KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

King County
Department of Public Works

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Department of Public Works

Paul Tanaka, Director

Surface Water Management Division

Jim Kramer, Manager

Contributing Staff:

Randall Parsons, Senior Engineer, River and Water Resource Section
Don Wood, Senior Engineer, Project Management and Design Section
Curt Crawford, Senior Engineer, Drainage Investigation Section
Wendy Jackson, Claims Analyst, Finance and Billing Section
Karen Willie, Deputy Prosecuting Attorney, Prosecuting Attorneys Office

Consultants:

URS Corporation, Michael Bertman, David Browne, John Genskow, P.E., Joan Lee, Tom Kearns, John Knobbs, Paul Korsmo, Erma Lambert, Jan Rosholt, Rick Schaefer, Charlie Tang, CeliaWatkins, Dayna Woods
Resource Planning Associates, Gary Minton
Horton Dennis and Associates, Hal Hagenson
Dodds Consultting Engineers, Bruce Dodds
Tom Nesbitt

Parks, Planning and Resources Department

Jim Tracy, Acting Director

Building and Land Development Division

Irv Berteig, Manager

Contributing Staff:

Cindy Baker, Supervisor Subdivision Engineering Review, Subdivision Products Section
Jeff O'Neill, Supervisor, Commercial Site Planning
Jim Sanders, Development Engineer, Subdivision Products Section

Special thanks to:

All of the individuals, agencies and consulting firms who reviewed and contributed materials to this Manual including, but not limited to:
Chris Tiffany and Jill Reymore, Erosion Control Specialist King County Conservation District
SWM Staff
BALD, Engineering Review Staff
The Design Professionals Group:
Sue Burgemeister, Jim Goldsmith, Terre Harris, Malcom Leytham, George Lindsey, Walt Pine, Mark Reeves, Bob Scholes and others.
Mel Schaeffer, Dam Safety Section, Washington State Department of Ecology
Peter Birch, Stormwater Technical Manual, Washington State Department of Ecology
METRO, Water Quality Planners

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INTRODUCTION

OVERVIEW

King County's surface water features -- the rivers, lakes, wetlands, streams, and Puget Sound -- are a significant part of our natural beauty and rich heritage. Spawning salmon, meandering rivers, and clean water are important natural resources which must be managed wisely to protect their values.

This Surface Water Design Manual contains the requirements and standards for designing surface and storm water management systems in King County. As part of the permit approval process for certain types of permits for proposed projects, King County requires the construction of surface water and storm water management systems to mitigate the impacts of on natural and existing man-made drainage systems.

This Manual regulates proposed projects by a mixture of requirements, performance, and design standards. Requirements are quite specific. Performance and design standards are less specific, directing the design engineer to accomplish a defined goal in a consistent manner considering site constraints, objectives of a project, and technical limitations.

These requirements and standards are enforced by two divisions within two separate departments of King County: the Building and Land Development (BALD) Division of the Parks, Planning and Resources Department and the Surface Water Management (SWM) Division of the Department of Public Works. The BALD Division is responsible for the drainage review and approval of the engineering plans and for the administration of the Sensitive Areas Ordinance and Rules and all other King County codes governing development. The SWM Division is responsible for developing the requirements and standards, which includes publishing, up-dating and providing the technical support for this Manual. The SWM Division also designs, constructs and maintains the King County capital drainage facilities, participates in the review of major development proposals, and reviews requests for major variances to the requirements and standards in Chapter 1 and portions of Chapter 3 of this Manual.

The chapters of this Manual are organized as follows:

Chapter 1 - SUMMARY AND GUIDE TO ALL REQUIREMENTS

Describes or references all King County requirements for the analysis and design of drainage systems.

Chapter 2 - PLAN REVIEW PROCEDURES

Describes the procedures for the submittal and drainage review of engineering plans, including report and plan formats and scopes.

Chapter 3 - HYDROLOGIC ANALYSIS

Presents the acceptable methods of hydrologic analysis used to estimate runoff and the hydraulic routing techniques for the analyze and design of drainage systems.

Chapter 4 - HYDRAULIC ANALYSIS AND DESIGN

Presents the acceptable methods of hydraulic analysis and design standards used to analyze and design drainage systems.

Chapter 5 - TEMPORARY EROSION AND SEDIMENTATION CONTROL STANDARDS

Presents the required measures to be shown on the erosion/sedimentation control plan, including the methods used to size sedimentation facilities. It also describes effective management practices which may be needed to supplement the required erosion/sedimentation control measures.

DEFINITIONS - A formal list of the words, terms and abbreviations accompanied by their meaning as applied in this Manual.

APPENDICES:

APPENDIX A - MAINTENANCE REQUIREMENTS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

Contains the frequency, thresholds and standards for maintenance of all privately maintained storm drainage facilities.

APPENDIX B - MASTER DRAINAGE PLAN OBJECTIVES, CRITERIA AND COMPONENTS AND REVIEW PROCESS

Describes in a general outline the objectives, criteria and components and review process of Master Drainage Plans prepared for Master Planned Developments and very large projects.

REFERENCE - Materials provided to the user of the Manual are strictly for reference only and have not been adopted by the public rule adopting this manual. The applicant is responsible to insure that the most current materials are used in preparing permit application.

CHAPTER 1
SUMMARY AND GUIDE TO ALL REQUIREMENTS

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CHAPTER 1
SUMMARY AND GUIDE TO ALL REQUIREMENTS

1.1 INTRODUCTION

This chapter describes when proposed projects require drainage review and summarizes or references all King County requirements for the analysis and design of drainage facilities for proposed projects. A careful reading will show you which specific requirements apply to your project and where you can find more detailed information on these requirements in this Manual.

1.1.1 WHEN IS DRAINAGE REVIEW REQUIRED?

Drainage review is required for any proposed project requiring one of the King County permits or approvals listed below;

<u>King County Permits and Approvals</u>

Commercial Building
Conditional Use[1]
Formal Subdivision (plat)
Clearing
Grading
Master Plan Development
Planned Unit Development
Single-Family Residential Building
Right-of-Way Use
Shoreline Substantial Development[1]
Administrative Subdivision (Short Plat)
Special Use [1]
Unclassified Use [1]
Zoning Reclassification [1]
Zoning Variance [1]

AND which would:

- o add more than 5,000 square feet of new impervious surface[2], OR
- o construct, modify, or discharge to a drainage system that collects and concentrates surface and storm water runoff from an on- or off-site drainage area of more than 5,000 square feet, OR
- o contain, or be adjacent to, a floodplain, stream, lake, wetland or closed depression, or a sensitive area as defined by the Sensitive Areas Ordinance and Rules (King County Code, Chapter 21.54), or is located within an adopted Critical Drainage Area (see Reference Section).

If drainage review is required for your permit, then review this chapter to determine your drainage requirements. The King County drainage requirements described in this chapter are of two types:

(1) Core Requirements, and

(2) Special Requirements

---

[1] If the proposed project will require subsequent permits with full drainage review, then the drainage review may be deferred until application for the later permits.

[2] See Definition Section

The seven Core Requirements apply to every project which requires drainage review. Twelve Special Requirements may apply to a project depending on the nature of the project and its location. For example, a detention pond may have more restrictive detention performance conditions when the project is in a "Critical Drainage Area." It is highly likely that one, if not several, Special Requirements will apply to a given project. Document how the Core and Special Requirements apply to your project and include this information in your permit application.

In addition to the exceptions provided for specific requirements, variances may be granted in rare cases. The variance process is described at the end of this chapter in Section 1.4.

All calculations for both Core and Special Requirements used to prepare plans and specifications for drainage facilities must follow the analysis and design methods described in the subsequent chapters of this Manual:

FOR APPROVED CALCULATION METHODS AND DESIGN REQUIREMENTS CONCERNING:	REFER TO:
Design storms, runoff estimates, hydrograph analysis, storage requirements, etc.	Chapter 3 Hydrologic Analysis
Conveyance systems, routing, retention/ detention facilities, control structures, infiltration systems, water quality facilities, etc.	Chapter 4 Hydraulic Analysis and Design
Erosion, sedimentation, cover practices, etc.	Chapter 5 Temporary Erosion and Sedimentation Control Standards

All procedures for submitting plans and specifications for engineering review of drainage analysis and design for proposed projects are described in Chapter 2: Plan Review Process. During engineering review, King County Building and Land Development (BALD) Division staff will evaluate the proposed project for compliance with the drainage requirements described in this Manual. BALD Division staff will also evaluate a proposed project for compliance with other King County requirements (which are not described in this Manual), such as those described in the Sensitive Areas Ordinance, Critical Drainage Areas, and P-suffix conditions of adopted Community Plans.

1.1.2 OTHER AGENCIES MAY ALSO REQUIRE DRAINAGE REVIEW

Other agencies such as those listed below may require drainage review for a proposed project's impact on surface and storm waters. The applicant should take care to note that these other agency drainage requirements are separate from, and in addition to, King County's drainage requirements. The applicant will be responsible to coordinate joint agency drainage review, including resolution of any conflicting requirements between agencies.

Agency	Permit/Approval
Seattle/King County Health Department	On-Site Sewage Disposal and Well Permits
Washington State Department of Transportation	Developer/Local Agency Agreement
Washington State Department of Ecology	Short Term Water Quality Modification Approval
Washington State Department of Fisheries	Hydraulic Project Approval
Washington State Department of Wildlife	Hydraulic Project Approval
Washington State Department of Ecology	Dam Safety Permit
United States Army Corps of Engineers	Section 10 Permit
United States Army Corps of Engineers	Section 404 Permit

1.2 CORE REQUIREMENTS

The seven Core Requirements are:

(1) **Discharge at the Natural Location.** The discharge from a proposed project site must occur at the natural location.

(2) **Off-Site Analysis.** All proposed projects must identify the upstream tributary drainage area and perform a downstream analysis. Levels of analysis required depend on the problems identified or predicted. At a minimum, a Level 1 analysis must be submitted with the initial permit application.

(3) **Runoff Control.** Proposed projects must provide runoff controls to limit the developed conditions peak rates of runoff to the pre-development peak rates for specific design storm events based on the runoff from defined existing site conditions, and install biofiltration measures.

(4) **Conveyance System.** All conveyance systems for proposed projects must be analyzed, designed and constructed for existing tributary off-site runoff and developed on-site runoff from the proposed project.

(5) **Temporary Erosion and Sedimentation Control.** All projects that require engineered drainage plans shall provide Temporary Erosion and Sedimentation Control (TESC) measures that minimize the transport of sediment to drainage facilities, water resources, and adjacent properties.

(6) **Maintenance and Operation.** Maintenance of all drainage facilities constructed or modified by a proposed project is the responsibility of the property owner (see Maintenance Requirements for Privately Maintained Drainage Facilities in Appendix A), except King County may assume maintenance of drainage facilities constructed for formal Plat Subdivisions, planned unit developments, and some Short Plat Subdivisions two years after construction approval.

(7) **Bonds and Liability.** All drainage facilities for proposed projects (except drainage stub-out connections, downspout roof drain infiltration systems and downspout dispersion systems for single-family residential lots) must be constructed in conformance with the bond and liability requirements of King County Code 9.04.100.

1.2.1 CORE REQUIREMENT #1: DISCHARGE AT THE NATURAL LOCATION

All surface and storm water runoff from a proposed project that proposes to construct new, or modify existing drainage facilities must be discharged at the natural location so as not to be diverted onto, or away from, the adjacent downstream property.

Proposals which do not discharge at the natural location in order to address an existing or anticipated problem will be considered as a variance (see Section 1.4).

Discharge from the proposed project must produce no significant adverse impact to the drainage system of the downhill property. Where no conveyance system exists at the adjacent downstream property line and the discharge was previously unconcentrated flow, any concentrated runoff must:

(1) be conveyed across the downstream properties to an acceptable discharge point (see Core Requirement #2: Off-Site Analysis), with drainage easements secured from the downstream owners and recorded at the King County Office of Records and Elections prior to drainage plan approval, OR

(2) be discharged onto a rock pad shaped in a manner so as to disperse flow if the runoff is less than 0.2 cfs peak runoff rate discharged from the site for the 100-year, 24-hour design storm event, OR

(3) be conveyed to a dispersal trench (see Figure 4.3.6B) or other infiltration system if the runoff is less than 0.5 cfs peak runoff rate discharged from the site for the 100-year, 24-hour design storm event, provided the applicant can demonstrate that there will be no significant adverse impact to the drainage system of the downhill property.

1.2.2 CORE REQUIREMENT #2: OFF-SITE ANALYSIS

A proposed project initial submittal shall include an Off-Site Analysis Report that evaluates drainage system problems (ponding water, high/low flows, siltation, erosion, etc.) upstream, on-site, and downstream of the proposed project. The design engineer shall demonstrate that the proposed project has been designed so that it neither aggravates (increases the magnitude, frequency, or duration of) an existing drainage problem nor creates a new drainage problem.

Exemption: Permits and approvals requiring drainage review will be exempt from performing an Off-Site Analysis when the BALD Division determines that the proposed development contains sufficient measures to adequately protect the downstream drainage system AND,

(1) the proposed new impervious surface[3] to be constructed is 5,000 square feet, or less, OR

(2) the drainage area from which surface and storm water runoff is to be collected and concentrated is 5,000 square feet, or less.

Levels of Off-site Analysis
The Off-Site Analysis report requirements vary depending on the specific site and downstream conditions. Each project submittal shall include at least a Level 1 analysis. Upon review of the Level 1 analysis, BALD may require a Level 2 or Level 3 analysis. If conditions warrant, additional, more detailed analysis may be required.

Level 1 Analysis: The Level 1 analysis is a qualitative survey of each downstream system leaving a site. This analysis is required for all proposed projects and shall be submitted with the initial permit application. Depending on the findings of the Level 1 analysis, the Level 2 or 3 analysis may need to be completed and/or additional information may be required. If further analysis is required, the applicant may schedule a meeting with BALD Division staff.

Level 2 or 3 Analysis: If problems are identified in the Level 1 analysis, either a Level 2 (rough quantitative) analysis or a Level 3 (more precise quantitative) analysis shall be performed to further define and evaluate proposed mitigation for the problem. The BALD Division will determine whether a Level 2 or 3 analysis is required based on the evidence of existing or potential problems identified in the Level 1 analysis and on the proposed on-site drainage facilities design. The Level 3 analysis is required when results need to be as accurate as possible: for example, if the site is flat; or if the system is affected by downstream controls; or if minor changes in the drainage system could flood roads, buildings, or septic systems; or if the proposed project will contribute more than 15 percent of the total peak flow to the drainage problem location. The Level 2 or 3 analysis may not be required, if the BALD Division determines that adequate mitigation can be developed from the Level 1 analysis.

Additional Analysis: Additional, more detailed, hydrologic analysis may be required if the BALD Division determines that the analysis has not been sufficient to analyze the impacts of a proposed project on an existing or potential drainage problem. This more detailed analysis will generally include synthesizing, summing, and phasing hydrographs for the major drainage areas (defined by major drainage system components affecting routing such as impoundments, restrictions, confluences, etc.) tributary to the drainage problem areas. The SWM Division will review this additional analysis.

Specific Requirements for Off-site Analysis: Regardless of the level of Off-Site Analysis required, the applicant shall: define and map the study area (Task 1), review resources (Task 2), inspect the study area (Task 3), describe the drainage system and problems (Task 4), and propose mitigation measures (Task 5) as described below.

[3] See Definition Section

Task 1: Study Area Definition and Maps
The requirements to define and map the study area are the same for all levels of analysis. The upstream portion of the study area shall encompass the entire tributary drainage area (the area that drains to the proposed project site). The remaining portion of the study area shall extend downstream of the proposed project discharge location to a point on the drainage system where the proposed project site constitutes a minimum of 15 percent of the total tributary drainage area, but in no event less than 1/4 mile.

The Off-Site Analysis shall include: (1) A site map showing property lines, (2) a copy of the assessor's map of the property, and (3) the best available topographical map (e.g., from BALD, Roads and Engineering Division Map Counter, Sewer District, or at a minimum a USGS 1:24000 Quadrangle Topographic map) with the study area boundaries and potential/existing problems (Task 4) shown. Other maps, diagrams, and photographs such as aerial photos may be helpful in describing the study area.

Task 2: Resource Review
To assist the design engineer in preparing an Off-Site Analysis, King County has gathered information regarding existing and potential flooding and erosion problems. For all levels of analysis, all of the resources described below shall be reviewed for existing/potential problems in the Off-Site Analysis study area (upstream and downstream of the project site):

Adopted Basin Plans and Finalized Drainage Studies[4]
Basin Reconnaissance Summary Reports and 1" = 400' scale problem summary maps[4]
Critical Drainage Area Maps[4]
Flood plain/floodway (FEMA) Maps
Other Off-Site Analysis Reports in the same sub-basin, if available
Sensitive Areas Folio (Document distance downstream from proposed project to nearest sensitive areas identified in the folio)
SWM Division Drainage Investigation Section Problems Maps
US Department of Agriculture, King County Soils Survey
Wetlands Inventory Maps

Potential/existing problems identified in the above documents shall be documented in the Drainage System Table (See References Section) as well as described in the text of the Level 1 Off-Site Analysis Report. If a document is not available for your site, note in the report that the information was not available as of a particular date. If necessary, additional resources are available from King County, METRO, the Washington State Departments of Fisheries, Wildlife, and Ecology, the United States Army Corps of Engineers, and the public works departments of other municipalities in the vicinity of the proposed project site.

Task 3: Field Inspection
Physically inspect the existing on- and off-site drainage system of the study area for each discharge location. Specifically, investigate any evidence of the following existing/potential problems and drainage features.

Level 1 Inspection:
Investigate any problems reported or observed during the resource review.
Locate existing/potential constrictions or lack of capacity in the existing drainage system.(Locate all existing/potential capacity problems and apply reasoning in Tasks 4 and 5 to eliminate from further analysis.)
Identify existing/potential flooding, especially of commercial or residential structures, road access or septic drain fields. (Identify all existing/potential flooding problems and see Task 5 for method to eliminate from further analysis.)
Identify existing/potential overtopping, scouring, bank sloughing or sedimentation.
Identify significant destruction of aquatic habitat or organisms (for example, severe siltation, bank erosion, or incision in a stream).

[4] Reports available when this Manual was prepared are in the Reference Section.

Collect qualitative data on features such as land use, impervious surfaces, topography, and soil types.
Collect information on pipe sizes, channel characteristics, drainage structures, wetland/stream/steep slope (Sensitive) areas.
Verify tributary basins delineated in Task 1.
Contact neighboring property owners or residents in the area about past or existing drainage problems and describe in the report (Optional).
Note the date and weather conditions at the time of inspection.

Level 2 or 3 Inspection:
Perform a Level 1 Inspection.
Document existing site conditions (approved drainage systems or pre-1979 aerial photographs) as defined in Core Requirement # 3.
Collect quantitative field data (For Level 2, Collect non-survey field data using hand tapes, hand reel, and rods, and for Level 3 collect field survey profile and cross-section topographic data prepared by an experienced surveyor.)

Task 4: Drainage System Description and Problem Screening
Each drainage system component and problem shall be addressed in the Off-Site Analysis Report: on a map (Task 1), in the narrative, and in the Drainage System Table (See Reference 10B).

Drainage system components:
The following information about drainage system components such as pipes, culverts, bridges, outfalls, ponds, tanks, and vaults shall be included in the report:

Location (corresponding map label and distance downstream/upstream from site discharge)
Physical description (type, size, length, slope, vegetation, and cover)
Problems
Field observations

Existing/potential problems:
All existing/potential problems (ponding water, high/low flows, siltation, erosion, etc.) identified in the resource review or field inspection shall be described in the report as follows regardless of whether the proposed project may or may not aggravate the problem. Then, problems that are not of concern will be screened from further analysis.

Type of problem: magnitude, frequency, and/or duration
Description of problem: ponding water, high or low flows, siltation, erosion, slides
Magnitude of or damage caused by problem: siltation of ponds, dried up ornamental ponds, road inundation, flooded property, flooded building, flooded septic system, significant destruction of aquatic habitat or organisms.
General frequency and duration of problem (Dates and time problem occurred, if available)
Design storm or flow (cfs) of the water when problem occurs (Optional for Level 1 and required for Levels 2 and 3)
Water surface elevation when problem occurs (for example, elevation of building foundation, crest of roadway, elevation of septic drain fields, or wetland/stream high water mark)
Names and concerns of involved parties (Optional for all levels of analysis)
Current mitigation of problem
Possible cause of problem
Why the proposed project will or will not aggravate (increase the magnitude, frequency, or duration) the existing problem nor create a new drainage problem. For example, the problem will not be aggravated if:

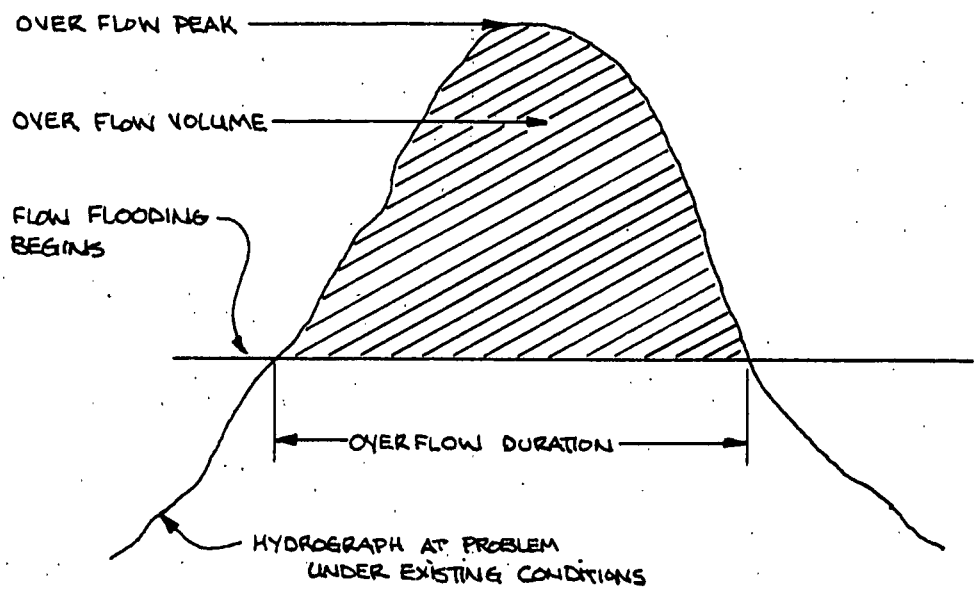
(1) it is an upgradient drainage problem that will not effect or be affected by project drainage systems; or
(2) it is a flooding problem and the project will not increase the elevation, duration, or frequency of elevated water; or
(3) it is a capacity problem and the project proposes controls (pipes, culverts, channels, etc.) that will convey runoff as specified in Core Requirement #4: Conveyance System.

Existing/potential problems that potentially do not result in changes in the magnitude, frequency, or duration may be eliminated from further analysis. The remaining problems of concern shall be discussed in the Level 1 mitigation narrative and may be addressed with a Level 2 or 3 analysis.

Task 5: Mitigation
For any existing/potential off-site drainage problems of concern, the design engineer shall demonstrate that the proposed project engineering plan has been designed so that it neither aggravates the existing drainage problem nor creates a new drainage problem. Aggravation of the problem can include increasing the magnitude, frequency, or duration of the problem. Quantitative analysis (such as application of Manning's equation to indicate capacity) is optional for Level 1 and is required for Levels 2 and 3 as follows.

Level 2 or 3 Analysis: At the existing/potential problem locations, mitigation may be demonstrated by showing that the overflow peak, overflow volume, and overflow duration associated with the identified flood problem will not increase under developed conditions for the 2, 10- and 100-year, 24-hour design storms. The following definitions will apply and are indicated in Figure 1.2.2A: (1) the "overflow peak" at any location and for any design storm of interest will be the peak flow of the total runoff hydrograph which exceeds the capacity of the drainage system; (2) the "overflow volume" at any location and for any design storm of interest will be the volume of that portion of the total runoff hydrograph which exceeds the capacity of the drainage system; and (3) the "overflow duration" at any location and for any design storm of interest will be the length of time that the total runoff hydrograph exceeds the capacity of the drainage system.

FIGURE 1.2.2A OVERFLOW HYDROGRAPH



The general method of analysis for Levels 2 and 3 involves hydrograph synthesis, routing, summation, and phasing (see Chapter 3). Non-survey field data and computations using Manning's equation for normal flows is adequate for a Level 2 analysis. Survey data and use of the direct step backwater method and hydrograph routing is required for a Level 3 analysis (Task 3). These methods do not specify how to find the maximum release rate for a site with downstream problems.

A common approach is to set the maximum release rate equal to the flow leaving the proposed project at the level of storm (2-, 5-, 10-, 25-, 50-, or 100-year 24-hour) that results in the problem occurring and holding that release rate up to the 100-year, 24-hour storm.

To verify that the release rates will not increase overflow peak, overflow volume, or overflow duration, the applicant may develop hydrographs at each existing/potential drainage problem location for the 2-, 10-, and 100-year 24-hour design storm, based on the total composite drainage area tributary to that location for existing and developed conditions. Existing on-site conditions are defined in Core Requirement # 3 and developed on-site conditions are those proposed by the project. Off-site existing and developed conditions are the same and are the conditions present at the time of the Off-Site Analysis.

On-site Mitigation: Typically, a proposed project will provide on-site mitigation measures such as restrictive release rates; increased detention, retention, or infiltration; up-sized conveyance systems; piping sheet flow or open channels; or stream rehabilitation and protection. For downstream erosion problems, BALD may require proposed projects to set restrictive release rates.

Off-site Mitigation: Occasionally a proposed project will provide off-site mitigation measures such as elevating roadways, up-sizing culverts, stabilizing soils, revegetating, bioengineering, stream rehabilitation, armoring, or obtaining drainage easements. The applicant, following approval by the SWM Division, may arrange with the owners of the affected off-site properties to install measures which will correct the existing problem. Any required drainage easements shall be endorsed by the affected property owners and be recorded prior to approval of the proposed project engineering plan. When an existing drainage problem has been identified by the SWM Division, the applicant should contact the SWM Division to check for potential cost sharing mitigation.

1.2.3 CORE REQUIREMENT #3: RUNOFF CONTROL

Proposed projects must provide runoff control through a combination of peak rate runoff control and on-site biofiltration as described below.

Peak Rate Runoff Control

Proposed projects must provide peak rate runoff control to limit the developed conditions peak rates of runoff from specific design storm events not to exceed the peak rates for the "existing site conditions" described below. Three basic methods for peak rate runoff control are possible: detention, retention, and infiltration. Detention is the collection and temporary storage of surface water (typically over several hours) with the outflow rate restricted--usually to the pre-developed outflow rate. Retention is the collecting and holding of surface and stormwater with effectively no surface outflow (outflow occurs by evapotranspiration). Infiltration is the soaking of surface water into the ground (typically for several hours or days).

Infiltration not only reduces or eliminates surface runoff, but also helps to maintain the hydrologic balance of the surface water system. Infiltration can limit erosion and recharge groundwaters that supply water to wetlands, streams, and wells. Preserving infiltration after development is by far the most effective mechanism in preventing adverse impacts to the surface water system. Because of these benefits, King County encourages the use of infiltration systems for runoff control where the appropriate soil conditions exist.

Proposed project peak rate runoff control must be located on-site. An exemption from on-site peak rate runoff control may be granted for the special conditions specified at the end of this core requirement section.

Biofiltration

Proposed project runoff resulting from more than five thousand square feet of new impervious surface[5] for each threshold discharge area[6], and subject to vehicular use or storage of chemicals, shall be treated prior to discharge from the project site by on-site biofiltration measures as described in Section 4.6.4. Installation of a biofiltration facility (biofiltration swale or filter strip) to meet Core Requirement #3 does not exempt the applicant from installing a special water quality control facility (wetpond, wetvault, or water quality swale) to meet Special Requirement #5.

The biofiltration design flow rate shall be the peak rate of runoff for the 2-year 24-hour duration design storm event. Note, biofiltration facilities installed following peak rate runoff control facilities may be sized to treat the allowable release rate (existing site conditions) for the 2-year 24-hour duration design storm event for the peak rate runoff control facility. Biofiltration facilities installed prior to peak rate runoff control facilities shall be sized based on the developed conditions.

Proposed Project Site "Existing Site Conditions"

In performing the analysis for the design of runoff control, it is essential to first determine the proposed project site "existing site conditions" from which the pre-development runoff rates can be computed for specific design storms. Existing site conditions are not always synonymous with those of the natural, totally undeveloped site. In some instances substantial modifications (such as diversions, piping, clearing, and grading) have already increased and altered surface water runoff leaving the site, but no permit, nor accompanying engineering plan, was ever approved. In other instances, an approved drainage system exists and the existing system must be analyzed for its performance. There are two definitions for proposed project site "existing site conditions" depending on the site.

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[5] See Definition Section

[6] A threshold discharge area is an on-site area which drains to a single natural discharge location or multiple natural discharge locations that combine within 1/4-mile downstream.

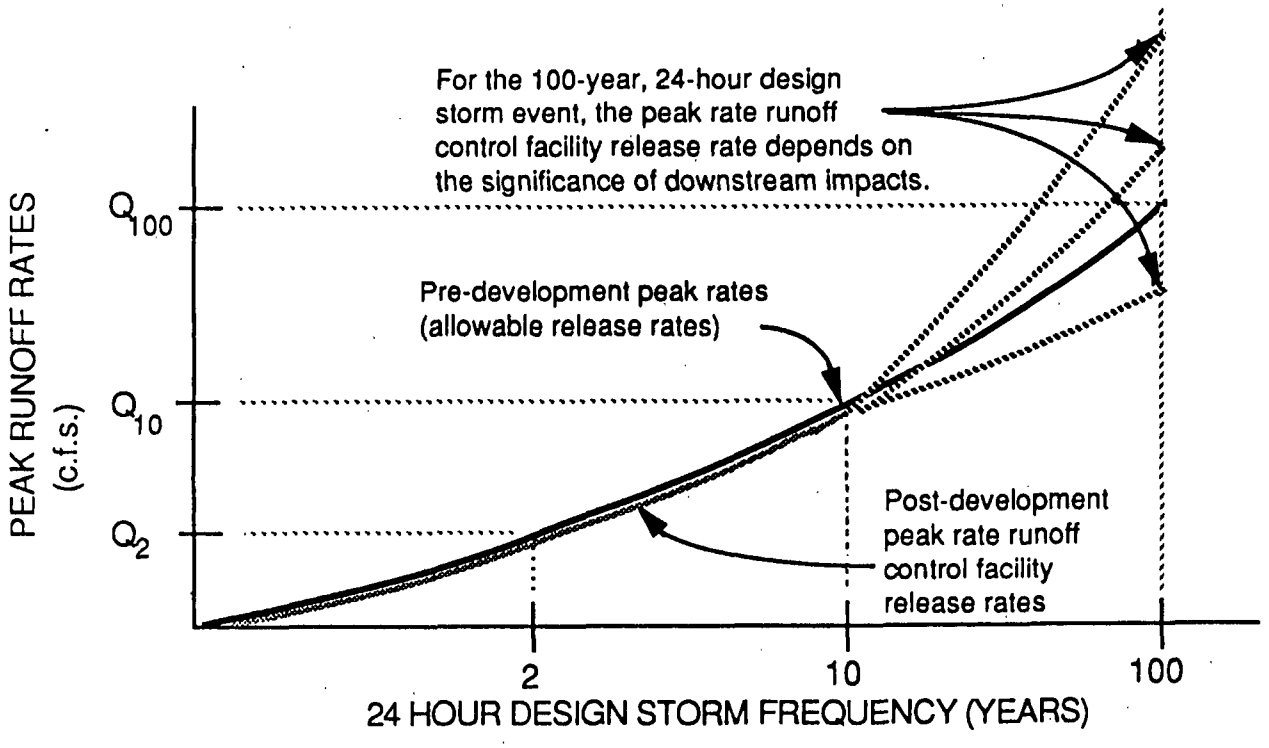
Sites with Existing Approved Drainage Systems: The proposed project site "existing site conditions" are defined as those that occur with the existing drainage facilities constructed per approved permits and engineering plans when required. The current performance of existing drainage and detention facilities shall be determined by using the analysis methods described in Section 3.5.

Sites with No Existing Approved Drainage Systems: The "existing site conditions" are defined as those that existed prior to May 1979. This is the date of publication of "Requirements and Guidelines for Storm Drainage Control in King County" by the King County Public Works Department's Hydraulics Division, the document which defined the on-site detention design criteria for implementing King County Ordinance 2281. If in question, the "existing site conditions" must be documented by the best available aerial photographs. If aerial photographs are not available, knowledge of the site by individuals familiar with the area will be admissible.

Peak Rate Runoff Control Performance Curve

A "peak rate runoff control performance curve" plots the allowable peak runoff rates for a range of design storm frequencies, as illustrated in Figure 1.2.3A the "Standard Peak Rate Runoff Control Performance Curve". In the absence of other Special Requirements which dictate a more thorough analysis, the BALD Division evaluates peak rate runoff control only for the 2-, 10-, and 100-year frequency storm events represented on this curve. Peak rate runoff control facilities must be designed to produce post-development peak runoff rates at or below this curve for the 2- and 10-year, 24-hour duration design storm events. More restrictive runoff control performance curves may be required under conditions specified in the "Special Requirements" section of this chapter.

FIGURE 1.2.3A STANDARD PEAK RATE RUNOFF CONTROL PERFORMANCE CURVE



The post developed runoff for the 100-year, 24-hour duration design storm event shall be routed through the conveyance system and the peak rate runoff control facilities to evaluate any significant adverse impacts downstream (see Sections 1.2.2 and 1.2.4). Additional control to reduce the post-developed peak runoff for the 100-year, 24-hour duration design storm event is one mechanism that may be used to mitigate significant adverse impacts downstream. The required performance above the 10-year, 24-hour duration design storm up to the 100-year, 24-hour duration design storm event, therefore, is dependent upon downstream conditions and how much attenuation the peak rate runoff control facility designed for 2- and 10-year, 24-hour duration design storm events provides for the 100 year, 24-hour duration design storm event.

If runoff does not leave the project site under existing site conditions for the 2- and 10-year, 24-hour duration design storm events, the peak rate runoff control facility must be designed to produce peak runoff rates at or below the performance curve for all design storm events up to and including the 100-year, 24-hour event as well as the 100-year, 7-day event. Sites with little or no runoff may also be subject to Special Requirement #7: Closed Depressions.

Detention Facilities

There are two main types of detention facilities: ponds; and, tanks or vaults. The methods of analysis and design standards for detention facilities can be found in Section 4.4.

Factor of Safety: The design volume of detention facilities used to meet the standard peak rate runoff control performance curve for the 2- and 10-year, 24-hour duration design storm events shall be increased by a 30 percent factor of safety. This requirement shall be met by increasing proportionally by 30 percent the design detention volume between each 1 foot of storage depth without increasing the total depth of storage or altering the design control orifice/weir sizing.

Detention Ponds: Detention ponds are the most desirable alternative for detention facilities for water quality benefits, relative ease of inspection and access for maintenance. King County encourages the design of multi-purpose detention ponds which can serve the multiple purposes of recreation (such as playgrounds or picnic areas), wildlife habitat (wetlands areas) and aesthetics (landscaping to provide for a natural appearance). Multi-purpose ponds must meet all the requirements of the purposes they are required to perform. In multi-purpose ponds incorporating recreational facilities, the recreational facilities must be designed in a manner compatible with the storm water functions and maintenance standards. Detention ponds may combine the performance requirements of wetponds (see Special Requirement #5 and Sections 4.6.2 and 4.6.3).

Detention Tanks and Vaults: Detention tanks and vaults are underground facilities for the storage of surface water. Tanks are typically constructed from corrugated pipe and vaults are constructed from reinforced concrete. Tanks and vaults provide less water quality benefit (biofiltration and biologic activity) than ponds, therefore, biofiltration measures are especially important.

Private Parking Lot Ponding: Private parking lots may be used to provide additional peak rate runoff control detention volume for the post-developed peak rates of runoff for design storms greater than the 10-year, 24-hour duration design storm provided that:

(1) the depth of water detained can not exceed 1.0 feet at any location in the parking lot; AND

(2) the minimum gradient of the parking lot area subject to ponding shall be 1 percent; AND

(3) the emergency overflow path meets the same requirements as for infiltration systems; AND

(4) fire lanes used for emergency equipment shall be free of standing water up to the design storm.

Roof Ponding: Ponding of roofs of structures will be allowed to be used for peak rate runoff control detention volume provided that:

(1) the depth of water ponded can not exceed 1.0 feet at any location on the roof; AND

(2) the minimum pitch of the roof area subject to ponding shall be 1/4 inch to 1 foot; AND

(3) the roof support structure is analyzed by a structural engineer to address the weight of the ponded water; AND

(4) the roof area subject to ponding is water-proofed with a method with a minimum expected service life of 30 years.

Retention Facilities

There are two basic types of retention facilities: ponds and closed depressions. Retention ponds are constructed by a combination of excavation and/or berming. Closed depressions may be established as retention facilities, and in some cases enlarged to accommodate additional surface and stormwater runoff by excavation and/or berming.

Usually retention facilities will not be a cost effective means for providing peak rate runoff control, but rather are employed to control the increased volume of runoff from a proposed project as is required by Special Requirement #7: Closed Depressions in Section 1.3.7.

The pre- and post-development peak runoff rates for the 100-year, 7-day duration design storm events are evaluated, along with the standard peak rate runoff control performance curve, when retention facilities are employed in order to control increased volume of runoff from proposed projects. In these cases, retention facilities shall be analyzed and sized using the methods described in Section 3.6, and designed using the design standards contained in Section 4.4. Note, in some cases, retention facilities will have significant infiltration capability and, in these cases, must also meet the design standards contained in Section 4.5.

Infiltration Facilities

Infiltration facilities, as with detention systems, must be sized to meet the required peak rate runoff control performance curve. More restrictive runoff control curves may be required under conditions specified in the "Special Requirements" Section 1.3. Note, the factors of safety for infiltration systems are incorporated within the methods of analysis and design standards described in Section 4.5. For the design requirements and standards for infiltration facilities see Section 4.5.

There are many practical limitations on infiltration facilities, due to the very slow permeability rates of some soils and the need to prevent contamination of groundwater resources. The following Soil Conservation Service series soils: Arents ("An" only), Everett, Indianola, Klaus, Neilton, Pilchuck, Puyallup and Ragnar are most likely to be suitable for infiltration; any other soil types should be very carefully evaluated for use in systems other than downspout systems. A soils report is required for all proposed infiltration facilities to verify the mapped soils series or to classify the series of the soil (if previously unmapped). Soils logs are prepared to provide the data for the report and to investigate and confirm that the seasonal high groundwater is at least 3 feet below the bottom of a proposed infiltration system (except roof downspout systems). Where doubt exists as to the depth of seasonal high groundwater an investigation must be conducted during the winter months prior to permit approval.

Infiltration facilities may not be operated until all proposed project improvements which produce surface runoff are complete, especially revegetation and landscaping. In the case of projects with individual lots remaining undeveloped, these lots must contain and infiltrate their runoff through individual sediment traps (see Section 5.4.5.1) acting as infiltration ponds as until permanent improvements and landscaping are established. An alternative to this approach is to provide a single large temporary settling pond on an undeveloped tract, as discussed in Section 4.5.2. A typical detail of the sediment trap shall be provided and included as a condition of the final plat. It is not necessary to design a trap for each individual lot. Instead, a single trap may be designed based on the average lot size, topography, soil type and anticipated impervious area.

Infiltration facilities must be designed based on infiltration testing and a soils report prepared by a professional civil engineer with expertise in soil engineering. To maintain outflow rates of the infiltration tanks and ponds, all inflow must be pretreated for sediment removal (see Section 5.4).

An emergency overflow path must be identified for infiltration facilities and noted on the engineering plan. This overflow path must be analyzed to meet the requirements of Core Requirements #1 (see Section 1.2.1) and #2 (see Section 1.2.2) for the 100-year, 24-hour duration design storm, except Downspout Infiltration Systems (see Section 4.5.1).

Infiltration facilities may be especially useful in the following circumstances, provided the proper soil conditions are present and all requirements can be met.

(1) The proposed project discharges to a closed depression.

(2) The proposed project discharges to a severely undersized conveyance system that restricts the runoff volume that can be accommodated.

(3) The proposed project is in a Critical Drainage Area requiring runoff volume control.

Exemptions From On-Site Peak Rate Runoff Control

On-site peak rate runoff control will not be required for a proposed project in the following situations.

Negligible Peak Runoff Rate Increase[7]:

(1) The proposed project site post-developed peak runoff rate for the 100-year, 24-hour duration design storm event is calculated for each discharge location[8] to be less than 0.5 cfs more than the peak runoff rate for the existing site conditions; OR,

(2) The project proposes to construct 5,000 square feet, or less, of new impervious surface.

Direct Discharge: The proposed project will discharge surface and stormwater runoff without on-site peak rate runoff control directly to:

A Regional Facility. Direct discharge of surface and stormwater runoff to a regional facility will be allowed if:

- the facility has been demonstrated to adequately control the proposed project's increased peak rate of runoff by an adopted King County basin plan or by a detailed drainage analysis approved by the SWM Division; AND
- the facility will be available by the time of construction of the project; AND
- the conveyance system to the regional facility can accommodate, with no significant adverse impact to the drainage systems, the design peak runoff for the proposed project site and the equivalent area[9] developed to the full zoning potential.

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[7] Proposed projects in adopted critical drainage areas, basin plans and community plans requiring peak runoff rate or runoff volume controls more strict than standard controls shall not qualify for this exemption.

[8] A threshold discharge area is an on-site area which drains to a single natural discharge location or multiple natural discharge locations that combine within 1/4-mile downstream.

[9] The equivalent area is the area tributary to the receiving water body equal to or less than the shortest, straight line distance from the discharge point from the receiving water body (or regional facility) to the furthermost point of the proposed development.

A Receiving Water. Direct discharge of surface and stormwater runoff to the receiving waters listed below may be allowed if:

- o proposed projects that require Master Drainage Plans (see Special Requirement #3) shall demonstrate no significant adverse impact to the drainage systems from direct discharge to a river; AND

- o the conveyance system to the receiving water can accommodate, with no significant adverse impact, the design peak runoff for the proposed project site and the equivalent area developed to the full zoning potential.

  Cedar River
  Green/Duwamish River (below river mile 6.0, F.E.M.A.)
  Lake Sammamish
  Lake Washington
  Puget Sound
  Sammamish River
  Skykomish River
  Snoqualmie River including the North, South and Middle Forks
  Tolt River
  White/Stuck River

A Lake, Wetland or Closed Depression. See Special Requirement #8: Use of Lakes, Wetlands or Closed Depressions for Peak Rate Runoff Quantity Control, in Section 1.3.8. The applicant should note that many lakes, wetlands or closed depressions will not qualify for this exemption.

Bypasses

On-Site Runoff Bypass: Proposed project runoff may bypass the proposed project peak rate runoff control facilities provided that:

(1) the proposed project peak rate runoff control facilities are designed to compensate for the controlled project area by limiting the total developed peak runoff rate (the sum of the controlled and uncontrolled hydrographs) to the pre-development peak runoff rates for the proposed project site at the point(s) of discharge, AND

(2) both the bypass area and the peak rate runoff control facility discharge to the same subbasin, AND

(3) all discharges, including the bypass, are subject to the biofiltration requirements of this Core Requirement if the threshold is exceeded, AND

(4) the discharge from the bypass will have no significant adverse impact to the drainage systems on downstream properties.

Off-Site Runoff Bypass: Upstream off-site runoff must bypass the proposed project on-site peak rate runoff control facilities in a separate conveyance system, unless the existing peak runoff rate from the upstream off-site area for the 100-year, 24-hour design storm event is less than 50 percent of the proposed project site developed conditions peak runoff rate for the 100-year, 24-hour duration design storm event.

Tracts

The runoff control facilities to be maintained and operated by the King County Department of Public Works (see Section 1.2.6) must be located in a tract or right-of-way created by a legal subdivision and dedicated to King County. Access roads serving these facilities must also be located in the tract or right-of-way and must be connected to an improved King County road right-of-way. Enclosed runoff control facilities (tanks or vaults) may be allowed in private right-of-way for a road, provided the easement includes provisions for access and maintenance of the facility.

1.2.4 CORE REQUIREMENT #4: CONVEYANCE SYSTEM

All conveyance systems for proposed projects must be analyzed, designed and constructed for existing tributary off-site runoff and developed on-site runoff from the proposed project. The applicant shall demonstrate one of the following:

(1) The on-site conveyance system of the proposed project:

(a) exists, or will be constructed, and is sized to convey the peak rate runoff as required below, AND

(b) complies with specific requirements for conveyance system composition, pumps, interflow interception, easements, outfalls, and single-family residential lots, OR

(2) The project is exempt from this requirement.

Sizing

The on-site conveyance system adequacy shall be demonstrated using the Backwater Analysis Methods described in Section 4.3.4 and 4.3.7. When significant storage volume exists in the conveyance system (such as upstream of an existing roadway embankment/cross culvert) these methods shall be used in conjunction with the Hydrograph Routing Method described in Section 3.5.4. The runoff originating on the project site plus any existing upstream runoff that will be conveyed through the project site shall be included in the analysis.

The conveyance system analysis shall use the following design storms, clearances, and other conveyance system element specific requirements:

(1) For pipe systems:

Pipe systems shall be designed to convey and contain at least the peak runoff rate for the 25-year design storm using the Methods of Analysis described in Section 4.3.4. Structures for pipe systems must be demonstrated to provide a minimum of 0.5 feet of freeboard between the hydraulic grade line and the top of the structure for the 25 year peak rate of runoff. Structures may overtop for the 100-year peak rate of runoff as described below. When overtopping occurs for the 100-year peak rate of runoff the additional flow over the ground surface is analyzed using the methods described in Section 4.3.7 and added to the flow capacity of the pipe system determined by the backwater analysis.

Exceptions: The upstream end of a pipe system that is open and receives runoff from a natural conveyance element or the following man-made conveyance elements (ditches, channels and retention/detention ponds) shall be analyzed and sized as a culvert as described in (2) below.

(2) For culverts:

Culverts shall be designed to convey the peak runoff rate for the 25-year design storm event using the Methods of Analysis for Culverts described in Section 4.3.5 and to meet the designated headwater requirements. In addition, culverts must be demonstrated to convey the 100-year design storm under surcharged conditions.

(3) For drainage ditches or channels:

Drainage ditches or channels shall be designed to convey at least the peak runoff from the 25-year design storm using the Methods of Analysis described in Section 4.3.7 with a minimum freeboard to overflow of 0.5 feet. In addition, drainage

ditches or channels must be demonstrated to convey the peak runoff from the 100-year design storm without overtopping.

Surcharged conditions for pipe systems and culverts, and bank-full conditions for existing open ditches and channels are acceptable for demonstrating the adequacy of the conveyance system to convey the peak runoff for the 100-year design storm provided that:

(1) runoff is contained within defined conveyance system elements without inundating or overtopping the crown of a roadway; AND/OR

(2) no portions of a building will be flooded; AND/OR

(3) if overland sheet flow occurs, it will flow through a drainage easement or covenant.

The downstream conveyance system must be analyzed as required in Section 1.2.2, Core Requirement #2: Off-site Analysis.

Composition

Conveyance systems shall be constructed of vegetation-lined channels, as opposed to pipe systems, where feasible. Vegetative channels shall generally be considered feasible if: (1) the channel gradient generally does not exceed five percent, (2) no modifications to currently adopted standard roadway cross sections in the King County Road Standards are necessitated by the channel, AND (3) the channel would be accessible for maintenance (see Section 1.2.6).

Bridges

Bridges shall be designed to pass the 100-year runoff (estimated for facilities without continuous flow/frequency records by using the peak runoff for the 100-year design storm) with the clearance as specified in Section 4.3.5.

Pump System

Pump systems (includes the pumps, force mains, electrical equipment, structures and appurtenances) are not allowed on storm drainage systems in King County. A variance (see Section 1.4) from this requirement, which will usually also require a variance from Core Requirement #1: Discharge at the Natural Location in Section 1.2.1, may be requested. Any pump system will be required to meet the following minimum conditions:

(1) The pump system is not used to circumvent any other King County drainage requirements, and construction and operation of the pump system will not violate any other King County requirements.

(2) The pump system is the only alternative to solve a flooding problem impacting existing residential or commercial structures or prohibiting reasonable access.

(3) The pump system has a storage facility (pond, tank, or vault), sized to hold 25 percent of the total volume of runoff for the developed tributary drainage area for the 2-year, 24-hour duration design storm event. This storage requirement is in addition to any peak rate runoff control requirements.

(4) The pump system has a dual pump (alternating) provided with an external alarm system.

(5) Pump systems that serve commercial projects or single-family homes must be maintained by the property owner(s).

(6) Pump systems serving more than one property must be granted in an easement to, and operated and maintained by King County. Prior to engineering plan approval for these pump systems, a fee must be paid to the SWM Division equal to the capital replacement costs for the pump systems mechanical and electrical components.

Outfalls

An outfall is defined as a point where collected and concentrated surface and stormwater runoff is discharged from the project site or into an open drainage feature. These drainage features include ditches, channels, swales, streams, rivers, ponds, lakes, or other open bodies of water. In most cases an outfall will consist of a pipe discharging runoff from a detention facility or storm drainage pipe system.

Energy Dissipation. Due to their relatively smooth surfaces, pipes can convey water at sufficiently high velocities to cause accelerated erosion at the discharge point. Any outfall, therefore, must dissipate some energy of the runoff prior to discharge into an erodible receiving drainage feature. A number of very effective mechanisms to achieve this goal are described in Chapter 4. At a minimum, rock erosion protection is required at outfalls from all drainage systems/elements, except outfalls that are completely submerged at least 2 feet below the mean low water line of, and extend at least 20 feet into, the receiving open drainage feature. Design engineers are also encouraged to investigate and propose alternative mechanisms which they can demonstrate to be as effective.

Outfalls To Tidal Basins. For outfalls discharging to Puget Sound (and the Green River up to River Mile 6.0), the design tailwater elevation shall be 8.5 feet K.C.A.S. datum as established by F.E.M.A. map panel 19P of Volume 2 of 4, King County, WA (see Figure 4.3.8A).

Outfalls on Slopes or Above Steep Slopes. Outfalls proposed on or above slopes greater than 15 percent and greater than 20 feet in height and above Steep Slopes (as defined by the Sensitive Areas Ordinance and Rules) must meet the following criteria:

(1) The discharge must be less than 0.5 cfs for the 100-year, 24-hour design storm for existing pre-developed conditions or a tightline conveyance system must be constructed to convey the runoff to the bottom of the slope with adequate energy dissipation at the bottom.

(2) The outfall must be upslope from any steep slope buffer.

Oil/Water Separation

Oil/water separation must be provided in all pipe drainage systems conveying runoff from paved areas subject to vehicular use or storage of chemicals prior to discharge from the project site or into an open drainage feature. Providing oil/water separation at the project detention or water quality facility will alleviate the need for oil/water separation within the system tributary to those facilities except where needed to protect groundwater (see Sections 4.4.7 and 4.6.4).

Single-Family Residential Lots

Drainage Stub-Outs

Drainage stub-outs shall be provided for each proposed single-family residential lot served by a new roadway using a pipe system for conveyance, except for those lots where individual roof downspout infiltration systems (see Section 4.5.1) are required and certain lots where downspout dispersion systems as described below and in Section 4.5.6 are used. Stub-outs shall conform to the following:

(1) Each drainage stub-out shall be connected to the pipe system at a structure and be suitably located at the lowest elevation on the lot, so as to service all future roof downspout and driveways and yard drains. (Note: Does not preclude the connection of footing drains or other subsurface drains.) Each drainage stub-out shall have free-flowing, positive drainage to an existing or proposed structure on the pipe conveyance system or to an approved outfall location.

(2) Drainage stub-outs shall be located with a five-foot-high, 2" x 4" stake marked "storm drainage". The drainage stub-out shall extend above surface level, be visible and be secured to the stake.

(3) Pipe material shall conform to pipe materials specifications (see Section 4.3.4) and, if non-metallic, the pipe shall be buried with metal wire or other metal detection feature.

(4) Drainage easements, dedicated to the owners of lots they serve, are required for drainage stub-outs designed to convey flows through other single-family residential lots.

(5) The applicant is responsible for coordinating the locations of all drainage stub-out conveyance lines with respect to the utilities (sanitary sewer, water, power, gas, telephone, television, etc.).

(6) All drainage stub-outs shall be maintained by the owner(s) of the single-family residential lot(s) they service.

Downspout Dispersion Systems

Dispersion of roof runoff (see Section 4.5.6) is required on residential lots in new plats and short plats which are larger than 22,000 square feet. Dispersion of roof runoff is allowed on residential lots less than 22,000 square feet where the overflow can travel over at least 25 feet of vegetated area before leaving the property and does not pose a significant flooding or erosion problem. Dispersion systems shall conform to the following:

(1) at least 25 feet of vegetative cover (that is an area not classified as a steep slope as defined by the Sensitive Area Ordinance and Rules) will separate the dispersion system from a downslope property line or top of a steep slope; AND

(2) the dispersion system does not discharge to a slope greater than 40% and more than 10 feet high without the written recommendation of a geologist or geotechnical engineer; AND

(3) the downspout dispersion system shall not discharge flow over any on-site septic tank drainfield trenches.

For individual single-family residential lots that have not previously been covered under an approved drainage plan, where the lot area is under 22,000 square feet, splash blocks may be used in place of other downspout systems, provided that:

(1) a minimum of one downspout per 700 square feet of roof surface area is provided; AND

(2) sheet flow from splash blocks is directed across a minimum of 10 feet of vegetative cover within the lot boundaries before entering a designated buffer as defined by Sensitive Areas Ordinance and Rules or an adjacent property; AND

(3) discharge will not flow over any on-site septic tank drainfield; AND

(4) discharge will not create an erosion or flooding problem.

Interception of Interflow

Interflow is near-surface groundwater that moves laterally through the soil horizon following the hydraulic gradient of underlying relatively impermeable soils. When interflow is expressed on the surface it is termed a "spring" or "seepage". Any significant springs or areas of seepage, that impact a roadway or structure proposed by the project must be intercepted and directed into the conveyance system.

Drainage Easements

The conveyance systems to be maintained and operated by the King County Department of Public Works (see Section 1.2.6) on private property must be located in a drainage easement granted to King County. All other drainage facilities and conveyance systems which convey off-site or between lot flows must be located in a drainage easement dedicated to convey surface and storm water, however, the individual property owner(s) maintain the drainage facilities within these drainage easements. The legal instrument creating drainage easements on private property must contain language that requires a private property owner to obtain written approval from the SWM Division prior to removing vegetation from the drainage easement containing open, vegetated drainage facilities (such as swales, channels, ditches, ponds, etc...). See Drainage Easements in Reference 10G.

Exemption

Permits and approvals requiring drainage review will be exempt from demonstrating that a conveyance system exists or will be constructed when the BALD Division determines that the proposed development contains sufficient measures to adequately protect the downstream drainage systems; AND

The project proposes to:

- construct 5,000 square feet, or less, of new impervious surface; AND
- construct, modify, or discharge to a drainage system that collects and concentrates surface and storm water runoff from an on- or off-site drainage area of 5,000 square feet, or less.

1.2.5 CORE REQUIREMENT #5: TEMPORARY EROSION AND SEDIMENTATION CONTROL

All projects that require engineered drainage plans shall provide Temporary Erosion and Sedimentation Control (TESC) measures that minimize the transport of sediment to drainage facilities, water resources, and adjacent properties. To accomplish this goal, TESC measures shall be designed, installed, and maintained in accordance with the following minimum requirements. Details of the Best Management Practices (BMPs) that can be used to comply with the minimum requirements are in Chapter Five and are referenced below. The intent of this Core Requirement and Chapter Five is to provide enough flexibility and alternatives so that the TESC measures are appropriate to specific projects. The final decision on the appropriateness of TESC measures shall be made by the county.

Minimum Requirements

(1) Clearing Limits: Prior to any site clearing or grading, those areas that are to remain undisturbed during project construction shall be delineated (Section 5.4.1). At a minimum, clearing limits shall be installed at the edges of all sensitive area buffers.

(2) Cover Measures: Temporary and permanent cover measures shall be provided to protect disturbed areas (Section 5.4.2). Temporary cover shall be installed if an area is to remain unworked for more than seven days during the dry season (April 1 to September 30) or for more than two days during the wet season (October 1 to March 31). These time limits may be relaxed if an area poses a low risk of erosion due to soil type, slope gradient, anticipated weather conditions, or other factors. Conversely, the county may reduce these time limits if site conditions warrant greater protection or if significant precipitation is expected. Any area to remain unworked for more than 30 days shall be seeded or sodded, unless the county determines that winter weather makes vegetation establishment infeasible. During the wet season, slopes and stockpiles 3H:1V or steeper and with more than ten feet of vertical relief shall be covered if they are to remain unworked for more than 12 hours. Also during the wet season, the material necessary to cover all disturbed areas must be stockpiled on-site. The intent of these cover requirements is to have as much area as possible covered during any period of precipitation.

(3) Perimeter Protection: Perimeter protection to filter sediment from sheetwash shall be located downslope of all disturbed areas and shall be installed prior to upslope grading (Section 5.4.3). Perimeter protection includes the use of vegetated strips, as well as more conventional, constructed measures, such as silt fences. During the wet season, 50 linear feet of silt fence (and the necessary stakes) per acre of disturbed area must be stockpiled on-site.

(4) Traffic Area Stabilization: Unsurfaced entrances, roads, and parking areas used by construction traffic shall be stabilized to minimize erosion and tracking of sediment off-site (Section 5.4.4). Stabilized construction entrances shall be installed as the first step in clearing and grading. At the county's discretion, road and parking area stabilization is not required during the dry season (unless dust is a concern) or if the site is underlain by coarse-grained soils. Roads and parking areas shall be stabilized immediately after initial grading.

(5) Sediment Retention: Surface water collected from disturbed areas of the site shall be routed through a sediment pond or trap prior to release from the site (Section 5.4.5). An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (Section 5.4.3). Also, if the soils and topography are such that no off-site discharge of surface water is anticipated up to and including the developed 2-year, 24-hour design storm, sediment ponds and traps are not required. No discharge up to and including the developed 10-year, 24-hour design storm shall be required if the project size, expected timing and duration of construction, or downstream conditions warrant a

higher level of protection (see the introduction to Section 5.4.5). At the county's discretion, sites may be worked during the dry season without sediment ponds and traps if there is some other form of protection of surface waters, such as a 100-foot, forested buffer between the disturbed areas and adjacent surface waters. Protection of catch basins is required for inlets that are likely to be impacted by sediment generated by the project and that do not drain to an on-site sediment pond or trap. Sediment retention facilities shall be installed prior to grading of any contributing area.

(6) Surface Water Control: All surface water from disturbed areas shall be intercepted, conveyed to a sediment pond or trap, and discharged downslope of any disturbed areas (Section 5.4.6). An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (Section 5.4.3). Also, if the soils and topography are such that no off-site discharge of surface water is anticipated up to and including the developed 2-year, 24-hour design storm, surface water controls are not required. No discharge up to and including the 10-year, 24-hour design storm shall be required if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection (see the introduction to Section 5.4.5). At the county's discretion, sites may be worked during the dry season without surface water controls, if there is some other form of protection of surface waters, such as a 100-foot, forested buffer between the disturbed areas and adjacent surface waters. Significant sources of upslope surface water that drain onto disturbed areas shall be intercepted and conveyed to a stabilized discharge point downslope of the disturbed areas. Surface water controls shall be installed concurrently with or immediately following rough grading.

(7) Dust Control: Preventative measures to minimize the wind transport of soil shall be taken when a traffic hazard may be created or when sediment transported by wind is likely to be deposited in water resources (Section 5.4.7).

(8) Wet Season Construction: Any site with exposed soils during the wet season (October 1 to March 31) shall be subject to the special provisions in Section 5.4.8. In addition to the cover requirements in minimum requirement 2, these provisions include covering any newly seeded areas with mulch and identifying and seeding as much disturbed area as possible the first week of October in order to provide grass cover for the wet season.

(9) Construction within Sensitive Areas and Buffers: Any construction that will result in disturbed areas on or within a stream or associated buffer, a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake shall be subject to the special provisions of Section 5.4.9. These provisions include, whenever possible, phasing the project so that construction in these areas is limited to the dry season. Also, more conservative BMPs shall be considered by the design engineer in order to protect surface water quality. The county may require more conservative BMPs, including more stringent cover requirements. Any project proposing work within 50 feet of a steep slope hazard area shall evaluate the need for diverting runoff that might flow over the top of the slope.

(10) Maintenance: All TESC measures shall be maintained and reviewed on a regular basis as prescribed in the maintenance requirements for each BMP and Section 5.4.10. A TESC supervisor shall be designated by the applicant and shall be responsible for maintenance and review of TESC and for compliance with all permit conditions relating to TESC. The TESC supervisor must be available for rapid response to TESC problems. For minor projects, the applicant may serve as the TESC supervisor. The name, address, and phone number of the TESC supervisor

shall be supplied to the county prior to the start of construction. A sign shall be posted at all primary entrances to the site identifying the TESC supervisor and their phone number. The requirement for a TESC supervisor does not relieve the applicant of ultimate responsibility for the project and compliance with county code.

The site shall be reviewed by the TESC supervisor at least once a month during the dry season, weekly during the wet season, and within 24 hours of significant storms. The county can require that a written record of these reviews be kept on-site with copies submitted to DDES within 48 hours. The county can also require that the applicant designate a TESC supervisor with demonstrated experience in TESC to perform these reviews and to be responsible for TESC.

(11) Final Stabilization: Prior to obtaining final construction approval, the site shall be stabilized, the structural TESC measures, such as silt fences and sediment traps, removed, and drainage facilities cleaned (Section 5.4.11). The removal of TESC measures is not required for those projects, such as plats, that will be followed by additional construction under a different permit. In these circumstances, the need for removing or retaining the measures must be evaluated on a site-specific basis.

TESC Implementation

The first step in controlling erosion and sedimentation is the preparation of a TESC plan that includes a detailed construction sequence by the design engineer and that complies with the minimum requirements (Section 2.3.2.4). All TESC measures shall conform to the details and specifications in Chapter 5 of this manual, unless an alternative is approved by King County (Section 5.5). Large, complex projects may be required by the county to phase construction and to submit multiple TESC plans for the different stages of construction. Development of new TESC plans is not required for changes that are necessary during construction.

The second step in controlling erosion and sedimentation is to install the BMPs as per the approved TESC plan. However, the TESC plan will usually only be directly applicable to site development in the early stages of clearing and grading due to changing site conditions. The third step in controlling erosion and sedimentation is to maintain and modify the TESC measures as the site conditions change so that the site is always in compliance with the minimum requirements and Chapter Five.

TESC Performance

The TESC measures shall perform so that no sediment larger than silt (#200 sieve, 0.075 mm) leaves the site or enters on-site wetlands, streams, or lakes. "Leaves the site" shall be interpreted liberally. For example, if the standard is applied to individual lots within a subdivision, it may, depending on the site, be appropriate to apply the standard at the outlet of the drainage system rather than at the edge of the lot. If the site does not meet this standard, any measures or areas that do not comply with the minimum requirements shall be brought into compliance. If the standard is exceeded, even though the site is in compliance with the minimum requirements, the county may require additional measures. Additionally, if at any time the county determines that the existing construction site may pose a hazard to adjacent property or may adversely impact drainage facilities or water resources, even though the performance standard is being met, the county can require measures beyond those in the minimum requirements. The county can require that the TESC supervisor have a #200 sieve on-site.

It should be noted that even if the performance standard is met, the project must still be in compliance with the eleven minimum requirements. The performance standard is intended to be used to pinpoint problems, not to measure success. Most projects will be able to easily meet the performance standard if the project is in compliance with the minimum requirements.

There are some projects that may be able to meet the intent of this Core Requirement while varying from the minimum requirements. If a project is designed and constructed such that it meets the

intent of this Core Requirement, the county may determine that strict adherence to the minimum requirements is unnecessary. A variance is not required in these circumstances. Certain types of projects are particularly likely to warrant this greater level of flexibility. Road and utility projects often pose difficult erosion control challenges because they frequently cross surface waters, and narrow right-of-ways constrain areas available to treat and store sediment-laden water. Because of these factors, road and utility projects are allowed greater flexibility in meeting the intent of this core requirement (Section 5.6). Projects that, due to site conditions or project scope, pose a very low risk of erosion or sediment transport may also warrant greater flexibility. For instance, projects on relatively flat, well-drained soils, projects that are constructed in closed depressions, or projects that only disturb a small percentage of a forested site may be able to meet the intent of this requirement with very few TESC measures. More information on intent and general TESC principles to which every project shall adhere are contained in Sections 5.1 and 5.2.

Other TESC Requirements

As part of the implementation of the National Pollutant Discharge Elimination System (NPDES), projects that will disturb more than five acres of total area must apply for coverage under the Washington State Department of Ecology's Baseline General Permit for Stormwater (Section 5.7). The five acre threshold applies even if the five acres are to be disturbed in phases, as long as the construction is "part of a larger common plan of development or sale."

1.2.6 CORE REQUIREMENT #6: MAINTENANCE AND OPERATION

Maintenance and operation of all drainage facilities is the responsibility of the applicant/property owner in compliance with King County maintenance standards (see Maintenance Requirements for Privately Maintained Drainage Facilities, Appendix A), except those facilities that the King County Public Works Department is granted an easement or covenant and assumes maintenance and operation of as described below.

Facilities for Which the King County Public Works Department Assumes Maintenance and Operation Two Years After Construction Approval

The King County Public Works Department will assume maintenance and operation of drainage facilities[10] for:

(1) formal Plat Subdivisions and Planned Unit Developments except where drainage facilities are approved by King County to be maintained by approved homeowners associations; AND

(2) Short Plat Subdivisions where drainage facilities serve more than one residential lot.

King County will assume maintenance and operation of these facilities two years after final construction approval by the BALD Division and an inspection by the SWM Division to assure the facilities have been properly maintained and operating as designed.

Facilities for Which King County Public Works Department Does Not Assume Maintenance and Operation

The SWM Division may inspect these privately-maintained facilities for compliance with the Maintenance Requirements for Privately Maintained Drainage Facilities described in Appendix A. If the property owner(s) fail to maintain their facilities to the acceptable standards, the SWM Division may issue a written notice specifying the required actions. If these actions are not performed in a timely manner, the SWM Division may enter the property to perform the actions needed and bill the property owner for the cost of the actions. In the event a hazard to public safety exists, written notice may not be required.

A copy of the Maintenance and Operation Manual, submitted as part of the permit application (see Section 2.3.1), shall be retained on-site, and shall be transferred with the property to the new owner. A stainless steel plate shall be permanently attached inside the principle control structure. Engraved information on the plate shall include:

- Name and file number of project
- Name and company of 1) Developer, 2) Engineer, and 3) Contractor
- Date constructed
- Date of manual used for design
- Release rate and design storm
- Release mechanism size, type and invert elevation
- List of stage, discharge and volume at one foot increments
- Elevation of overflow

[10] NOTE: King County does not assume maintenance of lot drainage systems or drainage stub-outs serving single-family residential lot downspout, footing, or yard drains.

1.2.7 CORE REQUIREMENT #7: BONDS AND LIABILITY

All drainage facilities constructed or modified for permits requiring engineering plans must observe the bond and liability requirements of King County Code 9.04.100. There are two bonding procedures for projects constructing drainage facilities. The drainage facilities restoration and site stabilization bond and the maintenance and defect bond.

Prior to commencing construction, the person required to construct the drainage facilities pursuant to the K.C.C. 9.04,050 posts a drainage facilities restoration and site stabilization bond. This bond must be an amount sufficient to cover the cost of corrective work on or off the site performed specifically for the given project. Before King County will release the project's restoration and site stabilization bond, the applicant must:

(1) Construct the drainage system facilities and receive final construction approval from the BALD Division.

(2) Pay all required fees.

In addition, for any drainage facilities to be maintained and operated by King County Public Works Department, the applicant must:

(1) Post a maintenance and defect bond for a period of two years.

(2) Maintain the drainage facilities during the two year period following posting of the maintenance and defect bond.

Before King County will release the maintenance and defect bond and assume maintenance and operation of the facility, the applicant must:

(1) Record the final plat.

(2) Dedicate to King County, and establish boundary survey stakes for all property tracts and easements containing facilities to be maintained by King County.

(3) Receive a final inspection by the SWM Division to assure the drainage facilities have been properly maintained and are operating as designed.

(4) Correct any defects noted in the final inspection.

1.3 SPECIAL REQUIREMENTS

In addition to the seven Core Requirements, twelve Special Requirements may apply to a proposed project. Each set of requirements below is preceded by the conditions in which the requirements apply its "threshold." Most thresholds can be assessed and the special requirements determined in advance of formal engineering plan preparation. Other thresholds may require a special study before a determination can be made as to the application of a Special Requirement to a proposed project.

The twelve Special Requirements are:

(1) Critical Drainage Areas

(2) Compliance with an Existing Master Drainage Plan

(3) Conditions requiring a Master Drainage Plan

(4) Adopted Basin or Community Plans

(5) Special Water Quality Controls

(6) Coalescing plate oil/water separators

(7) Closed Depressions

(8) Use of Lakes, Wetlands or Closed Depressions for Runoff Control

(9) Delineation of the 100 year Floodplain.

(10) Flood Protection Facilities for Type 1 and Type 2 Streams

(11) Geotechnical Analysis and Report

(12) Soils Analysis and Report

1.3.1 SPECIAL REQUIREMENT #1: CRITICAL DRAINAGE AREAS

King County Code 9.04.060 provides the authority to establish critical drainage areas within which any proposed projects must comply with the special requirements.

Threshold	Requirement
IF a proposed project lies within a designated critical drainage area as indicated on Critical Drainage Area maps at the BALD Division Permit Center . . .	THEN the proposed project drainage review and engineering plans shall be prepared in accordance with the special critical drainage area requirements that have been formally adopted by public rule (see Reference Section).

1.3.2 SPECIAL REQUIREMENT #2: COMPLIANCE WITH AN EXISTING MASTER DRAINAGE PLAN

Master Drainage Plans (MDP's) are comprehensive drainage system plans which are prepared for Master Planned Developments (MPD's) or other large proposed projects as described below in Special Requirement #3. These plans require more comprehensive hydrologic, geologic, and environmental analysis than a drainage plan normally required for a smaller project.

Threshold	Requirement
IF a proposed project lies within an area covered by an approved Master Drainage Plan as listed at the BALD Division Permit Center . . .	THEN the proposed project's drainage review and engineering plans shall be prepared in accordance with any special requirements of the Master Drainage Plan.

1.3.3 SPECIAL REQUIREMENT #3: CONDITIONS REQUIRING A MASTER DRAINAGE PLAN

Threshold	Requirement
IF a proposed project: (a) is a Master Planned Development (MPD) as described in an adopted Community Plan; OR (b) is a subdivision or Planned Unit Development (PUD) that will eventually have more than 100 single-family residential lots and encompasses a contiguous drainage subbasin of more than 200 acres; OR (c) is a commercial development or Planned Unit Development (PUD) that will eventually construct more than 50 acres of impervious surface; OR (d) will clear an area of more than 500 acres within a contiguous drainage sub-basin...	THEN a Master Drainage Plan (MDP) must be prepared. Approval of the MDP is required prior to permit approval. The MDP generally shall be required to address the objectives, criteria and contain the components listed in Appendix B.

1.3.4 SPECIAL REQUIREMENT #4: ADOPTED BASIN OR COMMUNITY PLANS

King County Council adopts Basin and Community Plans to provide for the comprehensive assessment of resources and the needs to accommodate growth, while controlling adverse impacts to the environment. Following collection of hydrologic, physiographic, and land use data and analysis by computer modeling, a final Basin Plan may recommend land use, regional capital projects, and special drainage requirements for proposed projects within the area covered by the Basin Plan. Community plans may also contain some special drainage requirements through "P-Suffix" zoning designations.

Threshold	Requirement
IF a proposed project lies within an area with an adopted Basin or Community Plan as listed at the BALD Division Permit Center. . .	THEN the proposed project drainage review and engineering plans shall be prepared in conformance with the special requirements of the adopted Basin Plan or Community Plan (see Reference section).

When the adopted Basin or Community Plan does not specify requirements for drainage review and engineering plans, the requirements of this manual, the Surface Water Design Manual, shall be followed.

Some information regarding Basin and Community Plans is in Reference Sections 1A and 1B of this manual. Copies of all adopted Basin and Community Plans are available for reference at the BALD Division Permit Center.

Examples of the special drainage and engineering plan requirements which are sometimes imposed by these plans include:

(1) stream buffers wider than normally required by the Sensitive Areas Ordinance and Rules

(2) stricter flow quantity control, such as design to a different frequency storm event

(3) more extensive water quality controls

(4) groundwater recharge

(5) discharge to a constructed regional detention facility

Some special requirements mandated by Basin Plans may reduce the standard detention performance requirements, such as when on-site detention for the less frequent events (10-year or 100-year) is waived for certain subcatchments within a basin.

Variances for specific drainage requirements mandated by Basin Plans are pursued through the Design Manual variance process described in Section 1.4. Variances for development requirements specified under Community Plans through "P-Suffix" zoning designations require a zoning variance that has been reviewed by qualified staff. When a requirement is specified under both a Community Plan and a Basin Plan, only a zoning variance will be required.

1.3.5 SPECIAL REQUIREMENT #5: SPECIAL WATER QUALITY CONTROLS

Threshold	Requirement
IF any threshold discharge area[11] of the proposed project contains more than 1 acre of new impervious surface that will be subject to vehicular use or storage of chemicals and: (a) proposes direct discharge of runoff to a regional facility, receiving water, lake, wetland, or closed depression without on-site peak rate runoff control; OR (b) proposes discharge of runoff through overland flow or on-site infiltration into a Class 1 or 2 stream, or Class 1 wetland, within one mile radius downstream from the project site.	THEN the threshold discharge area[11] shall have a wetpond meeting the standards described below employed (in addition to peak rate control requirements) to treat a project's runoff prior to discharge from the site. A wetvault or water quality swale, as described below, may be used when a wetpond is not feasible because of physical site constraints or impacts to sensitive areas.

Wetponds or Wetvault

Wetponds and Wetvaults contain a permanent pool of water depending on the frequency and quantity of inflow, and (for Wetponds) the rate of permeability of the underlying soil. The Wetponds and Wetvaults fill with the initial onset of frequent storms such that the major portion of the volume of runoff is treated. The principal mechanism of treatment is settlement due to establishment of calm conditions. In Wetponds treatment is enhanced by the mechanisms of biofiltration and biologic activity.

The size (water surface area and volume) of the Wetpond or Wetvaults shall be determined as follows:

(1) The design water surface area in the Wetpond or Wetvault shall be a minimum of one percent of the impervious surface area in the drainage sub-basin contributing to the facility.

(2) The design volume of the Wetpond or Wetvault shall be a minimum of the total volume of runoff (see Chapter 3: Hydrologic Analysis) from the tributary sub-basin proposed developed conditions using a water quality design storm event having a total precipitation (Pt-wq), where Pt-wq is one-third of the two-year, 24-hour total precipitation ($P_2/3$, P_2 is obtained from Figure 3.5.1C). This water quality design storm event approximates the runoff from the mean annual storm event.

Other design criteria are found in Section 4.6.2.

[11] A threshold discharge area is an on-site area which drains to a single natural discharge location or multiple natural discharge locations that combine within 1/4-mile downstream.

Water Quality Swale

Water Quality Swales treat runoff by acting as filters for the runoff from frequent storms. The principal mechanism of treatment is slowing of particles to which pollutants are attached allowing them to settle out. This treatment is enhanced by the "taking-up" of the dissolved fraction of pollutants by the vegetation.

The Water Quality Swale shall be designed based on the following criteria:

(1) The Water Quality Swale width and profile must be designed to convey the peak runoff for the 2-year, 24-hour design storm event for the tributary sub-basin proposed developed conditions at a maximum design depth of 0.25 foot and maximum design velocity of 1.5 foot per second, designed using a Mannings "n" value of 0.35, having minimum of 3:1 side slopes, and providing a minimum of one foot of freeboard above the design water surface.

(2) Above the peak runoff for the 2-year, 24-hour duration design storm event for the proposed developed conditions, runoff must bypass the Water Quality Swale in a separate conveyance to the point of discharge. A mechanism must be provided at the bypass point to allow the water quality swale to be manually taken "off-line" for maintenance and repair.

(3) The design length of the Water Quality Swale shall be 200 feet for each 5 acres of impervious surface subject to vehicular use or storage of chemicals in the tributary drainage sub-basin.

Hydraulic analysis and design standards for Wetponds and Wetvaults, and Water Quality Swales can be found in Section 4.6 of Chapter 4: Hydraulic Analysis and Design.

1.3.6 SPECIAL REQUIREMENT #6: COALESCING PLATE OIL/WATER SEPARATORS

Threshold	Requirement
IF a proposed project will construct more than 5 acres of impervious surface in any threshold discharge area[12] that will be subject to: (a) petroleum storage or transfer; OR (b) high vehicular use (more than 2,500 vehicle trips per day); OR (c) heavy equipment use, storage or maintenance...	THEN a coalescing plate, or equivalent, oil/water separator (as described below) shall be employed in the threshold discharge area[12] to treat the project's runoff prior to treatment by a wetpond, wetvault, or water quality swale, and/or discharge from the project site (including infiltration).

Coalescing plate oil/water separators consist of a bundle of plates made of fiberglass or polypropylene installed in a concrete vault. The plates are closely spaced (not less than 3/4-inch apart) and are inclined at an angle of from 45° to 60° from horizontal. These plates improve the hydraulic conditions that promote removal of oil and fine suspended sediments and assist in concentrating the pollutants for removal. Because of this enhanced removal efficiency, they require frequent inspection and maintenance to operate as designed.

The coalescing plate oil/water separator shall be designed based on the following criteria:

(1) The design flow rate for determining the quantity of runoff to be treated, and the required plate area, shall be the peak rate of runoff (Q_{wq}) from the tributary drainage sub-basin proposed developed conditions. Q_{wq} is determined using a water quality design storm event (computed using the methods described in Chapter 3: Hydrologic Analysis) having a total precipitation ($P_{t\text{-}wq}$), where $P_{t\text{-}wq}$ is one-third of the 2-year, 24-hour total precipitation ($P_2/3$, P_2 is obtained from Figure 3.5.1C). This water quality design storm event approximates the runoff from the mean annual storm event.

(2) Peak runoff in excess of Q_{wq} must bypass the coalescing plate oil/water separator vault. A mechanism must be provided at the bypass point to take the separator "off-line".

(3) Coalescing plate oil/water separators shall treat runoff prior to discharge to special water quality control and/or peak rate runoff control facilities.

Hydraulic analysis and design standards for coalescing plate oil/water separators are described in Section 4.6.4.

[12] See Definition Section.

1.3.7 SPECIAL REQUIREMENT #7: CLOSED DEPRESSIONS

Closed depressions are low-lying areas which have no, or such a limited, surface outlet that in most storm events the area acts as a retention basin, holding water for infiltration into the ground or evaporation into the air. By their nature many closed depressions may contain wetlands which will require projects to meet the requirements of the Sensitive Areas Ordinance and Rules.

Threshold	Requirement
IF a proposed project will discharge runoff to an existing closed depression that has greater than 5,000 square feet of water surface area at overflow elevation. . .	THEN the project must meet the requirements below:

(1) when a closed depression is contained solely on a project site, the ponded volume of rainfall previously contained by the closed depression for the 100-year, 24-hour duration or the 100-year, 7-day duration design storm events, whichever is greater must be retained in dead storage on-site; AND

(2) the volume of runoff from the proposed project to any off-site closed depression must not increase, for the 2-, 10-, and 100-year, 24-hour duration, and the 100-year, 7-day duration design storm events, except as allowed under the conditions of Special Requirement #8: Use of Lakes, Wetlands or Closed Depressions for Peak Rate Runoff Control.

On-site infiltration and retention are the two potential mechanisms that may assist in satisfying these requirements. Section 3.6 provides additional discussion on how to apply the hydrologic analysis to meet these requirements. Section 4.5 contains the analysis and design of infiltration systems.

Potential overflow routes shall be analyzed to address potential adverse impacts per Core Requirement #2: Off-Site Analysis in Section 1.2.2.

1.3.8 SPECIAL REQUIREMENT #8: USE OF LAKES, WETLANDS OR CLOSED DEPRESSIONS FOR PEAK RATE RUNOFF CONTROL

Threshold	Requirement
IF a project proposes to:	THEN the project must:
(a) use a lake, wetland or closed depression for peak rate runoff control consistent with Core Requirement #3: Runoff Control; OR	(a) meet all requirements of the Sensitive Areas Ordinance and Rules for such use;
(b) use a lake, wetland, or closed depression to receive a direct discharge consistent with an exemption from Core Requirement #3: Runoff Control; OR	(b) include water quality controls consistent with Special Requirement #5: Special Water Quality Controls; AND
(c) increase the volume of runoff to an off-site closed depression . . .	(c) observe limits on any increases to the floodplain as described below.

Sensitive Areas Ordinance

As lakes and wetlands are sensitive areas by definition, the rules contained in the Sensitive Areas Ordinance and Rules must be met, even if the particular water body was not included in the County Wetlands Inventory. Note: review under the Sensitive Areas Ordinance may result in precluding the use of a lake, wetland or closed depression as a retention/detention facility in many cases.

Water Quality Controls

The controls specified under Special Requirement #5: Special Water Quality Controls in Section 1.3.5 must be met if the proposed project will construct more than one (1) acre of impervious surface that will be subject to vehicular use or storage of chemicals.

Floodplain

The increased volume of runoff from the proposed project, (and the increased volume of runoff from the equivalent area[13] developed to the full zoning potential)) may not increase the 100-year floodplain elevation of a lake, wetland, or closed depression more than 0.01 feet unless:

(1) The lake, wetland, or closed depression is contained totally on the proposed project site; AND

(2) There are no existing flooding problems; AND

(3) The outlet control will be modified so that the peak rates of outflow from the lake, wetland, or closed depression with construction of the proposed project will not increase for the 2-, 10-, or 100-year, 24-hour or 100-year, seven-day duration design storms, and to allow adjustment for future control of the entire tributary basin for full build-out developed runoff conditions (based on current zoning or community plan, whichever is the higher density use); AND

[13] The equivalent area is the area tributary to the receiving water body equal to or less than the shortest, straight line distance from the discharge point from the receiving water body (or regional facility) to the furthermost point of the proposed development.

(4) The applicant has secured drainage easements from all of the property owners abutting the lake, wetland, or closed depression for the change in the floodplain on their property and for access to the control structure; AND

(5) All other permits required for such outlet control changes (such as a King County Shorelines permit and several of those from the other agencies listed in the beginning of this chapter) for such outlet control changes have been secured.

1.3.9 SPECIAL REQUIREMENT #9: DELINEATION OF 100 YEAR FLOODPLAIN

Threshold	Requirement
IF a proposed project contains or abuts a stream, lake, wetland or closed depression, or if other King County regulations require study of flood hazards. . .	THEN the 100 year floodplain boundaries (and floodway, if available, or if development is proposed within the 100 year floodplain), based on an approved flood hazard study as described below, shall be delineated on the site improvement plans and profiles, and on any final subdivision maps prepared for the proposed project.

Approved Flood Hazard Study

If an approved flood hazard study exists, then it may be used as basis for delineating the floodplain and floodway boundaries provided it was prepared in a manner consistent with this Manual and other King County flood hazard regulations. If an approved flood hazard study does not exist then one shall be prepared based on the requirements described in section 4.3.8.

1.3.10 SPECIAL REQUIREMENT #10: FLOOD PROTECTION FACILITIES FOR TYPE 1 AND 2 STREAMS

Threshold	Requirement
IF a proposed project contains or abuts a Class 1 or 2 stream that has an existing flood protection facility (such as levees, revetment and berms), OR proposes to construct a new, or modify an existing, flood protection facility....	THEN the flood protection facilities shall be analyzed and/or designed as described below and to demonstrate conformance with the Federal Emergency Management Administration (FEMA) regulations (44 CFR).

Minimum Analysis and Report

The analysis and report shall at a minimum include the following:

Conduct a field reconnaissance survey of the existing and/or proposed flood protection facilities area. Prepare a map locating and characterizing any existing flood protection facilities and the surrounding area. Such features as type and extent of existing soils, depositional materials, and evidence of erosion including scour, slumping and undercutting shall be noted. Obtain subsurface soil data (if necessary) to perform the geotechnical analysis.

Prepare a report which describes the existing geotechnical conditions and recommends design criteria and analytical approaches for design of the flood protection facilities. The analysis shall evaluate the stability of the existing and/or proposed flood protection facilities to determine factors of safety against liquefaction induced by earthquakes and embankment failure due to piping or rapid drawdown of the stream.

In addition, the flood protection facilities shall be analyzed and/or designed in conformance with published Army Corps of Engineers standards.

Access

If not currently established, the property owner shall grant a 30 foot wide Flood Protection Facility Easement to King County from the top of bank (defined as the point of stability under existing or proposed conditions) or the sensitive area buffer boundary (defined by the Sensitive Areas Ordinance and Rules), whichever is further, landward along the full frontage of the flood protection facilities, and construct a 15 foot wide access road (surfaced in conformance with the access road standards as described in section 4.4.4) within and along the landward edge of the Flood Protection Facility Easement. The access road shall be accessible for vehicular access from at least one point, through an easement granted to King County. This easement can be on the proposed project site or may be from connection to an existing, fully accessible access road on an adjacent site fronting the stream.

1.3.11 SPECIAL REQUIREMENT #11: GEOTECHNICAL ANALYSIS AND REPORT

Threshold	Requirement
IF a project proposes to construct: (1) a pond or an infiltration system (excluding roof downspout or dispersion system): (a) within 200 feet from the top of a steep slope, OR (b) on a slope with a gradient steeper than 15 percent; OR (c) using a berm higher than 6 feet. (2) or modify existing flood protection facilities . . .	THEN a geotechnical analysis and report shall be prepared and stamped by a geotechnical professional civil engineer that shall address at a minimum the analysis described below.

Minimum Analysis and Report

The analysis and report shall at a minimum address the effects of groundwater interception and infiltration from the pond, infiltration system, or flood protection facilities, in particular, the expression of seepage faces on steep slope, piping around outfall systems, lubrication of potential slip planes and changes in soil bearing strength due to saturation and liquefaction. These potential adverse impacts shall be examined assuming normal and rare conditions, such as should the emergency overflow system be used during a 100-year, 24-hour duration design storm event due to plugged outlet pipe. In addition, adverse impacts from the construction of the proposed facility shall be addressed.

Based on the results of these analyses, an analysis evaluating the probability and consequences of failure shall be performed for the facility and the down slope areas that would be impacted as the result of pond overflow and/or slope failure.

1.3.12 SPECIAL REQUIREMENT #12: SOILS ANALYSIS AND REPORT

Threshold	Requirement
IF the soils underlying a proposed project have not been mapped, or if the existing soils maps are in error or not of sufficient resolution to allow the proper engineering analysis of the proposed site to be performed . . .	THEN a soils analysis and report shall be prepared and stamped by a professional civil engineer with expertise in soils to verify and/or map the underlying soils by addressing the minimum as described below.

Minimum Analysis and Report

The soils analysis and report shall, at a minimum, characterize and classify the underlying soils based on the SCS Classification system and soil texture method, identify any impacted areas containing expressions of groundwater interflow, and describe any special characteristics of the underlying soils that should be addressed by the proposed project. These special characteristics shall include, but not be limited to: load-bearing capacity; suitability for use as general site fill, roadway, and pond embankment materials; erodibility during construction; and the ability to support vegetation for stabilization.

1.4 VARIANCE PROCESS

This variance process is provided for the necessary occasions on which a proposed project justifies varying from one of the core or special requirements, or any other specific requirement or standard contained in the manual. Proposed variances should be approved prior to final permit approval.

The following types of variances[1] are provided to give flexibility to the process and encourage innovation:

Standard Variances: These are variances from the following design manual chapters and sections:

- Chapter 2, Plan Review Procedures (all sections)
- Chapter 4, Hydraulic Analysis and Design (Sections 4.1 through 4.5)
- Chapter 5, Temporary Erosion and Sedimentation Control Standards (all sections)

Complex Variances: These are variances from the design manual chapters and sections listed below. Complex variances typically require more in-depth review because they frequently deal with requirements that affect basic county policies or other agencies.

- Chapter 1, Summary and Guide To All Requirements (All Sections)
- Chapter 3, Hydrologic Analysis (All Sections)
- Chapter 4, Hydraulic Analysis and Design (Section 4.6)
- Appendix A, Maintenance Requirements for Privately Maintained Drainage Facilities
- Appendix B, Master Drainage Plan Objective, Criteria Components and Review Process

Preapplication Variances: This type of variance may be requested when the applicant needs a variance decision to determine whether a project is feasible, or if the results are needed to determine whether a project is viable before funding a full application. The approval of preapplication variances is tied by condition to the project proposal presented at a preapplication meeting with DDES.

Experimental Design Variances: This type of variance is used for proposing new designs or methods different from those in the manual, that are not uniquely site-specific, and where data sufficient to establish functional equivalence do not exist.

Blanket Variances: This type of variance may be established by the county based on approval of any of the above-mentioned variances that can be applied globally to design requirements independent of site conditions and can be applied routinely. Blanket variances are used to effect minor changes or corrections to manual design requirements or to add new designs and methodologies to the manual.

1.4.1 VARIANCE AUTHORITY

The Department of Development and Environmental Services (DDES) shall have full authority to determine if and what type of variance is required for any project proposal subject to drainage review. The authority to grant variances is distributed as follows:

- DDES shall have full authority to approve or deny standard, complex, and preapplication variances.

[1]Additional information on the above variances and the variance process can be found in Reference Sections 10I, 11A, and 11B.

- The SWM Division shall have full authority to approve or deny experimental design variances.
- Both DDES and the SWM Division must approve blanket variances.

At any time, variance authority may be transferred between DDES and the SWM Division through a memorandum or an amendment to the manual. This memorandum or amendment will include specific guidelines for deferral of variance authority. For information on specific deferrals of variance authority now in effect, see Reference Section 11B, Interim Changes to Requirements: Administrative Changes.

1.4.2 CRITERIA FOR GRANTING VARIANCES

Variances from the requirements described in this manual may be granted provided that granting the variance will:

- produce a compensating or comparable result that is in the public interest; AND
- meet the objectives of safety, function, appearance, environmental protection, and maintainability based on sound engineering judgment.

Where it has been demonstrated that meeting the criteria for producing a compensating or comparable result will deny reasonable use of a property, the applicant shall produce the best practicable alternative as determined by the director of DDES. The director or his/her designee shall assess the case to affirm that denial of reasonable use would occur and require a best practicable alternative that best achieves the spirit and intent of the requirement. DDES staff shall provide recommendation to the director on the best practicable alternative to be required.

Granting any variance that would be in conflict with the requirements of any other department will require review and concurrence with that department.

Special Criteria for Experimental Water Quality Facilities

Experimental design variances that request the use of experimental water quality facilities will be approved by SWM on a limited basis if, upon evaluation, SWM agrees that the following criteria are met:

- The new design is likely to meet the identified target pollutant removal goal based on limited data and theoretical considerations;
- Construction of the facility can, in practice, be successfully carried out;
- Maintenance considerations are included in the design, and costs are not excessive or are borne and reliably performed by the applicant or the property owner; and
- A share of the cost of monitoring to determine facility performance is contributed by the applicant or property owner.

Conditions for approval for these variances may include a requirement for setting aside an extra area and bonding for construction of a conventional facility should the experimental facility fail. Once satisfactory operation of the experimental facility is verified, the set aside area could be developed and the bond released.

1.4.3 VARIANCE REQUEST APPLICATION PROCESS

Standard and Complex Variances

- Proposed variances should be approved prior to final permit approval.

- The completed variance request application forms must be submitted to DDES, along with sufficient engineering information (described in Chapter 2), in order for the request to be evaluated. The application shall note the specific requirement from which the variance is sought. A sample variance request application is provided at the end of this section.

- If the variance request involves the use of a previously unapproved construction material or construction practice, the applicant should submit documentation that includes, but is not limited to, a record of successful use by other agencies and/or evidence of meeting criteria for quality and performance such as that for the American Association of State Highway and Transportation Officials (AASHTO) and the American Society of Testing and Materials (ASTM).

- A fee reduction may be requested if it is demonstrated that the variance request requires little or no engineering review. See Reference Section 10I: Fee Reduction for more details.

Preapplication Variances

The application process is the same as for standard and complex variances, except that requests will be accepted prior to permit application, and then only if:

- the applicant provides justification at a preapplication meeting with DDES that a variance decision is needed to determine the viability of the proposed project, AND

- sufficient engineering information to evaluate the request is provided.

Experimental Design Variances

The application process is the same as for standard and complex variances, except that requests will be accepted prior to permit application.

1.4.4 VARIANCE REQUEST REVIEW PROCESS

Standard and Complex Variances

- DDES staff will review the variance request application forms and documentation for completeness and inform the applicant in writing within 15 working days as to whether additional information is required from the applicant in order to complete the review. The applicant will also be informed if DDES has determined that special technical support is required from the SWM Division in cases where the variance involves a major policy issue or potentially impacts a SWM drainage facility.

- The SWM Division will respond to requests for technical support from DDES within 15 working days following receipt of all necessary information from the applicant.

- The Land Use Services Division Manager/designee or Building Services Division Manager/designee of DDES will review and either approve or deny the variance request in writing within 15 working days following receipt of all necessary information from the applicant. This may be extended to 30 working days if SWM technical support is deemed necessary.

- Approvals of standard and complex variances will expire upon expiration of the permit to which they apply.

Preapplication Variances

The review process is the same as standard and complex variances, except that approvals will expire one year after the approval date, unless a complete permit application is submitted and accepted.

Experimental Design Variances

- DDES staff will refer requests for experimental design variances to SWM Division staff along with recommendations, if any, within 15 working days of submittal.
- Upon receipt of the request from DDES, SWM staff will review the submitted material and any DDES staff recommendations, and inform the applicant within 15 working days as to whether additional information is required in order to complete the review. The applicant will also be informed as to how much time is estimated by SWM to complete its review.
- The SWM division manager will review and either approve or deny the variance request in writing.

