged stands of Douglas fir is 142 cubic feet per acre per year, occurring at age 70.

The main limitation affecting timber harvesting is the muddiness caused by seasonal wetness. Unsurfaced roads are soft when wet and are subject to deep rutting during rainy periods. Logging roads require suitable surfacing for year-round use. Rounded pebbles and cobbles for road construction are readily available.

Equipment and logs on the surface result in a moderate degree of compaction when the soil is moist and a moderate degree of soil displacement when the soil is dry. Carefully laying out roads and skid trails, properly timing their use, and using low-pressure ground equipment can reduce the degree of compaction and displacement. A moderate reduction in productivity can be expected to result from unmanaged fires in undisturbed areas.

Seedling mortality and establishment are the main concerns affecting timber production. Reforestation can be accomplished by planting Douglas fir or red alder seedlings. A low content of moisture in the surface layer during the growing season hinders the survival of planted and naturally established seedlings. If seed trees are available, natural reforestation of cutover areas by red alder occurs readily and reforestation by western hemlock occurs periodically. When openings are made in the canopy, the uncontrolled invasion and growth of competing plants can prevent the establishment of seedlings. Competing vegetation can be controlled by mechanical or chemical means.

The main limitation affecting homesite development is the seasonal high water table. The wetness can be reduced by building the house on a pad and by installing drainage tile around footings if a suitable outlet is available. The dense glacial till is rippable and therefore, is not a serious limitation for most engineering uses. In shallow excavations special retainer walls may be needed to keep cutbanks from caving.

The main limitations on sites for septic tank absorption fields are a poor filtering capacity in the substratum and the seasonal high water table. During the rainy season, the effluent from onsite sewage disposal systems can seep at points downslope. Installing the absorption field in the loamy subsoil or in fill approved by the health district helps to compensate for these limitations.

This map unit is in capability subclass IIIe.

49—Everett very gravelly sandy loam, 8 to 15 percent slopes. This very deep, somewhat excessively drained soil is on outwash terraces and moraines. It formed in a mixture of volcanic ash and alluvium over glacial outwash and glacial till. The native vegetation is mainly conifer and shrubs. Elevation is 100 to 500 feet. The average annual precipitation is about 40 inches, the average annual air temperature is about 50 degrees F, and the average frost-free period is about 180 days.

Typically, the surface is covered with a mat of undecomposed needles, twigs, and rotting wood 4 inches thick. When mixed to a depth of 6 inches, the surface layer is dark brown very gravelly sandy loam. The subsoil is dark brown very gravelly sandy loam 12 inches thick. The substratum to a depth of 60 inches is variegated very gravelly sand. The depth to very gravelly sand ranges from 14 to 24 inches. In some areas the surface layer is very gravelly loam, gravelly sandy loam, or gravelly loam. In other areas the soil has a substratum of very gravelly sand at a depth of 24 to 36 inches, has a weakly cemented hardpan at a depth of 40 to 60 inches, has 15 to 35 percent rock fragments in the subsoil, or has a substratum of very gravelly sandy loam.

Included in this unit are small areas of Birchbay, Clipper, and Squalicum soils and small areas of Everett soils that have a stony surface or have slopes of more than 15 percent or less than 8 percent. Included areas make up about 10 percent of the total acreage.

Permeability is rapid in the upper part of the Everett soil and very rapid in the lower part. Available water capacity is low. The effective rooting depth is 60 inches. Runoff is slow, and the hazard of water erosion is slight.

This unit is used mainly as woodland. It also is used for hay and pasture, as a source of aggregate, and as site for homes.

Douglas fir is the main woodland species. Among the

TABLE 17.--WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months
					Ft		
28*:							
Chuckanut	B	None	---	---	>6.0	---	---
Shalcar	D	None	---	---	+1-1.5	Apparent	Oct-May
29*:							
Chuckanut	B	None	---	---	>6.0	---	---
Urban land.							
30 Clendenen	D	None	---	---	1.0-1.5	Perched	Nov-Jun
31 Clipper	C	None	---	---	2.0-4.0	Apparent	Nov-Apr
32, 33, 34 Comar	C	None	---	---	1.5-3.5	Perched	Jan-Feb
35 Crinker	C	None	---	---	>6.0	---	---
36, 37 Cupples	C	None	---	---	1.5-3.0	Perched	Dec-Apr
38 Dekapen	C	None	---	---	2.0-3.0	Perched	Dec-Apr
39, 40 Deming	B	None	---	---	>6.0	---	---
41 Diobsud	C	None	---	---	1.5-3.0	Perched	Nov-May
42, 43, 44 Edfro	D	None	---	---	1.0-1.5	Perched	Dec-Apr
45*:							
Edmonds	D	None	---	---	1.0-2.5	Apparent	Nov-Apr
Woodlyn	D	None	---	---	1.0-2.5	Apparent	Nov-Apr
46 Eliza	D	Frequent	Brief	Nov-Apr	1.0-2.5	Apparent	Nov-Apr
47*:							
Eliza	D	Frequent	Long	Dec-Apr	0-1.0	Apparent	Nov-Apr
Tacoma	D	Frequent	Long	Dec-Apr	0-1.0	Apparent	Nov-Apr
48 Everett	B	None	---	---	3.5-5.0	Perched	Dec-Apr
49, 50 Everett	A	None	---	---	>6.0	---	---
51*:							
Everett very gravelly sandy loam	A	None	---	---	>6.0	---	---

See footnote at end of table.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permea- bility	Available water capacity	Soil reaction	Salinity	Shrink- swell potential	Erosion factors K	Erosion factors T	Wind erodi- bility group	Organic matter
	In	Pct	g/cc	In/hr	In/in	pH	mmhos/cm					Pct
40---------------- Deming	0-3	---	0.85-1.00	0.6-2.0	0.15-0.20	3.6-5.0	<2	Low--------	0.24	5	---	10-15
	3-15	---	0.85-1.00	0.6-2.0	0.15-0.20	3.6-5.0	<2	Low--------	0.20			
	15-37	---	0.90-1.20	0.6-2.0	0.10-0.15	4.5-5.5	<2	Low--------	0.10			
	37-60	---	1.10-1.30	2.0-6.0	0.10-0.15	4.5-5.5	<2	Low--------	0.05			
41---------------- Diobsud	0-7	---	0.85-1.00	0.6-2.0	0.15-0.25	4.5-5.5	<2	Low--------	0.20	2	---	10-15
	7-20	---	0.85-1.00	0.6-2.0	0.15-0.25	4.5-5.5	<2	Low--------	0.20			
	20-37	---	0.90-1.10	0.6-2.0	0.10-0.15	4.5-5.5	<2	Low--------	0.20			
	37	---	---	---	---	---	---	-----------	----			
42---------------- Edfro	0-4	---	0.95-1.15	0.6-2.0	0.15-0.20	3.6-4.4	<2	Low--------	0.20	1	---	5-10
	4-18	---	0.95-1.15	0.6-2.0	0.15-0.20	4.5-5.5	<2	Low--------	0.10			
	18-60	---	---	---	---	---	---	-----------	----			
43---------------- Edfro	0-3	---	0.95-1.15	0.6-2.0	0.15-0.20	3.6-4.4	<2	Low--------	0.20	1	---	5-10
	3-19	---	0.95-1.15	0.6-2.0	0.15-0.20	4.5-5.5	<2	Low--------	0.10			
	19	---	---	---	---	---	---	-----------	----			
44---------------- Edfro	0-3	---	0.90-1.10	0.6-2.0	0.15-0.20	3.6-4.4	<2	Low--------	0.17	1	---	5-10
	3-16	---	0.90-1.15	0.6-2.0	0.15-0.20	4.5-5.5	<2	Low--------	0.10			
	16	---	---	---	---	---	---	-----------	----			
45*:												
Edmonds----------	0-11	---	0.90-1.10	0.6-2.0	0.30-0.40	5.1-6.0	<2	Low--------	0.20	2	---	3-9
	11-18	---	0.90-1.10	0.6-2.0	0.20-0.30	5.1-6.0	<2	Low--------	0.20			
	18-37	0-5	1.50-1.70	6.0-20	0.10-0.15	5.6-6.5	<2	Low--------	0.10			
	37-60	0-5	1.50-1.70	>20	0.10-0.14	5.6-6.5	<2	Low--------	0.02			
Woodlyn----------	0-9	---	0.90-1.10	0.6-2.0	0.30-0.40	5.1-6.0	<2	Low--------	0.20	1	---	3-9
	9-12	---	0.90-1.10	0.6-2.0	0.20-0.30	5.1-6.0	<2	Low--------	0.20			
	12-25	---	---	---	---	---	<2	-----------	----			
	25-60	0-5	1.50-1.70	>20	0.10-0.14	5.6-6.5	<2	Low--------	0.02			
46---------------- Eliza	0-11	15-25	0.90-1.15	0.6-2.0	0.19-0.21	5.1-6.0	<2	Low--------	0.37	5	---	3-9
	11-24	15-25	0.95-1.20	0.6-2.0	0.19-0.21	4.5-6.0	<2	Low--------	0.43			
	24-52	5-20	1.00-1.20	0.6-2.0	0.10-0.15	3.6-6.0	4-8	Low--------	0.28			
	52-60	5-20	1.25-1.35	0.6-2.0	0.10-0.15	3.6-5.0	>8	Low--------	0.28			
47*:												
Eliza------------	0-4	15-25	0.90-1.15	0.6-2.0	0.19-0.21	5.1-6.0	<2	Low--------	0.37	5	---	3-9
	4-24	15-25	0.95-1.20	0.6-2.0	0.19-0.21	4.5-6.0	<2	Low--------	0.43			
	24-52	5-20	1.00-1.20	0.6-2.0	0.10-0.15	3.6-6.0	4-8	Low--------	0.28			
	52-60	5-20	1.25-1.35	0.6-2.0	0.10-0.15	3.6-5.5	>8	Low--------	0.28			
Tacoma-----------	0-11	5-18	0.60-1.10	0.6-2.0	0.19-0.21	3.6-5.5	4-8	Low--------	0.37	5	---	10-20
	11-60	5-18	0.85-1.20	0.2-0.6	0.14-0.16	3.6-5.5	4-8	Low--------	0.49			
48---------------- Everett	0-6	---	0.90-1.10	0.6-2.0	0.15-0.20	5.1-6.0	<2	Low--------	0.17	2	---	3-9
	6-13	---	0.95-1.20	0.6-2.0	0.10-0.20	5.1-6.5	<2	Low--------	0.20			
	13-25	---	1.10-1.20	2.0-20	0.10-0.15	5.1-6.5	<2	Low--------	0.15			
	25-41	0-5	1.50-1.70	>20	0.03-0.05	5.1-6.5	<2	Low--------	0.10			
	41	---	---	---	---	---	---	-----------	----			
49, 50------------ Everett	0-6	---	0.90-1.10	0.6-2.0	0.08-0.13	5.6-6.5	<2	Low--------	0.20	1	---	3-9
	6-18	---	0.95-1.20	6.0-20	0.08-0.13	5.6-6.5	<2	Low--------	0.10			
	18-60	0-5	1.50-1.70	>20	0.02-0.05	5.6-6.5	<2	Low--------	0.10			