1.4.5 APPEAL PROCEDURE

The applicant may appeal the denial of a variance request or appeal the variance decision by submitting a formal letter, within 15 working days of the decision, to the director of the department in which the decision was made. This letter must include justification for review of the decision along with a copy of the variance request with the conditions (if applicable) and a listing of all previously submitted material. The department director or designee shall respond to the applicant in writing within 15 working days. The decision shall be final.

1.4.6 BLANKET VARIANCES

Blanket variances will each be established by memorandum between DDES and SWM based on:

- a previously approved standard, complex, preapplication, or experimental design variance and supporting documentation, AND
- information presenting the need for the blanket variance. Typically, blanket variances should apply globally to design or procedural requirements and be independent of site conditions.

Both DDES and SWM must approve a blanket variance (see Reference Section 11A, Interim Changes to Requirements: Blanket Variances.)

King County
Dept. of Development and Environmental Services
Land Use Services Division
3600 136th Place Southeast
Bellevue, Washington 98006-1400

SURFACE WATER DESIGN MANUAL REQUIREMENTS / STANDARDS VARIANCE REQUEST

Project Name:	DDES File No. DDES Engineer/Planner Name:
Project Address:	Design Engineer: Phone:
Applicant: Phone:	Signature: Date:
Signature: Date:	Engineering Firm Name:
Address: City, State, Zip Code:	Address: City, State, Zip Code:

INSTRUCTIONS TO APPLICANT/DESIGN ENGINEER:

Please be sure to include all plans, sketches, photos and maps which may assist in complete review and consideration of this variance request. Failure to provide all pertinent information may result in delayed processing or denial of your request. Please submit this request and applicable fee to the Intake Counter, at Eastpointe Plaza Building, 3600 - 136th Place Southeast, Bellevue, WA 98006-1400. For additional information, phone 296-6600.

REFER TO SECTION 1.4 IN CHAPTER 1 OF THE SURFACE WATER DESIGN MANUAL FOR VARIANCES

DESCRIPTION OF VARIANCE REQUEST: ☐ Standard ☐ Complex ☐ Experimental ☐ Blanket ☐ Pre-application

APPLICABLE SECTION(S) OF STANDARDS:

JUSTIFICATION (see attachments, pages ____ to ____):

AUTHORIZATION SIGNATURES:

DDES Director/Designee Determination:

☐ Approval ☐ Conditional Approval (see below) ☐ Denial

☐ SWM Approval Signed:_____ Date:_____ (Experimental & Blanket variances only)

CONDITIONS OF APPROVAL:

☐ See attached Memo Dated: _____

DDES, Land Use Services Division, Engineering Review Supervisor:	DDES, Bldg. Serv. Div., Site Engineering & Planning Supervisor:
Signed: Date:	Signed: Date:

ORIGINAL: DDES File-white [ ] COPIES TO: SWM Division-Pink [ ] DDES Inspection-Canary [ ] Applicant-Goldenrod [ ] Design Engineer-Green [ ]

CHAPTER 2
PLAN REVIEW PROCEDURES

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

CHAPTER 2
PLAN REVIEW PROCEDURES

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

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Section 2.3.2 Site Improvement Plans

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CHAPTER 2
PLAN REVIEW PROCEDURES

This chapter details the required procedures for the submittal of the drainage aspects of engineering plans as part of a permit application to the King County Building and Land Development (BALD) Division. Taking care that your plans comply with these formats and plan specifications will facilitate review and approval, with a minimum of time-consuming corrections and resubmittals.

The intent of these procedures is to present consistent formats for the engineering plans and the technical support data required to develop the plans. These conventions are necessary to review engineering plan designs for compliance with King County ordinances and regulations and that the intent of the plan is easily understood and implemented in the field. Properly drafted engineering plans and supporting information will also facilitate the construction, operation and maintenance of the proposed system long after its review and approval.

Please note that this chapter primarily describes how to submit drainage plans for review - what must be submitted, in what formats, at what times, to what offices. The design requirements that these plans must address are contained in Chapter 1 "Summary and Guide to All Requirements." The specific design methods and standards to be used are contained in Chapters 3, 4 and 5.

Several key forms used in the Plan review process are reproduced in Reference Section 10, "Plan Review Procedures Forms and Worksheets". The review process and submittal requirements for different types of development are contained in the Reference Section with the exception of Master Drainage Plans which are contained in Appendix B. For detailed information on specific requirements on any permit type, and the appropriate submittal location, please refer to the Development Assistance Bulletins prepared by BALD for this purpose.

2.1 BUILDING AND LAND DEVELOPMENT DIVISION REVIEW PROCESS

The BALD Division is responsible for the review of all engineering aspects on private development proposals. Drainage review is a primary concern of engineering design. This section outlines the processes involved in submitting engineering plans to the BALD Division. Details on the review process and how it varies with the type of development permit are presented in the Reference Section.

Submittals - The initial submittal of any type of permit application shall include:

(1) documentation on how the Core and Special Requirements apply to the project; AND

(2) a downstream analysis (Core Requirement #2: Off-Site Analysis); AND

(3) an environmental checklist; AND

(4) additional requirements specific to the permit type.

All preliminary and engineering plans and specifications must be stamped by a professional civil engineer registered in the State of Washington. All reproductions of site improvement plans and the cover page of copies of the Technical Information Report submitted must be signed and dated by the professional civil engineer approving the design.

All land boundary surveys used, and legal descriptions prepared, for preparing preliminary and engineering plans must be stamped by a professional land surveyor registered in the State of Washington. Topographic survey data and mapping prepared specifically for a proposed project may be performed by the professional civil engineer stamping the engineering plans as allowed by the Washington State Board of Registration for Professional Engineers and Land Surveyors.

2.1.1 PRELIMINARY PLANS SUBMITTAL

Preliminary plans are submitted as part of the initial application. The supporting documents specified in Section 2.2.1 must accompany the preliminary plans.

Preliminary plans are not required for certain permits. For these permits the initial submittal to the BALD Division is a set of engineering plans. See the Reference Section for the current permit application process. The BALD Division may also require a conceptual drainage design to address any drainage concerns (such as wetlands, steep slopes, floodplains, etc.) identified on the plan or through site visits. The components of this design will vary from project to project, but always will consist of elements of the Technical Information Report, such as "Project Overview", "Off-site Analysis", "Conveyance System Analysis and Design", etc., described in Section 2.2.

2.1.2 ENGINEERING PLANS SUBMITTAL

An engineering plan will be required if:

- a hydrologic, geotechnical, or soils analysis is required; OR
- new drainage facilities must be constructed, or existing drainage facilities modified; OR
- site restrictions (such as building setback lines, floodplain limits and drainage easements) are required.

The drainage portion of engineering plans shall consist of:

- a Technical Information Report (TIR) (specified in Section 2.3.1), AND
- a set of Site Improvement Plans (specified in Section 2.3.2)

Exemption: Less stringent requirements apply to certain individual Residential Building Permits and to Short Plats, as described in Section 2.3.

Refer to the Development Assistance Bulletins and the Reference Section for specific details on requirements, such as the submittal and expiration periods set for each type of permit application and the applicable review fees.

Prior to plan approval, the BALD Division will make a set of reproducible mylars, cost to be paid by the applicant, and return the original set to the applicant's engineer. The BALD Division will retain this reproducible, utilizing it to make copies for public inspection, distribution and base reference as required. At the time the development is accepted for maintenance by King County, the BALD Division set of reproducibles shall be replaced by the corrected original set for permanent public records at the Department of Public Works map counter, 9th floor, King County Administration Building.

2.1.3 PLAN CHANGES AND REVISIONS AFTER PERMIT ISSUANCE

If changes or revisions to the originally approved plans require additional review, the revised plans shall be submitted to the BALD Division for approval prior to construction. The plan change submittals shall be accompanied by:

- the appropriate Plan Change Order form(s)
- one copy of the revised TIR
- three sets of the engineering plans

Plan changes and revisions shall be prepared, reviewed and processed as described in the Reference Section for engineering plan submittals.

2.1.4 FINAL CORRECTED PLAN SUBMITTAL

During the course of construction, changes to the approved plan are often required to address unforeseen field conditions or plan design improvements.. Once construction is completed, it is the applicants responsibility to submit to the BALD Division a "Final Corrected Plan" which is an engineering drawing that accurately represents the project as constructed. These corrected drawings must be professionally drafted revisions applied to the original approved plan and include all changes made during the course of construction, except that the erosion/sedimentation control plan should not be included. The final corrected plan must be stamped, signed and dated by a civil engineer registered in the State of Washington.

2.1.5 FINAL RECORDING SUBMITTAL

Any Subdivision or Planned Unit Development to be "finaled", thereby completing the subdivisions process and legally forming the new lots, requires a final plat submittal for approval and recording. Any Binding Site Plans also require a final submittal for approval and recording. The final plat or map page, shall contain the elements summarized in Section 2.4 and specified in detail in Development Assistance bulletins published by the BALD Division. Submittals shall be accompanied with appropriate fees as prescribed by ordinance.

Final submittals shall be allowed only after the approval of preliminary plans and any required engineering plans and after the construction of any required drainage facilities.

All final plat map sheets and pages shall be prepared by a professional land surveyor registered in the State of Washington and shall conform with all state and local statutes. Details on final submittals and recording are presented in the Reference Section.

2.2 PRELIMINARY PLANS SPECIFICATIONS

2.2.1 SUBDIVISIONS, MASTER PLANNED DEVELOPMENTS AND PLANNED UNIT DEVELOPMENTS

Applications for preliminary approval on **Subdivisions, Master Planned Developments and Planned Unit Developments** must include the following plans and supporting documents.

Plans

- o Sheet size: 24" X 36"
- o Name of proposed subdivision - limit of 32 letters.
- o Title block
- o North arrow indicator (north at top or left side of sheet)
- o Scale indicated
- o Section, Township and Range indicated
- o Legal description shown and verified - typed or printed
- o Surveyor's signature and seal shown
- o Topography
  - Field topographic base map to accompany application
  - Verification of field survey
  - Notation for field or aerial survey
  - Datum
  - Location of all sensitive areas (include King County designation number or identify as undesignated)

The following chart should be used to determine the topography requirements:

Zoning Designation	Contour Intervals	Sensitive Area Designation
Densities of developed area of over 2 DU per Acre	2' @ less than 15% slope 5' @ 15% slope or more	Field verify location of all indicated sensitive areas on map
Densities of developed area of 2 DU or less per acre	5' intervals	Field verify location of all indicated sensitive areas on map

- o Show all structures within 200 feet of the plat boundaries in unplatted areas
- o Show all street names or numbers
- o Show all utility purveyors
- o Show all land use information
- o Dimension all lots
- o Note all adjoining parcels within 500 feet.
- o Provide vicinity map to clearly locate the subdivision
- o Note all known Sensitive Areas
- o Identify all density calculations
  - Total area
  - Right-of-Way
  - Non-Useable open space
  - Total lot area
  - Open space for lot make up area
  - Allowable number of lots
- o Name, address and phone number of land surveyor, developer and owner
- o Proposed use (i.e. townhouse via PUD, single family, etc.)
- o Boundary lines of all land use zones
- o Sight distance for entry to all County roads.
- o Typical section for lot layout or clustering design
- o Identify areas of substantial grading outside of propose rights-of-ways (this relates to lot yield and steep slopes)
- o Show all Sensitive Areas as defined by the King County Sensitive Areas folio (must also include any previously undesignated sensitive areas). Note that field verification of all indicated sensitive areas on the map must be noted on plat mat.

Supporting Documents

- o Application Form
- o Legal description (1 copy, typed, 8-1/2" x 11" with parcel numbers for the subject property)
- o Environmental Checklist (17 copies)
- o Preliminary Plat Map (32 copies - Note; fold so that plat name is on outside sheet).
- o Environmental Impact Statement (if required)
- o Water Availability Letter
- o Sewer Availability Letter;
  - Is project within the "Local Service Area" (LSA).
  - Sewer Availability Letter for sewers (if served by Public Sewers, a Health Dept. letter is not necessary).
  - Health Dept. approval for septics (needed when septic system will be used to treat sanitary waste.)
- o Fees - reference current fee ordinance
- o Supplemental Information
  - Photos
  - Reports
  - Petitions
- o Proof of legal lot

- o Assessor's Maps - (Property in red with 500' strip around the boundary - for parcels owned by the applicant)
- o Traffic Impacts
- o Drainage Downstream Analysis

Supplemental information will also be required if the development impacts sensitive areas, or will cause traffic or other problems. The extent of the supplemental information which will be required can be estimated at the initial application screening, but not determined definitively until as late as the SEPA Threshold Determination.

2.2.2 SHORT PLATS

Application for **Short Plats** must include the following Plot Plan and Health Department Approval Map.

Plot Plan

Applications for Short Plats must include a Proposed Short Plat drawing submitted on a 8-1/2 x 14" form provided by BALD. The drawing shall include the following minimum information:

- o Short Plat application number
- o North arrow (use circle indicator at top upper left of page)
- o Name of person preparing drawing
- o Vicinity map to clearly locate property
- o Boundary lines and lot layout
- o Lot dimensions
- o Structures and driveway locations
- o Scale
- o Street or road frontage and names
- o Sight distances for all entries onto county roads.
- o Terrain features (e.g. steep slopes, top of bank, wetlands, creek centerline)
- o Easement's, recorded and proposed

Health Department Approval Map

Each application shall also include the Health Department Approval Map showing the locations of test holes and drainfield areas when not on sanitary sewers. Additional submittal requirements (such as legal description, proof of legal lot, etc.) may be found in the Development Assistance Bulletin provided by BALD.

2.3 ENGINEERING PLANS SPECIFICATIONS

Specifications for full engineering plans--a Technical Information Report and Site Improvement Plans--are described in Sections 2.3.1 and 2.3.2. Some individual Residential Building Permits and Short Plats, will, however; require preparation of less than the full engineering plans or no engineering plans at all.

Modified Engineering Plan Allowed

In most cases, a Modified Engineering Plan will be allowed for individual Residential Building Permits not requiring major drainage improvements. Such items as detention facilities (except downspout roof drain infiltration systems), conveyance systems for off-site drainage, bridges, or right of way improvements are considered major improvements which will require a full engineering plan. The Modified Site Improvement Plan will apply to those permit applications only proposing infiltration systems or driveway culverts.

Residential building permits on lots with constructed drainage facilities, or approved drainage plans for the lot, will not require a Modified Engineering Plan provided the permit submittal contains a Modified Site Improvement Plan that shows the connection of proposed roof and yard drains to the existing approved and constructed drainage stub-outs, and/or other approved runoff control facilities designed for the lot during format plat engineering plan review, and the BALD Division determines that these measures are adequate to protect the downstream drainage system.

The Modified Site Improvement Plans:

- shall be drawn on a 11" X 17" or larger sheet.
- accurately locate the structure and its access, showing observance of the setback requirements given in this manual and in the Sensitive Areas Ordinance.

Some portions of Technical Information Report may still be required, however, even when the Modified Engineering Plan is allowed. More specific requirements for the contents of a Modified Engineering Plan depend on the project and can only be determined after the initial permit application.

No Engineering Plan Required

Short Plat applications (1) which set aside all drainage features and sensitive areas in easements or tracts, (2) for which no alteration or construction of a drainage system is required or proposed, and (3) for which engineering plans for roadway construction are not a condition of preliminary approval require no engineering plans, but instead may submit the drainage information on a final Short Plat map page. This map page shall meet the specifications of Section 2.4.2

All other applications will require full engineering plans.

2.3.1 TECHNICAL INFORMATION REPORT

The full Technical Information Report (TIR) shall contain the following eleven sections, preceded by a table of contents:

Table of Contents

I. Project Overview
II. Preliminary Conditions Summary
III. Off-Site Analysis
IV. Retention/Detention Analysis and Design
V. Conveyance Systems Analysis and Design
VI. Special Reports and Studies
VII. Basin and Community Planning Areas
VIII. Other Permits
IX. Erosion/Sedimentation Control Design
X. Bond Quantities Worksheet, Retention/Detention Facility Summary Sheet and Sketch, and Declaration of Covenant
XI. Maintenance and Operations Manual

The TIR should be a comprehensive supplemental report containing all technical information and analysis necessary to develop the Site Improvement Plan. This report should contain all

calculations, conceptual design analysis, reports and studies required and used to construct a complete Site Improvement Plan based on sound engineering practices and careful geotechnical and hydrological design.

The Technical Information Report must be stamped and dated by a professional civil engineer registered in the State of Washington. Every TIR must contain each of these sections; however, if a section does not apply, the applicant may simply mark with "N/A." This standardized format will allow a quicker, and more efficient review of information required to supplement the Site Improvement Plan. A consistent format will also provide accurate and time efficient researching of TIR's approved for other projects in the same basin.

When the TIR package requires revisions, the revisions must be submitted in a complete TIR package.

The table of contents should include a list of the eleven section headings and their respective page numbers, a list of tables with page numbers and a list of numbered references, attachments and appendices.

TIR SECTION I. PROJECT OVERVIEW

The project overview shall identify and discuss difficult site parameters and the natural drainage system functions. The overview should also describe the drainage to or from adjacent property, including bypass flows.

The project overview must provide a general description of what is being proposed to be constructed on the site, the predeveloped and post developed conditions of the site, the area of the site, the size of the improvements, and the disposition of the storm water runoff before and after development. The following figures are required:

Figure 1. TIR Worksheet

Include a copy of the TIR Worksheet (see Reference 10B).

Figure 2. Site Location

Provide a map which shows the general location of the site. Identify all roads which border the site and significant geographic features and sensitive areas (lakes, streams, steep slopes, etc.).

TIR SECTION II. PRELIMINARY CONDITIONS SUMMARY

This section shall be included with the Site Improvement Plan for any Plats, Short Plats or Planned Unit Development. Commercial Permit applications following a Rezone, Conditional Use, Mitigated Determination of Non-Significance (MDNS), or Shoreline Permit must also contain a preliminary conditions summary. The intent of this section is to make sure all preliminary approval conditions pertaining to site engineering issues have been addressed in the Site Improvement Plan submittal. The design engineer shall review each adopted condition and provide a brief statement which explains how the design addresses or conforms to the conditions. The following figures are required:

Figure 3. Drainage Basins, Subbasins, and Site Characteristics

Show acreages of subbasins. Identify all site characteristics. Show existing discharge points to and from the site. Show existing construction and future flows at all discharge points and downstream hydraulic structures. Use a minimum USGS 1:2400 topographic map as a base for the figure. Show (and cite) the length of travel and farthest upstream end of a proposed storm system in the development to any proposed stormwater retention/detention facility.

Figure 4. Soils

Show the soils within the following areas: 1) the project site, 2) the area draining to the site, and 3) the drainage system downstream of the site for the distance of the Downstream Analysis (see Section 1.2.2). Copies of King County Soil Survey maps may be used; however if the maps do not appear to accurately represent the soils for a proposed project (including off-site areas of concern), it is the design engineer's responsibility to assure that the actual soil types that exist on the site are properly mapped. Soil classification symbols which conform to the SCS Soil Survey for King County should be used.

If a Special Soils Report is required, a figure in the Special Soils Report that meets the above requirements may be referenced to satisfy this requirement.

TIR SECTION III. OFF-SITE ANALYSIS

Any engineering plan which proposes construction of drainage facilities shall include identification of the upstream tributary areas and downstream analysis conducted in accordance with the requirements of Section 1.2.2, Chapter 1. That analysis must be included in this section.

TIR SECTION IV. RETENTION/DETENTION ANALYSIS AND DESIGN

Existing Site Hydrology (Part A)

This section should include a discussion of assumptions and site parameters used in analyzing the existing site hydrology.

The acreages, curve numbers, times of concentration and travel times used to determine existing flow characteristics, along with basin maps, graphics and exhibits for each subbasin affected by the development, should be included.

Delineation and acreages of areas contributing runoff to the site, retention/detention facility location, outfall and overflow route must be provided on a topographical map. The scale of the map and the contour intervals must be sufficient to determine the basin and subbasin boundaries accurately. The direction of flow, the acreage of areas contributing drainage, the limits of development, the length of travel and grade of the drainage course (from the furthest upstream point through the development) should all be indicated on the map.

Each subbasin contained within, or flowing through, the site should be individually labeled. The hydrograph/flow calculations for a given subbasin should be labeled identically to that subbasin (i.e., if the subbasin is "A", the hydrograph and calculation set must be labeled subbasin "A").

All natural streams and drainage features including wetlands and depressions must be shown. Rivers, closed depressions, streams, lakes and wetlands must have 100-year floodplain (and floodway where applicable) delineated as required in Chapter 1 and by the Sensitive Areas Ordinance and Rules.

Developed Site Hydrology (Part B)

Provide a narrative, mathematical and graphical presentation of parameters selected and values used for the developed site conditions, including acreages, runoff coefficients (C or CN), time of concentration (Tc), travel times (Tt), roadway layouts and all constructed drainage facilities.

Developed subbasin areas and flows should be clearly depicted on a map, referenced to computer printouts or calculation sheets with relevant areas highlighted and tabulated in a listing of all developed subbasin flows.

Include all maps, exhibits, graphics and references used to determine developed site hydrology. Maintain the same subbasin labeling as used for the existing site hydrology whenever possible. If

the boundaries of the subbasin have been modified under the developed condition, modify the labeling accordingly, (i.e. Subbasin "Am" is a modified version of existing Subbasin "A").

Hydrologic Analysis (Part C)

The design engineer shall include a brief discussion of the performance required to calculate the size of conveyance systems and retention/detention systems.

Retention/Detention System (Part D)

Provide an illustrative sketch of the retention/detention facility and its appurtenances. This sketch should show basic measurements necessary to calculate the storage volumes available from zero to the maximum head, all orifice/restrictor sizes and head relationships, and control structure/restrictor orientation to the detention facility.

Include all calculations, equations, references, storage/volume tables, graphs and any other aides necessary to clearly show results and methodology used to determine the storage facility volumes. This section of the TIR should provide a clear sequence of how the storage facility size was determined.

TIR SECTION V. CONVEYANCE SYSTEM ANALYSIS AND DESIGN

This section should present the detailed analysis of any existing conveyance systems and the analysis and design of the proposed stormwater collection and conveyance system for the development. This information should be presented in a clear, concise manner that can be easily followed, checked and verified. All pipes, culverts, catch basins, channels, swales and other stormwater conveyance appurtenances must be clearly labeled and correspond directly to the engineering plans.

The minimum information should include pipe flow tables, flow profile computation tables, nomographs, charts, graphs, detail drawings and other tabular or graphic aides used to design and confirm performance of the conveyance system.

Verification of capacity and performance must be provided for each element of the conveyance system. Show design velocities and flows for all drainage facilities within the development, as well as those off-site which are affected by the development. Figure 4.3.3C (note limitations) or equal presentation may be used to tabulate this information. If the final design results are on a computer printout, provide also a separate summary tabulation of conveyance system performance.

TIR SECTION VI. SPECIAL REPORTS AND STUDIES

Some site characteristics such as steep slopes or wetlands pose unique road and drainage design problems which are particularly sensitive to stormwater runoff. As a result, King County may require the preparation of special reports and studies which further address the site characteristics, the potential for impacts associated with the development, and the measures which would be implemented to mitigate impacts. Special reports shall be prepared by persons with expertise in the particular area of analysis. Subjects of special reports may include:

- Geotechnical/Soils
- Wetlands
- Floodplains
- Slope Protection/Stability
- Groundwater
- Fluvial Geomorphology (Erosion & Deposition)
- Anadromous Fisheries Impacts
- Structural Design
- Geology
- Hydrology
- Water Quality
- Structural Fill

TIR SECTION VII. BASIN AND COMMUNITY PLAN AREAS

If the proposed development lies within an adopted Basin (see Reference section) or Community Plan area, reference the basin or community plan and the date of publication, and identify which

sections/pages of the plan specify requirements affecting drainage system design (such as P-suffix restrictions and stricter detention performance). In addition, restrictions affecting overall site development should be listed. If an applicable "P" suffix condition specifies additional road or drainage measures or conflicts with standard conditions, then the more restrictive condition shall be applied.

TIR SECTION VIII. OTHER PERMITS

Construction of road and drainage facilities may require additional permits from other agencies for some projects. These additional permits may contain more restrictive drainage plan requirements. This section of the TIR should provide the title of any other permits, the agencies requiring the other permits, and identify the permit requirements that affect the drainage plan. Examples of other permits are listed in Section 1.1.2.

TIR SECTION IX. TEMPORARY EROSION AND SEDIMENTATION CONTROL ANALYSIS AND DESIGN

Include in this section all hydrologic and hydraulic information used to analyze and design the temporary erosion and sedimentation control (TESC) facilities. The report shall address the eleven minimum requirements of Core Requirement 5, the measures that will be implemented and justification for any proposed exceptions to the minimum requirements.

TIR SECTION X. BOND QUANTITIES WORKSHEET, RETENTION/DETENTION FACILITY SUMMARY SHEET AND DECLARATION OF COVENANT

Bond Quantities Worksheet

Each plan submittal will require a construction quantity summary to establish appropriate bond amounts. Using the Bond Quantities Worksheet furnished by the BALD Division (see Reference 10E), the design engineer shall separate existing right-of-way and erosion control quantities from other on-site improvements. In addition, the engineer shall total the amounts based on the unit prices listed on the form.

Retention/Detention Facility Summary Sheet and Sketch

Following approval of the plans, a Retention/Detention Facility Summary Sheet and Sketch (see Reference 10C) shall be submitted along with an 8-1/2" x 11" plan sketch for each retention/detention facility proposed for construction. The plan shall show north arrow, the R/D tract, facility access road, extent of facility and control structure location. The approximate street address shall be noted.

Declaration of Covenant (privately maintained commercial retention/detention facilities only)

A declaration of covenant (see Reference 10D) as described in Appendix A of Ordinance 4938 must be signed and recorded at the office of King County Records and Elections before any permit with privately maintained retention/detention facilities are approved.

TIR SECTION XI. MAINTENANCE AND OPERATIONS MANUAL

For each R/D facility which is to be privately maintained or those that have special non-standard features, the design engineer shall prepare a maintenance and operations manual. The manual should be simply written and should contain a brief description of the R/D facility, what it does and how it works. In addition, the manual shall provide an outline of maintenance tasks and recommended frequency at which each task should be performed (see Section 1.2.6) and a copy of the Maintenance Requirements for Privately Maintained Drainage Facilities (see Appendix A).

2.3.2 SITE IMPROVEMENT PLANS

Site Improvement Plans shall portray design concepts in a common format. This format must be capable of presenting all the information necessary for persons trained in engineering to review the plans, as well as those persons skilled in construction work to build the project according to the

design engineer's intent. Supporting documentation for the site improvement plans must also be presented in an orderly and concise format that can be systematically reviewed and understood by others. A good format is also important for easy access to information for future reference.

The land survey data on which the Engineering Plans are based must be on King County Aerial Survey (KCAS) datum (see Figure 4.3.8A for datum correlations KCAS). If KCAS control is not available within a reasonable distance from the site, a permanent monument (KCRS Drawing No. 29) with an assumed elevation of 100.00 shall be set on the site in a readily accessible location which will be indicated on the plans.

The Site Improvement Plans consist of all the plans, profiles, details, notes and specifications necessary to construct road, drainage structures and off-street parking improvements. These include:

- o Base map (see below)
- o Plan and profile, improvement site plans (see below)
- o Erosion/sedimentation control (ESC) plan (see below)

NOTE: The site improvement plans must also include grading plans if on-site grading extends beyond the roadway grading for subdivision development.

The site plans must generally use the King County Standard Map Symbols and must include the Standard Plan Notes (see Reference section).

Site Improvement Plan Base Map

Well designed engineering plans must consider all existing elements of the site and incorporate them into the proposed design concept. A Site Improvement Plan Base Map provides a common base and reference in the development and design of any project.

<u>The Site Improvement Plan</u>

A base map helps ensure that the engineering plans, grading plans and ESC are all developed from the same background information. This base map shall include the following:

BM1:	Ground Surface Topography	Provide topography within the site and extending beyond the property line (see Section 2.4.2). Contour lines must be shown, spacing as described in "Plan View: Site Plan and Roadway Elements" below.
BM2:	Surface Water Discharge	Provide ground surface elevations for a reasonable "fan" around points of discharge extending at least 50 feet downstream of all point discharge outlets.
BM3:	Hydrologic Features	Provide spot elevations in addition to contour lines to aid in delineating the boundaries and depth of all existing floodplains, wetlands, channels, swales, streams, storm drainage systems, roads (low spots), bogs, depressions, springs, seeps, swales, ditches, pipes, groundwater and seasonal standing water.
BM4:	Other Natural Features	Show the location and relative sizes of other natural features such as rock outcroppings, existing vegetation and trees 12" in diameter and greater that could be disturbed by the project improvements and construction activities (within tree canopy), noting species.

BM5:	Flows	Provide arrows which indicate direction of surface flow on all public and private property and for all existing conveyance systems.
BM6:	Floodplains/ Floodways	Show the floodplain/floodways as required by Flood Hazard Portion of the Sensitive Areas Ordinance and Rules.
BM7:	General Background Information	Show the location and limits of all existing: Property boundaries Structures Dimensions of easements Dimensions of total property Roads and rights-of-way Sanitary sewers and water utilities Common open space Public dedications
BM8:	Development Limitations	Delineate limitations to the development that may occur as identified on the TIR worksheet, Part 8 (see Reference 10B).

Site Plan and Profiles

General: Plan Formatting

(1) Plan sheets and profile sheets or combined plan and profile sheets, specifications and detail sheets as required, shall be on sheet sizes 24" x 36". Original sheets shall be good quality reproducibles, mylar or equal.

(2) Drafting details shall generally conform to King County Standard Map Symbols (see Reference section), with lettering size (before reduction) no smaller than Leroy 100. Existing features shall be shown with dashed lines, and/or are half-toned (screened), in order to clearly distinguish existing features from proposed improvements.

(3) Each submittal shall contain a project information/cover sheet (see Reference section) with the following:

- Title: Project name and BALD Division file number.
- Table of contents (if more than three pages).
- Vicinity map.
- Name and phone of utility field contacts and One-Call number 1-800-424-5555 (e.g., water, sanitary sewer, gas, power, telephone and TV).
- King County's preconstruction/inspection notification requirements.
- Name and phone of surveyor.
- Name and phone of owner/agent.
- Name and phone of applicant.
- Legal description.
- Plan approval signature block for BALD Division.
- Name and phone of engineering firm preparing plans (company logos acceptable).
- Fire Marshal's approval stamp (if required).
- Statement that mailbox locations have been designated or approved by the U.S. Postal Service (where required).
- List of conditions of preliminary approval on all site improvements.

Note: If this information is provided on the architectural plans for Commercial Building Permits, then it may be omitted from the Commercial Engineering Site Plans.

A blank sample or computer file of the information sheet format is available from BALD Division upon request.

(4) For subdivisions, each site improvement plan package shall contain a separate page(s) of the revised Preliminary Plan altered through engineering design and the original version submitted with the Preliminary Plan. In addition to the elements outlined in Section 2.2.1, the plan shall include the following:

- all project phasing and proposed division boundaries.
- all natural and proposed drainage collection and conveyance systems with catch basin numbers shown.

For other permits, an overall site plan shall be included if more than three plan sheets are used. The overall plan shall include the items above and complete property area development, right-of-way layout, street names and road classification, all indexed to the detail plan sheets.

(5) Each sheet of the plan set shall be stamped, signed and dated by a professional civil engineer licensed in the State of Washington. At least one sheet showing all boundary survey information must be provided that has been stamped by the professional land surveyor licensed in the State of Washington.

(6) Detail sheets shall provide sufficient information to construct complex elements of the plan. Details may be provided on plan and profile sheets if space allows.

(7) A title block shall be provided on each plan sheet. The title block shall list at a minimum the development title, the name, address, and phone number of the firm or individual preparing the plan, a revision block, page (of pages) numbering, and sheet title (e.g., road and drainage, grading, erosion/sedimentation control).

(8) Location and label for each section or other detail shall be provided.

(9) Native Growth Protection Easements shall be designated as required by the Sensitive Areas Ordinance and Rules.

(10) All match lines with matched sheet number shall be provided.

(11) All division or phase lines and the proposed limits of construction under the permit application shall be indicated.

(12) Wetlands shall be labeled with the number from the wetland inventory, or shall be labeled as "uninventoried" if not listed on the wetland inventory.

(13) The General, Drainage and Structural Notes that apply to the plan shall be provided on the plans (see Reference section).

(14) Commercial Building Permit applications shall include the designated zoning for all properties adjacent to the development site(s).

<u>Plan View; Site Plan and Roadway Elements</u>

(1) Property lines, right-of-way lines, and widths for proposed road and intersecting roads shall be provided.

(2) All existing and proposed roadway features such as centerline, edge of pavement and shoulder, ditchlines, curbs and/or sidewalks shall be provided. In addition, points of access to abutting properties and roadway continuations shall be shown.

(3) Existing and proposed topography contours shall be shown at 2-foot intervals (5-foot intervals for slopes greater than 15 percent, 10-foot intervals for slopes greater than 40 percent). Contours may be extrapolated from USGS mapping, aerial photos or other topography map resources. However, contours shall be field verified for roadway and stream centerlines, floodplains and for drainage tracts easements, and conveyance systems. Contours shall extend 50 feet beyond property lines to resolve questions of setback, cut and fill slopes, drainage swales, ditches, and access or drainage to adjacent property.

(4) The location of all existing utilities and proposed utilities (except those designed by the utility and not currently available) shall be shown to the extent that these will be affected by the proposed project. All existing utility poles shall be clearly identified.

(5) All roads and adjoining subdivisions shall be identified.

(6) Right-of-way for all proposed roadways shall be shown with sufficient dimensioning to clearly show exact locations on all sections of existing/proposed dedicated public roadway.

(7) Areas of existing pavement and areas of new pavement shall be clearly differentiated.

(8) For subdivision projects, drawing scales shall be generally 1" = 50'; however, 1" = 100' shall be optional for development of lots one acre or larger. For commercial or multi-family projects, scales shall be generally 1" = 20'; however, 1" = 10', 1" = 40' and 1" = 50' are acceptable. Details for clarification, including those for intersections and existing driveways, should be shown on a larger scale.

Plan View: Drainage Conveyance

(1) All catch basins and curb inlets shall be sequentially numbered starting from the furthest downstream structure.

(2) Existing storm drainage facilities shall be represented in dashed lines and labeled as existing.

(3) Existing storm drainage facilities to be removed shall be clearly labeled as "existing to be removed."

(4) Slope, length, diameter and material for all pipes, culverts and stubouts shall be shown. Material may be noted in the plan notes.

(5) Catch basins shall be clearly labeled as to size and type or indicate in the plan notes.

(6) Downspout or footing drain stubout locations to all lots intending to connect to the storm drainage retention/detention system shall be clearly labeled. All stubouts shall be located to allow gravity flow from the lowest corner of the lot to the connecting catch basin.

(7) Datum, benchmark locations and elevations shall be represented on each plan sheet.

(8) All stubout locations for any future pipe connections shall be clearly labeled.

(9) All drainage easements, tracts, access easements, Native Growth Protection Easements, Sensitive Area Tracts, Sensitive Area Setback Areas, and building setback lines shall be clearly shown on the plans. Show dimensions, type of restriction and use.

(10) Using arrows, indicate drainage direction of hydraulic conveyance systems.

Plan View: Other

(1) Show the location, identification and dimensions of all buildings, property lines, streets, alleys and easements.

(2) Verify condition of all public rights-of-way and the rights to use them as proposed.

(3) Show locations of structures on abutting properties within 25 feet of the proposed project site.

(4) Show the location of all proposed drainage facility fencing, together with a typical section view of each.

(5) Provide section details of all retaining walls and rockeries including sections through critical portions of the rockeries or retaining walls.

(6) Show all existing and proposed buildings with projections and overhangs.

Profiles: Roadway and Drainage

(1) Provide existing centerline ground profile at 50-foot stations and at significant ground breaks and topographic features, with average accuracy to within 0.1 feet on unpaved surface and 0.02 feet on paved surface.

(2) For publicly maintained roadways, provide final road and storm drain profile with stationing the same as the horizontal plan, reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevation of 0.01 feet; to include tie-in with intersecting pipe runs.

(3) On a grid of numbered lines, provide a continuous plot of vertical positioning against horizontal.

(4) Show finish road grade and vertical curve data; road data measured at centerline or edge of pavement. Include stopping sight distance.

(5) Show all roadway drainage, including detention tanks, that are within the right-of-way or easement.

(6) Slope, length, size and type (in plan notes or on a detail sheet) for all pipes and detention tanks in public right-of-way shall be shown on the profile.

(7) Indicate the inverts of all pipes and culverts and the elevations of catch basin grates or lids. If the plan and profile elements are on separate sheets, then the elevations of catch basin grates or manhole lids and pipe inverts shall appear on both the plan view and profile view.

(8) For pipes that are proposed to be within 2.0 or less feet of finished grade, dimension the minimum cover requirements.

(9) Indicate roadway stationing and offset for all catch basins.

(10) Whenever possible, show profile aligned underneath the plan view.

(11) Indicate vertical and horizontal scale.

(12) Clearly label all profiles with respective street names and plan sheet reference numbers if drawn on separate sheets.

(13) Locate match points with existing pavements and show elevations.

(14) Show all property boundaries.

(15) Label all match line locations.

(16) Provide profiles for all 12-inch and larger pipes and for channels (that are not roadside ditches).

(17) Show the location of all existing and proposed (if available or critical for clearance) gas, water and sanitary sewer crossings.

(18) Show energy dissipater locations.

(19) Identify datum used and all benchmarks (may be shown on plan view instead). Datum and benchmarks must refer to established control when available.

(20) Vertical scale shall be 1" = 5'. As an exception, vertical scale shall be 1" = 10' if optional 1" = 100' horizontal scale is used on projects with lots 1 acre or larger. Clarifying details, including those for intersections and existing driveways, should be done to a larger scale.

Details

Retention/Detention and Infiltration System Details

(1) Provide a to-scale drawing of each R/D pond or vault, including the tract boundaries.

(2) Show predeveloped and finished grade contours at 2-foot intervals. Show and label maximum design water elevation.

(3) Dimension all berm widths.

(4) Show and label at least two cross-sections through pond. One cross-section must include the restrictor.

(5) Specify soils and compaction requirements for pond construction.

(6) Show location and detail of emergency overflows and spillways.

(7) Specify rock protection/energy dissipation requirements and details.

(8) Provide inverts of all pipes, grates, inlets, tanks, vaults and spot elevations of pond bottom.

(9) Show location of access road to control manhole and pond bottoms.

(10) Provide plan and section view of all energy dissipaters, including rock splash pads. Specify the size of rock and thickness.

(11) Show bollard location on plans. Typically, bollards are located at the entrance to drainage facility access roads.

(12) The size, type (or in plan notes), slope and length of all pipes on the pond detail must be shown.

(13) Section and plan review of restrictor/control structure must be shown to scale. The plan view will show location and orientation of all inlet pipes, outlet pipes and the T-section.

(14) Details shall be drawn at one of the following scales: 1" = 1', 1" = 2', 1" = 4', 1" = 5', 1" = 10', or 1" = 20'.

Structural Plan Details

Any submittal which proposes a structure (e.g., bridge crossing, reinforced concrete footings, walls or vaults) shall include plan sheets necessary to provide complete working drawings showing dimensions, steel placement and specifications for construction. Structures may require a design prepared and stamped by a professional structural engineer licensed in the State of Washington and application for a separate Commercial Building Permit.

2.3.3 TEMPORARY EROSION AND SEDIMENTATION CONTROL PLAN

Provide sufficient information to justify the overall TESC plan and the choice of individual BMPs. At a minimum, there shall be a discussion of each of the eleven minimum requirements of Core Requirement 5. This discussion shall include the applicability of each of the minimum requirements to the project, the measures that will be used to comply with the minimum requirements, and justification for any proposed exceptions to the minimum requirements.

Include all hydrologic and hydraulic information used to analyze and size the TESC facilities shown in the engineering plans. Describe the methodology and attach any graphics or sketches used to size the facilities. Areas with a particularly high susceptibility to erosion because of slopes and/or soils shall be identified. Any special measures to be taken to protect these areas shall be discussed. Additionally, any special measures proposed to protect water resources on or near the site shall be discussed (Section 5.4.9). Any TESC recommendations in any of the special reports prepared for the project shall be identified. If these recommendations are not included in the TESC plan, justification shall be provided.

If exceptions from or modifications to the existing standards of Chapter Five are proposed, then the rationale must be clearly presented. If techniques or products different from those approved in Chapter Five are proposed, any available supporting documentation must be provided so that the county can determine if the proposed alternatives provide protection similar to that of the measures specified in Chapter Five.

The following list provides the basic information requirements for the Temporary Erosion and Sedimentation Control plan. The plan must be in accordance with Core Requirement 5 and Chapter Five. The list below has been organized to parallel the eleven minimum requirements of Core Requirement 5 and the specifications of Sections 5.4.1 through 5.4.11. Note that the TESC plan may be simplified by the use of the symbols and codes provided for each TESC measure in Chapter Five. In general, the TESC plan shall be submitted as a separate plan sheet(s). There may be, however, some relatively simple projects where providing a separate grading and TESC plan is unnecessary.

General

(1) The engineering plan shall be used as the base of the TESC plan. Certain detailed information (e.g. pipe catch basin size, stub out locations, etc.) that is not relevant may be omitted to make the TESC plan easier to comprehend. At a minimum, the TESC plan shall include all of the information required for the Base Map (Section 2.3.2.1), as well as existing and proposed roads, driveways, parking areas, buildings and drainage facilities, utility corridors not associated with roadways, all sensitive areas and buffers, and proposed final topography. A smaller scale may be used to provide better comprehension and understanding.

(2) The TESC plan shall generally be designed for proposed topography, not existing topography, since rough grading is usually the first step in site disturbance.

(3) Areas with a high susceptibility to erosion shall be identified (Section 2.3.1).

(4) Provide all details necessary to clearly illustrate the intent of the TESC design.

(5) The plan shall be consistent with the information provided in Section IX of the TIR.

(6) Include TESC measures for all on and off-site utility construction included in the permit.

(7) Specify the construction sequence. An example construction sequence is provided in the Reference section.

(8) Include standard TESC Notes (see Reference section).

Clearing Limits

(1) Clearing limits shall be delineated.

(2) Provide typical detail sufficient for installation and maintenance of clearing limits.

Cover Measures

(1) Specify the type and location of temporary cover measures to be used on site.

(2) If more than one type of cover is to be used on-site, indicate the areas where the different measures shall be used, including steep cut and fill slopes.

(3) If the type of cover measures to be used will vary depending on the time of year, soil type, gradient, or some other factor, specify the conditions that control the use of the different measures.

(4) Specify the nature and location of permanent cover measures. If a landscaping plan is prepared, this may not be necessary.

(5) Specify the approximate amount of cover measures necessary to cover all disturbed areas.

(6) If netting or blankets are specified, provide typical detail sufficient for installation and maintenance.

(7) Specify the seed mixes, fertilizers, and soil amendments to be used. Also, specify the application rate for each item.

Perimeter Protection

(1) Specify the location and type of perimeter protection to be used.

(2) Provide typical details sufficient for installation and maintenance of perimeter protection.

(3) If silt fence is to be used, specify the type of fabric to be used.

Traffic Area Stabilization

(1) Locate the construction entrance(s).

(2) Provide typical detail sufficient for installation and maintenance of the construction entrance.

(3) Locate the construction roads and parking areas.

(4) Specify the measure(s) that will be used to create stabilized construction roads and parking areas. Provide sufficient detail to install and maintain.

Sediment Retention

(1) Show the locations of all sedimentation ponds and traps.

(2) Dimension pond berm widths and all inside and outside pond slopes.

(3) Indicate the trap/pond storage required and the depth, length and width dimensions.

(4) Provide typical section views throughout pond and outlet structure.

(5) Provide typical details of the control structure and dewatering mechanism.

(6) Detail stabilization techniques for outlet/inlet.

(7) Provide details sufficient to install cell divider.

(8) Specify mulch and/or recommended cover of berms and slopes.

(9) Indicate the requirement for mark at 1 foot depth for sediment removal.

(10) Indicate catch basins that are to be protected.

(11) Provide details of the catch basin protection sufficient to install and maintain.

Surface Water Control

(1) Locate all pipes, ditches, interceptor ditches and swales that will be used to convey storm water.

(2) Provide details sufficient to install and maintain all conveyances.

(3) Indicate locations of outlet protection and provide detail of protections.

(4) Indicate locations and outlets of any possible dewatering systems.

(5) Indicate the location of any level spreaders and provide details sufficient to install and maintain.

(6) Provide all temporary pipe inverts.

(7) Provide location and specifications for the interception of runoff from disturbed areas and the conveyance of the runoff to a non-erosive discharge point.

(8) Provide location and details of rock check dams.

(9) Provide front and side sections of typical rock check dams.

Wet Season Requirements

(1) Provide a list of all applicable wet season requirements.

Sensitive Areas Restrictions

(1) Specify the type, locations, and details of any measures necessary to comply with requirements to protect surface waters.

(2) Specify the type, locations, and details of any measures necessary to comply with any additional protection required to protect steep slopes.

2.4 FINAL PLAT RECORDING DOCUMENT SPECIFICATIONS

The final plat for recording submittal only applies to Regular Subdivisions (Plats), PUD's, Binding Site Plans and Short Plats. This plan is required per state and local statutes.

A final plat is not required for any other permit.

2.4.1 REGULAR SUBDIVISIONS, PUD'S AND BINDING SITE PLANS

Applications for final recording of plats and PUD's must include the following plans and supporting documents.

Plans

- 18 X 22" mylars and 7 prints
- Border line 1/2" along outside edge.
- Plat Name (not to exceed 32 characters, including spaces).
- BALD File Number in left lower corner below border.
- If more than 2 map sheets, including a map index sheet showing outline of indexed sheets.

- North Arrow
- Scale
- Established Meridan
- Size of plat streets (right of way widths and radius of cul-de-sacs).
- Street names and numbers.
- Tie-ins to existing plat monuments with bearing and distances.
- Description of monuments and physical characteristics,
- Proper Approval and Dedication forms
- Land Surveyor's Certification
- Dimensions of all easements, tracts, building set backs, top of slopes, wetland boundaries, and floodplains
- Include pertinent restrictions as they apply to easements, tracts and building set back lines.
- Dedication and indemnification clause as provided in Ordinance 5952.

Supporting Documents

- Plat Certificate
- Fire Engineer's Approval
- Health Department Approval
- One set of mathematical calculations of boundary, each street centerline, block exterior, each lot, tract or parcel. Mathematical closure shall not exceed .02 of a foot.
- If subdivision is based on a United States public land survey, one set of the section breakdowns (this may be shown on the Map sheets).
- Proper form of professional land surveyor's Certificate of Monumentation.

Plat certificates are a form showing property ownership and encumbrances prepared by a title company. This form needs to be provided no more than 30 days prior to recording. Plan mylars are not required until after BALD has completed review of the print sets.

Applications will be accepted (but not processed) without Health Department approval.

2.4.2 SHORT PLATS

Applications for Short Plats must include a map page submitted on an 8-1/2 X 14" form provided by BALD. In addition to the requirements described in the Development Assistance Bulletin prepared by BALD, the map page shall include the following information:

- Identify and clearly delineate any sensitive area or drainage feature (including flood plains).

- Include pertinent restrictions as they apply to easements, tracts and building set back lines.

CHAPTER 3
HYDROLOGIC ANALYSIS

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

CHAPTER 3 HYDROLOGIC ANALYSIS

KING COUNTY, WASHINGTON
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Section 3.1 Design Storm

Section 3.2 Computation Methods

Section 3.3 Peak Rate Runnoff Control Facility Performance

Section 3.4 Hydrologic Design Process

Section 3.5 Hydrograph Method

Section 3.5.1 Design Storm Hyetograph
Section 3.5.2 Runoff Parameters
Section 3.5.3 Hydrograph Synthesis
Section 3.5.4 Hydrograph Routing
Section 3.5.5 Hydrograph Summation and Phasing
Section 3.5.6 Computer Applications

Section 3.6 Closed Depression Analysis

LIST OF VARIABLES USED IN HYDROLOGIC ANALYSIS

A	=	Basin area (acres)
A_b	=	Bottom area of detention facility
Cn	=	Curve Number (SCS Method)
d_b	=	Bottom orifice diameter (inches)
dt	=	Top orifice diameter (inches)
H	=	Stage height or water depth (feet)
H_d	=	Design depth for total detention volume
H_2	=	2 - year stage height or water depth above outlet invert
H_{10}	=	10-year stage height or water depth above outlet invert
H_{100}	=	100-year stage height or water depth above outlet invert
H_o	=	Stage height of pond bottom above outlet invert
h	=	Design head (feet)
h_b	=	Bottom orifice design head
h_t	=	Top orifice design head
h_2	=	2-year head above bottom orifice
h_{10}	=	10-year head above top orifice
h_{100}	=	100-year head above top orifice
I	=	Inflow (Level Pool Routing)
I_R	=	Peak rainfall intensity (Rational Method)
$I(t)$	=	Instantaneous hydrograph (SBUH Method)
i_R	=	Unit peak rainfall intensity factor (Rational Method)
k_c	=	Time of concentration velocity factor for channel flow
k_s	=	Time of concentration velocity factor for shallow concentrated flow
L	=	Flow length (feet)
n	=	Manning's friction factor
n_s	=	Manning's frcition factor for sheet flow only
O	=	Outflow (Level Pool Routing)
P	=	Precipitation.
P_R	=	Total precipitation for 24-hour duration design storm
P_2Q_{rel}	=	2-year release rate
$P_{10}Q_{rel}$	=	10-year release rate
$P_{100}Q_{rel}$	=	100-year release rate
P_2Q_{dev}	=	2-year developed flow rate
$P_{10}Q_{rel}$	=	10-year developed flow rate
$P_{100}Q_{dev}$	=	100-year developed flow rate
Q	=	Flow rate
$Q(t)$	=	Runoff Hydrograph (SBUH Method)
Q_b	=	Bottom orifice flow rate
Q_t	=	Top orifice flow rate
Q_d	=	Runoff depth (SCS Method)
Q_R	=	Rational Method Peak Flow
$R(t)$	=	Precipitation excess (SBUH Method)
S	=	Storage
S_2	=	2-year storage volume
S_{10}	=	10-year storage volume
S_{100}	=	100-year storage volume
S_o	=	Slope (ft/ft)
T_c	=	Time of Concentration
T_t	=	Travel Time
t	=	Time step
V	=	Velocity
w	=	Routing Constant (SBUH Method)

CHAPTER 3
HYDROLOGIC ANALYSIS

The broad definition of Hydrology is "the science which studies the source, properties, distribution, and laws of water as it moves through its closed cycle on the Earth (the Hydrologic Cycle)." As applied in this Manual, however, the term "hydrologic analysis" addresses and quantifies only a small portion of this cycle. That portion is the relatively short-term movement of water over the land resulting directly from precipitation and is called surface water runoff. Localized and long-term groundwater movement must also be of concern, but generally only as they affect or relate to the movement of water on or near the surface, such as stream base flow or infiltration systems. This chapter presents the acceptable methods for estimating the quantity and characteristics of surface water runoff, as well as the assumptions and data required as input to the methods. These methods are used to analyze existing and design proposed drainage systems and facilities. The chapter contents have been organized to present the logical sequence of application of the methods described.

- Design Storm - Describes the design storm to be used in the methods.
- Computation Methods - Describes the acceptable computation methods.
- Retention/Detention Facility Performance - Describes the release rate performance used for sizing retention/detention facilities.
- Hydrologic Design Process - Provides a sequential description of the design process using hydrograph analysis.
- Hydrograph Method - Each section describes the data, assumptions and the mechanics of the method.
  - Design storm hyetograph
  - Runoff parameters
  - Hydrograph synthesis
  - Hydrograph routing
  - Hydrograph summation and phasing
  - Computer applications

The readers and users of this Manual who are interested in the background regarding the selection of these methods are directed to the Surface Water Quantity Control Policy section in the "Overview of Surface Water Policies in King County" paper located in the "REFERENCE" section at the back of this Manual. This Surface Water Quantity Control Policy section describes: (1) the background on why the storm event methods of hydrologic analysis was chosen for the analysis and design of all drainage facilities in King County; (2) the basis for the selection of the peak rate runoff control performance concept; (3) the reasons for selecting the specific design storm events; and (4) the reasons for selecting the SCS-based methods.

Caution: A complete basic understanding of the hydrologic, geologic, and environmental processes integral to surface waster systems is essential for the proper and accurate application of the methods contained in this Chapter. As is clearly stated in the Washington State Professional Engineers Board of Registration, professional engineers must only practice and endorse work in the areas of engineering for which they are competent through years of education and experience.

3.1 DESIGN STORM

The design storms to be used in King County are based on two parameters:

- Total rainfall volume (depth in inches).
- Rainfall distribution (dimensionless).

The design storm event is specified by return frequency and duration. Section 3.5.1 explains total rainfall depth and rainfall distribution associated with a design storm.

3.2 COMPUTATION METHODS

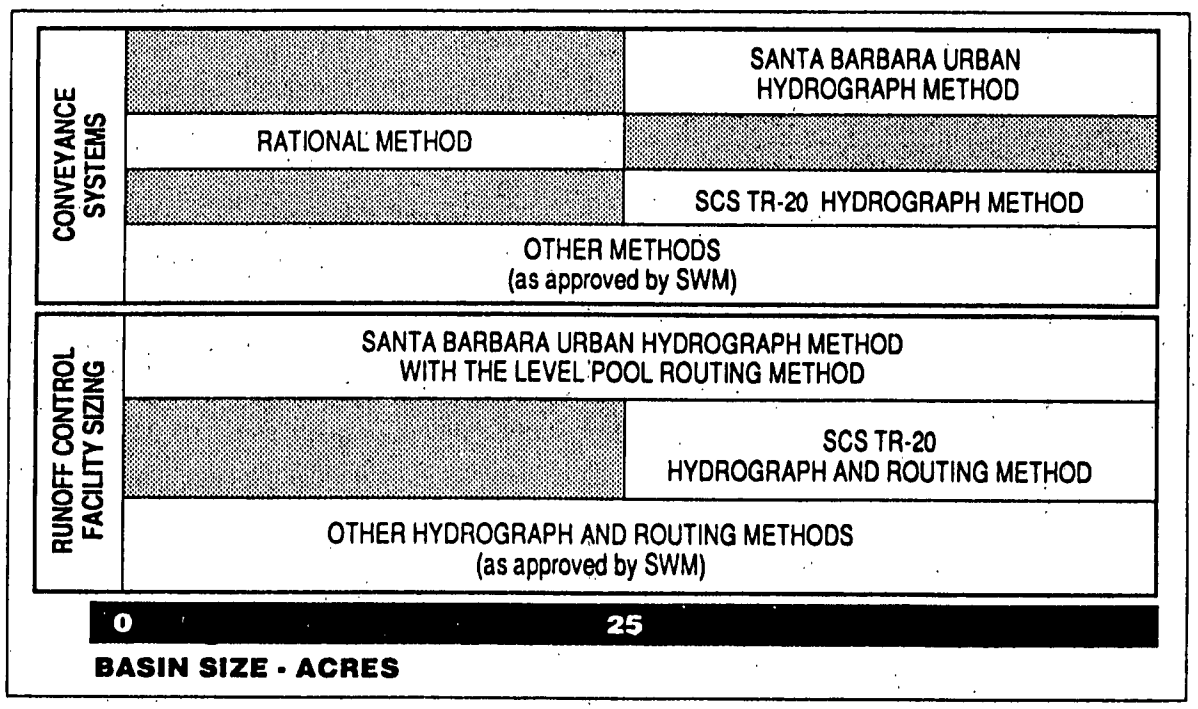
All conveyance systems, existing and proposed, will be analyzed and designed using the analysis methods described in Section 3.5 and 4.3.3.

All runoff control facilities, existing and proposed, will be analyzed using hydrograph analysis methods described in Section 3.5.

> EXCEPTION: For large projects, such as Master Planned Developments (MPD) and projects that contain drainage basins of over 200 acres, the SWM Division encourages, and may require (both prior to and after development), the collection of actual rainfall and runoff data to be used in developing a calibrated SCS model or a continuous model and for monitoring. These projects fall under the classification of Master Drainage Plans (MDP) and will be reviewed by the SWM Division. The SCS TR-20 and Army Corps of Engineers HEC-1 computer models are also acceptable, along with models using the Santa Barbara Urban Hydrograph technique, in performing this calibrated modeling. Contact the SWM Division for information on the model's data, formulation, calibration, and monitoring requirements. (See Core Requirement #3: Runoff Control, in Chapter 1, and Appendix B, for additional information on the requirements for Master Drainage Plans).

Figure 3.2A defines the acceptable computation methods and their limits of application according to basin sizes.

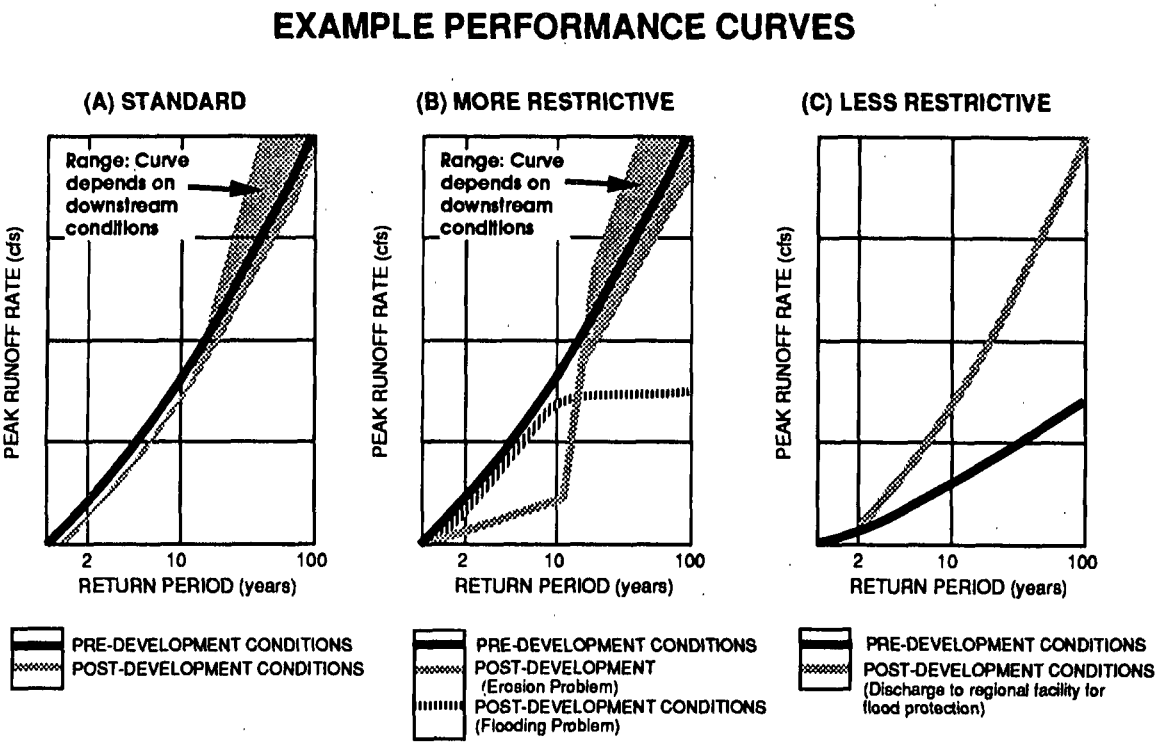
FIGURE 3.2A COMPUTATION METHODS BY BASIN SIZE



3.3 PEAK RATE RUNOFF CONTROL FACILITY PERFORMANCE

The release rate requirements for a peak rate runoff control facility are represented by a "performance curve" which is the plot of allowable peak flow rates (in cfs) versus design storm frequency. The objective of this performance curve is to limit the developed peak runoff rates to predeveloped levels for a range of design storm frequencies. To achieve this objective, King County typically requires that more than one design storm frequency be used to define a performance curve (usually the 2-, 10- and 100-year, 24-hour storm events). The 2-year and 100-year storms were chosen to address the lower and upper range of frequencies on the performance curve, while the 10-year storm is intended to address the intermediate range of frequencies. The performance curve is formed by connecting the existing peak runoff rates for the design storm frequency events. Similarly, the developed peak runoff rates released from the facility for these storm events form a curve which does not exceed the existing peak flow rate curve at the design storm frequencies (as shown in Figure 3.3A).

FIGURE 3.3A EXAMPLE PERFORMANCE CURVES



More restrictive performance curves may be required where there are known or anticipated erosion and/or flooding problems downstream. For example, a specific downstream erosion problem may be addressed by adjusting the performance curve at the 2-year frequency level to obtain greater control and attenuation of the more frequent storm events (see Figure 3.3A). Similarly, to address a specific downstream flooding problem, the performance curve may be adjusted at the 10-year and/or 100-year frequency level to obtain greater control of the less frequent storm events.

In those basins or portions of basins which have been designated as Critical Drainage Areas by King County, the more restrictive performance curves will be applied to new developments. Basin-specific performance curves for Critical Drainage Areas are available from the BALD Division office.

In other cases a less restrictive performance curve may be appropriate such as where a regional facility may be providing flood control for less frequent storms. The less restrictive performance curves will normally only be developed as part of a regional hydrologic analysis such as that performed for a Basin Plan or a Master Drainage Plan.

3.4 HYDROLOGIC ANALYSIS AND DESIGN PROCESS

This section presents the general process involved in conducting a hydrologic analysis using hydrograph methods to design retention/detention facilities for a project. The process is described as follows:

1. Review the Core and Special Requirements in Chapter 1 to determine all requirements which will apply to the proposed project.

2. Determine, and be prepared to demonstrate in the Technical Information Report, the "existing site runoff conditions" per Core Requirement #3: Runoff Control in Chapter 1, Section 1.2.3.

3. Identify and delineate the overall drainage basin for each discharge point from the development site under existing conditions.

   - Identify existing land uses.

   - Identify existing soil types using SCS soil survey or on-site evaluation.

   - Identify existing drainage features such as streams, conveyance systems, detention facilities, ponding areas, depressions, etc.

4. Select and delineate pertinent subbasins based on existing conditions.

   - Select homogeneous (having generally consistent soils, topography and land use) subbasin areas per Section 3.5.2 under "Area."

   - Select separate subbasin areas for on-site and off-site drainage.

   - Select separate subbasin areas for major drainage features.

5. Determine runoff parameters for each subbasin under existing conditions.

   - Identify pervious and impervious areas.

   - Select curve numbers per Section 3.5.2 under "Curve Number."

   - Compute time of concentration per Section 3.5.2 under "Travel Time and Time of Concentration."

6. Determine allowable release rates for the appropriate design storms.

   - Compute "existing condition" runoff hydrographs for each design storm from each subbasin per Section 3.5.3. "Hydrograph Synthesis."

   - For subbasins which drain to an existing storage facility (e.g., existing detention facilities, ponding areas, closed depressions, etc.) route the hydrographs for each design storm through the facility per Section 3.5.4, "Hydrograph Routing." This will yield the attenuated versions of the hydrographs which then become the new "existing condition" hydrographs for the subbasin.

- o Sum the appropriate subbasin hydrographs to obtain the total existing runoff hydrographs for each design storm per Section 3.5.5, under "Hydrograph Summation."
- o Using the peak flow rates extracted from the existing runoff hydrographs, select the appropriate release rate for each design storm according to the required performance curve, the on-site and off-site bypass criteria per Core Requirement #3: Runoff Control in Chapter 1, Section 1.2.3.

7. Repeat steps 3 through 5 for the proposed developed site condition.

8. Design and size the detention facility per the methods presented in Section 3.5.4, "Hydrograph Routing."
   - o Compute "developed condition" runoff hydrographs for the design storms for each subbasin per Section 3.5.3.
   - o Sum the appropriate subbasin hydrographs to obtain the total developed runoff hydrographs for each design storm per Section 3.5.5 under "Hydrograph Summation."
   - o Use the developed runoff hydrographs and an iterative process to size the detention facility to meet the required performance curve. To meet performance, the developed runoff hydrograph for each design storm, when routed through the detention facility, must not yield an outflow rate greater than the allowable release rate selected for that storm in step 6.

9. Design and size the new conveyance systems for the proposed development.
   - o Select subbasins tributary to each element of the proposed drainage system.
   - o Compute the total runoff hydrographs to each segment and extract the peak flow rate, or compute the peak rate using the Rational Method presented in Chapter 4, Section 4.3.3 (see Figure 3.2A).
   - o Use the peak flow rate to design and size each segment per the criteria given in Chapter 4, Section 4.3.

3.5 HYDROGRAPH METHOD

To obtain a realistic and consistent hydrologic analysis from one development site to the next, King County requires that all developments use the hydrograph analysis methods presented in this section for drainage planning and design. The "HYD" computer program, developed by the SWM Division and included with this Manual, uses these methods to generate, add and route hydrographs.

Hydrograph analysis utilizes the standard plot of runoff flow versus time for a given design storm, thereby allowing the key characteristics of runoff such as peak, volume, and phasing to be considered in the design of drainage facilities.

The physical characteristics of the site and the design storm determine the magnitude, volume and duration of the runoff hydrograph. Other factors such as the conveyance characteristics of channel or pipe, merging tributary flows, branching of channels, and flooding of lowlands can alter the shape and magnitude of the hydrograph. In the following sections, the key elements of hydrograph analysis are presented, namely:

- o Design storm hyetograph.
- o Runoff parameters.
- o Hydrograph synthesis.

- o Hydrograph routing.
- o Hydrograph summation and phasing.
- o Computer applications.

3.5.1 DESIGN STORM HYETOGRAPH

All storm event hydrograph methods require the input of a rainfall distribution or design storm hyetograph. The design storm hyetograph is essentially a plot of rainfall depth versus time for a given design storm frequency and duration. It is usually presented as a dimensionless plot of unit rainfall depth (incremental rainfall depth for each time interval divided by the total rainfall depth) versus time.

The two hyetographs provided in this section are to be used for all hydrograph analysis. The first hyetograph (presented in Figure 3.5.1A and Table 3.5.1A) is required for all design storms of 24-hour duration. The hyetograph is the standard SCS Type 1A rainfall distribution resolved to 10-minute time intervals for greater sensitivity in computing peak rates of runoff in urbanizing basins. The second hyetograph (presented in Figure 3.5.1B and Table 3.5.1B) is required for the 100-year, 7-day duration design storm. It was derived from the SCS Type 1A rainfall distribution resolved to 60-minutes time intervals to simplify its use. The emphasis of the 100-year, 7-day storm is on volume rather than peak rate of runoff. Both hyetographs were interpolated by SWM Division Staff from the SCS mass distribution curve and may differ slightly from the distributions used in other SCS-based computer models, particularly those which are not resolved to 10-minute time intervals.

The design storm hyetograph is constructed by multiplying the dimensionless hyetograph times the total rainfall depth, in inches, (P_R) for the design storm.

The total depth of rainfall (in tenths of an inch) for storms of 24-hour duration and 2, 5, 10, 25, 50 and 100-year recurrence intervals are published by the National Oceanic and Atmospheric Administration (NOAA). The information is presented in the form of "isopluvial" maps for each state. Isopluvial maps are contour maps where the contours represent total inches of rainfall for a specific duration.

The isopluvial maps for the western portion of King County for the 2, 5, 10, 25, 50 and 100-year recurrence interval and 24-hour duration storm events are shown in Figures 3.5.1C to 3.5.1H. They were taken from the NOAA Atlas 2, "Precipitation - Frequency Atlas of the Western United States, Volume IX-Washington." The 100-year, 7-day isopluvial map shown in Figure 3.5.1I was taken from the U.S. Weather Bureau Technical Paper No. 49, "Two-to-Ten-Day Precipitation for Return Periods 2 to 100 years in the Contiguous United States." For projects in the areas of King County not shown on these maps use the NOAA Atlas 2, Volume IX - Washington. The Washington State DOT manual has these maps or contact the SWM Division to obtain a copy of this atlas if not available elsewhere.

For project sites with tributary drainage areas above elevation 1000 MSL, an additional total precipitation must be added to the total depth of rainfall, for the 25, 50, and 100-year design storm events, to account for the potential average snowmelt which occurs during major storm events. This M_s factor is computed as follows:

M_s (in inches) = 0.004 (MB_{el} - 1000);

Where

MB_{el} = the mean tributary basin elevation above sea level (in feet).

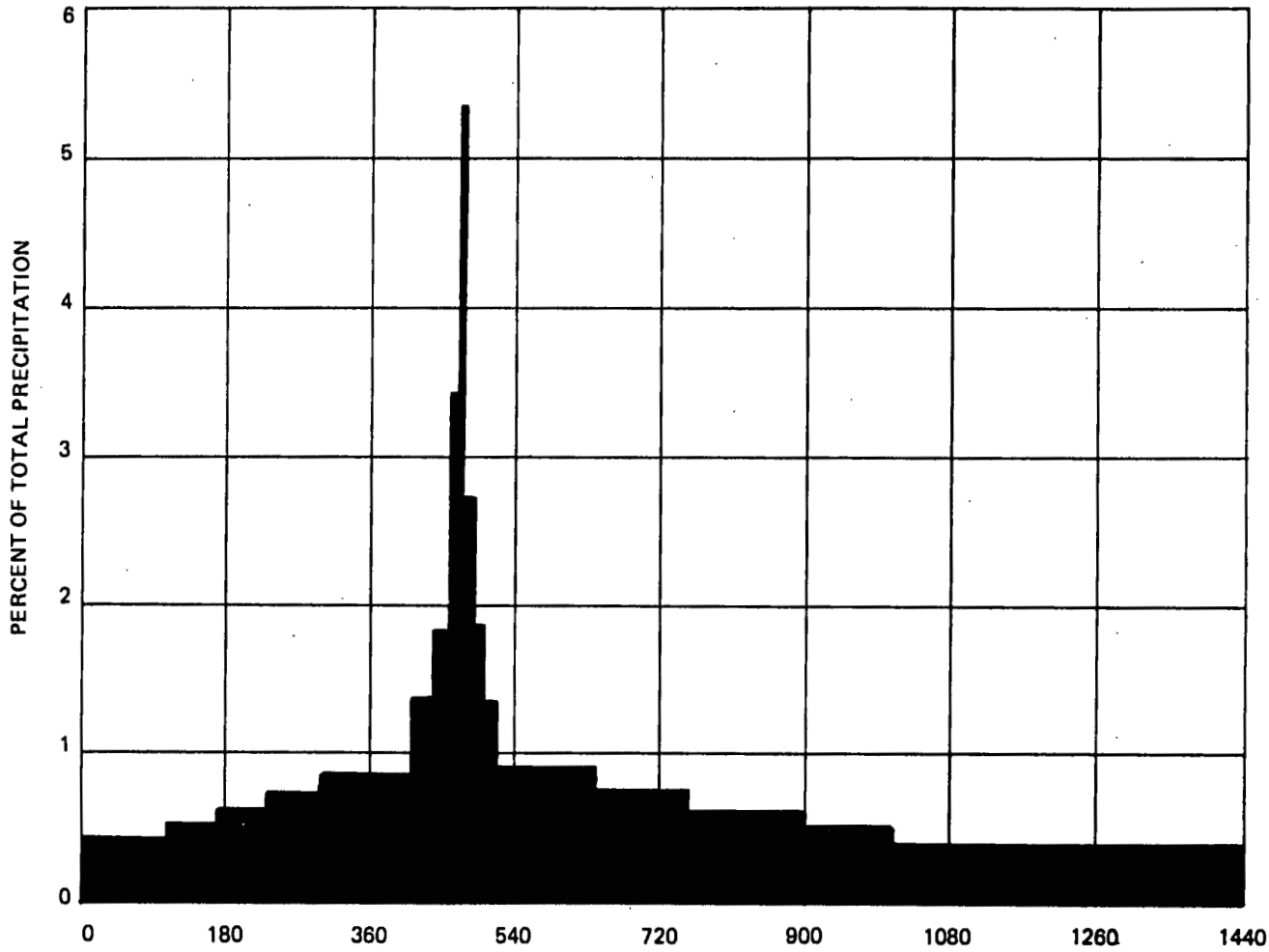
Example:

Given: Project location: East of North Bend near I-90. MB_{el} = 1837 feet.
Design Storm Event: 25-year (for culvert sizing); P_{25} = 7 inches

Compute: M_S = 0.004 (MB_{el} - 1000) = (0.004) (1837 - 1000) = <u>3.35 inches</u>

Adjusted P_{25} = P_{25} + M_S
= (7 inches) + (3.35 inches) = <u>10.35 inches</u>

FIGURE 3.5.1A 24-HOUR DESIGN STORM HYETOGRAPH



100 YEAR - 24 HOUR HYETOGRAPH
SCS TYPE 1A DISTRIBUTION
RESOLVED TO 10 MINUTE TIME STEPS

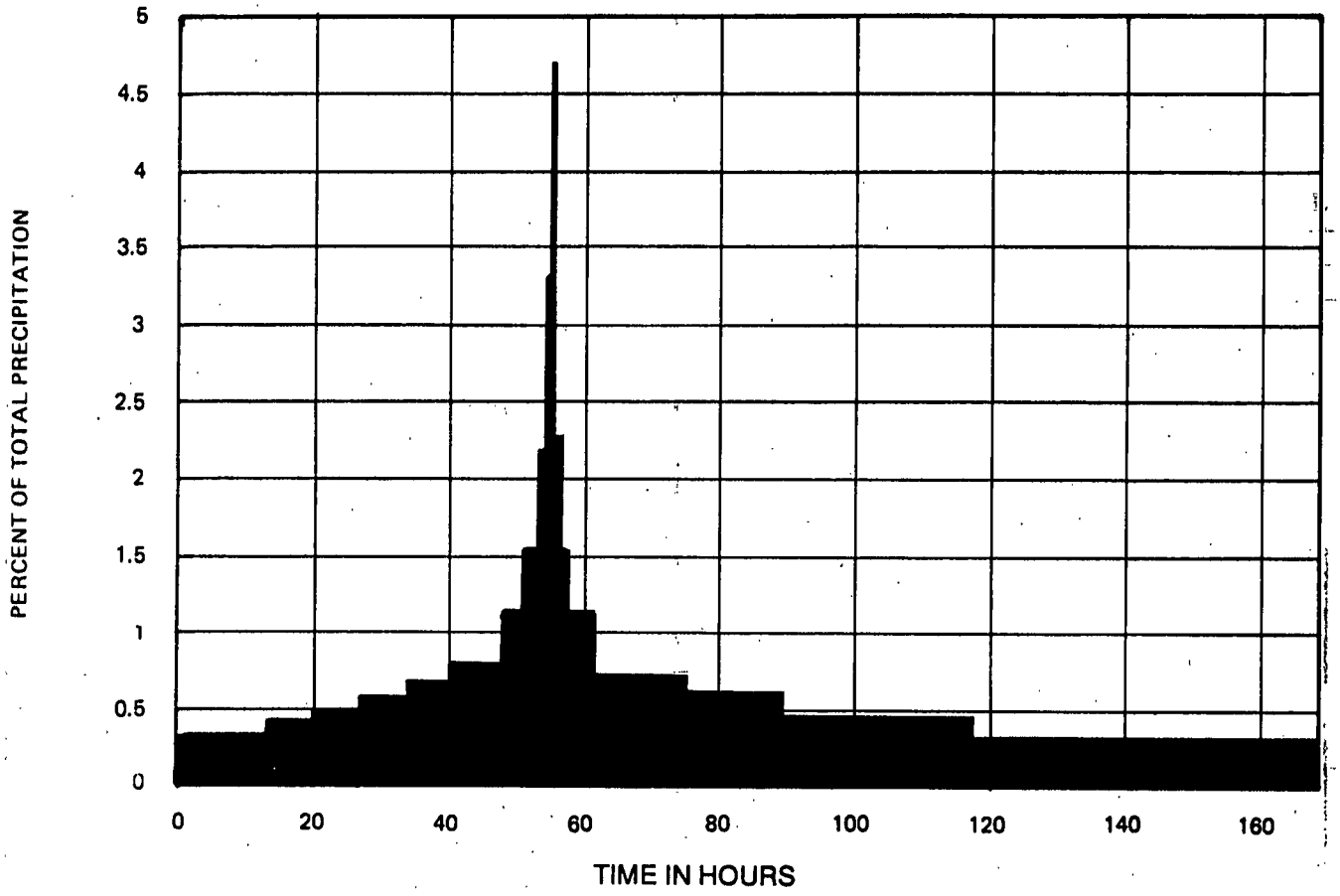
TABLE 3.5.1A 24-HOUR DESIGN STORM HYETOGRAPH VALUES

Time From Beginning of Storm (Min.)	Percent Rainfall	Cumulative Percent Rainfall	Time From Beginning of Storm (Min.)	Percent Rainfall	Cumulative Percent Rainfall
0 - 10	0.40	0.40	490 - 500	1.34	47.68
10 - 20	0.40	0.80	500 - 510	1.34	49.02
20 - 30	0.40	1.20	510 - 520	1.34	50.36
30 - 40	0.40	1.60	520 - 530	0.88	51.24
40 - 50	0.40	2.00	530 - 540	0.88	52.12
50 - 60	0.40	2.40	540 - 550	0.88	53.00
60 - 70	0.40	2.80	550 - 560	0.88	53.88
70 - 80	0.40	3.20	560 - 570	0.88	54.76
80 - 90	0.40	3.60	570 - 580	0.88	55.64
90 - 100	0.40	4.00	580 - 590	0.88	56.52
100 - 110	0.50	4.50	590 - 600	0.88	57.40
110 - 120	0.50	5.00	600 - 610	0.88	58.28
120 - 130	0.50	5.50	610 - 620	0.88	59.16
130 - 140	0.50	6.00	620 - 630	0.88	60.04
140 - 150	0.50	6.50	630 - 640	0.88	60.92
150 - 160	0.50	7.00	640 - 650	0.72	61.64
160 - 170	0.60	7.60	650 - 660	0.72	62.36
170 - 180	0.60	8.20	660 - 670	0.72	63.08
180 - 190	0.60	8.80	670 - 680	0.72	63.80
190 - 200	0.60	9.40	680 - 690	0.72	64.52
200 - 210	0.60	10.00	690 - 700	0.72	65.24
210 - 220	0.60	10.60	700 - 710	0.72	65.96
220 - 230	0.70	11.30	710 - 720	0.72	66.68
230 - 240	0.70	12.00	720 - 730	0.72	67.40
240 - 250	0.70	12.70	730 - 740	0.72	68.12
250 - 260	0.70	13.40	740 - 750	0.72	68.84
260 - 270	0.70	14.10	750 - 760	0.72	69.56
270 - 280	0.70	14.80	760 - 770	0.57	70.13
280 - 290	0.82	15.62	770 - 780	0.57	70.70
290 - 300	0.82	16.44	780 - 790	0.57	71.27
300 - 310	0.82	17.26	790 - 800	0.57	71.84
310 - 320	0.82	18.08	800 - 810	0.57	72.41
320 - 330	0.82	18.90	810 - 820	0.57	72.98
330 - 340	0.82	19.72	820 - 830	0.57	73.55
340 - 350	0.95	20.67	830 - 840	0.57	74.12
350 - 360	0.95	21.62	840 - 850	0.57	74.69
360 - 370	0.95	22.57	850 - 860	0.57	75.26
370 - 380	0.95	23.52	860 - 870	0.57	75.83
380 - 390	0.95	24.47	870 - 880	0.57	76.40
390 - 400	0.95	25.42	880 - 890	0.50	76.90
400 - 410	1.33	26.76	890 - 900	0.50	77.40
410 - 420	1.33	28.10	900 - 910	0.50	77.90
420 - 430	1.33	29.44	910 - 920	0.50	78.40
430 - 440	1.80	31.24	920 - 930	0.50	78.90
440 - 450	1.80	33.04	930 - 940	0.50	79.40
450 - 460	3.40	36.44	940 - 950	0.50	79.90
460 - 470	5.40	41.84	950 - 960	0.50	80.40
470 - 480	2.70	44.54	960 - 970	0.50	80.90
480 - 490	1.80	46.34	970 - 980	0.50	81.40

TABLE 3.5.1A 24-HOUR DESIGN STORM HYETOGRAPH VALUES

Time From Beginning of Storm (Min.)	Percent Rainfall	Cumulative Percent Rainfall
980 - 990	0.50	81.90
990 - 1000	0.50	82.40
1000 - 1010	0.40	82.80
1010 - 1020	0.40	83.20
1020 - 1030	0.40	83.60
1030 - 1040	0.40	84.00
1040 - 1050	0.40	84.40
1050 - 1060	0.40	84.80
1060 - 1070	0.40	85.20
1070 - 1080	0.40	85.60
1080 - 1090	0.40	86.00
1090 - 1100	0.40	86.40
1100 - 1110	0.40	86.80
1110 - 1120	0.40	87.20
1120 - 1130	0.40	87.60
1130 - 1140	0.40	88.00
1140 - 1150	0.40	88.40
1150 - 1160	0.40	88.80
1160 - 1170	0.40	89.20
1170 - 1180	0.40	89.60
1180 - 1190	0.40	90.00
1190 - 1200	0.40	90.40
1200 - 1210	0.40	90.80
1210 - 1220	0.40	91.20
1220 - 1230	0.40	91.60
1230 - 1240	0.40	92.00
1240 - 1250	0.40	92.40
1250 - 1260	0.40	92.80
1260 - 1270	0.40	93.20
1270 - 1280	0.40	93.60
1280 - 1290	0.40	94.00
1290 - 1300	0.40	94.40
1300 - 1310	0.40	94.80
1310 - 1320	0.40	95.20
1320 - 1330	0.40	95.60
1330 - 1340	0.40	96.00
1340 - 1350	0.40	96.40
1350 - 1360	0.40	96.80
1360 - 1370	0.40	97.20
1370 - 1380	0.40	97.60
1380 - 1390	0.40	98.00
1390 - 1400	0.40	98.40
1400 - 1410	0.40	98.80
1410 - 1420	0.40	99.20
1420 - 1430	0.40	99.60
1430 - 1440	0.40	100.00

FIGURE 3.5.1B 100-YEAR 7-DAY HYETOGRAPH



100 YEAR - 7 DAY HYETOGRAPH
SCS TYPE 1A DISTRIBUTION
RESOLVED TO 1 HOUR TIME STEPS

TABLE 3.5.1B 100-YEAR, 7-DAY DESIGN STORM HYETOGRAPH VALUES

Time From Beginning of Storm (Hr.)	Percent Rainfall	Cumulative Percent Rainfall
0 - 1	0.34	0.34
1 - 2	0.34	0.68
2 - 3	0.34	1.02
3 - 4	0.34	1.36
4 - 5	0.34	1.70
5 - 6	0.34	2.04
6 - 7	0.34	2.38
7 - 8	0.34	2.72
8 - 9	0.34	3.06
9 - 10	0.34	3.40
10 - 11	0.34	3.74
11 - 12	0.34	4.08
12 - 13	0.43	4.51
13 - 14	0.43	4.94
14 - 15	0.43	5.37
15 - 16	0.43	5.80
16 - 17	0.43	6.23
17 - 18	0.43	6.66
18 - 19	0.43	7.09
19 - 20	0.51	7.60
20 - 21	0.51	8.11
21 - 22	0.51	8.62
22 - 23	0.51	9.13
23 - 24	0.51	9.64
24 - 25	0.51	10.15
25 - 26	0.51	10.66
26 - 27	0.60	11.26
27 - 28	0.60	11.86
28 - 29	0.60	12.46
29 - 30	0.60	13.06
30 - 31	0.60	13.66
31 - 32	0.60	14.26
32 - 33	0.60	14.86
33 - 34	0.70	15.56
34 - 35	0.70	16.26
35 - 36	0.70	16.96
36 - 37	0.70	17.66
37 - 38	0.70	18.36
38 - 39	0.70	19.06
39 - 40	0.70	19.76
40 - 41	0.81	20.57
41 - 42	0.81	21.38
42 - 43	0.81	22.19
43 - 44	0.81	23.00
44 - 45	0.81	23.81
45 - 46	0.81	24.62
46 - 47	0.81	25.43
47 - 48	1.15	26.58
48 - 49	1.15	27.73
49 - 50	1.15	28.88
50 - 51	1.54	30.42
51 - 52	1.54	31.96
52 - 53	2.20	34.16
53 - 54	3.30	37.46
54 - 55	4.70	42.16
55 - 56	2.30	44.46
56 - 57	1.54	46.00
57 - 58	1.15	47.15
58 - 59	1.15	48.30
59 - 60	1.15	49.45
60 - 61	1.15	50.60
61 - 62	0.75	51.35
62 - 63	0.75	52.10
63 - 64	0.75	52.85
64 - 65	0.75	53.60
65 - 66	0.75	54.35
66 - 67	0.75	55.10
67 - 68	0.75	55.85
68 - 69	0.75	56.60
69 - 70	0.75	57.35
70 - 71	0.75	58.10
71 - 72	0.75	58.85
72 - 73	0.75	59.60
73 - 74	0.75	60.35
74 - 75	0.75	61.10
75 - 76	0.62	61.72
76 - 77	0.62	62.34
77 - 78	0.62	62.96
78 - 79	0.62	63.58
79 - 80	0.62	64.20
80 - 81	0.62	64.82
81 - 82	0.62	65.44
82 - 83	0.62	66.06
83 - 84	0.62	66.68
84 - 85	0.62	67.30
85 - 86	0.62	67.92
86 - 87	0.62	68.54
87 - 88	0.62	69.16
88 - 89	0.62	69.78
89 - 90	0.46	70.24
90 - 91	0.46	70.70
91 - 92	0.46	71.16
92 - 93	0.46	71.62
93 - 94	0.46	72.08
94 - 95	0.46	72.54
95 - 96	0.46	73.00
96 - 97	0.46	73.46
97 - 98	0.46	73.92
98 - 99	0.46	74.38

TABLE 3.5.1B 100-YEAR, 7-DAY DESIGN STORM HYETOGRAPH VALUES

Time From Beginning of Storm (Hr.)	Percent Rainfall	Cumulative Percent Rainfall
99 -100	0.46	74.84
100-101	0.46	75.30
101-102	0.46	75.76
102-103	0.46	76.22
103-104	0.46	76.68
104-105	0.46	77.14
105-106	0.46	77.60
106-107	0.46	78.06
107-108	0.46	78.52
108-109	0.46	78.98
109-110	0.46	79.44
110-111	0.46	79.90
111-112	0.46	80.36
112-113	0.46	80.82
113-114	0.46	81.28
114-115	0.46	81.74
115-116	0.46	82.20
116-117	0.46	82.66
117-118	0.34	83.00
118-119	0.34	83.34
119-120	0.34	83.68
120-121	0.34	84.02
121-122	0.34	84.36
122-123	0.34	84.70
123-124	0.34	85.04
124-125	0.34	85.38
125-126	0.34	85.72
126-127	0.34	86.06
127-128	0.34	86.40
128-129	0.34	86.74
129-130	0.34	87.08
130-131	0.34	87.42
131-132	0.34	87.76
132-133	0.34	88.10
133-134	0.34	88.44
134-135	0.34	88.78
135-136	0.34	89.12
136-137	0.34	89.46
137-138	0.34	89.80
138-139	0.34	90.14
139-140	0.34	90.48
140-141	0.34	90.82
141-142	0.34	91.16
142-143	0.34	91.50
143-144	0.34	91.84
144-145	0.34	92.18
145-146	0.34	92.52
146-147	0.34	92.86
147-148	0.34	93.20
148-149	0.34	93.54
149-150	0.34	93.88
150-151	0.34	94.22
151-152	0.34	94.56
152-153	0.34	94.90
153-154	0.34	95.24
154-155	0.34	95.58
155-156	0.34	95.92
156-157	0.34	96.26
157-158	0.34	96.60
158-159	0.34	96.94
159-160	0.34	97.28
160-161	0.34	97.62
161-162	0.34	97.96
162-163	0.34	98.30
163-164	0.34	98.64
164-165	0.34	98.98
165-166	0.34	99.32
166-167	0.34	99.66
167-168	0.34	100.00

FIGURE 3.5.1C 2-YEAR 24-HOUR ISOPLUVIALS

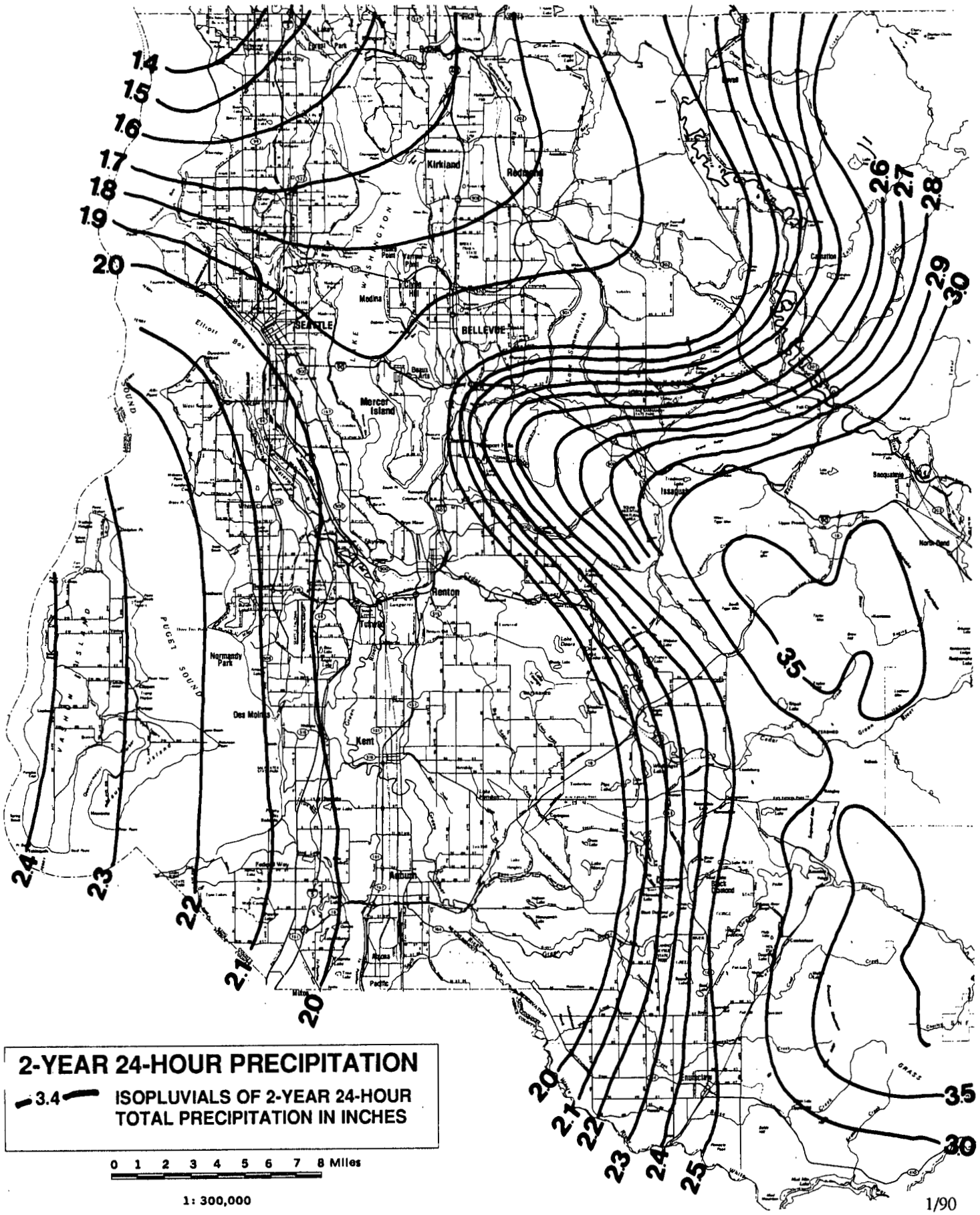


FIGURE 3.5.1D 5-YEAR 24-HOUR ISOPLUVIALS

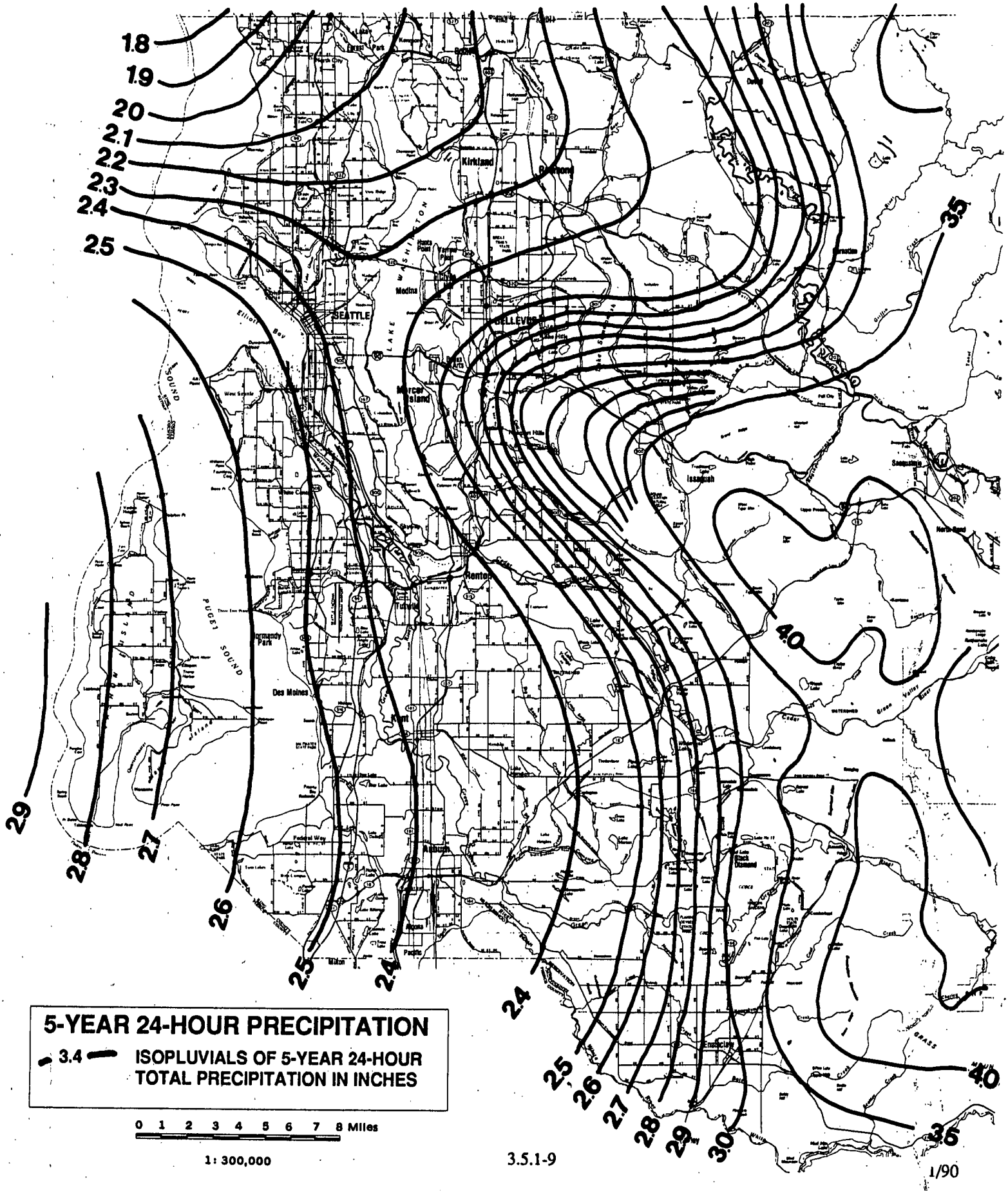


FIGURE 3.5.1E 10-YEAR 24-HOUR ISOPLUVIALS

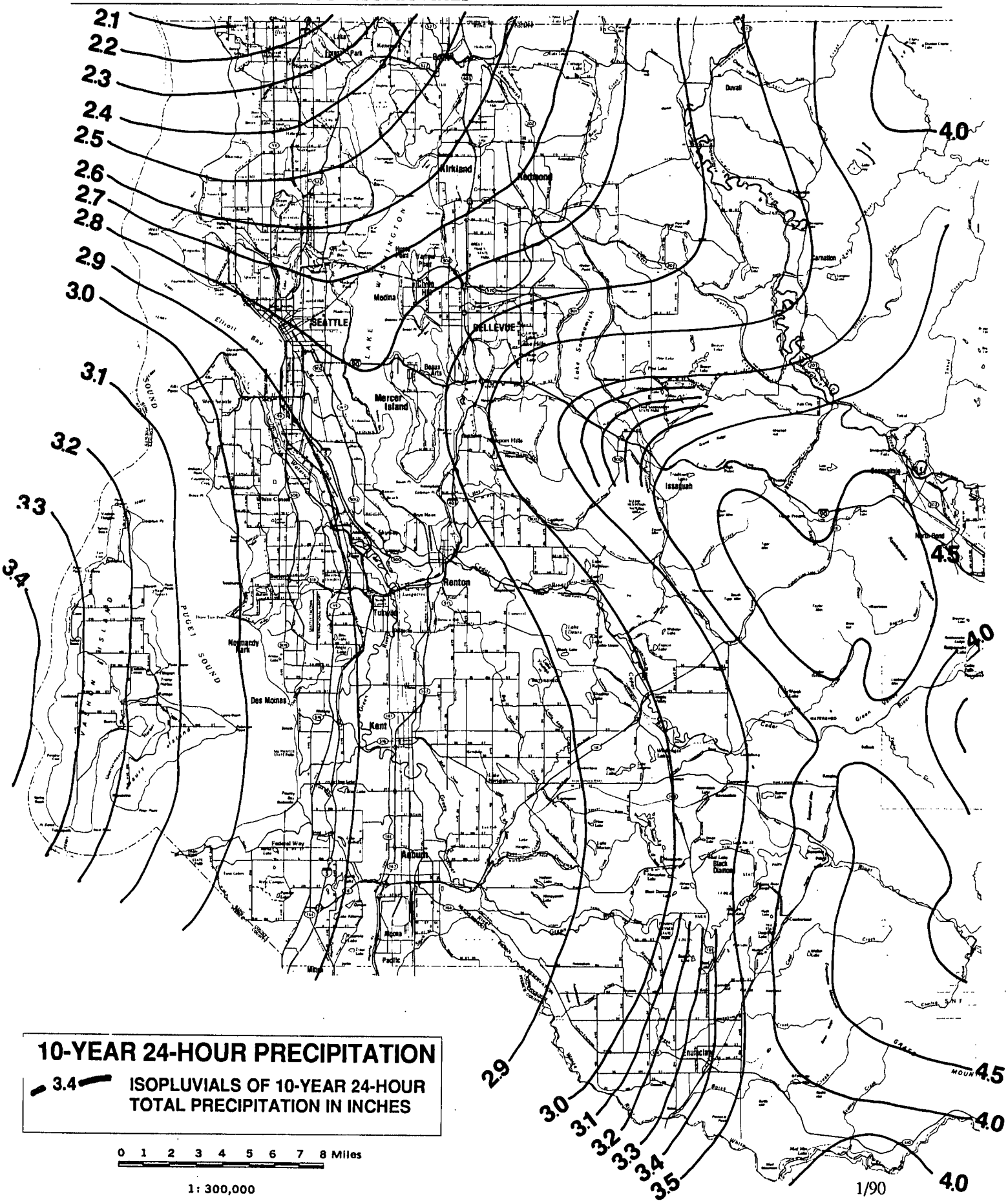


FIGURE 3.5.1F 25-YEAR 24-HOUR ISOPLUVIALS

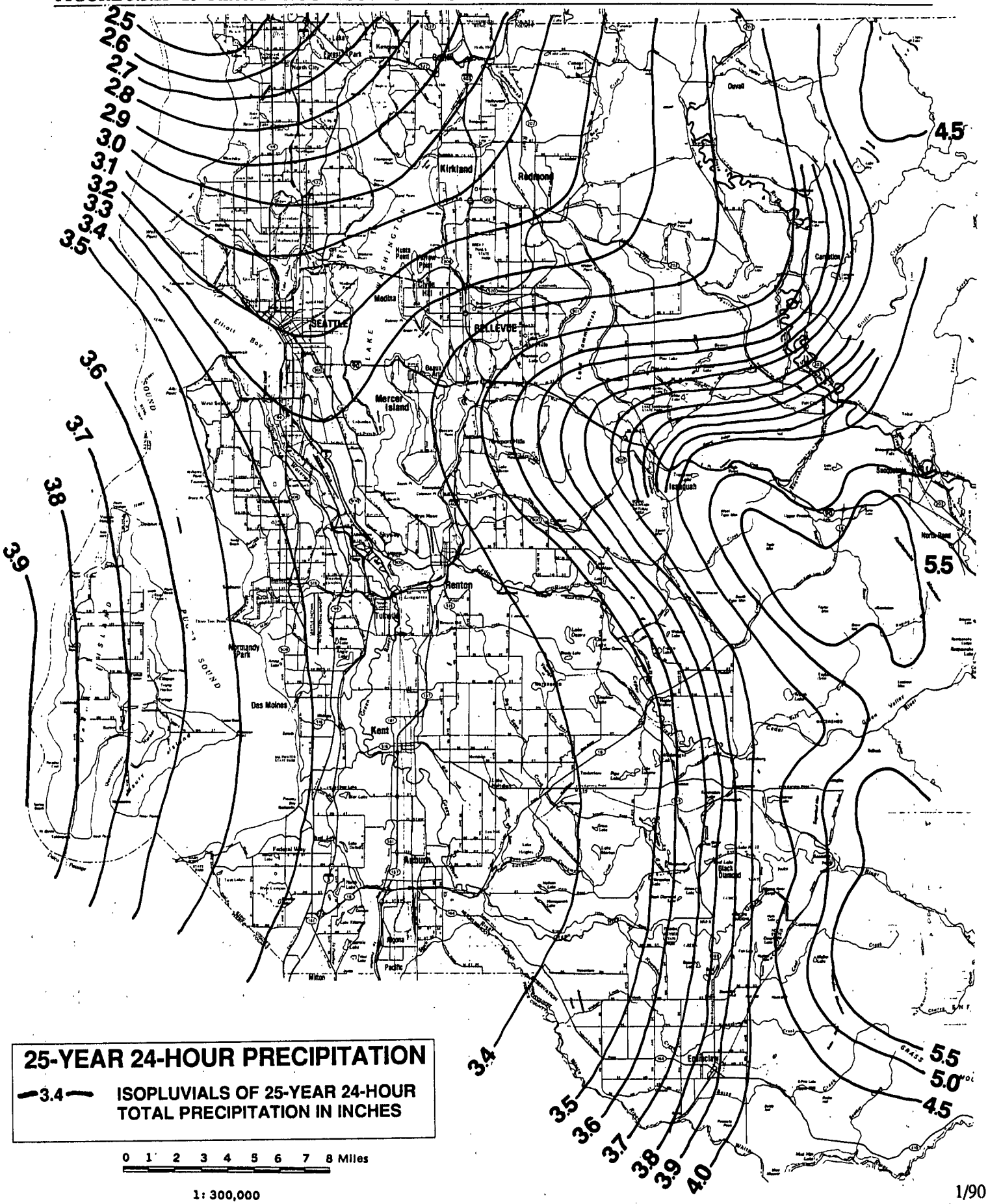


FIGURE 3.5.1G 50-YEAR 24-HOUR ISOPLUVIALS

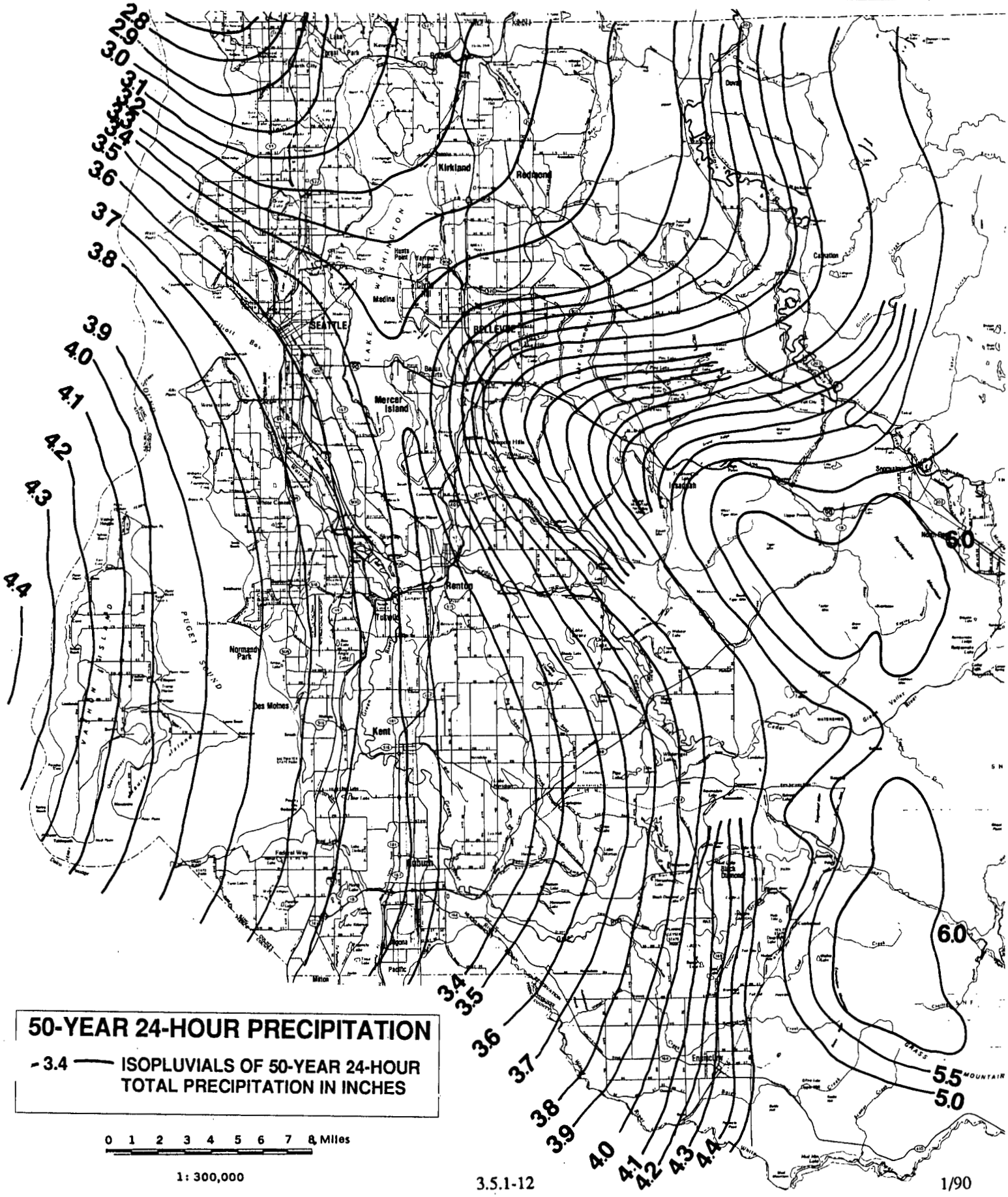


FIGURE 3.5.1H 100-YEAR 24-HOUR ISOPLUVIALS

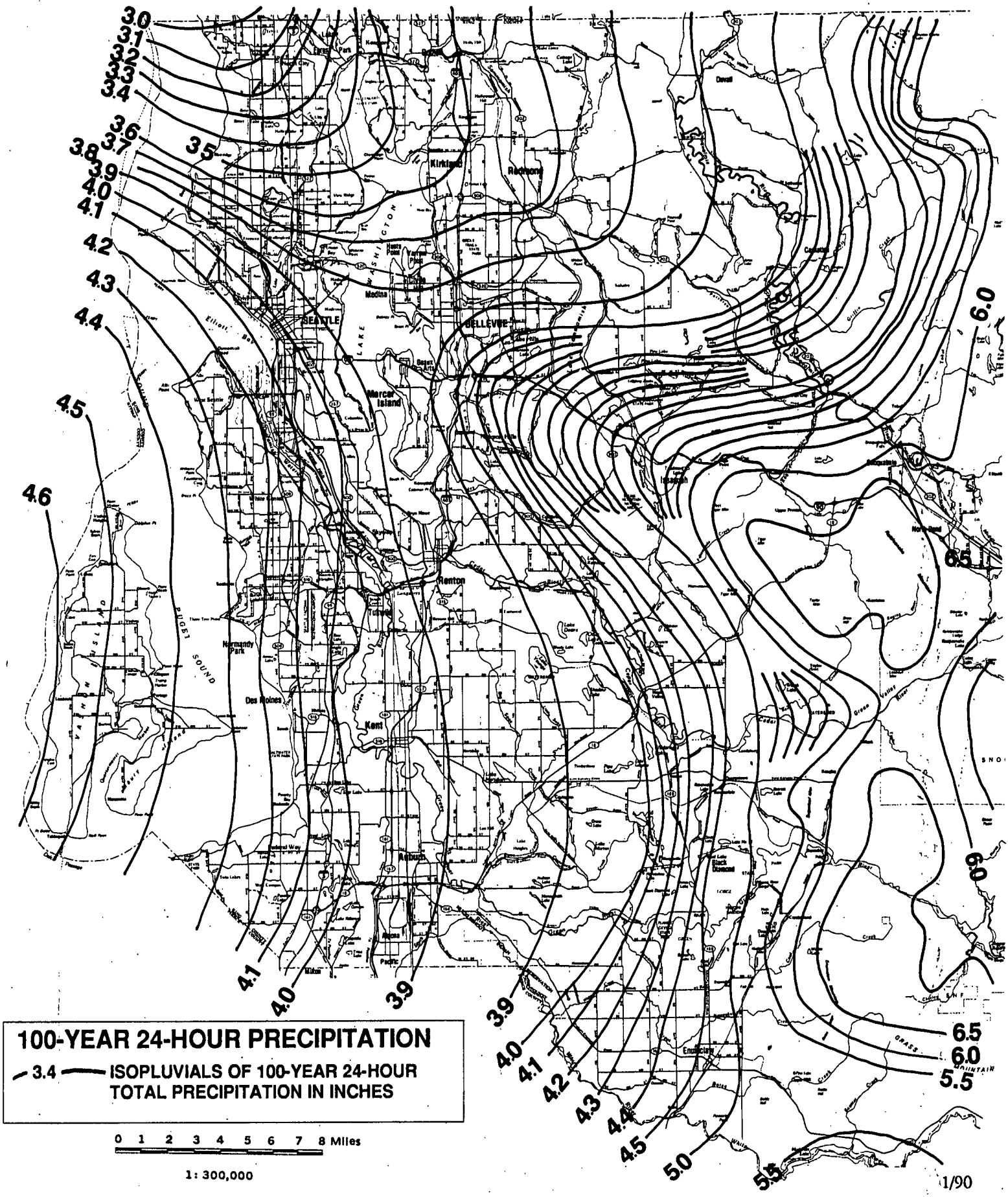
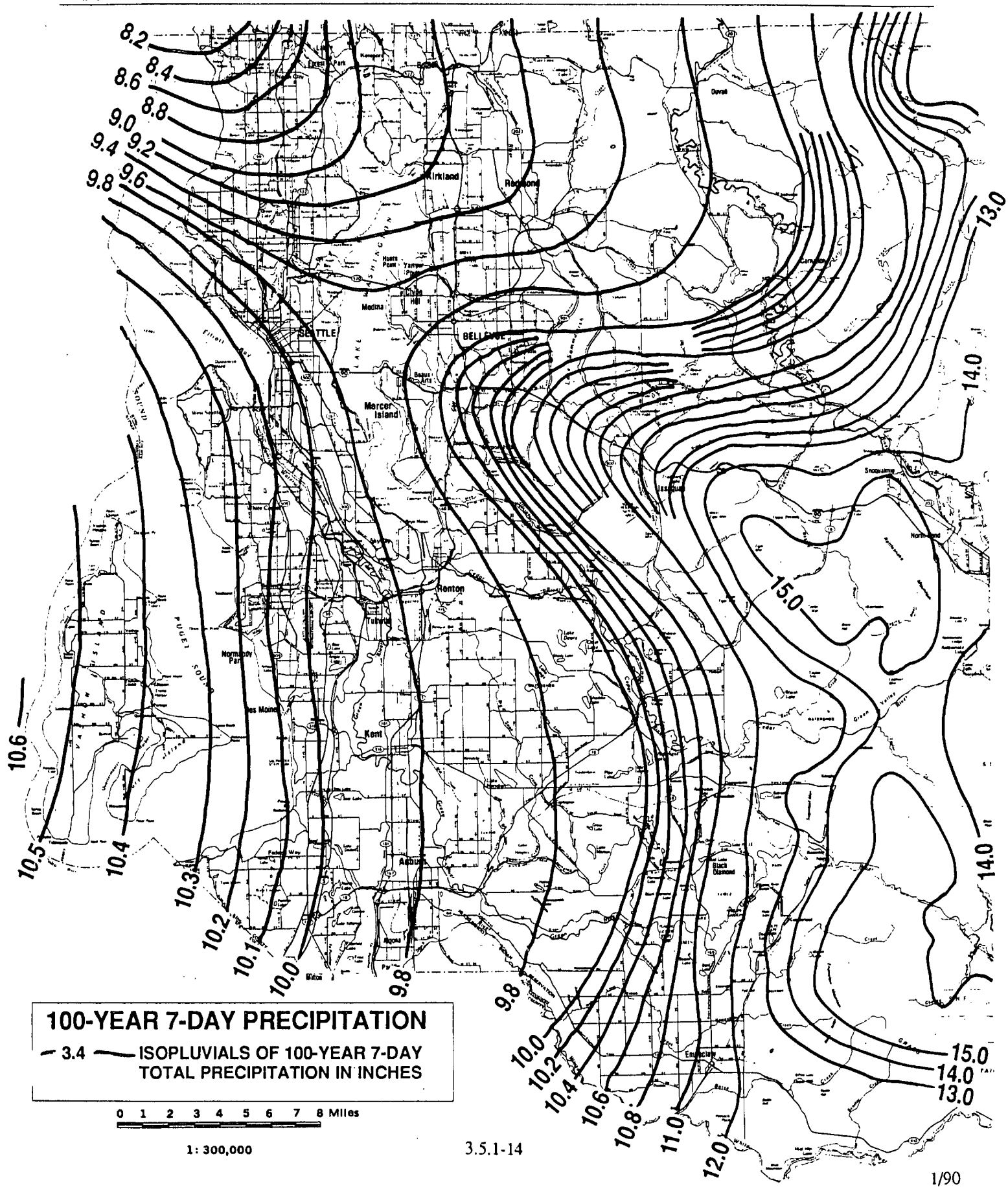


FIGURE 3.5.1I 100-YEAR 7-DAY ISOPLUVIALS



3.5.2 RUNOFF PARAMETERS

All storm event hydrograph methods require the input of parameters which describe the physical drainage basin characteristics. These parameters provide the basis from which the runoff hydrograph is developed. This section describes the three key parameters (area, curve number, and time of concentration) used to develop the runoff hydrograph using the method of hydrograph synthesis in Section 3.5.3.

Area

To obtain the highest degree of accuracy in hydrograph analysis requires the proper selection of homogeneous basin areas. Significant differences in land use within a given drainage basin must be addressed by dividing the basin area into subbasin areas of similar land use and/or runoff characteristics. For example, a drainage basin consisting of a concentrated residential area and a large forested area should be divided into two subbasin areas accordingly. Hydrographs should then be computed for each subbasin area and summed to form the total runoff hydrograph for the basin.

To further enhance the accuracy of hydrograph analysis, all pervious and impervious areas within a given basin or subbasin shall be analyzed separately. This may be done by either computing separate hydrographs for each area and combining them to form the total runoff hydrograph or, computing the precipitation excess for each area and combining the two to obtain the total precipitation excess which is then used to develop the runoff hydrograph (this procedure is performed automatically by the Santa Barbara Urban Hydrograph method explained further in Section 3.5.3, "Hydrograph Synthesis"). By analyzing pervious and impervious areas separately the errors associated with averaging these areas are avoided and the true shape of the runoff hydrograph is better approximated.

Curve Number

The Soil Conservation Service (SCS) has for many years conducted studies into the runoff characteristics of various land types. After gathering and analyzing extensive data, SCS has developed relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. These relationships have been characterized by a single runoff coefficient called a "curve number." The National Engineering Handbook - Section 4: Hydrology (NEH-4, SCS, August 1972) contains a detailed description of the development and use of the curve number method.

SCS has developed "curve number" (CN) values based on soil type and land use. The combination of these two factors is called the "soil-cover complex." The soil-cover complexes have been assigned to one of four hydrologic soil groups, according to their runoff characteristics. SCS has classified over 4,000 soil types into these four soil groups. Table 3.5.2A shows the hydrologic soil group of the most common soils in King County and provides a brief description of the four hydrologic soil group classifications.

Table 3.5.2B shows the CN's, by land use description, for the four hydrologic soil groups found in King County. These numbers are for a 24-hour duration storm and typical antecedent soil moisture conditions preceding 24-hour storms in Western Washington. Note these CN's are not, therefore, "average," but rather calibrated by the SCS for Western Washington and should not be used with "wet" or "dry" modifications when following the method as applied in this manual. If using the SCS method calibrated to actual rainfall and/or runoff data, then start with the original SCS CN's published in TR-55 and make modifications as necessary.

The following are important criteria/considerations for selection of CN values:

(1) Many factors may affect the CN value for a given land use. For example, the movement of heavy equipment over bare ground may compact the soil so that it has a lesser infiltration rate and greater runoff potential than would be indicated by strict application of the CN value based on predevelopment conditions at the site.

(2) CN values can be area weighted when they apply to pervious areas of similar CN's (within 20 CN points). However, high CN areas should not be combined with low CN areas (unless the low CN areas are less than 15% of the subbasin). In this case, separate hydrographs should be generated and summed to form one hydrograph.

FIGURE 3.5.2A HYDROLOGIC SOIL GROUP OF THE SOILS IN KING COUNTY

SOIL GROUP	HYDROLOGIC GROUP*	SOIL GROUP	HYDROLOGIC GROUP*
Alderwood	C	Orcas Peat	D
Arents, Alderwood Material	C	Oridia	D
Arents, Everett Material	B	Ovall	C
Beausite	C	Pilchuck	C
Bellingham	D	Puget	D
Briscot	D	Puyallup	B
Buckley	D	Ragnar	B
Coastal Beaches	Variable	Renton	D
Earlmont Silt Loam	D	Riverwash	Variable
Edgewick	C	Salal	C
Everett	A/B	Sammamish	D
Indianola	A	Seattle	D
Kitsap	C	Shacar	D
Klaus	C	Si Silt	C
Mixed Alluvial Land	Variable	Snohomish	D
Neilton	A	Sultan	C
Newberg	B	Tukwila	D
Nooksack	C	Urban	Variable
Normal Sandy Loam	D	Woodinville	D

HYDROLOGIC SOIL GROUP CLASSIFICATIONS

A. (Low runoff potential). Soils having high infiltration rates, even when thoroughly wetted, and consisting chiefly of deep, well-to-excessively drained sands or gravels. These soils have a high rate of water transmission.

B. (Moderately low runoff potential). Soils having moderate infiltration rates when thoroughly wetted, and consisting chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. (Moderately high runoff potential). Soils having slow infiltration rates when thoroughly wetted, and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

* From SCS, TR-55, Second Edition, June 1986, Exhibit A-1. Revisions made from SCS, Soil Interpretation Record, Form #5, September 1988.

TABLE 3.5.2B SCS WESTERN WASHINGTON RUNOFF CURVE NUMBERS

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 and grasslands	74	82	89	92
Meadow or pasture:		65	78	85	89
Wood or forest land:	undisturbed or older second growth	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% or more of the area	68	80	86	90
fair condition:	grass cover on 50% to 75% of the area	77	85	90	92
Gravel roads and parking lots		76	85	89	91
Dirt roads and 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)				
1.0 DU/GA	15	Separate curve number shall be selected for pervious and impervious portion of the site or basin			
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				
Planned unit developments, condominiums, apartments, commercial business and industrial areas.	% impervious must be computed				

(1) For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 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.

(3) Separate CN values must be selected for the pervious and impervious areas of an urban basin or subbasin. For single family residential areas the percent impervious given in Table 3.5.2B shall be used to compute the respective pervious and impervious areas. For proposed commercials, P.U.D.'s etc., the percent impervious must be computed from the site plan. For all other land uses the percent impervious must be estimated from best available aerial topography and/or field reconnaissance. The pervious area CN value shall be a weighted average of all the pervious area CN's within the subbasin. The impervious area CN value shall be 98.

(4) For storm duration other than 24 hours, an adjustment must be made to the CN values given in Table 3.5.2B. Based on information obtained from SCS, the following equation shall be used for adjusting these CN's for the 7-day design storm:

$$CN_{7\text{-day}} = 0.1549\ CN + 0.8451\ ((CN^{2.365}/631.8) + 15)$$

Example: The following is an example of how CN values are selected for a sample project.

Select CN's for the following development:

Existing Land Use	--	forest (undisturbed)
Future Land Use	--	residential plat (3.6 DU/GA)
Basin Size	--	10 acres
Soil Type	--	80% Alderwood, 20% Ragnar

Table 3.5.2A shows that Alderwood soil belongs to the "C" hydrologic soil group and Ragnar soil belongs to the "B" group. Therefore, for the existing condition, CN's of 76 and 64 are read from Table 3.5.2B and area weighted to obtain a CN value of 74. For the developed condition with 3.6 DU/GA the percent impervious of 39 percent is interpolated from Table 3.5.2B and used to compute pervious and impervious areas of 6.1 acres and 3.9 acres respectively. The 6.1 acres of pervious area consists of yards and lawns covering the same proportions of Alderwood and Ragnar soil (80 percent and 20 percent respectively). Therefore, CN's of 90 and 85 are read from Table 3.5.2B and area weighted to obtain a pervious area CN value of 89. The impervious area CN-value is 98. The result of this example are summarized below:

On-Site Condition	Existing	Developed
Land use	Forest	Residential
Pervious area	10 ac.	6.1 ac.
CN of pervious area	74	89
Impervious area	0 ac	3.9 ac
CN of impervious area	---	98

SCS Curve Number Equations

The rainfall-runoff equations of the SCS curve number method relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity, as follows:

$$Q_d = (P_R - 0.2S)^2 / (P_R + 0.8S) \text{ for } P_R \geq 0.2S$$

and $$Q_d = 0 \quad \text{for } P_R < 0.2S$$

where

Q_d = runoff depth in inches over the area,
P_R = precipitation depth in inches over the area, and
S = potential maximum natural detention, in inches over the area, due to infiltration, storage, etc.

The area's potential maximum detention, S, is related to its curve number, CN:

$$S = (1000 / CN) - 10$$

The combination of the above equations allows for estimation of the total runoff volume by computing the total runoff depth, Q_d, given the total precipitation depth, P_R. For example, if the curve number of the area is 70, then the value of S is 4.29. With a total precipitation for the design event of 2.0 inches, the total runoff depth would be:

$$Q_d = [2.0 - 0.2\,(4.29)]^2 / [2.0 + 0.8\,(4.29)] = \underline{0.24 \text{ inches}}$$

This computed runoff represents inches over the tributary area. Therefore, the total volume of runoff is found by multiplying Q_d by the area (with necessary conversions):

Total runoff Volume (cu-ft)	=	3,630 (cu-ft/ac-in)	X	Q_d (in)	X	A (ac)

If the area is 10 acres, the total runoff volume is:

3,630 cu. ft./acre-in. x 0.24 in. x 10 acres = <u>8,712 cu. ft.</u>

When developing the runoff hydrograph, the above equation for Q_d is used to compute the incremental runoff depth for each time interval from the incremental precipitation depth given by the design storm hyetograph. This time distribution of runoff depth is often referred to as the precipitation excess and provides the basis for synthesizing the runoff hydrograph.

Travel Time and Time of Concentration for Use in Hydrograph Analysis
(based on the methods described in Chapter 3, SCS publication 210-VI-TR-55, Second Ed., June 1986)

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system. T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{60\,V} \quad \text{[Travel Time Equation]}$$

where

T_t = travel time (min)
L = flow length (ft)
V = average velocity (ft/s), and
60 = conversion factor from seconds to minutes.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments.

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m}$$

where

T_c = time of concentration (min), and
m = number of flow segments

Sheet Flow: Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (n_s) (a modified Manning's effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment) is used. These n_s values are for very shallow flow depths of about 0.1 foot and are only used for travel lengths up to 300 feet. Table 3.5.2.C gives Manning's n_s values for sheet flow for various surface conditions.

For sheet flow up to 300 feet, use Manning's kinematic solution to directly compute T_t:

$$\text{Sheet flow: } T_t = \frac{0.42\,(n_s L)^{0.8}}{(P_2)^{0.5}\,(s_o)^{0.4}}$$

where

T_t = travel time (min),
n_s = sheet flow Manning's effective roughness coefficient (from Table 3.5.2C),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), (see Figure 3.5.1C) and
s_o = slope of hydraulic grade line (land slope, ft/ft)

Velocity Equation

A commonly used method of computing average velocity of flow, once it has measurable depth, is the following equation:

$$V = k\sqrt{s_o}$$

where:

V = velocity (ft/s)
k = time of concentration velocity factor (ft/s)
s_o = slope of flow path (ft/ft)

"k" is computed for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation:

$$k = (1.49\,(R)^{0.667})/n;$$

where

R = an assumed hydraulic radius
n = Manning's roughness coefficient for open channel flow (from Table 4.3.7B in Chapter 4)

TABLE 3.5.2C "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 hard packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s <= 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=0.025)	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 pipes	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**

**See Chapter 5, Table 5.3.6C for additional Mannings "n" values for open channels

Shallow Concentrated Flow: After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values from Table 3.5.2C in which average velocity is a function of watercourse slope and type of channel. After computing the average velocity using the Velocity Equation above, the travel time (T_t) for the shallow concentrated flow segment can be computed using the Travel Time Equation described above.

Open Channel Flow: Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangle sheets. The k_c values from Table 3.5.2C used in the Velocity Equation above or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full conditions. After average velocity is computed the travel time (T_t) for the channel segment can be computed using the Travel Time Equation above.

Lakes or Wetlands: Sometimes it is necessary to estimate the velocity of flow through a lake or wetland at the outlet of a watershed. This travel time is normally very small and can be assumed as zero. Where significant attenuation may occur due to storage effects, the flows should be routed using the "level pool routing" technique described in Section 3.5.4.

Limitations: The following limitations apply in estimating travel time (T_t).

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and the "level pool routing" technique described in Section 3.5.4 should be used to determine the outflow rating curve through the culvert or bridge.

Example: The following is an example of travel time and time of concentration calculations.

Given: An existing drainage basin having a selected flow route composed of the following 5 segments:

(Note: Drainage basin is in Federal Way and has a P_2 = 2.1 inches, from Figure 3.5.1C.)

Segment 1: L = 200 ft, Forest with dense brush (sheet flow)
s_o = 0.03 ft/ft, n_s = 0.80

Segment 2: L = 300 ft, Pasture (shallow concentrated flow)
s_o = 0.04 ft/ft, k_s = 11

Segment 3: L = 50 ft, Small pond (year around)
s_o = 0.00 ft/ft, k_c = 0

Segment 4: L = 300 ft, Grassed waterway (intermittent channel)
s_o = 0.05, k_c = 17

Segment 5: L = 500 ft, Grass-lined stream (continuous)
s_o = 0.02, k_c = 27

Calculate travel times (T_t's) for each reach and then sum them to calculate the drainage basin time of concentration (T_c).

Segment 1: Sheet flow, $T_t = \dfrac{0.42\,(n_s L)^{0.8}}{(P_2)^{0.5}\,(s_o)^{0.4}}$

(L < 300 feet)

$$T_1 = \frac{(0.42)\,[(0.80)(200)]^{0.8}}{(2.1)^{0.5}\,(0.03)^{0.4}} = \underline{68 \text{ minutes}}$$

Segment 2: Shallow concentrated flow $V = k_s \sqrt{s_o}$

$$V_2 = (11)\sqrt{(0.04)} = 2.2 \text{ ft/s}$$

$$T_2 = \frac{L}{60V} = \frac{(300)}{60(2.2)} = \underline{2 \text{ minutes}}$$

Segment 3: Flat water surface

$$T_3 = \underline{0 \text{ minutes}}$$

Segment 4: Intermittent channel flow

$$V_4 = (17)\sqrt{(0.05)} = 3.8 \text{ ft/s}$$

$$T_4 = \frac{(300)}{60(3.8)} = \underline{1 \text{ minute}}$$

Segment 5: Continuous stream

$$V_5 = (27)\sqrt{(0.02)} = 3.8 \text{ ft/s}$$

$$T_5 = \frac{(500)}{60(3.8)} = \underline{2 \text{ minutes}}$$

$$T_c = T_1 + T_2 + T_3 + T_4 + T_5$$

$$T_c = 68 + 2 + 0 + 1 + 2 = \underline{73 \text{ minutes}}$$

It is important to note how the initial sheet flow segment's travel time dominates the time of concentration computation. This will nearly always be the case for relatively small drainage basins and in particular for the existing site conditions. This also illustrates the significant impact urbanization has on the surface runoff portion of the hydrologic process.

3.5.3 HYDROGRAPH SYNTHESIS

This section presents a description of the hydrograph methods used to synthesize the runoff hydrograph from precipitation excess (time distribution of runoff depth) and time of concentration.

King County the SWM Division staff have used and tested two similar hydrograph methods: the Soil Conservation Service Unit Hydrograph (SCSUH) method and the Santa Barbara Urban Hydrograph (SBUH) method. Both methods are based on the SCS Curve Number (CN) approach and utilize basic SCS equations for computing soil absorption and precipitation excess. The SCSUH method works by converting the incremental runoff depths (precipitation excess) for a given basin and design storm into unit hydrographs of equal time base according to basin time of concentration and adds them to form the total runoff hydrograph. The SBUH method, on the other hand, converts the incremental runoff depths into

instantaneous hydrographs which are then routed through an imaginary reservoir with a time delay equal to the basin time of concentration. Based on comparison of both methods, King County the SWM Division staff have found the SBUH method to be the more consistent and better suited for analysis of relatively small subbasins. Therefore, the SBUH method has been chosen as the "yard stick" method for hydrograph analysis in King County. (Note, no field testing has been conducted of this method, however, data is being collected that may be useful in calibrating the parameters locally.)

Other hydrograph methods will be accepted if they can be shown to provide consistent and reasonable results similar to the SBUH method. The SCSUH method, also known as the SCS TR-20 method, and others will be acceptable within the limitations given in Figure 3.2A.

The Santa Barbara Urban Hydrograph Method

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District, California. The SBUH method directly computes a runoff hydrograph without going through an intermediate process (unit hydrograph) as the SCSUH method does. By comparison, the calculation steps of the SBUH method are much simpler and can be programmed on a calculator or a spreadsheet program.

The SBUH method uses two steps to synthesize the runoff hydrograph:

Step one - computing the instantaneous hydrograph, and

Step two - computing the runoff hydrograph.

The instantaneous hydrograph, I(t), in cfs, at each time step, dt, is computed as follows:

$$I(t) = 60.5\ R(t)\ A/dt$$

where

R(t) = total runoff depth (both impervious and pervious runoffs) at time increment dt, in inches (also known as precipitation excess)

A = area in acres

dt = time interval in minutes*

*NOTE: A maximum time interval of 10 minutes will be used for all design storms of 24-hour duration. A maximum time interval of 60 minutes will be used for the 100-year, 7-day design storm.

The runoff hydrograph, Q(t), is then obtained by routing the instantaneous hydrograph I(t), through an imaginary reservoir with a time delay equal to the time of concentration, Tc, of the drainage basin. The following equation estimates the routed flow, Q(t):

$$Q(t+1) = Q(t) + w[I(t) + I(t+1) - 2Q(t)]$$

where,

$w = dt/(2Tc + dt)$, dt = time interval in minutes

Example: To illustrate the SBUH method, Figure 3.5.3A shows a runoff hydrograph computed by this method. Note, this example was prepared using the LOTUS 123 spreadsheet program and illustrates how well the method can be performed with a personal computer.

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 1

Compute: Existing Runoff Hydrograph

Given: East Kent Hill Project

Total Project Area	
At =	10 acres
Pt =	2.9 inches
dt =	10 min
Tc =	73 min
w =	0.064 =dt / (2*Tc+dt)

Pervious Area	Impervious Area	units
Ap = 10.00	Ai = 0.00	acres
CNp = 74	CNi = 98	
Sp = 3.51	Si = 0.20	inches
0.2Sp = 0.70	0.2Si = 0.04	inches

Equations:

Col.[2]= Previous Col.[2] + dt = Time Elapsed
Col.[3]= SCS Type 1A Rainfall Distribution (24-hour Table 3.5.1A)
Col.[4]= Col.[3] * Pt = 10-year, 24-hour Hyetograph = Incremental Rainfall
Col.[5]= Previous Col.[4] + Present Col.[3] = Accumulated Rainfall
Col.[6]= If Col.[5]<=0.2Sp, then = 0.0, else = (Col.[5]-0.2Sp)^2 / (Col.[5] +0.8Sp)
Col.[7]= Present Col.[6] - Previous Col.[6] = Perv. Area Incremental Runoff
Col.[8]= If Col.[5]<=0.2Si, then = 0.0, else = (Col.[5]-0.2Si)^2 / (Col.[5]+0.8Si)
Col.[9]= Present Col.[8] - Previous Col.[8] = Imp. Area Incremental Runoff
Col.[10]= ((Ap/At) * Col.[7]) + ((Ai/At) * Col.[9]) = Total Project Runoff
Col.[11]= (60.5 * Col.[10] * At) / dt = Instant Hydrograph
Col.[12]= Previous Col.[12] + w * (Previous Col.[11] + Present Col.[11] - 2 * Previous Col.[12])
Volume= Sum of Col.[12] * dt * (60 sec./min.)

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs		
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distribution % of Pt	[4] Incremental Rainfall inches	[5] Accumulated Rainfall inches	[6] Accumulated Runoff inches	[7] Incremental Runoff inches	[8] Accumulated Runoff inches	[9] Incremental Runoff inches	[10] Total Project Runoff inches	[11] Instant Hydrograph cfs	[12] Design Hydrograph cfs
0	0	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
1	10	0.40	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.00	0.00
2	20	0.40	0.012	0.023	0.000	0.000	0.000	0.000	0.000	0.00	0.00
3	30	0.40	0.012	0.035	0.000	0.000	0.000	0.000	0.000	0.00	0.00
4	40	0.40	0.012	0.046	0.000	0.000	0.000	0.000	0.000	0.00	0.00
5	50	0.40	0.012	0.058	0.000	0.000	0.001	0.001	0.000	0.00	0.00
6	60	0.40	0.012	0.070	0.000	0.000	0.004	0.002	0.000	0.00	0.00
7	70	0.40	0.012	0.081	0.000	0.000	0.007	0.003	0.000	0.00	0.00
8	80	0.40	0.012	0.093	0.000	0.000	0.011	0.004	0.000	0.00	0.00
9	90	0.40	0.012	0.104	0.000	0.000	0.015	0.005	0.000	0.00	0.00
10	100	0.40	0.012	0.116	0.000	0.000	0.020	0.005	0.000	0.00	0.00
11	110	0.50	0.015	0.131	0.000	0.000	0.027	0.007	0.000	0.00	0.00
12	120	0.50	0.015	0.145	0.000	0.000	0.035	0.008	0.000	0.00	0.00
13	130	0.50	0.015	0.160	0.000	0.000	0.044	0.008	0.000	0.00	0.00
14	140	0.50	0.015	0.174	0.000	0.000	0.053	0.009	0.000	0.00	0.00
15	150	0.50	0.015	0.189	0.000	0.000	0.062	0.009	0.000	0.00	0.00
16	160	0.50	0.015	0.203	0.000	0.000	0.072	0.010	0.000	0.00	0.00
17	170	0.60	0.017	0.220	0.000	0.000	0.084	0.012	0.000	0.00	0.00
18	180	0.60	0.017	0.238	0.000	0.000	0.097	0.013	0.000	0.00	0.00
19	190	0.60	0.017	0.255	0.000	0.000	0.110	0.013	0.000	0.00	0.00
20	200	0.60	0.017	0.273	0.000	0.000	0.123	0.013	0.000	0.00	0.00
21	210	0.60	0.017	0.290	0.000	0.000	0.137	0.014	0.000	0.00	0.00
22	220	0.60	0.017	0.307	0.000	0.000	0.151	0.014	0.000	0.00	0.00
23	230	0.70	0.020	0.328	0.000	0.000	0.168	0.017	0.000	0.00	0.00
24	240	0.70	0.020	0.348	0.000	0.000	0.185	0.017	0.000	0.00	0.00
25	250	0.70	0.020	0.368	0.000	0.000	0.202	0.017	0.000	0.00	0.00
26	260	0.70	0.020	0.389	0.000	0.000	0.219	0.017	0.000	0.00	0.00
27	270	0.70	0.020	0.409	0.000	0.000	0.237	0.018	0.000	0.00	0.00
28	280	0.70	0.020	0.429	0.000	0.000	0.255	0.018	0.000	0.00	0.00
29	290	0.82	0.024	0.453	0.000	0.000	0.276	0.021	0.000	0.00	0.00
30	300	0.82	0.024	0.477	0.000	0.000	0.297	0.021	0.000	0.00	0.00
31	310	0.82	0.024	0.501	0.000	0.000	0.318	0.021	0.000	0.00	0.00
32	320	0.82	0.024	0.524	0.000	0.000	0.340	0.022	0.000	0.00	0.00
33	330	0.82	0.024	0.548	0.000	0.000	0.362	0.022	0.000	0.00	0.00
34	340	0.82	0.024	0.572	0.000	0.000	0.384	0.022	0.000	0.00	0.00
35	350	0.95	0.028	0.599	0.000	0.000	0.409	0.026	0.000	0.00	0.00

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 2

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs			
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distri-bution % of Pt	[4] Incre-mental Rainfall inches	[5] Accum-ulated Rainfall inches	[6] Accum-lated Runoff inches	[7] Incre-mental Runoff inches	[8] Accum-lated Runoff inches	[9] Incre-mental Runoff inches	[10] Total Project Runoff inches	[11] Instant Hydro-graph cfs	[12] Design Hydro-graph cfs	
36	360	0.95	0.028	0.627	0.000	0.000	0.435	0.026	0.000	0.00	0.00	
37	370	0.95	0.028	0.655	0.000	0.000	0.461	0.026	0.000	0.00	0.00	
38	380	0.95	0.028	0.682	0.000	0.000	0.486	0.026	0.000	0.00	0.00	
39	390	0.95	0.028	0.710	0.000	0.000	0.512	0.026	0.000	0.00	0.00	
40	400	0.95	0.028	0.737	0.000	0.000	0.539	0.026	0.000	0.02	0.00	
41	410	1.33	0.039	0.776	0.001	0.001	0.575	0.037	0.001	0.07	0.01	
42	420	1.33	0.039	0.814	0.003	0.002	0.612	0.037	0.002	0.12	0.02	
43	430	1.33	0.039	0.853	0.006	0.003	0.649	0.037	0.003	0.16	0.03	
44	440	1.80	0.052	0.905	0.011	0.005	0.699	0.050	0.005	0.29	0.06	
45	450	1.80	0.052	0.957	0.017	0.006	0.750	0.050	0.006	0.37	0.09	
46	460	3.40	0.099	1.056	0.032	0.015	0.845	0.096	0.015	0.91	0.16	
47	470	5.40	0.157	1.212	0.065	0.032	0.998	0.153	0.032	1.96	0.33	
48	480	2.70	0.078	1.291	0.084	0.020	1.075	0.077	0.020	1.19	0.49	
49	490	1.80	0.052	1.343	0.099	0.014	1.126	0.051	0.014	0.87	0.56	
50	500	1.34	0.039	1.382	0.110	0.011	1.164	0.038	0.011	0.68	0.59	
51	510	1.34	0.039	1.421	0.122	0.012	1.202	0.038	0.012	0.72	0.60	
52	520	1.34	0.039	1.460	0.134	0.012	1.240	0.038	0.012	0.74	0.62	
53	530	0.88	0.026	1.485	0.142	0.008	1.265	0.025	0.008	0.51	0.62	Q peak
54	540	0.88	0.026	1.511	0.151	0.009	1.291	0.025	0.009	0.52	0.60	
55	550	0.88	0.026	1.536	0.160	0.009	1.316	0.025	0.009	0.53	0.59	
56	560	0.88	0.026	1.562	0.169	0.009	1.341	0.025	0.009	0.54	0.59	
57	570	0.88	0.026	1.587	0.178	0.009	1.366	0.025	0.009	0.55	0.58	
58	580	0.88	0.026	1.613	0.187	0.009	1.391	0.025	0.009	0.56	0.58	
59	590	0.88	0.026	1.638	0.197	0.010	1.416	0.025	0.010	0.58	0.58	
60	600	0.88	0.026	1.664	0.206	0.010	1.442	0.025	0.010	0.59	0.58	
61	610	0.88	0.026	1.689	0.216	0.010	1.467	0.025	0.010	0.60	0.58	
62	620	0.88	0.026	1.715	0.226	0.010	1.492	0.025	0.010	0.61	0.58	
63	630	0.88	0.026	1.740	0.237	0.010	1.517	0.025	0.010	0.62	0.59	
64	640	0.88	0.026	1.766	0.247	0.010	1.543	0.025	0.010	0.63	0.59	
65	650	0.72	0.021	1.787	0.256	0.009	1.563	0.021	0.009	0.52	0.59	
66	660	0.72	0.021	1.808	0.264	0.009	1.584	0.021	0.009	0.53	0.58	
67	670	0.72	0.021	1.828	0.273	0.009	1.604	0.021	0.009	0.54	0.57	
68	680	0.72	0.021	1.849	0.282	0.009	1.625	0.021	0.009	0.54	0.57	
69	690	0.72	0.021	1.870	0.291	0.009	1.646	0.021	0.009	0.55	0.57	
70	700	0.72	0.021	1.891	0.300	0.009	1.666	0.021	0.009	0.55	0.56	
71	710	0.72	0.021	1.912	0.310	0.009	1.687	0.021	0.009	0.56	0.56	
72	720	0.72	0.021	1.933	0.319	0.009	1.708	0.021	0.009	0.57	0.56	
73	730	0.72	0.021	1.954	0.328	0.009	1.729	0.021	0.009	0.57	0.56	
74	740	0.72	0.021	1.975	0.338	0.010	1.749	0.021	0.010	0.58	0.57	
75	750	0.72	0.021	1.995	0.348	0.010	1.770	0.021	0.010	0.59	0.57	
76	760	0.72	0.021	2.016	0.358	0.010	1.791	0.021	0.010	0.59	0.57	
77	770	0.57	0.017	2.033	0.365	0.008	1.807	0.016	0.008	0.47	0.57	
78	780	0.57	0.017	2.049	0.373	0.008	1.823	0.016	0.008	0.48	0.55	
79	790	0.57	0.017	2.066	0.381	0.008	1.840	0.016	0.008	0.48	0.54	
80	800	0.57	0.017	2.082	0.389	0.008	1.856	0.016	0.008	0.48	0.54	
81	810	0.57	0.017	2.099	0.397	0.008	1.873	0.016	0.008	0.49	0.53	
82	820	0.57	0.017	2.116	0.405	0.008	1.889	0.016	0.008	0.49	0.52	
83	830	0.57	0.017	2.132	0.413	0.008	1.905	0.016	0.008	0.49	0.52	
84	840	0.57	0.017	2.149	0.422	0.008	1.922	0.016	0.008	0.50	0.52	
85	850	0.57	0.017	2.165	0.430	0.008	1.938	0.016	0.008	0.50	0.51	
86	860	0.57	0.017	2.182	0.438	0.008	1.955	0.016	0.008	0.50	0.51	
87	870	0.57	0.017	2.198	0.446	0.008	1.971	0.016	0.008	0.51	0.51	
88	880	0.57	0.017	2.215	0.455	0.008	1.987	0.016	0.008	0.51	0.51	
89	890	0.50	0.015	2.229	0.462	0.007	2.002	0.014	0.007	0.45	0.51	
90	900	0.50	0.015	2.244	0.470	0.007	2.016	0.014	0.007	0.45	0.50	
91	910	0.50	0.015	2.258	0.477	0.008	2.031	0.014	0.008	0.45	0.49	
92	920	0.50	0.015	2.273	0.485	0.008	2.045	0.014	0.008	0.46	0.49	
93	930	0.50	0.015	2.287	0.492	0.008	2.059	0.014	0.008	0.46	0.49	
94	940	0.50	0.015	2.302	0.500	0.008	2.074	0.014	0.008	0.46	0.48	
95	950	0.50	0.015	2.316	0.508	0.008	2.088	0.014	0.008	0.46	0.48	
96	960	0.50	0.015	2.331	0.516	0.008	2.103	0.014	0.008	0.47	0.48	

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 3

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs		
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distri-bution % of Pt	[4] Incre-mental Rainfall inches	[5] Accum-ulated Rainfall inches	[6] Accum-lated Runoff inches	[7] Incre-mental Runoff inches	[8] Accum-lated Runoff inches	[9] Incre-mental Runoff inches	[10] Total Project Runoff inches	[11] Instant Hydro-graph cfs	[12] Design Hydro-graph cfs
97	970	0.50	0.015	2.345	0.523	0.008	2.117	0.014	0.008	0.47	0.48
98	980	0.50	0.015	2.360	0.531	0.008	2.131	0.014	0.008	0.47	0.48
99	990	0.50	0.015	2.374	0.539	0.008	2.146	0.014	0.008	0.47	0.48
100	1000	0.50	0.015	2.389	0.547	0.008	2.160	0.014	0.008	0.48	0.48
101	1010	0.40	0.012	2.400	0.553	0.006	2.172	0.012	0.006	0.38	0.47
102	1020	0.40	0.012	2.412	0.559	0.006	2.183	0.012	0.006	0.38	0.46
103	1030	0.40	0.012	2.424	0.566	0.006	2.195	0.012	0.006	0.38	0.45
104	1040	0.40	0.012	2.435	0.572	0.006	2.206	0.012	0.006	0.39	0.44
105	1050	0.40	0.012	2.447	0.579	0.006	2.218	0.012	0.006	0.39	0.43
106	1060	0.40	0.012	2.458	0.585	0.006	2.229	0.012	0.006	0.39	0.43
107	1070	0.40	0.012	2.470	0.591	0.006	2.241	0.012	0.006	0.39	0.42
108	1080	0.40	0.012	2.482	0.598	0.006	2.252	0.012	0.006	0.39	0.42
109	1090	0.40	0.012	2.493	0.604	0.006	2.264	0.012	0.006	0.39	0.42
110	1100	0.40	0.012	2.505	0.611	0.007	2.275	0.012	0.007	0.39	0.41
111	1110	0.40	0.012	2.516	0.617	0.007	2.287	0.012	0.007	0.40	0.41
112	1120	0.40	0.012	2.528	0.624	0.007	2.299	0.012	0.007	0.40	0.41
113	1130	0.40	0.012	2.540	0.631	0.007	2.310	0.012	0.007	0.40	0.41
114	1140	0.40	0.012	2.551	0.637	0.007	2.322	0.012	0.007	0.40	0.41
115	1150	0.40	0.012	2.563	0.644	0.007	2.333	0.012	0.007	0.40	0.41
116	1160	0.40	0.012	2.574	0.650	0.007	2.345	0.012	0.007	0.40	0.41
117	1170	0.40	0.012	2.586	0.657	0.007	2.356	0.012	0.007	0.40	0.40
118	1180	0.40	0.012	2.598	0.664	0.007	2.368	0.012	0.007	0.40	0.40
119	1190	0.40	0.012	2.609	0.671	0.007	2.379	0.012	0.007	0.41	0.40
120	1200	0.40	0.012	2.621	0.677	0.007	2.391	0.012	0.007	0.41	0.41
121	1210	0.40	0.012	2.632	0.684	0.007	2.402	0.012	0.007	0.41	0.41
122	1220	0.40	0.012	2.644	0.691	0.007	2.414	0.012	0.007	0.41	0.41
123	1230	0.40	0.012	2.656	0.698	0.007	2.425	0.012	0.007	0.41	0.41
124	1240	0.40	0.012	2.667	0.704	0.007	2.437	0.012	0.007	0.41	0.41
125	1250	0.40	0.012	2.679	0.711	0.007	2.448	0.012	0.007	0.41	0.41
126	1260	0.40	0.012	2.690	0.718	0.007	2.460	0.012	0.007	0.41	0.41
127	1270	0.40	0.012	2.702	0.725	0.007	2.472	0.012	0.007	0.42	0.41
128	1280	0.40	0.012	2.714	0.732	0.007	2.483	0.012	0.007	0.42	0.41
129	1290	0.40	0.012	2.725	0.739	0.007	2.495	0.012	0.007	0.42	0.41
130	1300	0.40	0.012	2.737	0.746	0.007	2.506	0.012	0.007	0.42	0.41
131	1310	0.40	0.012	2.748	0.753	0.007	2.518	0.012	0.007	0.42	0.41
132	1320	0.40	0.012	2.760	0.760	0.007	2.529	0.012	0.007	0.42	0.41
133	1330	0.40	0.012	2.772	0.767	0.007	2.541	0.012	0.007	0.42	0.42
134	1340	0.40	0.012	2.783	0.774	0.007	2.552	0.012	0.007	0.42	0.42
135	1350	0.40	0.012	2.795	0.781	0.007	2.564	0.012	0.007	0.43	0.42
136	1360	0.40	0.012	2.806	0.788	0.007	2.575	0.012	0.007	0.43	0.42
137	1370	0.40	0.012	2.818	0.795	0.007	2.587	0.012	0.007	0.43	0.42
138	1380	0.40	0.012	2.830	0.802	0.007	2.599	0.012	0.007	0.43	0.42
139	1390	0.40	0.012	2.841	0.809	0.007	2.610	0.012	0.007	0.43	0.42
140	1400	0.40	0.012	2.853	0.816	0.007	2.622	0.012	0.007	0.43	0.42
141	1410	0.40	0.012	2.864	0.823	0.007	2.633	0.012	0.007	0.43	0.42
142	1420	0.40	0.012	2.876	0.831	0.007	2.645	0.012	0.007	0.43	0.43
143	1430	0.40	0.012	2.888	0.838	0.007	2.656	0.012	0.007	0.43	0.43
144	1440	0.40	0.012	2.899	0.845	0.007	2.668	0.012	0.007	0.44	0.43
145	1450	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.40
146	1460	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.35
147	1470	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.30
148	1480	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.27
149	1490	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.23
150	1500	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.20
151	1510	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.18
152	1520	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.15
153	1530	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.13
154	1540	0.00	0.000	2.899	0.845	0.000	2.668	0.000	0.000	0.00	0.12

Perv. CN=	74.0	Perv. Area =	10.00	Tpeak (hrs) =	8.8	Qpeak (cfs) =	0.62
Imp. CN =	98.0	Imp. Area =	0.00	Tc (min) =	73.0	Volume (ft^3) =	30,194

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 4

Compute: Developed Runoff Hydrograph

Given: East Kent Hill Project

Total Project Area	
At =	10 acres
Pt =	2.9 inches
dt =	10 min
Tc =	28 min
w =	0.152 =dt / (2*Tc+dt)

Pervious Area	Impervious Area	units
Ap = 6.10	Ai = 3.90	acres
CNp = 89	CNi = 98	
Sp = 1.24	Si = 0.20	inches
0.2Sp = 0.25	0.2Si = 0.04	inches

Equations:

Col.[2]= Previous Col.[2] + dt = Time Elapsed
Col.[3]= SCS Type 1A Rainfall Distribution (24-hour Table 3.5.1A)
Col.[4]= Col.[3] * Pt = 10-year, 24-hour Hyetograph = Incremental Rainfall
Col.[5]= Previous Col.[4] + Present Col.[3] = Accumulated Rainfall
Col.[6]= If Col.[5]<=0.2Sp, then = 0.0, else = (Col.[5]-0.2Sp)^2 / (Col.[5] +0.8Sp)
Col.[7]= Present Col.[6] - Previous Col.[6] = Perv. Area Incremental Runoff
Col.[8]= If Col.[5]<=0.2Si, then = 0.0, else = (Col.[5]-0.2Si)^2 / (Col.[5]+0.8Si)
Col.[9]= Present Col.[8] - Previous Col.[8] = Imp. Area Incremental Runoff
Col.[10]= ((Ap/At) * Col.[7]) + ((Ai/At) * Col.[9]) = Total Project Runoff
Col.[11]= (60.5 * Col.[10] * At) / dt = Instant Hydrograph
Col.[12]= Previous Col.[12] + w * (Previous Col.[11] + Present Col.[11] - 2 * Previous Col.[12])
Volume= Sum of Col.[12] * dt * (60 sec./min.)

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs		
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distri-bution % of Pt	[4] Incre-mental Rainfall inches	[5] Accum-ulated Rainfall inches	[6] Accum-lated Runoff inches	[7] Incre-mental Runoff inches	[8] Accum-lated Runoff inches	[9] Incre-mental Runoff inches	[10] Total Project Runoff inches	[11] Instant Hydro-graph cfs	[12] Design Hydro-graph cfs
0	0	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
1	10	0.40	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.00	0.00
2	20	0.40	0.012	0.023	0.000	0.000	0.000	0.000	0.000	0.00	0.00
3	30	0.40	0.012	0.035	0.000	0.000	0.000	0.000	0.000	0.00	0.00
4	40	0.40	0.012	0.046	0.000	0.000	0.000	0.000	0.000	0.00	0.00
5	50	0.40	0.012	0.058	0.000	0.000	0.001	0.001	0.000	0.03	0.01
6	60	0.40	0.012	0.070	0.000	0.000	0.004	0.002	0.001	0.05	0.02
7	70	0.40	0.012	0.081	0.000	0.000	0.007	0.003	0.001	0.07	0.03
8	80	0.40	0.012	0.093	0.000	0.000	0.011	0.004	0.002	0.09	0.05
9	90	0.40	0.012	0.104	0.000	0.000	0.015	0.005	0.002	0.11	0.06
10	100	0.40	0.012	0.116	0.000	0.000	0.020	0.005	0.002	0.12	0.08
11	110	0.50	0.015	0.131	0.000	0.000	0.027	0.007	0.003	0.17	0.10
12	120	0.50	0.015	0.145	0.000	0.000	0.035	0.008	0.003	0.18	0.12
13	130	0.50	0.015	0.160	0.000	0.000	0.044	0.008	0.003	0.20	0.14
14	140	0.50	0.015	0.174	0.000	0.000	0.053	0.009	0.003	0.21	0.16
15	150	0.50	0.015	0.189	0.000	0.000	0.062	0.009	0.004	0.22	0.18
16	160	0.50	0.015	0.203	0.000	0.000	0.072	0.010	0.004	0.23	0.19
17	170	0.60	0.017	0.220	0.000	0.000	0.084	0.012	0.005	0.29	0.21
18	180	0.60	0.017	0.238	0.000	0.000	0.097	0.013	0.005	0.30	0.24
19	190	0.60	0.017	0.255	0.000	0.000	0.110	0.013	0.005	0.31	0.26
20	200	0.60	0.017	0.273	0.001	0.000	0.123	0.013	0.006	0.33	0.28
21	210	0.60	0.017	0.290	0.001	0.001	0.137	0.014	0.006	0.36	0.30
22	220	0.60	0.017	0.307	0.003	0.001	0.151	0.014	0.006	0.38	0.32
23	230	0.70	0.020	0.328	0.005	0.002	0.168	0.017	0.008	0.47	0.35
24	240	0.70	0.020	0.348	0.008	0.003	0.185	0.017	0.008	0.50	0.39
25	250	0.70	0.020	0.368	0.011	0.003	0.202	0.017	0.009	0.52	0.43
26	260	0.70	0.020	0.389	0.015	0.004	0.219	0.017	0.009	0.55	0.46
27	270	0.70	0.020	0.409	0.019	0.004	0.237	0.018	0.009	0.57	0.49
28	280	0.70	0.020	0.429	0.023	0.005	0.255	0.018	0.010	0.59	0.52
29	290	0.82	0.024	0.453	0.029	0.006	0.276	0.021	0.012	0.72	0.56
30	300	0.82	0.024	0.477	0.036	0.007	0.297	0.021	0.012	0.74	0.61
31	310	0.82	0.024	0.501	0.043	0.007	0.318	0.021	0.013	0.77	0.66
32	320	0.82	0.024	0.524	0.051	0.008	0.340	0.022	0.013	0.79	0.69
33	330	0.82	0.024	0.548	0.059	0.008	0.362	0.022	0.013	0.81	0.73
34	340	0.82	0.024	0.572	0.068	0.009	0.384	0.022	0.014	0.84	0.76
35	350	0.95	0.028	0.599	0.078	0.011	0.409	0.026	0.016	0.99	0.80

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 5

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs			
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distribution % of Pt	[4] Incremental Rainfall inches	[5] Accumulated Rainfall inches	[6] Accumulated Runoff inches	[7] Incremental Runoff inches	[8] Accumulated Runoff inches	[9] Incremental Runoff inches	[10] Total Project Runoff inches	[11] Instant Hydrograph cfs	[12] Design Hydrograph cfs	
36	360	0.95	0.028	0.627	0.089	0.011	0.435	0.026	0.017	1.02	0.86	
37	370	0.95	0.028	0.655	0.101	0.012	0.461	0.026	0.017	1.04	0.91	
38	380	0.95	0.028	0.682	0.113	0.012	0.486	0.026	0.018	1.06	0.96	
39	390	0.95	0.028	0.710	0.126	0.013	0.512	0.026	0.018	1.08	0.99	
40	400	0.95	0.028	0.737	0.139	0.013	0.539	0.026	0.018	1.10	1.02	
41	410	1.33	0.039	0.776	0.158	0.019	0.575	0.037	0.026	1.57	1.12	
42	420	1.33	0.039	0.814	0.178	0.020	0.612	0.037	0.027	1.61	1.26	
43	430	1.33	0.039	0.853	0.199	0.021	0.649	0.037	0.027	1.64	1.37	
44	440	1.80	0.052	0.905	0.229	0.029	0.699	0.050	0.037	2.27	1.55	
45	450	1.80	0.052	0.957	0.259	0.031	0.750	0.050	0.038	2.32	1.77	
46	460	3.40	0.099	1.056	0.320	0.061	0.845	0.096	0.074	4.50	2.27	
47	470	5.40	0.157	1.212	0.423	0.103	0.998	0.153	0.123	7.42	3.39	
48	480	2.70	0.078	1.291	0.478	0.054	1.075	0.077	0.063	3.82	4.06	Q peak
49	490	1.80	0.052	1.343	0.515	0.037	1.126	0.051	0.043	2.58	3.80	
50	500	1.34	0.039	1.382	0.543	0.028	1.164	0.038	0.032	1.94	3.33	
51	510	1.34	0.039	1.421	0.572	0.028	1.202	0.038	0.032	1.95	2.91	
52	520	1.34	0.039	1.460	0.600	0.029	1.240	0.038	0.032	1.96	2.62	
53	530	0.88	0.026	1.485	0.619	0.019	1.265	0.025	0.021	1.30	2.32	
54	540	0.88	0.026	1.511	0.639	0.019	1.291	0.025	0.022	1.30	2.01	
55	550	0.88	0.026	1.536	0.658	0.019	1.316	0.025	0.022	1.31	1.80	
56	560	0.88	0.026	1.562	0.677	0.019	1.341	0.025	0.022	1.31	1.65	
57	570	0.88	0.026	1.587	0.697	0.020	1.366	0.025	0.022	1.32	1.55	
58	580	0.88	0.026	1.613	0.717	0.020	1.391	0.025	0.022	1.32	1.48	
59	590	0.88	0.026	1.638	0.737	0.020	1.416	0.025	0.022	1.33	1.43	
60	600	0.88	0.026	1.664	0.756	0.020	1.442	0.025	0.022	1.33	1.40	
61	610	0.88	0.026	1.689	0.777	0.020	1.467	0.025	0.022	1.33	1.38	
62	620	0.88	0.026	1.715	0.797	0.020	1.492	0.025	0.022	1.34	1.37	
63	630	0.88	0.026	1.740	0.817	0.020	1.517	0.025	0.022	1.34	1.36	
64	640	0.88	0.026	1.766	0.837	0.020	1.543	0.025	0.022	1.35	1.35	
65	650	0.72	0.021	1.787	0.854	0.017	1.563	0.021	0.018	1.10	1.31	
66	660	0.72	0.021	1.808	0.871	0.017	1.584	0.021	0.018	1.11	1.25	
67	670	0.72	0.021	1.828	0.888	0.017	1.604	0.021	0.018	1.11	1.21	
68	680	0.72	0.021	1.849	0.904	0.017	1.625	0.021	0.018	1.11	1.18	
69	690	0.72	0.021	1.870	0.921	0.017	1.646	0.021	0.018	1.11	1.16	
70	700	0.72	0.021	1.891	0.938	0.017	1.666	0.021	0.018	1.12	1.14	
71	710	0.72	0.021	1.912	0.955	0.017	1.687	0.021	0.018	1.12	1.14	
72	720	0.72	0.021	1.933	0.973	0.017	1.708	0.021	0.019	1.12	1.13	
73	730	0.72	0.021	1.954	0.990	0.017	1.729	0.021	0.019	1.12	1.13	
74	740	0.72	0.021	1.975	1.007	0.017	1.749	0.021	0.019	1.12	1.13	
75	750	0.72	0.021	1.995	1.024	0.017	1.770	0.021	0.019	1.13	1.13	
76	760	0.72	0.021	2.016	1.042	0.017	1.791	0.021	0.019	1.13	1.13	
77	770	0.57	0.017	2.033	1.055	0.014	1.807	0.016	0.015	0.89	1.09	
78	780	0.57	0.017	2.049	1.069	0.014	1.823	0.016	0.015	0.90	1.03	
79	790	0.57	0.017	2.066	1.083	0.014	1.840	0.016	0.015	0.90	0.99	
80	800	0.57	0.017	2.082	1.097	0.014	1.856	0.016	0.015	0.90	0.96	
81	810	0.57	0.017	2.099	1.111	0.014	1.873	0.016	0.015	0.90	0.94	
82	820	0.57	0.017	2.116	1.124	0.014	1.889	0.016	0.015	0.90	0.93	
83	830	0.57	0.017	2.132	1.138	0.014	1.905	0.016	0.015	0.90	0.92	
84	840	0.57	0.017	2.149	1.152	0.014	1.922	0.016	0.015	0.90	0.91	
85	850	0.57	0.017	2.165	1.166	0.014	1.938	0.016	0.015	0.90	0.91	
86	860	0.57	0.017	2.182	1.180	0.014	1.955	0.016	0.015	0.90	0.91	
87	870	0.57	0.017	2.198	1.194	0.014	1.971	0.016	0.015	0.90	0.91	
88	880	0.57	0.017	2.215	1.208	0.014	1.987	0.016	0.015	0.91	0.91	
89	890	0.50	0.015	2.229	1.221	0.012	2.002	0.014	0.013	0.80	0.89	
90	900	0.50	0.015	2.244	1.233	0.012	2.016	0.014	0.013	0.80	0.86	
91	910	0.50	0.015	2.258	1.246	0.012	2.031	0.014	0.013	0.80	0.84	
92	920	0.50	0.015	2.273	1.258	0.012	2.045	0.014	0.013	0.80	0.83	
93	930	0.50	0.015	2.287	1.270	0.012	2.059	0.014	0.013	0.80	0.82	
94	940	0.50	0.015	2.302	1.283	0.012	2.074	0.014	0.013	0.80	0.81	
95	950	0.50	0.015	2.316	1.295	0.012	2.088	0.014	0.013	0.80	0.81	
96	960	0.50	0.015	2.331	1.308	0.012	2.103	0.014	0.013	0.80	0.81	

FIGURE 3.5.3A EXAMPLE SBUH RUNOFF HYDROGRAPH-PAGE 6

Time		Rainfall			Pervious Area		Impervious Area		Total Runoff/Hydrographs		
[1] Time Step No. #	[2] Time min.	[3] Rainfall Distri-bution % of Pt	[4] Incre-mental Rainfall Inches	[5] Accum-ulated Rainfall Inches	[6] Accum-lated Runoff Inches	[7] Incre-mental Runoff Inches	[8] Accum-lated Runoff Inches	[9] Incre-mental Runoff Inches	[10] Total Project Runoff Inches	[11] Instant Hydro-graph cfs	[12] Design Hydro-graph cfs
97	970	0.50	0.015	2.345	1.320	0.012	2.117	0.014	0.013	0.80	0.80
98	980	0.50	0.015	2.360	1.333	0.013	2.131	0.014	0.013	0.80	0.80
99	990	0.50	0.015	2.374	1.345	0.013	2.146	0.014	0.013	0.80	0.80
100	1000	0.50	0.015	2.389	1.358	0.013	2.160	0.014	0.013	0.80	0.80
101	1010	0.40	0.012	2.400	1.368	0.010	2.172	0.012	0.011	0.64	0.78
102	1020	0.40	0.012	2.412	1.378	0.010	2.183	0.012	0.011	0.64	0.74
103	1030	0.40	0.012	2.424	1.388	0.010	2.195	0.012	0.011	0.64	0.71
104	1040	0.40	0.012	2.435	1.398	0.010	2.206	0.012	0.011	0.64	0.69
105	1050	0.40	0.012	2.447	1.408	0.010	2.218	0.012	0.011	0.64	0.68
106	1060	0.40	0.012	2.458	1.418	0.010	2.229	0.012	0.011	0.64	0.67
107	1070	0.40	0.012	2.470	1.428	0.010	2.241	0.012	0.011	0.65	0.66
108	1080	0.40	0.012	2.482	1.439	0.010	2.252	0.012	0.011	0.65	0.66
109	1090	0.40	0.012	2.493	1.449	0.010	2.264	0.012	0.011	0.65	0.65
110	1100	0.40	0.012	2.505	1.459	0.010	2.275	0.012	0.011	0.65	0.65
111	1110	0.40	0.012	2.516	1.469	0.010	2.287	0.012	0.011	0.65	0.65
112	1120	0.40	0.012	2.528	1.479	0.010	2.299	0.012	0.011	0.65	0.65
113	1130	0.40	0.012	2.540	1.489	0.010	2.310	0.012	0.011	0.65	0.65
114	1140	0.40	0.012	2.551	1.500	0.010	2.322	0.012	0.011	0.65	0.65
115	1150	0.40	0.012	2.563	1.510	0.010	2.333	0.012	0.011	0.65	0.65
116	1160	0.40	0.012	2.574	1.520	0.010	2.345	0.012	0.011	0.65	0.65
117	1170	0.40	0.012	2.586	1.530	0.010	2.356	0.012	0.011	0.65	0.65
118	1180	0.40	0.012	2.598	1.540	0.010	2.368	0.012	0.011	0.65	0.65
119	1190	0.40	0.012	2.609	1.551	0.010	2.379	0.012	0.011	0.65	0.65
120	1200	0.40	0.012	2.621	1.561	0.010	2.391	0.012	0.011	0.65	0.65
121	1210	0.40	0.012	2.632	1.571	0.010	2.402	0.012	0.011	0.65	0.65
122	1220	0.40	0.012	2.644	1.581	0.010	2.414	0.012	0.011	0.65	0.65
123	1230	0.40	0.012	2.656	1.592	0.010	2.425	0.012	0.011	0.65	0.65
124	1240	0.40	0.012	2.667	1.602	0.010	2.437	0.012	0.011	0.65	0.65
125	1250	0.40	0.012	2.679	1.612	0.010	2.448	0.012	0.011	0.65	0.65
126	1260	0.40	0.012	2.690	1.622	0.010	2.460	0.012	0.011	0.65	0.65
127	1270	0.40	0.012	2.702	1.633	0.010	2.472	0.012	0.011	0.65	0.65
128	1280	0.40	0.012	2.714	1.643	0.010	2.483	0.012	0.011	0.65	0.65
129	1290	0.40	0.012	2.725	1.653	0.010	2.495	0.012	0.011	0.65	0.65
130	1300	0.40	0.012	2.737	1.664	0.010	2.506	0.012	0.011	0.65	0.65
131	1310	0.40	0.012	2.748	1.674	0.010	2.518	0.012	0.011	0.65	0.65
132	1320	0.40	0.012	2.760	1.684	0.010	2.529	0.012	0.011	0.65	0.65
133	1330	0.40	0.012	2.772	1.695	0.010	2.541	0.012	0.011	0.65	0.65
134	1340	0.40	0.012	2.783	1.705	0.010	2.552	0.012	0.011	0.65	0.65
135	1350	0.40	0.012	2.795	1.715	0.010	2.564	0.012	0.011	0.65	0.65
136	1360	0.40	0.012	2.806	1.726	0.010	2.575	0.012	0.011	0.65	0.65
137	1370	0.40	0.012	2.818	1.736	0.010	2.587	0.012	0.011	0.66	0.65
138	1380	0.40	0.012	2.830	1.746	0.010	2.599	0.012	0.011	0.66	0.65
139	1390	0.40	0.012	2.841	1.757	0.010	2.610	0.012	0.011	0.66	0.66
140	1400	0.40	0.012	2.853	1.767	0.010	2.622	0.012	0.011	0.66	0.66
141	1410	0.40	0.012	2.864	1.778	0.010	2.633	0.012	0.011	0.66	0.66
142	1420	0.40	0.012	2.876	1.788	0.010	2.645	0.012	0.011	0.66	0.66
143	1430	0.40	0.012	2.888	1.798	0.010	2.656	0.012	0.011	0.66	0.66
144	1440	0.40	0.012	2.899	1.809	0.010	2.668	0.012	0.011	0.66	0.66
145	1450	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.56
146	1460	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.39
147	1470	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.27
148	1480	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.19
149	1490	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.13
150	1500	0.00	0.000	2.899	1.809	0.000	2.668	0.000	0.000	0.00	0.09

Perv. CN=	89.0	Perv. Area =	6.10	Tpeak (hrs) =	8.00	Qpeak (cfs) =	4.06
Imp. CN =	98.0	Imp. Area =	3.90	Tc (min) =	28.0	Volume (ft^3) =	77,696

3.5.4 HYDROGRAPH ROUTING

This section presents the methodology for routing a hydrograph through an existing retention/detention facility or closed depression, and for sizing a new retention/detention facility using hydrograph analysis.

Storage Routing Technique

The "level pool routing" technique presented here is one of the simplest and most commonly used hydrograph routing methods. (Note, it is included as the "Route" subroutine in the "HYD" program included with this Manual) This method is described in "Handbook of Applied Hydrology," Chow, Ven Te, 1964, and elsewhere, and is based on the continuity equation:

Inflow - Outflow = Change in storage

$$\left[\frac{I_1+I_2}{2}-\frac{O_1+O_2}{2}\right]=\frac{\Delta S}{\Delta t} = S_2-S_1$$

where

I	=	Inflow at time 1 and time 2
O	=	Outflow at time 1 and time 2
S	=	Storage at time 1 and time 2
Δt	=	Time interval, 2-1

The time interval, Δt, must be consistent with the time interval used in developing the inflow hydrograph. As indicated in Section 3.5.3, the time interval used for a 24-hour storm is 10 minutes while the time interval used for a 7-day storm is 60 minutes. The Δt variable can be eliminated by dividing it into the storage variables to obtain the following rearranged equation:

$$I_1 + I_2 + 2S_1 - O_1 = O_2 + 2S_2$$

If the time interval, Δt, is in minutes, the units of storage (S) are now [cf/min] which can be approximated* to cfs by multiplying times 1 min/60 sec.

The terms on the left-hand side of the equation are known from the inflow hydrograph and from the storage and outflow values of the previous time step. The unknowns O_2 and S_2 can be solved interactively from the given stage-storage and stage-discharge curves.

The following section gives the specific hydrograph routing steps:

(1) Develop stage-storage relationship

- For retention/detention facilities with vertical sides (vaults), the stored volume is simply the bottom area times the height.

- For ponds with equal sides and 3:1 side slopes, the stored volume can be approximated* by averaging the pond surface area with the bottom area. The following equation was derived based on this assumption and for a square pond but provides a reasonable trial estimation for typical ponds of other shapes.

$$S(H) = 12H^3+6\sqrt{A_b}\,H^2+A_b\,H$$

where

H = stage height (ft.) or water depth above pond bottom
A_b = area of pond bottom (sq. ft.)
S(H) = storage (cu. ft.) at stage height, H.

- Actual pond volumes and surface areas should be computed based on the following equation:

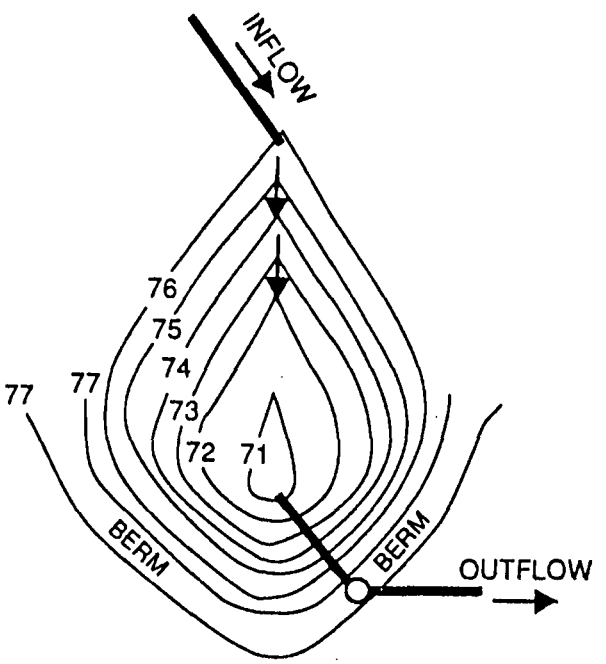
$$V = \frac{h}{3}\left(A_t + A_b + \sqrt{A_t A_b}\right)$$

where h = depth, A_t = area of top, and A_b = area of the bottom (see Pond Geometry Equations in the Reference Section)

o For irregularly shaped areas the stage-storage curve may be developed as follows:

a) Obtain topographic contours of an existing or proposed retention/detention facility site and planimeter (or otherwise compute) the area enclosed by each contour. For example, see Figure 3.5.4A in which each contour represents a one-foot interval. Contour 71 is the lowest portion of the site and represents zero storage. Contour 76 represents a potential stage of 5 feet above the bottom the facility.

FIGURE 3.5.4A PROPOSED RETENTION/DETENTION SITE CONTOURS AT ONE-FOOT INTERVALS



Area within each contour	
71	600 sq. ft.
72	4400 sq. ft.
73	8700 sq. ft.
74	11400 sq. ft.
75	14500 sq. ft.
76	19000 sq. ft.

b) Calculate the average end area within each set of contours. For the example given above, the average end area between contours 71 and 72 would be:

$$\frac{600 + 4400}{2} = 2500 \text{ sq. ft.}$$

c) Calculate the volume between each set of contours by multiplying the average end area within each set of contours by the difference in elevation. To illustrate, the volume between contours 71 and 72 would be:

(2500)(1 foot) = 2500 cu. ft.

Similarly,

Area 72-73 - 6550 cu. ft.
Area 73-74 - 10050 cu. ft.
Area 74-75 - 12950 cu. ft.
Area 75-76 - 16750 cu. ft.

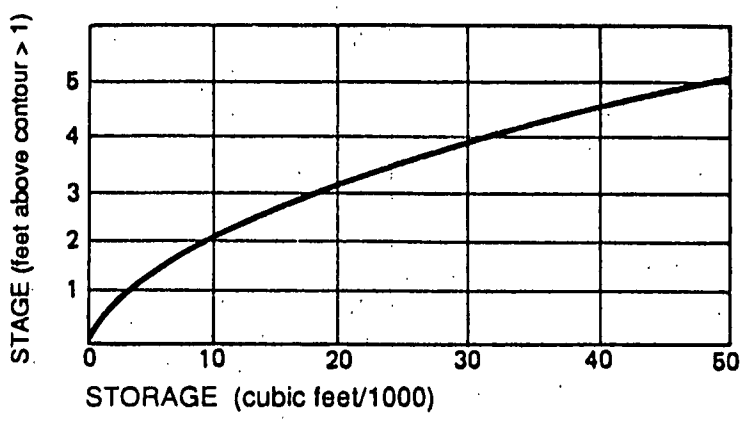
d) Define the total storage below each contour. This is just the sum of the volumes computed in the previous step up to the contour in question. For example, there is no storage below contour 71, 2500 cu. ft. below Contour 72, and (6550 + 2500 =) 9050 cu. ft. below Contour 73.

In summary,

Contours	Stage	Sum of Volumes	Total Volume
Contours 71-72	1	0 + 2500	= 2500 cu. ft.
Contours 72-73	2	2500 + 6500	= 9050 cu. ft.
Contours 73-74	3	9050 + 10050	= 19100 cu. ft.
Contours 74-75	4	19100 + 12950	= 32050 cu. ft.
Contours 75-76	5	32050 + 16750	= 48800 cu. ft.

Figure 3.5.4B is a plot of the stage-storage relationship for this example. The curve will be needed in later steps.

FIGURE 3.5.4B STAGE-STORAGE RELATIONSHIP



(2) Develop a curve called the "routing curve" which is simply a plot of outflow for a given stage versus a term, O + 2S, for the same stage. This curve may be easily plotted by setting up a table like Table 3.5.4A. The units for the expression of outflow, O, are cubic-feet per second for the time period of interest. For this example, the time period, Δt, of 60 minutes will be used for illustrative purposes. (Usually Δt will be 10 minutes to correspond to the time steps used in

preparing the hydrographs.) Therefore, all variables in the rearranged continuity equation must have the units of cfs. This means that the storage which was plotted in cubic feet must be converted from ft^3 to cfs by dividing it by the time interval, Δt. For the storage below Contour 72 this would be:

$$\frac{S}{\Delta t} = \frac{2500\ ft^3}{(60\ min)} \quad \frac{1\ min}{60\ sec} = \underline{0.694\ cfs}$$

TABLE 3.5.4A TABULATION OF DATA FOR ROUTING CURVE

Elevation Feet	Stage Feet	Outflow* O cfs	Storage S cfs**	2S cfs	O + 2S cfs
72	1	1.76	.694	1.388	3.15
73	2	2.49	2.514	5.028	7.52
74	3	3.05	5.306	10.612	13.66
75	4	3.52	8.903	17.806	21.33
76	5	3.94	13.556	27.112	31.05

* from 8" orifice, stage-discharge relationship [Q = (orifice area)(0.62) $\sqrt{2gh}$, where h = stage]

** from stage-storage curve, Figure 3.5.4B, volume converted to cfs for 60-minute time intervals.

For this example, the maximum allowable outflow was arbitrarily selected to be 4.0 cfs (this value is normally the pre-developed runoff rate from the site) and the maximum stage in the pond of 5 feet.

The "Outflow" column in table 3.5.4A is the stage-discharge relationship for an 8-inch orifice outlet pipe. The 8-inch pipe size was chosen because the maximum allowable outflow is approximately 4.0 cfs at the maximum desired storage depth of 5 feet. From Table 3.5.4A, the routing curve is plotted as shown in Figure 3.5.4C.

(3) The final step is to route the inflow hydrograph through the proposed storage facility by completing successive columns of Table 3.5.4B for each time period. For illustrative purposes a simple triangular shaped inflow hydrograph will be assumed as shown in Figure 3.5.4D.

FIGURE 3.5.4C ROUTING CURVE FOR t = 60 MINUTES

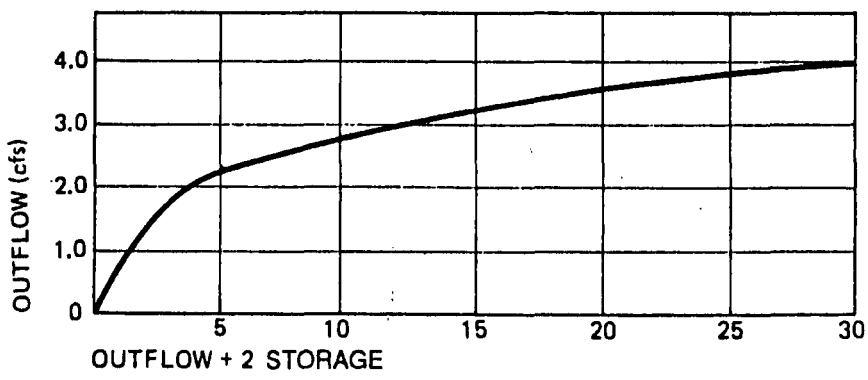


FIGURE 3.5.4D SIMPLIFIED EXAMPLE OF INFLOW HYDROGRAPH

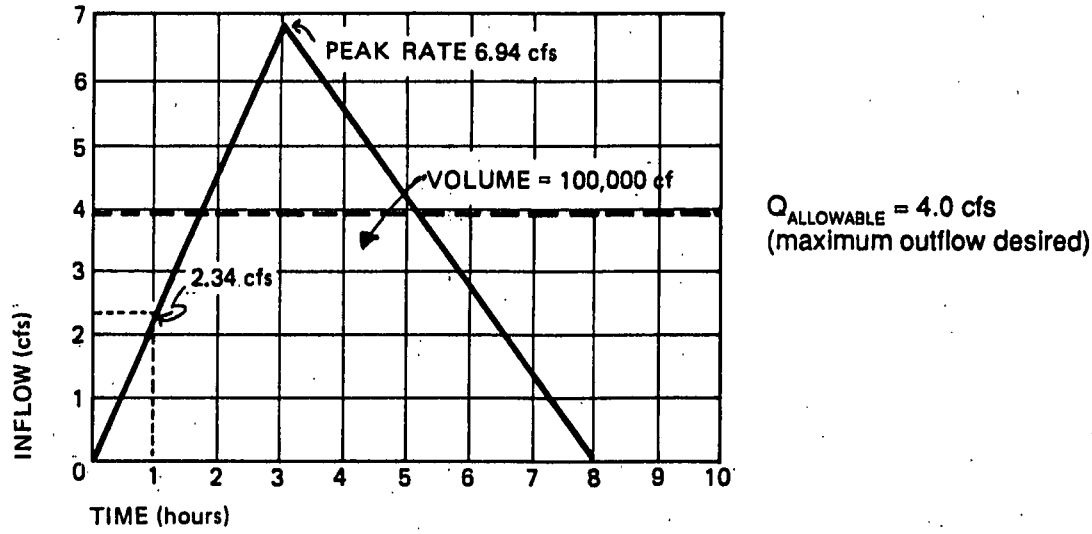


TABLE 3.5.4B TABULAR CALCULATION OF OUTFLOW USING LEVEL POOL ROUTING

Row	Variables	Time Periods (Δt = 60 min/usually Δt = 10min.)) 1	2	3	4	5	6	7	8	9	10	11	12
(1)	I_1	0	2.34	4.64	6.94	5.55	4.18	2.79	1.39	0	0	0	0
(2)	I_2	2.34	4.64	6.94	5.55	4.18	2.79	1.39	0	0	0	0	0
(3)	$2S_1$	0	0.84	3.97	10.17	16.23	18.96	18.76	15.97	10.86	5.21	1.11	0
(4)	$I_1+I_2+2S_1$	2.34	7.82	15.55	22.66	25.96	25.93	22.94	17.36	10.86	5.21	1.11	0
(5)	O_1	0	1.50	2.35	3.03	3.40	3.60	3.57	3.40	3.10	2.55	1.55	0
(6)	O_2+2S_2	2.34	6.32	13.20	19.63	22.56	22.33	19.37	13.96	7.76	2.66	-	0
(7)	$Stage_1$ (ft)	0	0.7	2.31	2.90	3.77	4.12	4.10	3.75	3.05	2.65	0.80	0
(8)	Elevation (ft)	71.0	71.7	73.31	73.90	74.77	75.12*	75.10	74.75	74.05	73.65	71.80	71.0

* Maximum floodplain elevation

The routing table is completed by the following steps. Keep in mind the equation used:

$$I_1 + I_2 + 2S_1 - O_1 = O_2 + 2S_2 \text{ (For each time period, } \Delta t)$$

Step

1. Initial inflow, I_1, is the inflow at the beginning of each time period and is read from the inflow hydrograph for each time period. For period 1, I_1 in this example is zero, and this is entered in Row (1) of the routing table.

2. I_2, inflow at the end of the time period, is read from the inflow hydrograph, and entered in Row (2) for each time period. This same value is the initial inflow for the next time period. For our example, I_2, for time period 1 is 2.34 cfs; this is also entered in Row (1) of time period 2 as I_1.

3. Two times the initial storage, $2S_1$, is entered in Row (3). For the example, initial storage for time period 1 is zero. Subsequent values entered as $2S_1$ are calculated after the remaining values for the preceding time period are filled in. This is explained below.

4. Enter in Row (4) the sum of Rows (1), (2), and (3), for the appropriate time period. In this case, the sum for time period 1 is 2.34

5. O_1, outflow initially for the time period, is entered in Row (5). For time period 1, O_1 is zero in this case. Subsequent values are read from the routing curve after Row (6) has been calculated. This is explained below.

6. From the routing equation, the entry in Row (6), $O_2 + 2S_2$, is the difference between Row (4), $I_1 + I_2 + 2S_1$, and Row (5), O_1. For time period 1, this value is 2.34. This is entered and the process repeated.

7. The value of O_1 for the next time period is read from the routing curve (Figure 3.5.4C) for the previous value of $O_2 + 2S_2$. In this case, a value of 1.50 is obtained for O_1 for time period 2, corresponding to ($O_2 + 2S_2 = 2.34$). Therefore, 1.50 is entered in Row (5) for time period 2.

8. The value of $2S_1$ for the next time period is the difference between the previous value of ($O_2 + 2S_2$) and the corresponding value of O_1 read from the routing curve as in Step 7, above. For this example,

$O_2 + 2S_2$	=	2.34 (for time period 1)
O_1	=	1.50 (for time period 2)
$2S_1 = (O_2+2S_2) - O_1$	=	0.84 (for time period 2)

Therefore, enter 0.84 in Row (3) for time period 2.

9. Find the sum of Rows (1), (2), and (3) and enter value in Row (4).

10. Subtract value in Row (5) from Row (4) and enter result in Row (6).

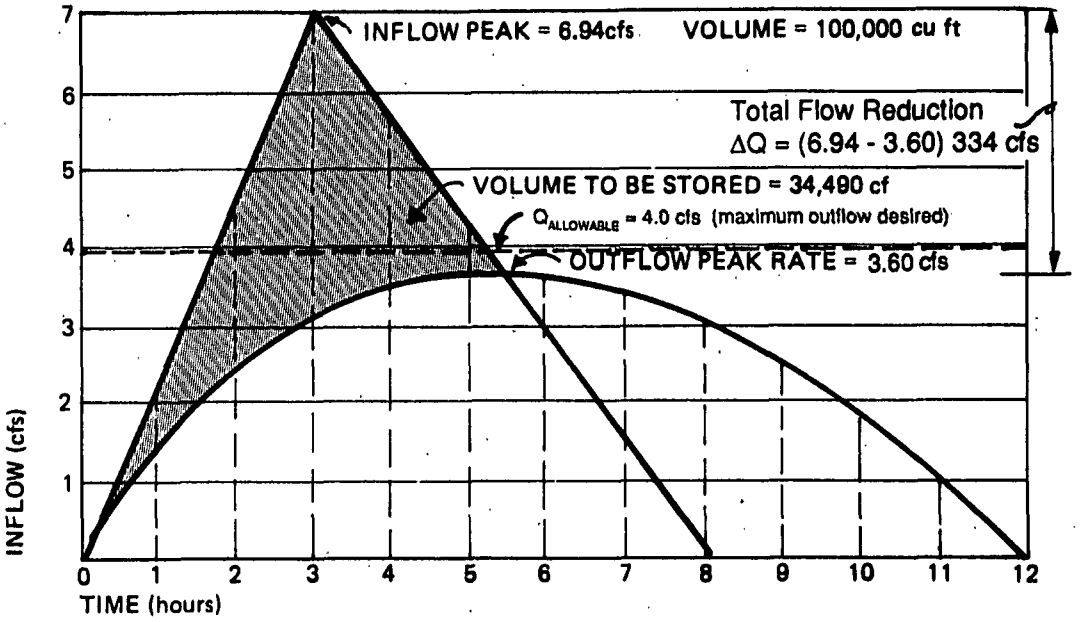
11. Refer to routing curve for next value of O_1, corresponding to result of Step 10.