See footnote at end of table.

APPENDIX B: DRAINAGE MODEL DATA

Basins I-A and I-B

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: EMR BASIN I
Site Address: East Maple Ridge
City : Blaine, WA
Report Date : 12/8/2006
Gage : Blaine
Data Start : 1948
Data End : 1999
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Basin 1-B
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	2.345

Basin : Basin I-A
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	37.22

DEVELOPED LAND USE
Basin : Basin I-A
Flows To : Pond 1
GroundWater: No

Land Use	Acres
TILL GRASS:	21.04
IMPERVIOUS:	14.87

Basin : Basin I-B
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	1.487
TILL GRASS:	0.4
IMPERVIOUS:	0.458

RCHRES (POND) INFORMATION
Pond Name: Pond 1
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 6ft.
Bottom Length: 900ft.
Bottom Width : 70ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 8.936 acre-ft.
Discharge Structure
Riser Height: 5 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 3.25 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 4.25 in. **Elevation:** 3.3 ft.
Orifice 3 Diameter: 4 in. **Elevation:** 4 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	1.446	0.000	0.000	0.000
0.072	1.456	0.105	0.075	0.000
0.144	1.466	0.210	0.105	0.000
0.217	1.475	0.316	0.129	0.000
0.289	1.485	0.423	0.149	0.000
0.361	1.495	0.531	0.167	0.000
0.433	1.504	0.639	0.183	0.000
0.506	1.514	0.748	0.197	0.000
0.578	1.524	0.858	0.211	0.000
0.650	1.533	0.968	0.224	0.000
0.722	1.543	1.079	0.236	0.000
0.794	1.553	1.191	0.247	0.000
0.867	1.563	1.304	0.258	0.000
0.939	1.572	1.417	0.269	0.000
1.011	1.582	1.531	0.279	0.000
1.083	1.592	1.646	0.289	0.000
1.156	1.602	1.761	0.298	0.000
1.228	1.612	1.877	0.307	0.000
1.300	1.621	1.994	0.316	0.000
1.372	1.631	2.111	0.325	0.000
1.444	1.641	2.229	0.333	0.000
1.517	1.651	2.348	0.342	0.000
1.589	1.661	2.468	0.350	0.000
1.661	1.671	2.588	0.358	0.000
1.733	1.680	2.709	0.365	0.000
1.806	1.690	2.831	0.373	0.000
1.878	1.700	2.953	0.380	0.000
1.950	1.710	3.076	0.387	0.000
2.022	1.720	3.200	0.394	0.000
2.094	1.730	3.325	0.401	0.000
2.167	1.740	3.450	0.408	0.000
2.239	1.750	3.576	0.415	0.000
2.311	1.759	3.703	0.422	0.000
2.383	1.769	3.830	0.428	0.000

2.456	1.779	3.958	0.435	0.000
2.528	1.789	4.087	0.441	0.000
2.600	1.799	4.217	0.447	0.000
2.672	1.809	4.347	0.453	0.000
2.744	1.819	4.478	0.460	0.000
2.817	1.829	4.610	0.466	0.000
2.889	1.839	4.742	0.472	0.000
2.961	1.849	4.876	0.477	0.000
3.033	1.859	5.009	0.483	0.000
3.106	1.869	5.144	0.489	0.000
3.178	1.879	5.279	0.495	0.000
3.250	1.889	5.415	0.500	0.000
3.322	1.899	5.552	0.576	0.000
3.394	1.909	5.690	0.657	0.000
3.467	1.919	5.828	0.710	0.000
3.539	1.929	5.967	0.754	0.000
3.611	1.940	6.107	0.792	0.000
3.683	1.950	6.247	0.826	0.000
3.756	1.960	6.388	0.858	0.000
3.828	1.970	6.530	0.887	0.000
3.900	1.980	6.673	0.915	0.000
3.972	1.990	6.816	0.942	0.000
4.044	2.000	6.960	1.056	0.000
4.117	2.010	7.105	1.135	0.000
4.189	2.020	7.251	1.198	0.000
4.261	2.031	7.397	1.252	0.000
4.333	2.041	7.544	1.302	0.000
4.406	2.051	7.692	1.349	0.000
4.478	2.061	7.840	1.392	0.000
4.550	2.071	7.990	1.434	0.000
4.622	2.082	8.140	1.473	0.000
4.694	2.092	8.290	1.511	0.000
4.767	2.102	8.442	1.548	0.000
4.839	2.112	8.594	1.584	0.000
4.911	2.122	8.747	1.618	0.000
4.983	2.133	8.900	1.651	0.000
5.056	2.143	9.055	1.875	0.000
5.128	2.153	9.210	2.383	0.000
5.200	2.163	9.366	3.053	0.000
5.272	2.174	9.522	3.852	0.000
5.344	2.184	9.680	4.760	0.000
5.417	2.194	9.838	5.765	0.000
5.489	2.205	9.997	6.858	0.000
5.561	2.215	10.16	8.033	0.000
5.633	2.225	10.32	9.283	0.000
5.706	2.235	10.48	10.60	0.000
5.778	2.246	10.64	11.99	0.000
5.850	2.256	10.80	13.45	0.000
5.922	2.267	10.97	14.96	0.000
5.994	2.277	11.13	16.54	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	1.031891
5 year	1.631382
10 year	2.093846
25 year	2.753629
50 year	3.300846

100 year	3.896669

Flow Frequency Return Periods for Developed Unmitigated

Return Period	Flow(cfs)
2 year	9.604827
5 year	13.222165
10 year	15.682295
25 year	18.863011
50 year	21.284725
100 year	23.751458

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.870794
5 year	1.328163
10 year	1.679372
25 year	2.180153
50 year	2.596006
100 year	3.049762

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	1.244	0.658
1950	1.142	0.712
1951	1.542	1.514
1952	0.397	0.469
1953	0.536	0.575
1954	0.947	0.619
1955	0.718	1.329
1956	0.956	1.675
1957	1.137	0.753
1958	0.499	0.697
1959	0.690	0.544
1960	0.968	0.653
1961	0.749	0.560
1962	0.693	0.542
1963	0.781	0.585
1964	1.396	1.551
1965	3.213	1.351
1966	1.154	0.565
1967	1.238	1.194
1968	1.309	1.169
1969	0.759	0.555
1970	0.308	0.381
1971	1.352	0.843
1972	1.174	1.620
1973	0.890	1.397
1974	0.915	0.874
1975	0.766	0.584
1976	1.480	1.522
1977	0.779	0.608
1978	1.126	0.690
1979	1.466	0.728
1980	1.502	1.810
1981	0.681	0.631
1982	1.628	1.465
1983	0.824	0.818
1984	3.729	2.075
1985	2.210	0.806
1986	3.372	1.252
1987	1.076	0.843

1988	0.835	0.604
1989	1.049	1.058
1990	1.393	1.219
1991	0.966	1.008
1992	1.077	0.924
1993	1.003	0.625
1994	0.412	0.400
1995	1.045	1.275
1996	1.277	1.032
1997	2.058	2.414
1998	0.400	0.497
1999	2.993	3.090

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	**Predeveloped**	**Developed**
1	3.7294	3.0903
2	3.3715	2.4139
3	3.2126	2.0748
4	2.9933	1.8103
5	2.2102	1.6753
6	2.0584	1.6195
7	1.6284	1.5507
8	1.5416	1.5221
9	1.5018	1.5139
10	1.4796	1.4653
11	1.4661	1.3970
12	1.3962	1.3511
13	1.3931	1.3286
14	1.3519	1.2750
15	1.3089	1.2523
16	1.2774	1.2189
17	1.2442	1.1944
18	1.2382	1.1691
19	1.1739	1.0577
20	1.1537	1.0321
21	1.1424	1.0079
22	1.1370	0.9237
23	1.1264	0.8745
24	1.0769	0.8434
25	1.0758	0.8431
26	1.0485	0.8178
27	1.0454	0.8058
28	1.0035	0.7529
29	0.9684	0.7277
30	0.9657	0.7117
31	0.9565	0.6972
32	0.9469	0.6903
33	0.9151	0.6582
34	0.8897	0.6528
35	0.8355	0.6312
36	0.8242	0.6253
37	0.7814	0.6192
38	0.7793	0.6077
39	0.7658	0.6038
40	0.7593	0.5851
41	0.7488	0.5836
42	0.7182	0.5752
43	0.6931	0.5646
44	0.6897	0.5603
45	0.6808	0.5550
46	0.5360	0.5441
47	0.4990	0.5420

48	0.4115	0.4968
49	0.4002	0.4693
50	0.3970	0.3998
51	0.3078	0.3812

1/2 2 year to 50 year

Flow(CFS)	Predev	Final	Percentage	Pass/Fail
0.5159	4432	3225	72.0	Pass
0.5441	3920	2503	63.0	Pass
0.5722	3481	2221	63.0	Pass
0.6003	3136	2039	65.0	Pass
0.6285	2811	1908	67.0	Pass
0.6566	2535	1806	71.0	Pass
0.6847	2283	1717	75.0	Pass
0.7129	2059	1610	78.0	Pass
0.7410	1871	1515	80.0	Pass
0.7691	1696	1405	82.0	Pass
0.7972	1547	1303	84.0	Pass
0.8254	1413	1194	84.0	Pass
0.8535	1289	1090	84.0	Pass
0.8816	1170	996	85.0	Pass
0.9098	1070	907	84.0	Pass
0.9379	980	809	82.0	Pass
0.9660	893	703	78.0	Pass
0.9942	815	634	77.0	Pass
1.0223	745	590	79.0	Pass
1.0504	664	560	84.0	Pass
1.0786	597	536	89.0	Pass
1.1067	544	508	93.0	Pass
1.1348	494	481	97.0	Pass
1.1629	440	445	101.0	Pass
1.1911	402	413	102.0	Pass
1.2192	365	376	103.0	Pass
1.2473	336	343	102.0	Pass
1.2755	306	304	99.0	Pass
1.3036	276	272	98.0	Pass
1.3317	254	246	96.0	Pass
1.3599	237	216	91.0	Pass
1.3880	216	190	87.0	Pass
1.4161	197	169	85.0	Pass
1.4442	185	147	79.0	Pass
1.4724	159	129	81.0	Pass
1.5005	133	110	82.0	Pass
1.5286	114	97	85.0	Pass
1.5568	96	88	91.0	Pass
1.5849	88	79	89.0	Pass
1.6130	77	66	85.0	Pass
1.6412	66	54	81.0	Pass
1.6693	63	41	65.0	Pass
1.6974	56	30	53.0	Pass
1.7255	52	25	48.0	Pass
1.7537	45	21	46.0	Pass
1.7818	39	18	46.0	Pass
1.8099	35	17	48.0	Pass
1.8381	30	16	53.0	Pass
1.8662	29	14	48.0	Pass
1.8943	26	13	50.0	Pass
1.9225	24	13	54.0	Pass
1.9506	20	13	65.0	Pass
1.9787	16	13	81.0	Pass
2.0069	14	13	92.0	Pass
2.0350	13	13	100.0	Pass

2.0631	11	9	81.0	Pass
2.0912	11	8	72.0	Pass
2.1194	11	8	72.0	Pass
2.1475	10	8	80.0	Pass
2.1756	10	8	80.0	Pass
2.2038	10	8	80.0	Pass
2.2319	9	8	88.0	Pass
2.2600	9	7	77.0	Pass
2.2882	9	7	77.0	Pass
2.3163	9	7	77.0	Pass
2.3444	9	7	77.0	Pass
2.3725	9	7	77.0	Pass
2.4007	9	5	55.0	Pass
2.4288	8	4	50.0	Pass
2.4569	7	4	57.0	Pass
2.4851	7	4	57.0	Pass
2.5132	7	4	57.0	Pass
2.5413	7	4	57.0	Pass
2.5695	7	4	57.0	Pass
2.5976	7	4	57.0	Pass
2.6257	7	4	57.0	Pass
2.6538	7	4	57.0	Pass
2.6820	6	4	66.0	Pass
2.7101	6	4	66.0	Pass
2.7382	6	3	50.0	Pass
2.7664	6	3	50.0	Pass
2.7945	6	2	33.0	Pass
2.8226	5	2	40.0	Pass
2.8508	5	2	40.0	Pass
2.8789	5	2	40.0	Pass
2.9070	5	2	40.0	Pass
2.9352	5	2	40.0	Pass
2.9633	5	1	20.0	Pass
2.9914	4	1	25.0	Pass
3.0195	3	1	33.0	Pass
3.0477	3	1	33.0	Pass
3.0758	3	1	33.0	Pass
3.1039	3	0	.0	Pass
3.1321	3	0	.0	Pass
3.1602	3	0	.0	Pass
3.1883	3	0	.0	Pass
3.2165	2	0	.0	Pass
3.2446	2	0	.0	Pass
3.2727	2	0	.0	Pass
3.3008	2	0	.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0.9343 acre-feet
On-line facility target flow: 0.4809 **cfs.**
Adjusted for 15 min: 0.5059 **cfs.**
Off-line facility target flow: 0.3223 **cfs.**
Adjusted for 15 min: 0.3391 **cfs.**

Basin I-C

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: EMR BASIN I-C
Site Address: East Maple Ridge
City : Blaine, WA
Report Date : 12/11/2006
Gage : Blaine
Data Start : 1948
Data End : 1999
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Basin I-C
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	17.01

DEVELOPED LAND USE
Basin : Basin I-C
Flows To : Pond 2
GroundWater: No

Land Use	Acres
TILL GRASS:	10.55
IMPERVIOUS:	6.42

RCHRES (POND) INFORMATION
Pond Name: Pond 2
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 7ft.
Bottom Length: 270ft.
Bottom Width : 90ft.
Side slope 1: 2 To 1
Side slope 2: 2 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Volume at Riser Head: 4.340 acre-ft.
Discharge Structure