Continue this process until the <u>outflow</u> hydrograph, as represented by the tabulated values of O_1, returns to zero.

Row (7) of entries in the Table 3.5.4B (Stage at the beginning of each time period) is obtained by dividing each value of $2S_1$ by 2, and referring to the stage-storage curve, Figure 3.5.4B. For example, for time period 3, $2S_1$ equals 3.97 cfs-min, half of which is 1.98 cfs-min. Referring to stage-storage curve for storage of 1.98 cfs-min. (or 1.98 x 3600 = 7,128 cu. ft.), a stage of 1.6 feet is obtained. Adding these stages to the elevation of the first contour (71) allows floodplain or maximum water surface (Row (8)) for each time period to be computed.

Finally, plot the values of O_1 for each time period to plot the complete outflow hydrograph, as shown in Figure 3.5.4E. The volume which must be stored is represented by the dark shaded area, and may be obtained through graphical techniques. The volume may also be closely estimated from the largest tabulated value of $2S_1$, divided by 2, and converted to cubic feet. This will exactly coincide with the true peak <u>only</u> if the two hydrographs cross exactly at the end of a time interval. However, this inaccuracy in volume would be very small, and for practical purposes may be neglected.

FIGURE 3.5.4E SIMPLIFIED EXAMPLE OF INFLOW AND OUTFLOW HYDROGRAPH



In summary, the characteristics of this sample retention/detention facility and the selected eight-inch orifice outlet are such that the peak runoff rate will be reduced below the required 4.0 cfs. Furthermore, the full five feet of available storage is not used and the maximum floodplain elevation generated in the pond is 75.12 feet. This indicates that additional trials or iterations could be performed to optimize the size and outlet control of this sample retention/detention pond.

Sizing a Peak Rate Runoff Control Facility for Multiple Design Storm Events

To design a storage facility to meet King County's performance requirements of 2, 10, and 100-year storm control, it is usually necessary to perform many iterative routings to arrive at a minimum facility size with the proper outlet (orifice) control. Each iterative routing requires that the facility size (stage-storage curve) and/or outlet configuration (stage-discharge curve) be adjusted and tested for performance. Such iteration can be cumbersome, even with the use of a computer. To minimize the number of iterations, a graphical evaluation of the developed inflow hydrographs is useful in approximating the storage volume and outlet configuration of a hypothetical detention pond that meets the performance requirements, prior to beginning the iteration process to finalize the design of a detention facility.

The following example presents a graphical approach to approximating storage volume and outlet configuration.

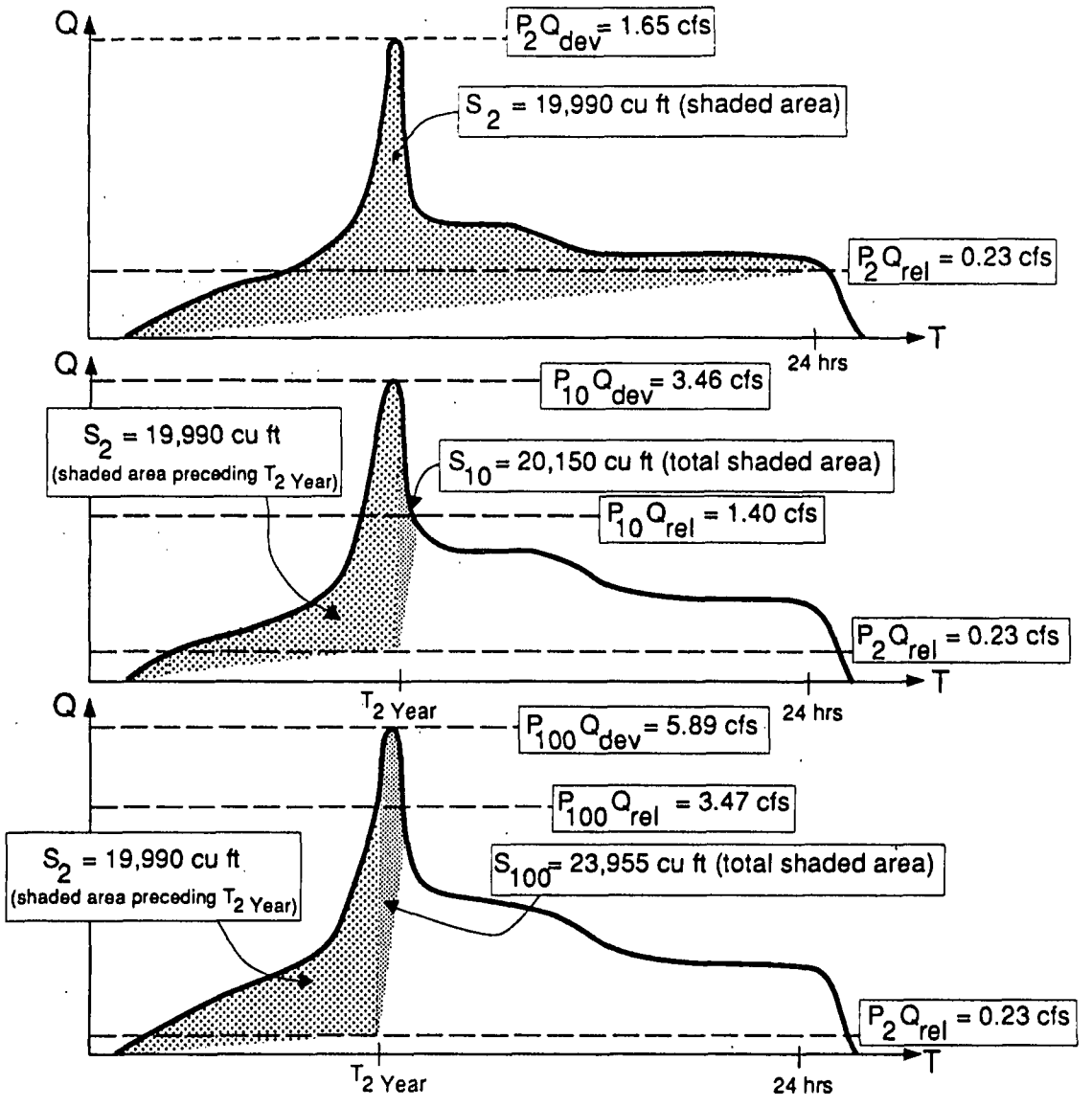
(1) Assume the following performance requirements (allowable release rates) and developed peak inflow rates have been noted from hydrographs generated for the purposes of sizing a standard on-site detention pond:

Design Storm	Allowable Release	Developed Inflows
2-year, 24-hour	P_2Q_{rel} = 0.23 cfs	P_2Q_{dev} = 1.65 cfs
10-year, 24-hour	$P_{10}Q_{rel}$ = 1.40 cfs	$P_{10}Q_{dev}$ = 3.46 cfs
100-year, 24-hour	$P_{100}Q_{rel}$ = 3.47 cfs	$P_{100}Q_{dev}$ = 5.89 cfs

Note: This example illustrates detaining the peak flows for the 2, 10 and 100 year, 24-hour duration design storms. The Standard Peak Rate Runoff Control Performance curve requires determining peak flows for the 2- and 10-year 24-hour duration design storm, adding 30% additional volume, without increasing design head or orifice sizes, and then routing the 100-year developed flows

through the facility to evaluate performance. The required performance for the 100 year design storm may, therefore, in some cases be more than the predeveloped flow rate depending on downstream conditions.

(2) Plots of the developed inflow hydrographs are used to graphically approximate the detention storage required to achieve the performance.



(3) Starting with the 2-year hydrograph, the 2-year allowable release rate (P_2Q_{rel}) (which must not be exceeded) is plotted as a horizontal line extending from time zero to the point where it intercepts the falling limb of the hydrograph. A line is drawn from the beginning of the inflow hydrograph to this point. This line approximates the outflow rating curve of a control structure of a hypothetical detention facility which would restrict outflow to not exceed P_2Q_{rel} and thus approximates the rising limb of a hypothetical outflow hydrograph.

(4) As in standard inflow-outflow hydrograph analysis, the area under the inflow hydrograph, less the area under the rising limb of the hypothetical outflow hydrograph, graphically approximates the amount of inflow which must be stored, detained and released once the inflow hydrograph falls

below the allowable release rate. This volume of storage for the 2-year storm (as shaded) is termed S_2 and can thus be approximated by measuring the area with a planimeter. In this example, the vertical scale is 1" = 0.936 cfs and the horizontal scale is: 1" = 5.65 hours, then for a planimetered area measurement of 1.05 sq. in.: S_2 = (1.05 in.^{2})(0.936 cfs/in.)(5.65 hrs./in.)(3600 sec./hr.) = 19,990 cu. ft.

(5) The 10- and 100-year developed inflow hydrographs must now each be examined to determine which will require the most storage volume in addition to the 19,900 cu. ft. approximated for the 2-year storm. Note, the amount of storage volume needed to control the 10-year storm may exceed that of the 100-year when using this method. This occurs because the peak flows for the 10- and 100-year inflow hydrographs are similar in magnitude, and the difference between 10-year allowable release and developed peak rates can be substantially greater than for the 100-year. The interception point with the $P_{10}Q_{rel}$ thus occurs further down the falling limb than for the 100-year, resulting in a larger storage volume required.

The 10- or 100-year allowable release rate ($P_{10}Q_{rel}$ or $P_{100}Q_{rel}$) (which must not be exceeded) is plotted as a horizontal line extending from time zero to the point where it intercepts the falling limb of the corresponding hydrograph. By trial and error, the time (T_2-year) at which the S_2 volume occurs, while maintaining P_2Q_{rel}, is determined by planimeter. From this point, a line is drawn to connect to the $P_{10}Q_{rel}$ or $P_{100}Q_{rel}$ point on the falling limb. The area from time T_2-year under the inflow hydrograph to this point, less the area under the rising limb of the hypothetical outflow hydrograph (shown as the slender shaded triangle(s)), represents the additional storage volume needed to meet the required performance. The total storage volume S_{10} or S_{100} can then be computed by adding the additional storage volume to S_2.

(6) From the storage volumes computed above, choose the largest of the three volumes for the initial pond sizing. In this case the 100-year volume, S_{100}, is the largest. Therefore, call it S_d:

S_d = 23,955 cu. ft.

(7) Estimate the bottom area, A_b, of the pond assuming 3:1 side slopes and a design depth, H_d, of 4 feet. The following equation may be used:

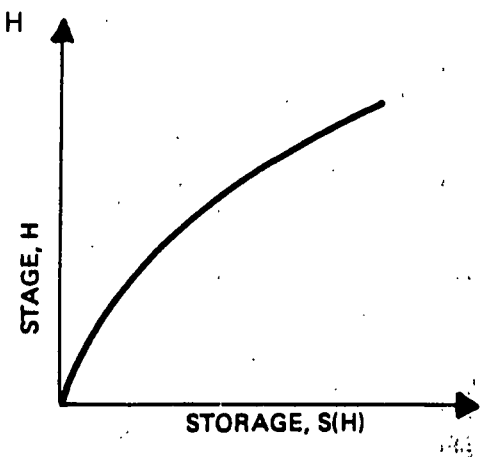
$$A_b = \left(\frac{\sqrt{4(S_d/H_d) - 12H_d^2}}{2} - 3H_d \right)^2$$

$$= 4154 \text{ sq. ft.}$$

(8) Compute the stage-storage curve using an approximate equation for square ponds with 3:1 side slopes or other equations or actual facility stage - storage:

$$S(H) = 1.2H^3 + (6\sqrt{A_b})\,H^2 + A_b\,H$$

Stage, H	Storage, S(H)
0.0	0.0
0.5	2,176
1.0	4,559
1.5	7,162
2.0	9,999
2.5	13,083
3.0	16,428
3.5	20,048
4.0	23,955



(9) From the stage-storage curve, determine the depth, H_2, required for the 2-year storage volume.

For S_2 = 19,990 cu. ft; H_2 = 3.49'

Note: Stage heights, H, should be adjusted so that they measure from the outlet invert rather than the pond bottom. In this example, the outlet invert is assumed to be at the same elevation as the pond bottom.

Special Note: It has been found through experience that usually only 2 orifices are necessary to meet King County's performance requirements. The bottom orifice is therefore sized to meet the 2-year performance requirement, while the top orifice is located above the 2-year water surface and is sized and situated such that both the 10-year and 100-year performance requirements are met. This is further illustrated as the example continues.

(10) Size the bottom orifice for the 2-year allowable release, P_2Q_{rel} = 0.23 cfs, using the following derivation of the orifice equation:

$$Q = Ca\sqrt{2gH} \qquad \text{Standard orifice equation}$$

where:
- C = entrance loss coefficient = 0.62 (typ.)
- a = area of orifice = $\pi d^2/4$
- d = diameter of orifice
- g = acceleration of gravity = 32.2 ft/s^2
- H = head on orifice

For 2-year allowable release:

P_2Q_{rel} = 0.23 cfs; H_2 = 3.49 ft.

$$P_2Q_{rel} = Ca\sqrt{2g\ H_2}$$

rearranging to solve for a:

$$a = P_2Q_{rel}/C\sqrt{2g\ H_2}$$

substituting for diameter:

$$d_b^2/4 = P_2Q_{rel}/\pi\ C\ \sqrt{2gH_2}$$

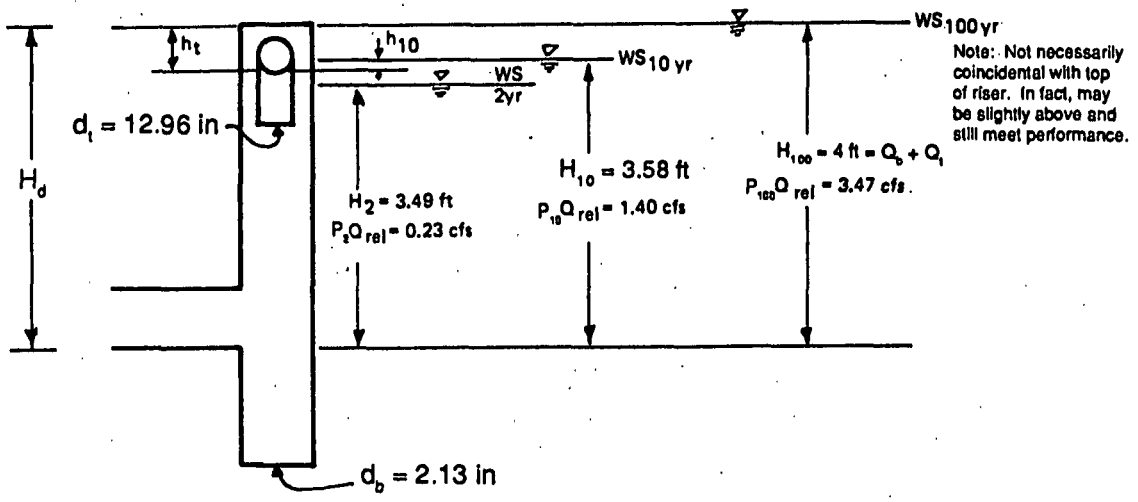
$$d_b^2 = 4P_2Q_{rel}/\ \pi\ C\sqrt{2gH_2}$$

$$d_b = \sqrt{4P_2Q_{rel}/\pi C\sqrt{2gH_2}}$$

$$d_b = \sqrt{4(0.23)/(3.14159)(0.62)\sqrt{2(32.2)(3.49)}}$$

$$d_b = 0.18 \text{ ft.} = \underline{2.13 \text{ in.}}$$

(11) Sketch and consider the following flow control restrictor schematic:



(12) Size and situate the top orifice at or above the 2-year water surface (WS 2-year). This may require some trial and error. The release rate for this orifice is:

Q_t = $Q_{total} - Q_b$, where Q_b = $(d_b^2/36.876)\,H_d^{1/2}$

Q_b = $((2.13)^2/36.876)(4)^{1/2}$ = 0.25 cfs

Q_t = 3.47 cfs - 0.25 cfs = 3.22 cfs

Q_{total} = $Q_b + Q_t$ = [Total flow at maximum head]

The size of this orifice will depend on its vertical location as specified by its head, h_t. h_t in this example must be less than 0.51 feet so that the top orifice is above the 2-year water surface. Therefore, try h_t = 0.5':

$$\text{Top Orifice Diameter, } d_t = \sqrt{\frac{36.876\,(3.22)}{0.5}} = \underline{12.96''}$$

(13) Check for 10-year volume by:

a) Computing h_{10} (See diagram above)

$$h_{10} = \left[\frac{36.876\,(P_{10}Q_{rel})}{(d_t)^2}\right]^2 = \left[\frac{36.876\,(1.40)}{(12.96)^2}\right]^2$$

$$= 0.09'$$

b) Computing H_{10} = 3.49' + 0.09' = 3.58'

c) Check stage-storage curve to see if there is sufficient volume at H_{10} = 3.58':

For H = 3.58': S(H) = 20,730 cu. ft.

Recalling S_{10} = 20,150 cu. ft.

20,730 cu. ft. > 20,150 cu. ft. okay

Note: Since the top-orifice size of 12.96" is too large to feasibly install in the upper 0.5 feet of the riser pipe, a notch weir must be substituted per details and equations given in Section 4.4.7 Control Structures. Also, the 100 year water surface in this example is shown at the same elevation as the top of the riser. This will not necessarily be the case. In fact, it may be slightly above the riser and still meet performance.

The stage/storage/discharge information for a hypothetical detention facility developed above can then be used as a guide to design the actual detention facility. The design is checked using the "level pool routing" technique described at the beginning of this section. The stage/storage/discharge data from the actual facility design is used with each of the developed inflow hydrographs routed through the facility in order to demonstrate that the required performance is met. (Note, the 30% factor of safety then is applied to the hypothetical facility stage-storage data, the actual pond design developed, and then the 100-year developed hydrograph is checked.

This is the point in the process where a number of iterations may be required in order to calibrate and optimize the actual facility design to meet performance with the minimal amount of storage volume. With experience, techniques and methods can be developed that can assist the design engineer in this process. The SWM Division has developed the RDFAC computer program, provided with this Manual, that performs this trial design of ponds, tanks, or vaults as runoff control facilities.

3.5.5 HYDROGRAPH SUMMATION AND PHASING

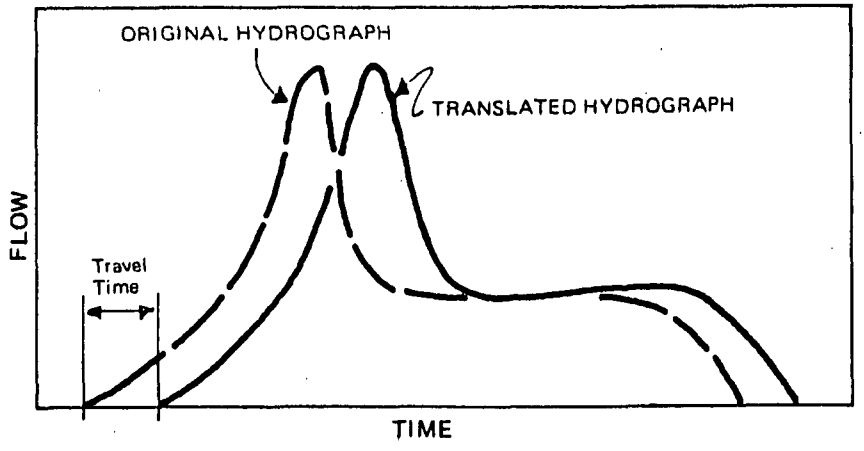
One of the key advantages of hydrograph analysis is the ability to accurately describe the cumulative effect of runoff from several basins and/or subbasins having different runoff characteristics and travel times. This cumulative effect is best characterized by a single hydrograph which is obtained by summing the individual hydrographs from tributary basins at a particular "discharge point of interest." The general procedure for performing a hydrograph summation is described below:

Hydrograph Summation

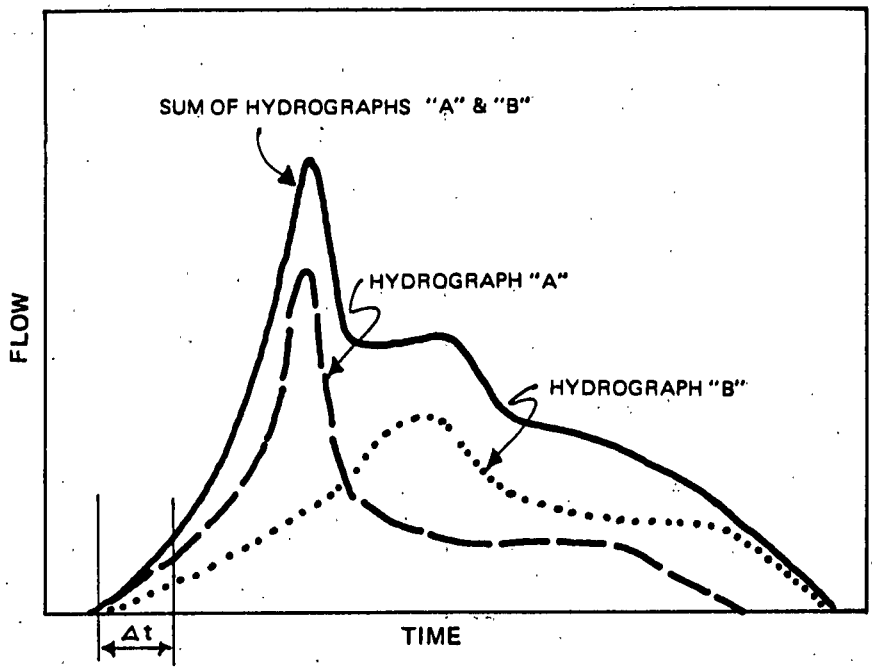
(1) Select the "discharge point of interest" at which the hydrographs will be summed.

(2) Estimate the time required for each hydrograph to travel from its point discharge to the "discharge point of interest." This travel time can be estimated using the methods presented in Section 3.5.2, under "Travel Time and Time of Concentration."

(3) Shift each hydrograph according to its travel time to the "discharge point of interest" as shown below:



(4) Sum the shifted hydrographs by adding the ordinate flow values at each time interval as shown below:



Note: Δt has been previously defined as 10 minutes or less for a 24-hour duration storm and 60 minutes for a 7-day duration storm.

Hydrograph Phasing Analysis

The ability to characterize cumulative effects through the summation of hydrographs provides a valuable tool for analyzing the interaction of on-site and off-site hydrographs both before and after development. This interaction of hydrographs is generally referred to as "hydrograph phasing" due to the similarity with compound wave-shapes. This hydrograph phasing analysis is required in order to determine the effects of the compound hydrograph shape on the downstream system. (See Chapter 1, Section 1.2.2, "Core Requirement #2: Off-Site Analysis").

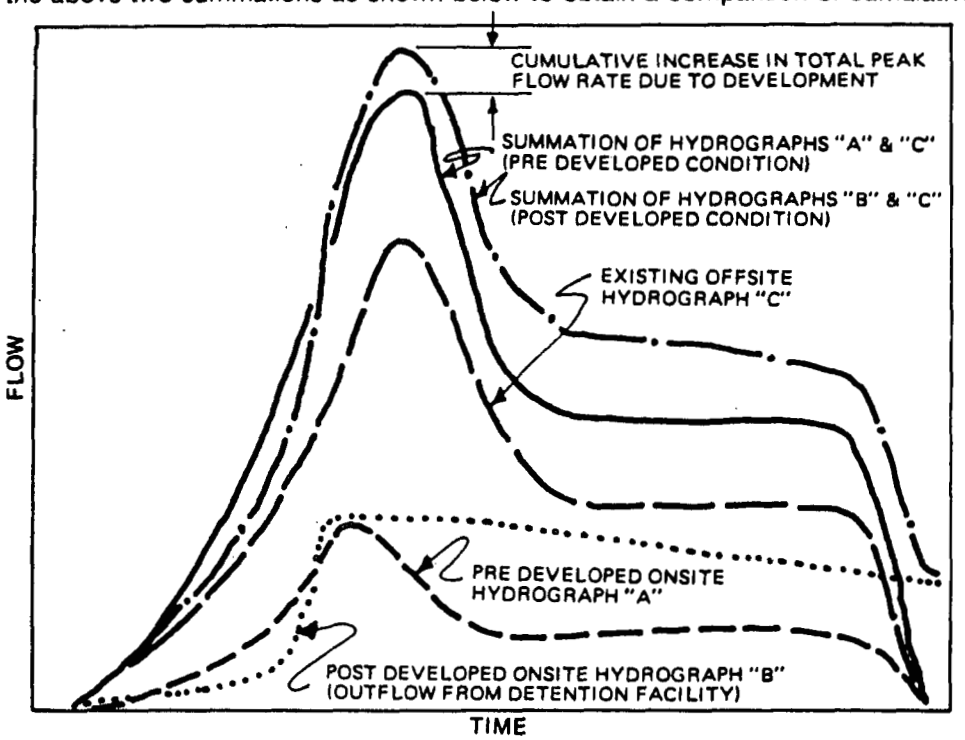
The general procedure for performing a hydrograph phasing analysis is as follows:

(1) Select the "discharge point of interest" at which the on-site and off-site runoff hydrographs will be summed and compute travel times as explained under "Hydrograph Summation."

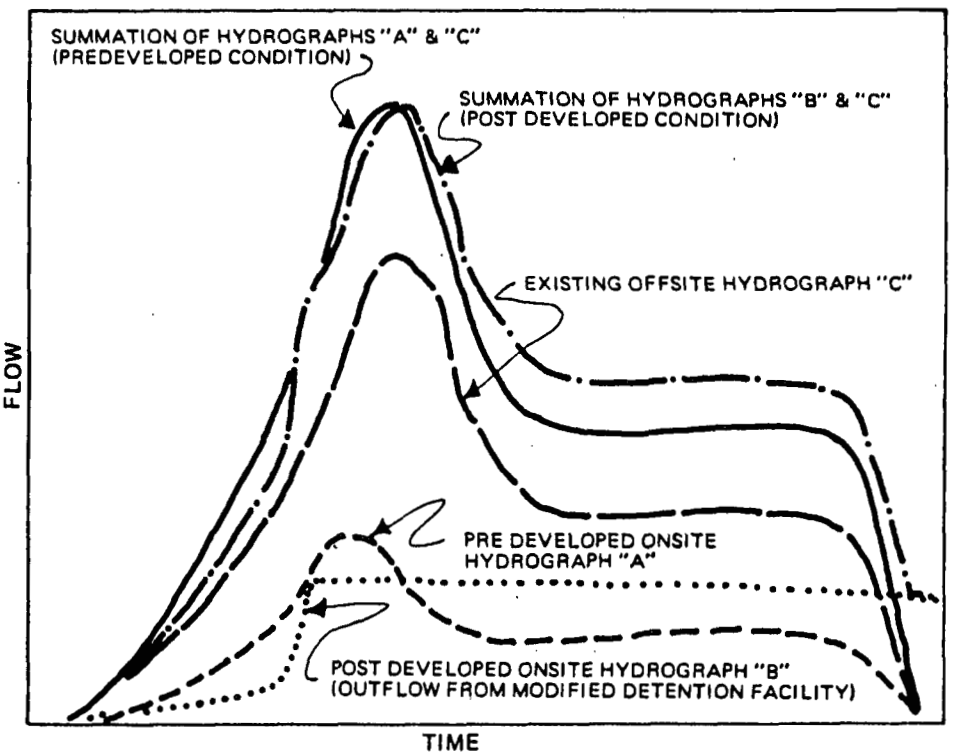
(2) Compute the predeveloped on-site hydrograph and the existing off-site hydrograph for the design storm of interest. Shift and sum these hydrographs as explained under "Hydrograph Summation."

(3) Compute the post-developed on-site hydrograph. If on-site detention is provided, this hydrograph will be the outflow hydrograph from the facility. Shift and sum this hydrograph with the existing off-site hydrograph.

(4) Plot the above two summations as shown below to obtain a comparison of cumulative effects:



The above example plot illustrates how a development with standard on-site detention can cause an increase in peak flow at some point downstream. The SWM Division may require this condition be addressed by either upgrading the downstream system, or by reducing the release rate from the detention facility such that the cumulative effect downstream is negligible as shown in the plot below:



3.5.6 COMPUTER APPLICATIONS

SBUH Method and Level Pool Routing

The computations required to generate the runoff hydrographs and perform the level pool routing techniques presented in this chapter can be performed manually. However, due to their volume and repetitive nature, a programmable calculator and/or a personal computer will perform these computations much quicker and with a likely higher degree of accuracy. Because of the familiarity nearly all practicing engineers have with either a programmable calculator (such as the Hewlett Packard 41 Series) or a personal computer running either a computer language (such as BASIC, FORTRAN or PASCAL) or a spreadsheet application (such as LOTUS123, SUPERCALC, EXCEL or MULTIPLAN), the SWM Division encourages engineers to write their own routines to perform the hydrograph analysis. This serves three purposes: (1) it requires the engineer to fully understand the mechanics of the methods, (2) it provides an opportunity to become more familiar with the computer and software, and (3) it will provide the engineer with the background to write additional specialized programs such as for complex hydraulic routing useful in design. Table 3.5.6A has been provided to assist engineers and software developers in checking the programs they write.

SWM Division Computer Models

The SWM Division has made available programs ("HYD", RDFAC and "BW") and application templates developed in-house. These are included with this Manual with documentation provided on the disk, but with no formal support. Software developers have developed programs that they market and support. The SWM Division will review these programs as they are developed and proposed for use to perform the computations in this Chapter.

Other SCS Method Event Computer Models

Since the SWM Division has selected the SBUH Method as the "yard stick" method for generating runoff hydrographs, it is essential that any other computer model proposed for use in King County also be based on the SCS methods and be demonstrated to produce hydrographs which have a similar peak, duration, total volume and approximate shape as the SBUH Method. To assist engineers or software developers seeking SWM Division approval of a proposed model, the following series of "sample" sites (Table 3.5.6A) has been included to demonstrate consistency with SBUH.

Continuous Simulation Computer Models

The SWM Division will review these models and any developed programs as they are developed and proposed for use to perform the analyses required in this Chapter.

TABLE 3.5.6A SAMPLED SBUH HYDROGRAPH COMPUTATIONS

24-Hour Precip. (inches)	Pervious Area (acres)	Pervious Area CN	Impervious Area (acres)	Impervious Area CN	Tc (minutes)	Peak Flow (CFS)
3.72	0.25	77	0	0	25	0.07
3.72	0.01	74	0.24	98	1	0.28
3.72	0.70	74	0.30	98	14	0.43
3.72	0.70	39	0.30	98	14	0.25
3.72	1.0	61	0	0	10	0.05
3.72	6.2	74	3.8	98	5	5.54
3.72	6.2	55	3.8	98	10	3.31
3.72	15.5	39	9.5	98	15	7.67
3.72	25.0	70	0	0	90	1.99
3.72	62.0	74	38.0	98	15	46.50
3.72	160.0	72	40.0	98	30	51.70
3.72	10.0	25	0	0	20	0.00
2.64	10.0	70	0	0	20	0.39
2.64	10.0	55	20	0	50	0.13
1.78	10.0	70	0	0	20	0.14
1.78	10.0	55	0	0	50	0.01

3.6 CLOSED DEPRESSION ANALYSIS

The analysis of closed depressions (and in some cases, retention ponds) requires careful assessment of the existing hydrologic performance in order to evaluate the impacts a proposed project will have. For closed depressions, the applicable requirements in Special Requirement #7, Closed Depressions, Chapter 1, and the Sensitive Areas Ordinance and Rules should be thoroughly reviewed prior to proceeding with the analysis.

Analysis and Design Criteria

The infiltration rates used in the analysis of closed depressions shall be determined by a soils report meeting the criteria described in Section 4.5.2. At least 2 tests per acre and a minimum of 4 infiltration tests shall be performed to prepare an average surface infiltration rate based on the following criteria:

(1) For closed depressions containing standing water, infiltration tests shall be performed on dry land adjacent to, and on opposite sides of the standing water (as is feasible), such that the elevation of the testing surface at the bottom of the test pit is one foot above the standing water elevation.

(2) For closed depressions without standing water, infiltration tests shall be performed in the bottom of the closed depression at locations of similar elevation, and on opposite sides of the bottom area (as is feasible), such that the elevation of the testing surface at the bottom of the test pits is at least one foot above any observed groundwater table.

Projects proposing to modify or compensate for replacement storage in a closed depression shall meet the design criteria in Section 4.4.4 "Ponds."

Method of Analysis

Closed depressions are analyzed using hydrographs routed as described in Section 3.5.4 "Hydrograph Routing." Infiltration shall be addressed where appropriate. In assessing the impacts of a proposed project on the performance of a closed depression there are three cases that dictate different applications of the performance standard as follows:

(1) CASE 1:
The 100-year, 7-day duration design storm flow from the drainage basin tributary to the closed depression for the existing conditions is routed into the closed depression using only infiltration as outflow. If runoff does not overflow the closed depression, then no runoff may leave the closed depression for the 100-year, 7-day duration design storm following development of a proposed project. This may be accomplished by excavating additional storage volume in the closed depression (subject to all applicable requirements, for example providing a defined overflow system).

(2) CASE 2:
The 100-year, 7-day duration design storm flow from the drainage basin tributary to the closed depression for the existing conditions is routed into the closed depression using only infiltration as outflow. If runoff does overflow the closed depression, then the 100-year, 24-hour duration design storm flow from the drainage basin tributary to the closed depression is routed into the closed depression using only infiltration as outflow. If this does not cause overflow, then the allowable release rate is that which occurred for the 100-year, 7-day duration design storm. This performance can be met by excavating additional storage volume in the closed depression (subject to all applicable requirements, for example providing a defined overflow system).

(3) CASE 3:

The 100-year, 7-day duration design storm flow and the 100-year, 24-hour duration design storm flow from the drainage basin tributary to the closed depression for the existing conditions are routed into the closed depression using only infiltration as outflow, and both cause overflow to occur. Then the closed depression shall be analyzed as a detention/infiltration pond. The required performance, therefore, is to not exceed the existing runoff rates for the 2, 10, and 100-year, 24-hour duration and 100-year, 7-day duration design storms. This will require that a control structure, emergency overflow spillway, access road, and other design criteria described in Section 4.4.4 "Ponds" be met and, if it is to be maintained by King County, the closed depression placed in a tract dedicated to King County. If it is to be privately maintained, it must be located in a drainage easement dedicated to the public.

CHAPTER 4
HYDRAULIC ANALYSIS AND DESIGN

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

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CHAPTER 4
HYDRAULIC ANALYSIS AND DESIGN

4.1 PURPOSE AND SCOPE

This chapter presents King County approved methods for the hydraulic analysis and design of drainage facilities. Before proceeding with the hydraulic analysis, drainage plan and design, the design engineer should thoroughly review the requirements in Chapter 1 for their application to a proposed project.

The information presented in this chapter begins with a brief description of General Design Criteria, applicable to the overall hydraulic analysis, and is then separated into four main sections:

- o Conveyance Systems
- o Retention/Detention Facilities
- o Infiltration Systems
- o Water Quality Facilities

Each of these sections contain the methods of analysis, design criteria, and standard details for the particular facility type. They are organized with similar formats to provide consistency and quick reference to information. They may include:

- o An Overview of topic and purpose.
- o Design Guidelines and criteria for system design and alternative system applications.
- o Site Constraints such as easement requirements, building setbacks, etc.
- o Subsections with most containing the following information:
  - An introduction to the topic.
  - Specific Design Criteria such as acceptable materials, maximum slopes, geometrics, etc.
  - Methods of Analysis for hydraulic system design including standard charts, nomographs, tables, etc. and reference to applicable material.
  - Standard Details acceptable to the County are provided or referenced in other publications.

4.2 GENERAL DESIGN CRITERIA

This manual and the King County Road Standards provide established standards for engineering design, suitability of purpose and method of analysis. The Washington State Department of Transportation/APWA (WSDOT/APWA) Standard Specifications for Road, Bridge and Municipal Construction, most recent edition, also provides approved specifications and standards for design and construction. For projects constructed by the King County Department of Public Works, the Engineering Services Section of the Roads Division prepares and updates a supplement to the State standards titled the "King County General Special Provisions".

4.3 CONVEYANCE SYSTEM DESIGN AND ANALYSIS

4.3.1 OVERVIEW

A conveyance system includes all portions of the surface water system, either natural or man-made, that transport storm and surface water runoff. The purpose of the conveyance system is to drain surface water from properties, up to a specific design flow, so as to provide protection to property and the environment.

A properly designed pipe system will maximize hydraulic efficiency by utilizing proper material, slope and pipe size. An ideal channel section will be sized to provide adequate capacity for design flows while minimizing erosion and allowing for aesthetics, habitat preservation and enhancement.

A human-made conveyance system should emulate the natural conveyance system to the extent feasible. Inflow to the system and discharge from the system should occur at the natural drainage points as determined by topography and existing drainage patterns.

Conveyance systems can be separated into the following five categories:

- Pipe systems
- Culverts and bridges
- Outfalls
- Open channels and constructed swales
- Floodplains/floodways

4.3.2 ANALYSIS AND ROUTE DESIGN REQUIREMENTS

Analysis

- All existing and proposed conveyance systems shall be analyzed and designed using the peak flows from the hydrographs developed using the procedures described in Chapter 3.

  Exception: For drainage subbasins 25 acres or less, and having a time of concentration of less than 100 minutes, the capacity of conveyance elements shall be determined using the Rational Method described in Section 4.3.3. Refer to Figure 3.2A to determine appropriate computation method and limits of application according to basin size.

Route Design

- The most efficient route selected for new conveyance systems will result from careful consideration of the topography of the area to be traversed and the legal property boundaries.

- Unless topography prohibits, new conveyance system alignments on private property must be located in drainage easements that are adjacent and parallel to property lines. Drainage easements should be located entirely on one property and not split between adjacent properties.

  Exception: Streams and natural drainage channels will not be relocated strictly to meet this requirement.

- Aesthetic considerations and traffic routes may dictate the placement and alignment of open channels. Appropriate vehicular and pedestrian traffic crossings must be provided in the design.

Easements and Building Setback Lines

- All public and privately maintained conveyance systems shall be located in drainage easements or covenants granted to King County as required in Section 1.2.4.

  Exception: Roof downspout, minor yard and footing drains, unless they convey off-site or between lot flows.

- Any portion of the drainage easement for the conveyance system (shown in Table 4.3.2A) shall not be located within an adjacent property or right-of-way. Building setback lines may cross into adjacent property or rights-of-way. Easements within road rights-of-way shall be per King County Road Standards.

- The distance between the center line of storm drainage pipes or culverts and building or other structure footings shall be no closer than the building setback line distance shown in Table 4.3.2A, unless a geotechnical/structure analysis is performed to demonstrate design stability, and maintenance/replacement access remains unobstructed.

- The distance between the top-of-bank of a channel or constructed swale and a building or other structure footing shall be no closer than the building setback line distance shown in Table 4.3.2A.

- Table 4.3.2A lists the required widths and building setback lines for drainage easements. For all pipes or any channel or constructed swale greater than thirty feet wide, facilities must be placed in the center of the easement. For channels or constructed swales less than or equal to 30 feet wide, the easement extends to only one side of the facility.

TABLE 4.3.2A EASEMENT WIDTHS AND BUILDING SETBACK LINES

For Pipes: Inside Diameter (D)	Easement Width	BSBL (From Easement)
1D ≤ 18"	10 feet	5 feet
18" < ID ≤ 36"	12 feet	5 feet
36" < ID ≤ 60"	15 feet	7.5 feet
60" < ID	ID plus 10 feet	10 feet
For Channels and Swales: Top Width of Channel (W)	Easement Width	BSBL (From Easement)
W ≤ 10 feet	W plus 10 feet on one side	5 feet
10 feet < W ≤ 30 feet	W plus 15 feet on one side	7.5 feet
30 feet < W	W plus 15 feet on both sides	10 feet

4.3.3 RATIONAL METHOD

During the preparation of this manual, the need was acknowledged to continue to allow a simple method for analyzing and sizing conveyance elements for small drainage subbasins. Due to it's familiarity by the civil engineering profession, and long history of use in King County, the decision was made to continue to allow the use of the Rational Method with some specific limitations.

Limitations

- Only for use in predicting a conservative peak flow rate to be used in determining the required capacity for conveyance elements.
- Drainage subbasin area (A) cannot exceed 25 acres for a single calculation.
- The time of concentration (T_c) must be computed using the method described below and cannot exceed 100 minutes. It is made equal to 6.3 minutes when computed to be less than 6.3 minutes (see Figure 4.3.3A).

Equation

The following is the traditional Rational Method equation:

$$Q_R = CI_RA$$

where:

Q_R = peak flow (cfs) for a storm of peak rainfall intensity "I_R" of a given return frequency (R)
C = estimated runoff coefficient (ratio of rainfall that becomes runoff)
I_R = peak rainfall intensity (inches/hour) for a given return frequency (R)
A = drainage subbasin area (acres)

"C" Values

The allowable runoff coefficients to be used in this method are shown in Table 4.3.3A by type of land cover. These values were selected following a review of the values previously acceptable for use in the Rational Method in King County and as described in several engineering handbooks. The values for single family residential areas were computed as composite values (as illustrated below) based on the estimated percentage of coverage by roads, roofs, yards and unimproved areas for each density. For drainage basins containing several land cover types, the following formula may be used to compute a composite runoff coefficient "C_c".

$$C_c = ((C_1 \times A_1) + (C_2 x A_2) + ... + (C_n x A_n))/A_t$$

where:

A_t = total area (acres)

$A_{1,2,n}$ = areas of land cover types (acres)

$C_{1,2,n}$ = runoff coefficients for each area land cover type

TABLE 4.3.3A RUNOFF COEFFICIENTS - "C" VALUES FOR THE RATIONAL METHOD*

GENERAL LAND COVERS

LAND COVER	C	LAND COVER	C
Dense forest	0.10	Playgrounds	0.30
Light forest	0.15	Gravel areas	0.80
Pasture	0.20	Pavement and roofs	0.90
Lawns	0.25	Open water (pond, lakes, wetlands)	1.00

SINGLE FAMILY RESIDENTIAL AREAS
(Density is in dwelling units per gross acreage (DU/GA))

LAND COVER DENSITY	C	LAND COVER DENSITY	C
0.20 DU/GA (1 unit per 5 ac.)	0.17	3.00 DU/GA	0.42
0.40 DU/GA (1 unit per 2.5 ac.)	0.20	3.50 DU/GA	0.45
0.80 DU/GA (1 unit per 1.25 ac.)	0.27	4.00 DU/GA	0.48
1.00 DU/GA	0.30	4.50 DU/GA	0.51
1.50 DU/GA	0.33	5.00 DU/GA	0.54
2.00 DU/GA	0.36	5.50 DU/GA	0.57
2.50 DU/GA	0.39	6.00 DU/GA	0.60

For land covers not listed above, an area-weighted "C x At" sum should be computed based on the following equation: $C \times A_t = (C_1 x A_1) + (C_2 x A_2) + ... + (C_n x A_n)$, where $A_t = (A_1 + A_2 + ... + A_n)$, the total drainage basin area.

* (For use only in determining peak design flow for analyzing and sizing pipes, culverts or channels)

"I_R" Peak Rainfall Intensity

The peak rainfall intensity (I_R) for the specified return frequency ($_R$) design storm is determined using a unit peak rainfall intensity factor (i_R) for a given return frequency ($_R$) design storm using the following equation:

$I_R = (P_R)(i_R)$

where:

P_R = is the total precipitation at the project site for the 24-hour duration design storm event for the given return frequency (from the Isopluvial Maps in Figures 3.5.1C through 3.5.1H)

i_R = $(a_R)(T_c)^{-(b_R)}$; the unit peak rainfall intensity factor

Where

T_c = time of concentration (minutes), calculated using the method described below only (T_c minimum value is 6.3 minutes)

a_R and b_R are coefficients (from Table 4.3.3B) used to adjust the equation for the design storm return frequency ($_R$)

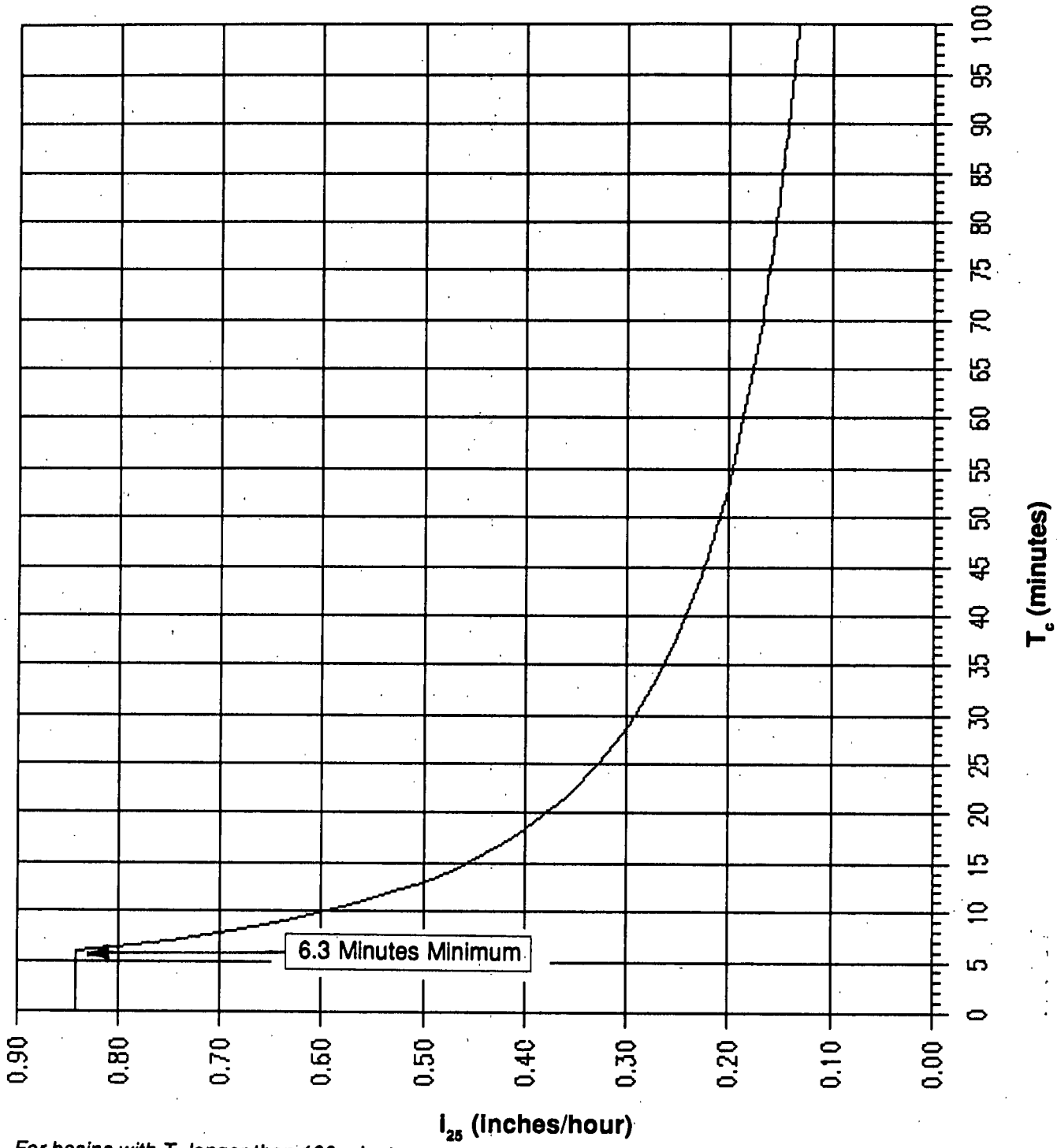
This "i_R" equation was developed by SWM Division staff from equations originally developed by Ron Mayo, P.E.. It is based on the original Renton/Seattle Intensity/Duration/Frequency (I.D.F.) curves. Rather than requiring a family of curves for various locations in King County this equation adjusts proportionally the Renton/Seattle I.D.F. curve data by using the 24-hour duration total precipitation isopluvial maps. This adjustment is based on the assumption that the localized geo-climatic conditions that control the total volume of precipitation at a specific location also control the peak intensities proportionally.

Figure 4.3.3A has been included to demonstrate that this unit peak rainfall intensity (i_R) will generate a curve with the same characteristics as the historic 25 year I.D.F. curve. Note, T_c must not be less than 6.3 minutes or greater than 100 minutes. On the historic I.D.F. curves the lower limit was set at 5 minutes, 6.3 minutes was selected based on the mathematical limits of the equation coefficients.

TABLE 4.3.3B COEFFICIENTS FOR THE RATIONAL METHOD "i_R" -EQUATION

DESIGN STORM RETURN FREQUENCY (YEARS)	a_R	b_R
2 Year	1.58	0.58
5 Year	2.33	0.63
10 Year	2.44	0.64
25 Year	2.66	0.65
50 Year	2.75	0.65
100 Year	2.61	0.63

FIGURE 4.3.3A RATIONAL METHOD UNIT PEAK RAINFALL INTENSITY (25 YEAR STORM) "i_{25}"



For basins with T_c longer than 100 minutes use the Hydrograph Analysis Method to obtain Q_R (See Section 3.5)

"T_c" Time of Concentration (Rational Method Only)

The time of concentration is defined as the time it takes runoff to travel overland (from the onset of precipitation) from the most hydraulically distant location in the drainage basin to the point of discharge. Note that when the C_c of a drainage basin exceeds 0.60, it may be important to compute the T_c and peak rate of flow from the impervious area separately. The computed peak rate of flow for the impervious surface alone may exceed that for the entire drainage basin using the total drainage basin T_c. The higher of the two peak flow rates shall then be used to size the conveyance element. The T_c is computed by summation of the travel times(s) (T_t) of overland flow across separate flow path segments defined by the six categories of land cover from the chart published in 1975 by the Soil Conservation Service shown in Table 4.3.3C.

The equation for time of concentration is:

$$T_c = T_1 + T_2 + ... + T_n$$

where:

$T_{1,2,n}$ = consecutive flow path segments of different land cover category or having significant difference in flow path slope

TABLE 4.3.3C k_R VALUES FOR T_t USING THE RATIONAL METHOD

Land Cover Category	k_R
Forest with heavy ground litter and meadow	2.5
Fallow or minimum tillage cultivation	4.7
Short grass pasture and lawns	7.0
Nearly bare ground	10.1
Grassed waterway	15.0
Paved area (sheet flow) and shallow gutter flow	20.0

Travel time for each segment is computed using the following equation:

$$T_t = L/60V \text{ (minutes)}$$

(Note, the T_t through an open water body (such as a pond) shall be assumed to be zero with this method.)

where:

L = the distance of flow across a given segment (feet)

V = average velocity across the land cover (feet/second)

Average velocity (V) is computed using the following equation (or read from Figure 4.3.3B):

$$V = k_R \sqrt{s_o}$$

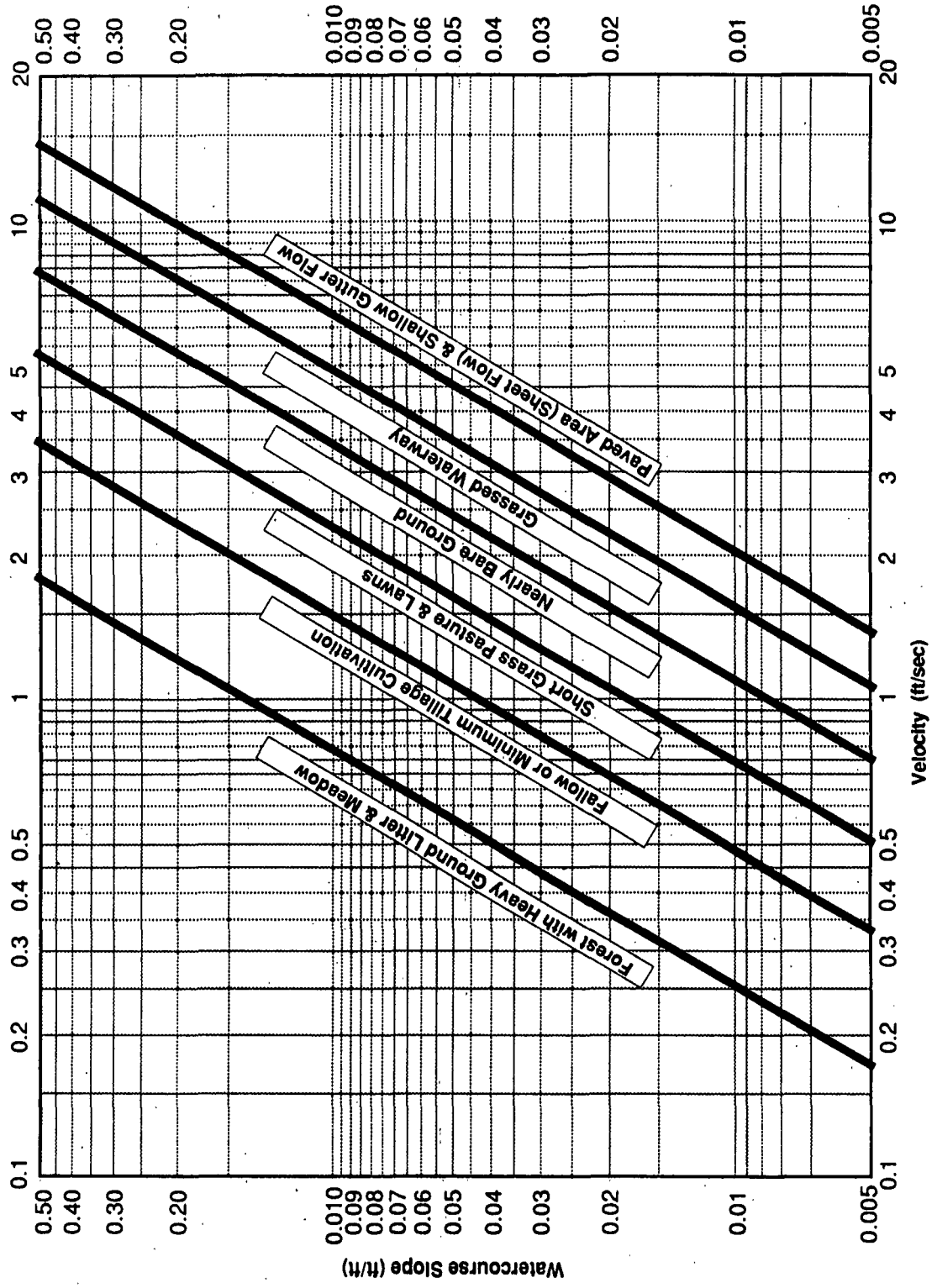
where:

k_R = time of concentration velocity factor (feet/second) (see Table 4.3.3C)

s_o = slope of flow path (feet/feet)

FIGURE 4.3.3B AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR OVERLAND FLOW*

***For use with the Rational Method only; From Soil Conservation Service, Tech. Release No. 55, January 1975**



Example

Compute the peak flow (Q_{25}) to size a new roadway cross culvert for a 22.8 acre drainage basin east of Kent, P_{25} = 3.42 inches.

Given: AREAS

A_1	=	10.5 acres of single family residential area at 3.8 DU/GA
A_2	=	8.9 acres of light forest
A_3	=	3.4 acres of pasture
A_t	=	22.8 total acres

DESCRIPTION OF FLOW PATH SEGMENTS FOR T_c

L_1	=	300 feet	s_1	=	0.08	forest land cover	k_R = 2.5
L_2	=	200 feet	s_2	=	0.03	meadow	k_R = 2.5
L_3	=	1000 feet	s_3	=	0.015	grassed waterway (ditch)	k_R = 15.0

Compute: COMPOSITE RUNOFF COEFFICIENT "C_c"

A_1:C_1 From Table 4.3.3A, C for 4.00 DU/GA = 0.48, C for 3.50 DU/GA = 0.45, therefore C_1 for 3.80 DU/GA by visual interpolation = 0.47.

A_2:C_2 = 0.15

A_3:C_3 = 0.20

$$C_c = ((C_1 \times A_1) + (C_2 \times A_2) + (C_3 \times A_3))/A_t$$
$$= ((0.47 \times 10.5) + (0.15 \times 8.9) + (0.20 \times 3.4))/22.8 = \underline{0.30}$$

PEAK RAINFALL INTENSITY "I_R", "I_{25}"

First, compute T_c:

$$T_1 = L_1/60V_1 = L_1/60(k_R \sqrt{s_1}) = (300)/60((2.5)\sqrt{(0.08)})$$
$$= \underline{7 \text{ minutes}}$$

$$T_2 = L_2/60V_2 = L_2/60(k_R \sqrt{s_2}) = (200)/60((2.5)\sqrt{(0.03)})$$
$$= \underline{8 \text{ minutes}}$$

$$T_3 = L_3/60V_3 = L_3/60(k_R \sqrt{s_3}) = (1000)/60((15)\sqrt{(0.015)})$$
$$= \underline{9 \text{ minutes}}$$

$T_c = T_1 + T_2 + T_3 = 7 + 8 + 9 =$ <u>24 minutes</u> (<100, OK to continue)

Second, compute I_R: I_{25}:

$$I_{25} = (a_R)(T_c)^{-(b_R)} = (2.66)(24)^{-(0.65)} = \underline{0.34}$$

Third, compute I_R: I_{25}:

$$I_{25} = (P_{25})(I_{25}) = (3.42)(0.34) = \underline{1.16}$$

PEAK RUNOFF RATE

$$Q_{25} = C\ I_{25}\ A = C_c\ I_{25}\ A = (0.30)(1.16)(22.8) = \underline{7.9 \text{ cfs}}$$

Pipe System Analysis and Sizing

Figure 4.3.3C has been provided to allow for the tabular computation of "C-A" values used in sizing a new pipe system. Following computation of the time of concentration to the first structure, where flow enters the proposed pipe system, the travel times through the pipe lengths are added to become the T_c for the design flow at the next downstream pipe run. The flows computed at structures (manholes and catch basins) may be used in Section 4.3.4 to estimate the water surface profile along the pipe system.

FIGURE 4.3.3C RATIONAL METHOD FOR CONVEYANCE SYSTEM ANALYSIS AND SIZING

CONVEYANCE SYSTEM ANALYSIS AND SIZING TABLE USING THE RATIONAL METHOD

Location		Sub Basin Number	Area (ac)	C	C•A	Sum C•A	T_c (min.)	i_R	I_R	Q_R (c.f.s.)	Pipe (in.)	Typ. n	Slope (ft.ft.)	Q_F (pipe full)	V (pipe full)	V (at Q_R)	L (ft.)	T_t (min.)
From	To																	

Project:	R	P_R	Calcs by:	Job No:
Location: ____ 1/4 ____ 1/4 Sec. ____ TWP ____ RGE. ____			Date: / /	Page of

4.3.4 PIPE SYSTEMS

Pipe systems are networks of storm drain pipes, catch basins, manholes, inlets and outfalls designed and constructed to convey surface water. The hydraulic analysis of flow in storm drain pipes typically is limited to "gravity flow"; however, in analyzing existing systems it may be necessary to address pressurized conditions. Pump systems (allowed only by variance, see Core Requirement #4 in Section 1.2.4) shall be designed using the hydraulic methods which apply to sanitary sewer pump systems.

Design Criteria For Pipe Systems

(1) Pipe material, joints and protective treatment shall be in accordance with WSDOT/APWA Standard Specifications Section 9.05 as modified by the County General Special Provisions and AASHTO and ASTM treatment as noted below.

NOTE: The pipe materials and specifications included in this section are for conveyance systems installed per engineering plans required for King County permits/approvals. Other pipe materials and specifications are not excluded for use by private property owners for drainage systems they construct and maintain when such systems are not required by or granted to King County.

- o Materials allowed* for storm pipe systems:
  - Plain concrete (12" diameter only, and only as driveway culvert)
  - Ductile iron (water supply, Class 50 or 52)
  - Reinforced concrete pipe
  - Galvanized corrugated iron or steel pipe, Treatment 1 through 6.
  - Galvanized steel spiral rib pipe, Treatment 1 through 6.
  - Corrugated aluminum pipe
  - Aluminum spiral rib pipe
  - Aluminized Type 2 corrugated steel (meets AASHTO treatment M274 and M56)
  - Corrugated high density polyethylene pipe (CPEP) - smooth interior (see note 1)
  - Corrugated high density polyethylene pipe (CPEP) - single wall, fully corrugated (see note 2)
  - Polyvinyl chloride (PVC) sewer pipe (see note 3)
  - High density polyethylene pipe (HDPP) (see note 4)

  * Refer to the King County Road Standards for pipe materials allowed for storm pipe in King County road right-of-way.

NOTES:

1. CPEP - Smooth interior pipe and fittings shall be manufactured from high density polyethylene resin which shall meet or exceed the requirements of Type 111, Category 4 or 5, Grade P33 or P34, Class C per ASTM D1248. In addition, the pipe shall comply with all material and stiffness requirements of AASHTO M294.

2. CPEP - single wall, fully corrugated allowed only for use in temporary storm sewer systems, as downspout/footing/yard drain collectors on private property (smooth interior required in road right-of-way for drainage stub-outs or perforated as subgrade drain per KCRS). Pipe and fittings shall comply with all of the requirements of AASHTO M252 for 3" through 10" diameter and AASHTO M294 for 12" through 24" diameter.

3. PVC pipe must be SDR 35 or thicker and meet the requirements of ASTM D3034 and is allowed only for use in privately maintained drainage systems or as allowed in road right-of-way per KCRS.

4. HDPP is normally used outside of King County rights-of-way such as on steep slope installations (see Section 4.3.6). Connections to King County road drainage systems are allowed for pipe diameters of 12" or greater. HDPP shall comply with the requirements of Type III C5P34 as tabulated in ASTM D1248 and have the PPI recommended designation of PE3408 and have an ASTM D3350 cell classification

of 345434C or 345534C. The pipe shall have a manufacturer's recommended hydrostatic design stress rating of 800 psi based on a material with a 1600 psi design basis determined in accordance with ASTM D2837-69. The pipe shall have a suggested design working pressure of 50 psi at 73.4 degrees F and SDR of 32.5.

- o Allowable Joints:
  - Concrete pipe shall be rubber gasketed.
  - Ductile pipe joints shall be flanged or restrained mechanical joints.
  - CMP shall be rubber gasketed and securely banded.
  - Spiral rib pipe shall be "hat-banded" with neoprene gaskets.
  - CPEP-smooth interior pipe shall be joined by split corrugated couplings, with gasket, which are at least 4 corrugations wide and exceed the soil tightness requirements of the AASHTO Standard Specifications for Highway Bridges, Section 23 (2.23.3).
  - CPEP-single wall, fully corrugated pipe shall be joined by split or snap-on couplings for 3" through 10" diameter pipe, and by split corrugated couplings with gasket for 12" through 24" diameter pipe. Couplings for 12" through 24" diameter pipe shall be at least 7 corrugations wide and shall exceed the soil tightness requirements of the AASHTO Standard Specifications for Highway Bridges, Section 23 (2.23.3).
  - PVC pipe shall be installed following procedures outlined in ASTM D2321, joints shall conform to ASTM D3212, and gaskets shall conform to ASTM F477.
  - High density polyethylene shall be jointed by butt fusion methods or flanged per KCRS.

(2) Pipe Sizes, Slopes and Velocities

- o Table 4.3.4A presents the pipe sizes and lengths along with the minimum slopes and velocities and design flow by structure. Table 4.3.4B presents the maximum pipe slopes and velocities, and requirements for anchoring pipe systems, by pipe material. (see Figure 4.3.4J and 4.3.4K) If site constraints result in velocities less than 3 fps at the design flow, impacts from sedimentation in the pipe system shall be addressed for maintenance considerations (e.g., larger pipes, closer spacing of catch basins).

- o For pipe systems to be maintained by King County, the design engineer shall use the following pipe sizes: 8" (only in special cases, see Table 4.3.4A), 12", 18", 24", and 30". For pipes larger than 30" diameter, increasing increments of 6" intervals shall be used (36, 42, 48, etc...).

- o Change of Pipe Size (does not apply to detention tanks):
  - Changes of pipe sizes (increase or decrease) is allowed only at junctions and structures must be located at all junctions. (Exceptions may be allowed per Section 7.03D of the King County Road Standards.)
  - When connecting pipes at structures match any of the following: (in descending order of "first choice" in best design priority) crowns, 80% diameters or inverts of pipes (or use drop manholes per KCRS).
  - Downsizing for pipes larger than 12 inches may be allowed provided pipe capacity is adequate for design flows.

(3) Structures

- o Table 4.3.4C presents the allowable structures and pipe sizes allowed by size of structure.

- o The methods described in Chapter 5, Sections 4 and 5, of the Washington State Department of Transportation (WSDOT) Hydraulics Manual can be used in determining the capacity of inlet grates when capacity is of concern with the following exceptions:
  - Use design peak flows as required in Chapter 1, Section 1.2.4, of this manual.
  - Assume grate areas on slopes are 80% free of debris. "Vaned" grates, 95%.
  - Assume grate areas in sags or low spots are 50% free of debris. "Vaned" grates, 75%

- Catch basin (or manhole) diameter shall be determined by pipe orientation at the junction structure. A plan view of the junction structure, drawn to scale, will be required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must ensure a minimum distance (of solid concrete wall) between pipe openings of 8" for 48" and 54" catch basin's and 12" for 72" and 96".

  Evaluation of the structural integrity for H-20 loading may be required for multiple junction catch basins and other structures.

- Catch basins shall be provided within 50 feet of the entrance to a pipe system to provide for silt and debris removal.

- HDPP pipe systems longer than 100 feet must be secured at the upstream end and the downstream end placed in a 4' section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of this pipe material.

- The maximum slope of the ground surface for a radius of 5' around a catch basin grate or solid lid shall be 3:1.

TABLE 4.3.4A PIPE SIZES AND LENGTHS BETWEEN STRUCTURES

	Upstream Structure to Downstream Structure	Pipe Diameter (Inches)	Minimum Slope (%) and Min. Velocity (fps) at Design Flow	Maximum Length (ft)
*	Inlet to CB/MH	12	0.5%, 3.0 fps	60
**	Inlet to CB/MH	8	0.5%, 3.0 fps	40
**	CB to CB	8	0.5%, 3.0 fps	100
***	CB/MH to CB/MH	12 or greater	0.2%, 3.0 fps	300

* King County maintained roadways: on cross-street connections from single inlets to main storm drain, the pipe shall generally be 12-inch minimum diameter, and single inlets shall be catch basins with sumps. In special cases, such as shallow gradients or conflict with underground utilities, pipe may be minimum 8-inch diameter, and inlet may be simple inlet (KCRS Dwg. No. 40).

** 8-inch-diameter pipe typically allowed only for privately maintained systems, except as noted (*).

*** Maximum spacing of surface drainage courses between inlets or catch basins shall be 150 feet on grades less than 1% and 200 feet on grades from 1% to 3%. Otherwise, maximum spacing shall be 300 feet on grades over 3%, or as required by grate flow capacities.

TABLE 4.3.4B MAXIMUM PIPE SLOPES AND VELOCITIES

Pipe Material	Pipe Slope Above Which Pipe Anchors Required and Minimum Anchor Spacing	Max. Slope Allowed	Max. Velocity @ Full Flow
* CMP, *Spiral Rib, *PVC, CPEP-singlewall	20% (1 anchor per 100 L.F. of pipe)	30%***	30 fps
*Concrete or *CPEP-smooth interior	10% (1 anchor per 50 L.F. of pipe)	20%***	30 fps
Ductile Iron	40% (1 anchor per pipe section)	None	None
High Density Polyethylene **HDPP	50% (1 anchor per 100 L.F. of pipe - cross slope installations only)	None	None

* Not allowed in landslide hazard areas.
** Butt-fused pipe joints required. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.
*** Maximum slope of 200% allowed for these pipe materials with no joints (one section) with structures at each end and properly grouted.

TABLE 4.34C ALLOWABLE STRUCTURES AND PIPE SIZES

	Maximum Pipe Diameter	
Catch Basin Type[1]	[2]CMP, Spiral Rib CPEP, HDPP, PVC	Concrete and Ductile Iron
Inlet[4]	12"	12"
Type 1[3]	18"	12"
Type 1L[3]	24"	18"
Type 2-48-inch dia.	30"	24"
Type 2-54-inch dia.	36"	30"
Type 2-72-inch dia.	54"	48"
Type 2-96-inch dia.	72"	72"

[1] Catch basins, including manhole steps, ladder, and handholds shall conform to King County Road Standards.

[2] Generally these pipe materials will be one size larger than concrete due to smaller wall thickness. However, for angled connections or those with several pipes on the same plane, this will not apply.

[3] Maximum 5 vertical feet allowed between grate and invert elevation.

[4] Normally allowed only for use in privately maintained drainage systems and must discharge to a C.B. immediately downstream. (see Table 4.3.4A)

(4) Pipe Alignment/Connections/Cover

- Pipes must be laid true to line and grade with no curves, bends or deflections in any direction [except for HDPP and Ductile Iron with flanged restrained mechanical joint bends (not greater than 30°) on steep slopes which can be demonstrated to drain along entire invert].

- A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

- Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on roof/footing/yard drain systems on pipes 8" in diameter, or less, with clean-outs upstream of each wye or tee. Additional exceptions may be made per Section 7.03D of the King County Road Standards.

- Provide 6 inches minimum vertical and 3 feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits. Clearances within King County rights-of-way shall be per the KCRS. For crossings of sanitary sewer lines the Washington Department of Ecology criteria will apply. For crossings of swale easements, provide 6 inches minimum vertical backfill between required pipe cover material and base of swale.

- Pipe cover over storm pipes in King County road right-of-way shall be per the KCRS or as specified in Tables 4.3.4D through 4.3.4U, "Pipe Cover Specifications". Pipe cover is measured from the finished grade elevation down to the top of the outside surface of the pipe. Note that for pipes less than 12" diameter (when not listed in these tables), use the cover specifications for the 12" diameter pipes. Under drainage easements, collector roadways, driveways, parking stalls, or other areas subject to light vehicular loading, pipe cover may be reduced to 1' minimum if recommended by pipe manufacturers.

- PVC SDR 35 minimum cover shall be 3 feet; maximum cover shall be 30 feet.

- Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to 1' minimum.

(5) Debris Barriers

Debris barriers (trash racks) are required on all pipes 18" to 36" in diameter entering a closed pipe system. See Figure 4.3.4G for required debris barrier on pipe ends outside of roadways. See Figure 4.3.4H and Section 4.3.5 for requirements on pipe ends (culverts) projecting from driveway or roadway side slopes.

(6) Drainage Easements

Drainage easements are required for maintenance and access over pipes located outside of the road right-of-way (see Section 1.2.4), except downspout roof drains, yard drains and footing drains. (See Section 4.3.2 for easement widths and building setbacks).

TABLE 4.3.4D FILL HEIGHTS – CONCRETE PIPE

Pipe Diameter (Inches)	Maximum Cover (Feet) By Compaction Design									
	Plain		Class II		Class III		Class IV		Class V	
	A	C	A	C	A	C	A	C	A	C
12	18	57	10	32	14	43	21	65	26	82
18	18	52	11	33	14	44	22	67	28	85
24	16	50	11	33	15	45	22	69	28	86
30			11	33	15	45	23	69	29	87
36			11	33	15	45	23	69	29	88
48			12	30	15	41	23	63	29	80
60			12	28	16	38	24	59	30	74
72			12	27	16	37	24	56	30	70
84			12	27	16	33	24	53	30	67
96			12	27	16	33	24	53	30	67
108			12	25	16	33	24	52	30	67

Minimum Coverage 2 Feet
Note: Design A and Design C refer to Figure 4.3.4I "Pipe Compaction Designs and Backfill"

TABLE 4.3.4E FILL HEIGHTS – CORRUGATED HIGH DENSITY POLYETHYLENE PIPE

Pipe Diameter (Inches)	Maximum Fill Height (Cover) (Feet)	
	Normal	Fully projected
3	87	87
4	87	87
5	88	88
6	90	90
8	88	88
10	87	87
12	84	58
15	82	59
18	88	62
24	90	61
30	(not yet approved)	
36	(not yet approved)	
42	(not yet approved)	
48	(not yet approved)	

Minimum Coverage 2 Feet

CORRUGATED HIGH DENSITY POLYETHYLENE PIPE (CPEP) - SMOOTH INTERIOR
(Fully corrugated - smooth interior)

TABLE 4.3.4F FILL HEIGHTS – CORRUGATED STEEL PIPE 2 2/3" x 1/2" (Helical)

Pipe Diameter (Inches)	Maximum Cover (Feet)				
	.064" (16 ga)	.079" (14 ga)	.109" (12 ga)	.138" (10 ga)	.168" (8 ga)
12	100	100	100	100	100
18	100	100	100	100	100
24	98	100	100	100	100
30	78	98	100	100	100
36	65	81	100	100	100
42	56	70	98	100	100
48	49	61	86	100	100
54		54	76	98	100
60			68	88	100
66				80	98
72				73	90
78					80
84					69

Minimum Cover 2 Feet

TABLE 4.3.4G FILL HEIGHTS – CORRUGATED STEEL PIPE 3" x 1" (Helical)

Pipe Diameter (Inches)	Maximum Cover (Feet)				
	.064" (16 ga)	.079" (14 ga)	.109" (12 ga)	.138" (10 ga)	.168" (8 ga)
36	75	94	100	100	100
42	64	80	100	100	100
48	56	70	99	100	100
54	50	62	88	100	100
60	45	56	79	100	100
66	41	51	72	92	100
72	37	47	66	84	100
78	34	43	60	78	95
84	32	40	56	72	89
90	30	37	52	67	83
96		35	49	63	77
102		33	46	59	73
108			44	56	69
114			41	53	65
120			39	50	62

Minimum Cover 2 Feet

TABLE 4.3.4H FILL HEIGHTS – CORRUGATED STEEL PIPE 5" x 1" (Helical)

Pipe Diameter (Inches)	Maximum Cover (Feet) .064" (16 ga)	.079" (14 ga)	.109" (12 ga)	.138" (10 ga)	.168" (8 ga)
30	80	100	100	100	100
36	67	83	100	100	100
42	57	71	100	100	100
48	50	62	88	100	100
54	44	55	78	100	100
60	40	50	70	90	100
66	36	45	64	82	100
72	33	41	58	75	92
78	31	38	54	69	85
84	28	35	50	64	79
90	26	33	47	60	73
96	FF*	31	44	56	69

Minimum Cover 2 Feet
* FF indicates flexibility factor controls

TABLE 4.3.4I FILL HEIGHTS – CORRUGATED STEEL PIPE 6" x 2" (Helical)

Pipe Diam (Inches)	Pipe Diam (feet)	Min. Cover (feet)	Maximum Cover (Feet) .109" (12 ga)	.138" (10 ga)	.168" (8 ga)	.188" (7 ga)	.218" (5 ga)	.249" (3 ga)	.280" (1 ga)
60	5	2	42	63	83	92	100	100	100
72	6	2	35	53	69	79	94	100	100
84	7	2	30	45	59	67	81	95	100
96	8	2	27	40	52	59	71	84	92
108	9	2	23	35	46	53	64	75	81
120	10	2	21	31	42	47	57	67	74
132	11	2	19	29	37	42	52	61	66
144	12	2	18	26	37	40	47	56	61
156	13	2	16	24	31	36	43	52	56
168	14	2	15	22	30	33	41	48	53
180	15	2	14	20	28	31	38	44	49
192	16	2	0	19	26	30	35	42	46
204	17	3		18	24	28	33	40	43
216	18	3		0	23	26	31	37	41
228	19	3				25	30	35	39
240	20	3				23	29	33	37
252	21	3				0	27	31	35

TABLE 4.3.4J FILL HEIGHTS – CORRUGATED STEEL PIPE ARCH 2 2/3" x 1/2" (Helical)

Span x Rise (in. x in.)	Corner Radius (in.)	Thickness (in.)	Thickness Gage	Min. Cover (feet)	Maximum Cover (Feet) for Corner Pressure 2 tons/ft^2	Maximum Cover (Feet) for Corner Pressure 3 tons/ft^2
17 x 13	3	0.064	(16 ga)	2	12	18
21 x 15	3	0.064	(16 ga)	2	10	14
24 x 18	3	0.064	(16 ga)	2	7	13
28 x 20	3	0.064	(16 ga)	2	5	11
35 x 24	3	0.064	(16 ga)	2.5	NS	7
42 x 29	3 1/2	0.064	(16 ga)	2.5	NS	7
49 x 33	4	0.079	(14 ga)	2.5	NS	6
57 x 38	5	0.109	(12 ga)	2.5	NS	8
64 x 43	6	0.109	(12 ga)	2.5	NS	9
71 x 47	7	0.138	(10 ga)	2	NS	10
77 x 52	8	0.168	(8 ga)	2	5	10
83 x 57	9	0.168	(8 ga)	2	5	10

NS = Not Suitable

TABLE 4.3.4K FILL HEIGHTS – CORRUGATED STEEL PIPE ARCH 3" x 1" (Helical)

Span x Rise (in. x in.)	Corner Radius (in.)	Thickness (in.)	Thickness Gage	Min. Cover (feet)	Maximum Cover (Feet) 2 Ton Soil (ft)	Maximum Cover (Feet) 3 Ton Soil (ft)
40 x 31	5	0.064	(16 ga)	2.5	8	12
46 x 36	6	0.064	(16 ga)	2	8	13
53 x 41	7	0.064	(16 ga)	2	8	13
60 x 46	8	0.064	(16 ga)	2	8	13
66 x 51	9	0.064	(16 ga)	2	9	13
73 x 55	12	0.064	(16 ga)	2	11	16
81 x 59	14	0.064	(16 ga)	2	11	17
87 x 63	14	0.064	(16 ga)	2	10	16
95 x 67	16	0.079	(14 ga)	2	11	17
103 x 71	16	0.109	(12 ga)	2	10	15
112 x 75	18	0.109	(12 ga)	2	10	16
117 x 79	18	0.109	(12 ga)	2	10	15
128 x 83	18	0.138	(10 ga)	2	9	14
137 x 87	18	0.138	(10 ga)	2	8	13
142 x 91	18	0.168	(8 ga)	2	7	12

TABLE 4.3.4L FILL HEIGHTS – CORRUGATED STEEL STRUCTURAL PLATE PIPE ARCH

3/4" BOLTS, 4 BOLTS PER FOOT

Span x Rise (ft - in x ft - in)	Corner Radius (in.)	Thickness (in.)	Thickness Gage	2 Ton Soil Min. Cover (in.)	2 Ton Soil Max. Cover (ft.)	3 Ton Soil Min. Cover (in.)	3 Ton Soil Max. Cover (ft.)
6 - 1 x 4 - 7	18	0.109	(12 ga)	24	16	24	24
7 - 0 x 5 - 1	18	0.109	(12 ga)	24	14	24	21
7 - 11 x 5 - 7	18	0.109	(12 ga)	24	13	24	19
8 - 10 x 6 - 1	18	0.109	(12 ga)	24	11	24	17
9 - 9 x 6 - 7	18	0.109	(12 ga)	24	10	24	15
10 - 11 x 7 - 1	18	0.109	(12 ga)	24	9	24	14
11 - 10 x 7 - 7	18	0.109	(12 ga)	24	7	24	13
12 - 10 x 8 - 4	18	0.109	(12 ga)	30	6	24	12
14 - 1 x 8 - 9	18	0.109	(12 ga)	30	5	24	11
15 - 4 x 9 - 3	18	0.138	(10 ga)	NS	NS	24	10
15 - 10 x 9 - 10	18	0.138	(10 ga)	NS	NS	24	9
16 - 7 x 10 - 1	18	0.138	(10 ga)	NS	NS	24	9
13 - 3 x 9 - 4	31	0.109	(12 ga)	24	13	24	17*
14 - 2 x 9 - 10	31	0.109	(12 ga)	24	12	24	16*
15 - 4 x 10 - 4	31	0.138	(10 ga)	24	11	24	15*
16 - 3 x 10 - 10	31	0.138	(10 ga)	24	11	24	14*
17 - 2 x 11 - 4	31	0.138	(10 ga)	30	10	30	13*
18 - 1 x 11 - 10	31	0.168	(8 ga)	30	10	30	12*
19 - 3 x 12 - 4	31	0.168	(8 ga)	30	9	30	13
19 - 11 x 12 - 10	31	0.188	(6 ga)	30	9	30	13
20 - 7 x 13 - 2	31	0.188	(6 ga)	36	7	36	13

* Fill limited by seam strength.
NS = Not Suitable

TABLE 4.3.4M FILL HEIGHTS – CORRUGATED ALUMINUM PIPE 2 2/3" x 1/2" (Helical)

Pipe Diameter (Inches)	Maximum Cover (Feet) .060" (16 ga)	.075" (14 ga)	.105" (12 ga)	.135" (10 ga)	.164" (8 ga)
12	100	100	100	100	100
18	95	100	100	100	100
24	71	89	100	100	100
30	57	71	100	100	100
36	47	59	83	100	100
42	40	51	71	92	100
48		FF*	61	80	98
54			50	65	80
60				53	66
66				FF*	53
72					42

Minimum Cover 2 Feet
* FF indicates flexibility factor controls

TABLE 4.3.4N FILL HEIGHTS – CORRUGATED ALUMINUM PIPE 3" X 1" (HELICAL)

Pipe Diameter (Inches)	Maximum Cover (Feet) .060" (16 ga)	.075" (14 ga)	.105" (12 ga)	.135" (10 ga)	.164" (8 ga)
36	54	68	96	100	100
42	46	58	82	100	100
48	41	51	72	96	100
54	36	45	64	85	100
60	32	41	57	77	90
66	29	37	52	70	82
72	27	34	48	64	75
78		31	44	59	69
84			41	55	64
90			38	51	60
96			35	47	56
102				42	50
108				38	45
114					41
120					37

Minimum Cover 2 Feet

TABLE 4.3.4O FILL HEIGHTS – CORRUGATED ALUMINUM PIPE 6" x 1" (Helical)

Pipe Diameter (Inches)	Maximum Cover (Feet) .060" (16 ga)	.075" (14 ga)	.105" (12 ga)	.135" (10 ga)	.164" (8 ga)
30	57	71	100	100	100
36	47	59	83	99	100
42	41	51	71	91	100
48	35	44	62	80	95
54	31	40	55	71	87
60	29	35	50	64	78
66	26	32	45	58	71
72	23	29	42	54	65
78		27	38	49	60
84			35	45	55
90			33	42	52
96				40	49
102				37	45
108				33	41
114					37

Minimum Cover 2 Feet

TABLE 4.3.4P FILL HEIGHTS – CORRUGATED ALUMINUM STRUCTURAL PLATE PIPE 9" x 2 1/2"

GALVANIZED STEEL BOLTS

Pipe Diameter (inches)	(feet)	Gage Thickness 0.0100"	0.125"	0.150"	0.175"	0.200"	0.225"	0.250"
60	5	31	45	60	70	81	92	100
72	6	25	37	50	58	67	77	86
84	7	22	32	42	50	58	66	73
96	8	19	28	37	44	50	57	64
108	9	17	25	33	39	45	51	57
120	10	15	22	30	35	40	46	51
132	11	14	20	27	32	37	42	47
144	12	12	18	25	29	33	38	43
156	13		17	23	27	31	35	39
168	14			31	25	29	33	36
180	15				23	27	30	34

Minimum Cover 2 Feet

TABLE 4.3.4Q FILL HEIGHTS – CORRUGATED ALUMINUM PIPE ARCH 2 2/3" x 1/2" (Helical)

Span x Rise (in. x in.)	Corner Radius (in.)	Thickness (in.)	Gage	Min. Cover (in.)	Maximum Cover (Feet) 2 Ton Soil (ft)	3 Ton Soil (ft)
17 x 13	3	0.060	(16 ga)	24	12	18
21 x 15	3	0.060	(16 ga)	24	10	14
24 x 18	3	0.060	(16 ga)	24	7	13
28 x 20	3	0.060	(16 ga)	24	5	11
35 x 24	3	0.060	(16 ga)	30	NS	7
42 x 29	3 1/2	0.060	(16 ga)	30	NS	7
49 x 33	4	0.075	(14 ga)	30	NS	6
57 x 38	5	0.135	(10 ga)	30	NS	8
64 x 43	6	0.135	(10 ga)	30	NS	9
71 x 47	7	0.164	(8 ga)	24	NS	10

NS = Not Suitable

TABLE 4.3.4R FILL HEIGHTS – CORRUGATED ALUMINUM STRUCTURAL PIPE ARCH 3" x 1" (Helical)

Span x Rise (in. x in.)	Corner Radius (in.)	Thickness (in.)	Thickness Gage	Min. Cover (in.)	Maximum Cover (Feet) 2 Ton Soil (ft)	Maximum Cover (Feet) 3 Ton Soil (ft)
40 x 31	5	0.060	(16 ga)	30	8	12
46 x 36	6	0.060	(16 ga)	24	8	13
53 x 41	7	0.060	(16 ga)	24	8	13
60 x 46	8	0.060	(16 ga)	24	8	13
66 x 51	9	0.060	(16 ga)	24	9	13
73 x 55	12	0.075	(14 ga)	24	11	16
81 x 59	14	0.075	(14 ga)	24	11	17
87 x 63	14	0.105	(12 ga)	24	10	16
95 x 67	16	0.105	(12 ga)	24	11	17
103 x 71	16	0.135	(10 ga)	24	10	15
112 x 75	18	0.135	(10 ga)	24	10	16
117 x 79	18	0.164	(8 ga)	24	10	15

TABLE 4.3.4S FILL HEIGHTS – CORRUGATED ALUMINUM STRUCTURAL PLATE PIPE ARCH

9" x 2 1/2" 3/4" Steel Bolts, 5 1/3 Bolts Per Foot

Span x Rise (ft - in x ft - in)	Corner Radius (in.)	Minimum Gage (in.)	Min. Cover (in.)	Maximum Cover (Feet) 2 Ton Soil (ft)	Maximum Cover (Feet) 3 Ton Soil (ft)
5 - 11 x 5 - 5	31.8	0.100	24	24[2]	24[2]
6 - 6 x 5 - 9	31.8	0.100	24	22[2]	22[2]
7 - 3 x 6 - 0	31.8	0.100	24	20[2]	20[2]
7 - 11 x 6 - 4	31.8	0.100	24	28[2]	18[2]
8 - 7 x 6 - 7	31.8	0.100	24	17[2]	17[2]
9 - 3 x 6 - 10	31.8	0.100	24	15[2]	15[2]
10 - 1 x 7 - 1	31.8	0.100	24	14[2]	14[2]
10 - 8 x 7 - 5	31.8	0.100	24	13[2]	13[2]
11 - 6 x 7 - 8	31.8	0.100	24	12[2]	12[2]
12 - 1 x 7 - 11	31.8	0.125	24	14	16[2]
12 - 10 x 8 - 3	31.8	0.150	24	13	14[2]
13 - 7 x 8 - 6	31.8	0.150	24	13	18[2]
13 - 11 x 9 - 5	31.8	0.150	24	12	17[2]
14 - 8 x 9 - 8	31.8	0.175	24	12	18
15 - 4 x 10 - 0	31.8	0.175	24	11	17
16 - 1 x 10 - 4	31.8	0.200	24	10	16
16 - 9 x 10 - 8	31.8	0.200	26	10	15
17 - 3 x 11 - 0	31.8	0.225	27	10	15
18 - 0 x 11 - 4	31.8	0.255	27	9	14
18 - 8 x 11 - 8	31.8	0.250	28	9	14

[1]For pipe-arch using steel or aluminum bolts, 3/4" dia., 5 1/3 bolts per foot.
[2]Fill limited by seam strength.

TABLE 4.3.4T FILL HEIGHTS – STEEL SPIRAL RIB PIPE

Diameter (inches)	Metal Thickness (Inches) 0.064 (16 ga)	0.079 (14 ga)	0.109 (12 ga)
24	46	--	--
30	37	--	--
36	31	--	--
42	26	37	--
48	23	32	--
54	21	29	40
60	19	26	36

Minimum Cover 2 Feet

Steel and Aluminized Steel Spiral Rib Pipe (0.75" x 0.95" ribs 11 3/4" o.c.)
and Steel Narrow Pitch Spiral Rib Pipe (0.375" x 0.4375" ribs 4.8" o.c.)

TABLE 4.3.4U FILL HEIGHTS – ALUMINUM SPIRAL RIB PIPE

Diameter (inches)	Metal Thickness (Inches) 0.060 (16 ga)	0.075 (14 ga)	0.105 (12 ga)	0.135 (10 ga)
18	34	49	--	--
24	25	36	63	82
30	19	28	50	65
36	15	24	41	54
42	12	19	35	46
48	10	17	30	40
54	--	14	27	35
60	--	12	24	30

Minimum Cover 2 Feet

Aluminum Alloy Spiral Rib Pipe (0.75" x 0.75" ribs 7.5" o.c.)
and Aluminum Alloy Narrow Pitch Spiral Rib Pipe (0.375 x 0.4357 ribs 4.8" o.c.)

Methods of Analysis

Two methods of hydraulic analysis using Manning's equation are used sequentially for the design and analysis of pipe systems. First, the Uniform Flow Analysis Method is used for the preliminary design of new pipe systems. Second, the Backwater Analysis Method is used to analyze both proposed, and existing, pipe systems to verify adequate capacity. See Sizing in Core Requirement # 4, Section 1.2.4 for the sizing requirements of pipe systems.

(1) Uniform Flow Analysis Method
Used for the preliminary sizing of new pipe systems to convey the peak rate of runoff for the 25 year design storm event.

Assumptions:
- o Flow is uniform in each pipe (ie., depth and velocity remain constant throughout the pipe for a given flow).
- o Friction head loss in the pipe barrel alone controls capacity. Other head losses (ie, entrance, exit, junction, etc.) and any backwater effects or inlet control conditions, which may be present or anticipated in the system, are not specifically addressed.

Each pipe within the system is sized and sloped such that it's barrel capacity at normal full flow (computed by Manning's Equation) is equal to or greater than the 25 year design flow. The nomograph in Figure 4.3.4A can be used for an approximate solution of Manning's Equation. For more precise results, or for partial pipe full conditions, solve Manning's Equation directly:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

or, using the continuity equation, Q = AV.

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Where
Q = Discharge in cfs
V = Velocity in fps
A = Area in ft^2
n = Manning's roughness coefficient in $s\text{-}ft^{1/6}$ (see Table 4.3.4V)
R = Hydraulic radius = area/wetted perimeter, in ft.
S = Slope of the energy grade line in ft/ft

For pipes flowing partially full, the actual velocity, may be estimated from the hydraulic properties shown in Figure 4.3.4B by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow).

Table 4.3.4V provides the recommended Manning's "n" values for preliminary design using the Uniform Flow Analysis Method for pipe systems. (Note, the "n" valves for this Method are 15% higher in order to account entrance, exit, junction and bend head losses.)

TABLE 4.3.4V MANNING'S "n" VALUES FOR PIPES

Type of Pipe Material	Analysis Method: Uniform Flow (Preliminary design)	Analysis Method: Backwater Flow (Capacity Verification)
A. Concrete pipe and CPEP-smooth interior pipe	0.014	0.012
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2-2/3" x 1/2" corrugation (riveted)		
a. plain or fully coated	0.028	0.024
b. paved invert (40% of circumference paved):		
(1) flow full depth	0.021	0.018
(2) flow 0.8 depth	0.018	0.016
(3) flow 0.6 depth	0.015	0.013
c. treatment 5	0.015	0.013
2. 3" x 1" corrugation	0.031	0.027
3. 6" x 2" corrugation (field bolted)	0.035	0.030
C. Helical 2-2/3" x 1/2" corrugation and CPEP-single wall	0.028	0.024
D. Spiral rib metal pipe and PVC pipe	0.013	0.011
E. Ductile iron pipe cement lined	0.014	0.012
F. High density polyethylene pipe (butt fused only)	0.009	0.009

(2) Backwater Analysis Method
Used to analyze the capacity of both proposed, and existing, pipe systems to convey the peak rate of runoff for the 25, and 100-year design storm events. (Note, structures for proposed pipe systems must be demonstrated to provide a minimum of 0.5 feet of freeboard between the headwater surface (hydraulic grade line) and the top of the structure for the 25 year peak rate of runoff. Structures may overtop for the 100-year peak rate of runoff as allowed by Core Requirement #4 in Section 1.2.4. When overtopping occurs for the 100-year peak rate of runoff the additional flow over the ground surface is analyzed using the methods described in Section 4.3.7 and added to the flow capacity of the pipe system determined, as described below.)

This method is used to compute a simple backwater profile (hydraulic grade line) through a proposed, or existing, pipe system for the purposes of verifying adequate capacity. It incorporates a re-arranged form of Manning's Equation expressed in terms of friction slope (ie, slope of the energy grade line in ft/ft). The friction slope is used to determine the head loss in each pipe segment due to barrel friction, which can then be combined with other head losses to obtain water surface elevations at all structures along the pipe system.

The backwater analysis begins at the downstream end of the pipe system and is computed back through each pipe segment and structure upstream. The friction, entrance and exit head losses computed for each pipe segment are added to that segment's tailwater elevation (the water surface elevation at the pipe's outlet) to obtain its "outlet control" headwater elevation. This elevation is then compared with the "inlet control" headwater elevation, computed assuming the pipe's inlet alone is controlling capacity using the methods for inlet control presented in Section 4.3.5. The condition that creates the highest headwater elevation then determines the pipe's capacity. The approach velocity head is then subtracted from the controlling headwater elevation and the junction and bend head losses are then added to compute the total headwater elevation which is then used as the tailwater elevation for the upstream pipe segment.

The Backwater Calculation Sheet in Figure 4.3.4C can be used to compile the head losses and headwater elevations for each pipe segment. The numbered columns on this sheet are described in Example 4.3.4A. An example calculation is performed in Example 4.3.4A Note, certain assumptions have been made to Note, certain assumptions have been made to simplify this analysis (as described in Figure 4.3.4D), therefore, this method should not be used to compute stage/discharge curves for level pool routing purposes. Instead, a more sophisticated backwater analysis using the computer software provided with this Manual, is recommended. The BWPIPE computer program in particular can be used to quickly compute a family of backwater profiles for a given range of flows through a proposed or existing pipe system. A schematic description of the nomenclature used in this program is provided in Figure 4.3.5H Documentation providing instructions on the use of this and the other backwater programs are located on the "BW" disk in a README.DOC file.