Riser Height: 6.25 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 2.125 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 2.3125 in. **Elevation:** 3.95 ft.
Orifice 3 Diameter: 3.125 in. **Elevation:** 5.1 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	0.558	0.000	0.000	0.000
0.100	0.562	0.056	0.038	0.000
0.200	0.566	0.112	0.053	0.000
0.300	0.570	0.169	0.065	0.000
0.400	0.574	0.226	0.075	0.000
0.500	0.579	0.284	0.084	0.000
0.600	0.583	0.342	0.092	0.000
0.700	0.587	0.401	0.099	0.000
0.800	0.591	0.460	0.106	0.000
0.900	0.596	0.519	0.113	0.000
1.000	0.600	0.579	0.119	0.000
1.100	0.604	0.639	0.124	0.000
1.200	0.608	0.700	0.130	0.000
1.300	0.613	0.761	0.135	0.000
1.400	0.617	0.822	0.140	0.000
1.500	0.621	0.884	0.145	0.000
1.600	0.625	0.946	0.150	0.000
1.700	0.630	1.009	0.155	0.000
1.800	0.634	1.072	0.159	0.000
1.900	0.638	1.136	0.163	0.000
2.000	0.643	1.200	0.168	0.000
2.100	0.647	1.264	0.172	0.000
2.200	0.652	1.329	0.176	0.000
2.300	0.656	1.395	0.180	0.000
2.400	0.660	1.460	0.184	0.000
2.500	0.665	1.527	0.188	0.000
2.600	0.669	1.593	0.191	0.000
2.700	0.674	1.661	0.195	0.000
2.800	0.678	1.728	0.198	0.000
2.900	0.683	1.796	0.202	0.000
3.000	0.687	1.865	0.205	0.000
3.100	0.691	1.934	0.209	0.000
3.200	0.696	2.003	0.212	0.000
3.300	0.700	2.073	0.215	0.000
3.400	0.705	2.143	0.219	0.000
3.500	0.710	2.214	0.222	0.000
3.600	0.714	2.285	0.225	0.000
3.700	0.719	2.357	0.228	0.000
3.800	0.723	2.429	0.231	0.000
3.900	0.728	2.501	0.234	0.000
4.000	0.732	2.574	0.269	0.000
4.100	0.737	2.648	0.295	0.000
4.200	0.742	2.722	0.313	0.000
4.300	0.746	2.796	0.329	0.000
4.400	0.751	2.871	0.343	0.000
4.500	0.755	2.946	0.356	0.000
4.600	0.760	3.022	0.368	0.000
4.700	0.765	3.098	0.379	0.000
4.800	0.769	3.175	0.389	0.000
4.900	0.774	3.252	0.399	0.000
5.000	0.779	3.330	0.409	0.000
5.100	0.784	3.408	0.418	0.000
5.200	0.788	3.486	0.509	0.000
5.300	0.793	3.565	0.551	0.000
5.400	0.798	3.645	0.585	0.000

5.500	0.802	3.725	0.615	0.000
5.600	0.807	3.806	0.642	0.000
5.700	0.812	3.886	0.668	0.000
5.800	0.817	3.968	0.691	0.000
5.900	0.822	4.050	0.714	0.000
6.000	0.826	4.132	0.735	0.000
6.100	0.831	4.215	0.755	0.000
6.200	0.836	4.298	0.775	0.000
6.300	0.841	4.382	0.957	0.000
6.400	0.846	4.467	1.661	0.000
6.500	0.851	4.552	2.656	0.000
6.600	0.856	4.637	3.872	0.000
6.700	0.860	4.723	5.274	0.000
6.800	0.865	4.809	6.839	0.000
6.900	0.870	4.896	8.552	0.000
7.000	0.875	4.983	10.40	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	**Flow(cfs)**
2 year	0.44358
5 year	0.701284
10 year	0.900084
25 year	1.183706
50 year	1.418938
100 year	1.675066

Flow Frequency Return Periods for Developed Unmitigated

Return Period	**Flow(cfs)**
2 year	4.389491
5 year	6.052228
10 year	7.184387
25 year	8.649454
50 year	9.765754
100 year	10.903453

Flow Frequency Return Periods for Developed Mitigated

Return Period	**Flow(cfs)**
2 year	0.325318
5 year	0.528107
10 year	0.698638
25 year	0.961297
50 year	1.19518
100 year	1.465319

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	**Predeveloped**	**Developed**
1949	0.535	0.225
1950	0.491	0.294
1951	0.663	0.636
1952	0.171	0.191
1953	0.230	0.217
1954	0.407	0.219
1955	0.309	0.511
1956	0.411	0.718
1957	0.489	0.300
1958	0.215	0.219

1959	0.296	0.227
1960	0.416	0.230
1961	0.322	0.223
1962	0.298	0.203
1963	0.336	0.226
1964	0.600	0.633
1965	1.381	0.542
1966	0.496	0.202
1967	0.532	0.443
1968	0.563	0.414
1969	0.326	0.219
1970	0.132	0.159
1971	0.581	0.332
1972	0.505	0.679
1973	0.382	0.549
1974	0.393	0.344
1975	0.329	0.219
1976	0.636	0.643
1977	0.335	0.220
1978	0.484	0.281
1979	0.630	0.224
1980	0.646	0.754
1981	0.293	0.228
1982	0.700	0.619
1983	0.354	0.321
1984	1.603	1.007
1985	0.950	0.226
1986	1.449	0.447
1987	0.462	0.328
1988	0.359	0.216
1989	0.451	0.233
1990	0.599	0.411
1991	0.415	0.382
1992	0.463	0.357
1993	0.431	0.225
1994	0.177	0.157
1995	0.449	0.484
1996	0.549	0.374
1997	0.885	1.303
1998	0.172	0.191
1999	1.287	1.457

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	1.6031	1.4568
2	1.4493	1.3028
3	1.3810	1.0068
4	1.2867	0.7542
5	0.9501	0.7184
6	0.8848	0.6793
7	0.7000	0.6432
8	0.6627	0.6356
9	0.6456	0.6330
10	0.6360	0.6187
11	0.6302	0.5494
12	0.6002	0.5419
13	0.5988	0.5108
14	0.5811	0.4842
15	0.5627	0.4472
16	0.5491	0.4426
17	0.5348	0.4137
18	0.5323	0.4108

19	0.5046	0.3821
20	0.4960	0.3737
21	0.4911	0.3568
22	0.4888	0.3437
23	0.4842	0.3321
24	0.4629	0.3283
25	0.4625	0.3212
26	0.4507	0.3004
27	0.4494	0.2939
28	0.4314	0.2808
29	0.4163	0.2327
30	0.4151	0.2296
31	0.4112	0.2276
32	0.4070	0.2268
33	0.3934	0.2256
34	0.3825	0.2256
35	0.3592	0.2255
36	0.3543	0.2250
37	0.3359	0.2241
38	0.3350	0.2229
39	0.3292	0.2196
40	0.3264	0.2194
41	0.3219	0.2194
42	0.3087	0.2191
43	0.2980	0.2191
44	0.2965	0.2174
45	0.2927	0.2158
46	0.2304	0.2032
47	0.2145	0.2022
48	0.1769	0.1914
49	0.1720	0.1914
50	0.1706	0.1586
51	0.1323	0.1565

1/2 2 year to 50 year

Flow(CFS)	**Predev**	**Final**	**Percentage**	**Pass/Fail**
0.2218	4441	4022	90.0	Pass
0.2339	3948	2424	61.0	Pass
0.2460	3509	2237	63.0	Pass
0.2581	3133	2151	68.0	Pass
0.2702	2808	2060	73.0	Pass
0.2823	2535	1963	77.0	Pass
0.2943	2283	1850	81.0	Pass
0.3064	2059	1727	83.0	Pass
0.3185	1872	1596	85.0	Pass
0.3306	1708	1450	84.0	Pass
0.3427	1558	1296	83.0	Pass
0.3548	1420	1151	81.0	Pass
0.3669	1297	1000	77.0	Pass
0.3790	1175	858	73.0	Pass
0.3911	1068	710	66.0	Pass
0.4032	977	586	59.0	Pass
0.4153	898	471	52.0	Pass
0.4274	818	433	52.0	Pass
0.4395	745	409	54.0	Pass
0.4515	668	395	59.0	Pass
0.4636	598	378	63.0	Pass
0.4757	546	359	65.0	Pass
0.4878	494	342	69.0	Pass
0.4999	444	322	72.0	Pass
0.5120	402	307	76.0	Pass
0.5241	365	288	78.0	Pass