Details

In addition to the details shown as Figure 4.3.4G through J, Standard Construction Details are available in the King County Road Standards. The following table references commonly used details from the 1993 Road Standards:

K.C.R.S. Drawing Number	Title
2-002	Field-Tapping of Concrete Pipe
2-003	Catch Basin Type I
2-004	Catch Basin Type I-L
2-005	Catch Basin Type II-48", 54", 72", & 96"
2-006	Catch Basin Details
2-007–2-010	Manholes
2-011	Manhole Details
2-012	Curb Inlet
2-013–2-023	Frames, Grates, and Covers

FIGURE 4.3.4A NOMOGRAPH FOR SIZING CIRCULAR DRAINS FLOWING FULL

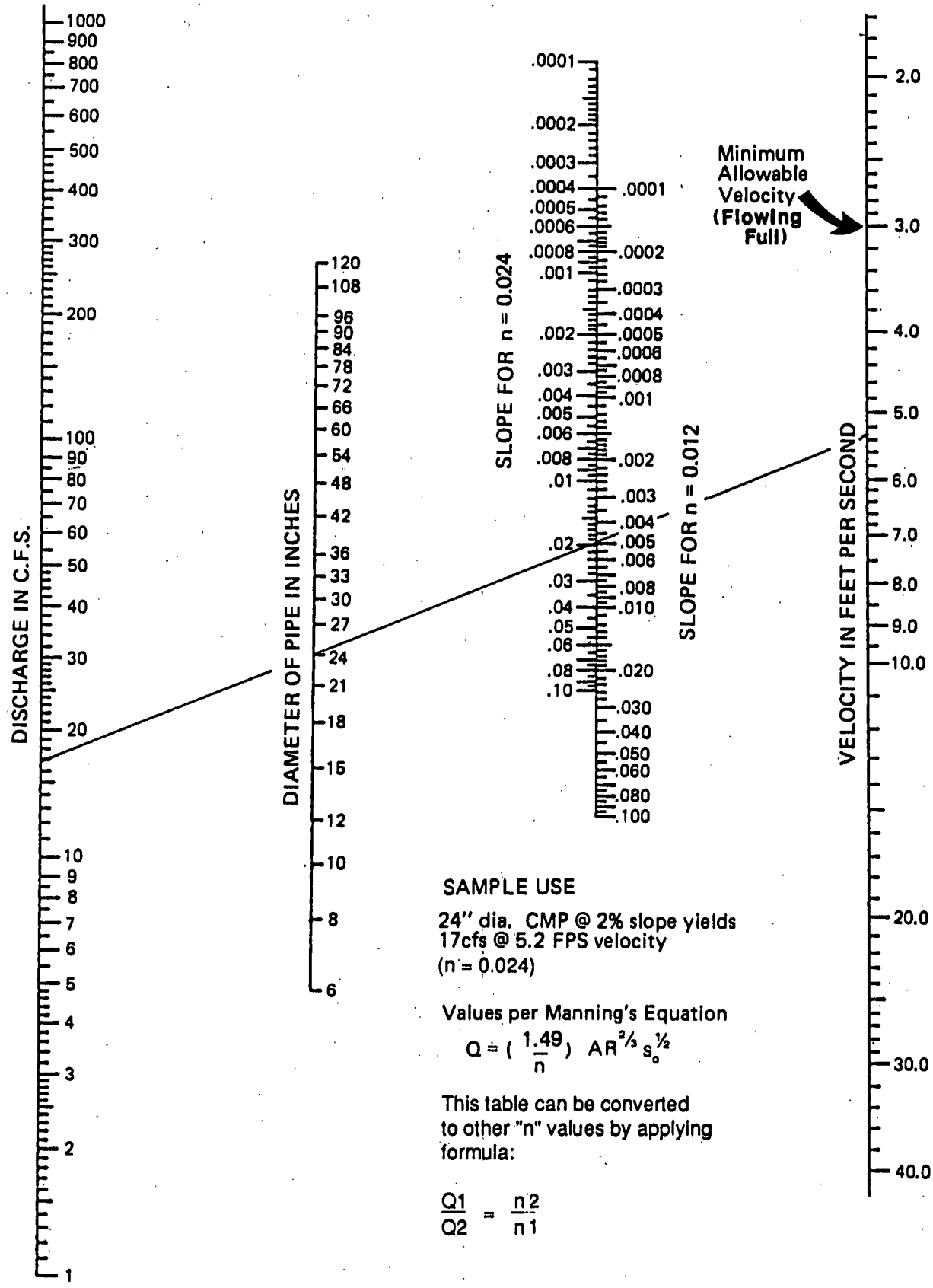


FIGURE 4.3.4B CIRCULAR CHANNEL RATIOS

Experiments have shown that n varies slightly with depth.
This figure gives velocity and flow rate ratios for varying n (solid line) and constant n (broken line) assumptions.

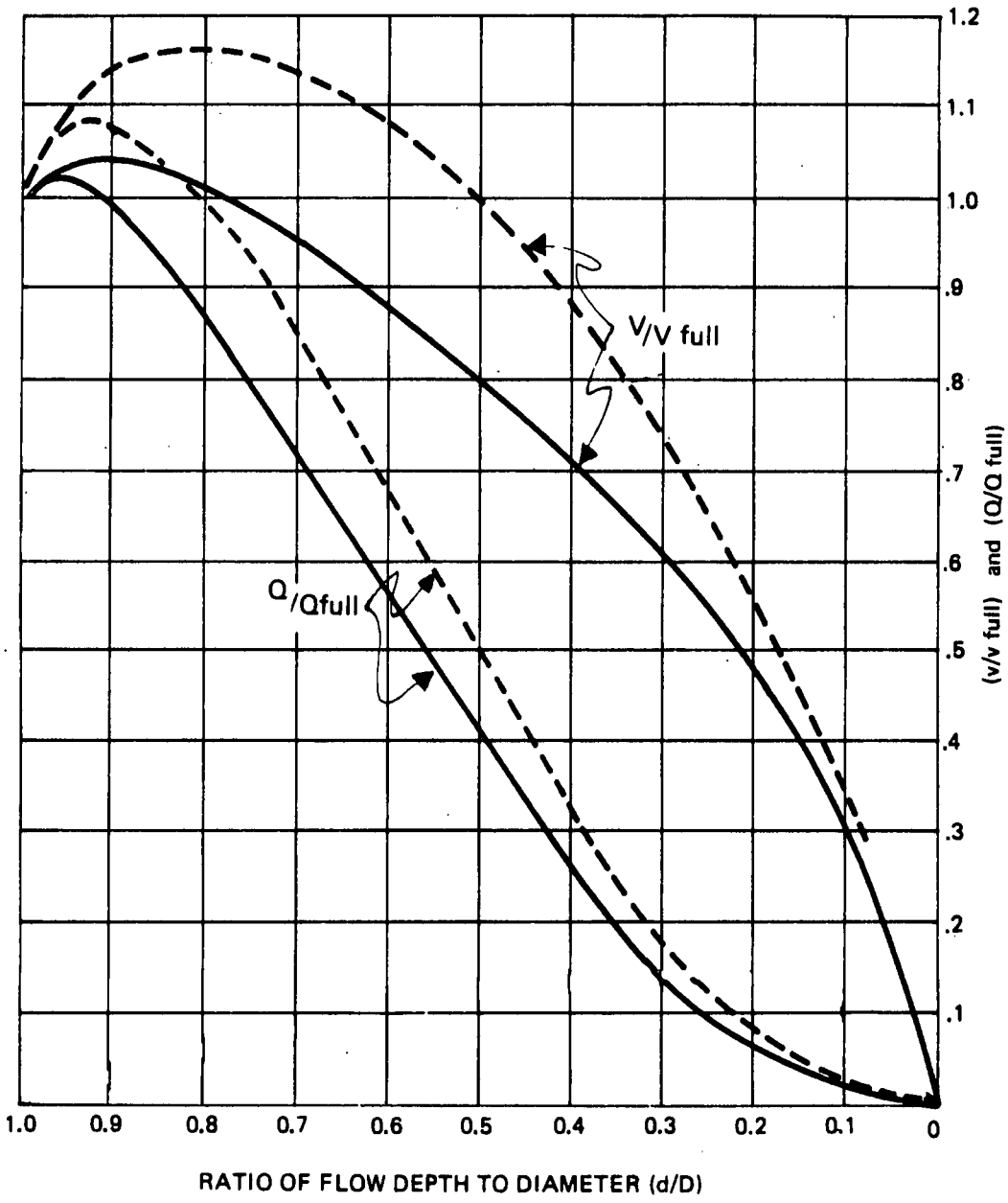


FIGURE 4.3.4C BACKWATER CALCULATION SHEET

BACKWATER CALCULATION SHEET

Pipe Segment CB to CB	(1) Q (cfs)	(2) Lngth (ft)	(3) Pipe Size	(4) "n" Value	(5) Outlt Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sqft)	(8) Barrl Vel (fps)	(9) Bar Vel Head (ft)	(10) TW Elev (ft)	(11) Fric-tion Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Contr Elev (ft)	(16) Inlet Contr Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)

FIGURE 4.3.4D BACKWATER CALCULATION SHEET NOTES

Column (1) - Design flow to be conveyed by pipe segment.
Column (2) - Length of pipe segment.
Column (3) - Pipe Size; indicate pipe diameter or span x rise.
Column (4) - Manning's "n" value.
Column (5) - Outlet Elevation of pipe segment.
Column (6) - Inlet Elevation of pipe segment.
Column (7) - Barrel Area is the full cross sectional area of the pipe.
Column (8) - Barrel Velocity is the full velocity in the pipe as determined by:

$V = Q/A$ or Col.(8) = Col.(1) / Col.(7)

Column (9) - Barrel Velocity Head = $V^2/2g$ or $(\text{Col.}(8))^2/2g$
Where, $g = 32.2\ ft/sec^2$ (acceleration due to gravity)

Column (10) - Tailwater (TW) Elevation; this is the water surface elevation at the outlet of the pipe segment. If the pipe's outlet is not submerged by the TW and the TW depth is less than $(D+d_c)/2$, set the TW elevation equal to $(D+d_c)/2$ to keep the analysis simple and still obtain reasonable results (D = pipe barrel height and d_c = critical depth, both in ft. See Figure 4.3.5G for determination of d_c).

Column (11) - Friction Loss = $S_f \times L$ or $S_f \times$ Col.(2)
Where, S_f is the friction slope or head loss per lineal foot of pipe as determined by Manning's Equation expressed in the form:

$S_f = (nV)^2/2.22\ R^{1.33}$

Column (12) - Hydraulic Grade Line (HGL) Elevation just inside the entrance of the pipe barrel; this is determined by adding the friction loss to the TW elevation:

Col.(12) = Col.(11) + Col.(10)

If this elevation falls below the pipe's inlet crown, it no longer represents the true HGL when computed in this manner. The true HGL will fall somewhere between the pipe's crown and either normal flow depth or critical flow depth, which ever is greater. To keep the analysis simple and still obtain reasonable results (ie, erring on the conservative side), set the HGL elevation equal to the crown elevation.

Column (13) - Entrance Head Loss = $K_e \times V^2/2g$ or $K_e \times$ Col.(9) Where, K_e = Entrance Loss Coefficient (from Table 4.3.5B) This is the head lost due to flow contractions at the pipe entrance.

Column (14) - Exit Head Loss = $1.0 \times V^2/2g$ or $1.0 \times$ Col.(9)
This is the velocity head lost or transferred downstream.

Column (15) - Outlet Control Elevation = Col.(12) + Col.(13) + Col.(14)
This is the maximum headwater elevation assuming the pipe's barrel and inlet/outlet characteristics are controlling capacity. It does not include structure losses or approach velocity considerations.

Column (16) - Inlet Control Elevation (See Section 4.3.5 for computation of inlet control on culverts). This is the maximum headwater elevation assuming the pipe's inlet is controlling capacity. It does not include structure losses or approach velocity considerations.

Column (17) - Approach Velocity Head; this is the amount of head/energy being supplied by the discharge from an upstream pipe or channel section, which serves to reduce the headwater elevation. If the discharge is from a pipe, the approach velocity head is equal to the barrel velocity head computed for the upstream pipe. If the upstream pipe outlet is significantly higher in elevation (as in a drop manhole) or lower in elevation such that its discharge energy would be dissipated, an approach velocity head of zero should be assumed.

Column (18) - Bend Head Loss = $K_b \times V^2/2g$ or $K_b \times$ Col.(17)
Where, K_b = Bend Loss Coefficient (from Figure 4.3.4E) This is the loss of head/energy required to change direction of flow in an access structure.

Column (19) - Junction Head Loss; this is the loss in head/energy which results from the turbulence created when two or more streams are merged into one within the access structure. Figure 4.3.4F can be used to determine this loss or it can be computed using the following equations derived from Figure 4.3.4F:

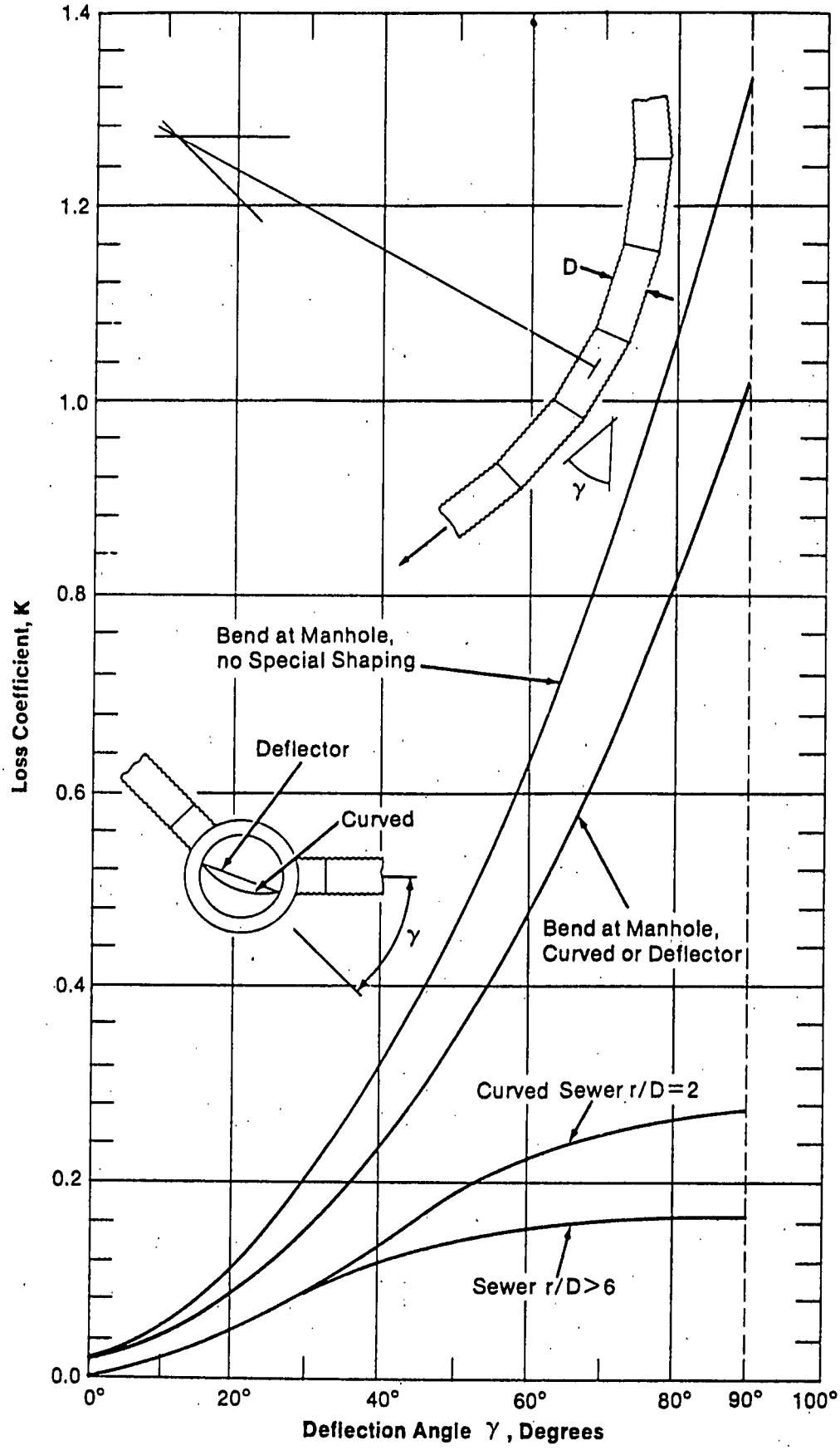
Junction Head Loss = $K_j \times V^2/2g$ or $K_j \times$ Col.(17)
Where, K_j is the Junction Loss Coefficient determined by:

$K_j = (Q_3/Q_1)/(1.18 + 0.63(Q_3/Q_1))$

Column (20) - Headwater (HW) Elevation; this is determined by combining the energy heads in Columns 17, 18, and 19 with the highest control elevation in either Column 15 or 16, as follows:

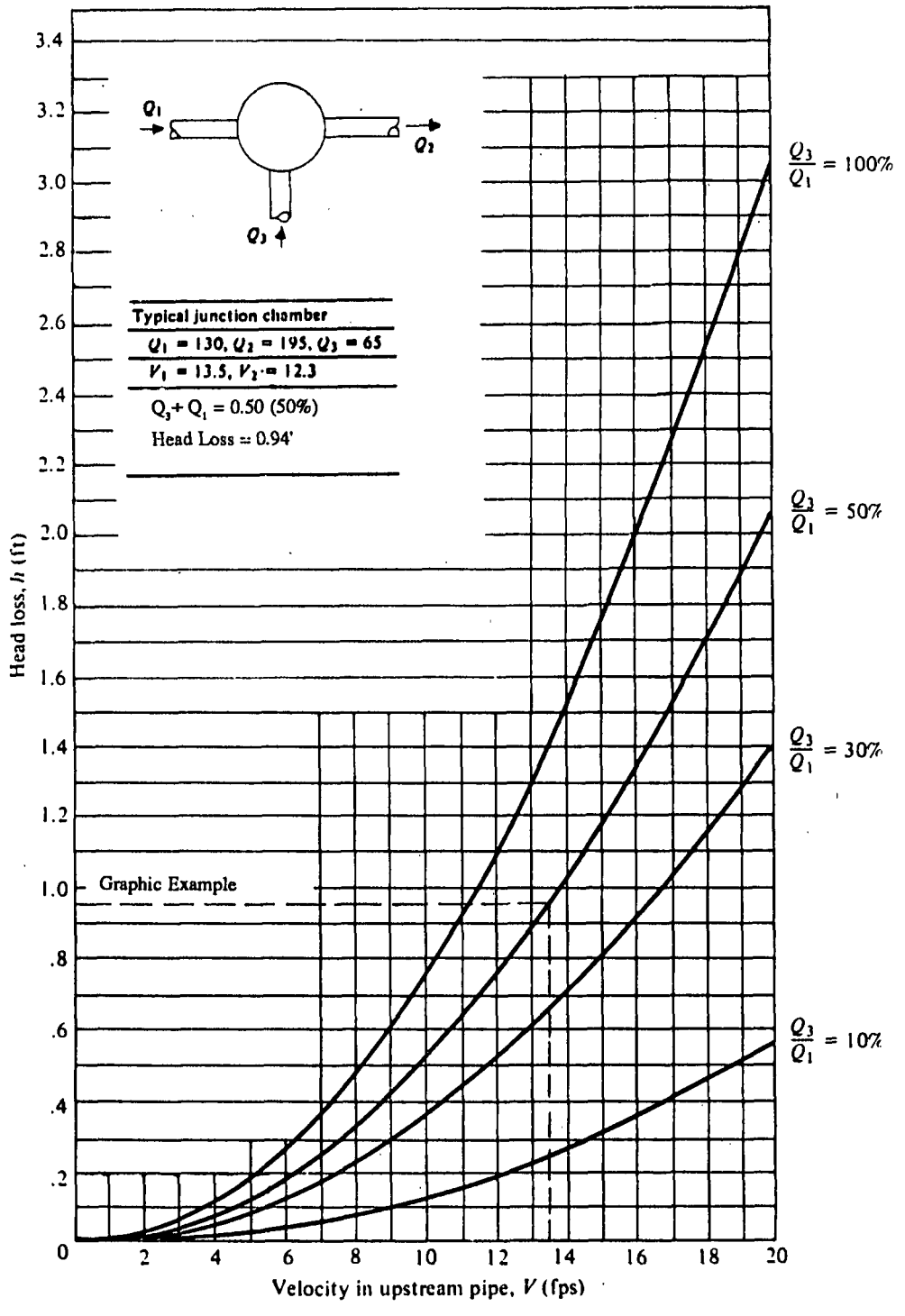
Col.(20) = Col.(15 or 16) - Col.(17) + Col.(18) + Col.(19)

FIGURE 4.3.4E* BEND HEAD LOSSES IN STRUCTURES



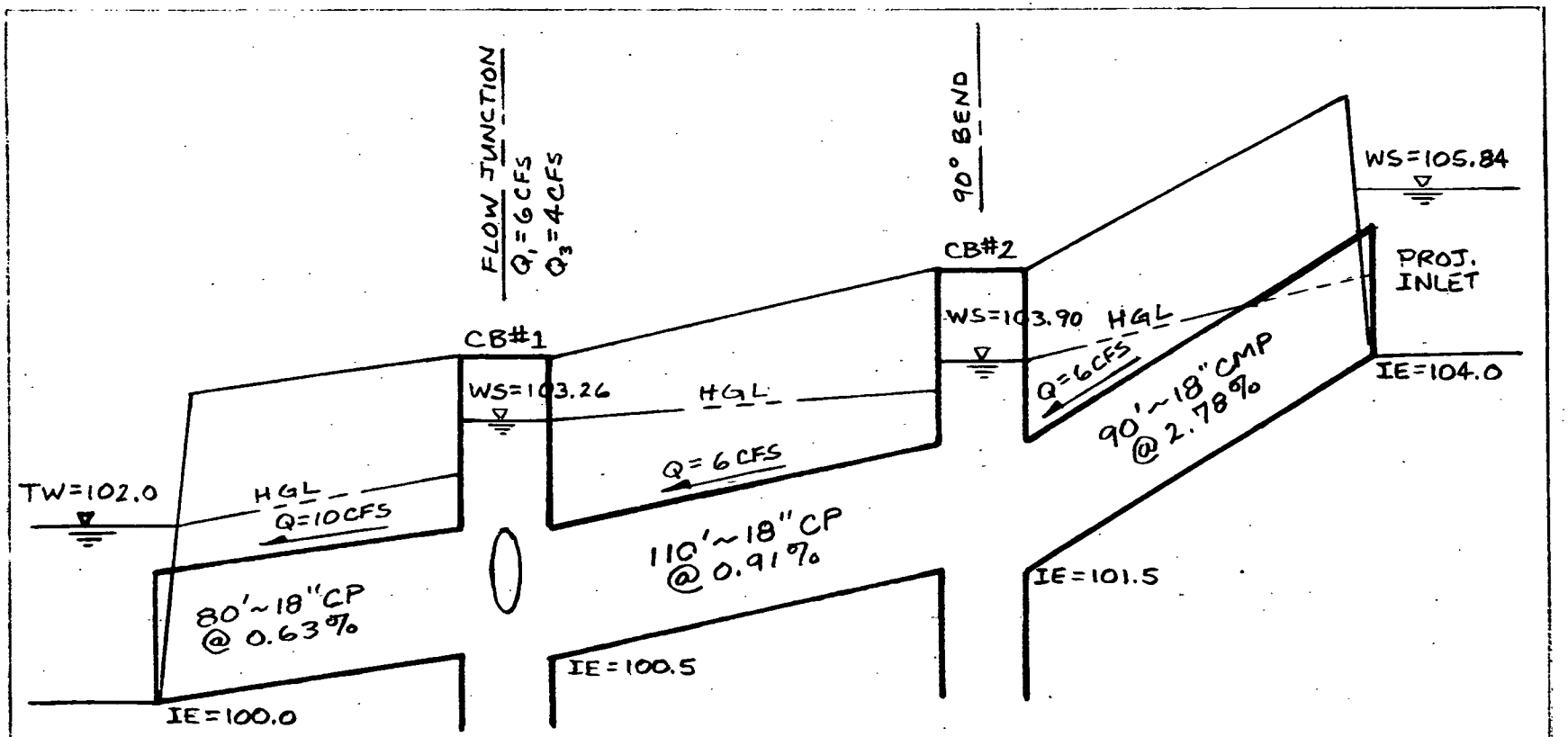
*From "Modern Sewer Design", copyright 1980, American Iron and Steel Institute

FIGURE 4.3.4F JUNCTION HEADLOSS IN STRUCTURES



Source: Baltimore County Department of Public Works

EXAMPLE 4.3.4A BACKWATER PIPE CALCULATION



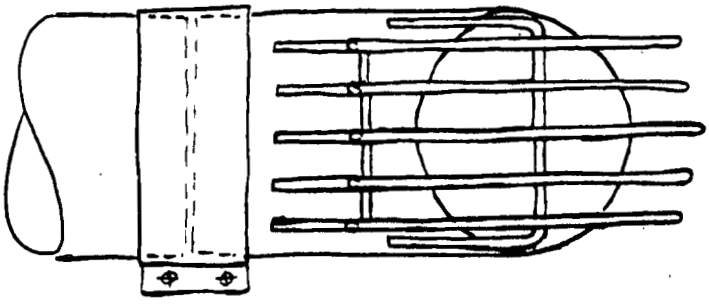
BACKWATER CALCULATION SHEET

SELECT THE GREATER ELEVATION

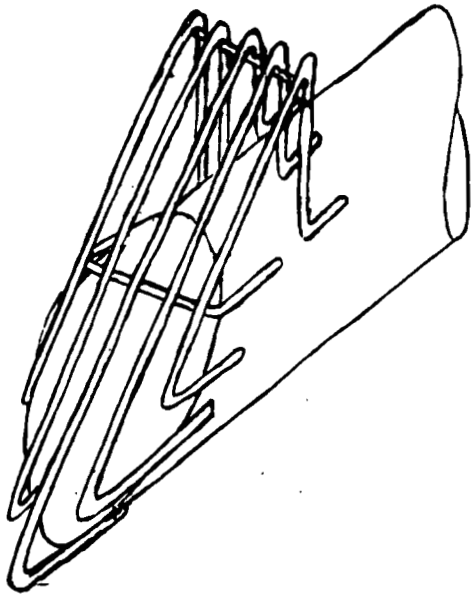
Pipe Segment CB to CB		(1) Q (cfs)	(2) Lngth (ft)	(3) Pipe Size	(4) "n" Value	(5) Outlt Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sqft)	(8) Barrl Vel (fps)	(9) Bar Vel Head (ft)	(10) TW Elev (ft)	(11) Friction Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Contr Elev (ft)	(16) Inlet Contr Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)
Outfall	1	10	80	18"	0.012	100.00	100.50	1.77	5.65	0.50	102.00	0.62	102.62	0.25	0.50	103.37	102.75	-0.18	0.002	0.07	103.26
1	2	6	110	18"	0.012	100.50	101.50	1.77	3.39	0.18	103.26	0.31	103.57	0.09	0.18	103.84	102.95	-0.18	0.24	0.0	103.90
2	Inlet	6	90	18"	0.024	101.50	104.00	1.77	3.39	0.18	103.90	1.00	(104.9) 105.50	0.16	0.18	105.84	105.80	-0.0	0.0	0.0	105.84

FIGURE 4.3.4G DEBRIS BARRIER

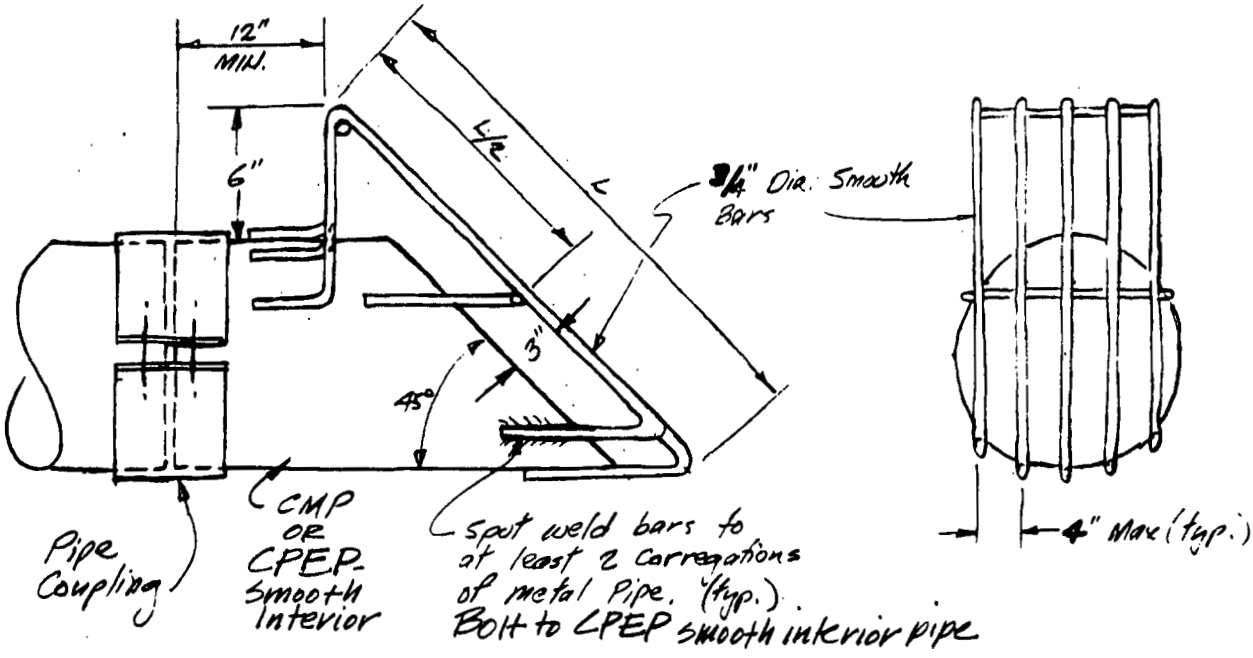
NOTE:
1. This Debris Barrier is for use outside roadways on pipes 36" dia. and smaller. See Figure 4.3.4H for Debris Barriers on pipes projecting from driveway or roadway sideslopes.
2. All steel parts must be galvanized and asphalt coated (Treatment 1 or better).
3. CPEP-smooth interior pipe requires bolts to secure debris barrier to pipe



PLAN



ISOMETRIC



SIDE VIEW

END VIEW

FIGURE 4.3.4H DEBRIS BARRIER

NOTES:

1. CMP* End-Section Shown; For Concrete Pipe Beveled End Section, see KCRS Dwg. No. 11.
2. All Steel Parts must be Galvanized and Asphalt Coated (Treatment 1 or better).

* or CPEP Smooth interior

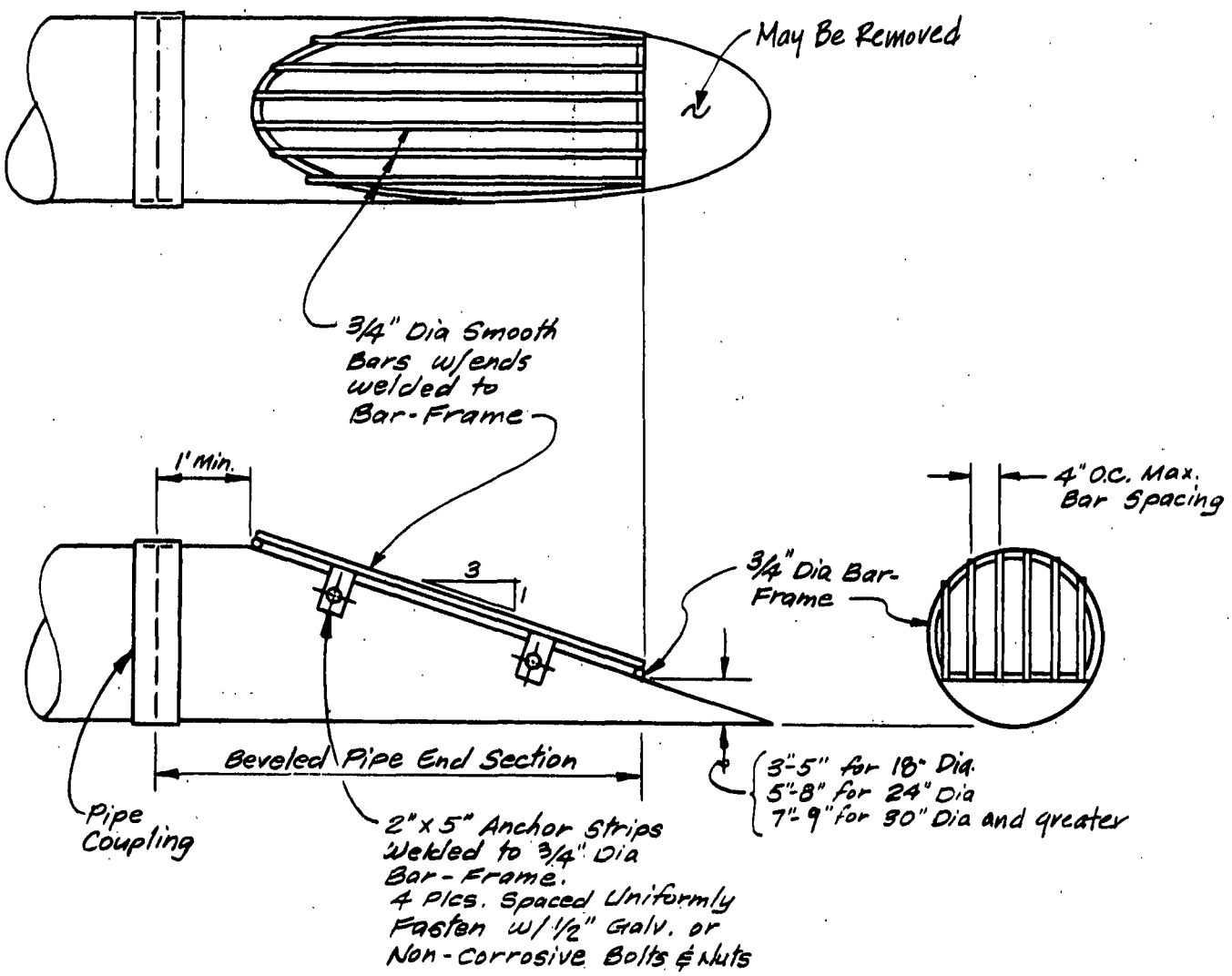
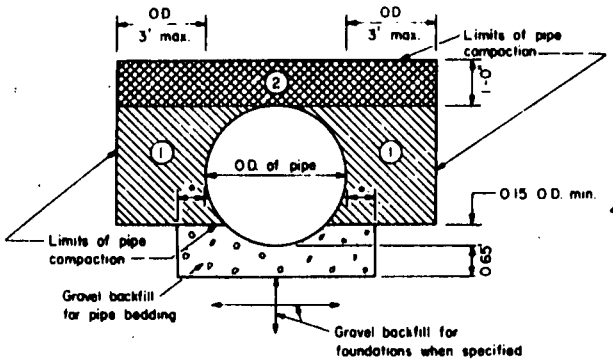
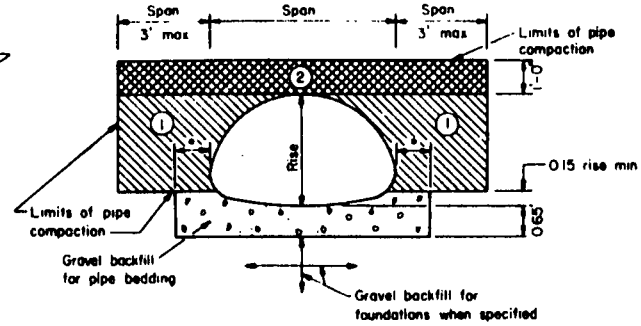


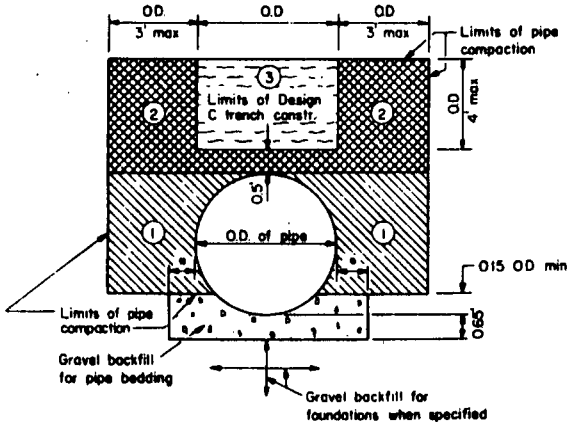
FIGURE 4.3.4I PIPE COMPARISON DESIGNS (A and C) AND BACKFILL



DESIGN A
(For Metal and Concrete Pipe)



TYPICAL PIPE-ARCH INSTALLATION



DESIGN C
(For Concrete Pipe With Circular Reinforcement Only)

CLEARANCE BETWEEN PIPES MULTIPLE INSTALLATIONS

PIPE	SIZE	MIN DIST. BETWEEN BARRELS
CIRCULAR PIPE CONC., CPEP, CMP DESIGN A (DIAMETER)	12" to 24"	12"
	30" to 96"	DIAM ÷ 2
	102" to 180"	48"
CIRCULAR PIPE CONCRETE ONLY DESIGN C (DIAMETER)	12" to 36"	2D
	42" to 96"	72"
	102" to 180"	72"
PIPE-ARCH METAL ONLY (SPAN)	18" to 36"	12"
	43" to 142"	SPAN ÷ 3
	148" to 199"	48"

LEGEND
PIPE COMPACTION ZONE

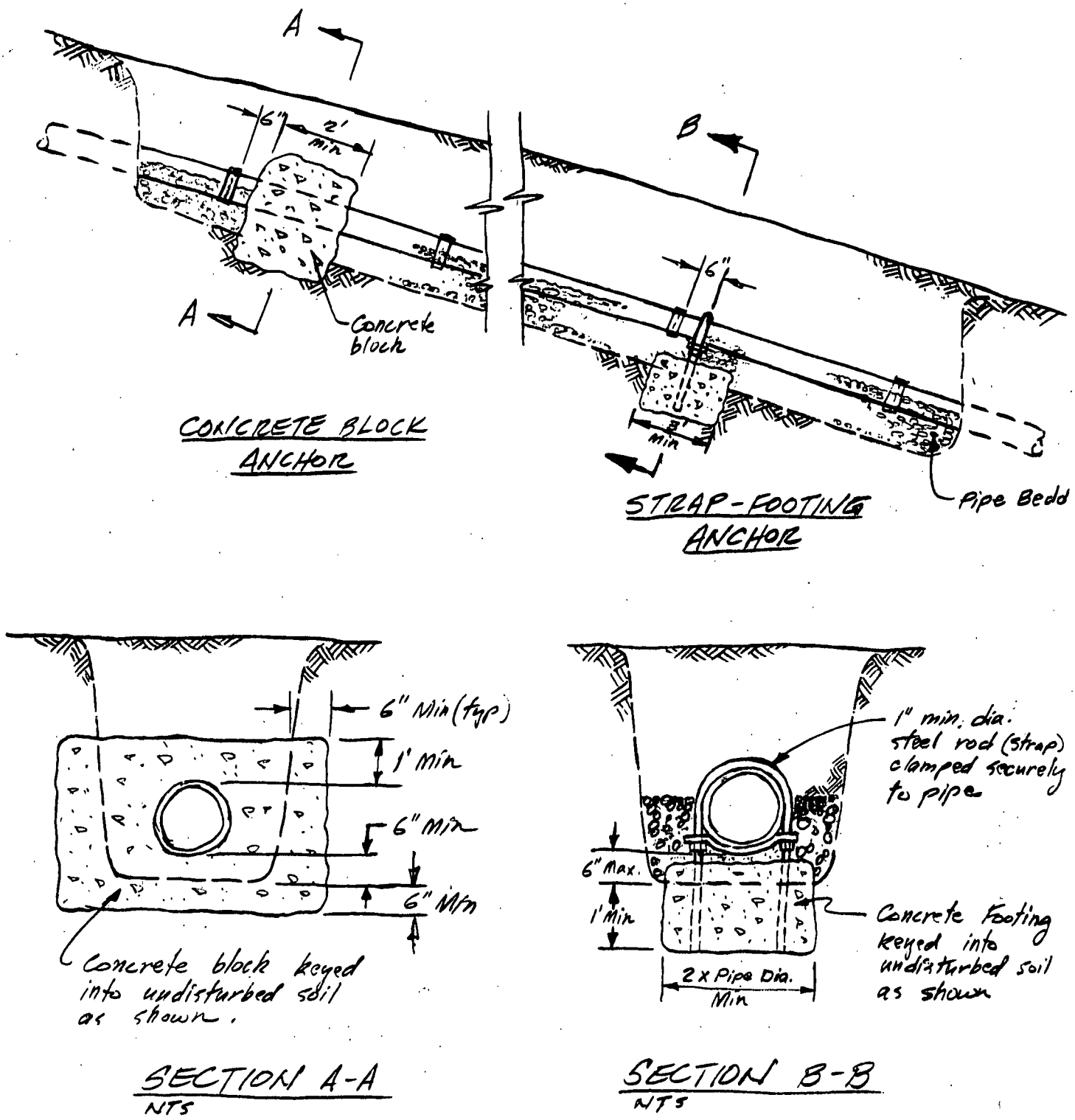
1. Backfill material placed in 0.5' loose layers and compacted to 95% maximum density.
2. Method B or C compaction.
3. Baled straw or hay with wires or strings cut (dry, commercial quality).

NOTES

1. Pipe compaction limits shown on this plan are for pipe construction in an embankment. For pipe construction in a trench, the horizontal limits of the pipe compaction zone shall be the walls of the trench.
2. All steel and aluminum pipe and pipe-arches shall be installed in accordance with Design A.
3. Concrete pipe with elliptical reinforcement shall be installed in accordance with Design A.
4. Concrete pipe, plain or with circular reinforcement, shall be installed with Design A or a combination of Designs A and C, as determined by the Engineer.
5. For Design C, it is essential that the walls for Zone 3 be constructed as near vertical as possible.
6. O.D. is equal to the outside diameter of a pipe or the outside span of pipe-arch. The dimensions shown as O.D. with 3' and 4' maximum shall be OD until O.D. equals 3' and 4' at which point 3' and 4' shall be used.

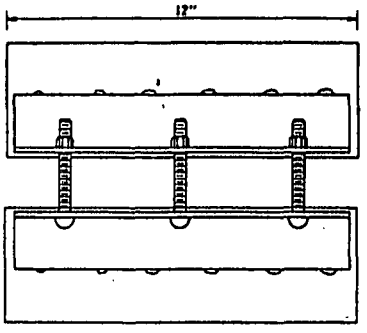
* 1'-0" for diameters 12" through 42" and for spans through 50". 2'-0" diameters greater than 42" and for spans greater than 50".

FIGURE 4.3.4J PIPE ANCHOR DETAIL



Note: For HDPP, pipe must be free to slide inside a 4' long section of pipe one size diameter larger.

FIGURE 4.3.4K CORRUGATED METAL PIPE COUPLING AND/OR GENERAL PIPE ANCHOR ASSEMBLY



SMOOTH COUPLING BAND FOR SMOOTH PIPE

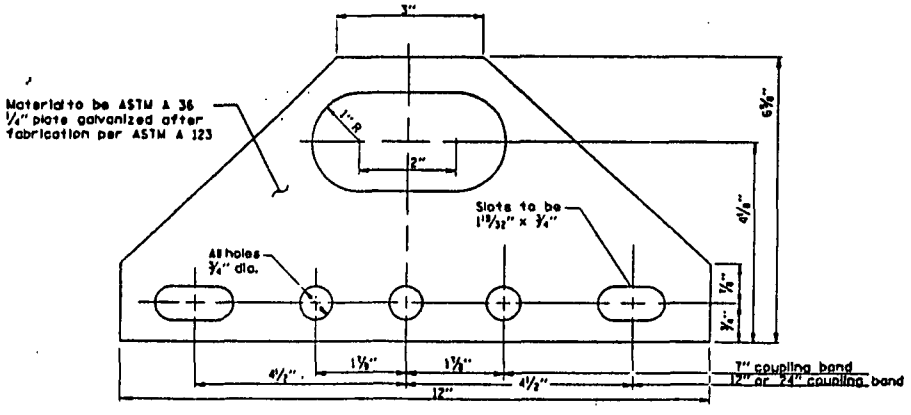
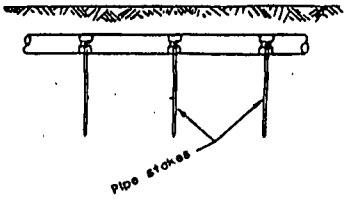
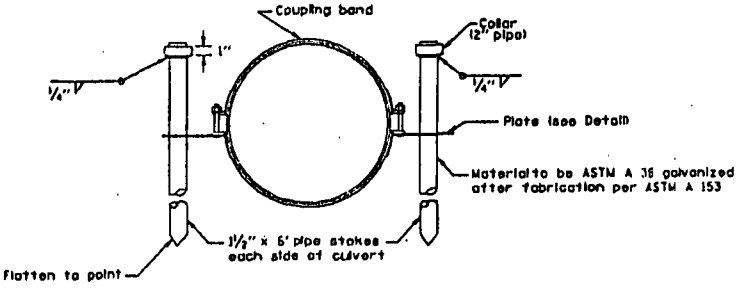


PLATE DETAIL





ANCHOR ASSEMBLY - CORRUGATED METAL PIPE

NOTES:
1. Payment for pipe anchors which shall include all pipe stakes and hardware shall be considered as incidental and shall be included in the per linear foot cost of pipe.
2. The smooth coupling band shall be used in combination with concrete pipe.
3. Concrete pipe without bell and spigot shall not be installed on grades in excess of 20%.
4. The first anchor shall be installed on the first section of the lower end of the pipe and remaining anchors evenly spaced throughout the installation.
5. If the pipe being installed has a manhole or catch basin on the lower end of the pipe, the first pipe anchor may be eliminated.
6. When C.M.P. is used, the anchors may be attached to the coupling bands used to join the pipe as long as the specified spacing is not exceeded.
7. All pipe anchors shall be securely installed before backfilling around the pipe.

4.3.5 CULVERTS AND BRIDGES

Culverts are relatively short segments of pipe of circular, elliptical, rectangular, or arch cross section. They are usually placed under road embankments to convey surface water flow safely under the embankment. They may be used to convey flow from constructed or natural channels including streams. Bridges are structures constructed over an obstacle (such as a waterway) to allow the continuation of a thoroughfare (such as a road). They generally consist of foundation abutments and/or piers which support a deck spanning the obstacle. The Sensitive Areas Ordinance and Rules contain the definitions of streams and requirements for crossing of streams. In addition to those requirements and the design criteria described below, other agencies such as the Washington State Departments of Fisheries or Wildlife may have additional requirements which will affect the design of proposed culverts and bridges.

Design Criteria for Culverts

Headwater

- For new culverts 18" diameter, or less, the maximum allowable 25-year design storm event headwater elevation (measured from the inlet invert) shall not exceed 2 times the pipe diameter/arch culvert rise.

- For new culverts larger than 18" diameter the maximum allowable 25-year design storm event headwater elevation (measured from the inlet invert) shall not exceed 1.5 times the pipe diameter/arch culvert rise.

- The maximum 25-year design storm event headwater elevation for new culverts shall not be less than 0.5 feet lower than the road or parking lot sub-grade.

Inlet

- For culverts 18" diameter and larger, the embankment around the culvert inlet shall be protected from erosion by rock lining or rip rap specified in Table 4.3.6A, except the length and height shall be as follows:
  - Length: extend upstream of culvert 5 feet minimum
  - Height: at design headwater elevation

- Trash Racks/Debris Barriers are required on culverts that are over 60 feet in length or that are inlets to pipe systems, and that are 18" to 36" in diameter (see Figure 4.3.4G and 4.3.4H.) Exceptions are culverts on Type 1 or 2 streams.

- Inlet structures, such as concrete headwalls, may provide a more economical design by allowing the use of smaller entrance coefficients, and hence smaller diameter culverts. When properly designed they will also protect the embankment from erosion and eliminate the need for rock lining.

- In order to maintain the stability of roadway embankments, concrete headwalls, wingwalls or tapered inlets and outlets may be required if right-of-way and/or easement constraints prohibit the culvert from extending to the toe of the embankment slopes. Normally concrete inlet structures/headwalls installed in or near roadway embankments must be flush with, and conforming to the slope, of the embankment.

Outlets

- For culverts 18" diameter and larger, the receiving channel of the outlet shall be protected from erosion by rock lining specified in Table 4.3.6A, except the height shall be 1 foot above maximum tailwater elevation or 1 foot above the crown - whichever is higher (See Figure 4.3.5I).

- Standard details for various culvert end-designs such as wing-walls and tapered inlets may be found in the Washington State Department of Transportation Highway Hydraulic Manual.

Methods of Analysis For Culverts

The theoretical analysis of culvert flow can be extremely complex because of the wide range of possible flow conditions which can occur due to various combinations of inlet and outlet submergence and flow regime within the culvert barrel. An exact analysis usually involves detailed backwater calculations, energy and momentum balance, and application of the results of hydraulic model studies.

Simple procedures have been developed, however, wherein the various flow conditions are classified and analyzed on the basis of a control section. A control section is a location where there is a unique relationship between the flow rate and the upstream water surface elevation. Many different flow conditions exist over time, but at any given time the flow is either governed by the culvert's inlet geometry (inlet control); or by a combination of inlet geometry, barrel characteristics, and tailwater elevation (outlet control). Figure 4.3.5B illustrates typical conditions of inlet and outlet control.

The procedures presented here provide for the analysis of both inlet and outlet control conditions to determine which is governing flow capacity and what that capacity is.

Inlet Control Analysis

Nomographs such as those provided in Figures 4.3.5C and 4.3.5D can be used to determine the inlet control headwater depth at design flow for various types of culverts and inlet configurations. These nomographs were originally developed by the Bureau of Public Roads - now the Federal Highway Administration (FHWA) - based on their studies of culvert hydraulics. These and other nomographs can be found in the FHWA publication, Hydraulic Design of Highway Culverts, HDS No.5 (Report No.FHWA-IP-85-15), September 1985; or the WSDOT Hydraulic Manual.

Also available in the FHWA publication, are the design equations used to develop the inlet control nomographs. These equations are presented below:

For **unsubmerged** inlet conditions defined by $Q/AD^{0.5} \leq 3.5$;

Form(1)* $HW/D = H_c/D + K(Q/AD^{0.5})^M - 0.5S^{**}$

Form(2)* $HW/D = K(Q/AD^{0.5})^M$

For **submerged** inlet conditions defined by $Q/AD^{0.5} \geq 4.0$;

$$HW/D = c(Q/AD^{0.5})^2 + Y - 0.5S^{**}$$

Where,

HW	=	Headwater depth above inlet invert, ft.
D	=	Interior height of culvert barrel, ft.
H_c	=	Specific head at critical depth ($d_c + V_c^2/2g$), ft.
Q	=	Flow, cfs.
A	=	Full cross sectional area of culvert barrel, sq ft.
S	=	Culvert barrel slope, ft/ft.
K,M,c,Y	=	Constants from Table 4.3.5A.
d_c	=	Critical depth (See Figure 4.3.5G), ft.
V_c	=	Flow velocity at critical depth, fps.
g	=	Acceleration due to gravity, 32.2 ft/sec^2.

* The appropriate equation form for various inlet types is specified in Table 4.3.5A
** For mitered inlets use +0.7S instead of -0.5S

Note, between the unsubmerged and submerged conditions, there is a transition zone ($3.5 < Q/AD^{0.5} < 4.0$) for which there is only limited hydraulic study information. The transition zone is defined empirically by drawing a curve between and tangent to the curves defined by the unsubmerged and submerged equations. In most cases, the transition zone is short and the curve is easily constructed.

Outlet Control Analysis

Nomographs such as those provided in Figures 4.3.5E and 4.3.5F can be used to determine the outlet control headwater depth at design flow for various types of culverts and inlets. Outlet control nomographs other than those provided can be found in FHWA HDS No.5 or the WSDOT Hydraulic Manual.

The outlet control headwater depth can also be determined using the simple backwater analysis procedure presented in Section 4.3.4 for analyzing pipe system capacity. This procedure is summarized as follows for culverts:

$$HW = H + TW - LS$$

Where,

H = $H_f + H_e + H_{ex}$
H_f = Friction Loss, ft. = $V^2n^2L/2.22R^{1.33}$
Note, if $(H_f+TW-LS) < D$, adjust H_f such that $(H_f+TW-LS) = D$. This will keep the analysis simple and still yield reasonable results (erring on the conservative side).
H_e = Entrance Head Loss, ft. = $K_e(V^2/2g)$
H_{ex} = Exit Head Loss, ft. = $V^2/2g$
TW = Tailwater depth above invert of culvert outlet, ft.
Note, if $TW < (D+d_c)/2$, set $TW = (D+d_c)/2$. This will keep the analysis simple and still yield reasonable results.
L = Length of culvert, ft.
S = Slope of culvert barrel, ft/ft.
D = Interior height of culvert barrel, ft.
V = Barrel velocity, fps.
n = Manning's roughness coefficient (from Table 4.3.4V).
R = Hydraulic radius, ft.
K_e = Entrance loss coefficient (from Table 4.3.5B).
g = Acceleration due to gravity, 32.2 ft/sec^2.
d_c = Critical depth (See Figure 4.3.5G), ft.

Note, the above procedure should not be used to develop stage/discharge curves for level pool routing purposes because its results are not precise for flow conditions where the hydraulic grade line falls significantly below the culvert crown (ie, less than full flow conditions).

Computer Analysis

The computer software package available with this manual, contains two computer programs which can be used to analyze culvert capacity and develop stage/discharge curves for level pool routing purposes. These are BWPIPE and BWCULV. A schematic description of the nomenclature used in these programs is provided in Figure 4.3.5H. User instructions are included with the computer programs on disc.

Methods of Analysis for Culverts Required to Provide for Fish Passage/Migration

In addition to the other hydraulic methods of analysis for culverts preceding this discussion, the following methods shall be used to apply the design criteria for culverts required to provide for fish migration/passage.

A design flow rate, designated as the Culvert Fish Passage Design Flow (Q_f), and the estimated base flow Q_b, shall be defined/estimated using the following methods for ungaged or gaged streams.

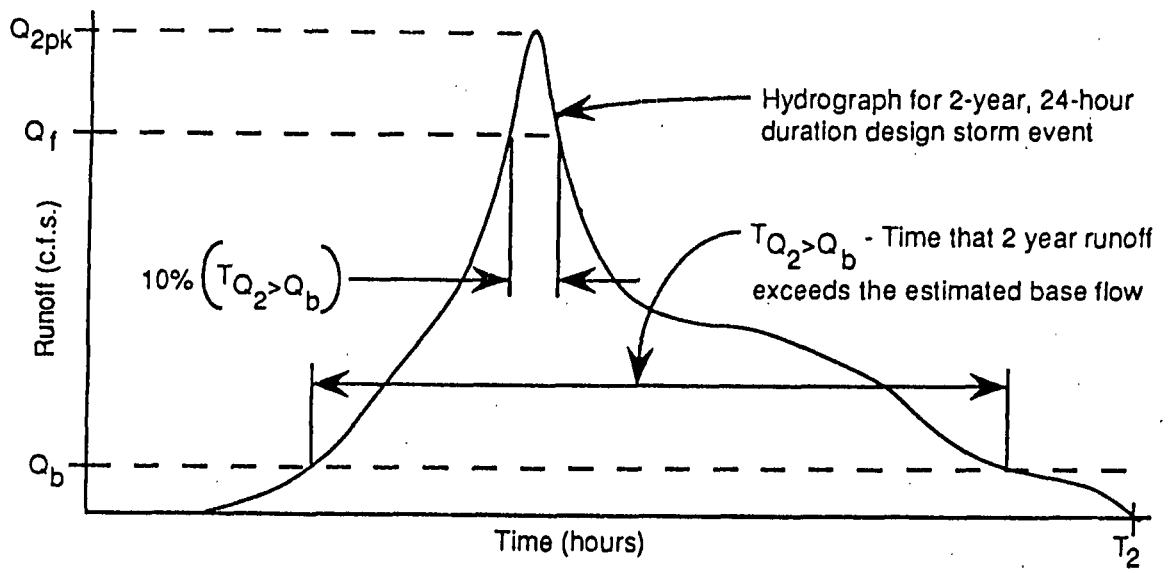
For ungaged streams:

- o Q_f shall be defined as the flow rate that will not be exceeded more than 10% of the time that the estimated runoff for the 2-year, 24-hour duration design storm event exceeds the estimated base flow (see Figure 4.3.5A).
- o Q_b shall be estimated by, either:
  - Using the mean daily discharge for the nearest hydrologically similar gaged stream, proportioned by tributary areas, OR using a flow equal to 50% of the peak rate of runoff to the culvert for the 2-year, 24-hour duration design storm event computed using only the pervious areas of the sub-basin tributary to the culvert.

For gaged streams, or for those streams that have been modeled using a continuous rainfall/runoff model:

- o Qf shall be the 1.5 year return frequency peak runoff.
- o Qb shall be estimated by using the mean daily discharge for the period of record proportioned by tributary area to the culvert using the technique described in Section 4.3.8, Hydrologic Analysis, Item 2(b).

FIGURE 4.3.5A DETERMINATION OF - Q_f: CULVERT FISH PASSAGE DESIGN FLOW



Design Criteria for Culverts Required to Provide for Fish Migration

Note, if the following criteria cannot be met a bridge or other structure that will span the stream should be installed. In addition, culverts must meet any additional requirements of the Sensitive Areas Ordinance and those of other agencies such as the Washington State Department of Fisheries.

Multiple Installations

- When more than one culvert is provided, fish passage criteria need only be applied to one of them. The culvert to which fish passage criteria are applied should be installed at least 1 foot lower than the other culvert(s).

Maximum Culvert Length

- The maximum length for any culvert shall not exceed 100 feet.

Velocities

The average water velocity for Q_f in the culvert should not exceed the following values:

- For culverts less than 60 feet long, average velocity should not exceed 4 feet/second.
- For culverts greater than 60 feet long, average velocity should not exceed 3 feet/second.

Water Depth

- The depth of water for Q_f should not be less than 0.8 feet at any point within the culvert.

Water Surface Profile

- A vertical drop in the water surface profile at any point within culvert influence for Q_f should not exceed 1.0 feet.

Slope

- The effective slope of the culvert at any point along its length should not exceed 0.5% for a culvert greater than 60 feet long, unless appropriate compensation is made by the addition of baffles within the culvert.
- In culverts less than 60 feet long, effective slope should not exceed 1% unless baffles are added. Culvert slope should not exceed 5% at any time, even with baffles.

Installation Below Grade

- The culvert should be installed so that the bottom of the structure is at least 1 foot below the natural grade line of the stream, or 20% of culvert diameter or rise, whichever is greater.
- The conveyance design capacity must be determined based on the free cross sectional area above the grade line through the culvert.

Outlet Pool and Tailwater Control

- An outlet pool with tailwater control capabilities should be constructed at the downstream end of the culvert.
- Length and width of the outlet pool should be twice the diameter of the culvert, and bottom elevation of the pool should be at least 2 feet below culvert invert elevation at the outlet.

- The crest elevation of the tailwater control device should be sufficient to provide a minimum depth of 0.8 feet throughout the culvert during the lowest stream discharge anticipated, or at least 0.8 feet above the lowest elevation in the culvert fishway or baffle structure.

- A small notch or depression should be provided at the tailwater control device to ensure that a passageway of sufficient depth for fish migration is available at minimum flows.

Culvert Baffles and Fishway

- Offset baffles should be constructed in the culvert barrel if the slope of the culvert exceeds the criteria outlined above.

Design Criteria and Analysis Methods For Bridges

Bridge designs must reflect the requirements of the Sensitive Areas Ordinance and Rules and those of other agencies such as the Washington State Departments of Fisheries or Wildlife.

- Bridge clearance requirements. Note that clearance means vertical distance between the design water surface and the bottom of any part of the bridge.

  (1) For Type 1 streams, the design clearance shall be a minimum of 6 feet.

  (2) For all other streams and constructed channels, the design clearance shall be a minimum of two feet or 25% of the mean channel width between ordinary high water marks at the crossing up to a 6-foot minimum clearance requirement, whichever is greater.

  (3) For lakes, wetlands or closed depressions, the design clearance shall be a minimum of two feet.

- On streams with levees, the portion of the approach slopes to a proposed bridge subject to floodwaters must be connected to the existing levees and the slopes designed to meet Federal Emergency Management Administration (FEMA) levee construction and stability standards.

- Locating bridge piers and abutments between the ordinary high water marks of a channel is discouraged.

- The Army Corps of Engineers Hydraulic Engineering Center publishes technical papers on methods used to address the hydraulic effects of bridge piers and abutments. The "Open-Channel Hydraulics" book by V.T. Chow also contains techniques for analyzing these hydraulic effects.

- The direct step backwater method described in Section 4.3.4 shall be used to analyze the hydraulic impacts of bridge piers and abutments to the water surface profile.

TABLE 4.3.5A CONSTANTS FOR INLET CONTROL EQUATIONS

SWM DESIGN MANUAL FIGURE	FHWA CHART NO.*	SHAPE AND MATERIAL	NOMOGRAPH SCALE	INLET EDGE DESCRIPTION	UNSUBMERGED EQUATION FORM	UNSUBMERGED K	UNSUBMERGED M	SUBMERGED c	SUBMERGED Y	Reference
4.3.5B	1	Circular	1	Square edge w/headwall	1	0.0098	2.0	0.0398	0.67	(56) (57)
		Concrete	2	Groove end w/headwall		.0078	2.0	.0292	.74	(56) (57)
			3	Groove end projecting		.0045	2.0	.0317	.69	(56) (57)
4.3.5C	2	Circular	1	Headwall	1	.0078	2.0	.0379	.69	(56) (57)
		CMP	2	Mitered to slope		.0210	1.33	.0463	.75	(57)
			3	Projecting		.0340	1.50	.0553	.54	(57)
–	3	Circular	A	Beveled ring, 45° bevels	1	.0018	2.50	.0300	.74	(57)
			B	Beveled ring, 33.7° bevels*		.0018	2.50	.0243	.83	(57)
–	8	Rectangular	1	30° to 75° wingwall flares		.026	1.0	.0385	.81	(56)
		Box	2	90° and 15° wingwall flares	1	.061	0.75	.0400	.80	(56)
			3	0° wingwall flares		.061	0.75	.0423	.82	(8)
–	9	Rectangular	1	45° wingwall flare d=.0430	2	.510	.667	.0309	.80	(8)
		Box	2	18° to 33.7° wingwall flare d=.0830		.486	.667	.0249	.83	(8)
–	10	Rectangular	1	90° headwall w/3/4" chamfers	2	.515	.667	.0375	.79	(8)
		Box	2	90° headwall w/45° bevels		.495	.667	.0314	.82	(8)
			3	90° headwall w/33.7° bevels		.486	.667	.0252	.865	(8)
–	11	Rectangular	1	3/4" chamfers; 45° skewed headwall	2	.522	.667	.0402	.73	(8)
		Box	2	3/4" chamfers; 30° skewed headwall		.533	.667	.0425	.705	(8)
			3	3/4" chamfers; 15° skewed headwall		.545	.667	.04505	.68	(8)
			4	45° bevels; 10°-45° skewed headwall		.498	.667	.0327	.75	(8)
–	12	Rectangular	1	45° non-offset wingwall flares	2	.497	.667	.0339	.803	(8)
		Box	2	18.4° non-offset wingwall flares		.493	.667	.0361	.806	(8)
		3/4" chamfers	3	18.4° non-offset wingwall flares 30° skewed barrel		.495	.667	.0386	.71	(8)
–	13	Rectangular	1	45° wingwall flares - offset	2	.497	.667	.0302	.835	(8)
		Box	2	33.7° wingwall flares - offset		.495	.667	.0252	.881	(8)
		Top Bevels	3	18.4° wingwall flares - offset		.493	.667	.0227	.887	(8)
–	18-19	C M Boxes	1	90° headwall	1	.0083	2.0	.0379	.69	(57)
			2	Thick wall projecting		.0145	1.75	.0419	.64	(57)
			3	Thin wall projecting		.0340	1.5	.0496	.57	(57)

* See FHWA HDS No. 5

TABLE 4.3.5A CONSTANTS FOR INLET CONTROL EQUATIONS (CONTINUED)

SWM DESIGN MANUAL FIGURE	FHWA CHART NO.*	SHAPE AND MATERIAL	NOMOGRAPH SCALE	INLET EDGE DESCRIPTION	UNSUBMERGED EQUATION FORM	UNSUBMERGED K	UNSUBMERGED M	SUBMERGED c	SUBMERGED Y	Reference
–	29	Horizontal	1	Square edge with headwall	1	0.0100	2.0	.0398	.67	(57)
		Ellipse	2	Groove end with headwall		.0018	2.5	.0292	.74	(57)
		Concrete	3	Groove end projecting		.0045	2.0	.0317	.69	(57)
–	30	Vertical	1	Square edge with headwall	1	.0100	2.0	.0398	.67	(57)
		Ellipse	2	Groove end with headwall		.0018	2.5	.0292	.74	(57)
		Concrete	3	Groove end projecting		.0095	2.0	.0317	.69	(57)
–	34	Pipe Arch	1	90° headwall	1	.0083	2.0	.0496	.57	(57)
		18" Corner	2	Mitered to slope		.0300	1.0	.0463	.75	(57)
		Radius CM	3	Projecting		.0340	1.5	.0496	.53	(57)
–	35	Pipe Arch	1	Projecting	1	.0296	1.5	.0487	.55	(56)
		18" Corner	2	No Bevels		.0087	2.0	.0361	.66	(56)
		Radius CM	3	33.7° Bevels		.0030	2.0	.0264	.75	(56)
–	36	Pipe Arch	1	Projecting	1	.0296	1.5	.0487	.55	(56)
		31" Corner		No Bevels		.0087	2.0	.0361	.66	(56)
		Radius CM		33.7° Bevels		.0030	2.0	.0264	.75	(56)
–	40-42	Arch CM	1	90° headwall	1	.0083	2.0	.0379	.69	(57)
			2	Mitered to slope		.0300	2.0	.0463	.75	(57)
			3	Thin wall projecting		.0340	1.5	.0496	.57	(57)
–	55	Circular	1	Smooth tapered inlet throat	2	.534	.555	.0196	.89	(3)
			2	Rough tapered inlet throat		.519	.64	.0289	.90	(3)
–	56	Elliptical inlet face	1	Tapered inlet-beveled edges	2	.536	.622	.0368	.83	(3)
			2	Tapered inlet-square edges		.5035	.719	.0478	.80	(3)
			3	Tapered inlet-thin edge projecting		.547	.80	.0598	.75	(3)
–	57	Rectangular	1	Tapered inlet throat	2	.475	.667	.0179	.97	(3)
–	58	Rectangular	1	Side tapered-less favorable edges	2	.56	.667	.0466	.85	(3)
		Concrete	2	Side tapered-more favorable edges		.56	.667	.0378	.87	(3)
–	59	Rectangular	1	Slope tapered-less favorable edges	2	.50	.667	.0466	.65	(3)
		Concrete		Slope tapered-more favorable edges		.50	.667	.0378	.71	(3)

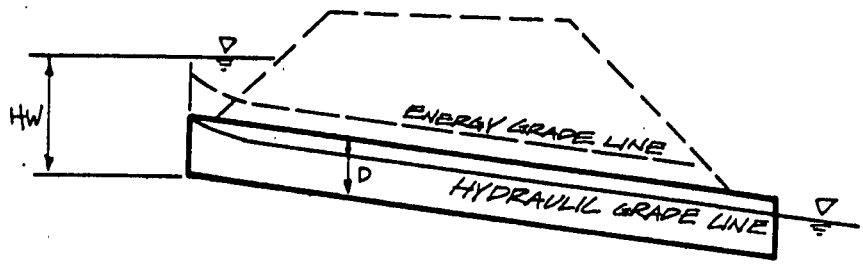
* See FHWA HDS No. 5

TABLE 4.3.5B ENTRANCE LOSS COEFFICIENTS

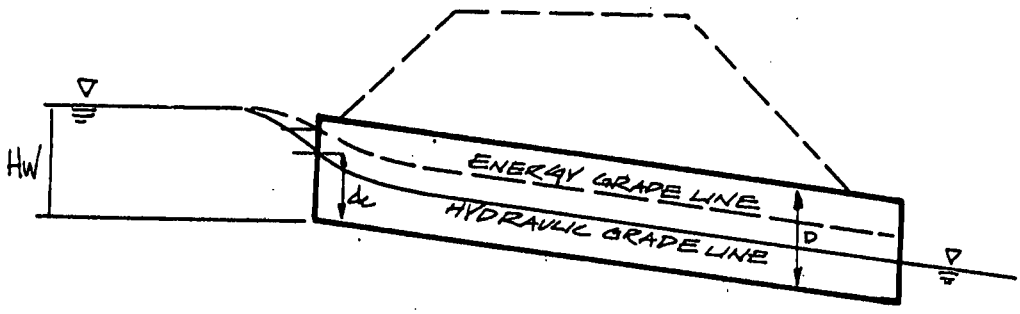
Type of Structure and Design of Entrance	Coefficient K_e
Pipe, Concrete, P.V.C., Spiral Rib, D.I., and CPEP- Smooth Interior	
Projecting from fill, socket (bell) end	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope*	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal and Other Non-Concrete or D.I.	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End-Section conforming to fill slope*	0.5
Beveled edges, 33.7° pr 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: "End Section conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance.

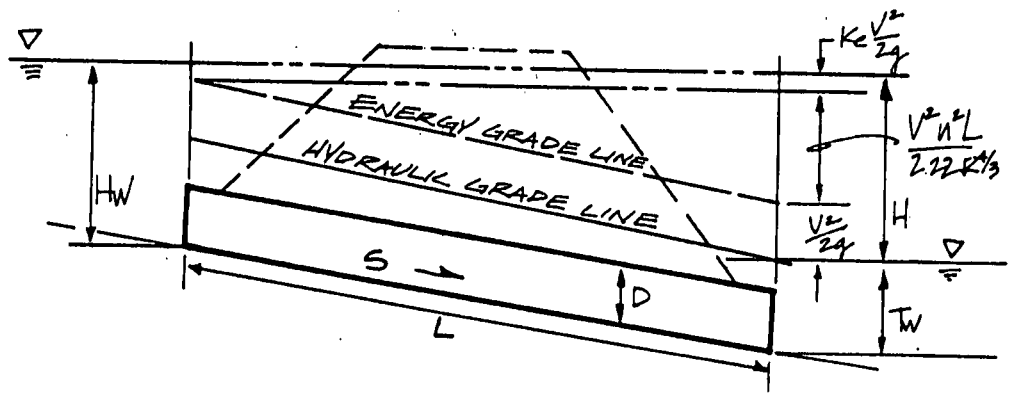
FIGURE 4.3.5B INLET/OUTLET CONTROL CONDITIONS



INLET CONTROL - SUBMERGED INLET



INLET CONTROL - UNSUBMERGED INLET



OUTLET CONTROL - SUBMERGED INLET AND OUTLET

FIGURE 4.3.5C HEADWATER DEPTH FOR SMOOTH INTERIOR PIPE CULVERTS WITH INLET CONTROL

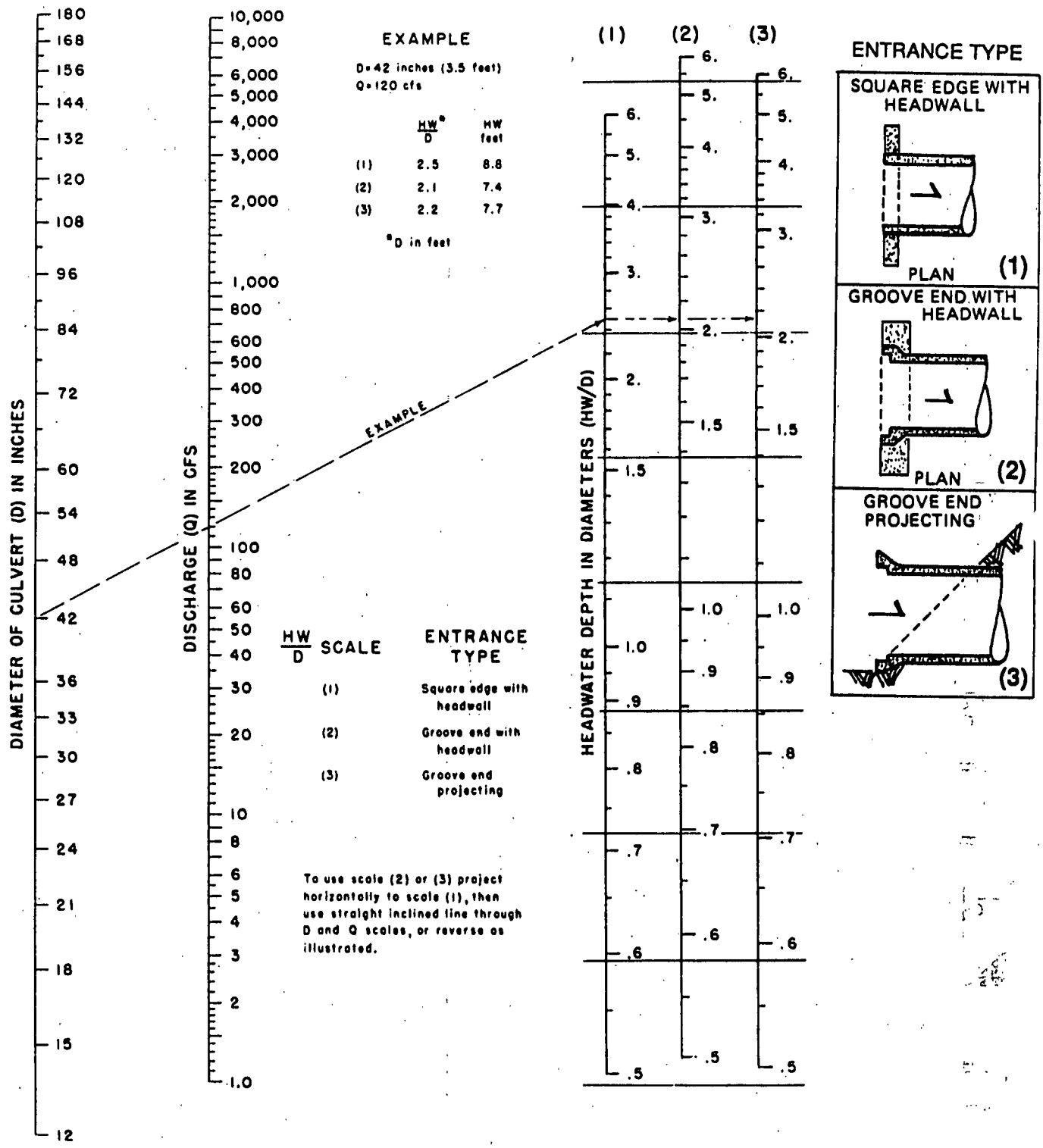


FIGURE 4.3.5D HEADWATER DEPTH FOR CORRUGATED PIPE CULVERTS W/INLET CONTROL

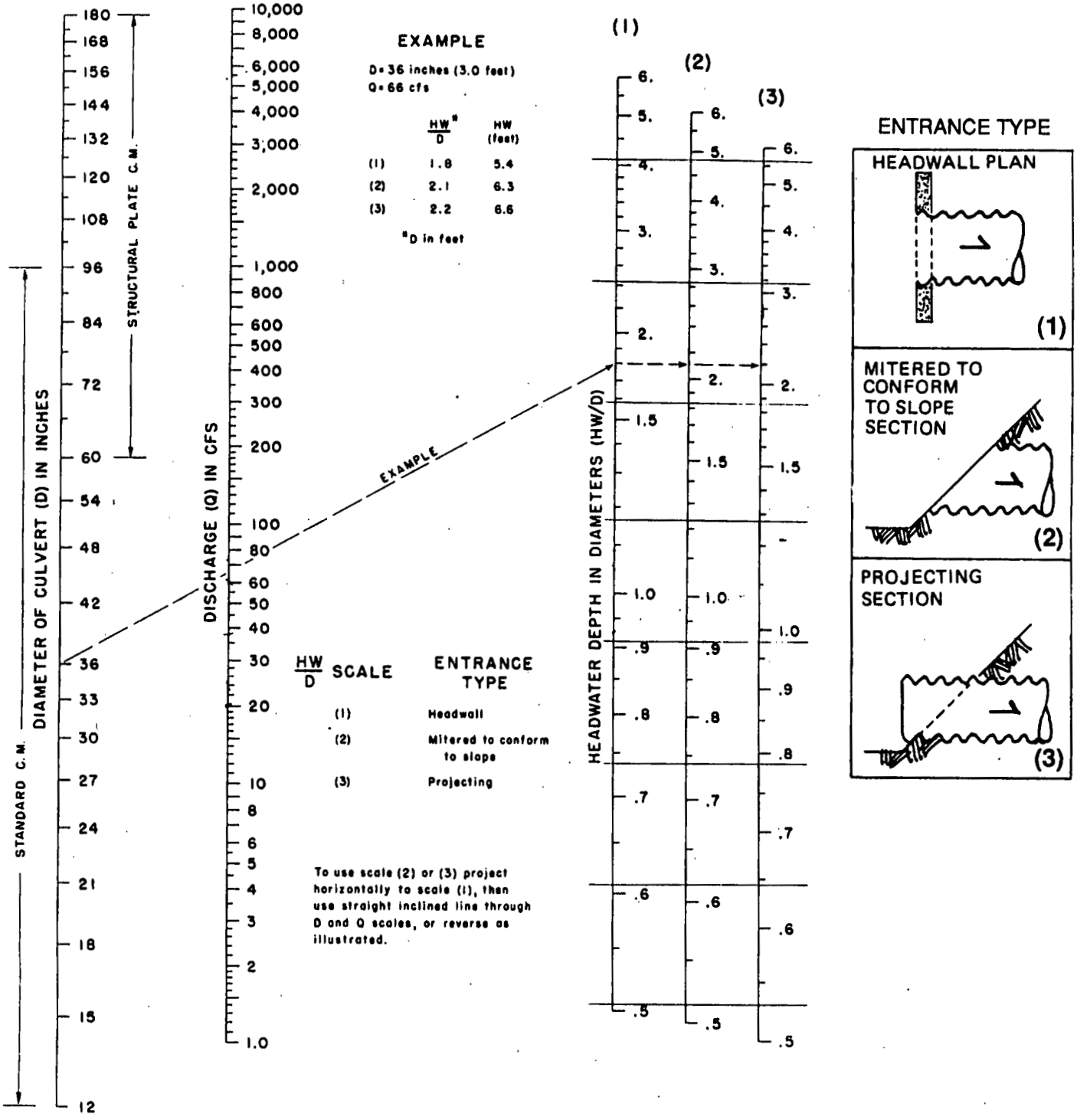


FIGURE 4.3.5E HEAD FOR CULVERTS (PIPE W/ "n" = 0.012), FLOWING FULL WITH OUTLET CONTROL

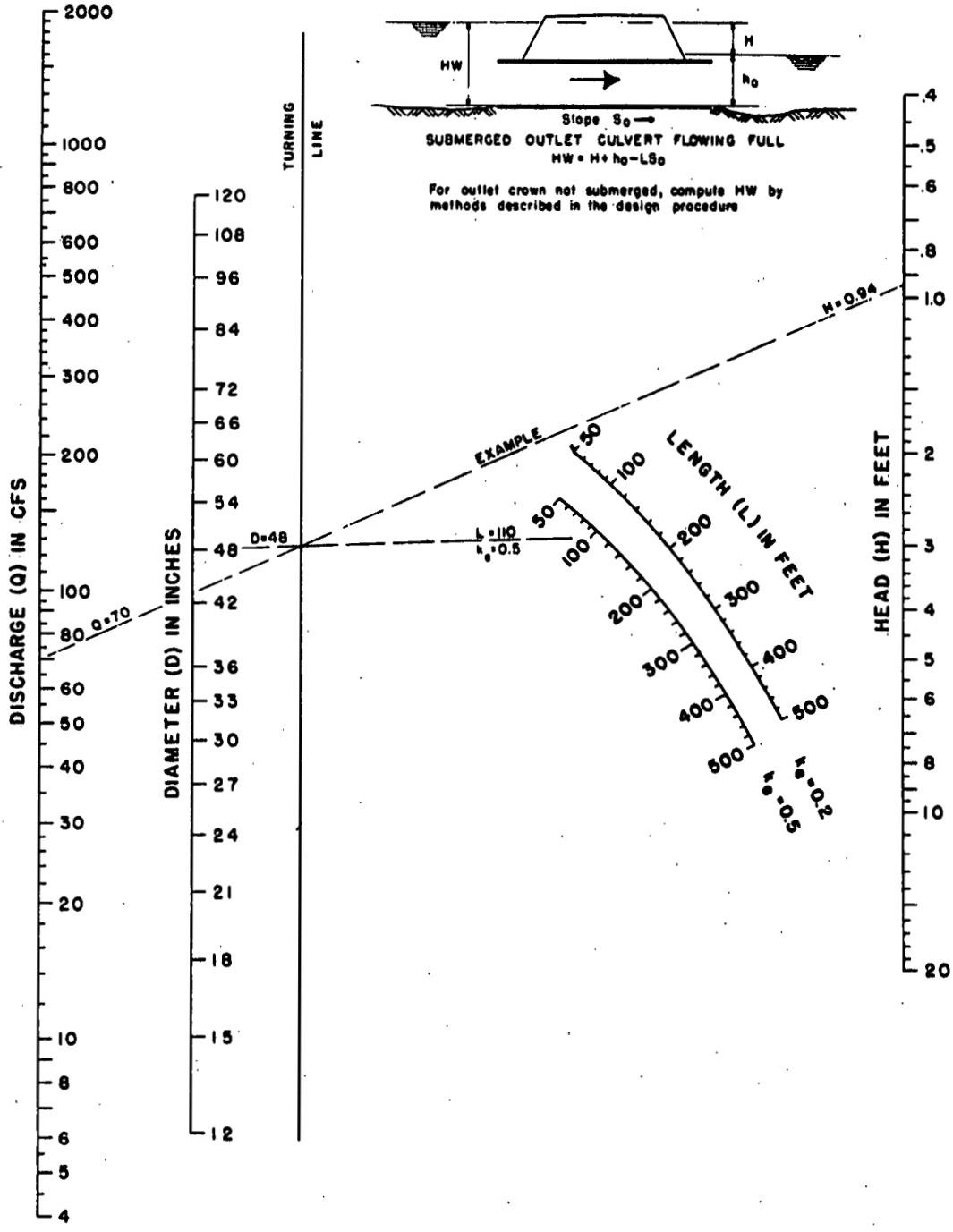


FIGURE 4.3.5F HEAD FOR CULVERTS (PIPE W/ "n" = 0.024), FLOWING FULL WITH OUTLET CONTROL

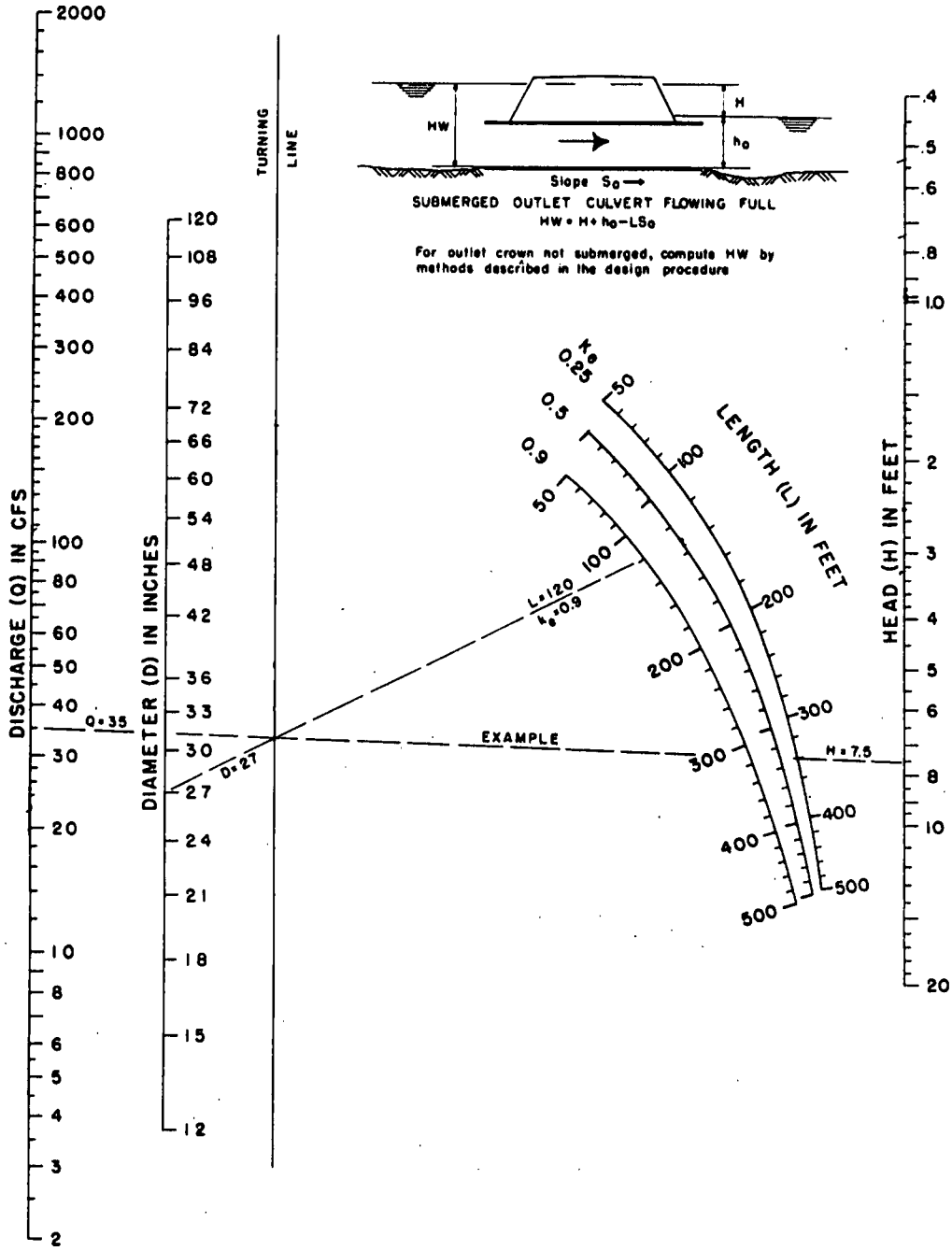
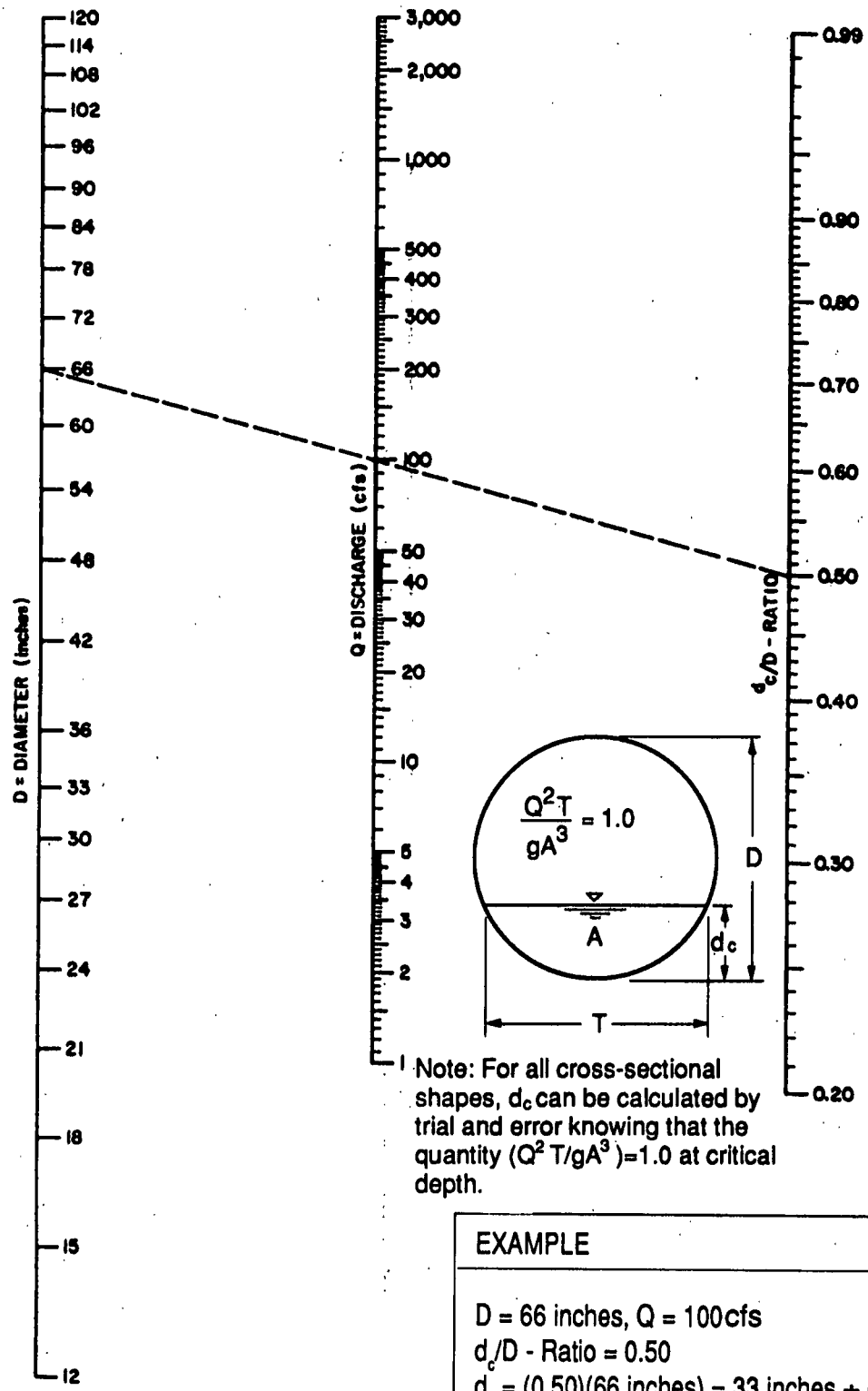


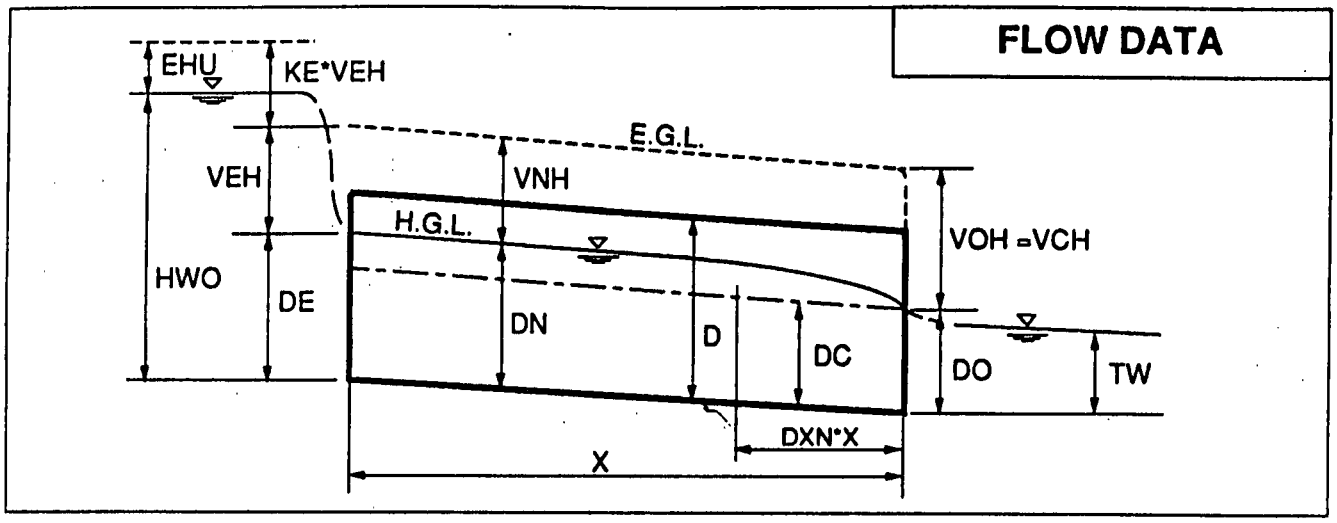
FIGURE 4.3.5G CRITICAL DEPTH OF FLOW FOR CIRCULAR CULVERTS



Note: For all cross-sectional shapes, d_c can be calculated by trial and error knowing that the quantity $(Q^2 T/gA^3)=1.0$ at critical depth.

EXAMPLE
D = 66 inches, Q = 100cfs d_c/D - Ratio = 0.50 d_c = (0.50)(66 inches) = 33 inches ÷ (12 inches/ft) d_c = 2.75 feet

FIGURE 4.3.5H BWPIPE/BWCULV - VARIABLE DEFINITIONS



FLOW DATA

DC - Critical Depth (ft)
DN - Normal Depth (ft)
TW - Tailwater Depth (ft)
DO - Outlet Depth (ft)
DE - Entrance Depth (ft)
HWO - Headwater (ft) assuming Outlet Control
HWI - Headwater (ft) assuming Inlet Control
DXN - Distance (expressed as a fraction of the pipe length) from the oultlet to where the flow profile intersects with normal depth. DXN will equal one under full-flow conditions and will equal zero when a hydraulic jump occurs at the oulet or when normal depth equals zero (normal depth will equal zero when the pipe grade is flat or reversed).

VBH - Barrel Velocity Head (ft) based on the average velocity determined by V=Q/Afull
VUH - Upstream Velocity Head (ft) based on an inputted velocity.