0.5362	336	262	77.0	Pass
0.5483	306	243	79.0	Pass
0.5604	276	226	81.0	Pass
0.5725	254	209	82.0	Pass
0.5846	237	191	80.0	Pass
0.5967	217	173	79.0	Pass
0.6087	197	150	76.0	Pass
0.6208	185	134	72.0	Pass
0.6329	163	118	72.0	Pass
0.6450	133	101	75.0	Pass
0.6571	114	93	81.0	Pass
0.6692	96	83	86.0	Pass
0.6813	88	74	84.0	Pass
0.6934	77	67	87.0	Pass
0.7055	66	56	84.0	Pass
0.7176	63	45	71.0	Pass
0.7297	56	36	64.0	Pass
0.7418	53	29	54.0	Pass
0.7539	45	22	48.0	Pass
0.7659	39	18	46.0	Pass
0.7780	35	16	45.0	Pass
0.7901	30	15	50.0	Pass
0.8022	29	13	44.0	Pass
0.8143	26	13	50.0	Pass
0.8264	24	13	54.0	Pass
0.8385	20	13	65.0	Pass
0.8506	17	12	70.0	Pass
0.8627	14	11	78.0	Pass
0.8748	13	11	84.0	Pass
0.8869	11	11	100.0	Pass
0.8990	11	10	90.0	Pass
0.9111	11	9	81.0	Pass
0.9231	10	9	90.0	Pass
0.9352	10	9	90.0	Pass
0.9473	10	9	90.0	Pass
0.9594	9	9	100.0	Pass
0.9715	9	9	100.0	Pass
0.9836	9	9	100.0	Pass
0.9957	9	9	100.0	Pass
1.0078	9	6	66.0	Pass
1.0199	9	6	66.0	Pass
1.0320	9	6	66.0	Pass
1.0441	8	6	75.0	Pass
1.0562	7	6	85.0	Pass
1.0683	7	6	85.0	Pass
1.0804	7	6	85.0	Pass
1.0924	7	6	85.0	Pass
1.1045	7	6	85.0	Pass
1.1166	7	6	85.0	Pass
1.1287	7	6	85.0	Pass
1.1408	7	6	85.0	Pass
1.1529	6	6	100.0	Pass
1.1650	6	6	100.0	Pass
1.1771	6	6	100.0	Pass
1.1892	6	5	83.0	Pass
1.2013	6	4	66.0	Pass
1.2134	5	4	80.0	Pass
1.2255	5	3	60.0	Pass
1.2376	5	3	60.0	Pass
1.2496	5	3	60.0	Pass
1.2617	5	3	60.0	Pass
1.2738	5	3	60.0	Pass
1.2859	4	3	75.0	Pass

1.2980	3	3	100.0	Pass
1.3101	3	2	66.0	Pass
1.3222	3	2	66.0	Pass
1.3343	3	2	66.0	Pass
1.3464	3	2	66.0	Pass
1.3585	3	2	66.0	Pass
1.3706	3	2	66.0	Pass
1.3827	2	2	100.0	Pass
1.3948	2	1	50.0	Pass
1.4068	2	1	50.0	Pass
1.4189	2	1	50.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0.6675 acre-feet
On-line facility target flow: 0.3724 **cfs.**
Adjusted for 15 min: 0.3724 **cfs.**
Off-line facility target flow: 0.2016 **cfs.**
Adjusted for 15 min: 0.2016 **cfs.**

Basin II

WESTERN WASHINGTON HYDROLOGY MODEL V2
PROJECT REPORT

Project Name: EMR BASIN II
Site Address: East Maple Ridge
City : Blaine, WA
Report Date : 12/11/2006
Gage : Blaine
Data Start : 1948
Data End : 1999
Precip Scale: 1.00

PREDEVELOPED LAND USE

Basin : Basin II
Flows To : Point of Compliance
GroundWater: No

Land Use	Acres
TILL FOREST:	31.88

DEVELOPED LAND USE
Basin : Basin I-A
Flows To : Pond 3
GroundWater: No

Land Use	Acres
TILL GRASS:	19.27
IMPERVIOUS:	13.96

RCHRES (POND) INFORMATION
Pond Name: Pond 3
Pond Type: Trapezoidal Pond
Pond Flows to : Point of Compliance
Pond Rain / Evap is not activated.
Dimensions
Depth: 6.5ft.
Bottom Length: 250ft.
Bottom Width : 250ft.
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 2 To 1
Side slope 4: 2 To 1
Volume at Riser Head: 8.791 acre-ft.

Discharge Structure
Riser Height: 5.5 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 3 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 3 in. **Elevation:** 3.25 ft.
Orifice 3 Diameter: 4 in. **Elevation:** 4.25 ft.

Pond Hydraulic Table

Stage(ft)	Area(acr)	Volume(acr-ft)	Dschrg(cfs)	Infilt(cfs)
0.000	1.435	0.000	0.000	0.000
0.100	1.441	0.144	0.075	0.000
0.200	1.446	0.288	0.106	0.000
0.300	1.452	0.433	0.129	0.000
0.400	1.458	0.579	0.149	0.000
0.500	1.464	0.725	0.167	0.000
0.600	1.469	0.871	0.183	0.000
0.700	1.475	1.018	0.198	0.000
0.800	1.481	1.166	0.211	0.000
0.900	1.487	1.315	0.224	0.000
1.000	1.493	1.464	0.236	0.000
1.100	1.499	1.613	0.248	0.000
1.200	1.504	1.763	0.259	0.000
1.300	1.510	1.914	0.270	0.000
1.400	1.516	2.065	0.280	0.000
1.500	1.522	2.217	0.289	0.000
1.600	1.528	2.370	0.299	0.000
1.700	1.534	2.523	0.308	0.000
1.800	1.540	2.677	0.317	0.000
1.900	1.546	2.831	0.326	0.000
2.000	1.552	2.986	0.334	0.000
2.100	1.558	3.141	0.343	0.000
2.200	1.564	3.297	0.351	0.000
2.300	1.570	3.454	0.358	0.000
2.400	1.576	3.611	0.366	0.000
2.500	1.582	3.769	0.374	0.000
2.600	1.588	3.928	0.381	0.000
2.700	1.594	4.087	0.388	0.000
2.800	1.600	4.247	0.396	0.000
2.900	1.606	4.407	0.403	0.000
3.000	1.612	4.568	0.409	0.000
3.100	1.618	4.729	0.416	0.000
3.200	1.624	4.891	0.423	0.000
3.300	1.630	5.054	0.482	0.000
3.400	1.637	5.218	0.527	0.000
3.500	1.643	5.382	0.560	0.000
3.600	1.649	5.546	0.588	0.000
3.700	1.655	5.711	0.613	0.000
3.800	1.661	5.877	0.636	0.000
3.900	1.667	6.044	0.657	0.000
4.000	1.674	6.211	0.677	0.000
4.100	1.680	6.378	0.697	0.000
4.200	1.686	6.547	0.715	0.000
4.300	1.692	6.715	0.826	0.000
4.400	1.698	6.885	0.912	0.000
4.500	1.705	7.055	0.976	0.000
4.600	1.711	7.226	1.030	0.000
4.700	1.717	7.397	1.079	0.000
4.800	1.724	7.569	1.124	0.000
4.900	1.730	7.742	1.166	0.000
5.000	1.736	7.915	1.205	0.000
5.100	1.742	8.089	1.243	0.000
5.200	1.749	8.264	1.279	0.000
5.300	1.755	8.439	1.313	0.000

5.400	1.761	8.615	1.347	0.000
5.500	1.768	8.791	1.379	0.000
5.600	1.774	8.968	1.872	0.000
5.700	1.781	9.146	2.747	0.000
5.800	1.787	9.325	3.870	0.000
5.900	1.793	9.504	5.194	0.000
6.000	1.800	9.683	6.692	0.000
6.100	1.806	9.864	8.344	0.000
6.200	1.813	10.04	10.14	0.000
6.300	1.819	10.23	12.06	0.000
6.400	1.826	10.41	14.11	0.000
6.500	1.832	10.59	16.27	0.000

ANALYSIS RESULTS

Flow Frequency Return Periods for Predeveloped

Return Period	Flow(cfs)
2 year	0.831354
5 year	1.314341
10 year	1.686931
25 year	2.218494
50 year	2.659366
100 year	3.139398

Flow Frequency Return Periods for Developed Unmitigated

Return Period	Flow(cfs)
2 year	8.662068
5 year	11.916621
10 year	14.128951
25 year	16.988252
50 year	19.164583
100 year	21.380853

Flow Frequency Return Periods for Developed Mitigated

Return Period	Flow(cfs)
2 year	0.628164
5 year	1.016478
10 year	1.335217
25 year	1.815532
50 year	2.234559
100 year	2.710291

Yearly Peaks for Predeveloped and Developed-Mitigated

Year	Predeveloped	Developed
1949	1.002	0.450
1950	0.920	0.556
1951	1.242	1.168
1952	0.320	0.356
1953	0.432	0.408
1954	0.763	0.412
1955	0.579	1.055
1956	0.771	1.308
1957	0.916	0.559
1958	0.402	0.404
1959	0.556	0.430
1960	0.780	0.467
1961	0.603	0.421
1962	0.558	0.384

1963	0.630	0.417
1964	1.125	1.218
1965	2.588	1.087
1966	0.930	0.377
1967	0.998	0.991
1968	1.055	0.947
1969	0.612	0.410
1970	0.248	0.292
1971	1.089	0.629
1972	0.946	1.203
1973	0.717	1.105
1974	0.737	0.628
1975	0.617	0.411
1976	1.192	1.202
1977	0.628	0.408
1978	0.908	0.583
1979	1.181	0.417
1980	1.210	1.375
1981	0.549	0.435
1982	1.312	1.118
1983	0.664	0.620
1984	3.005	1.546
1985	1.781	0.414
1986	2.716	0.993
1987	0.867	0.636
1988	0.673	0.402
1989	0.845	0.461
1990	1.122	0.928
1991	0.778	0.833
1992	0.868	0.685
1993	0.808	0.415
1994	0.332	0.286
1995	0.842	0.976
1996	1.029	0.690
1997	1.658	2.671
1998	0.322	0.351
1999	2.412	2.427

Ranked Yearly Peaks for Predeveloped and Developed-Mitigated

Rank	Predeveloped	Developed
1	3.0046	2.6705
2	2.7163	2.4274
3	2.5883	1.5464
4	2.4116	1.3751
5	1.7807	1.3082
6	1.6584	1.2183
7	1.3119	1.2034
8	1.2420	1.2020
9	1.2099	1.1677
10	1.1921	1.1177
11	1.1811	1.1052
12	1.1249	1.0868
13	1.1223	1.0553
14	1.0892	0.9933
15	1.0546	0.9913
16	1.0292	0.9756
17	1.0024	0.9470
18	0.9976	0.9283
19	0.9458	0.8332
20	0.9295	0.6901
21	0.9204	0.6849
22	0.9160	0.6362

23	0.9075	0.6293
24	0.8676	0.6281
25	0.8667	0.6202
26	0.8447	0.5827
27	0.8423	0.5591
28	0.8085	0.5556
29	0.7802	0.4672
30	0.7780	0.4608
31	0.7706	0.4498
32	0.7629	0.4345
33	0.7372	0.4298
34	0.7168	0.4210
35	0.6731	0.4175
36	0.6641	0.4170
37	0.6296	0.4150
38	0.6279	0.4143
39	0.6170	0.4121
40	0.6117	0.4115
41	0.6033	0.4098
42	0.5786	0.4082
43	0.5584	0.4082
44	0.5557	0.4044
45	0.5485	0.4017
46	0.4319	0.3845
47	0.4021	0.3772
48	0.3316	0.3555
49	0.3224	0.3506
50	0.3198	0.2924
51	0.2480	0.2859

1/2 2 year to 50 year

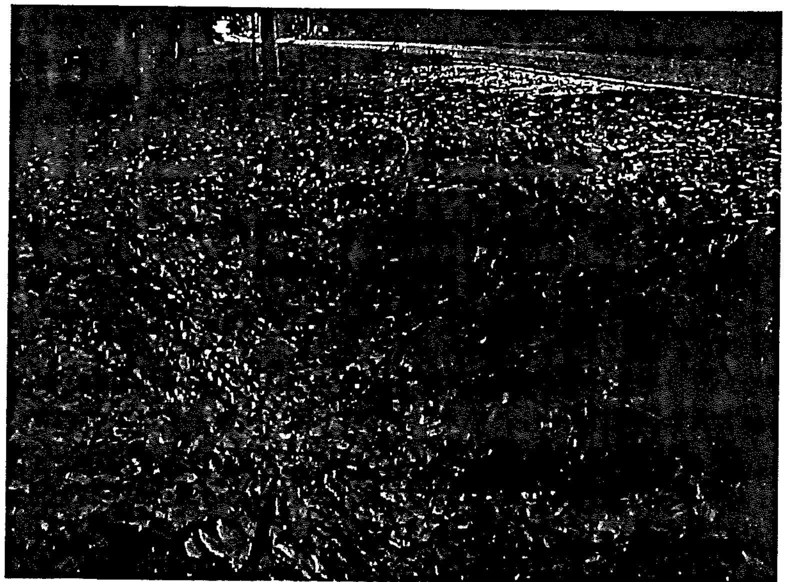
Flow(CFS)	**Predev**	**Final**	**Percentage**	**Pass/Fail**
0.4157	4430	3830	86.0	Pass
0.4383	3925	3048	77.0	Pass
0.4610	3480	2872	82.0	Pass
0.4837	3141	2720	86.0	Pass
0.5063	2808	2513	89.0	Pass
0.5290	2539	2342	92.0	Pass
0.5517	2283	2165	94.0	Pass
0.5743	2056	1982	96.0	Pass
0.5970	1872	1790	95.0	Pass
0.6196	1701	1583	93.0	Pass
0.6423	1548	1385	89.0	Pass
0.6650	1417	1176	82.0	Pass
0.6876	1290	979	75.0	Pass
0.7103	1167	808	69.0	Pass
0.7330	1071	746	69.0	Pass
0.7556	980	721	73.0	Pass
0.7783	896	691	77.0	Pass
0.8010	819	666	81.0	Pass
0.8236	745	633	84.0	Pass
0.8463	663	604	91.0	Pass
0.8689	598	579	96.0	Pass
0.8916	544	547	100.0	Pass
0.9143	492	519	105.0	Pass
0.9369	440	483	109.0	Pass
0.9596	404	446	110.0	Pass
0.9823	365	396	108.0	Pass
1.0049	337	354	105.0	Pass
1.0276	306	313	102.0	Pass
1.0503	276	278	100.0	Pass
1.0729	254	245	96.0	Pass

1.0956	237	212	89.0	Pass
1.1182	216	178	82.0	Pass
1.1409	197	157	79.0	Pass
1.1636	185	138	74.0	Pass
1.1862	159	119	74.0	Pass
1.2089	133	99	74.0	Pass
1.2316	114	84	73.0	Pass
1.2542	95	74	77.0	Pass
1.2769	88	63	71.0	Pass
1.2996	77	51	66.0	Pass
1.3222	66	38	57.0	Pass
1.3449	63	29	46.0	Pass
1.3675	56	18	32.0	Pass
1.3902	51	16	31.0	Pass
1.4129	45	15	33.0	Pass
1.4355	39	14	35.0	Pass
1.4582	35	14	40.0	Pass
1.4809	30	14	46.0	Pass
1.5035	29	12	41.0	Pass
1.5262	26	12	46.0	Pass
1.5489	24	10	41.0	Pass
1.5715	20	10	50.0	Pass
1.5942	16	9	56.0	Pass
1.6168	14	9	64.0	Pass
1.6395	13	9	69.0	Pass
1.6622	11	9	81.0	Pass
1.6848	11	9	81.0	Pass
1.7075	11	9	81.0	Pass
1.7302	10	9	90.0	Pass
1.7528	10	9	90.0	Pass
1.7755	10	8	80.0	Pass
1.7982	9	8	88.0	Pass
1.8208	9	7	77.0	Pass
1.8435	9	7	77.0	Pass
1.8661	9	7	77.0	Pass
1.8888	9	7	77.0	Pass
1.9115	9	7	77.0	Pass
1.9341	9	7	77.0	Pass
1.9568	8	6	75.0	Pass
1.9795	7	6	85.0	Pass
2.0021	7	6	85.0	Pass
2.0248	7	6	85.0	Pass
2.0475	7	6	85.0	Pass
2.0701	7	6	85.0	Pass
2.0928	7	6	85.0	Pass
2.1154	7	6	85.0	Pass
2.1381	7	5	71.0	Pass
2.1608	6	5	83.0	Pass
2.1834	6	4	66.0	Pass
2.2061	6	4	66.0	Pass
2.2288	6	4	66.0	Pass
2.2514	6	4	66.0	Pass
2.2741	5	4	80.0	Pass
2.2967	5	3	60.0	Pass
2.3194	5	3	60.0	Pass
2.3421	5	3	60.0	Pass
2.3647	5	3	60.0	Pass
2.3874	5	3	60.0	Pass
2.4101	4	3	75.0	Pass
2.4327	3	2	66.0	Pass
2.4554	3	2	66.0	Pass
2.4781	3	2	66.0	Pass
2.5007	3	2	66.0	Pass