EHU - Upstream Energy Head (ft) available after bend losses and junction losses have been subtracted from VUH.
VCH - Critical Depth Velocity Head (ft)
VNH - Normal Depth Velocity Head (ft)
VEH - Entrance Depth Velocity Head (ft)
VOH - Oulet Depth Velocity Head (ft)

COEFFICIENTS/INLET DATA

KE - Entrance Coefficient under Oulet Control
KB - Bend Loss Coefficient
KJ - Junction Loss Coefficient
K - Inlet Control Equation Parameter (See Table 4.3.5A)
M - Inlet Control Equation Parameter (See Table 4.3.5A)
C- Inlet Control Equation Parameter (See Table 4.3.5A)
Y - Inlet Control Equation Parameter (See Table 4.3.5A)
Q - Ratio - Ratio of tributary flow to main upstream flow or Q_3/Q_1

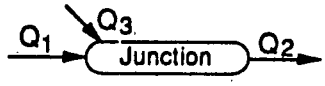
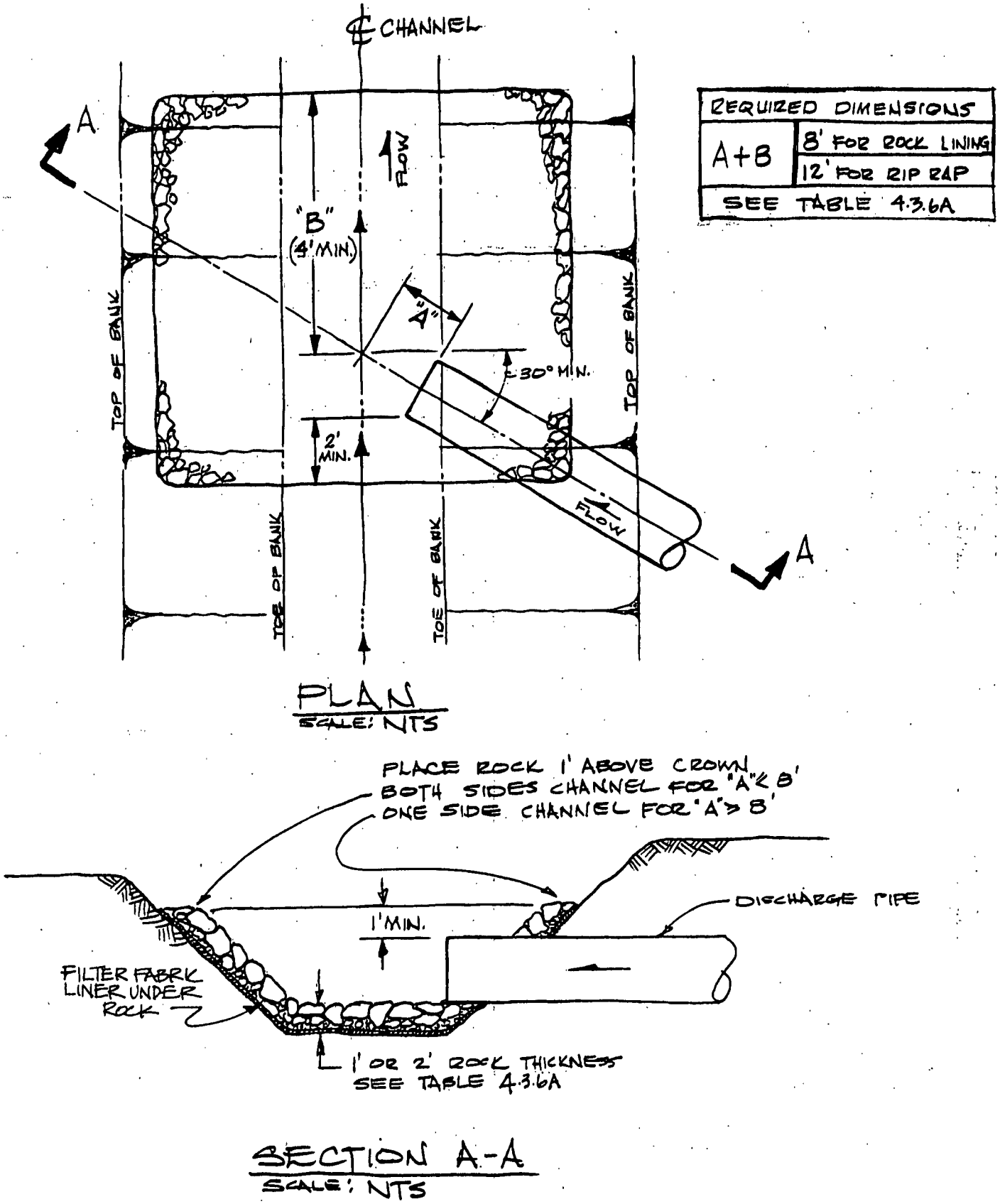


FIGURE 4.3.5I CULVERT DISCHARGE PROTECTION



4.3.6 OUTFALLS

Core Requirement #4, Section 1.2.4, provides the definition and general requirements for outfalls and for outfalls above steep slopes.

Design Criteria and Methods of Analysis for Outfalls

- All outfalls (at a minimum) shall be provided with a rock splash pad (See Figure 4.3.5I). The flow dispersal trench shown in Figure 4.3.6.B. shall only be used as an outfall as described in Core Requirement 1.2.1. For outfalls with a velocity at design flow greater than 10 fps, a gabion dissipator or engineered energy dissipator shall be required (see Table 4.3.6A).

- Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size.

- Engineered energy dissipators, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 fps. These should be designed using published or commonly known techniques found in such references as "Hydraulic Design of Energy Dissipators for Culverts and Channels" published by the Federal Highway Administration of the United States Department of Transportation; "Open Channel Flow", by V.T. Chow; "Hydraulic Design of Stilling Basins and Energy Dissipators", EM 25, Bureau of Reclamation 1978; and others, such as those published by the Soil Conservation Service.

- Examples of alternate mechanisms include concepts such as a bubble-up structure (which will eventually drain) and a structure fitted with reinforced concrete posts. Alternate mechanisms such as these should be designed using sound hydraulic principles and consideration of constructability and ease of maintenance.

- Inlet control will usually dictate outfall pipe system capacity. These conditions should be carefully examined, as well as the consequences, should the inlet to the pipe system become plugged or capacity exceeded.

Outfalls Systems Traversing Steep Slopes

- Based on past experience, outfall systems constructed of pipe segments which are banded and/or gasketed have failed. This has resulted from leaks developing at the joints, accelerating erosion around the pipe, and inevitable failure of the system.These failures on steep or unstable slopes can result in incision of the adjacent slopes and downstream sedimentation which clogs conveyance systems and destroys wildlife habitat.

- These outfall failures have directed King County's requirement for the use of continuously fused, welded or flange bolted mechanical joint pipe systems with proper anchoring for outfalls on steep slopes. For the past several years high density polyethylene pipe (HDPP) has been used very successfully in preventing these failures. While high in material costs, it's relative ease of installation, high performance and durability makes its life cycle cost comparable to, if not lower than, traditional installations. Ductile iron pipe with flange-bolted mechanical joints or "restrained-joints" also has proven reliable for steep slope applications.

Design Criteria for Outfall System Traversing Steep Slopes

- Outfall pipe systems can be installed in trenches with standard bedding on slopes up to 40%. On slopes greater than 40%, outfall pipe systems shall be placed on the ground surface with proper pipe anchorage and support.

- HDPP outfall systems must be designed to address the material limitations as specified by the manufacturer, in particular thermal expansion/contraction and pressure design. The coefficient of thermal expansion and contraction for HDPP is on the order of 0.001 inch per foot per

Fahrenheit degree. Sliding sleeve connections to address this thermal expansion and contraction shall be used. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections must be located as close to the discharge end of the outfall system as is practical.

- Due to HDPP's ability to transmit flows of very high energy, special consideration for energy dissipation must be made. A sample gabion mattress energy dissipator for this purpose has been provided as Figure 4.3.6A. Flows of very high energy will require a specifically engineered energy dissipator structure, as described above.

TABLE 4.3.6A ROCK PROTECTION AT OUTFALLS

Discharge Velocity At Design Flow (fps)		REQUIRED PROTECTION				
Greater than	Less than or equal to	Minimum Dimensions				
		Type	Thickness	Width	Length	Height
0	5	Rip Rap*	1 ft.	Diameter + 6 ft.	8 ft. or 4X Dia. whichever is greater	Crown + 1 ft.
5	10	Rip Rap**	1 ft.	Diameter + 6 ft. or 3X dia., whichever is greater	12 ft. or 4X dia. whichever is greater	Crown + 1 ft.
10	20	Gabion Outfall	1 ft.	(As required)	(As required)	Crown + 1 ft.
20	N/A	Engineered Energy Dissipator Required				

* Rip rap shall be in accordance with section 9-13.1 of the WSDOT/APWA Standard Specifications. Rip rap to be reasonably well graded with rock gradation as follows:

Passing 8 inch square sieve 100% or Maximum stone size 8"
Passing 6 inch square sieve 40-60% or Medium stone size 6"
Passing 2 inch square sieve 0-10% or Minimum stone size 2"

** Rip rap to be reasonably well graded with rock gradation as follows:

Maximum stone size 24" (nominal diameter)
Median stone size 16"
Minimum stone size 4"

Note: Rip rap sizing governed by side slopes on outlet channel, assumed to be ~3:1.

FIGURE 4.3.6A GABION OUTFALL DETAIL

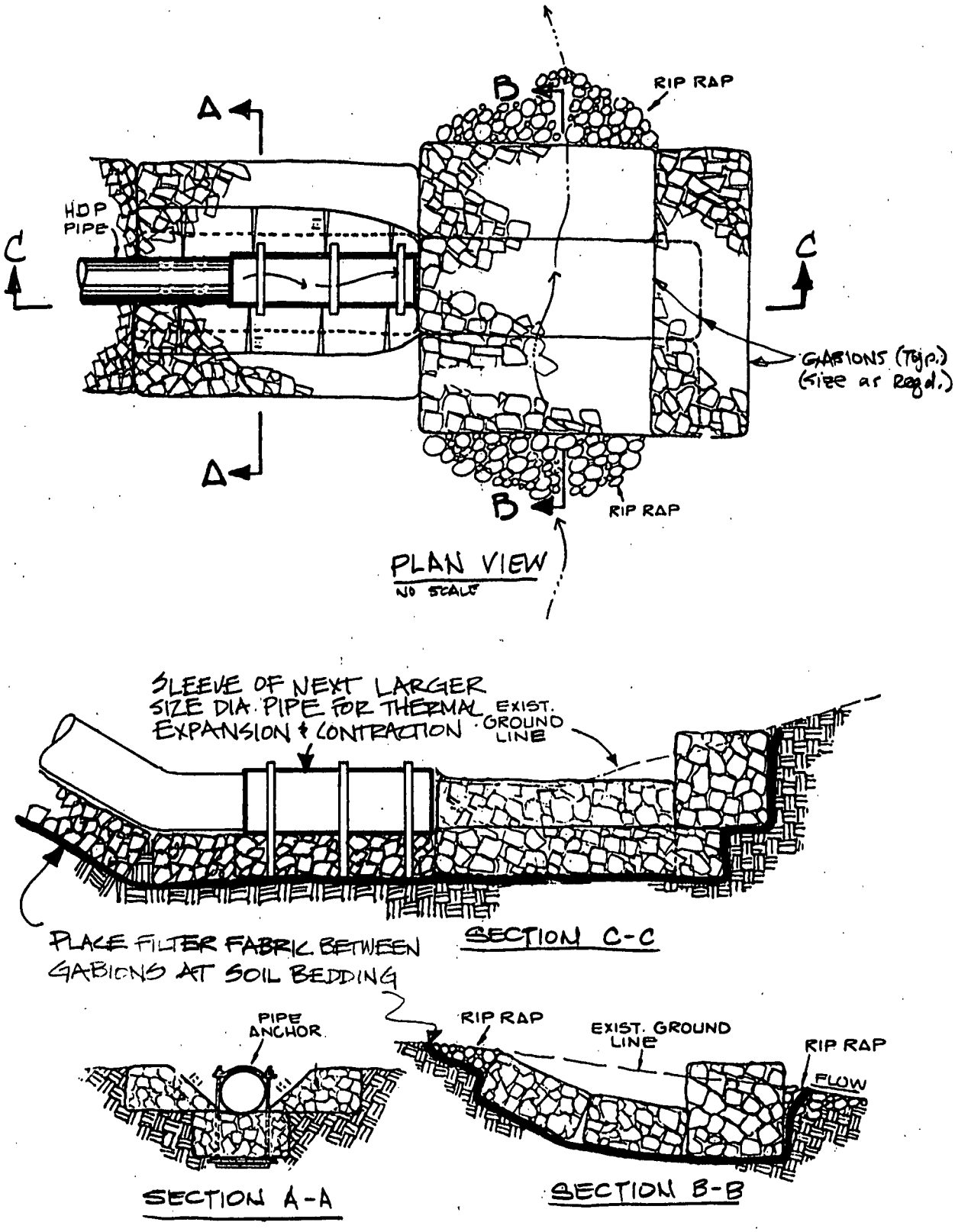
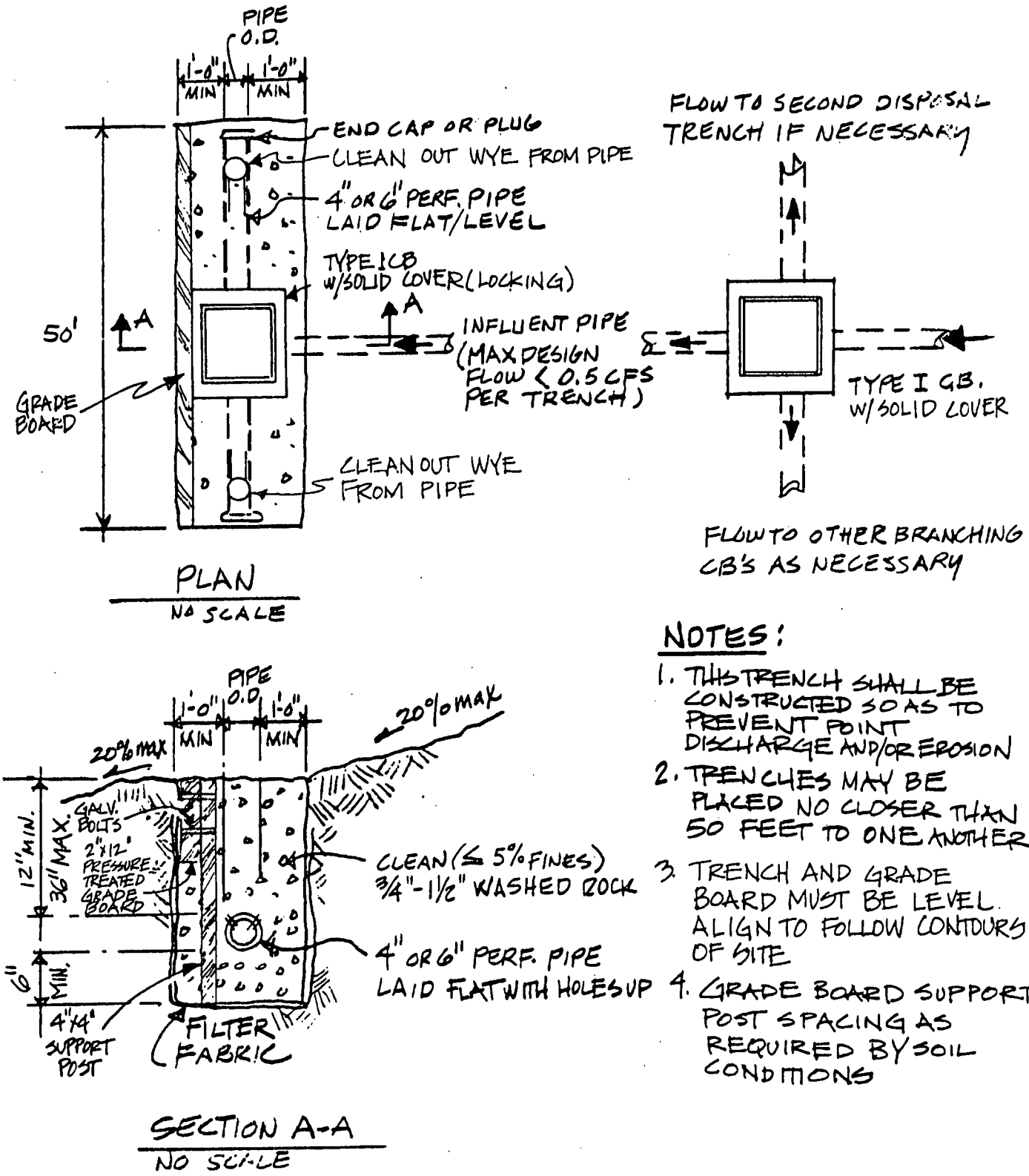


FIGURE 4.3.6B FLOW DISPERSAL TRENCH



NOTES:

1. THIS TRENCH SHALL BE CONSTRUCTED SO AS TO PREVENT POINT DISCHARGE AND/OR EROSION
2. TRENCHES MAY BE PLACED NO CLOSER THAN 50 FEET TO ONE ANOTHER
3. TRENCH AND GRADE BOARD MUST BE LEVEL. ALIGN TO FOLLOW CONTOURS OF SITE
4. GRADE BOARD SUPPORT POST SPACING AS REQUIRED BY SOIL CONDITIONS

4.3.7 OPEN CHANNELS

Open channels can be classified as either natural or constructed. Natural channels are generally referred to as streams, creeks or swales, while constructed channels are most often called ditches or, simply, channels. The Sensitive Areas Ordinance and Rules and Chapter 1 should be reviewed for requirements related to streams.

Natural channels are defined as those which have occurred naturally due to the flow of surface waters or those that, although originally constructed by human activity, have taken on the appearance of a natural channel including a stable route and biological community. They may vary hydraulically along each channel reach and should be left in their natural condition wherever feasible or required, in order to maintain natural hydrologic functions and wildlife habitat benefits from established vegetation.

Constructed channels are those constructed or maintained by human activity and include bank stabilization of natural channels. Constructed channels shall be either rock-lined, vegetation-lined, or lined with appropriately "bio-engineered" vegetation.

Vegetation-lined channels are the most desirable of the constructed channels when properly designed and constructed. The vegetation stabilizes the slopes of the channel, controls erosion of the channel surface and removes pollutants. The channel storage, low velocities, water quality benefits, and greenbelt multiple-use benefits create significant advantages over other constructed channels. The presence of vegetation in channels creates turbulence which results in loss of energy and increased flow retardance; therefore, the design engineer must consider sediment deposition and scour, as well as flow capacity.

Rock-lined channels are necessary where a vegetative lining will not provide adequate protection from erosive velocities. They may be constructed with quarry spall rip rap, gabions, or slope mattress linings. The rock lining increases the turbulence, resulting in a loss of energy and increased flow retardance. Rock lining also permits a higher design velocity and therefore a steeper design slope than in grass-lined channels. Rock linings are also used for erosion control at culvert/storm drain outlets, at sharp channel bends, channel confluences, and locally steepened channel sections.

Design Criteria

Geometry: Channel section geometry shall be trapezoidal, V-shaped parabolic, or segmental as shown in Figure 4.3.7D through 4.3.7F. Side slopes shall be not steeper than 3:1 for vegetation lined channels and 2:1 for rock-lined channels unless engineered (Roadside ditches shall be per King County Roads Standards).

Channel Freeboard: As specified in Section 1.2.4 for ditches and channels and Section 1.3.5 for constructed swales.

Maximum Slope/Velocity: Vegetation lined channels shall have bottom slope gradients of 5% or less and a maximum velocity at design flow of 5 fps. (See Table 4.3.7A).

Stabilization: Rock-lined channels or bank stabilization of natural channels shall be used when design flow velocities exceed 5 fps. Rock lining shall be in accordance with Table 4.3.7A or stabilized with bioengineering methods as described below.

Easements: An access easement for maintenance is required along all constructed channels located on private property. Required easement widths and building setback lines vary with channel top width as shown in Table 4.3.2A.

Bioengineered Channels And Bank Stabilization

Soil "Bioengineering" is a highly specialized science that uses living plants and plant parts to stabilize eroded or damaged land. Its application to eroded stream or river banks provides desirable alternatives to the conventional methods of rock armoring.

Properly "Bioengineered" systems are capable of providing a measure of immediate soil protection and mechanical reinforcement. As the plants grow they produce a vegetative protective cover and a root reinforcing matrix in the soil mantle. This root reinforcement serves several purposes:

(1) The developed anchor roots provide both shear and tensile strength to the soil, thereby providing protection from the frictional shear and tensile velocity components to the soil mantle during the time when flows are receding and pore pressure is high in the saturated bank.

(2) The root mat provides a living filter in the soil mantle which allows for the natural release of water after the high flows have receded.

(3) The combined root system exhibits active friction transfer along the length of the living roots. This consolidates soil particles in the bank and serves to protect the soil structure from collapsing and the stabilization measures from failing.

The vegetative cover provides immediate protection during high flows by laying flat against the bank and covering the soil like a blanket. It also reduces pore pressure in saturated banks through transpiration by acting as a natural "pump" to "pull" the water out of the banks after flows have receded.

Rip Rap Design
(from a paper prepared by M. Schaefer, Dam Safety Section, Washington State Department of Ecology.)

In the placing of rip rap, stones are placed on the channel sides and bottom to protect the underlying material from being eroded. Proper rip rap design requires the determination of the median size of stone, the thickness of the rip rap layer, the gradation of stone sizes and the selection of angular stones which will interlock when placed. Research by the U.S. Army Corps of Engineers has provided criteria for selecting the median stone size, W_{50} (Figure 4.3.7A). If the rip rap is to be used in a highly turbulent zone, such as at a culvert outfall, downstream of a stilling basin, at sharp changes in channel geometry, etc., the median stone (W_{50}) should be increased from 200% to 600% depending on the severity of the locally high turbulence. The thickness of the rip rap layer should generally be twice the median stone diameter (D_{50}) or at least that of the maximum stone. The rip rap should have a reasonably well graded assortment of stone sizes within the following gradation:

$$1.25 \leq \frac{Dmax}{D_{50}} \leq 1.50, \ \frac{D_{15}}{D_{50}} = 0.50, \ \frac{Dmin}{D_{50}} = 0.25$$

For a more detailed analysis and design procedure for rip rap requiring water surface profiles and estimates of tractive force, refer to the paper by Maynord et al, Journal of Hydraulic Engineering (A.S.C.E.), July 1989.

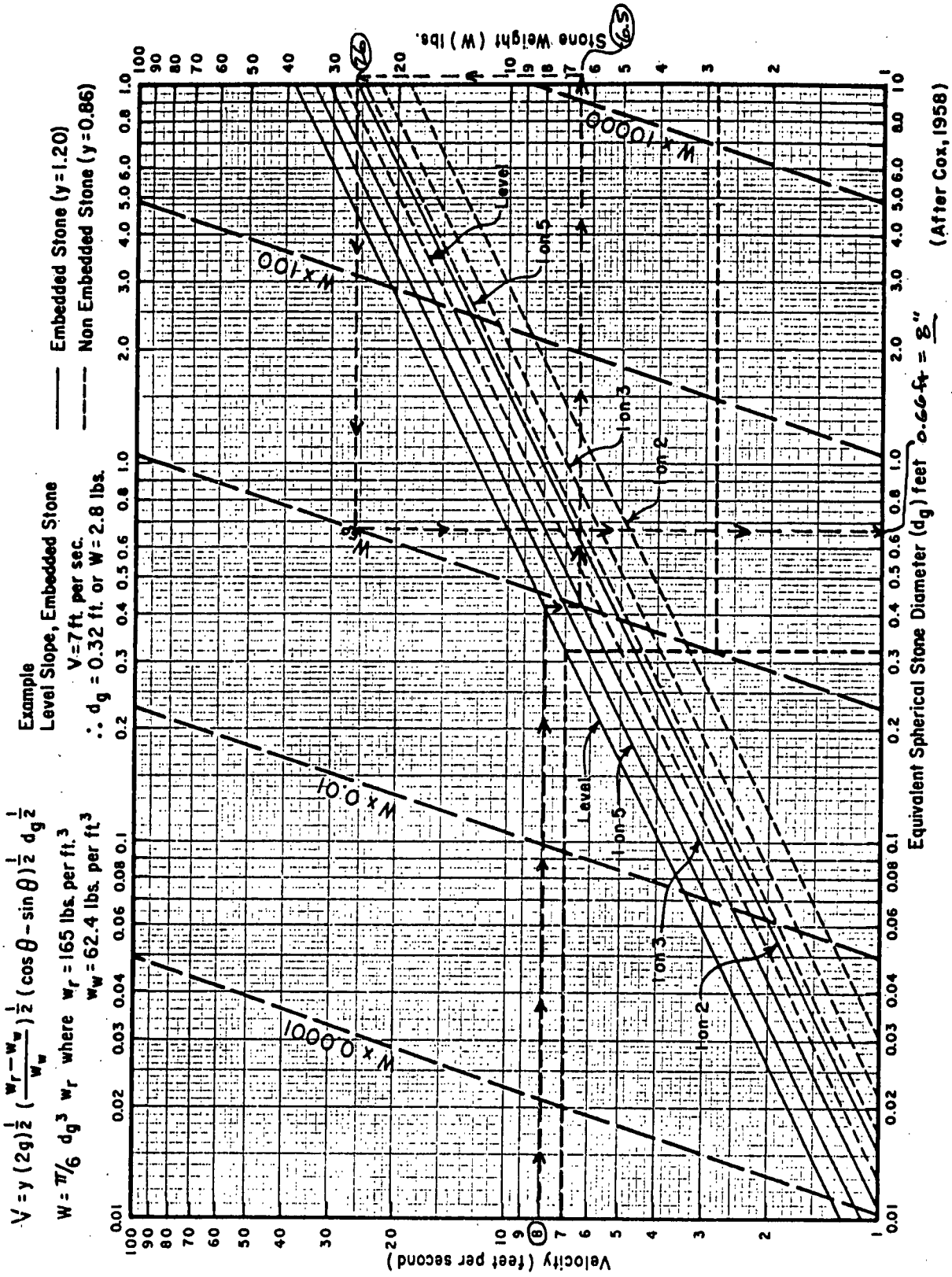
Rip Rap Filter Design

The rip rap should be underlain by a sand and gravel filter (or filter fabric) to keep the fine materials in the underlying channel bed from being washed through the voids in the rip rap. Likewise, the filter material must be selected so that it is not washed through the voids in the rip rap. Adequate filters can usually be provided by a reasonably well graded sand and gravel material where:

$$D_{15} < 5d_{85}$$

Where d_{85} refers to the sieve opening through which 85% of the material being protected will pass and D_{15} has the same interpretation for the filter material. A filter material with a D_{50} of 0.5 mm will protect any finer material including clay. Where very large rip rap is used it is sometimes necessary to use two filter layers between the material being protected and the rip rap.

FIGURE 4.3.7A MEAN CHANNEL VEL. vs MED. STONE WT. (W_{50}) AND EQUIVALENT STONE DIA.



Example:

What rip rap design should be used for protection of a stream bank at a culvert outfall where the outfall velocities in the vicinity of the downstream toe are expected to be about 8 fps?

From Figure 4.3.7A, W_{50} = 6.5 lbs, since the downstream area below the outfall will be subjected to severe turbulence, increase W_{50} by 400%,
use:

W_{50} = 26 lbs, D_{50} = 8.0 inches

The gradation of the rip rap is shown in Figure 4.3.7.B, and the minimum thickness would be 1 ft. (from Table 4.3.7A); however, 16 inches to 24 inches of rip rap thickness would provide some additional insurance that the rip rap will function properly in this highly turbulent area.

Inspection of 4.3.7.B shows that the gradation curve for ASTM C-33, size number 57 coarse aggregate (used in concrete mixes), would meet the filter criteria. Applying the filter criteria to the coarse aggregate would demonstrate that any underlying material whose gradation was coarser than that of a concrete sand would be protected.

For additional information and procedures for specifying filters for rip rap and general guidance, refer to the Army Corp of Engineers Manual EM 1110-2-1601 (1970) "Hydraulic Design of Flood Control Channels", paragraph 14, Rip Rap Protection.

METHODS OF ANALYSIS

Three methods of analysis are presented here for sizing and analyzing open channels.

(1) Mannings Equation for Preliminary Sizing of Open Channels

This method is used for preliminary sizing of open channel reaches of uniform cross-section and slope (ie., prismatic channels), and uniform roughness. It assumes the flow depth (or normal depth), and flow velocity, remain constant throughout the channel reach for a given flow.

The charts in Figures 4.3.7C and 4.3.7D can be used to obtain graphic solutions of Manning's Equation for common ditch sections. For conditions outside the range of these charts, or for more precise results, Manning's Equation can be solved directly from its classic forms:

$V = 1.49/n\ R^{2/3}\ S^{1/2}$ or $Q = 1.49/n\ A\ R^{2/3}\ S^{1/2}$

Table 4.3.7B provides a reference for selecting the appropriate "n" values for open channels. A number of engineering reference books, such as "Open-Channel Hydraulics" by V.T. Chow, (Table 5-6 and Figure 5-5), may also be used as a guide in the selection of "n" values. Figure 4.3.7E contains the geometric elements of common channel sections useful in determining area (A), wetted perimeter (WP), and hydraulic radius (R= A/WP)

Note, if flow restrictions occur which raise the water level above normal depth within a given channel reach, a backwater condition (or non-uniform flow) is said to exist. This condition can result from flow restrictions created by a downstream culvert, bridge, dam, pond, lake, etc., and even a downstream channel reach having a higher normal flow depth. If backwater conditions are found to exist for the design flow, a backwater profile should be computed to verify that the channel's capacity is still adequate as designed. The Direct Step or Standard Step backwater methods presented next, can be used for this purpose.

TABLE 4.3.7A CHANNEL PROTECTION

Velocity at Design Flow (fps)		Required Protection	Thickness	Min. Height Above Design Water Surface
Greater than	Less than or equal to			
0	5	Grass Lining***	N/A	0.5 ft.
5	8	Rip rap*, ***	1 ft.	1 ft.
8	12	Rip Rap**	2 ft.	2 ft.
12	20	Slope mattress Gabion, etc.	Varies	2 ft.

* Rip rap shall be in accordance with section 9-13.1 of the WSDOT/APWA Standard Specifications.

* Rip rap shall be reasonably well graded assortment of rock with the following gradation:

Maximum stone size 12"
Median stone size 8"
Minimum stone size 2"

** Rip rap shall be reasonably well graded assortment of rock with the following gradation:

Maximum stone size 24"
Median stone size 16"
Minimum stone size 4"

Note: Rip rap sizing governed by side slopes on channel, assumed ~3.1.

*** Bioengineered lining allowed for design flow up to 8 fps.

FIGURE 4.3.7B RIPRAP GRADATION CURVE

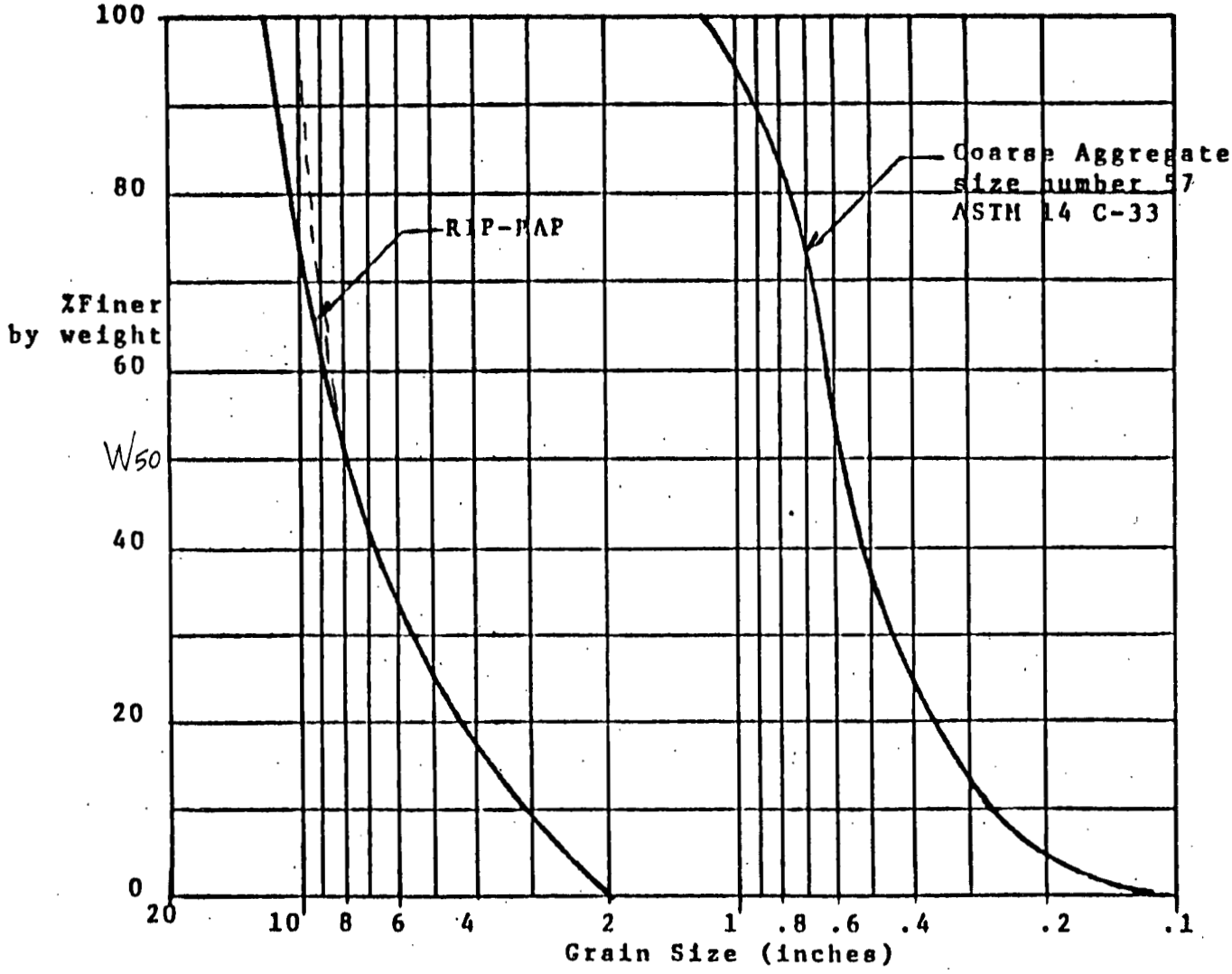


TABLE 4.3.7B VALUES OF THE ROUGHNESS COEFFICIENT, "n"

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

*Note, these "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity the "maximum" values listed in other references should be considered. For channel bank stability the minimum values should be considered.

FIGURE 4.3.7C DITCHES, COMMON SECTIONS

PROPERTIES OF DITCHES

NO.	DIMENSIONS				HYDRAULICS			
	SIDE SLOPES	B	H	W	a	p	R	$R^{2/3}$
D-1	—	—	6½"	5'-0"	1.84	5.16	0.356	0.502
D-1C	—	—	6"	25'-0"	6.25	25.5	0.245	0.391
D-2A	1½:1	2'-0"	1'-0"	5'-0"	3.50	5.61	0.624	0.730
B	2:1	2'-0"	1'-0"	6'-0"	4.00	6.47	0.618	0.726
C	3:1	2'-0"	1'-0"	8'-0"	5.00	8.32	0.601	0.712
D-3A	1½:1	3'-0"	1'-6"	7'-6"	7.88	8.41	0.937	0.958
B	2:1	3'-0"	1'-6"	9'-0"	9.00	9.71	0.927	0.951
C	3:1	3'-0"	1'-6"	12'-0"	11.25	12.49	0.901	0.933
D-4A	1½:1	3'-0"	2'-0"	9'-0"	12.00	10.21	1.175	1.114
B	2:1	3'-0"	2'-0"	11'-0"	14.00	11.94	1.173	1.112
C	3:1	3'-0"	2'-0"	15'-0"	18.00	15.65	1.150	1.097
D-5A	1½:1	4'-0"	3'-0"	13'-0"	25.50	14.82	1.721	1.436
B	2:1	4'-0"	3'-0"	16'-0"	30.00	17.42	1.722	1.437
C	3:1	4'-0"	3'-0	22'-0"	39.00	22.97	1.698	1.423
D-6A	2:1	—	1'-0"	4'-0"	2.00	4.47	0.447	0.584
B	3:1	—	1'-0"	6'-0"	3.00	6.32	0.475	0.609
D-7A	2:1	—	2'-0"	8'-0"	8.00	8.94	0.895	0.929
B	3:1	—	2'-0"	12'-0"	12.00	12.65	0.949	0.965
D-8A	2:1	—	3'-0"	12'-0"	18.00	13.42	1.341	1.216
B	3:1	—	3'-0"	18'-0"	27.00	18.97	1.423	1.265
D-9	7:1	—	1'-0"	14'-0"	7.00	14.14	0.495	0.626
D-10	7:1	—	2'-0"	28'-0"	28.00	28.28	0.990	0.993
D-11	7:1	—	3'-0"	42'-0"	63.00	42.43	1.485	1.302

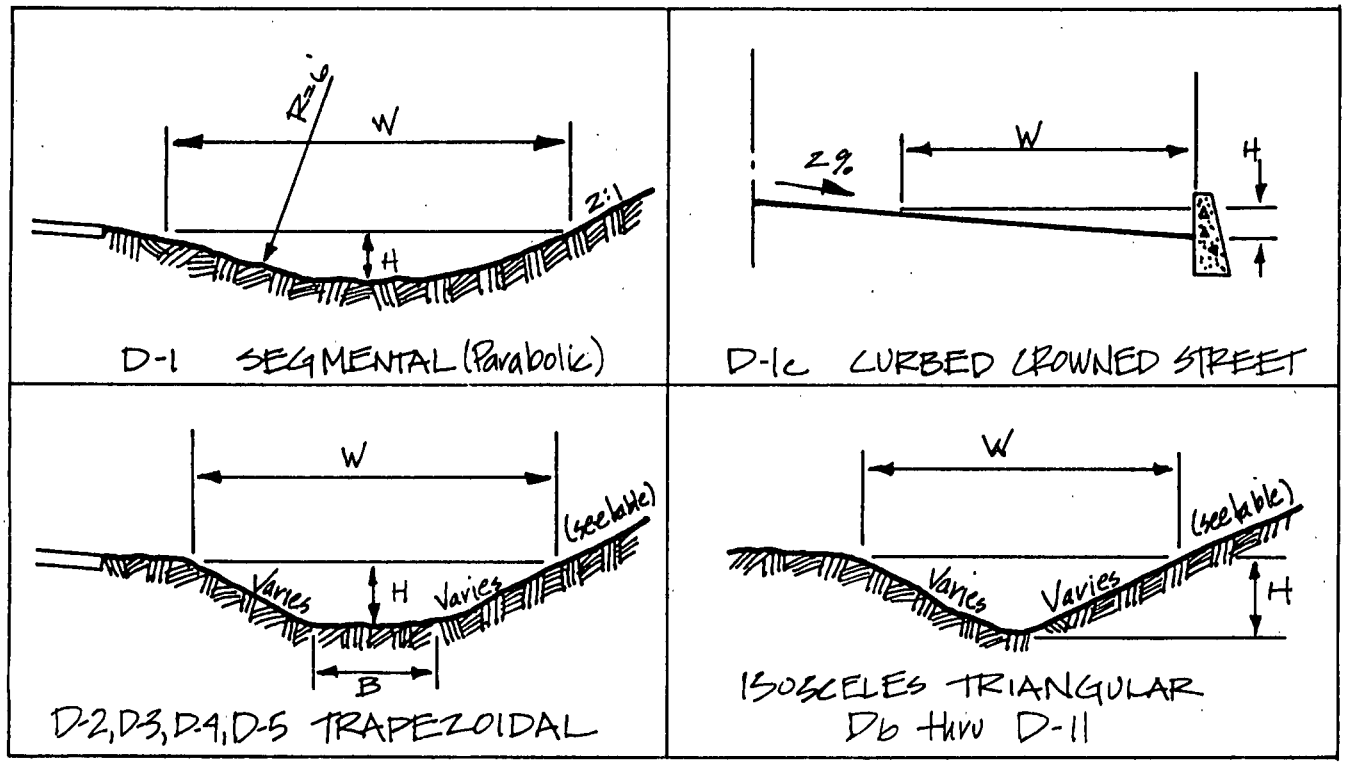


FIGURE 4.3.7D DRAINAGE DITCHES, COMMON SECTIONS

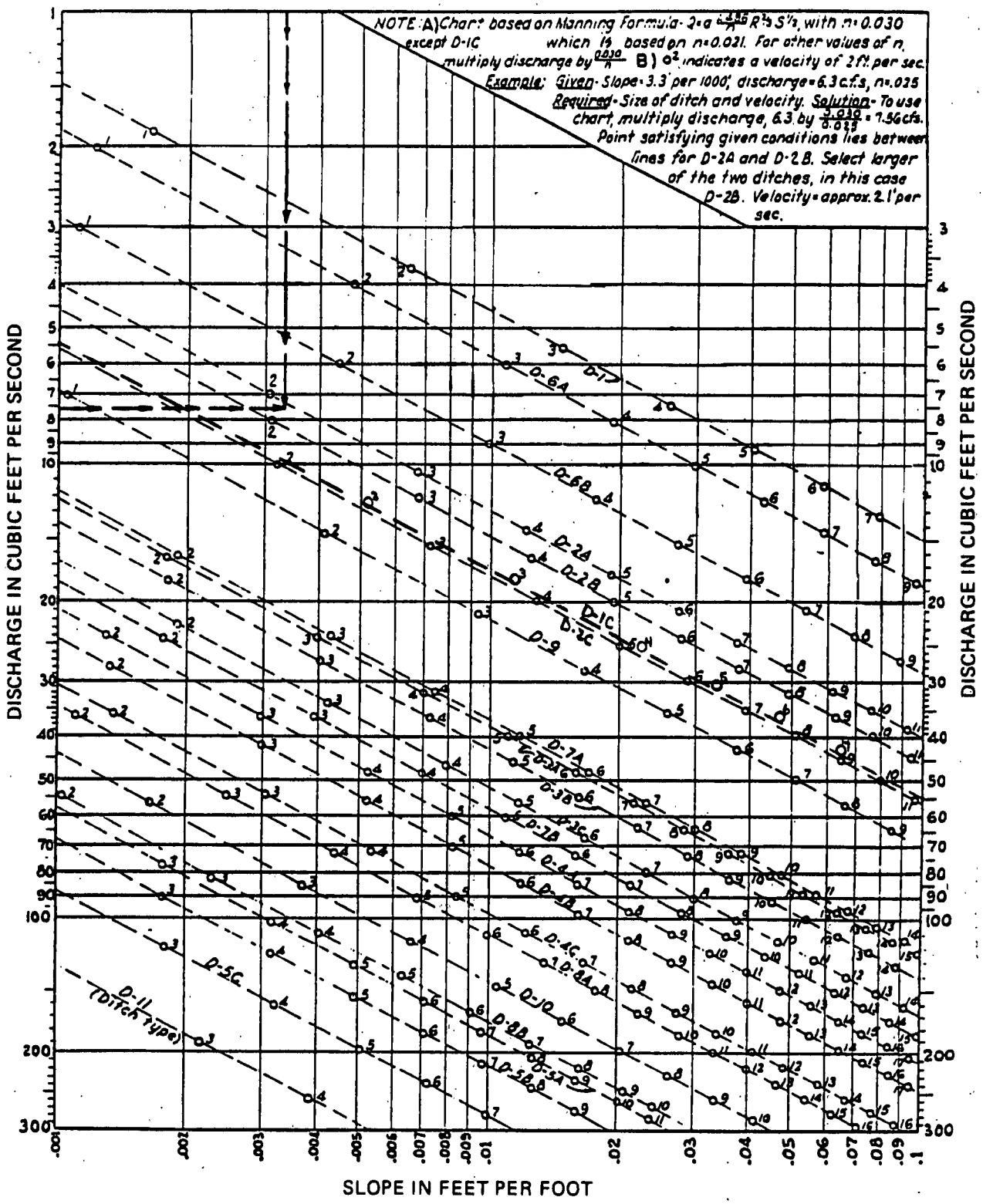
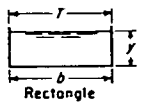
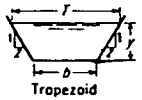
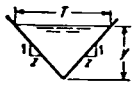
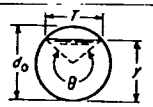
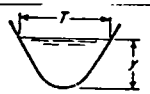
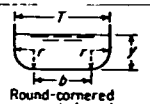
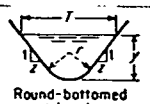


FIGURE 4.3.7E GEOMETRIC ELEMENTS OF COMMON SECTIONS

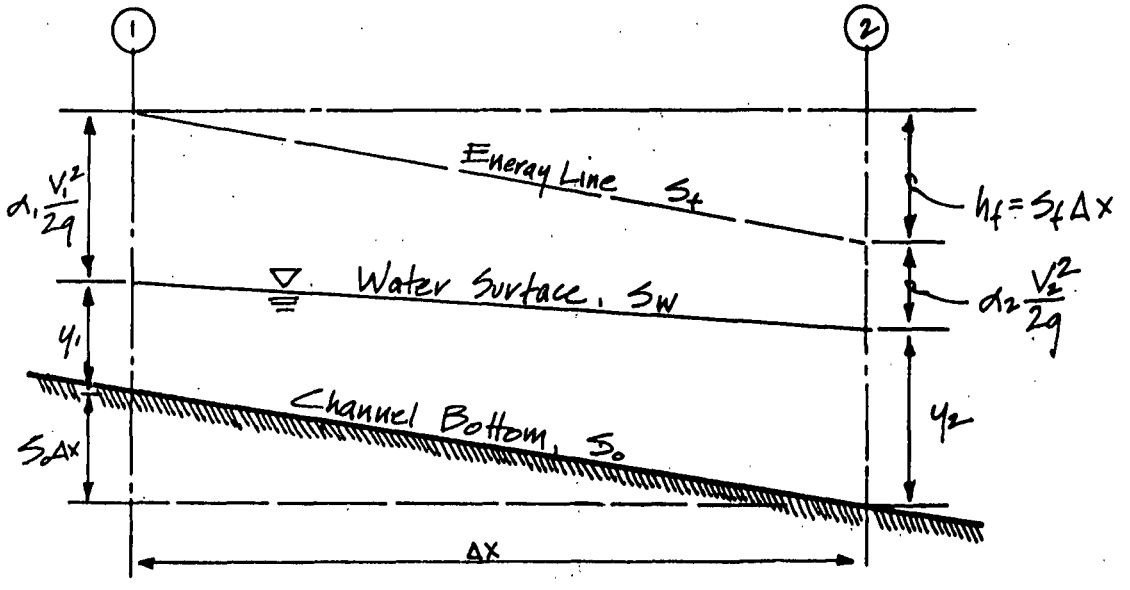
Section	Area A	Wetted perimeter P	Hydraulic radius R	Top width T	Hydraulic depth D	Section factor Z
 Rectangle	by	$b + 2y$	$\frac{by}{b + 2y}$	b	y	$by^{1.5}$
 Trapezoid	$(b + zy)y$	$b + 2y\sqrt{1 + z^2}$	$\frac{(b + zy)y}{b + 2y\sqrt{1 + z^2}}$	$b + 2zy$	$\frac{(b + zy)y}{b + 2zy}$	$\frac{[(b + zy)y]^{1.5}}{\sqrt{b + 2zy}}$
 Triangle	zy^2	$2y\sqrt{1 + z^2}$	$\frac{zy}{2\sqrt{1 + z^2}}$	$2zy$	$\frac{1}{2}y$	$\frac{\sqrt{2}}{2} zy^{2.5}$
 Circle	$\frac{1}{8}(\theta - \sin\theta)d_0^2$	$\frac{1}{2}\theta d_0$	$\frac{1}{4}\left(1 - \frac{\sin\theta}{\theta}\right) d_0$	$(\sin\frac{1}{2}\theta)d_0$ or $2\sqrt{y(d_0 - y)}$	$\frac{1}{8}\left(\frac{\theta - \sin\theta}{\sin\frac{1}{2}\theta}\right) d_0$	$\frac{\sqrt{2}}{32}\frac{(\theta - \sin\theta)^{1.5}}{(\sin\frac{1}{2}\theta)^{0.5}} d_0^{2.5}$
 Parabola	$\frac{2}{3}Ty$	$T + \frac{8}{3}\frac{y^2}{T}$ *	$\frac{2T^2y}{3T^2 + 8y^2}$ *	$\frac{3}{2}\frac{A}{y}$	$\frac{2}{3}y$	$\frac{2}{9}\sqrt{6}\, Ty^{1.5}$
 Round-cornered rectangle ($r > r$)	$\left(\frac{\pi}{2} - 2\right) r^2 + (b + 2r)y$	$(\pi - 2)r + b + 2y$	$\frac{(\pi/2 - 2)r^2 + (b + 2r)y}{(\pi - 2)r + b + 2y}$	$b + 2r$	$\frac{(\pi/2 - 2)r^2}{b + 2r} + y$	$\frac{[(\pi/2 - 2)r^2 + (b + 2r)y]^{1.5}}{\sqrt{b + 2r}}$
 Round-bottomed triangle	$\frac{T^2}{4z} - \frac{r^2}{z}(1 - z\cot^{-1} z)$	$\frac{T}{z}\sqrt{1 + z^2} - \frac{2r}{z}(1 - z\cot^{-1} z)$	$\frac{A}{P}$	$2[z(y - r) + r\sqrt{1 + z^2}]$	$\frac{A}{T}$	$A\sqrt{\frac{A}{T}}$

* Satisfactory approximation for the interval $0 < z \leq 1$, where $z = 4y/T$. When $z > 1$, use the exact expression $P = (T/2)[\sqrt{1 + z^2} + 1/z \ln(z + \sqrt{1 + z^2})]$.

(2) Direct Step Backwater Method for Analyzing Channel Capacity

This method can be used to compute backwater profiles on prismatic channel reaches (ie., reaches having uniform cross-section and slope) where a backwater condition or restriction to normal flow is known to exist. The method can be applied to a series of prismatic channel reaches in secession beginning at the downstream end of the channel and computing the profile upstream.

To illustrate analysis of a single reach, consider the following diagram:



Equating the total head at cross-sections 1 and 2, the following equation may be written:

$$S_o \Delta x + y_1 + \frac{\alpha_1 V_1^2}{2g} = y_2 + \frac{\alpha_2 V_2^2}{2g} + S_f \Delta x$$

Solving for Δx,

$$\Delta x = \frac{E_2 - E_1}{S_o - S_f} = \frac{\Delta E}{S_o - S_f}$$

Where E is specific energy and assuming $\alpha_1 = \alpha_2 = \alpha$, where α is the energy coefficient which corrects for the non-uniform distribution of velocity over the channel cross-section.

$$E = y + \frac{\alpha V^2}{2g}$$

and:
- y = depth of flow
- V = mean velocity
- α = energy coefficient
- S_o = bottom slope
- S_f = friction slope $= \frac{n^2 V^2}{2.21\ R^{4/3}}$
- g = acceleration due to gravity = 32.2 ft/s^2

Typical values of the energy coefficient, α, are as follows:

Channels, regular section	1.15
Natural Streams	1.3
Shallow vegetated flood fringes (includes channel)	1.75

For a given flow, channel slope, Manning's "n", and energy coefficient, α, together with a beginning water surface elevation, y_2, the values of $\triangle x$ may be calculated for arbitrarily chosen values of y_1. The coordinates defining the water surface profile are obtained from the cumulative sum of $\triangle x$ and corresponding values of y.

The normal flow depth, y_n, should first be calculated from Manning's Equation to establish the upper limit of the backwater effect.

Calculating the coordinates of the water surface profile using this method is an iterative process achieved by choosing a range of flow depths, beginning at the downstream end, and proceeding incrementally up to the point of interest or to the point of normal flow depth. This is best accomplished by the use of a table (see Figure 4.3.7F) or computer program (as discussed below).

To illustrate this method, an example is provided in Figure 4.3.7G.

(3) Standard Step Backwater Method for Analyzing Channel Capacity

This method is a variation of the Direct Step Backwater Method and can be used to compute backwater profiles on both prismatic and non-prismatic channels. In this method, stations are established along the channel where cross-section data is known or has been determined through field survey. The computation is carried out in steps from station to station rather than throughout a given channel reach as is done in the Direct Step method. As a result, the analysis involves significantly more trial and error calculation in order to determine the flow depth at each station.

Because of the iterative calculations involved, use of a computer to perform the analysis, is recommended. The BWCHAN computer program included in the software package available with this manual, is based on the Standard Step Backwater method, and can be used for all channel capacity analysis. It can also be combined with the BWPIPE and BWCULV programs, to analyze an entire drainage conveyance system. A schematic description of the nomenclature used in the BWCHAN program is provided in Figure 4.3.7H. User instructions are included with the program on disc.

FIGURE 4.3.7F OPEN CHANNEL FLOW PROFILE COMPUTATION

Q = _____ n = _____ S_o = _____ α = _____ Y_n = _____

y (1)	A (2)	R (3)	$R^{4/3}$ (4)	V (5)	$\alpha V^2/2g$ (6)	E (7)	ΔE (8)	S_f (9)	$\bar{S}_f$ (10)	$S_o - \bar{S}_f$ (11)	Δx (12)	x (13)

FIGURE 4.3.7G EXAMPLE DIRECT STEP BACKWATER METHOD

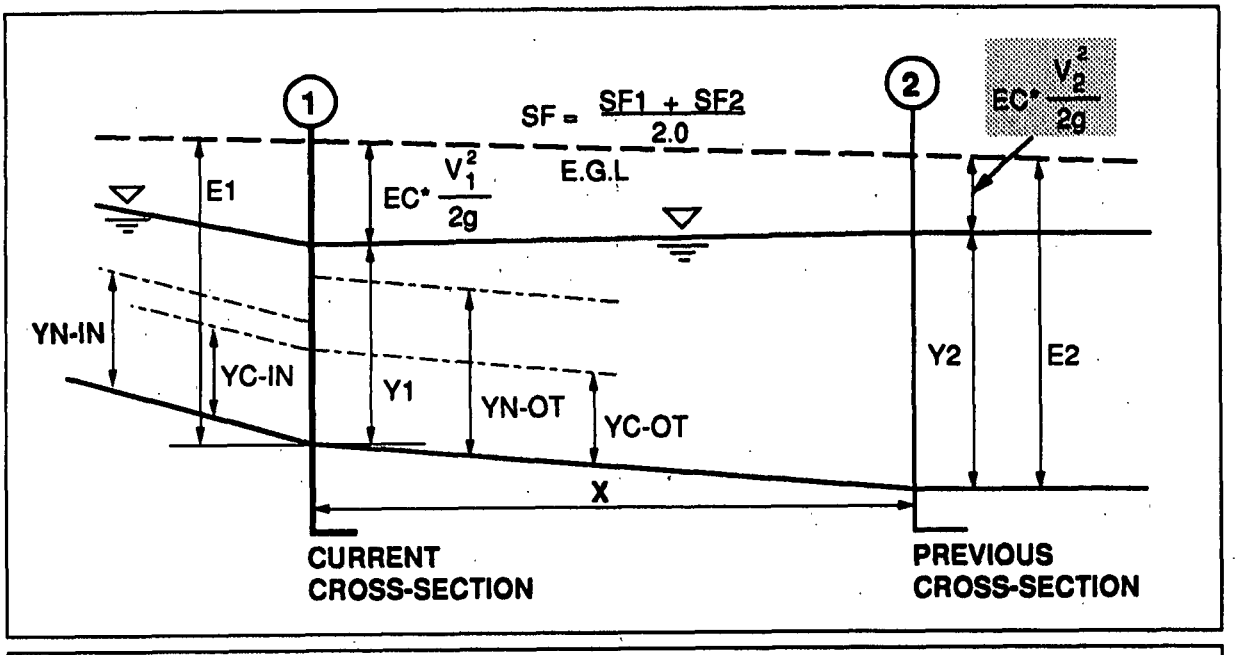
y (1)	A (2)	R (3)	$R^{4/3}$ (4)	V (5)	$\alpha V^2/2g$ (6)	E (7)	ΔE (8)	S_f (9)	$\bar{S}_f$ (10)	$S_o - \bar{S}_f$ (11)	Δx (12)	x (13)
6.0	72.0	2.68	3.72	0.42	0.0031	6.0031	—	0.00002	—	—	—	—
5.5	60.5	2.46	3.31	0.50	0.0040	5.5040	0.4990	0.00003	0.000025	0.00698	71.50	71.5
5.0	50.0	2.24	2.92	0.60	0.0064	5.0064	0.4976	0.00005	0.000040	0.00696	71.49	142.99
4.5	40.5	2.01	2.54	0.74	0.0098	4.5098	0.4966	0.00009	0.000070	0.00693	71.64	214.63
4.0	32.0	1.79	2.17	0.94	0.0157	4.0157	0.4941	0.00016	0.000127	0.00687	71.89	286.52
3.5	24.5	1.57	1.82	1.22	0.0268	3.5268	0.4889	0.00033	0.000246	0.00675	72.38	358.90
3.0	18.0	1.34	1.48	1.67	0.0496	3.0496	0.4772	0.00076	0.000547	0.00645	73.95	432.85
2.5	12.5	1.12	1.16	2.40	0.1029	2.6029	0.4467	0.00201	0.001387	0.00561	79.58	512.43
2.0	8.0	0.89	0.86	3.75	0.2511	2.2511	0.3518	0.00663	0.004320	0.00268	131.27	643.70

The step computations are carried out as shown in Figure 4.3.7G, above. The values in each column of the table are explained as follows:

- Col. 1. Depth of flow in ft. assigned from 6 to 2 ft.
- Col. 2. Water area in ft.^{2} corresponding to depth y in Col. 1
- Col. 3. Hydraulic radius in ft. corresponding to y in Col. 1
- Col. 4. Four-thirds power of the hydraulic radius
- Col. 5. Mean velocity in fps obtained by dividing Q(30 cfs) by the water area in Col. 2.
- Col. 6. Velocity head in feet
- Col. 7. Specific energy in feet obtained by adding the velocity head in Col. 6 to depth of flow in Col. 1.
- Col. 8. Change of specific energy in ft, equal to the difference between the E value in Col. 7 and that of the previous step.
- Col. 9. Friction slope S_f, computed from V as given in Col. 5 and $R^{4/3}$ in Col. 4.
- Col. 10. Average friction slope between the steps, equal to the arithmetic mean of the friction slope just computed in Col. 9 and that of the previous step.
- Col. 11. Difference between the bottom slope, S_o, and the average friction slope, S_f.
- Col. 12. Length of the reach in ft. between the consecutive steps. Computed by $\Delta X = \Delta E/(S_o - S_f)$ or by dividing the value in Col. 8 by the value in Col. 11.
- Col. 13. Distance from the beginning point to the section under consideration. This is equal to the cumulative sum of the values in Col. 12 computed for previous steps.

As with the hydrologic methods described in Chapter 3, there are a number of commercially available software programs available for use on personal computers that use variations of the standard step backwater method for determining water surface profiles. The most common and widely accepted program is published and is supported by the United States Army Corps of Engineers Hydraulic Engineering Center and is called HEC-2. It is the model required by the Federal Emergency Management Administration (FEMA) for use in performing flood hazard studies for preparing flood insurance maps. Other programs include WSP-2 published by the SCS, and WSPRO or E-431 published by U.S.G.S.

FIGURE 4.3.7H BWCHAN - VARIABLE DEFINITIONS



BWCHAN - VARIABLE DEFINITIONS

YC-IN - Critical Depth (ft) at current section based on ***Incoming*** flow rate.
YC-OT - Critical Depth (ft) at current section based on ***outgoing*** flow rate.
YN-IN - Normal Depth (ft) at current section based on ***Incoming*** flow rate/channel grade.
YN-OT - Normal Depth (ft) at current section based on ***outgoing*** flow rate/channel grade.
Y1 - Final Water Depth (ft) at current section
N-Y1 - Composite n-factor of current section for final depth, Y1.
A-Y1 - Cross-sectional Area (ft) of current section for final depth, Y1.
WP-Y1 - Wetted Perimeter (ft) of current section for final depth, Y1.
V-Y1 - Average velocity (fps) at current section for final depth, Y1.
E1 - Total Energy Head (ft) at current section ($Y1 + EC^*V_1^2/2g$).
E2 - Total Energy Head (ft) at previous or downstream section.
SF1 - Friction Slope of current section.
SF2 - Friction Slope of previous or downstream section.
DXY - Distance (expressed as a fraction of the current reach length) from the previous or downstream section to where the flow profile would intersect the final water depth, Y1, assuming Y1 were to remain constant throughout the reach.

EC - Energy Coefficient "α"
Q-TW - The flow rate used to determine Tailwater Height from an inputted HW/TW Data File.
TW-HT - Tailwater Height.
Q-Y1 - Flow rate (cfs) in channel at current section, for depth, Y1 (used in the program's "Adjust" option → N).
VU-Y1 - Upstream Velocity (fps) at current section for depth, Y1 ("Adjust" option).
V1-HD - Channel Velocity Head (ft) at current section.
VU-HD - Upstream Velocity Head (ft) at current section.

4.3.8 FLOODPLAIN/FLOODWAY ANALYSIS

Special Requirement #9: Delineation of the 100-year Floodplain in Section 1.3.9 and the King County Flood Hazard code describe the requirements used to evaluate the compatibility of a proposed project and an adjacent floodplain/floodway. This section describes the requirements for and techniques used to perform minor floodplain and major flood hazard studies.

Minor Floodplain Study

In some situations, a minor floodplain study must be performed in order to address the compatibility and impacts of a proposed project, such as in ditches behind roadway cross culverts or to delineate the 100-year floodplain. When evaluating the conveyance system capacity of drainage ditches, open channels or streams without an approved floodplain or flood hazard study, the floodplain may be determined using the direct step backwater method, standard step backwater method, or the software programs described in Section 4.3.7.

For lakes, wetlands and closed depressions where an existing 100-year floodplain study has not been performed the methods of analysis for Closed Depressions described in Section 3.5 in Chapter 3 shall be used based on assuming a static initial water surface elevation at the apparent ordinary high water mark of the lake or wetland.

Exception: If an approved floodplain study does not exist and the floodplain is not for a river defined as a "receiving water", a proposed project will not be required to submit a Minor Floodplain study to delineate the 100-year floodplain boundaries, but will be required to submit an engineering plan that demonstrates that any proposed project buildings, or building sites, access roads, or utilities that would be damaged if flooded, will be located on the site at an elevation of at least 10 vertical feet above the ordinary high water mark of the stream, lake, wetland or closed depression (or 2' above the downstream overflow elevation, whichever is less). The area of the proposed project site that is at or below this elevation will be dedicated as a drainage easement. The drainage easement must be labeled "Assumed 100-year Floodplain and Floodway" and the corresponding elevation must be identified as "Assumed Base Flood Elevation = _____' on the site improvement plans and on any final subdivision maps prepared for the proposed project. The required building setback line from this drainage easement shall be 10 feet.

Major Flood Hazard Studies

When a flood hazard study will be used for a flood hazard study under the Sensitive Area Code or to justify a Flood Insurance Rate Map revision to the Federal Emergency Management Administration (FEMA), the study must conform to FEMA regulations described in Part 65 of 44 CFR. Note that FEMA has a map correction process for individual properties based on demonstrating an error in the original mapping by submitting new technical information (see Part 70 of CFR Ch.1). In addition, the following information must be provided and procedures performed for all major flood hazard studies.

Information Required

The following information is required for review of floodplain/floodway analysis in addition to that required for the drainage plan of a proposed project.

(1) Two copies of a separate floodplain/floodway map stamped by a professional civil engineer registered in the State of Washington and a professional land surveyor registered in the State of Washington (for base survey). The map must accurately locate any proposed development with respect to the floodplain and floodway, the channel of the stream, existing development in the floodplain, all pertinent information such as the nature of any proposed project, legal description of the property on which the project would be located, fill quantity, limits and elevation, the building floor elevations, flood-proofing measures, and any use of compensatory storage.

The map must show elevation contours at a minimum of two foot vertical intervals and shall comply with survey and map guidelines published in the FEMA publication, "Guidelines and Specifications for Study Contractors." The map must show: elevations and ground contours; elevations and

dimensions of existing structures, fill and compensatory storage areas; size, location, elevation, and spatial arrangement of all proposed structures on the site; location and elevations of roadways, water supply lines, and sanitary sewer facilities.

(2) Two copies of a report stamped by a professional civil engineer which must include the calculations or any computer analysis input and output information and the following additional information.

(a) Valley cross-sections showing the channel of the stream, the floodplain adjoining each side of the channel, the computed floodway, the cross-sectional area to be occupied by any proposed development, and all historic high water information.
(b) Profiles showing the bottom of the channel, the top of both left and right banks, and existing and proposed base flood water surfaces.
(c) Plans and Specifications for flood-proofing any structures, construction and materials, filling, dredging, channel improvement, storage of materials, water supply, and sanitary facilities within the floodplain.
(d) Complete printout of input and output for HEC-2. Liberal use of comments will assist in understanding model logic and prevent review delays.
(e) One ready-to-run digital copy of each HEC-2 input file used in the study. Data shall be submitted on a double-sided, double-density (360 kilobyte) floppy disk in standard ASCII format, ready for use on an IBM-compatible PC.

Hydrologic Analysis (determination of flows)

The techniques used to determine the flows used in the analysis depend on the availability of gage data or whether a basin plan has been adopted. The first technique is for basins in adopted basin plan areas. The second technique is used if a gaging station exists on the stream. The third technique is used on ungaged catchments or those with an insufficient length of record. In all cases, the engineer shall be responsible for assuring that hydrologic methods used are technically reasonable and conservative, conform to the "Guidelines and Specifications for Study Contractors", and are acceptable by FEMA.

(1) The first technique is used for those areas of King County where a basin plan has been adopted by the County since 1986. The hydrologic model used in the basin plan shall be updated to include the latest changes in zoning, or any additional information regarding the basin which has been acquired since the adoption of the basin plan.

(2) The second technique uses the log-Pearson Type III distribution method as described in Bulletin 17B of the Hydrology Committee, United States Water Resources Council, entitled "Guidelines For Determining Flood Flow Frequency", revised September, 1981.

(a) This technique may only be used if data from a gaging station in the basin is available for a period of not less than ten years.

(b) If the difference in the drainage area on the stream at the study site and the drainage area to a gaging station on the stream at a different location in the same basin is less than or equal to 50 percent, the flow at the study site shall be determined by transferring the calculated flow at the gage to the study site using a drainage area ratio taken to the "0.86*" power by using the following equations. $Q_{ss} = Q_G (A_{ss}/A_G)^{0.86}$

Where: Q_{ss} = Estimated flow for the given return frequency on the stream at the study site.

Q_G = Flow for the given return frequency on the stream at the gage site.

A_{ss} = Drainage area tributary to the stream at the study site.

A_G = Drainage area tributary to the stream at the gage site.

*Per U.S.G.S, CUMMINGS, ET.AL.

(c) If the difference in the drainage area at the study site and the drainage area at a gaging station in the basin is more than 50 percent and a basin plan has not been prepared, the techniques described in paragraphs (3) below shall be used to determine a weighted value of the flow at the study site.

(d) In all cases where dams or reservoirs, floodplain development, or land use upstream may have altered the storage capacity or runoff characteristics of the basin so as to affect the validity of this technique, the synthetic hydrograph technique described below shall be used for the determination of the flows at the study site.

(3) The third technique uses synthetic hydrographs which consist of event hydrographs that are combined and routed through the basin to the downstream end of the study area, using the methods described in Chapter 3. The model shall be calibrated to historic rainfall events where rainfall data and flood elevations are available.

Hydraulic Analysis (determination of the flood elevations)

(1) Reconnaissance. The applicant's professional civil engineer is responsible for the collection of all existing data with regard to flooding in the study area. This shall include a literature search of all published reports in the study area and adjacent communities and an information search to obtain all unpublished information on flooding in the immediate and adjacent areas from federal, state, and local units of government. This information shall include specific information on past flooding in the area, drainage structures such as bridges and culverts that affect flooding in the area, available topographic maps, available community maps, photographs of past flood events, and general flooding problems within the community. A field reconnaissance shall be made by the applicant's professional civil engineer to determine hydraulic conditions of the study area, including type and number of structures, locations of cross-sections, and other parameters including roughness values which are necessary for the hydraulic analysis.

(2) Base data. Cross-sections to be used for the hydraulic analysis shall be obtained by surveying, or topographic information obtained from aerial photographs may be used in combination with surveyed cross-sections in hydraulic analysis. The elevation datum of all of the information to be used in the hydraulic model shall be verified. All information used shall be referenced directly to KCAS Datum unless the elevation datum is otherwise approved by the SWM Division.

(3) Methodology. Flood profiles and floodway studies shall be calculated by using the U.S. Army Corps of Engineers' HEC-2 computer model.

(4) Floodway determination. King County recognizes two distinct floodway definitions. The Federal Emergency Management Agency (FEMA) floodway describes the limit to which encroachment into the natural conveyance channel can cause one foot or less rise in water surface elevation. The zero-rise floodway is based upon the limit to which encroachment can occur without detectable water surface elevation or energy grade line changes.

a. Fema floodways are determined through the procedures outlined in the FEMA publication "Guidelines and Specifications for Study Contractors" using the 1-foot maximum allowable rise criteria.

b. Transitions shall take into account obstructions to flow such as road approach grades, bridges, piers, or other restrictions. General guidelines for transitions may be found in "HEC-2", Water Surface Profiles-Users Manual, Appendix IV, Application of HEC-2 Bridge Routines," published by the Hydrologic Engineering Center, Davis, CA.

c. Zero-rise floodways are assumed to include the entire 100-year floodplain until King County approves a detailed study which defines a zero-rise floodway.

d. Zero-rise means no detectable change in water surface elevation or energy grade line. For changes between the unencroached condition and encroachment to the zero-rise floodway, HEC-2 must report 0.00 as both the change in water surface elevation (DIFWSP) and the change in energy grade (DIFEG). HEC-2 must further report the exact same elevations for both conditions as the computed water surface (CWSEL) and energy grade (EG).

e. Floodway studies must reflect the transitions mentioned in requirement (b) above. Floodway boundaries are to follow stream lines, and should reasonably balance the rights of property owners on either side of the floodway. Use of the automatic equal conveyance encroachment options in the HEC-2 program will be considered equitable. For zero-rise floodway studies, or where HEC-2 automatic options are otherwise not appropriate, the floodway must be placed to minimize the top width of the floodway.

f. Floodway studies submitted for King County review must include the HEC-2 output summary tables called by:

J3	38	43	1	3	50	61	53	27	21	22
J3	28	54	110	150						

The J3 output variables include the following:

38 SECND: Cross section identification number which identifies the location of all other data in the table row.
43 Q: Steady-state flow past cross section in cfs.
1 CWSEL: Computed water surface elevation at cross section.
3 EG: Energy grade at cross section.
50 DIFWSP: Difference between two profiles' water surface elevation at one cross section (e.g., difference between natural and encroached water surface).
61 DIFEG: Difference between two profiles' energy grade at one cross section.
53 SSTA: Starting station where water surface intersects the ground (leftmost edge of floodplain).
27 STENCL: Station of encroachment left of the channel.
21 STCHL: Station of channel's left bank.
22 STCHR: Station of channel's right bank.
58 STENCR: Station of encroachment right of the channel.
54 ENDST: Ending station where the water surface intersects the ground (rightmost edge of floodplain).
110 HEC-2 standard encroachment data table.
150 HEC-2 standard summary (two tables).

(5) Previous floodplain studies. If differences exist between a study previously approved by the SWM Division and the applicant's professional civil engineer's calculated hydraulic floodways or flood profiles, the applicant's professional civil engineer shall provide justification and obtain approval for these differences from the SWM Division.

(6) Calculation of the flow profile. The flow profile and changes to that profile caused by development in the floodplain, as determined by the hydraulic model, shall be calculated to the nearest 0.01 foot.

(7) Adequacy of the hydraulic model. The following factors shall be considered by SWM to determine the adequacy of the hydraulic model and flow profiles.

(a) Cross-section spacing.

(b) Differences in energy grade.
Note: Significant differences in the energy grade from cross-section to cross-section are an indication that cross-sections should be more closely spaced or that other inaccuracies exist in the hydraulic model.

(c) Methods for analyzing the hydraulics of structures such as bridges and culverts.

(d) Lack of flow continuity.

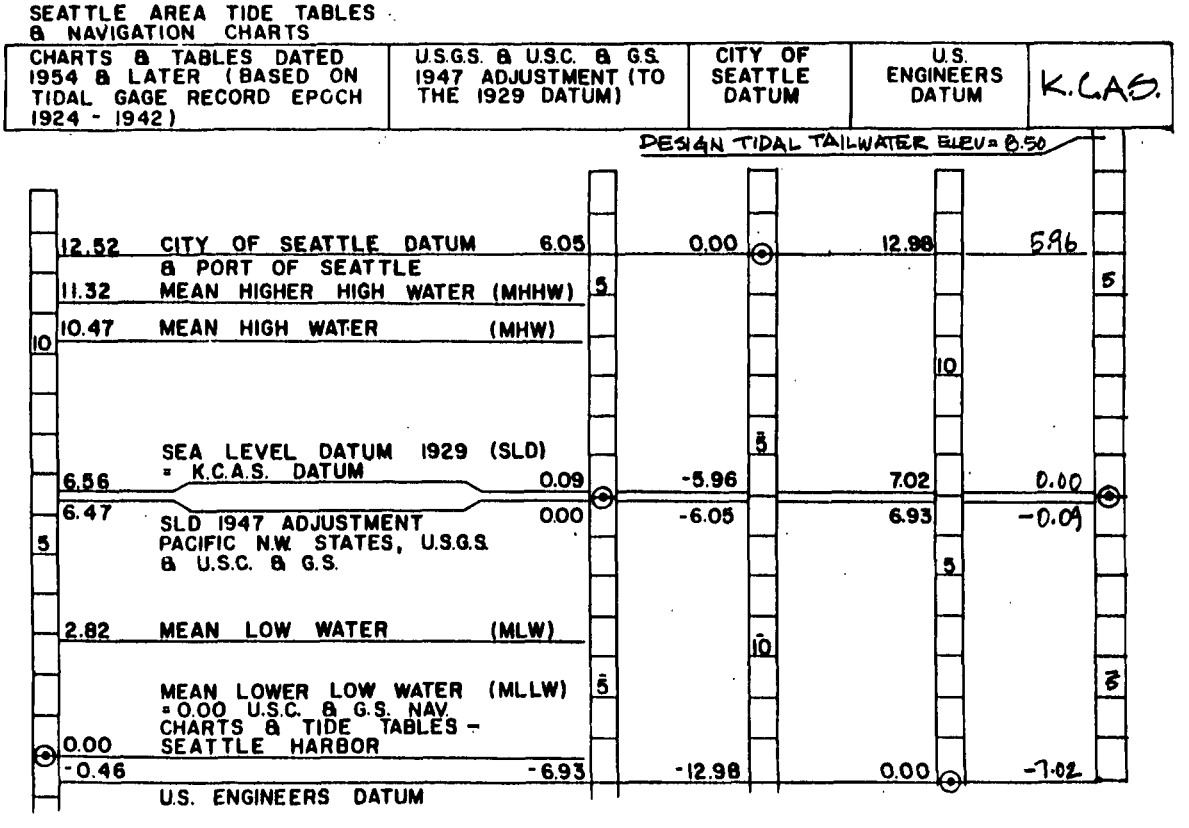
(e) Use of gradually-varied flow model.
Note: In certain circumstances, rapidly-varied flow techniques shall be used in combination with a gradually-varied flow model such as weir flow over a levee or dike, flow through the spillway of a dam, or special applications of bridge flow.

(f) Manning's "n" values.

(g) Calibration of the hydraulic model with past flood events.

(h) Special applications. In some cases, HEC-2 alone may not be sufficient for preparing the floodplain/floodway analysis. This may occur where sediment transport, two-dimensional flow, or other unique hydraulic circumstances affect the accuracy of the HEC-2 hydraulic model. In these cases, the applicant shall obtain SWM Division approval of other methods proposed for establishing the water surface profiles.

FIGURE 4.3.8A DATUM CORRELATIONS TO K.C.A.S.



4.4 RETENTION/DETENTION FACILITY ANALYSIS AND DESIGN

4.4.1 OVERVIEW

Retention/Detention (R/D) facilities, by design, provide temporary storage for increased surface water runoff resulting from development. Properly designed R/D facilities will release surface water at or below the naturally occurring runoff rate by temporarily storing the runoff for specific design storm events.

By definition, a detention facility temporarily stores water as opposed to retention, which suggests permanent storage. The two terms are used separately by King County in recognition of their functions for the management of surface water. Infiltration systems and closed depressions function more as retention facilities, while open ponds, tanks, and vaults perform more like detention facilities. However, they all eventually release their stored water, either directly downstream, or by infiltration or evapotranspiration.

In addition to runoff control, R/D facilities, if properly designed, can also provide valuable water quality enhancement to surface water runoff. Detention of small storms is particularly effective for the removal of pollutants in urban stormwater by gravity sedimentation. Infiltration, biofiltration, and nutrient reduction from biological activity in open pond R/D facilities also improve the water quality in runoff from developed areas.

4.4.2 DESIGN STANDARDS AND CRITERIA

This section provides the design engineer with standards and criteria for the design of R/D facilities to control surface water flow to reduce erosion and sedimentation, and to provide water quality protection.

Analysis

All R/D facilities shall be analyzed using the hydrograph methods and routing procedures described in Chapter 3. R/D facility design must take into consideration overflows and secondary overflow. Overflows include all facilities designed to bypass flows over or around the restrictor system. Overflow may result from higher intensity or longer duration storms than the design storm or result from plugged orifices or inadequate storage due to sediment buildup in the facility.

Secondary overflow occurs when the capacities of all conveyance facilities, and all overflow facilities are exceeded or are not functioning. In such instances, stormwater will often exit the conveyance system through catch basin grates and flow down the corridor of least resistance, whether that corridor be streets, yards, or overland. Careful consideration must be given to the impact of secondary overflows on public health, safety and welfare, property and wildlife habitat. When secondary overflow occurs, secondary drainage facilities designed following careful analysis and planning can significantly reduce impacts. Street alignments and grades are the key components in developing secondary drainage design, and consideration should be given early in the planning stages to their use as secondary overflow facilities.

R/D system site selection should consider both the natural topography of the area and property boundaries. Aesthetic and water quality considerations may also dictate locations. For example, ponds with wetland vegetation like cattails and bull rush, may fit the environment of a low density residential development, and due to water quality benefits, would also be appropriate for a high density residential or commercial development.

4.4.3 SITE CONSTRAINTS

Site constraints are any man-made restrictions like property lines, easements, structures, etc. that impose constraints on development. Constraints may also be imposed from natural features such as required by the Sensitive Areas Ordinance and Rules and these should also be reviewed for specific application to the proposed development. Man-made site constraints are as follows:

- Open R/D ponds shall not be located in dedicated public road right-of-way areas.

- All R/D facilities not located in King County right-of-way to be maintained by King County shall be in a tract dedicated to King County. Any tract not abutting public right-of-way will require a 15' wide extension of the tract for access to the R/D facility (see Section 1.2.6, Chapter 1).

4.4.4 PONDS

Open pond design for R/D facilities is the most desirable method for controlling runoff from developed areas. King County requires "dry pond" designs for most development. However, multi-purpose ponds that include "wetpond" and "infiltration" pond features may also be used in conformance with the following criteria:

Design Criteria

Capacity/Discharge: Volume and restrictor analysis shall be in accordance with performance and hydrograph routing requirements given in Chapter 3. Restrictor orifice structure design shall be per Section 4.4.7. Note that the design water surface elevation is the highest elevation which occurs in order to achieve the required discharge performance for the pond.

Geometrics: Minimum length to width ratio of the pond design water surface shall be 2:1 in order to enhance water quality benefits. Longer lengths allow more travel time and opportunity for low-flow infiltration, biofiltration, and sedimentation. The pond inlet and outlet shall therefore be located as far apart as possible in the pond to maximize these mechanisms.

- Ponds must be designed as "flow-through" facilities (no back-up ponds) with two sequential "cells" approximately dividing the detention volume equally between the cells.

- Interior side slopes up to the maximum water surface shall be no steeper than 3H:1V unless a fence is provided on the slope at the maximum water surface or higher on the slope.

- Exterior side slopes shall be not steeper than 2H:1V. Unless analyzed for stability by a geotechnical engineer.

- The pond bottom shall be level to facilitate sedimentation, and the pond bottom area shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.

- Pond walls may be retaining walls, provided that the design is prepared and stamped by a structural engineer registered in the State of Washington, that they are constructed of reinforced concrete per Section 4.4.6, that a fence is provided along the top of the wall, and that at least 25% of the pond perimeter will be a vegetated soil slope of not greater than 3H:1V.

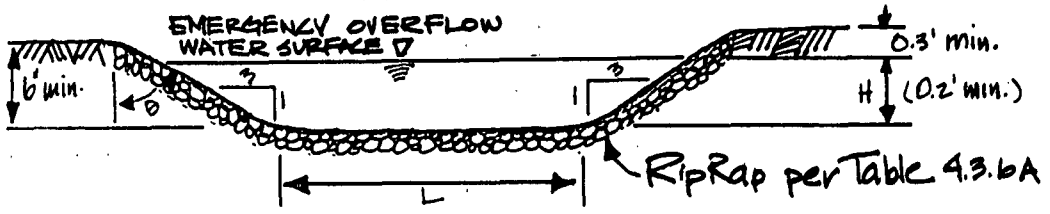
Overflow: A pond overflow system must provide controlled discharge of the 100-year, 24-hour design storm event for developed site conditions without overtopping any part of the pond embankment or exceeding the capacity of the emergency spillway. The design must provide controlled discharge directly into the downstream conveyance system. This assumes the pond will be full due to plugged control structure inflow pipe and/or plugged restrictor/orifices conditions.

- Open Type 2 catch basins can function as weirs (see Figure 4.4.4C) when used as pond overflow structures to control overtopping. The overflow structure as shown in Figure 4.4.4E may be required in some circumstances to protect embankments from overtopping.

Emergency Overflow Spillway: In addition to the above overflow requirements, an emergency overflow spillway (secondary overflow) must be provided to safely pass the 100-year, 24-hour design storm event (for developed site conditions and assuming the pond is full to the crest of the spillway) over the pond embankment in the event of control structure failure or for storm/runoff events exceeding design. The spillway must be located to direct overflows safely towards the downstream conveyance system and shall be located in existing soil wherever feasible. The emergency overflow spillway shall be armored with rip rap in conformance with Table 4.3.6A and shall extend to the toe of each face of the berm embankment.

- Design of emergency overflow spillways require the analysis of a broad-crested trapezoidal weir. The following weir section is required for the emergency overflow spillway:

FIGURE 4.4.4A WEIR SECTION FOR EMERGENCY OVERFLOW SPILLWAY



N.T.S.

- The emergency overflow spillway weir section shall be designed to pass the 100-year, 24-hour design storm event for developed conditions as follows:

  For this weir, $Q_{100} = C\,(2g)^{1/2}(2/3LH^{3/2} + 8/15\,\mathrm{Tan}\theta\,H^{5/2})$

  using C = 0.6 (discharge coefficient);
  Tan = 3 (for 3:1 slopes);
  = 72°;

  The equation becomes: $Q_{100} = 3.21\,(LH^{3/2} + 2.4H^{5/2})$

  To find width L, the equation is rearranged to use the computed Q_{100} (peak flow for the 100-year, 24-hour design storm) and trial values of H (0.2 feet minimum).

  $L = (Q_{100}/(3.21H^{3/2})) - (2.4H)$; 6 feet minimum

Access/Maintenance: Pond access tracts and roads are required when ponds do not abut public right-of-way. Road(s) shall provide access to the control structure and along side(s) of the pond as necessary for vehicular maintenance. For ponds with bottom widths of 15 feet or more, the access road shall extend to the pond bottom and an access pad provided to facilitate cleaning. For ponds less than 15 feet in width, an access road must extend along one side.

- Roads and pads shall meet the following criteria:

  - Maximum Grade: 15% to control structure, 20% into pond.
  - Provide 40' minimum outside turning radius on the access road to the control structure and the turnaround to the pond bottom.
  - Fence gates shall be provided for access roads at straight sections of road.
  - Access roads shall be 15' in width on curves and 12' on straight sections.
  - Access pads shall be 15' in width and 25' in length.

- Manhole and catch basin lids must be at either edge of an access road or pad and be at least three feet from a property line.

- Access shall be limited by a double-posted gate if a fence is required or by bollards. Bollards shall consist of two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

- Access roads and pads shall be constructed by utilizing one of the following techniques:

- Construct an asphalt surface meeting the same standard as King County residential minor access streets.
- Construct a gravel surface road meeting the King County Roads Standards for crushed surfacing base course or better.
- Construct a landscape block surface by removing all unsuitable material, laying a geotextile fabric over the native soil, placing landscape blocks (24"x 24"x 6"), filling the honeycombs with soil particles, and planting grass.

Berm Embankment/Slope Stabilization: Pond berm embankments higher than 6-feet shall require design by a geotechnical-civil engineer licensed in the State of Washington. The berm embankment shall have a minimum 15-foot top width where necessary for maintenance access; otherwise, top width may vary as recommended by the geotechnical-civil engineer.

o A berm dividing the pond into cells shall have a 5' minimum top width, a top elevation set one foot lower than the design water surface, maximum 3:1 side slopes, and a quarry spall and gravel filter "window" between the cells (see Figure 4.4.4F).

o For berm embankments 6 feet, or less than (including 1-foot freeboard), the minimum top width shall be 6 feet or as recommended by the geotechnical-civil engineer.

o The toe of the exterior slope of pond berm embankment must be no closer than 5 feet from the tract or easement property line.

o Pond berm embankment must be constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report) free of loose surface soil materials, roots and other organic debris.

o Pond berm embankments must be constructed by excavating a "key" equal to 50% of the berm embankment cross-sectional heighth and width (except on till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till).

o The berm embankment shall be constructed of compacted soil (95% minimum dry density, modified proctor method per ASTM D-1557), placed in 6" lifts, with the following soil characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content (note, in general, excavated glacial till will be well-suited for berm embankment material).

o Anti-seepage collars must be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth at the design water surface.

o Exposed earth on the pond bottom and side slopes shall be sodded or seeded with appropriate seed mixture (see Section 5.4.2.4). Establishment of protective vegetative cover shall be ensured with mulch (Section 5.4.2.1) and/or an erosion control netting or blanket (Section 5.4.2.2) as required.

Fencing: A chain link fence is required to be constructed at the maximum water surface elevation, or higher, when a pond slope is a wall or if the slope exceeds 3H:1V.

o The fence shall completely enclose the facility and be a minimum of 6 feet in height.

Exception: The fence may be a minimum of 4 feet in height if the depth of the impoundment (measured from the lowest elevation in the bottom of the impoundment, directly adjacent to the bottom of the fenced slope, up to the maximum water surface) is 4 feet or less.

o Access road gates shall be 16 feet in width consisting of two swinging sections 8 feet in width.

- Pedestrian access gates (if needed) shall be 4 feet in width.
- Fence material shall be No. 11 gauge galvanized steel fabric with bonded vinyl coating. Vinyl coating shall be compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in wooded areas).
- Fence posts shall be galvanized steel, with top caps, and set a minimum of 2 feet deep in concrete filled post hole. Corner and gate posts shall be set a minimum of 3 feet deep in concrete. Cross bars shall connect adjacent fence posts.
- All posts, cross bar, and gates shall be painted or coated the same color as the vinyl clad fence fabric.

Signage:

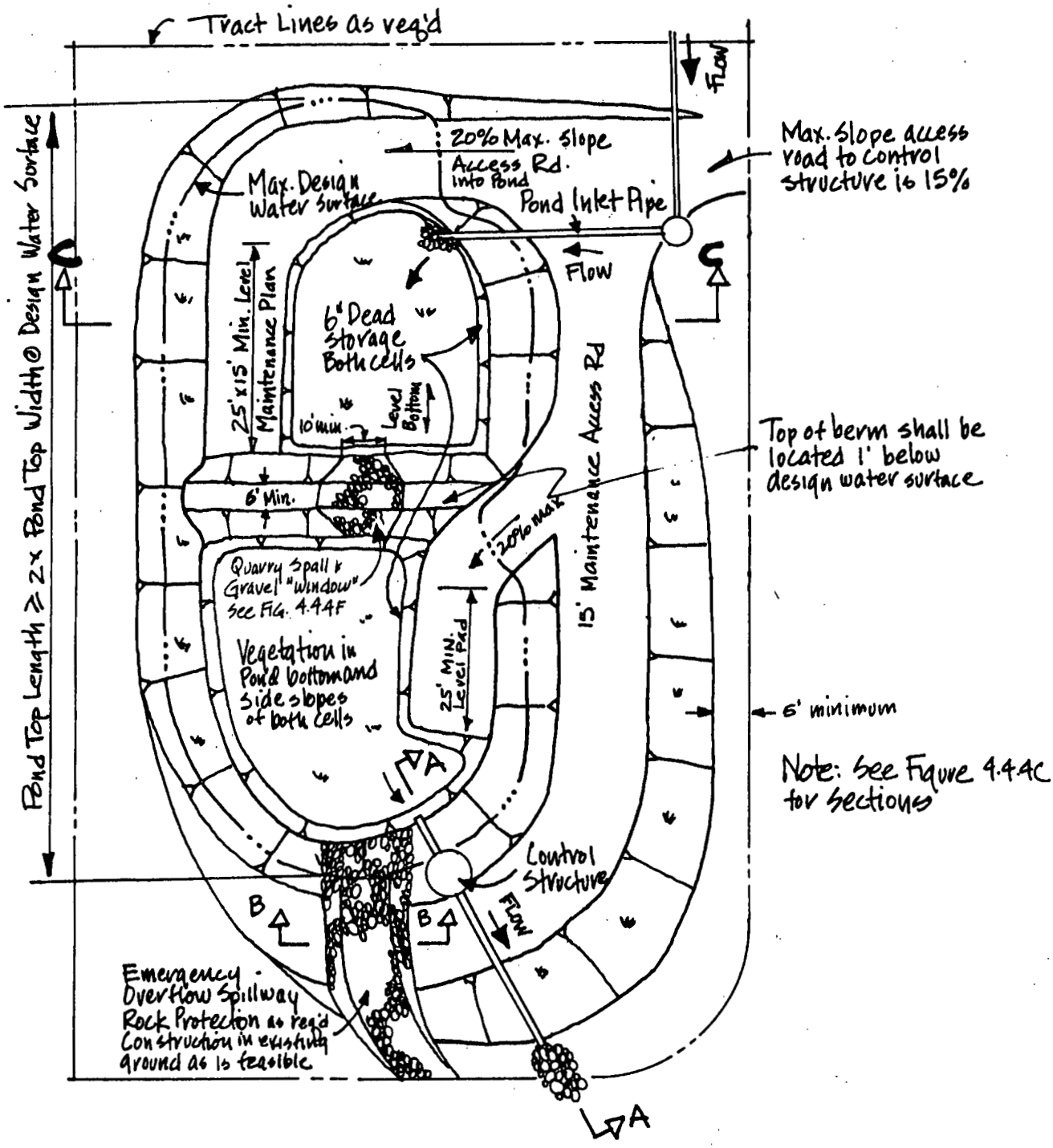
All permanent R/D ponds, infiltration ponds and wetponds, shall have signs placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths.

- The signs shall meet the design and installation requirements illustrated in Figure 4.4.4G.

Details

Standard details are shown in Figures 4.4.4B through G. Control structure details are shown in Section 4.4.7.