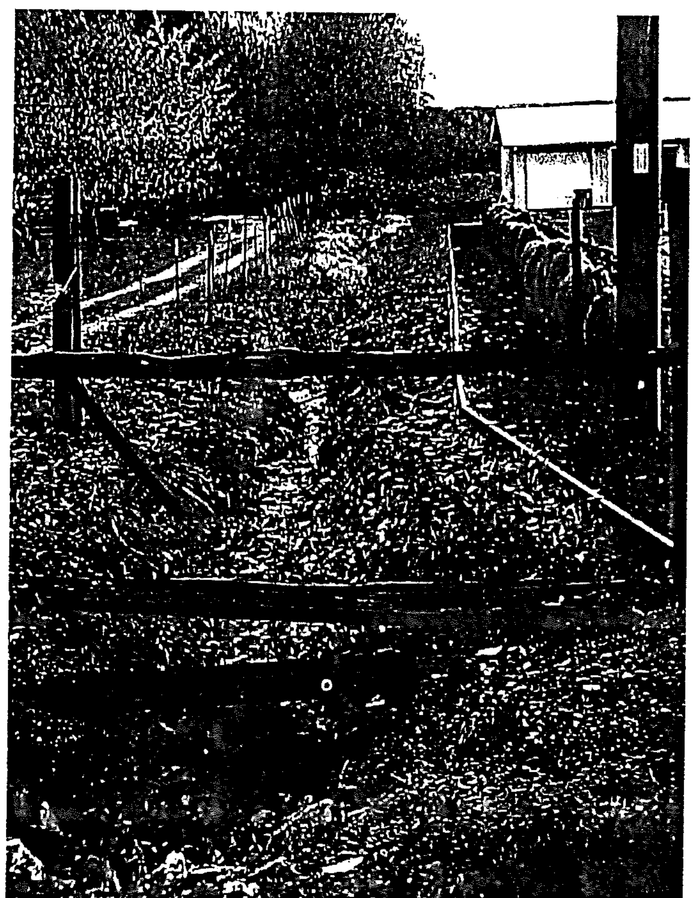
2.5234	3	1	33.0	Pass
2.5460	3	1	33.0	Pass
2.5687	3	1	33.0	Pass
2.5914	2	1	50.0	Pass
2.6140	2	1	50.0	Pass
2.6367	2	1	50.0	Pass
2.6594	2	1	50.0	Pass

Water Quality BMP Flow and Volume.
On-line facility volume: 0.7803 acre-feet
On-line facility target flow: 0.3945 **cfs.**
Adjusted for 15 min: 0.4161 **cfs.**
Off-line facility target flow: 0.2681 **cfs.**
Adjusted for 15 min: 0.2827 **cfs.**