FIGURE 4.4.4B TYPICAL DETENTION POND



Note: This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

FIGURE 4.4.4C TYPICAL DETENTION POND SECTIONS

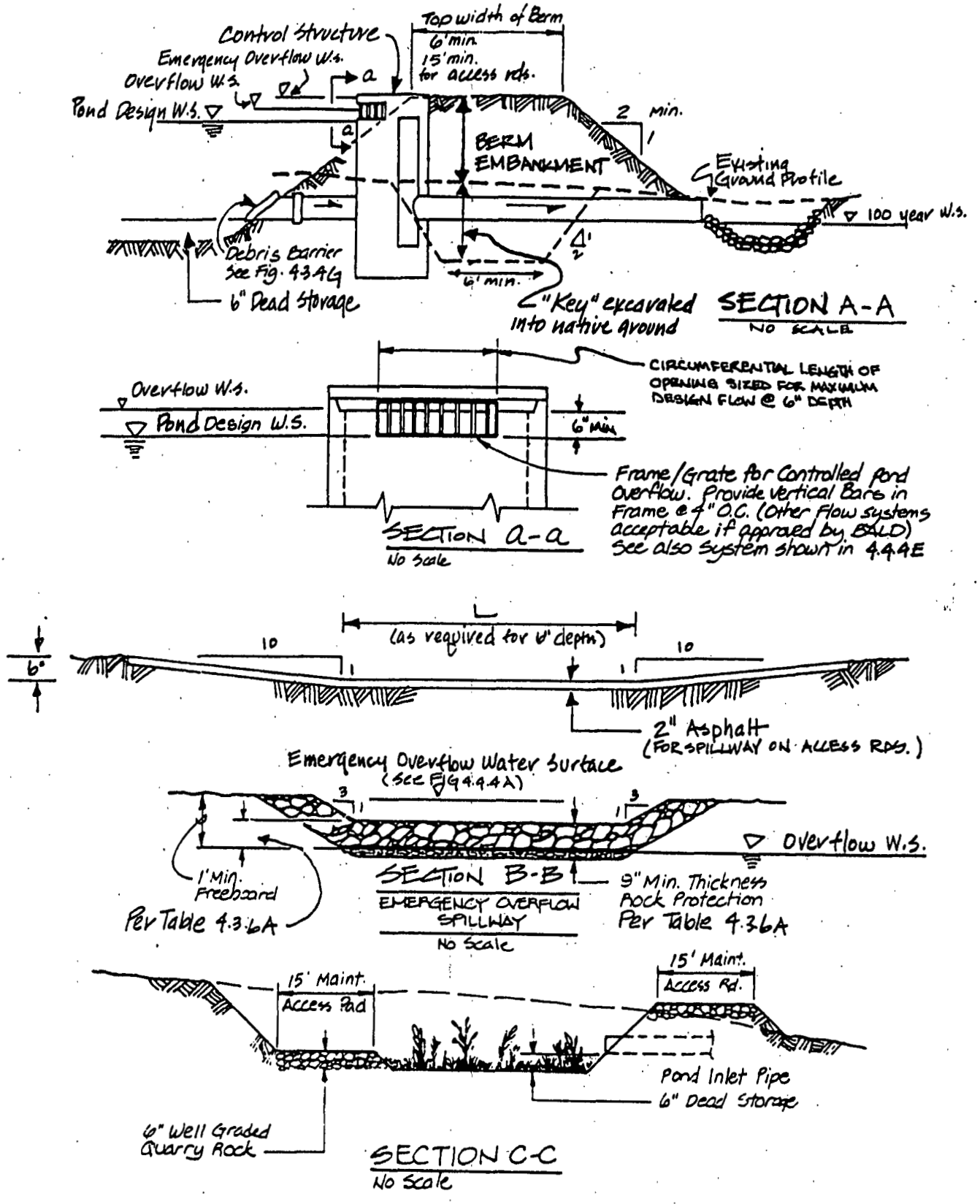
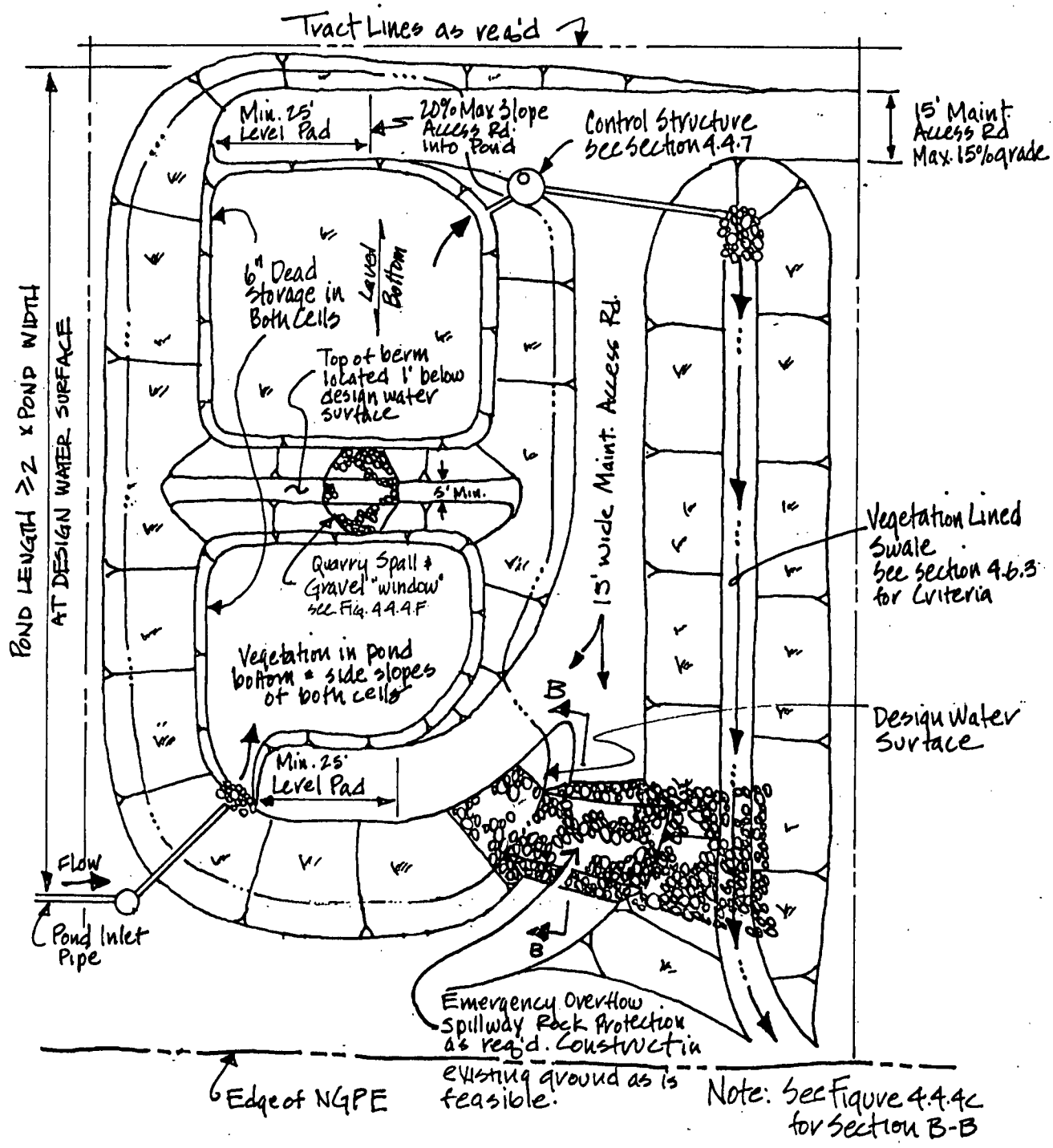
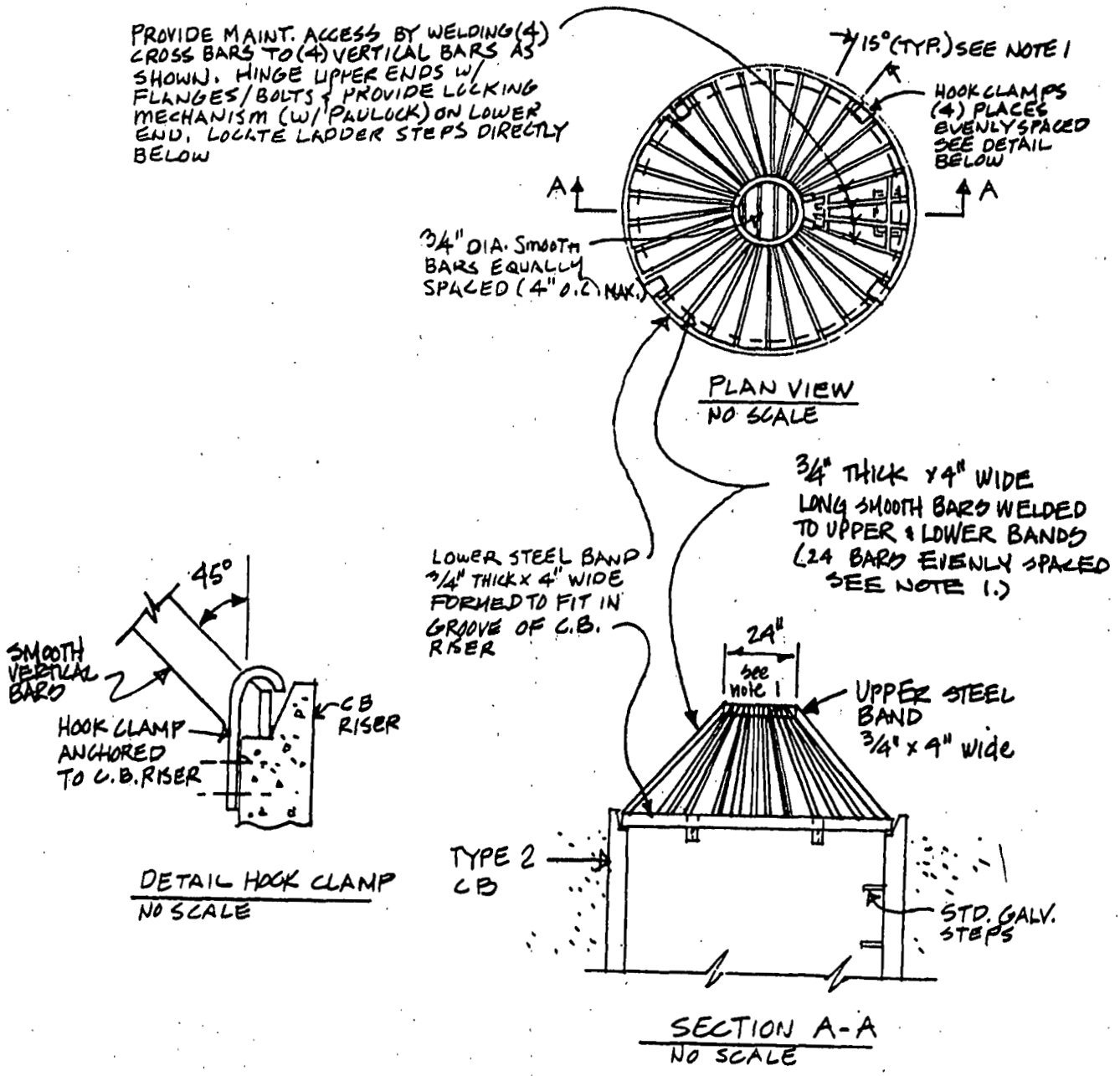


FIGURE 4.4.4D DETENTION POND WITH VEGETATION-LINED SWALE



Note: This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

FIGURE 4.4.4E OVERFLOW STRUCTURE



NOTES:

1. DIMENSIONS ARE FOR INSTALLATION ON 54" DIA. C.B. FOR DIFFERENT DIA C.B.'S, ADJUST DIMENSIONS TO MAINTAIN 45° ANGLE ON "VERTICAL" BARS AND 4" O.C. MAX. SPACING OF BARS AROUND LOWER STEEL BAND. WHEN VERTICAL BAR SPACING EXCEEDS 4" O.C., ADD CONCENTRIC HORIZONTAL RINGS, SPACED 4" O.C. TO THE STRUCTURE.
2. METAL PARTS: CORROSION RESISTANT, STEEL PARTS GALVANIZED.
3. THIS DEBRIS BARRIER IS ALSO RECOMMENDED FOR USE ON THE INLET TO ROADWAY CROSS-CULVERTS WITH HIGH POTENTIAL FOR DEBRIS COLLECTION. (EXCEPT ON TYPE 2 STREAMS)

FIGURE 4.4.4F QUARRY SPALL AND GRAVEL FILTER "WINDOW"

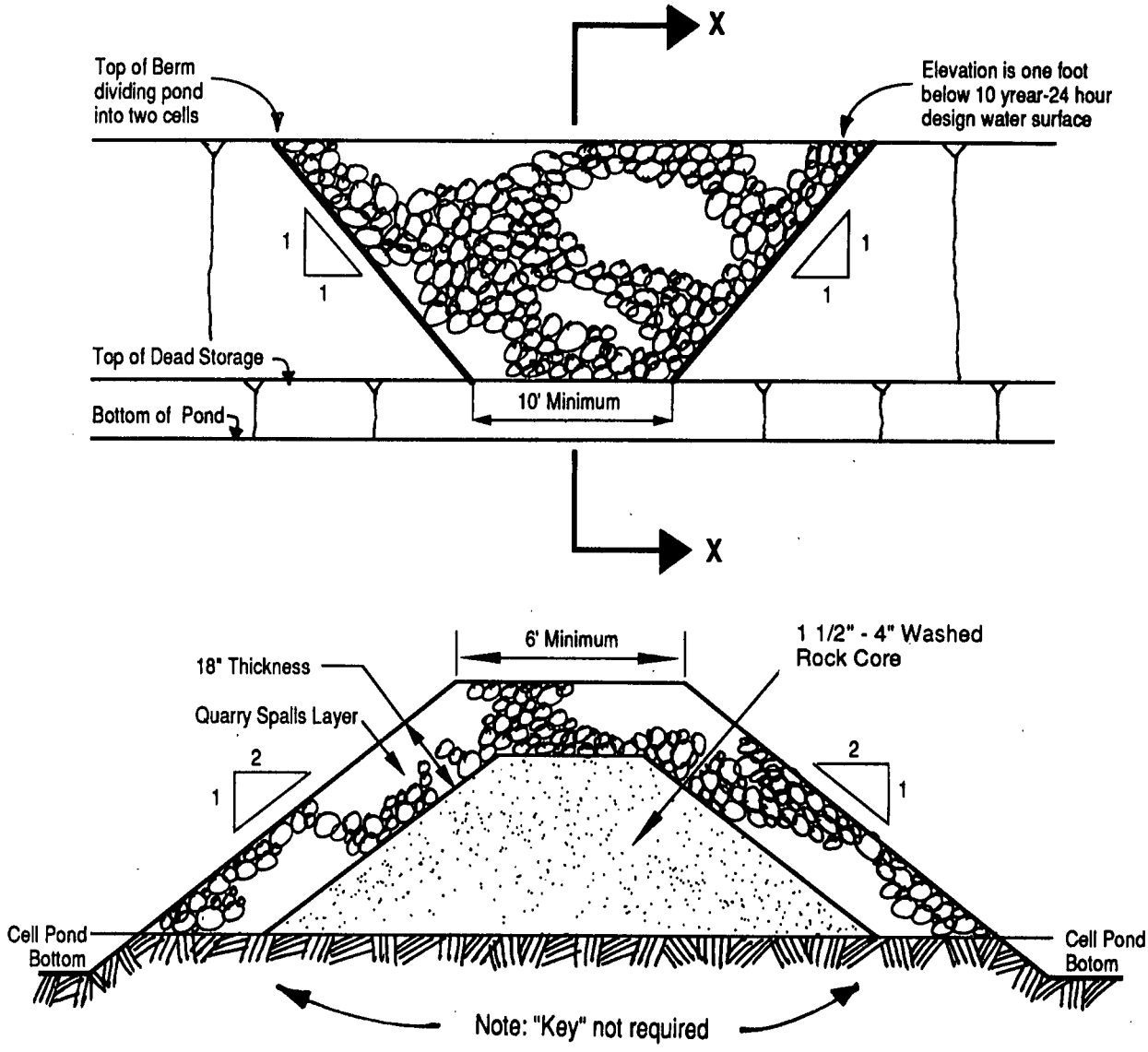
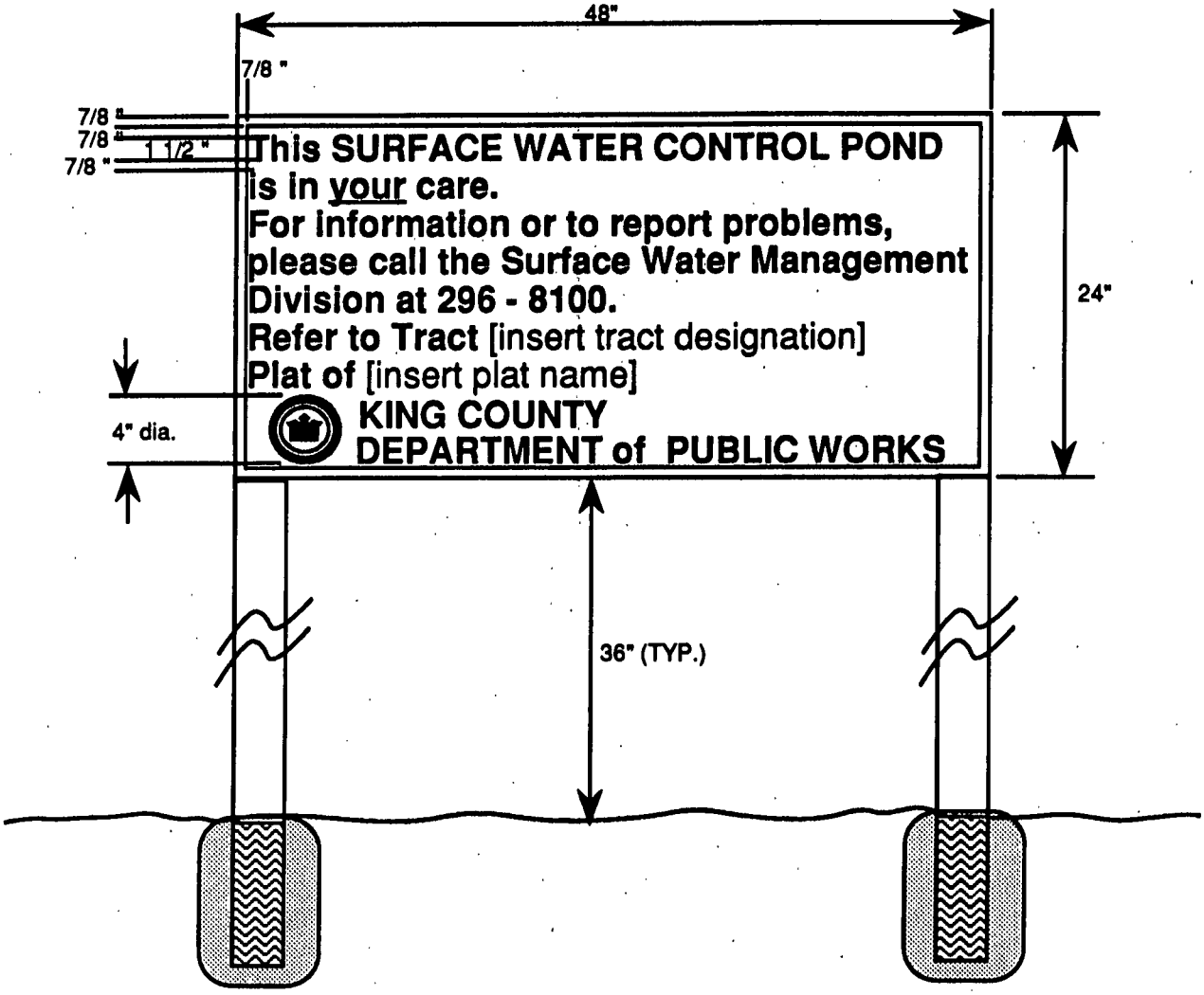


FIGURE 4.4.4G PERMANENT SURFACE WATER CONTROL POND SIGN



Specifications

Size:	48" by 24".
Material:	Grade "B" or better exterior plywood.
Paint:	Face - 3 coats outdoor enamel [sprayed].
	Back - 1 coat outdoor enamel[sprayed].
Lettering:	Silk screen enamel where possible, or hand-painted enamels.
Colors:	Black and White. White background, lettering and border in black.
Type face:	Helvetica. 1-1/2" tall with 7/8" spacing between letters and outer border.
	Outer border 1/4" width.
Installation:	Secured to chain link fence if available, otherwise install on two 8 foot long 4" x 4" posts, pressure treated, installed in 3 foot deep concrete filled post holes (8" min. dia.).

4.4.5 TANKS

Section 1.2.3 contains the definition of detention tanks and the limitations on their use.

Design Criteria For Tanks

Capacity/Discharge: Volume/outflow analysis shall be in accordance with the performance requirements in Chapter 1 and the hydrograph methods in Chapter 3. Restrictor/orifice structure design shall be per Section 4.4.7.

- The minimum pipe size allowed for a detention tank is 36" dia.

Materials: Pipe material, joints, and protective treatment for tanks shall be in accordance with WSDOT/APWA Standard Specifications Section 9.05, as modified by the County General Special Provisions, and AASHTO designations as noted below:
- Galvanized, corrugated iron or steel pipe and pipe arch, Treatment 1 through 6
- Aluminized Type 2 corrugated steel pipe and pipe arch (meets AASHTO designations M274 and M36)
- Galvanized steel spiral rib pipe, Treatment 1 through 6
- Aluminum spiral rib pipe
- Corrugated aluminum pipe and pipe arch
- Galvanized structural plate pipe and pipe arch, Treatment 1 through 6
- Reinforced concrete pipe
- Corrugated high density polyethylene pipe (CPEP) - Smooth interior
- Concrete vaults (see Section 4.4.6).

Structural Stability: All tanks shall meet structural requirements for overburden support and traffic loading if appropriate. HS-20 live loads must be accommodated for tanks lying under roadways or parking areas. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gage material than the pipe and/or require reinforcing ribs. Tanks shall be placed on stable, well consolidated native material with a suitable bedding. Tanks shall not be allowed in fill slopes, unless analyzed in a geotechnical report for stability and construction practices.

Buoyancy: In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy tendencies must be balanced by ballasting with either backfill or concrete backfill, providing concrete anchors, by increasing the total weight, or by providing subsurface drains to permanently lower the groundwater table. Calculations must be submitted which demonstrate stability.

Water Quality: Inflow shall enter through a sump (Type 2CB) that is connected to the detention tank by not greater than 2 feet of 36-inch minimum diameter pipe. The detention tank bottom shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment. Tank design shall be "flow-through" (see Figure 4.4.5B) with CB's in line to maximize water quality function and facilitate maintenance unless physically infeasible.

Minimum Access Requirements: The maximum depth to a tank invert shall be 20 feet. Spacing between access openings for tanks shall not exceed 100 feet. 36-inch minimum diameter CMP riser-type manholes of the same gage as the tank material per Figure 4.4.5A and B may be used for access along the length of the tank and at the upstream terminus of the tank if the tank is designed with a common inlet/outlet so that it is a backup system rather than a flow through system. Note, Figure 4.4.5B is not allowed for use in roadways, driveways, parking stalls, or anywhere it would be subjected to vehicular loads. All tank access openings must be readily accessible by maintenance vehicles.

Access Roads: Access roads are required to all detention tank control structures and risers. The access roads shall meet the requirements for access roads described in Section 4.4.4.

Locking Lids: All tank access openings shall have round, solid, locking lids using 1/2" diameter allen head screw locks (see KCRS Dwg. No. 49).

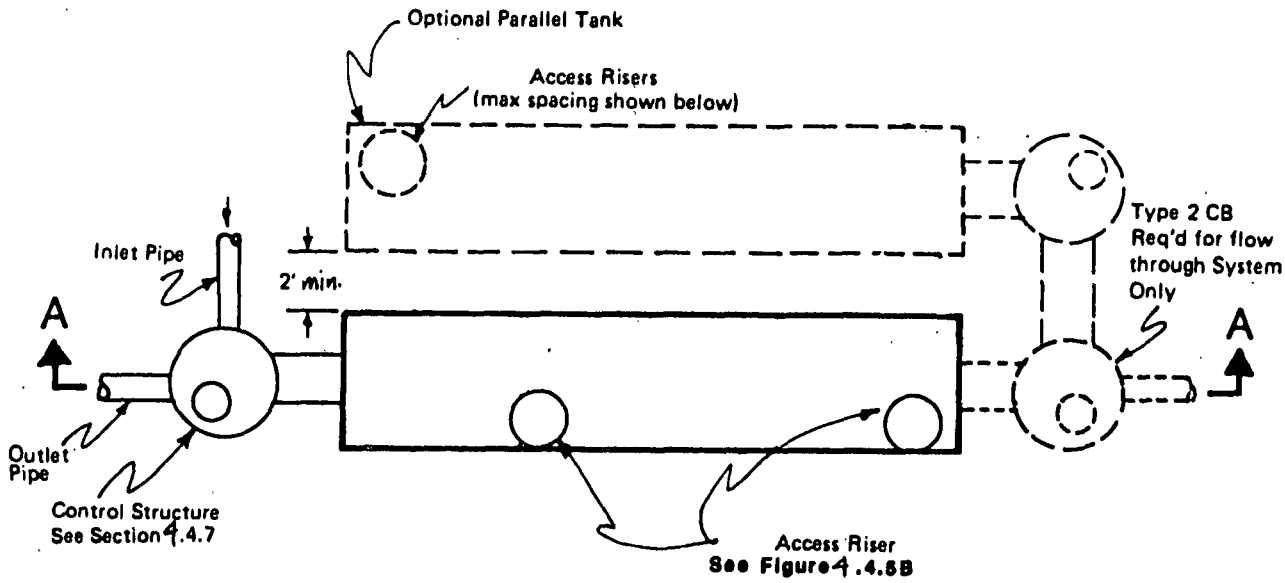
Control Structures: Outflow control structures are described in Section 4.4.7.

Note, control and access manholes shall have additional ladder rungs to allow ready access to all tank access pipes when catch is filled with water.

Details

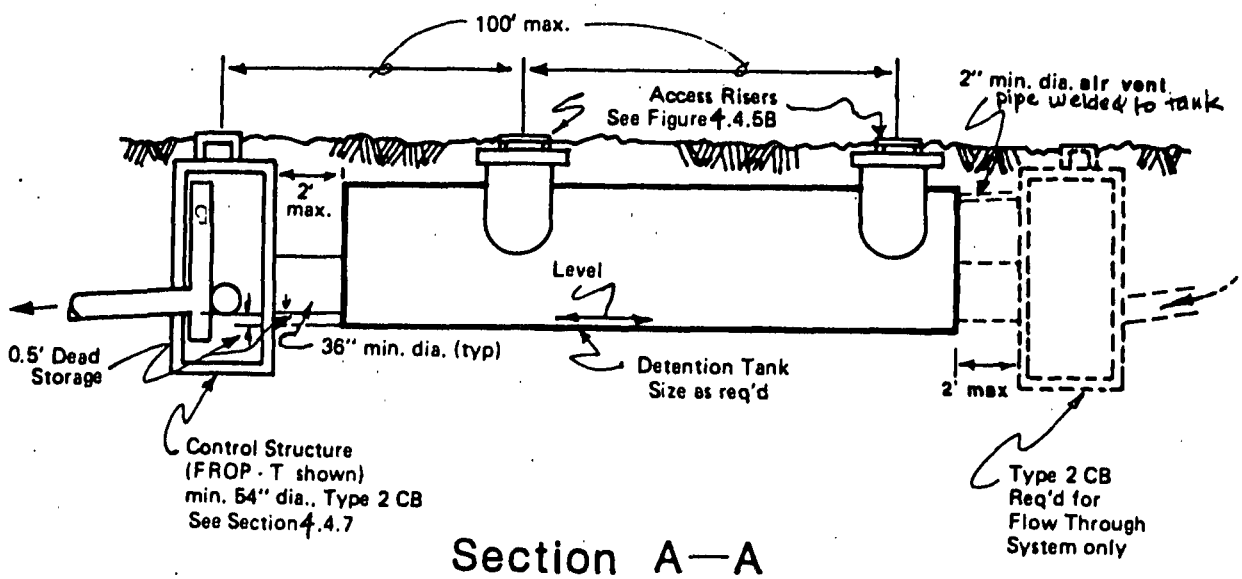
Standard tank details are shown in Figures 4.4.5A and B. Control structure details are shown in Section 4.4.7.

FIGURE 4.4.5A TYPICAL DETENTION TANK



Plan View

NO SCALE
"Flow Back Up" System Shown
Optional Designs for "Flow Through" System and Parallel Tanks Shown Dashed

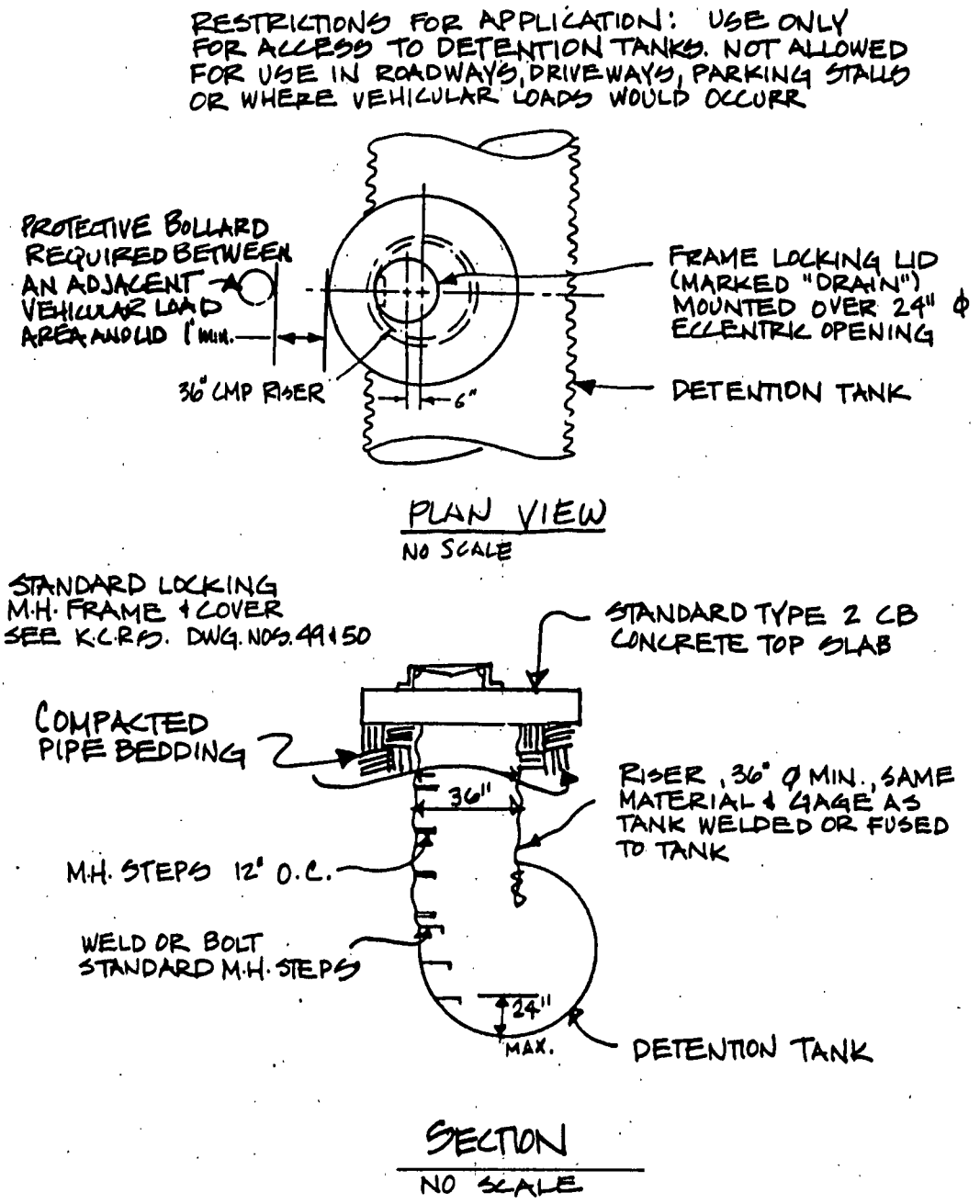


Section A—A

NO SCALE

NOTE: All metal parts corrosion resistant. Steel parts galvanized and asphalt coated (Treatment I or better)

FIGURE 4.4.5B DETENTION TANK ACCESS DETAIL



NOTES:

1. USE ADJUSTING BLOCKS AS REQ'D TO BRING FRAME TO GRADE
2. ALL MATERIALS TO BE ALUMINUM OR GALVANIZED & ASPHALT COATED (TREATMENT 1 or BETTER
3. MUST BE LOCATED FOR ACCESS BY MAINTENANCE VEHICLES

4.4.6 VAULTS

Section 1.2.3 contains the definition of vaults and the limitations on their use.

Design Criteria

Capacity/Discharge: Volume/outflow analysis shall be in accordance with the performance requirements in Chapter 1 and the hydrograph methods in Chapter 3. Restrictor/orifice structure design shall be per Section 4.4.7.

Materials: Minimum 3000 psi structural reinforced concrete. All construction joints must be provided with water stops. Pre-cast vaults shall be designed by a structural engineer.

Structural Stability: All vaults shall meet structural requirements for overburden support and HS-20 traffic loading. Cast-in-place wall sections shall be designed as retaining walls. All structural designs shall be stamped by a structural engineer licensed in the State of Washington. Structural designs for cast-in-place vaults require a separate commercial building permit issued by the BALD Division. Vaults shall be placed on stable, well consolidated native material with suitable bedding. Vaults shall not be allowed in fill slopes, unless analyzed in a geotechnical report for stability and construction practices.

Water Quality: Vault design shall be "flow-through" to maximize water quality function and facilitate maintenance. The vault bottom shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment. Vaults must be designed to provide approximately half the volume between the cells divided by a baffle wall. The top of the baffle wall must be set 1 foot below the design water surface elevation and have a minimum 6" wide slot or pipe orifice cast into the wall that must pass, at a minimum, the developed flow for the 2-year, 24-hour design storm with the invert of the slot or orifice set 6" above the bottom of the vault.

Minimum Access Requirements: Provide one access cover per 50 feet of length or width and at least 1 access cover with ladder to the bottom of the vault per cell if vault is divided into cells. The minimum internal height shall be 7 feet and the minimum width shall be 4 feet. (Note, concrete vaults may be minimum 3 feet in heighth and width if used as tanks with access manholes at each end.). The maximum depth to the vault invert shall be 20 feet.

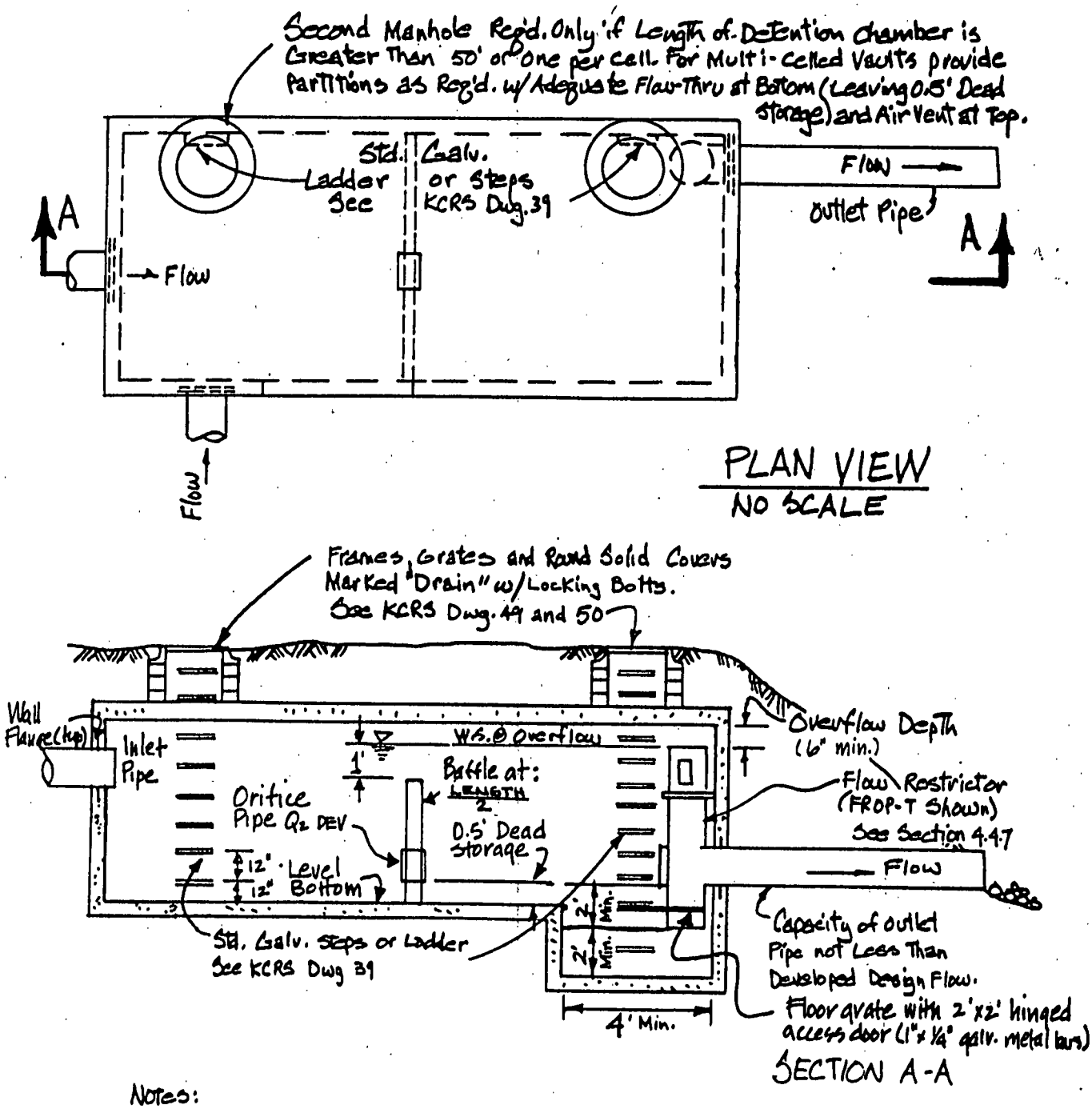
Access Roads: Access roads are required to at least one access cover for each cell. The access roads shall meet the requirements for access roads described in section 4.4.4.

Locking Lids: All vault access openings shall have round, solid, locking lids using 1/2" diameter allen head screw locks (see KCRS Dwg. No. 49).

Details

A standard vault detail is shown in Figure 4.4.6A. Control structure details are shown in Section 4.4.7.

FIGURE 4.4.6A TYPICAL DETENTION VAULT



Notes:

1. Plans Must be Designed & Stamped by a Registered Prof. Structural Engr.
2. All Metal Parts: Corrosion Resistant. Steel Parts Galvanized & Asphalt Coated (Treatment I or Better).
3. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.

4.4.7 CONTROL STRUCTURES

Control structures are catch basins with a restrictor device for controlling outflow from a facility to meet the desired performance. They also provide some function as an oil-water separator for control of petroleum-based pollutants and floatables. Oil-water separation measures are required for control of storms up to and including the 10-year design storm. Storm flows above the 10-year may be released without oil-water separation provided performance requirements are met (see Figure 4.4.7E).

The restrictor device is usually a multiple orifice, consisting of two (or more) orifices and a weir section sized and located to meet performance.

Design Criteria

Multiple Orifices: A maximum of 5 orifices may be used to meet performance requirements.

In most cases, only 2 orifices are necessary to meet the 2, 10, 100 year performance requirement: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume.

Several orifices may be located at the same elevation if necessary to meet performance.

Minimum orifice diameter is 0.5 inches.

Orifices may be constructed on a "Tee" section as shown in Figure 4.4.7G or on a baffle shown in Figure 4.4.7H.

In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to physically construct (e.g., a 13-inch-diameter orifice positioned 0.5 feet from top of riser). In these cases, a notch weir in the riser pipe may be used to meet performance as described below.

Riser and Weir Restrictor: Properly designed weirs may be used as flow restrictors (see Figures 4.4.7B, C, D and I). However, they must be sized to pass the developed peak flow for the 100-year, 24-hour design storm for developed site conditions.

If the notch weir flow is below the 10-year, 24-hour design storm flow, oil/water separation is required (see Figure 4.4.7F).

Riser (or weir) overflow may be utilized for that portion of the release rates above the 10-year, 24-hour design storm flow, provided the combined orifice and overflow do not exceed performance requirements (see Figure 4.4.7E). Figure 4.4.7J can be used to calculate the head in feet above a riser of given diameter and for a given flow (usually the 100-year, 24-hour design storm flow for developed conditions).

Access to Control Structure: A 15-foot-wide access road to the control structure is required for inspection and maintenance.

- Manhole/catch basin lids for control structures shall be "locking" and rim elevation shall match proposed finish grade.

Methods of Analysis

Retention/Detention storage volume and discharge rates shall be in accordance with the performance requirements described in Section 1.2.3, Chapter 1, and the hydrologic methods described in Chapter 3.

Flow analysis of orifices and weirs may be done using the following methods:

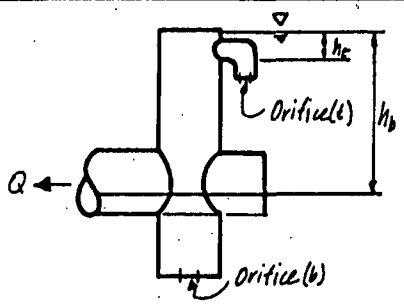
Orifices: Flow-through orifice plates in the Standard "Tee" Section or turn-down elbow may be approximated by the general equation:

$$Q = CA\sqrt{2gh} \text{ cfs}$$

where A = area of orifice, ft^2
C = 0.62, coefficient of discharge (for plate orifice)
h = hydraulic head in feet
g = 32.2 ft/sec^2

Figure 4.4.7A illustrates this simplified application of the orifice equation. Note the rigorous equation for computing flow.

FIGURE 4.4.7A SIMPLE ORIFICE



$$Q = CA_b\sqrt{2gh_b} + CA_t\sqrt{2gh_t}$$
$$= C\sqrt{2g}\,(A_b\sqrt{h_b} + A_t\sqrt{h_t})\text{cfs}$$

h_b = distance from hydraulic grade line at the 2 year flow of the outflow pipe to the overflow elevation

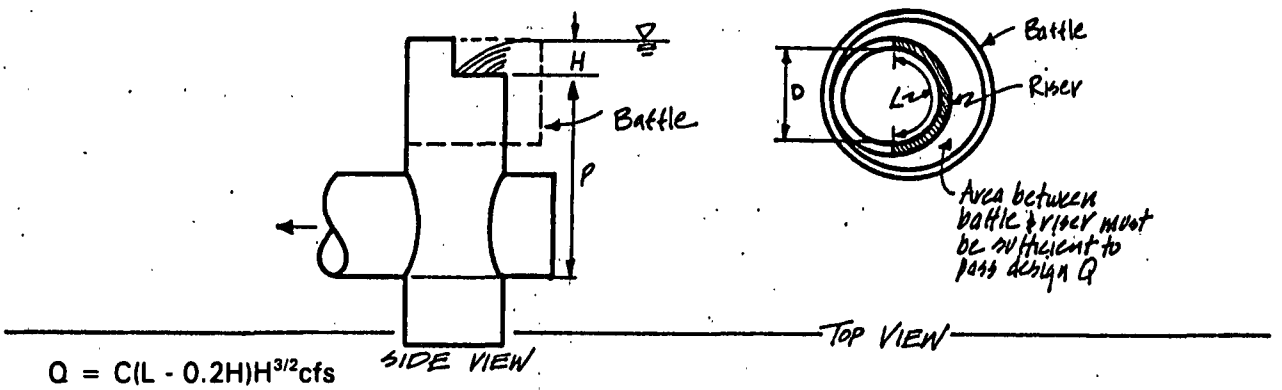
The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$\text{dia} = \sqrt{\frac{36.88Q}{(\sqrt{h})}}$$

where h = hydraulic head (in feet).
Q = flow in cubic feet per second.

Rectangular, Sharp Crested Weir: The notch weir design shown in Figure 4.4.7B may be analyzed using standard weir equations for the fully contracted condition.

FIGURE 4.4.7B NOTCH WEIR



$$Q = C(L - 0.2H)H^{3/2}\text{cfs}$$

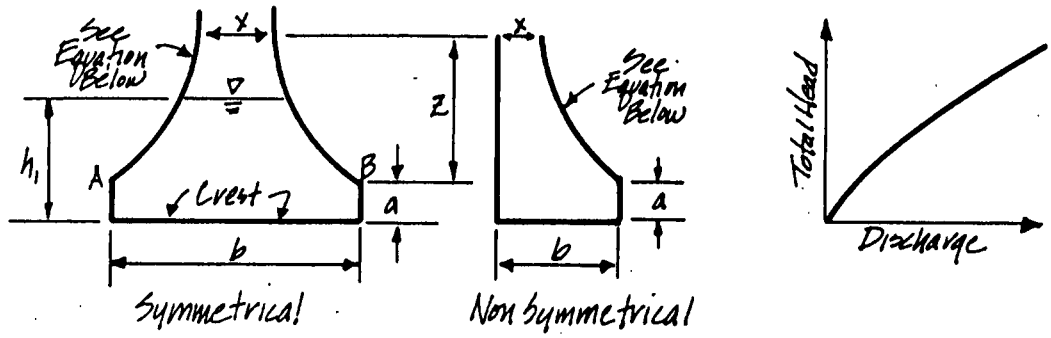
where C = 3.27 + 0.40 H/P (in feet).
L = Length of the portion of the riser circumference as necessary (in feet), not to exceed 50% of the circumference.
H&P as shown above
D = Inside riser diameter.

Note that to account for side contractions, subtract 0.1 H from L for each side of the notch weir.

Proportional or Sutro Weir: This weir is designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet required performance.

The Sutro Weir consists of a rectangular section joined to a curved portion which provides proportionality for all heads above the line A-B (see Figure 4.4.7C)

FIGURE 4.4.7C SUTRO WEIR



For this type of weir, the curved portion is defined by the equation (calculated in radians):

$$\frac{X}{b} = 1 - \frac{2}{\pi}\tan^{-1}\sqrt{\frac{z}{a}}$$

and the head-discharge relationship is:

$$Q = C_d\, b\sqrt{2ga\,(h_1 - a/3)}$$

Values of C_d for both symmetrical and non-symmetrical Sutro Weirs are summarized below in Table 4.4.7C:
(Note that when $b > 1.50$ or $a > 0.30$ use $C_d = 0.6$.)

TABLE 4.4.7C VALUES OF C_d FOR SUTRO WEIRS

C_d Values, Symmetrical

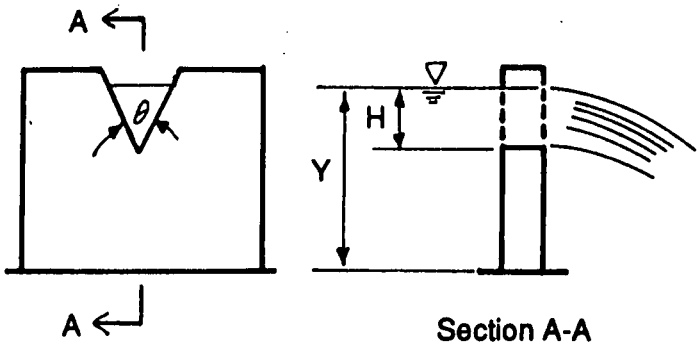
a,Ft	b, Ft 0.50	0.75	1.0	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608

C_d Values, Non-Symmetrical

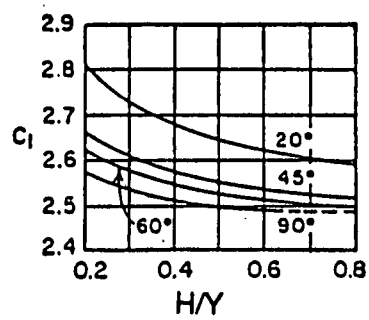
a,Ft	b, Ft 0.50	0.75	1.0	1.25	1.50
0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

V-Notch, Sharp Crested Weir: V-Notch weirs, as shown in Figure 4.4.7D, may be analyzed using standard equations for the fully contracted condition.

FIGURE 4.4.7D V-NOTCH, SHARP CRESTED WEIR



Where values of C_d may be taken from the following chart:



$Q = C_d (\text{Tan } \Theta/2) H^{5/2}$, in cfs

Details

Standard control structure details are shown in Figures 4.4.7E through I.

FIGURE 4.4.7E REQUIREMENTS FOR OIL/WATER SEPARATION WITH ORIFICE CONTROL

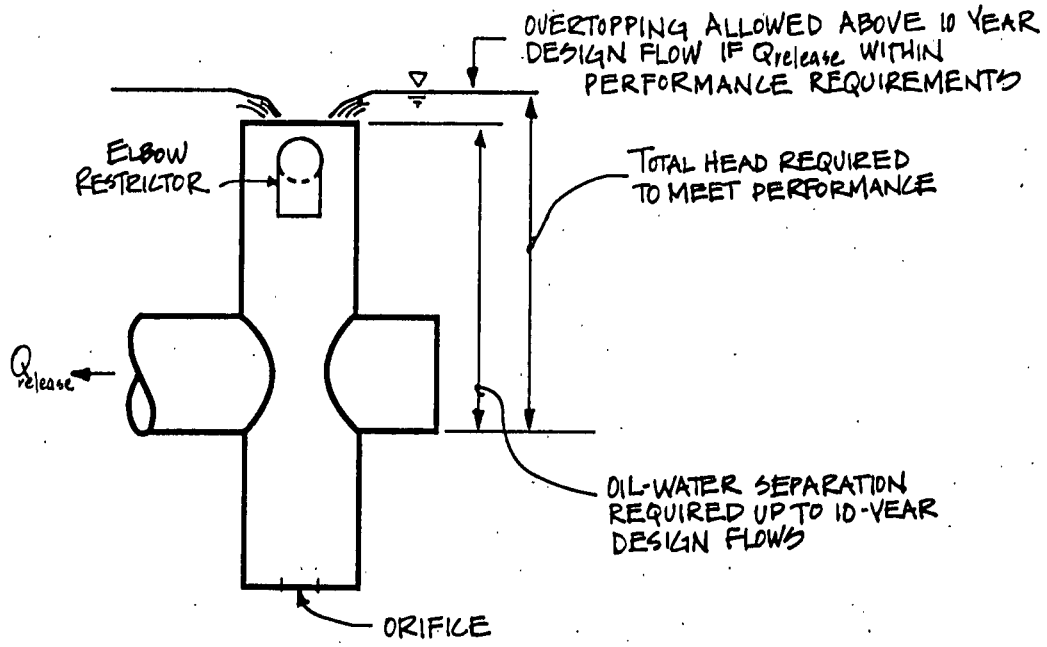


FIGURE 4.4.7F REQUIREMENTS FOR OIL/WATER SEPARATION WITH NOTCH CONTROL

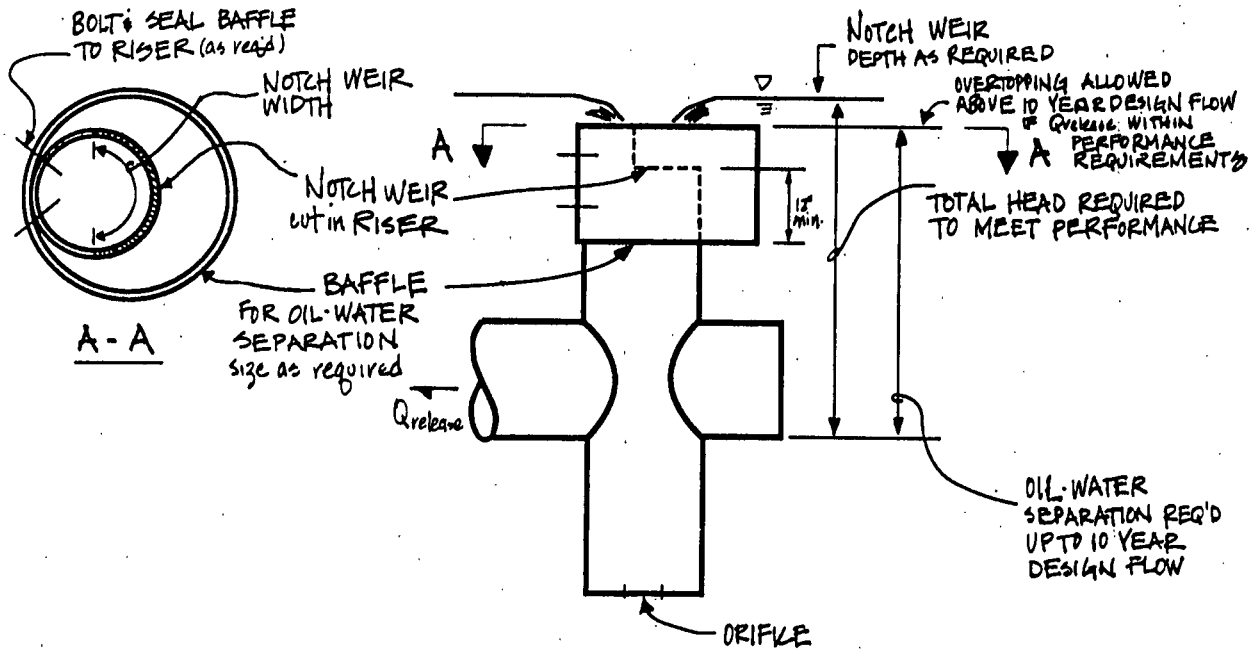
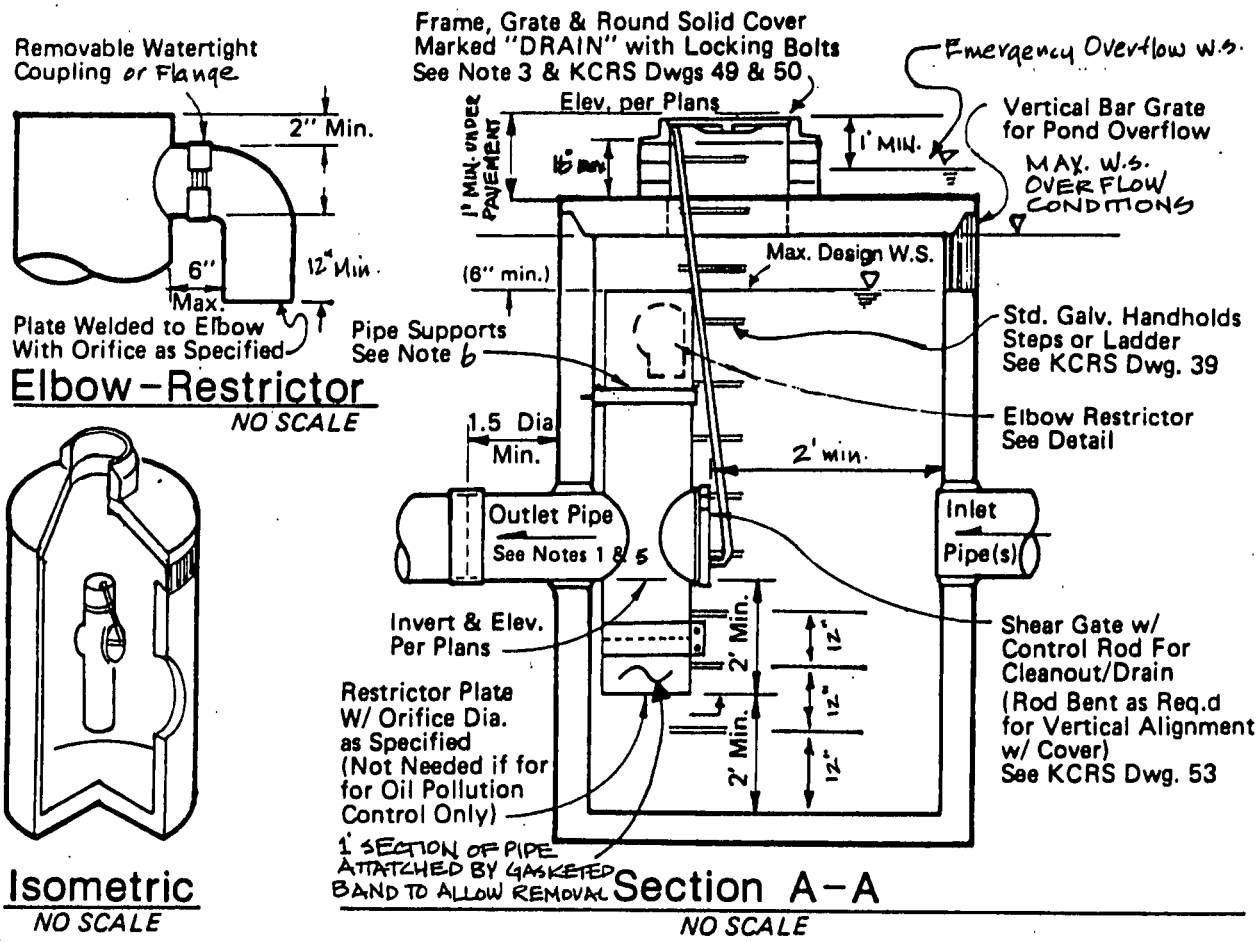


FIGURE 4.4.7G FLOW RESTRICTOR/OIL POLLUTION CONTROL DEVICE (FROP-T) (TEE)



NOTES

1. USE MIN. 54" DIA' CATCH BASIN TYPE 2
2. OUTLET CAPACITY: DEVELOPED DESIGN FLOW
3. METAL PARTS: CORROSION RESISTANT. GALVANIZED PIPE PARTS TO HAVE ASPHALT TREATMENT 1.
4. FRAME & LADDER OR STEPS OFFSET SO:
   A. CLEANOUT GATE IS VISIBLE FROM TOP.
   B. CLIMB-DOWN SPACE IS CLEAR OF RISER AND CLEANOUT GATE.
   C. FRAME IS CLEAR OF CURB.
5. IF METAL OUTLET PIPE CONNECTS TO CEMENT CONCRETE PIPE: OUTLET PIPE TO HAVE SMOOTH O.D. EQUAL TO CONCRETE PIPE I.D. LESS 1/4".
6. PROVIDE AT LEAST ONE 3" X .090 GAGE SUPPORT BRACKET ANCHORED CONCRETE WALL. (MAX. 3'-0" VERTICAL SPACING).
7. LOCATE ELBOW RESTRICTOR(S) AS NECESSARY TO PROVIDE MIN. CLEARANCE AS SHOWN.
8. LOCATE ADDITIONAL LADDER RUNGS IN STRUCTURES USED AS ACCESS TO TANKS OR VAULTS TO ALLOW ACCESS WHEN CATCH IS FILLED WITH WATER.

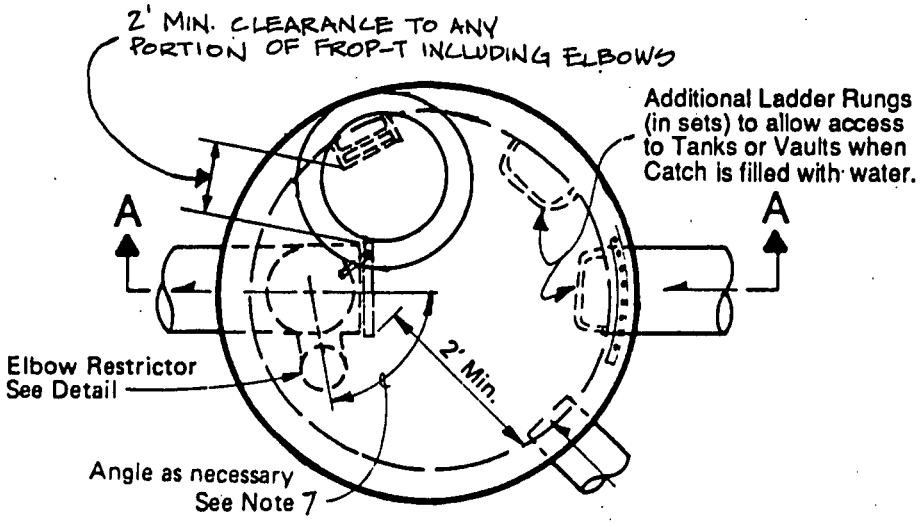
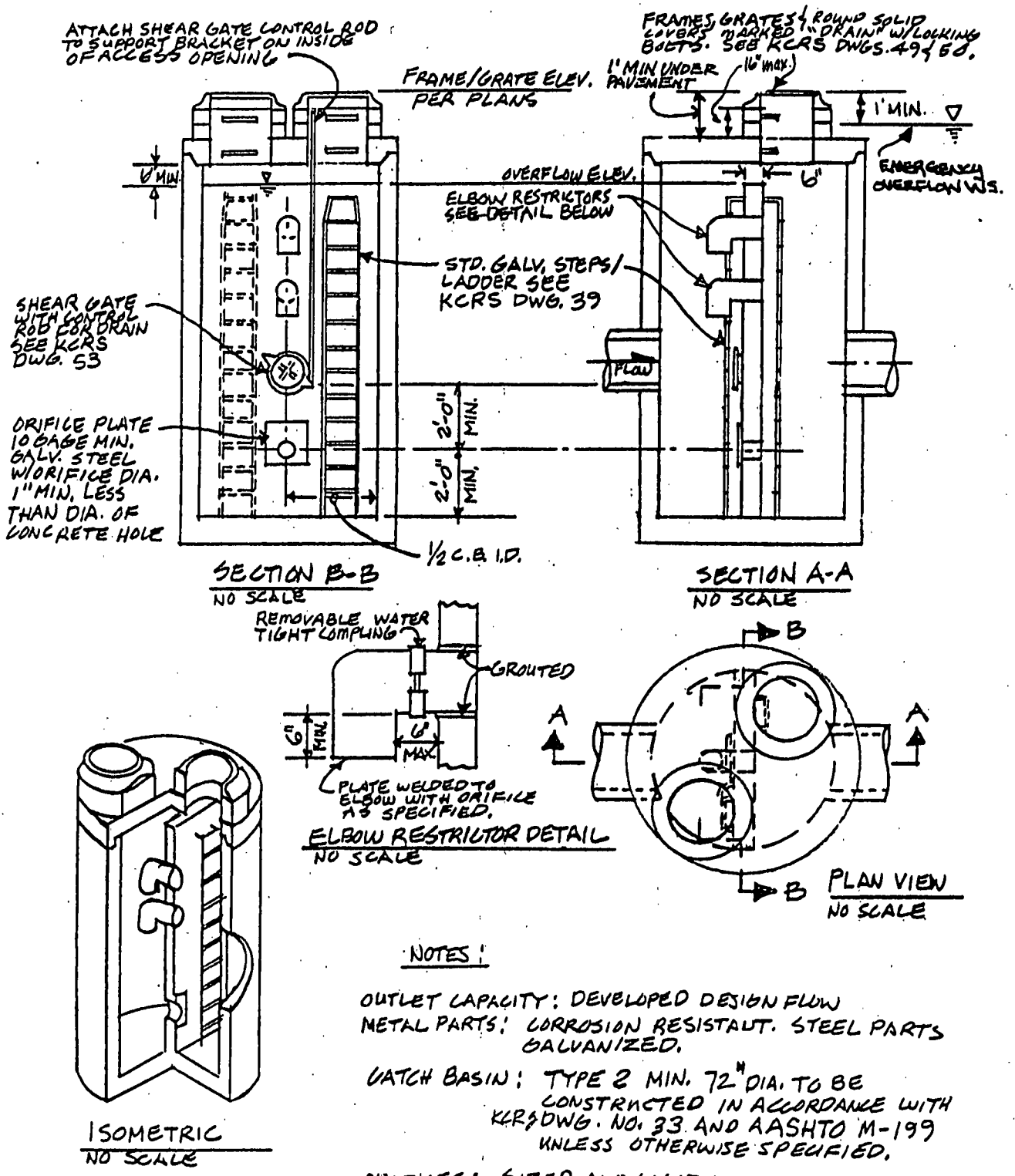


FIGURE 4.4.7H FLOW RESTRICTOR/OIL POLLUTION CONTROL DEVICE (FROP-B) (BAFFLE)



NOTES:

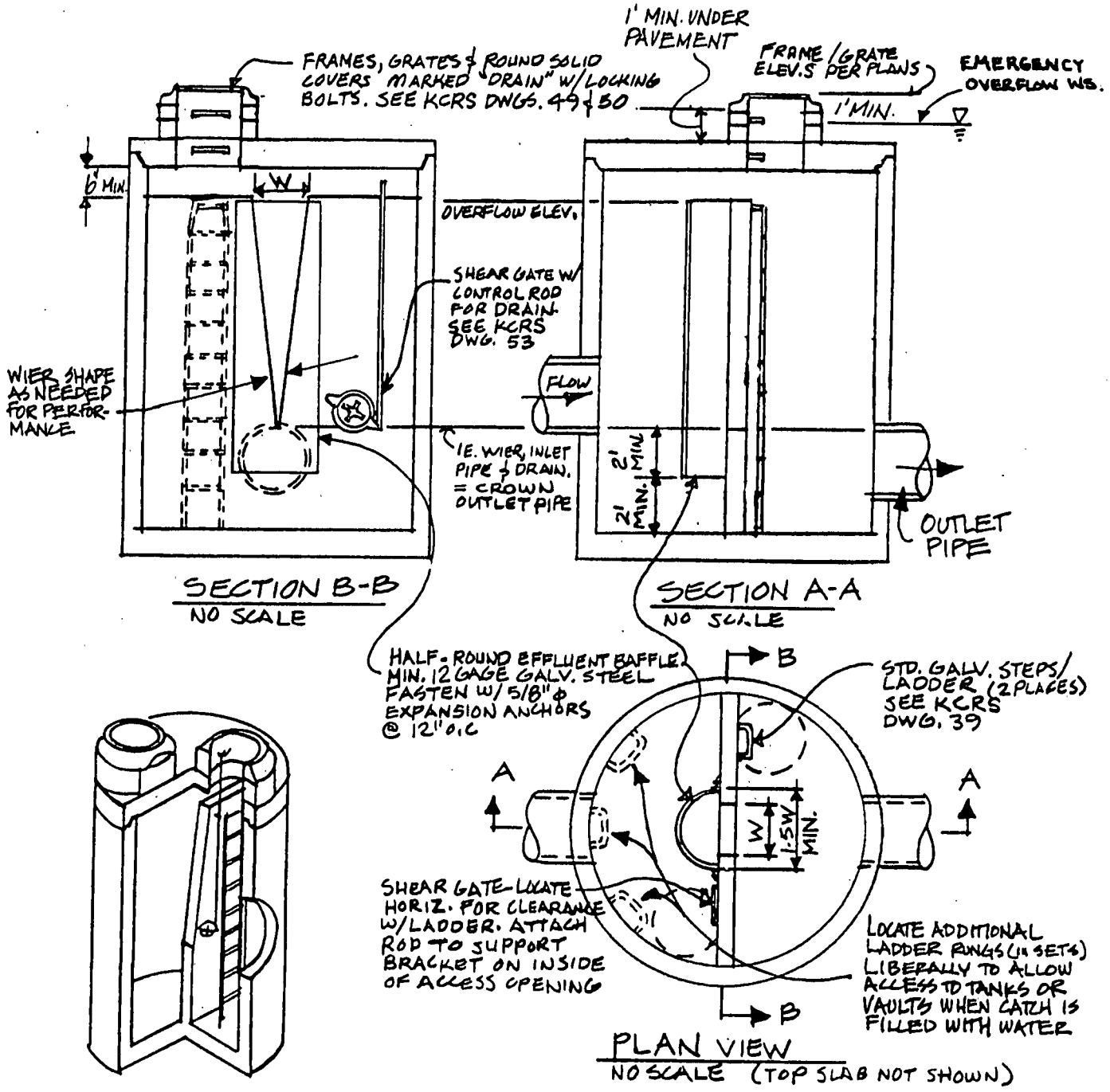
OUTLET CAPACITY: DEVELOPED DESIGN FLOW

METAL PARTS: CORROSION RESISTANT. STEEL PARTS GALVANIZED.

CATCH BASIN: TYPE 2 MIN. 72" DIA. TO BE CONSTRUCTED IN ACCORDANCE WITH KCRS DWG. NO. 33 AND AASHTO M-199 UNLESS OTHERWISE SPECIFIED.

ORIFICES: SIZED AND LOCATED AS REQUIRED. WITH LOWEST ORIFICE MIN. 2" FROM BASE.

FIGURE 4.4.7I FLOW RESTRICTOR/OIL POLLUTION CONTROL DEVICE (FROP-T) (WEIR)



NOTES:

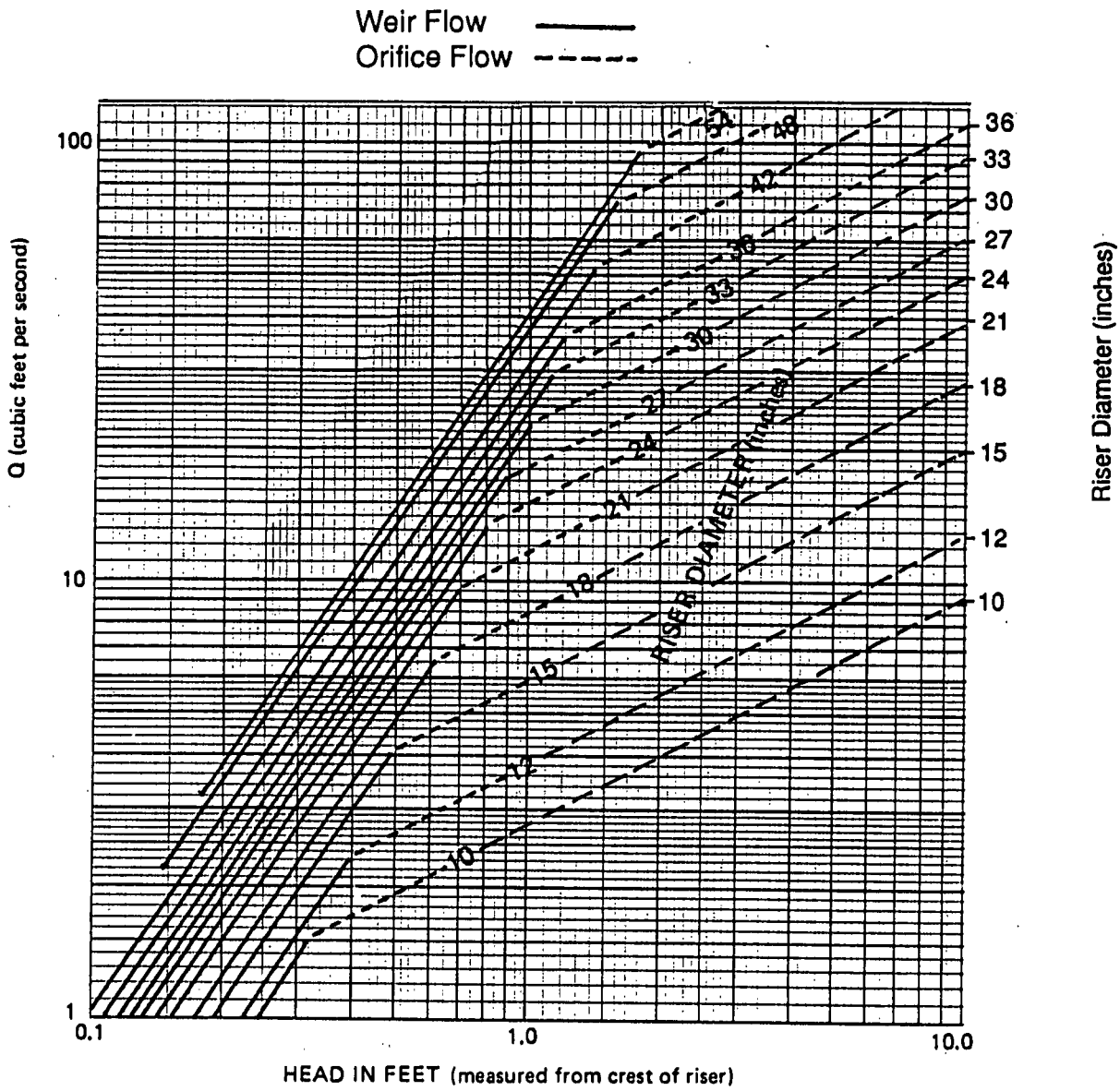
OUTLET CAPACITY: DEVELOPED DESIGN FLOW

METAL PARTS: CORROSION RESISTANT. STEEL PARTS GALVANIZED.

CATCH BASIN: TYPE 2 MIN. 72" DIA. TO BE CONSTRUCTED IN ACCORDANCE WITH KCRS DWG. NO. 33 AND AASHTO M-199 UNLESS OTHERWISE SPECIFIED

BAFFLE WALL: TO BE DESIGNED WITH CONCRETE REINFORCING AS REQUIRED

FIGURE 4.4.7J RISER INFLOW CURVES



SOURCE: USDA-SCS

$Q_{WIER} = 9.739\ DH^{3/2}$

$Q_{ORIFICE} = 3.782\ D^2H^{1/2}$

Q in cfs, D and H in feet

4.5 INFILTRATION SYSTEM ANALYSIS AND DESIGN

The specific requirements for the analysis and design of infiltration systems are dependent upon the type of facility. There are three basic types of infiltration systems allowed for use in King County: Roof Downspout Systems, Infiltration Tanks, and Infiltration Ponds. In general, ponds are preferable to tanks because of the ease of maintenance and the water quality treatment that surface soil and vegetation provide. Alternative systems such as small infiltration basins and modular pavement are also allowed, but these methods have many limitations. Requirements for the design of the various types of infiltration systems are presented in the sections which follow.

4.5.1 ROOF DOWNSPOUT INFILTRATION SYSTEMS

All roof runoff from lots in new plats and short plats must be either infiltrated or dispersed, or stub-outs to the plat drainage system must be provided. Where lots are less than 22,000 square feet and infiltration is feasible, infiltration is required either on the individual lot or within the plat. If infiltration is not feasible and the dispersion criteria are met, dispersion is allowed (see Section 4.5.6). If infiltration or dispersion is not used, stub-outs shall be provided to connect the roof drains to the plat drainage system. Connections to the stub-outs shall be perforated connections, as described in 4.5.6.

Roof downspout infiltration systems are infiltration trench systems intended only for use in infiltrating runoff from roof downspout drains. They are not designed to directly infiltrate any surface water that could transport sediment or pollutants such as from paved areas. Roof downspout systems are required in proposed plats and short plats where there is at least 3 feet of pervious soil above the water table and minimum lot size requirements are met, as detailed below. Where downspout infiltration is used, the roof area which is infiltrated need not be included in the impervious area used to calculate the R/D facility size.

Limitations

- A single roof downspout infiltration system can serve up to 5,000 square feet of roof area (A_R, described below).
- Not allowed on slopes greater than 25% (4:1).
- Not allowed in fill materials except in engineered sand and gravel fill, otherwise must be native soil. The placement of the engineered fill must be observed by a qualified representative of a licensed engineer, a geologist or soil scientist, and have a measured infiltration rate of not less than 3 inches per hour. Systems in engineered fill shall be designed using the fine sand criteria in Table 4.1.5B. Infiltration rates shall be tested using the methods described in Section 4.5.2
- Roof downspout systems should be located at least 30 feet from any water supply well.
- Limited for use only in the SCS soil types listed in Table 4.5.1A. See Figure 4.5.1A for USDA Soil Texture Triangle.
- Minimum lot size requirements shall be as shown in Table 4.5.1A.

TABLE 4.5.1A MINIMUM LOT SIZES FOR USE WITH DOWNSPOUT INFILTRATION

Soil Texture Class (U.S.D.A.)	Minimum Lot Size	With Septic System
Coarse sand or Cobbles	No min	1 acre*
Medium sand	No min	12,500 ft^2*
Fine sand, loamy sand	9600 ft^2	15,000 ft^2*
Sandy loam	12,000 ft^2	18,000 ft^2*
Loam	15,000 ft^2	.5 acre

On lots >22,000 ft^2, dispersion is required. Lots which are too small for infiltration systems shall either disperse the roof runoff (if the requirements in Section 4.5.6 are met) or tie into the proposed plat or short plat storm system.

* Typical minimum lot size allowed by Seattle-King County Health Department for gravity septic system in this soil type with 4 feet of original soil. Less than 4 feet of original pervious soil above maximum water table either increases minimum lot size for gravity septic systems to 1 acre for all the above soil types or else it requires the use of a pressure, mound or sand filter system. Coarse sand/gravel sites may be less than .5 acre with the use of a pressure, mound or sand filter system. Check with Seattle-King County Health Department for any changes or for specific site requirements.

NOTE: Minimum lot size, required separation between infiltration and septic systems, and distances from water supply wells shall be in accordance with Seattle-King County Health Department requirements.

Design Criteria

- See Figure 4.5.1 B and Figure 4.5.1C for details. Figure 4.5.1C applies to sites with coarse sand and cobble soils and is intended to provide additional water quality treatment in these coarse soils.
- For roof downspout infiltration systems, a short report must be prepared by suitably trained persons working under the supervision of a licensed Professional Engineer or by a septic system designer licensed by King County, which includes a site sketch and soils logs. The approximate location of the proposed downspout infiltration system and septic system (if applicable) shall be shown on the approved plans.
- A minimum of one soils log, minimum 4 feet in depth, that describes the SCS series of the soil, the textural class (as in Table 4.5.1A) of the soil horizon through the depth of the log, and notes any evidence of high groundwater level, such as mottling, shall be obtained for each proposed roof downspout system location. Note, trench bottoms must be a minimum of 1 foot above seasonal high groundwater level or impervious soil layers. A minimum of 3 feet of pervious soil is required in roof infiltration areas.
- Trenches may be located under pavement provided that a small yard drain/catch basin with a grate cover is placed at the end of the trench pipe such that if the trench infiltration capacity is exceeded, the overflow would occur out of the catch basin at an elevation of at least one foot below that of any overlying pavement, and in a location which can accommodate the overflow and meet the requirements of Section 1.2.1.
- Minimum spacing between trench center lines shall be 6 feet.
- All trenches shall be a minimum of 10 feet from any structure, property line, Native Growth Protection Easement, Sensitive Area Tract or Sensitive Area Setback Area. Trench setbacks from septic systems shall be in accordance with Seattle-King County Health Department requirements. A trench can be located within 10 feet downslope of a structure foundation. Plot plan must show location of all of these features. A copy of the plot plan showing the downspout infiltration system and the other features shall be framed and mounted on a garage wall in the completed structure.
- All trenches shall be a minimum of 50 feet from any steep slope (as defined by the Sensitive Areas Ordinance and Rules). This setback may be reduced to 15 feet based on a geotechnical engineering report but in no instances less than the buffer width.
- Trench length shall not exceed 100 feet from the inlet sump.
- Each trench shall have one observation pipe, that extends to the bottom of the trench, located at a point approximately halfway along the trench length.
- Filter fabric shall be placed over the drain rock prior to backfilling.
- Infiltration areas shall be clearly marked before site work begins to avoid disturbance of the soil during construction. No vehicle traffic shall be allowed within 10 feet of infiltration trench areas.

- A licensed septic system designer or suitably trained person working under the supervision of a licensed Professional Engineer shall make an inspection of the soil after the system is excavated, before the trenches are filled with rock to confirm that suitable soils are present.

Method of Analysis/Length of Roof Downspout Infiltration Trenches

The length of trench required is based on the U.S.D.A. soil texture class, the roof area and the site location, using Table 4.5.1B. The length of trench required is determined by dividing the roof area by 1000 and multiplying by the unit length l from the chart for the soil type and multiplying the result by the regional scale factor k shown in Figure 4.5.1D. The trench length L is computed using the following equation:

$$L = (A_R/1000)(l)(k)$$

Where:

A_R = area of the roof tributary to the system, ft^2. (Note: a typical single-family residence has a roof area of approximately 2,000 ft^2.)

l = the unit length of trench required per 1,000 ft^2 of roof area from Table 4.5.1B, ft^{-1}

k = the regional scale factor from Figure 4.5.1D.

TABLE 4.5.1B INFILTRATION TRENCH LENGTHS FOR RESIDENTIAL ROOF DOWNSPOUT INFILTRATION SYSTEMS

Soil Texture Class (U.S.D.A.)	Lineal Feet of Trench per 1000 ft^2 of Roof - Sea Tac	Lineal Feet of Trench per 1000 ft^2 of Roof - Landsburg
1. Coarse sands or Cobbles	15	20
2. Medium sand	25	30
3. Fine sand, loamy sand	60	75
4. Sandy loam	100	125
5. Loam	150	190

Example: Proposed residence located at Kent East Hill

Roof area (A_R) = 2,000 square feet; Soil Texture Class = loamy sand;

From Table 4.5.1A, 60 ft trench/1000 ft^2 of roof, from Figure 4.5.1D k = 1.0

L = (2000/1000)(60)(1.0) = <u>120 ft</u>

(Note: could be accomplished by two trenches).

FIGURE 4.5.1A U.S.D.A. SOIL TEXTURE TRIANGLE

Textural Triangle U.S.D.A.

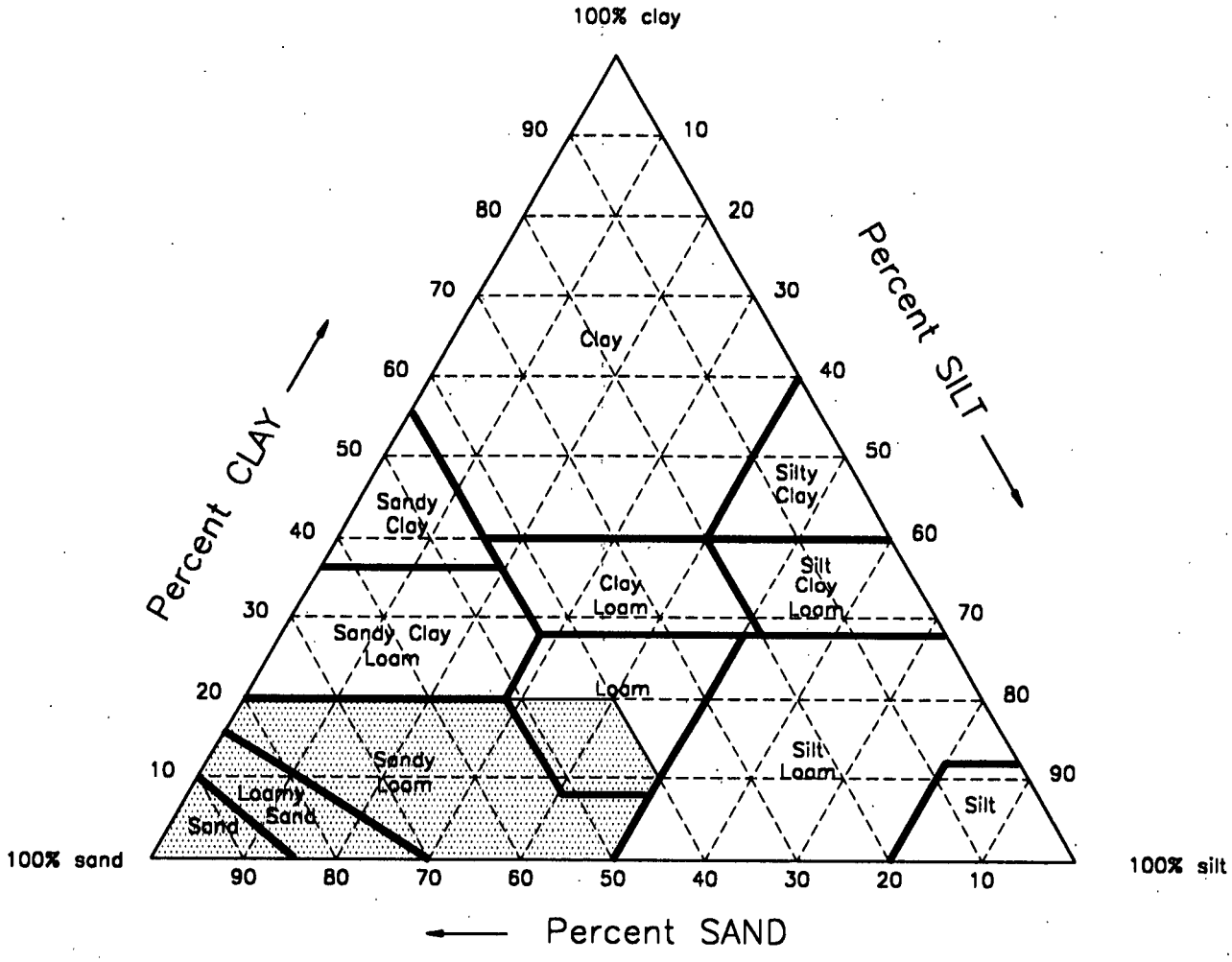


FIGURE 4.5.1B ROOF DOWNSPOUT INFILTRATION SYSTEM

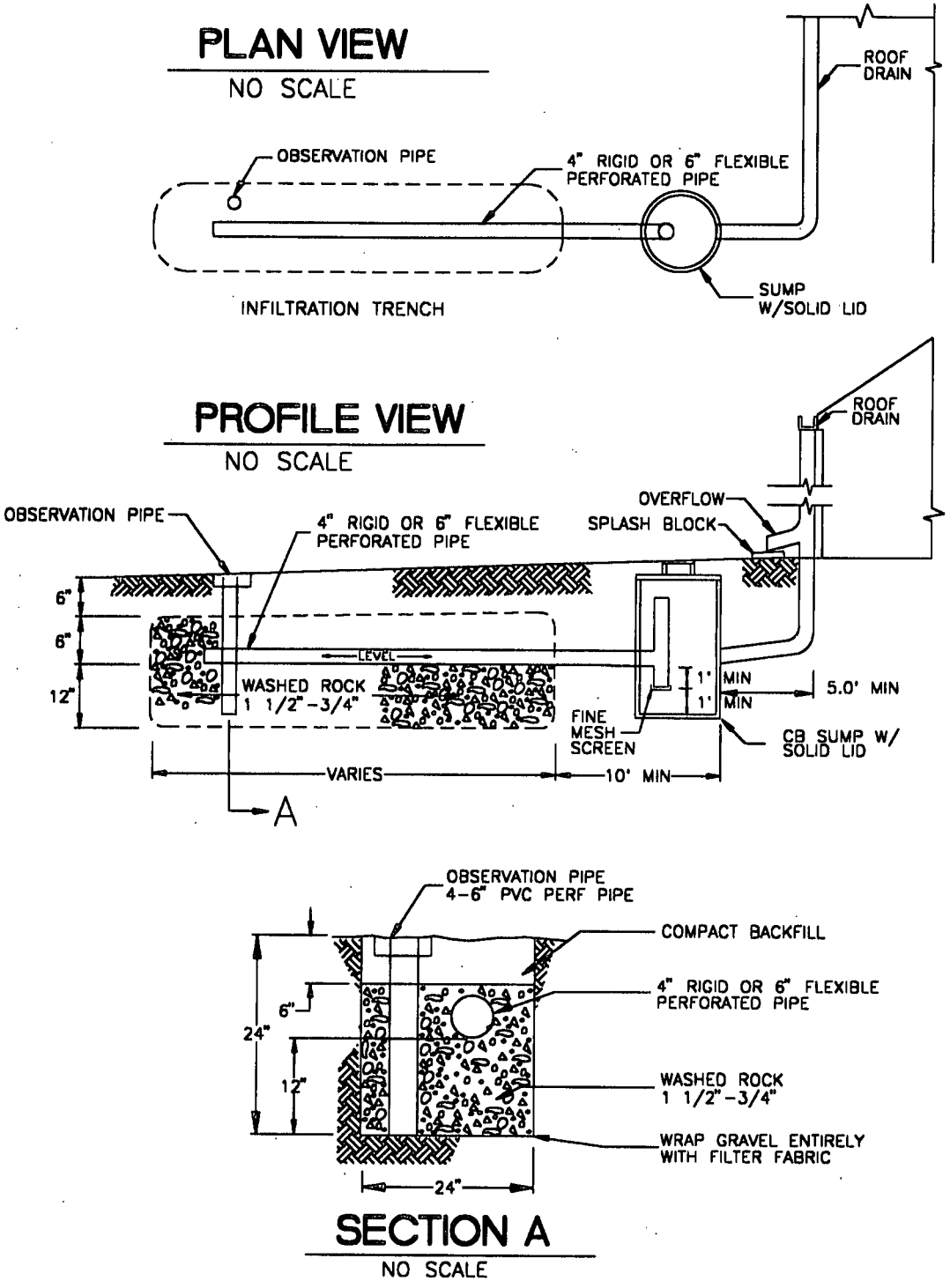
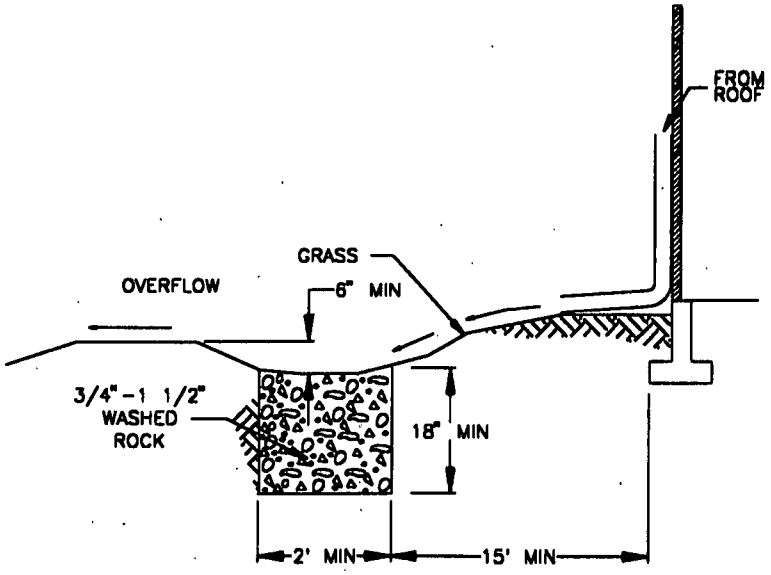
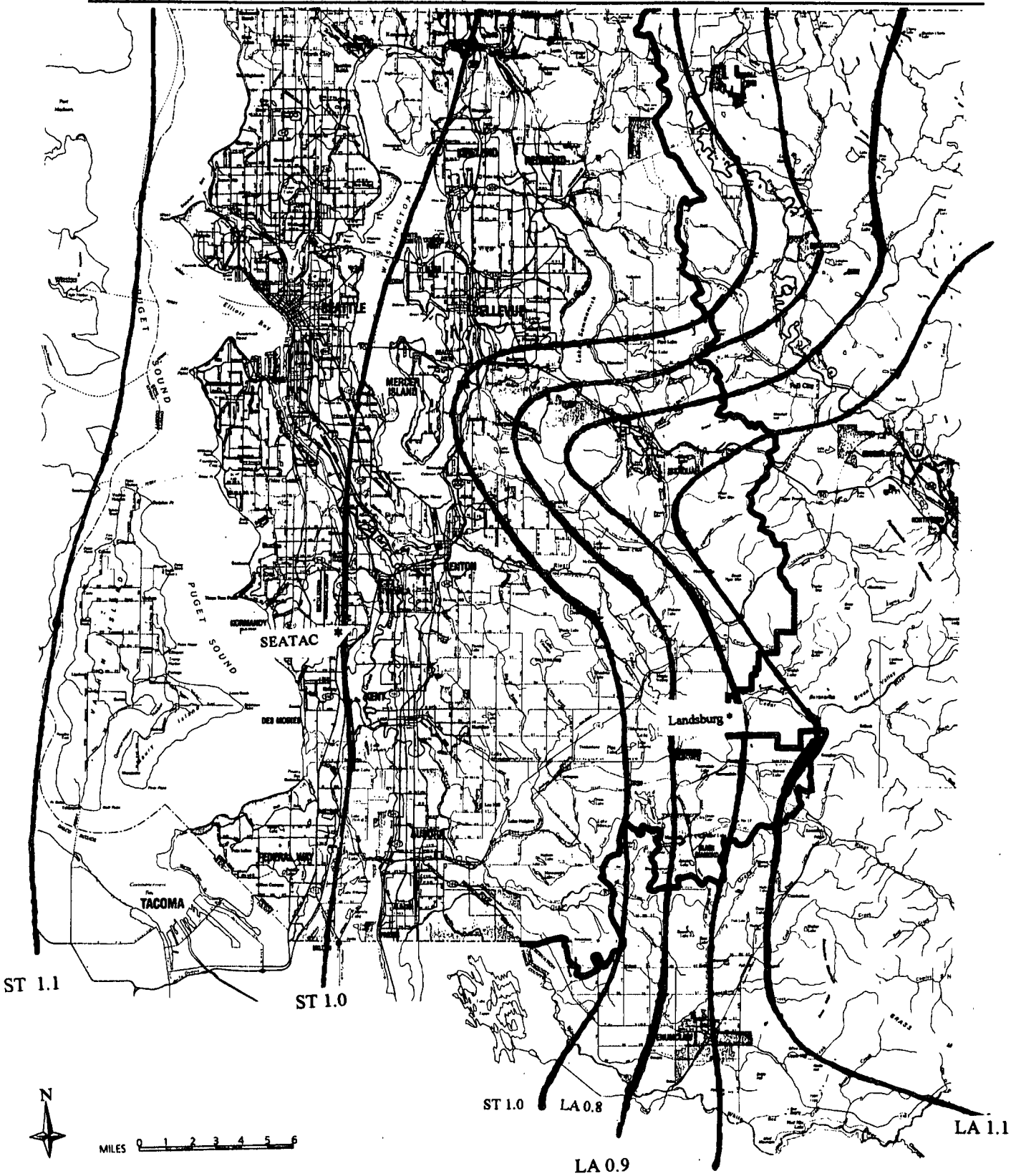


FIGURE 4.5.1C ROOF DOWNSPOUT INFILTRATION SYSTEM FOR COARSE SAND AND GRAVEL



X-SECTION
NO SCALE

FIGURE 4.5.1D REGIONAL SCALE FACTORS



4.5.2 REQUIREMENTS FOR TANKS AND PONDS

Soils Report

The applicant must demonstrate through infiltration testing, soil logs and the written opinion of a qualified soils engineer that sufficient permeable soil exists on the site to allow a properly functioning infiltration system to be constructed. The basic requirement is a minimum of 3 feet of permeable soil below the bottom of the facility (bottom of pond or excavation for tank) and at least 3 feet between the bottom of the facility and the maximum wet season water table. Test pits or borings should extend at least 5 feet below the bottom of the infiltration facility and at least one test hole should reach the water table. If the water table is very deep, the test hole need not extend more than one-fourth the maximum width of the pond below the bottom of a pond, or more than 5 feet below the bottom of a tank. If there is any question about the actual wet season water table elevation, measurements shall be made during the period when the water level in expected to be at a maximum. Any requirements related to steep slope or other sensitive area impacts should be addressed in the soil study. The engineer shall provide a report stating whether, in the engineer's professional opinion, the site is suitable for the proposed infiltration facility, and shall recommend a design infiltration rate, as discussed below.

Design Infiltration Rate

Infiltration rate tests are required in order to provide an estimate of the potential outflow rates for existing areas providing infiltration, such as closed depressions/wetlands and for proposed infiltration facilities. The maximum infiltration rates determined through these tests should not be faster than those shown in Table 4.5.2 for the given soil texture class. If they are faster, the rates shown in Table 4.5.2 should be used rather than the measured rates. The design infiltration rate shall be determined by infiltration testing, soil logs, and other testing and analysis that the soils engineer deems necessary. The design infiltration rate shall not be higher than the measured infiltration rate with the appropriate safety factor applied, and may be much lower when stratigraphy, depth to the water table, depth to impervious strata, infiltration receptor geometry and long-term clogging of the facility with fines is considered.

The actual infiltration rate of a pond or tank will be influenced by geometric hydraulic constraints. A shallow water table or impervious layer will reduce the effective infiltration rate of a large pond, but this will not be reflected in a small scale test. Clearly, a large pond built over a thin pervious stratum with a shallow water table will not function as well as the same pond built over a thick pervious stratum with a deep water table. These effects should be accounted for in the recommended design infiltration rate and in any other design recommendations which may be appropriate. The influence of the site geology on the effective infiltration rate could be analyzed by using groundwater modeling software or other analytic techniques. Selecting a suitable method of accounting for the groundwater and geologic conditions at a given site is the responsibility of the consultant. The soils engineer should work closely with the engineer designing the infiltration facility to ensure that appropriate design parameters are used.

Maximum Infiltration Rate Test

The maximum infiltration rate test is used to estimate the maximum sub-surface vertical infiltration rate of the soil below a proposed infiltration tank, pond or closed depression. The test is designed to simulate the physical process that will occur during design storm event conditions, therefore, a saturation period is required to approximate the soil moisture conditions that would occur during a major storm event.