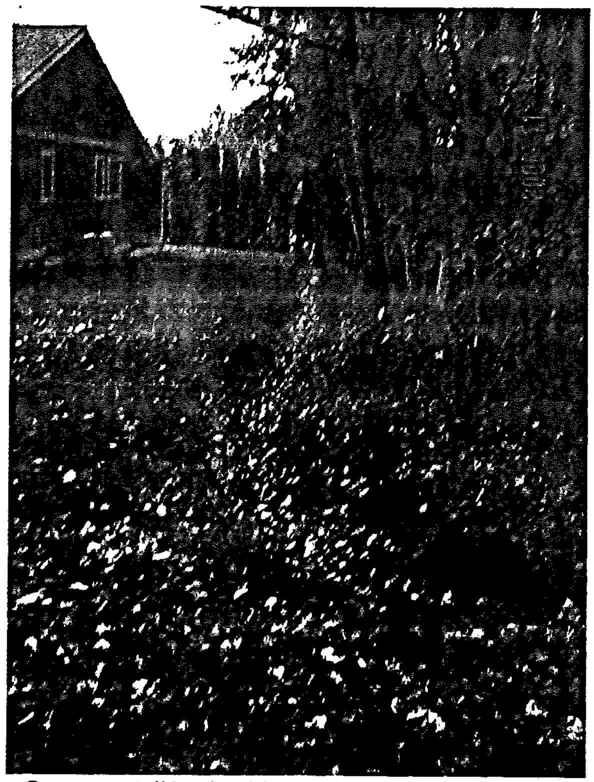
APPENDIX C: DOWNSTREAM CONVEYANCE PHOTOGRAPHS



Segment #2, South end of 18" culvert under H Street

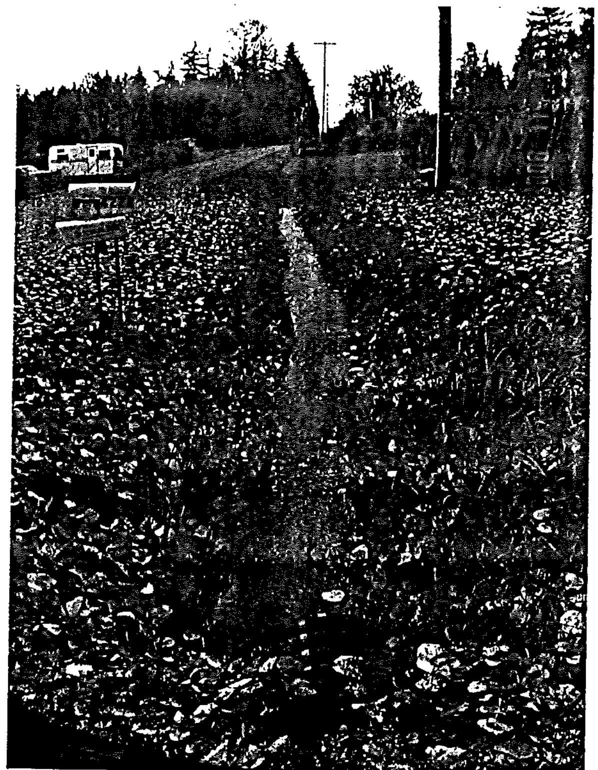


Segment #3 - looking south from H Street



Segment #9 - looking south from H Street

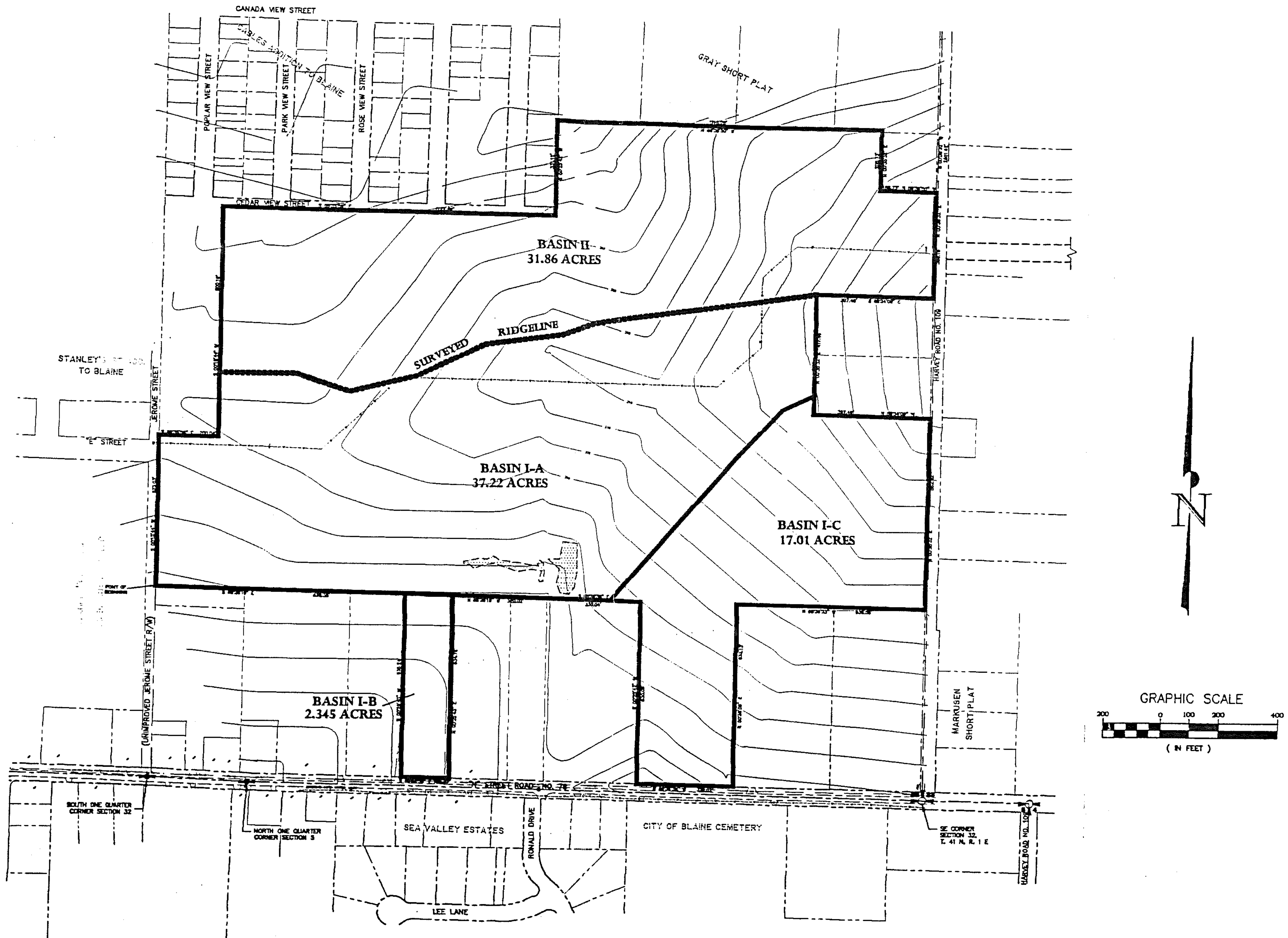
Segment #5 and #13



Segment 13 - looking west

Segment #13 and #6 - looking east

APPENDIX D: BASIN MAPS



EXISTING DRAINAGE BASINS

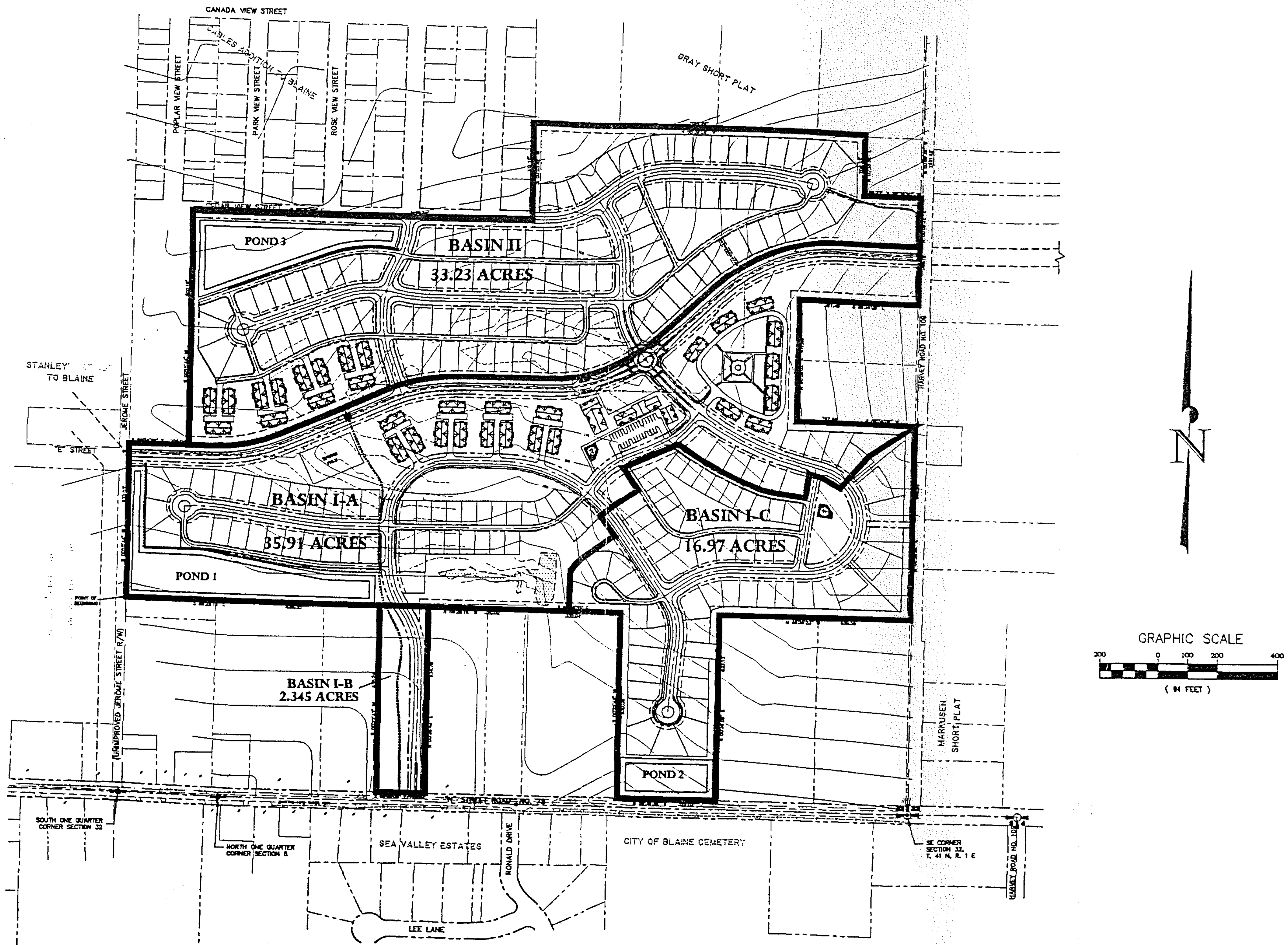
REVISION:	DRAWN BY:	DATE:	CHECKED BY:	DATE:
1				
2				
3				
4				

ASSOCIATED PROJECT CONSULTANTS, INC., P.S.
CIVIL ENGINEERS, PROJECT AND LAND USE MANAGEMENT, BUILDING, STRUCTURAL, AND ENVIRONMENTAL SERVICES
1401 ASTOR STREET, BELLINGHAM, WA. 98225
PHONE (360) 671-1146 FAX (360) 671-1169
A·P·C INCORPORATED

SEAL:

HORIZONTAL SCALE:
VERTICAL SCALE:
DRAWN BY: NGR
DATE: 12/11/06
APPROVED BY:
NORTH ROTATION & BASE POINT:

JOB NO.: 93-167
ACAD FILE:
CLIENT: THE CONNELLY COMPANY
SHEET: 1
PROJECT: EAST MAPLE RIDGE PLAT
OF: 2
TITLE: STORM DRAINAGE PLAN



DEVELOPED SITE DRAINAGE BASINS

REVISION:	DRAWN BY:	DATE:	CHECKED BY:	DATE:
1				
2				
3				
4				

SEAL:

ASSOCIATED PROJECT CONSULTANTS, INC., P.S.
CIVIL ENGINEERS, PROJECT AND LAND USE MANAGEMENT, BUILDING, STRUCTURAL, AND ENVIRONMENTAL SERVICES
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PHONE (360) 671-1146 FAX (360) 671-1169

A·P·C INCORPORATED

HORIZONTAL SCALE:
VERTICAL SCALE:
DRAWN BY: NGR
DATE: 12/11/06
APPROVED BY:
NORTH ROTATION & BASE POINT:

CLIENT: THE CONNELLY COMPANY
PROJECT: EAST MAPLE RIDGE PLAT
TITLE: STORM DRAINAGE PLAN

JOB NO.: 93-167
ACAD FILE:
SHEET: 2
OF: 2