Testing Procedure

(1) Excavations shall be made to the bottom elevation of the proposed infiltration facility. The maximum infiltration rate of the underlying soil shall be determined using either the EPA falling head percolation test procedure (Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA, 1980) or the double ring infiltrometer test (ASTM D3385).

(2) The test hole or apparatus is filled with water and maintained at depths above the test elevation for a period of not less than 4 hours (the saturation period).

(3) Following the saturation period, the rate shall be determined in accordance with the specified test procedures, with a head of 6 inches of water.

(4) The engineer shall perform sufficient tests to determine a representative infiltration rate for the site, but at least three tests shall be performed for each proposed tank or pond site, and at least 2 tests per acre and a minimum of 4 tests shall be performed for each closed depression. The measured rate shall have the following factor of safety applied: for the EPA method F.S. = 2.0; for ASTM D-3385, F.S. = 1.75.

(5) A minimum of two soils logs, extending a minimum of 5 feet in depth below the bottom of each proposed tank and a minimum of two soils logs, extending a minimum of 5 feet in depth below the bottom of each proposed pond shall be obtained for each 10,000 square feet (plan view area) of proposed pond infiltration surface area. The logs shall describe the S.C.S. series of the soil, the textural class of the soil horizon through the depth of the log, and note any evidence of high groundwater level, such as mottling.

TABLE 4.5.2 MAXIMUM INFILTRATION RATES FOR SOIL TYPES

Soil Texture Class (U.S.D.A.)	Maximum Infiltration Rates (Inches per Hour)	Maximum Infiltration Rates (Inches Per Minute)
1. Coarse sands or Cobbles	20	0.33
2. Medium sand	8.0	0.13
3. Fine sand, loamy sand	2.4	0.04
4. Sandy loam	1.0	0.017
5. Loam	0.50	0.008

100-Year Overflow Conveyance

An overflow route shall be identified in the event the tank or pond infiltration capacity is exceeded or the facility becomes plugged and fails. Ponds shall have an emergency spillway designed in accordance with the R/D pond standards. All infiltration overflow systems shall be designed to convey the 100-year 24-hour design storm event to the natural surface outlet. All overflow systems shall meet the requirements of Section 1.2.1.

Oil Spill Control

All infiltration facilities must have an oil spill control device upstream of the facility to capture any oil or other floatable contaminants before they enter the infiltration facility. The oil control device may consist of a Tee section in a catch basin or manhole. The oil control device shall provide protection up to the 10-year design storm.

Groundwater Protection Standards

The protection of groundwater quality is recognized as an issue of greater concern than in the past and groundwater protection standards are changing rapidly. Increased safeguards are required. The applicant must check state and other local regulations such as the Critical Aquifer Recharge Areas ordinance, basin plans, community plans, King County Health Department regulations and check with local water purveyors to determine if there are sole source aquifers, wellhead or groundwater protection zones, or aquifer recharge areas which may impose more stringent requirements on infiltration facilities than those in this manual. Groundwater purveyors should be responsible for determining the capture zones of their water supply wells. If federal, state or other local jurisdictions have more stringent groundwater protection requirements than those contained herein, the more stringent requirements shall apply.

In no case should infiltration ponds and tanks be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies. Where water supply wells exist nearby, it is the

responsibility of the applicant's engineer to locate such wells, meet any applicable protection standards and assess possible impacts of the proposed infiltration facility on groundwater quality. If negative impacts on a community water supply are possible, additional runoff treatment must be included in the facility design or relocation of the facility should be considered. At a minimum, all infiltration facilities located within the one-year capture zone of any well must provide a wet pond or water quality swale upstream of the infiltration facility.

Runoff Treatment

Inflow to infiltration ponds and tanks shall be pre-treated for sediment removal. A water quality facility or biofiltration facility as described in Special Requirement #5, Special Water Quality Controls (Section 1.3.5) which treats all runoff from the site (except from roofs) before it enters the infiltration facility satisfies this requirement; otherwise, a settling pond or vault as described below is required. Where Special Requirement #5 does not apply and the measured mean infiltration rate exceeds 9 inches per hour, a wet pond, wet vault, water quality swale or biofiltration facility must be used, since soils with high infiltration rates will generally not treat runoff as effectively as soils with slower infiltration rates.

Settling Pond/Vault Requirements

The settling pond or vault should be an overflow/flow-through type system installed upstream of the infiltration facility. The surface area of settling ponds/vaults must be at least 0.5% of the total impervious surface area tributary to the facility. Settling facilities must be between 4 feet and 6 feet deep and have a length to width ratio of at least 3:1. The inlet(s) and outlet should be situated to maximize the length of travel through the settling pond/vault. Berms or baffles may be used to lengthen the travel distance if site constraints limit the inlet/outlet placement. Inlets should be designed to minimize velocity and turbulence. Roof runoff need not be treated before entering an infiltration facility.

Erosion Control Requirements

Infiltration systems must not be put into service before the upstream areas are properly stabilized. Untreated runoff could permanently impair the functioning of an infiltration system. Section 1.2.3 of this manual states that "Infiltration facilities may not be operated until all proposed project improvements which produce surface runoff are complete, especially revegetation and landscaping. In the case of projects with individual lots remaining undeveloped, these lots must contain and infiltrate their runoff through individual sediment traps ... acting as infiltration ponds until permanent improvements and landscaping are established." An alternative to this approach is to provide a large sediment trap on an undeveloped tract to serve the undeveloped lots, which is to be left in place until all clearing and construction is complete and all permanent landscaping is in place (see Section 5.4.5-1 for design details). At the completion of all construction, the sediment trap must be cleaned out (taking care that no sediment enters the drainage system) and filled in, and the flow routed to the permanent drainage system.

Construction Guidelines for Infiltration Facilities

Excavation of infiltration systems should be done with a backhoe working at "arms length" to minimize disturbance and compaction of the completed infiltration surface. If the bottom of the facility will be less than three feet below grade, the facility area should be cordoned off so that construction traffic does not traverse the area. The exposed soil should be inspected by the soils engineer after the infiltration facility has been excavated to confirm that the soil conditions are suitable.

Two simple staff gages for measuring sediment depth should be installed at opposite ends of the bottom of ponds. The gages can consist of 1 inch pipe driven at least one foot into the soil in the bottom of the pond, with 6 inches of the pipe protruding above grade.

4.5.3 INFILTRATION TANKS

Infiltration tanks consist of underground pipe that has been perforated to allow detained surface water to be infiltrated. Figure 4.5.3A shows a typical infiltration tank.

Limitations

- Not allowed on slopes greater than 25% (4:1).
- Infiltration surface elevation (bottom of trench) must be in native soil (excavated at least one foot in depth).

Design Criteria

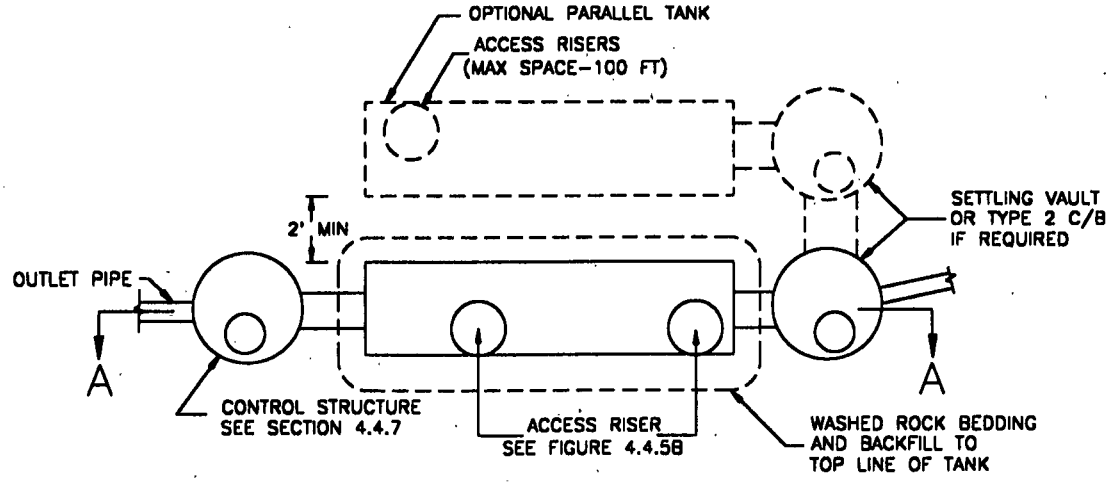
- Bottom of infiltration tank trench shall be at least three feet above the seasonal high groundwater level.
- The spacing and construction of structures, materials allowed, accessibility for maintenance, easements and hydraulic design methods shall be the same as those described for detention tanks in Section 4.4.5, except for features needed to allow infiltration.
- Minimum spacing between parallel tanks shall be equal to 2 times the distance from the bottom of the lowest tank to the ground surface.
- All tanks shall be a minimum of 20 feet from any structure, property line, Native Growth Protection Easement, Sensitive Area Tract or Sensitive Area Setback Area, and distance from any septic tank/drain field shall be consistent with the Seattle-King County Health Department requirements.
- All tanks shall be a minimum of 50 feet from any steep slope. A geotechnical report must address the potential impact of the tank infiltration on the steep slope (see Section 1.3.11).
- Tanks shall be bedded and backfilled with washed drain rock which extends at least 1 foot below the bottom of the tank, at least 2 feet beyond the sides, and extends to the top of the tank.
- Filter fabric shall be placed over the top of the drain rock prior to backfilling.

Method of Analysis

The size of the tank shall be determined by using the hydrograph methods described in Chapter 3 and the stage/discharge curve developed from the recommended design infiltration rate as described in Section 4.5.2. At a given stage the discharge can be computed using the area of the surface through which infiltration will occur (A_i) multiplied by the recommended design infiltration rate (in appropriate units). The area (A_i) used for determining the potential infiltration from the tank shall be computed by taking the lesser of two times the width of the tank, or the trench width, and multiplying by the length of the tank.

The storage volume in the tank is used to detain runoff prior to infiltration with the perforations providing the outflow mechanism. The perforations (holes) in the tank must be one inch in diameter and located in the bottom half of the tank starting at an elevation of 6 inches above the invert of the tank. The number and spacing of the perforations should be sufficient to allow complete utilization of the available infiltration capacity of the soils with a safety factor of 2.0 without jeopardizing the structural integrity of the tank.

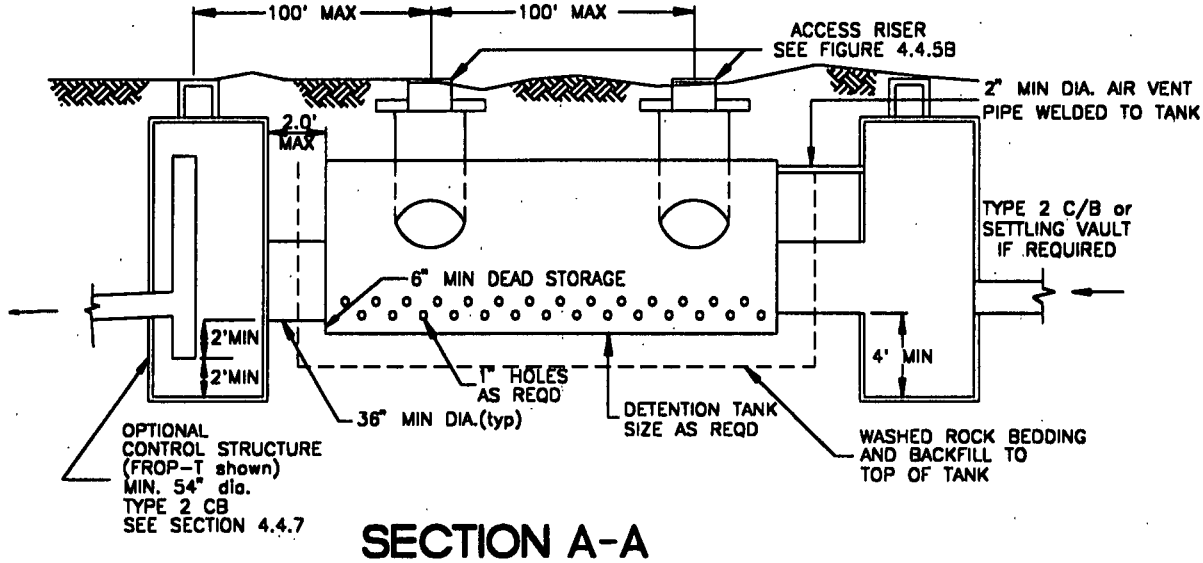
FIGURE 4.5.3A SAMPLE INFILTRATION TANK



PLAN VIEW

NO SCALE

Optional Design for Parallel Tank Shown Dashed



SECTION A-A

NO SCALE

NOTES: All metal parts corrosion resistant
Steel parts galvanized and asphalt coated
(Treatment I or better)

FILTER FABRIC TO BE PLACED
OVER WASHED ROCK BACKFILL

4.5.4 INFILTRATION PONDS

Infiltration ponds may be constructed using excavation and constructing berms. See Figure 4.5.4A for sample detail.

Limitations

- Not allowed on slopes greater than 25% (4:1).
- Infiltration surface elevation (bottom of pond) must be in native soil (excavated at least one foot in depth).

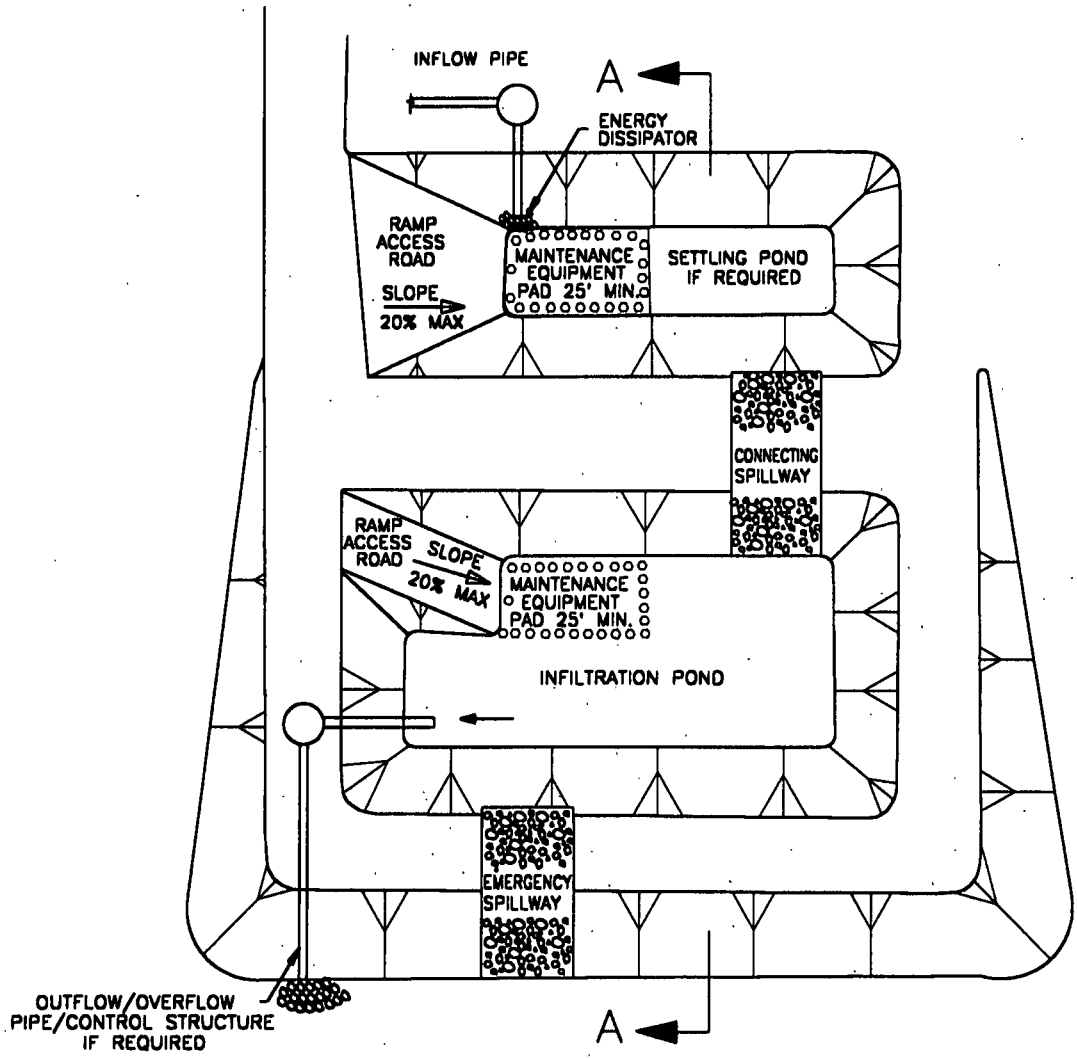
Design Criteria

- Bottom of the proposed pond must be at least 3 feet above the seasonal high groundwater level.
- The construction of structures, materials allowed, accessibility for maintenance, easements, and hydraulic design methods shall be the same as those described for detention ponds in Section 4.4.4, except as required for the infiltration design.
- All ponds (at the maximum potential water surface elevation) shall be a minimum of 20 feet from any structure, property line, Native Growth Protection Easement, Sensitive Area Tract, Sensitive Area Setback Area, and distances from any septic pond/drain field shall be consistent with the Seattle-King County Health Department requirements.
- All ponds shall be a minimum of 50 feet from any steep slope. A geotechnical report must address the potential impact of the pond infiltration on the steep slope (see Section 1.3.11).

Method of Analysis

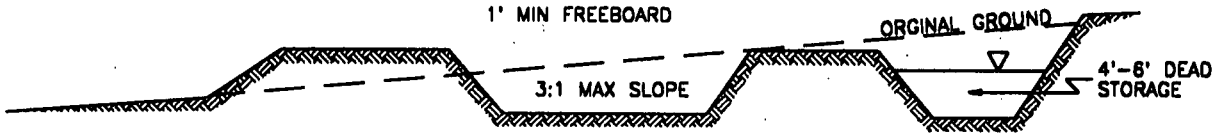
The size of the pond shall be determined by using the hydrograph methods described in Chapter 3 and the stage/discharge curve developed from the design infiltration rate recommended by the soils engineer, as described in Section 4.5.2. The storage volume in the pond is used to detain runoff prior to infiltration. At a given stage the discharge can be computed using the area of the pervious surface through which infiltration will occur (A_i) multiplied by the recommended design infiltration rate (in appropriate units). Berms, which should be constructed of impervious soil, and lined swales should not be included in the design pervious surface area.

FIGURE 4.5.4A SAMPLE INFILTRATION POND



PLAN VIEW

NO SCALE



SECTION A-A

NO SCALE

4.5.5 ALTERNATIVE SYSTEMS

The purpose of this section is to present alternative types of infiltration facilities. It is our aim to encourage the use of infiltration wherever feasible. We encourage the use of other alternative (experimental) systems not specifically described here, but such systems will require a variance.

Small Infiltration Basins

Small infiltration basins consist of a bottomless, pre-cast concrete catch basin or equivalent structure placed in an excavation filled with washed drain rock. Stormwater infiltrates through the drain rock into the surrounding soil. This facility is intended for use with contributing surface areas of less than 5000 square feet. Small infiltration basins can incorporate a variety of pre-treatment features including settlement basins, spill containment, and additional water quality pre-treatment (see Figure 4.5.5A for a generic design sketch). Runoff from paved areas must be treated by the use of filter strips or other appropriate water quality BMPs before runoff enters the infiltration portion of the system.

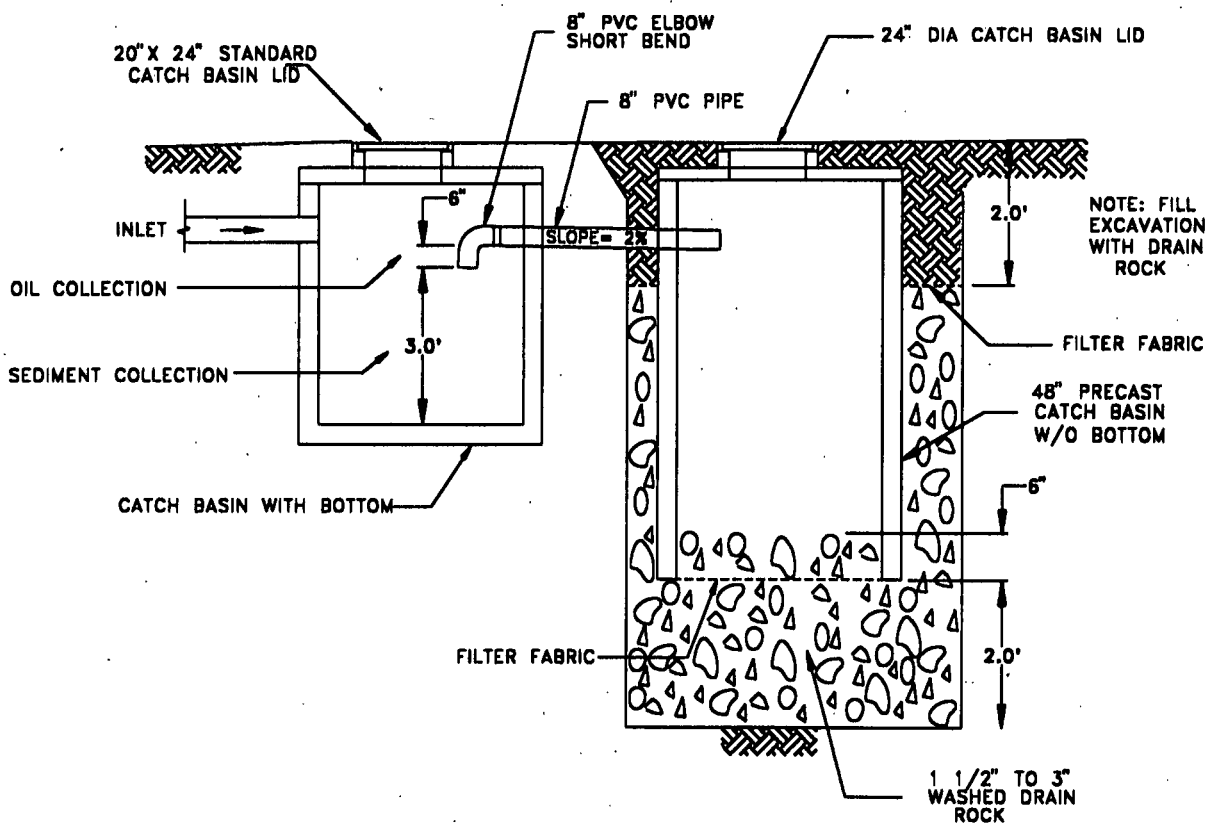
The design criteria for small infiltration basins are essentially the same as for infiltration tanks (see Sections 4.5.2 and 4.5.3), except that only one infiltration rate test and soil log is required for each small infiltration basin. Access into the basins shall be provided for inspection and maintenance. Designs could incorporate Type II catch basins, but equivalent designs using other materials may be accepted.

Modular Grid Pavement

Modular grid pavement is not a facility per se, but does provide localized infiltration. It is designed for low traffic driveways, overflow parking areas, maintenance access roads, etc. The use of modular grid pavement can decrease the size of retention/detention facilities, since the area covered by the pervious pavement may be considered to be a grassed pervious surface rather than an impervious surface when the site is modeled. Modular grid pavement consists of a lattice of concrete, plastic, or other load bearing material, over a permeable base course such as gravel or sand. The actual pavement design should be done by the project engineer, but a minimum of 6 inches of permeable base should be placed under the pavement. Grass may be grown in the interstices of the grid.

Modular grid pavement may be used off right-of-way in low-traffic or infrequently used areas (less than 6-10 trips per day). Provisions for the removal of oil and grease contaminated soils should be included in the maintenance plan for modular grid pavements. The finish grade of the soil surface within the pavers should be about three-fourths inch below the top of the pavers. Smooth surfaced walkways may be run across modular grid pavements, but impervious surfaced walkways should not exceed 10 percent of the total paved surface.

FIGURE 4.5.5A CONCEPTUAL SMALL INFILTRATION BASIN



X - SECTION

NO SCALE

4.5.6 DISPERSION OF ROOF RUNOFF

All roof runoff from lots in new plats and short plats must be either infiltrated or dispersed, or stub-outs to the plat drainage system must be provided. Where lots are less than 22,000 square feet and infiltration is feasible, infiltration is required either on the individual lot (see Section 4.5.1) or within the plat. If infiltration is not feasible and the dispersion criteria are met, dispersion is allowed (see below). If infiltration or dispersion is not feasible, stub-outs shall be used to connect the roof drains to the plat drainage system (where there is a pipe drainage system). Connections to the stub-outs shall be perforated connections, as described below.

Dispersion of roof runoff is required on residential lots in new plats and short plats which are larger than 22,000 square feet. The dispersion on lots exceeding 22,000 square feet may consist of either splash blocks at the downspouts or a downspout dispersion system, as described below. The system must be designed so that no significant erosion or flooding problems are created. The discharge points should be at least 50 feet from roadways or storm water collection systems and the area downstream should be vegetated for a distance of at least 50 feet. On large lots with dispersion systems where the distance to the property line, roadways and drainage collection points is at least 50 feet, the roof areas that are dispersed may be modeled as grassed rather than impervious area for plat or short plat R/D design. If the 50 foot minimum distance cannot be met, and the discharge can travel over at least 25 feet of vegetation before leaving the property, 50% of the dispersed roof area may be modeled as grassed pervious surface. Where the risk of a significant flooding or erosion problem exists or the travel path to the property line is less than 25 feet, a perforated stub-out connection (as described below) will be allowed, but no reduction of impervious area for flow control calculations will be allowed.

Dispersion of roof runoff is allowed on residential lots from 9600 to 22,000 square feet where the overflow can travel over at least 25 feet of vegetated area before leaving the property and does not pose a significant flooding or erosion problem. Dispersion trenches (as described below) or splash blocks may be used. Where dispersion trenches are used, 50% of the dispersed roof area may be modeled as grass covered pervious soil when sizing R/D facilities. No reduction in impervious area calculation is allowed where splash blocks are used. Stub-outs shall be provided for lots which do not disperse roof runoff, and stub-outs may be provided to all lots to collect drainage from footing drains, driveway drains, etc. The stub-out connections shall be perforated, as described below.

Dispersion of roof runoff is allowed on residential lots less than 9600 square feet where the overflow from the discharge points can travel over at least 25 feet of vegetated area before leaving the property and does not pose a significant flooding or erosion problem. Dispersion trenches or splash blocks may be used. No reduction in impervious area will be allowed on lots less than 9600 square feet. Stub-outs must be provided on all lots less than 9600 square feet. Where roof drains are connected to the stub-outs, a perforated connection shall be used.

TABLE 4.5.6 DISPERSION CRITERIA SUMMARY

LOT SIZE	>22,000 SF	9600-22,000	<9600 SF
Dispersion Trench	OK, CR*	OK, CR	OK, NC
Splash Blocks	OK, CR	OK, NC	OK, NC
Perforated Stub-out	OK, NC*	OK, NC	OK, NC
Credit	See Note 1	See Note 2	None

* CR = CREDIT, NC = NO CREDIT.

Note 1: Where the travel distance is at least 50 feet, 100% of the impervious roof area may be modeled as grassed pervious area when calculating required R/D size. Where the travel distance is between 25 and 50 feet, 50% of the impervious roof area may be modeled as grassed pervious area when calculating required R/D size.

Note 2: Where dispersion trenches are used and there is at least 25 feet of vegetated surface between the outfall and the property line, 50% of the impervious roof area may be modeled as grassed pervious area when calculating required R/D size.

Dispersion Trench System Design

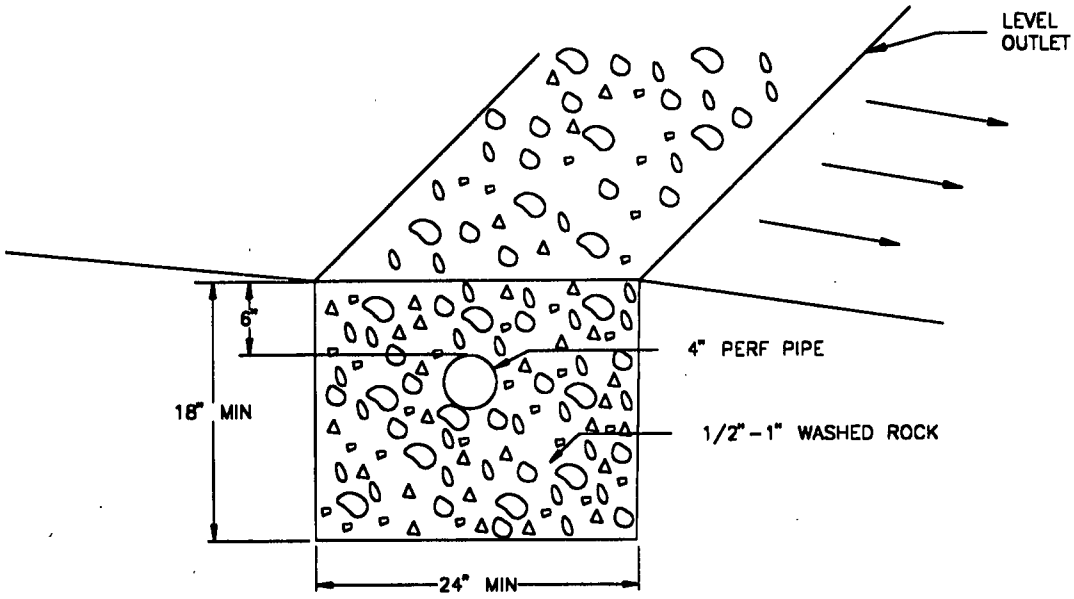
Downspout dispersion systems should be broken up to require a separate segment for each 700 square feet of roof, with no segments directly uphill from other segments. Discharge points are not to be located within 10 feet of property lines, adjacent to steep slopes, or in a manner which would cause flooding or erosion problems on downstream properties, or flow over septic systems. All discharges must be directed into vegetated areas.

Each trench segment should include a small catch basin (plastic is acceptable) for sediment removal and overflow. There should be 10 feet of trench per segment. The trenches should be level, 2 feet wide, 18 inches deep, filled with drain rock to the surface and have a 4 inch perforated pipe laid with 6 inches of rock cover (see Figure 4.5.6A).

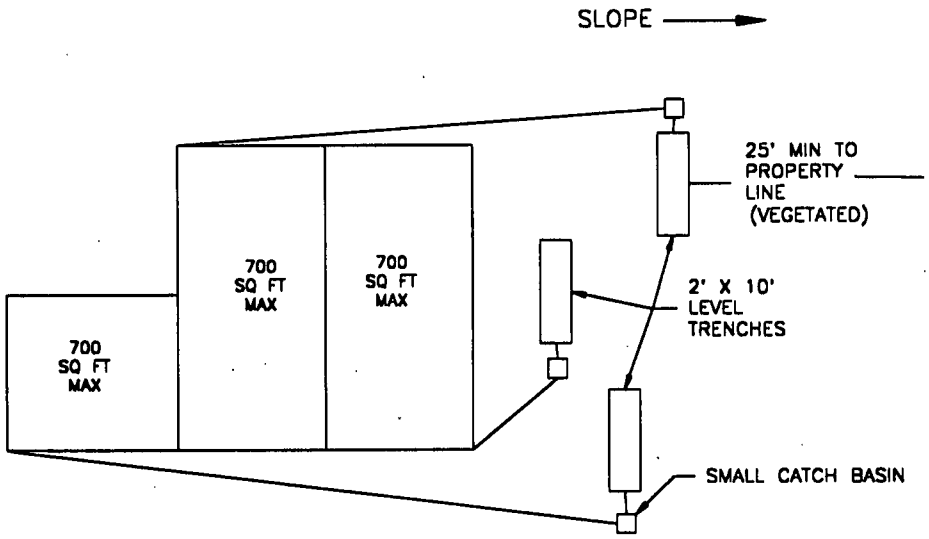
Perforated Stub-Out Design

The perforated stub-out connection shall be placed between the downspouts and the stub-out to the storm drain. The location of the perforated connection should be selected to allow a maximum amount of runoff to infiltrate into the ground (ideally a dry location on the site that is relatively well-drained). Perforated stub-out connections shall consist of at least 10 feet of perforated pipe laid in a level 2 foot wide trench backfilled with washed drain rock. The drain rock shall extend to a depth of at least 8 inches below the bottom of the pipe and shall cover the pipe. The pipe shall be laid level and the rock trench shall be covered with filter fabric and 6 inches of random fill (see Figure 4.5.6B).

FIGURE 4.5.6A DOWNSPOUT DISPERSION TRENCH



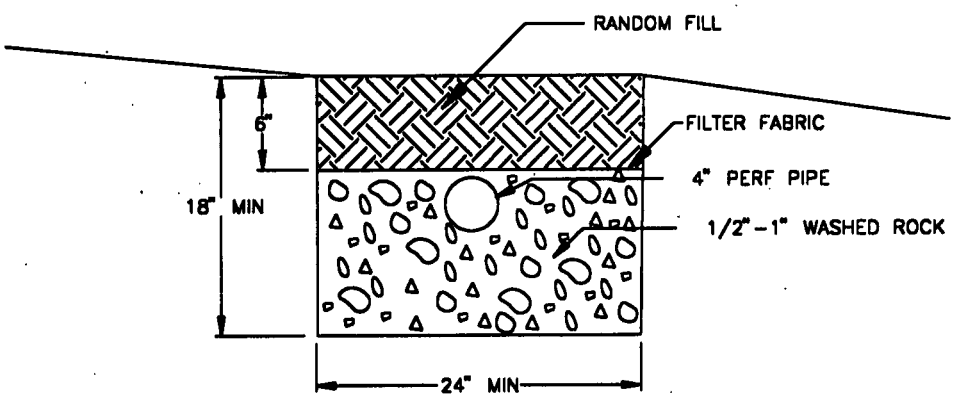
TRENCH X-SECTION



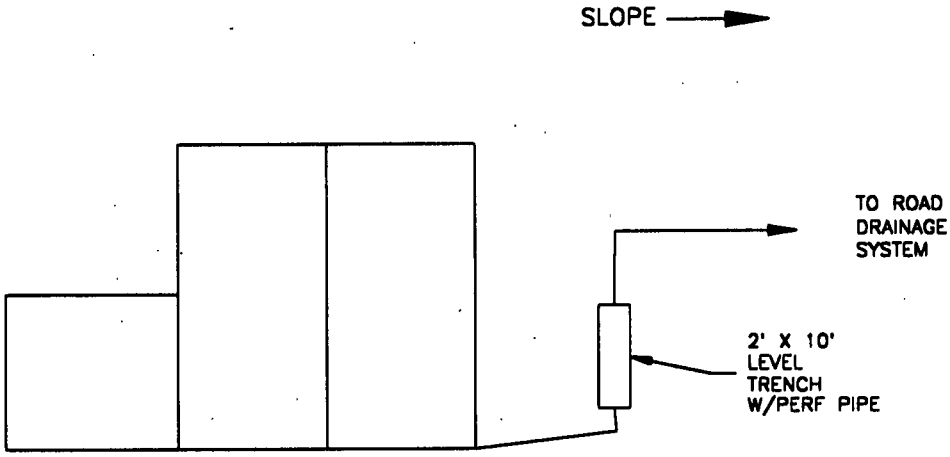
PLAN VIEW OF ROOF

NOTE: NOT TO SCALE

FIGURE 4.5.6B PERFORATED STUB-OUT DESIGN



TRENCH X-SECTION



PLAN VIEW OF ROOF

NOTE: NOT TO SCALE

4.6 WATER QUALITY FACILITY DESIGN

See the overview of Surface Water Policies in the Reference section, for a discussion of the mechanisms of pollutant removal and water quality benefits of wet ponds and swales.

Exemption: Runoff from roofs will not require water quality treatment for proposed projects required to provide any of the water quality facilities in this Section provided the roof runoff will not flow through the water quality facility, and the BALD Division determines that granting this exemption will not produce significant adverse impacts to downstream water quality. Note, this exemption does not exempt projects from providing peak rate runoff control for runoff from roofs, however, it may allow significant reduction in the required size of the water quality facilities contained in this Section.

Liner to Prevent Groundwater Contamination

Significant concern exists regarding the potential contamination of groundwater resources (both potable and aquatic) from inadequately treated surface water runoff that may be immediately infiltrated at water quality control facilities serving impervious areas of intensive use (such as for proposed arterial roadways, and multi-family residential, commercial, manufacturing and industrial projects). These water quality facilities include wetponds, water quality swales and biofiltration facilities located over rapidly draining soils.

In order to address this concern, these water quality facilities, proposed to be located in soils with a minimum infiltration rate (see Section 4.5.1), or permeability, of more than 9 inches per hour (0.15 inches per minute), must have a "lining" system to prohibit infiltration under the water quality facility. Of course, infiltration facilities provided for peak rate runoff control would be located downstream of these and any other water quality control facilities.

Design Criteria

- The liner material must be either a commercial heavy plastic pond liner (minimum 40 mil) or a bentonite clay (minimum 12" thick).
- A layer of compacted top soil (minimum 18" thick shall be placed over the liner prior to seeding with the appropriate seed mixture (see Section 5.5.4).

4.6.1 WATER QUALITY SWALES

Water Quality Swales

Water Quality Swale shall be designed to meet the requirements of Special Requirement #5: Special Water Quality Controls, Section 1.3.5.

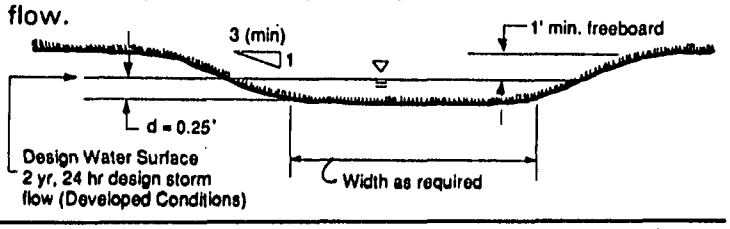
Design Criteria

- See Figure 4.6.1A for detail.
- The materials allowed, vegetation required, accessibility for maintenance, easements, and hydraulic design methods shall be the same as those described for open channels in Section 4.3.7.

Method of Analysis

The width of the swale bottom shall be determined by using the hydrograph methods described in Chapter 3 to compute the required design flow.

FIGURE 4.6.1A WATER QUALITY SWALE



4.6.2 WETPONDS AND WETVAULTS

Wetponds and Wetvaults shall be demonstrated to be designed to meet the requirements of Special Requirement #5: Special Water Quality Controls, Section 1.3.5, at the 4- to 7-foot design depth.

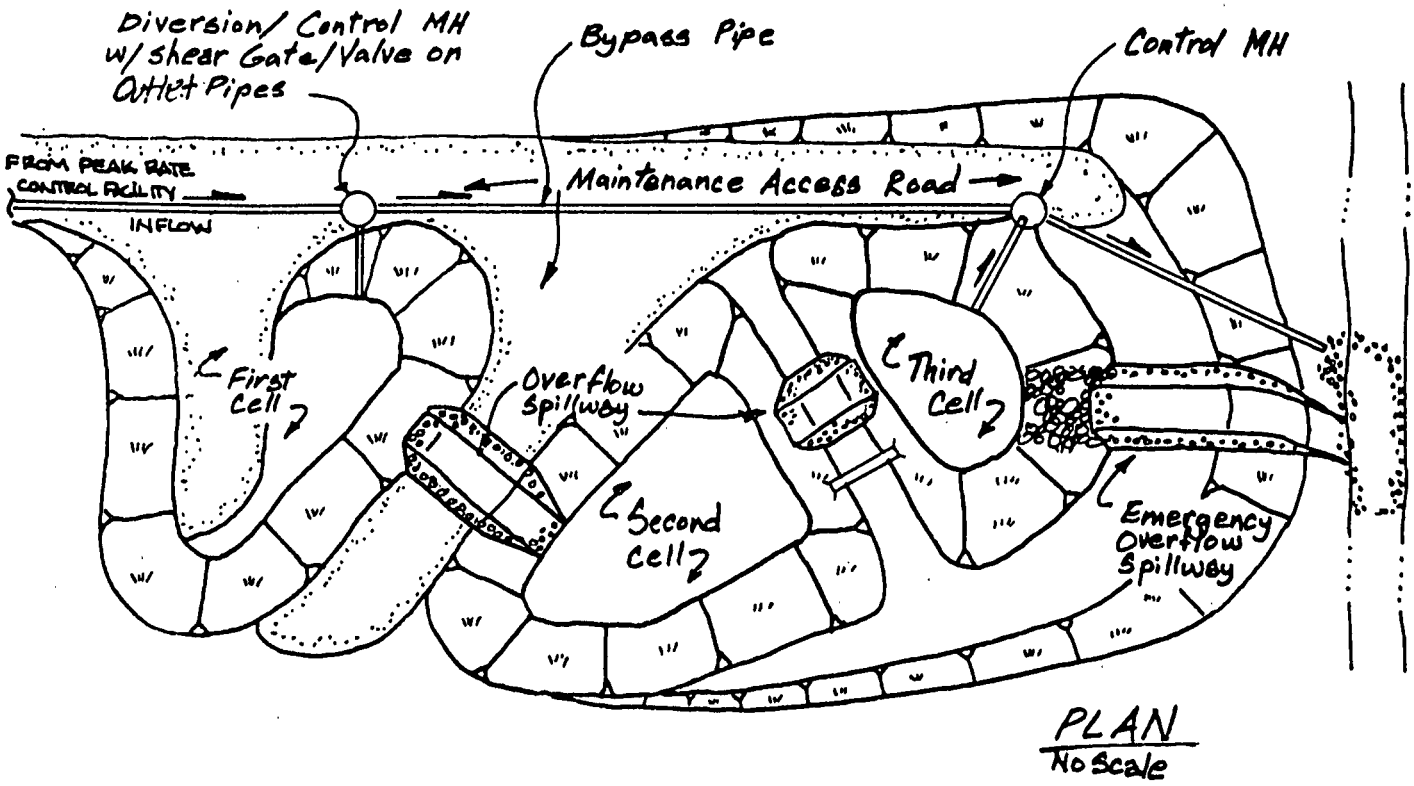
Design Criteria

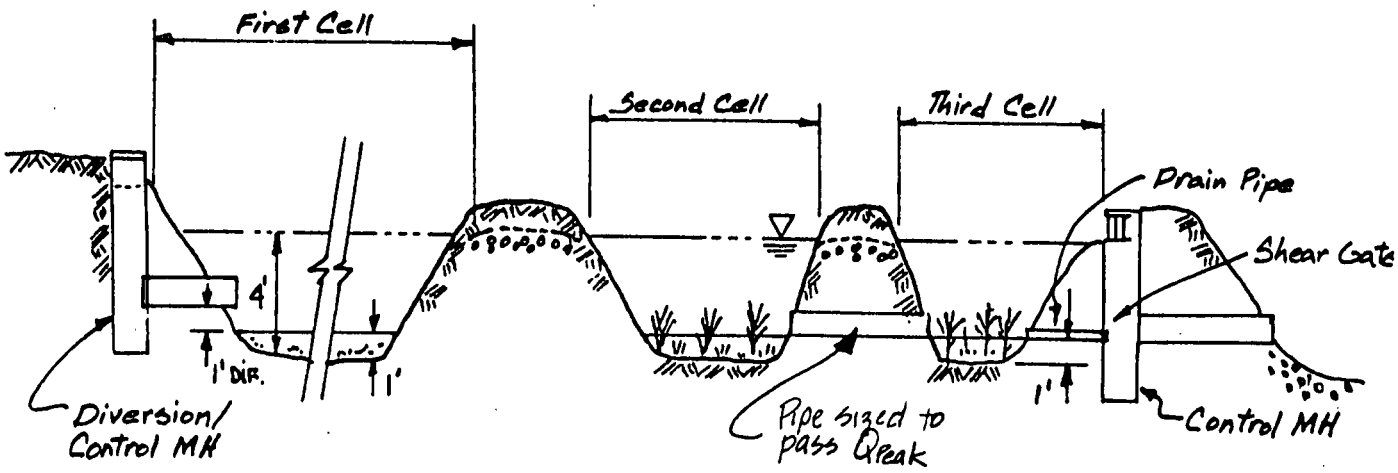
- See Figure 4.6.2A for details.
- The depth of the permanent pool in the facility shall be 3 to 6 feet plus one foot of dead storage for sediment.
- The inlet and outlet shall be placed to maximize travel time through the facility. The inlet shall be placed just above the dead storage.
- A gravity drain for maintenance shall provide an outlet invert of one foot above the bottom of the facility and shall be sized to drain the facility in four hours or less. Controlled by a valve in the control manhole.
- The peak flow for the Pt-wq design storm for the developed conditions shall pass through the facility. Flows in excess of the Pt-Wq design storm shall bypass the facility in a separate conveyance to the point of discharge. A mechanism must be provided at the bypass point to allow the facility to be taken "off-line" manually for maintenance and repair.
- The length-to-width ratio of the facility at the design surface area shall be no less than three-to-one (preferably five to one).
- The facility shall be divided into three cells. The first cell (the "forebay") shall contain approximately ten percent of the design surface area. The second cell shall contain approximately 45 percent of the design surface area.
- For Wetponds the construction of structures, materials allowed, vegetation required, accessibility for maintenance, easements and hydraulic design methods shall be the same as those described for detention ponds in Section 4.4.4.
- For Wetvaults the construction, materials allowed, accessibility for maintenance, easements and hydraulic design methods shall be the same as those described for detention vaults in Section 4.4.6.
- For Wetpond cells with design surface areas exceeding 10,000 square feet, a 5 foot wide safety bench shall be provided around the perimeter of the cell with a water depth not exceeding 1 foot in depth. The bench shall be planted with emergent wetlands vegetation (such as cattails) to discourage entry into the water.
- All facilities shall be a minimum of 20 feet from any structure, property line, NGPE, and distances from any septic tank/drain field shall be consistent with Seattle-King County Health Department requirements.
- All facilities shall be a minimum of 50 feet from any steep slope. A geotechnical report must address the potential impact of a wetpond on a steep slope (see Section 1.3.11).

Method of Analysis

The volume of storage in the facility and the peak flows for hydraulic design shall be determined by using the hydrograph methods described in Chapter 3.

FIGURE 4.6.2A SAMPLE WET POND





SECTION
No Scale

4.6.3 COMBINED WETPOND/DETENTION POND

Detention ponds that combine the performance requirements of wetponds shall be designed to:

- meet the requirements of Special Requirement #5: Special Water Quality Controls, Section 1.3.5, within the dead storage area of the detention pond.
- meet the requirements of Core Requirement #3: Runoff Control, Section 1.2.3., and Section 4.4 for the live storage detention area.

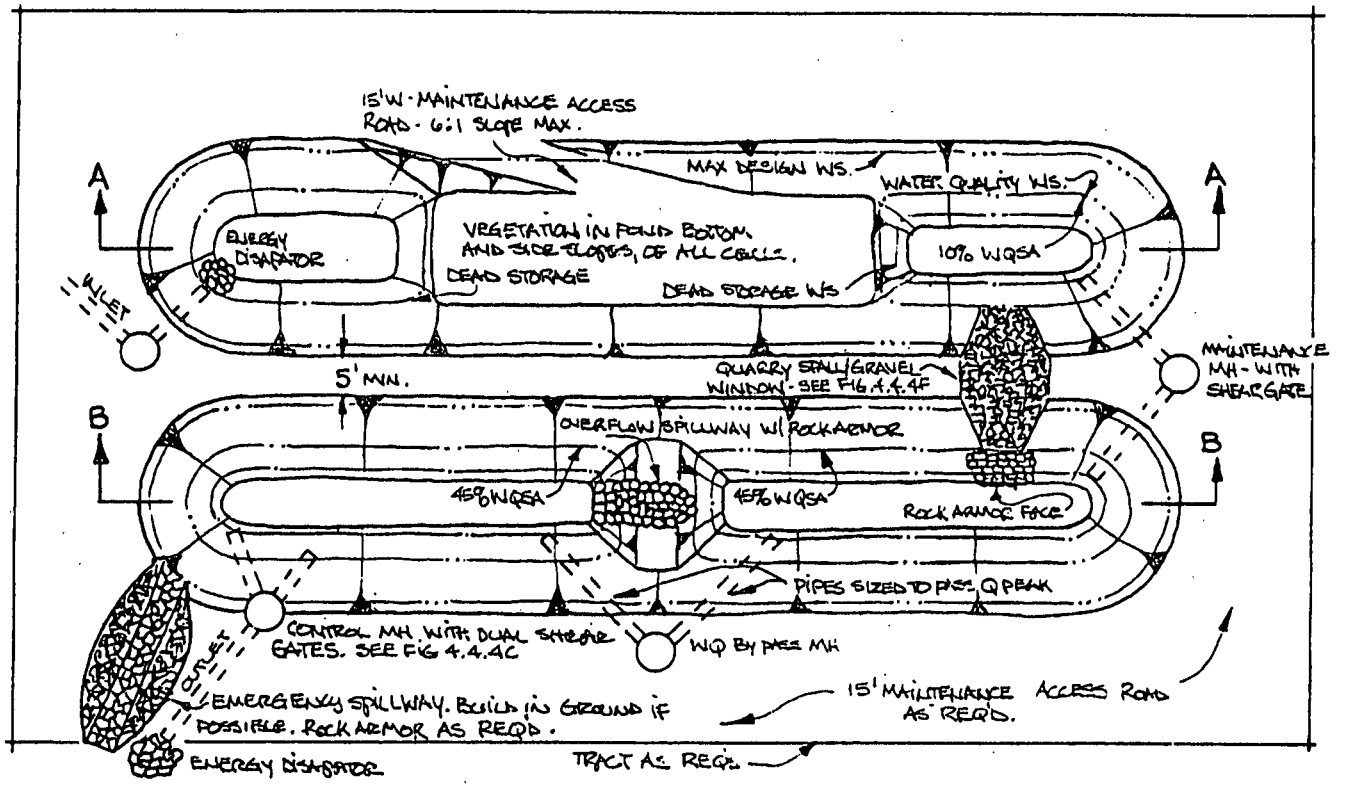
Design Criteria

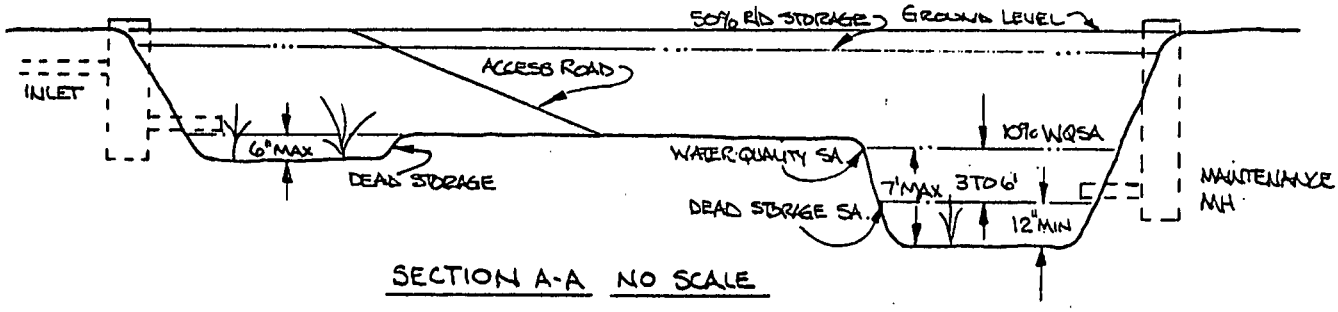
- See Figure 4.6.3A for details.
- The wetpond portion of the combined facility shall meet all design criteria in Section 4.6.2.
- Flows above the peak flow for the Pt-wq design storm for the developed conditions shall <u>not</u> bypass the facility. All flows are required to be conveyed through the facility.
- The detention portion of the combined facility shall be added above the wetpond storage and shall meet all design criteria in Section 4.4.
- The dead storage criteria for detention facilities is met by the wetpond storage and six inches of dead storage provided at the inlet covering one third of the first cell. The volume of the wetpond dead storage shall not be counted towards the detention volume requirements.
- The length-to-width ratio of the facility at the design surface area shall be no less than five-to-one due to the higher flows and energy of the facility.
- The sizing of the first cell shall be controlled by the requirement to contain 50 percent of the detention volume as live storage. Dead storage shall contain, at a minimum, the wetpond volume needed to produce 10 percent of the water quality surface area at the design elevation and be lined to minimize turbulence. The inflow shall be placed to maximize distance to the gravel window.
- The sizing of the remaining cells shall be controlled by the requirement to contain the wetpond volume as dead storage in two cells needed to produce 90 percent of the water quality surface area at the design elevation. Live storage shall contain, at a minimum, 50 percent of the detention volume.
- The control structure shall be based on the details in Section 4.7. The inlet crown elevation shall be placed at the wetpond design water surface (see Section 4.6.2). An additional gravity drain for maintenance shall be provided one foot above the bottom of the facility and shall be sized to drain the facility in six hours or less.

Method of Analysis

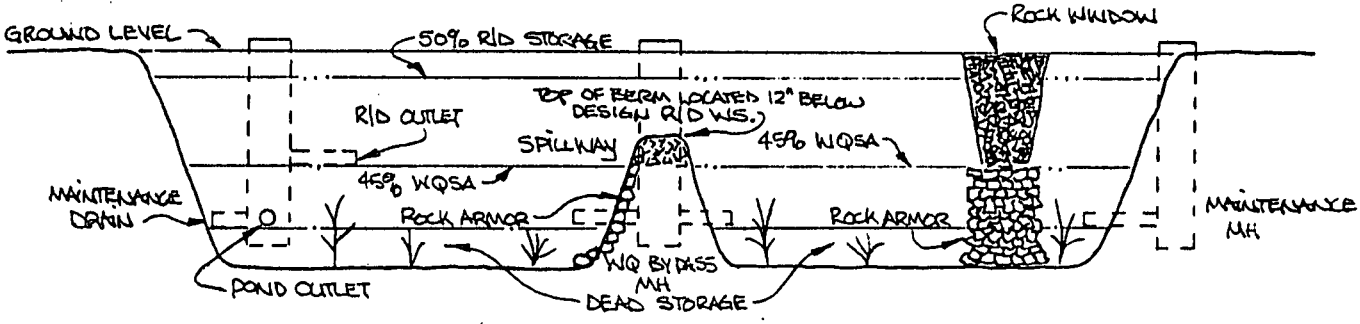
The volume of storage in the facility and the peak flows for hydraulic design shall be determined by using the hydrograph methods and routing procedures described in Chapter 3. The volume determined for the wetpond shall be added to the volume of the detention facility. Detention performance shall be analyzed assuming the wetpond is full.

FIGURE 4.6.3A SAMPLE COMBINED WETPOND/DETENTION POND





SECTION A-A NO SCALE



SECTION B-B NO SCALE

4.6.4 BIOFILTRATION FACILITIES

Core Requirement #3, in Section 1.2.3, specifies when biofiltration facilities must be provided to treat proposed project runoff. Note, biofiltration facilities may be installed prior to, or following, peak rate runoff control facilities but will always precede water quality ponds, vaults or swales.

Facilities designed to improve the quality of storm and surface water runoff through the application of biofiltration have been shown by a number of studies to be effective in removing a significant amount of the total suspended solids, fine sediments, some non-soluble heavy metals, and some nutrients from the runoff. Locally, a study by Professor Richard Horner of the University of Washington's Civil Engineering Department, sponsored by the Washington State Department of Ecology, the Municipality of Metropolitan Seattle (METRO), King County, and the cities of Bellevue, Mountlake Terrace and Redmond, developed guidelines for sizing biofiltration swales and filter strips. In addition, work performed by Dr. Gary Minton, Resource Planning Associates, for the City of Seattle "Water Quality: Best Management Practices" Manual has demonstrated the practical application of the results of both theoretical and empirical research to the design of biofiltration facilities.

There are two types of biofiltration facilities described in this Section. They are biofiltration swales and filter strips. A biofiltration swale is essentially a vegetation lined channel with the runoff treated by flowing at a shallow depth and relatively slow velocity through the vegetation. The biofiltration swale is best suited to treat runoff that has been collected and concentrated such as at the outfall to a peak rate runoff control facility. Filter strips are areas covered by vegetation over which runoff sheet flows at a very shallow depth and in a dispersed manor. Filter strips are well suited to treating runoff from impervious areas such as parking lots where frequent gaps in the extruded asphalt curbing provide dispersed inflow points to the filter strip.

Design Criteria

<u>General</u>

- Biofiltration swales and filter strips shall be designed consistent with the requirements for conveyance system analysis and route design criteria in Section 4.3.2 and the design criteria for open channels in Section 4.3.7, unless superseded by the following design criteria.
- Biofiltration swales shall have a maximum bottom width of 50 feet.
- Biofiltration swales shall have one foot high (and one foot keyed below the swale invert) check dams placed every 50 feet along their length starting 20 feet downstream from the inflow point. The check dams shall have 2:1 side slopes and be constructed of rip rap per table 4.3.6A (100 % passing an 8" sieve).
- Curbing for impervious areas tributary to filter strips shall be designed with a one-foot gap for every 5 feet of curbing.
- The transverse slope of impervious areas tributary to filter strips shall be level, and the impervious area cross slope shall not exceed 10 percent.

<u>Geometrics</u>

- Biofiltration swales shall be trapezoidal or rectangular in shape, based on the side slope and stabilization criteria contained in Section 4.3.7.
- The length of biofiltration swales should be at least 200 feet, wherever feasible. The length may be reduced to a minimum of 50 feet provided the surface area of the design water surface at the biofiltration design flow is equal to that computed based on a 200 foot length (see Method of Analysis below).
- The 200 feet of biofiltration swale length may be achieved by dividing the swale into segments (minimum 50 feet in length) with interconnecting pipes to transfer runoff between segments. This is particularly useful on slopes which exceed 6 percent where the segments can traverse the slope and thus "step" the biofiltration swale down the slope.

- Filter strips shall be designed so that each lineal foot of length will receive runoff from a maximum of 140 square feet of impervious surface.
- Filter strips shall be a minimum of 15 feet in width and a maximum of 30 feet in width (both measured in the plan view).

Slope

- Biofiltration swales may have slopes up to 6 percent.
- Where the slope of a biofiltration swale will be less than 0.5 percent, or the seasonal mean ground water level will be at or above the swale bottom, emergent wetland vegetation must be planted.
- Filter strips shall have a minimum cross slope of 2 percent and a maximum cross slope of 15 percent.
- The transverse slope of filter strips (at the point where the filter strip meets the impervious surface) shall be level.
- Runoff from a filter strip shall be intercepted at the bottom of the strip by a swale sized to convey the peak rate of runoff for the maximum design storm event away from the bottom of the strip.

Vegetation

Biofiltration swales and filter strips shall be vegetated based on the physical conditions using either an urban (lawn and other areas to be frequently mowed), rural (for use in areas to be left un-mowed and more natural in appearance), or wetlands (swales only) seed mixture (per Section 5.5.4).

Methods of Analysis

Use Manning's Equation Method for Preliminary Sizing of Open Channels, as described in Section 4.3.7, to determine the cross-sectional geometry of a biofiltration swale using the following parameters.

Biofiltration Design Flow Rate

- Biofiltration swales shall be sized using a biofiltration design flow rate as specified in Core Requirement #3, in Section 1.2.3, using the hydrograph methods described in Chapter 3.
- Filter strips shall be sized by providing 0.23 square feet of strip per one foot length of tributary unit area of impervious surface.

Manning's Roughness "n"

- Use a Manning's "n" of 0.35 when sizing a biofiltration swale for biofiltration function. Use an appropriate Manning's "n" from Table 4.3.7B (such as 0.027 for lawns) when evaluating the swale for conveyance capacity and maximum velocity for stability.

Slope

- Regardless of the actual proposed biofiltration swale slope, use a slope of 2 percent when sizing the swale for biofiltration function. Use actual proposed slope when evaluating the swale for conveyance capacity and stability.

Velocity

- The velocity of runoff through the biofiltration swale or filter strip at the biofiltration flow rate shall not exceed 1.5 feet per second at a Manning's "n" of 0.35.

- The velocity of runoff through the biofiltration swale or filter strip for the maximum conveyance capacity design flow rate (see Core Requirement #4, Section 1.2.4) shall not exceed 5 feet per second.

Design Flow Depth

- Biofiltration swales shall be designed using a design flow depth at the biofiltration design flow rate by assuming a winter design height of vegetation as shown in Table 4.6.4A.

TABLE 4.6.4A DESIGN FLOW DEPTH BY TYPE OF VEGETATION

Type of Vegetation	Winter Design Height	Design Flow Depth
Urban (lawns)	3 inches	1 inch
Rural (natural areas)	6 inches	4 inches
Wetlands (wet areas)	10 inches	8 inches

Design Process

Biofiltration Swales

(1) Compute the biofiltration design flow rate.
(2) Determine the preliminary route and actual slope.
(3) Compute the bottom width of the swale based on the proposed vegetation type and side slopes (3 to 1 preferred).
(4) Check the velocity at the biofiltration design flow rate (Ignore the check dams and use the actual swale slope). If in excess of 1.5 feet per second, re-design the swale by decreasing the actual swale slope, stepping down the slope by dividing the swale into segments, or increasing the width.
(5) If the swale length must be less than 200 feet in length, compute the surface area of the design water surface at the biofiltration design flow rate and widen the shortened swale to provide an equivalent surface area.
(6) Use the conveyance capacity maximum design flow rates and establish the required swale depth to provide adequate freeboard.
(7) Check the maximum velocity in the swale at the maximum design flow rate (Ignore the check dams when computing the maximum velocity.) If greater than 5 feet per second re-design the swale by decreasing the actual swale slope, stepping down the slope by dividing the swale into segments, or increasing the width.

Filter Strips

(1) Compute the required width of the filter strip by calculating the length of of tributary unit area of impervious surface per one foot length of strip and multiplying times 0.23 feet.
(2) Determine the preliminary design of the filter strip.
(3) Size the swale at the toe of the filter strip to convey the maximum design flow rates from the area tributary to the filter strip.

4.6.5 COALESCING PLATE OIL/WATER SEPARATORS

Coalescing plate oil/water separators are used to effectively remove oil and grease from surface water. They operate by using differential gravity separation of particles that have a different density than water. Particles of higher density than water (such as sediments) will settle down to the bottom, while particles with a lower density than water (such as oils) will rise to the top. Once separated from the water column the particles of interest can be removed. The most effective separator designs employ a series of parallel inclined plates that shorten the distance particles have

to settle and provide for self-cleaning of the plates through inclination at an angle in excess of the angle of repose of the particles. Coalescing plate oil/water separators shall be designed to meet the requirements of Special Requirement #6, in Section 1.3.6.

Design Criteria

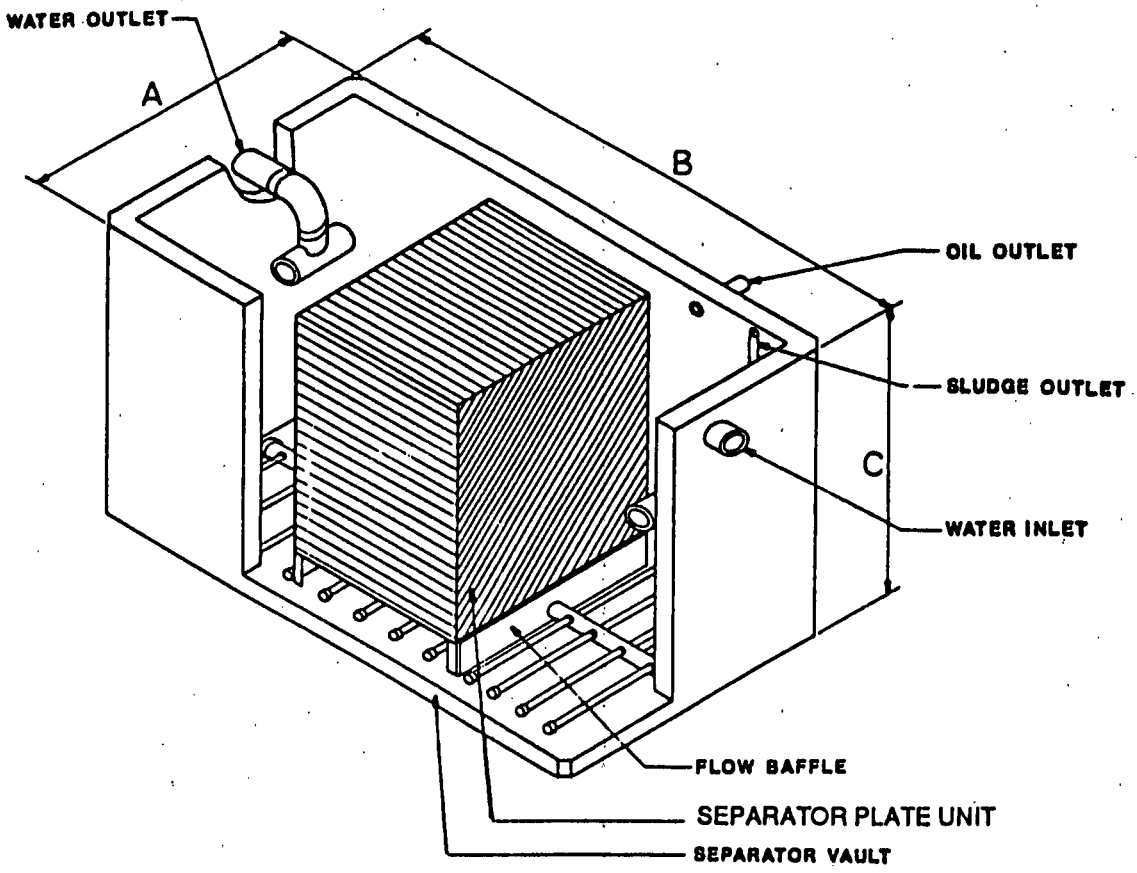
- See Figure 4.6.5A for sample detail.
- The amount of area contributing runoff to the separator should be limited to that area which will actually introduce oil and grease into the runoff in order to avoid needlessly over-sizing the facility.
- A gravity drain shall be provided one foot above the bottom of the separator vault and sized to allow the facility to be completely drained in one hour.
- Peak runoff flows above that for the water quality design storm (Pt-wq) must bypass the facility in a separate conveyance to the point of discharge. A mechanism must be provided at the bypass point to allow the facility to be manually taken "off-line" for maintenance and repair.
- The actual design and manufacture of the separator plates requires a detailed understanding of the internal hydraulic parameters required to optimize particle removal (such as plate spacing, angle of inclination) as well as selection of the most reliable materials for plate fabrication. Design engineers are, therefore, encouraged to employ pre-manufactured and standardized separator assemblies in the facilities they design supplied by well-established water resource equipment firms.
- The spacing and construction of structures, materials allowed, accessibility for maintenance, easements, and hydraulic design methods shall be the same as those described for detention vaults in Section 4.4.6.
- Oil/water separators shall be placed before biofiltration, water quality, and infiltration facilities except those facilities which are fed directly by sheetflow.

Method of Analysis

The storage volume in the separator vault and the size of the separator assembly shall be based on a process flow rate computed using the hydrograph methods described in Chapter 3, and on the separator assembly manufacturer's design criteria.

FIGURE 4.6.5A SAMPLE COALESCING PLATE SEPARATOR

Detail from system manufactured by PIPE, Inc.



Sq. Ft. of Effective Separation Area	Capacity at 0.25 GPM/ Sq. Ft.	Capacity at 0.50 GPM/ Sq. Ft.	A	B	C	Inlet Size	Outlet Size	Oil Outlet Size	Sludge Outlet Size
33	8 GPM	16 GPM	27"	62½"	30"	4"	4"	2"	2"
200	50 GPM	100 GPM	48"	72"	66"	4"	4"	2"	2"
300	75 GPM	150 GPM	56"	84"	72"	6"	6"	2"	2"
600	150 GPM	300 GPM	56"	84"	72"	8"	8"	3"	3"
1200	300 GPM	600 GPM	82"	154"	89"	10"	10"	3"	3"
2400	600 GPM	1200 GPM	92"	152"	98"	12"	12"	3"	3"
3200	800 GPM	1600 GPM	115"	187"	128"	15"	15"	4"	4"
4600	1150 GPM	2300 GPM	138"	186"	129"	18"	15"	4"	4"

1. Above capacities are based on 55° angle of inclination.
2. Larger Capacities available.

CHAPTER 5 EROSION/SEDIMENTATION CONTROL PLAN AND PRACTICES

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

CHAPTER 5
TEMPORARY EROSION AND SEDIMENTATION CONTROL STANDARDS

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

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Section 5.3 General TESC Requirements

Section 5.4 TESC Measures

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- *Section 5.4.1.1 Plastic or Metal Fence*
- *Section 5.4.1.2 Stake and Wire Fence*

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Section 5.7 Mulching

Section 5.8 Topsoiling

CHAPTER 5
TEMPORARY EROSION AND SEDIMENTATION CONTROL STANDARDS

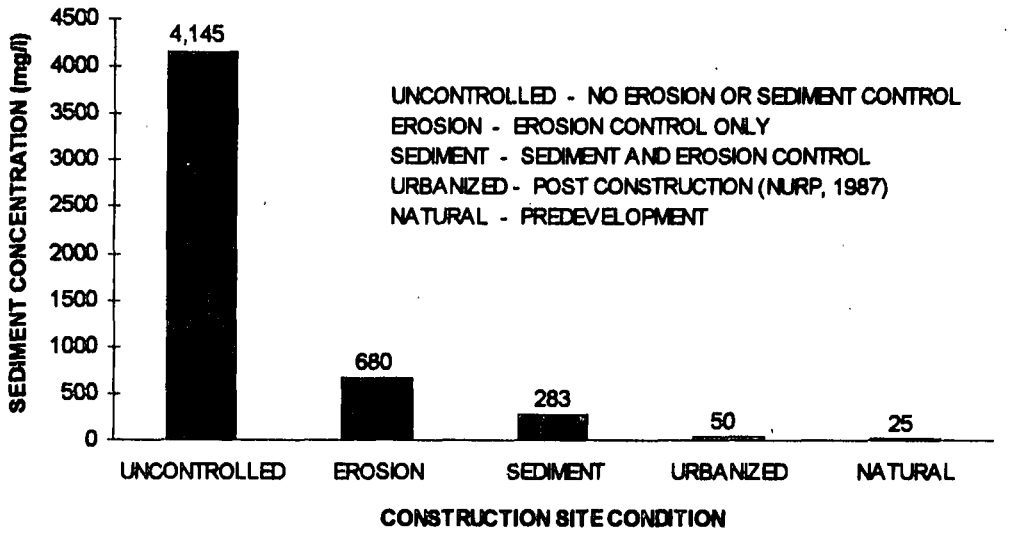
5.1 PURPOSE AND OVERVIEW

The purpose of temporary erosion and sediment control (TESC) is to prevent the transport of sediment to streams, wetlands, lakes, drainage systems, and adjacent properties. In most circumstances, however, it is impossible to completely prevent the transport of sediment to these features, either because of the difficulty in removing silt and clay-sized particles from runoff or because of large storms that overwhelm the TESC facilities. Due to the inherent difficulties in entirely preventing the transport of sediment, it is the responsibility of those involved in the design and construction of any project to utilize a variety of strategies to minimize erosion and the transport of sediment to the greatest extent possible. These strategies shall include overall project planning that reduces the risk of erosion through appropriate design and scheduling (Section 5.2) and traditional structural and cover measures, such as those described in Section 5.4.

Erosion and sediment control is necessary because erosion rates associated with uncontrolled construction sites are much higher than normal rates: often a thousand or more times that of undeveloped land. The erosion rates increase during construction due to the removal of soil cover, alteration of soil characteristics, and changes in site topography. These vastly accelerated erosion rates, together with the higher rates typical of urbanized areas, result in excessive deposition of sediment in water resources and drainage facilities. This excessive erosion and consequent sediment deposition can result in devastating impacts to surface waters such as smothering of salmonid spawning beds, algal blooms in lakes, and flooding due to obstruction of drainageways.

Applying erosion and sediment controls to construction sites can greatly reduce the delivery of sediment to surface waters. Figure 5.1A demonstrates how controls can significantly reduce the concentration of sediment leaving the site. Even with good controls, the concentration of sediment leaving the site will still be significantly higher than either undeveloped or developed conditions and this may result in significant adverse impacts; however, the likelihood of such impacts are dramatically less than if no controls are used.

FIGURE 5.1A MEDIAN STORM SEDIMENT CONCENTRATIONS (METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS, 1990)



5.2 TEMPORARY EROSION AND SEDIMENT CONTROL PRINCIPLES

This section provides basic information on the principles of erosion and sediment control that shall be applied to all projects in King County. This section is intended to highlight certain principles that are particularly critical to achieving effective control and that are the basis for Core Requirement 5. Projects that are consistent with these principles will generally meet the intent of the Core Requirement and this chapter, even if the details of the project are not entirely consistent with county standards. If a more complete treatment of TESC is needed, there are a number of useful references available (for example, Goldman et al., 1986). Additionally, information on permanent erosion control in natural channels is available in the Guidelines for Bank Stabilization Projects (King County, 1993).

- **Design the project to fit the natural topography, soils, and drainage patterns.** Through such practices as limiting disturbance of steeper slopes, avoiding disturbance of natural drainageways, or using soils with a high infiltration rate to treat polluted runoff, the characteristics of the site can be used to minimize erosion and sediment transport.

- **Emphasize erosion control, rather than sediment control.** Erosion control minimizes the entrainment of sediment by runoff, while sediment control removes entrained sediment from runoff. Erosion control is more efficient and cost-effective because it is impossible to entirely remove sediment from runoff once it is entrained. Examples of erosion control include covering disturbed soils and controlling surface runoff using measures such as dikes and lined ditches. One illustration of the relative effectiveness of erosion control is straw mulch which can reduce sediment concentrations in runoff over 90%. Since it is nearly impossible to entirely prevent erosion, it will also be necessary to incorporate sediment control facilities such as sedimentation ponds and silt fences. Sediment controls vary in their effectiveness, but typically reduce sediment concentrations 50 to 75%. However, sediment controls have little effect on the very fine sediment that causes turbidity, whereas cover measures, such as straw mulch, can be highly effective in reducing turbidity.

- **Minimize the extent and duration of area exposed.** Restricting clearing to only those areas necessary for construction is probably the single most effective form of erosion control. Additionally, exposing areas only as long as necessary reduces the risk of erosion substantially. This can be accomplished by planning the project so that areas are disturbed only when construction is imminent and by using mulches and/or seeding to cover disturbed areas as soon as grading is completed.

- **Keep runoff velocities low.** While erosion of exposed soil begins with a single raindrop, the largest volumes of eroded materials are typically associated with concentrated runoff forming rills and gullies. One of the best ways to minimize erosion, therefore, is to reduce the possibility of concentrated runoff by intercepting runoff and conveying it in a non-erosive manner to a sediment pond or trap. This can include the use of dikes, swales, and benches to intercept runoff on slopes and ditches or drains to convey the intercepted runoff.

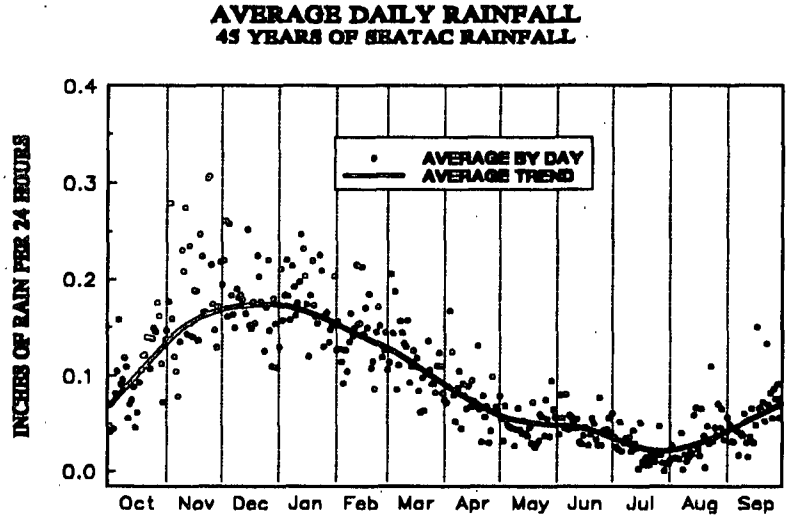
- **Retain sediment on site.** Sediment retention is less effective than erosion control measures, such as cover, but is nevertheless a vital part of most projects because it is impossible to completely prevent erosion and the entrainment of sediment by runoff. Sediment can be retained by allowing it to settle out in ponds and traps or by filtering runoff from small areas through vegetation or a silt fence. Note that settling and filtration typically only remove sand-sized and coarse silt particles. Fine silts and clays cannot be removed in these ways, unless the runoff is released to vegetated areas or if chemical flocculents, such as alum, are used.

- **Thoroughly monitor the site and maintain all TESC measures.** Maintenance and vigilance are the most vital components of effective TESC management. All measures require regular maintenance. The overall site also needs to be constantly examined to ensure that all areas are protected, that the measures are working together to provide maximum protection, and that all areas are mulched and/or vegetated as soon as possible.

- **Schedule major earthwork during the dry season.** The climate in the Puget Sound region is unique in that there are generally well defined wet and dry seasons (Figure 5.2A) and the wet season is characterized by a large number of low-intensity, but frequent and long-lasting,

storms. As a result, construction in the dry season is a very effective form of erosion control. If construction does occur in the wet season, the need for regular maintenance is even more imperative.

FIGURE 5.2A YEARLY RAINFALL PATTERN



5.3 GENERAL TESC REQUIREMENTS

To satisfy the King County requirements for TESC, the following steps are required of all construction projects:

1. In accordance with Sections 2.3.1 and 2.3.2.4, prepare and submit a Technical Information Report (TIR) and TESC plan for King County review. Incorporate any King County review comments as necessary to comply with Core Requirement 5 and this chapter.

2. Construct initial TESC measures on-site as per the approved TESC plan.

3. Inspect and maintain all TESC measures throughout construction in accordance with the inspection and maintenance standards of Section 5.4.10.

4. Make any changes or additions necessary during construction to ensure that TESC measures perform in accordance with Core Requirement 5 and Sections 5.4.1 through 5.4.9.

5. Prior to final construction approval, meet all the conditions in Section 5.4.11.

5.4 TESC MEASURES

This section details the TESC measures and Best Management Practices (BMPs) that are required to minimize erosion and sediment transport off a construction site. The measures and practices are grouped into 11 sections corresponding to each of the minimum requirements in Core Requirement 5. The introductory paragraphs at the beginning of most sections present the purpose of the measures, installation requirements relative to construction activity, guidelines for the conditions of use for each measure, and other information relevant to all BMPs in the section. Compliance with each of the 11 sections ensures compliance with the minimum requirements. Note, however, that additional measures shall be required by the County if the existing standards are insufficient to protect adjacent properties, drainage facilities, or water resources.

The standards for each individual TESC measure are divided into four sections:

1) Purpose
2) Conditions of Use
3) Design and Installation Specifications
4) Maintenance Requirements

A code and symbol for each measure have also been included for ease of use on TESC plans. Note that the "Conditions of Use" always refers to site conditions. As site conditions change, TESC measures must be changed to remain in compliance with the requirements of this chapter.

5.4.1 CLEARING LIMITS

Minimum Requirement 1 Prior to any site clearing or grading, those areas that are to remain undisturbed during project construction shall be delineated. At a minimum, clearing limits shall be installed at the edges of all sensitive area buffers.

Purpose The purpose of clearing limits is to prevent disturbance of those areas of the project site that are not designated for clearing or grading. This is important because limiting site disturbance is the single most effective method for reducing erosion. Clearing limits may also be used to control construction traffic (Sections 5.4.4.1 and 5.4.4.2), thus reducing the disturbance of soil and limiting the amount of sediment tracked off-site.

When to Install Clearing limits shall be installed prior to the clearing and/or grading of the site.

Measures to Use In most circumstances, marking clearing limits by delineating the site with a continuous length of brightly colored survey tape is sufficient. The tape can be supported by vegetation or stakes, and it shall be 3 to 6 feet high and highly visible. Sensitive areas and their buffers require more substantial protection and shall be delineated with plastic or metal safety fences (also referred to as Native Growth Protection Easement or NGPE fences) or stake and wire fences. Fencing may be required at the county's discretion to control construction traffic or at any location where greater protection is warranted. Permanent fencing may also be used if desired by the applicant. Silt fence, in combination with survey flagging, is also an acceptable method of marking sensitive areas and their buffers.

5.4.1.1 PLASTIC OR METAL FENCE

Code: FE Symbol:

Purpose

Fencing is intended to restrict clearing to approved limits, prevent disturbance of sensitive areas and sensitive area buffers, to limit construction traffic to designated construction entrances or roads, and to protect areas where marking with survey tape may not provide adequate protection.

Conditions of Use

1. At the boundary of sensitive areas or sensitive area buffers.
2. As necessary, to control vehicle access to and on the site (Sections 5.4.4.1 and 5.4.4.2).

Design and Installation Specifications

1. As per manufacturer's specifications.
2. The fence shall be at least 3 feet high and must be highly visible.
3. The fence shall not be wired or stapled to trees.

Maintenance Requirements

1. If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

2. Disturbance of a sensitive area, sensitive area buffer, or NGPE shall be reported to the county for resolution.

5.4.1.2 STAKE AND WIRE FENCE

Code: SWF Symbol:

Purpose

Fencing is intended to restrict clearing to approved limits, prevent disturbance of sensitive areas and sensitive area buffers, to limit construction traffic to designated construction entrances or roads, and to protect any areas where marking with survey tape may not provide adequate protection.

Conditions of Use

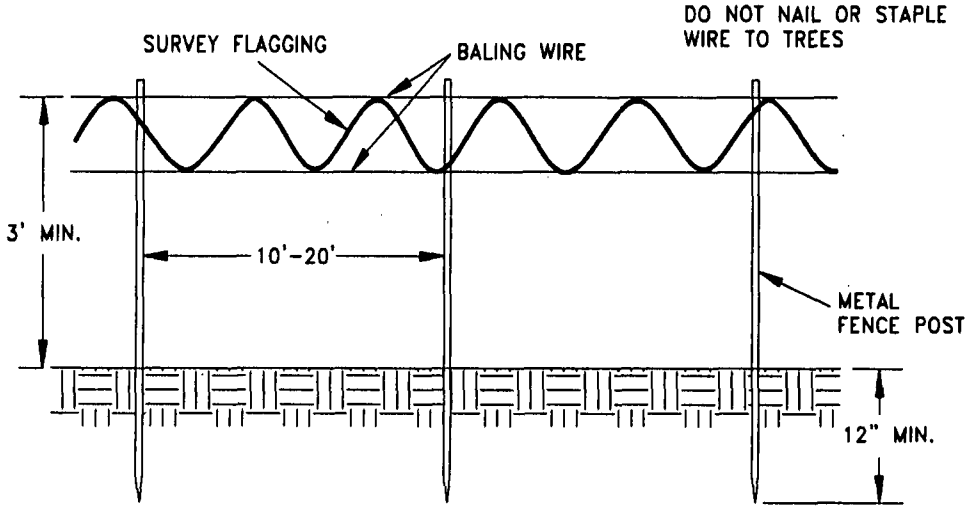
1. At the boundary of sensitive areas or sensitive area buffers.

2. As necessary, to control vehicle access to and on the site (Sections 5.4.4.1 & 5.4.4.2).

Design and Installation Specifications

1. See Figure 5.4.1.2A for detail.

FIGURE 5.4.1.2A STAKE AND WIRE FENCE



Maintenance Requirements

1. If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

2. Disturbance of a sensitive area, sensitive area buffer, or NGPE shall be reported to the county for resolution.

3. More substantial fencing shall be required by the county if the fence does not prevent encroachment into those areas that are not to be disturbed.

5.4.2 COVER MEASURES

Minimum Requirement 2 Temporary and permanent cover measures shall be provided to protect disturbed areas. Temporary cover shall be installed if an area is to remain unworked for more than seven days during the dry season (April 1 to September 30) or for more than two days during the wet season (October 1 to March 31). These time limits may be relaxed if an area poses a low risk of erosion due to soil type, slope gradient, anticipated weather conditions, or other factors. Conversely, the county may reduce these time limits if site conditions warrant greater protection or if significant precipitation is expected. Any area to remain unworked for more than 30 days shall be seeded or sodded, unless the county determines that winter weather makes vegetation establishment infeasible. During the wet season, slopes and stockpiles 3H:1V or steeper and with more than ten feet of vertical relief shall be covered if they are to remain unworked for more than 12 hours. Also during the wet season, the material necessary to cover all disturbed areas must be stockpiled on-site. The intent of these cover requirements is to have as much area as possible covered during any period of precipitation.

Purpose The purpose of covering exposed soils is to prevent erosion, thus reducing reliance on less effective methods that remove sediment after it is entrained in runoff. Cover is the only practical method of reducing turbidity in runoff. Structural measures, such as silt fences and sediment ponds, are only capable of removing coarse particles and in most circumstances have little to no effect on turbidity.

When to Install Any exposed soils that will remain unworked for more than the time limit set in minimum requirement 2 shall be covered by the end of the working day. If the exposed area is to remain unworked for more than 30 days, the area shall be seeded with the temporary seed mix or an equivalent mix that will provide rapid protection (Section 5.4.2.4). If the disturbed area is to remain unworked for a year or more or if the area has reached final grade, permanent seed mix or an equivalent mix shall be applied.

Measures to Use Cover methods include the use of mulch, erosion control nets and blankets, plastic covering, seeding, and sodding. Mulch and plastic sheeting are primarily intended to protect disturbed areas for a short period of time, typically days to a few months. Seeding and sodding are measures for areas that are to remain unworked for months. Erosion nets and blankets are to be used in conjunction with seeding steep slopes. The choice of measures is left to the designer, however, there are restrictions on the use of these methods, which are listed in the "Conditions of Use" and the "Design and Installation Specifications" sections for each measure. The methods listed are by no means exhaustive. Also, the details of installation can, and should, vary with the site conditions. Variations on the standards presented here are encouraged, if other cost-effective products or methods provide substantially equivalent or superior performance. A useful reference on the application of cover measures in the Puget Sound area is Horner, R.R., Guedrey, J., and Kortenhof, M.H., 1990.

5.4.2.1 MULCHING

Code: MU Symbol:

Purpose

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There are an enormous variety of mulches that can be used. Only the most common types are discussed in this section.

Conditions of Use

1. On disturbed areas that require cover measures for less than 30 days.
2. As a cover for seed during the wet season and during the hot summer months.
3. During the wet season, on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Design and Installation Specifications

1. For mulch materials, application rates and specifications, see Table 5.4.2.1A.

TABLE 5.4.2.1A MULCH STANDARDS AND GUIDELINES

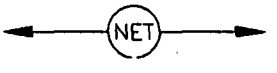
Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material	2"-3" thick; 2-3 bales per 1000 sq. ft. or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. Straw should be crimped to avoid wind blow. The thickness of straw may be reduced by half when used in conjunction with seeding.
Wood Fiber Cellulose	No growth inhibiting factors	Approx. 25-30 lbs. per 1000 sq. ft. or 1000-1500 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Some wood fiber with very long fibers can be effective at lower application rates and without seed or tackifier.
Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Sources for compost are available from the King County Commission for Marketing Recyclable Materials at 296-4439.
Chipped Site Vegetation	Average size shall be several inches.	2" minimum thickness	This is a cost-effective way to dispose of debris from clearing and grubbing and eliminates the problems associated with burning. It should generally not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.

Maintenance Standards

1. The thickness of the cover must be maintained.

2. Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

5.4.2.2 NETS AND BLANKETS

Code: NE Symbol: 

Purpose

To prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainageways during high flows. Nets are strands of material woven into an open, but high-tensile strength net (for example, jute net). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir fabric comes as both nets and blankets.

Conditions of Use

1. For permanent stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.

2. In general, nets and blankets are used in conjunction with seed for final stabilization of a slope, not for temporary cover. However, they can be used for temporary applications as long as the product is not damaged by repeated handling. In fact, this is a superior method of slope protection than plastic sheeting which generates high-velocity runoff (see Section 5.4.2.3).

3. Highly recommended for drainage ditches and swales. The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap.

Design and Installation Specifications

1. See Figures 5.4.2.2A and 5.4.2.2B for typical orientation and installation of nettings and blankets. The manufacturer's recommendations are also to be used for installation. Note that installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.

2. With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer thoroughly consult the manufacturer's information and that a site visit take place in order to insure that the product specified is appropriate.

3. Jute netting must be used in conjunction with mulch (Section 5.4.2.1). Excelsior, woven straw blankets, and coir (coconut fiber) blankets may be installed without mulch. Other types of products will have to be evaluated individually. In general, most nets (e.g., jute) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.

4. There are many other types of erosion control nets and blankets on the market not authorized above that may be appropriate in certain circumstances. Such products will have to be evaluated individually.

5. Purely synthetic blankets are allowed but shall only be used for long-term stabilization of waterways. The organic blankets authorized above are better for slope protection and short-term waterway protection because they retain moisture and provide organic matter to the soil, substantially improving the speed and success of revegetation.

FIGURE 5.4.2.2A WATERWAY INSTALLATION

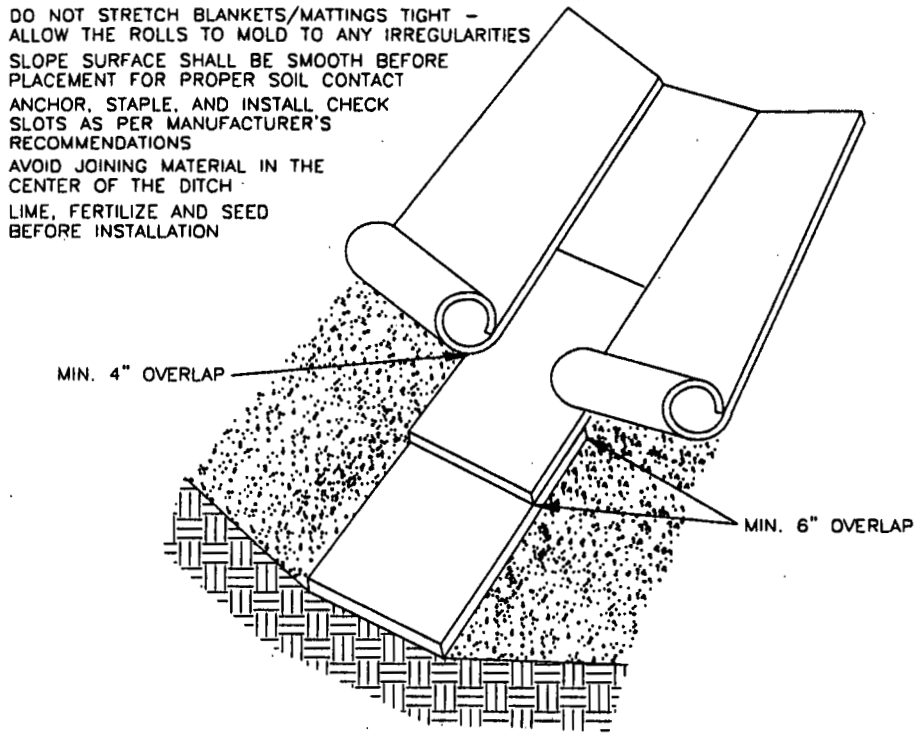
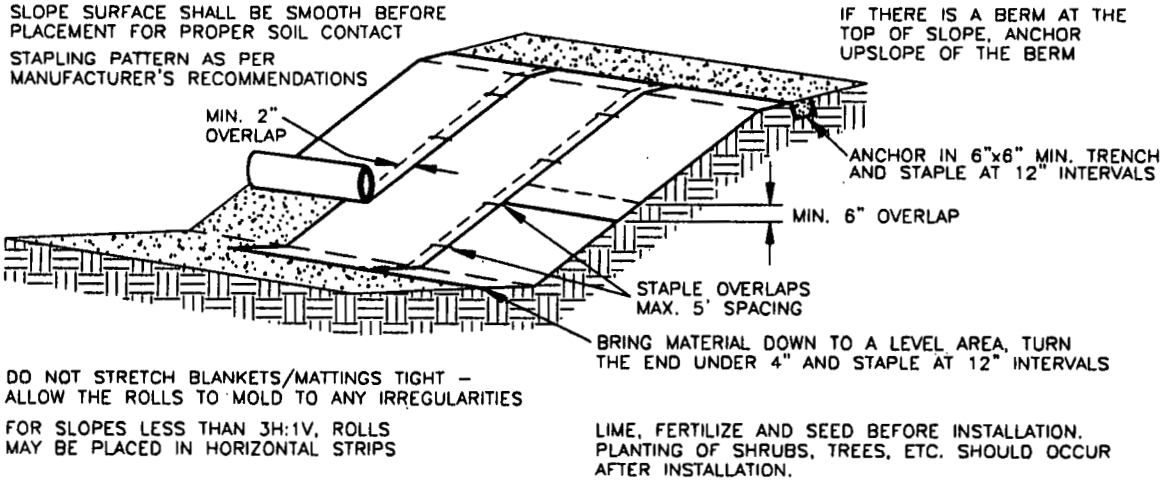


FIGURE 5.4.2.2B SLOPE INSTALLATION



Maintenance Standards

1. Good contact with the ground must be maintained, and there must not be erosion beneath the net or blanket.

2. Any areas of the net or blanket that are damaged or not in close contact with the ground shall be repaired and stapled.

3. If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.

5.4.2.3 PLASTIC COVERING

Code: PC Symbol: PC

Purpose

To provide immediate, short-term erosion protection to slopes and disturbed areas.

Conditions of Use

1. On disturbed areas that require cover measures for less than 30 days.

2. Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note that the relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term applications.

3. Clear plastic sheeting can be used over newly seeded areas to create a greenhouse effect and encourage grass growth. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.

3. Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.

NOTE: There have been many problems with plastic, usually attributable to poor installation and maintenance. However, the material itself can cause problems, even when correctly installed and maintained, because it generates high-velocity runoff and breaks down quickly due to ultraviolet radiation. In addition, if the plastic is not completely removed, it can clog drainage system inlets and outlets. It is highly recommended that alternatives to plastic sheeting be used whenever possible and that its use be as limited as possible.

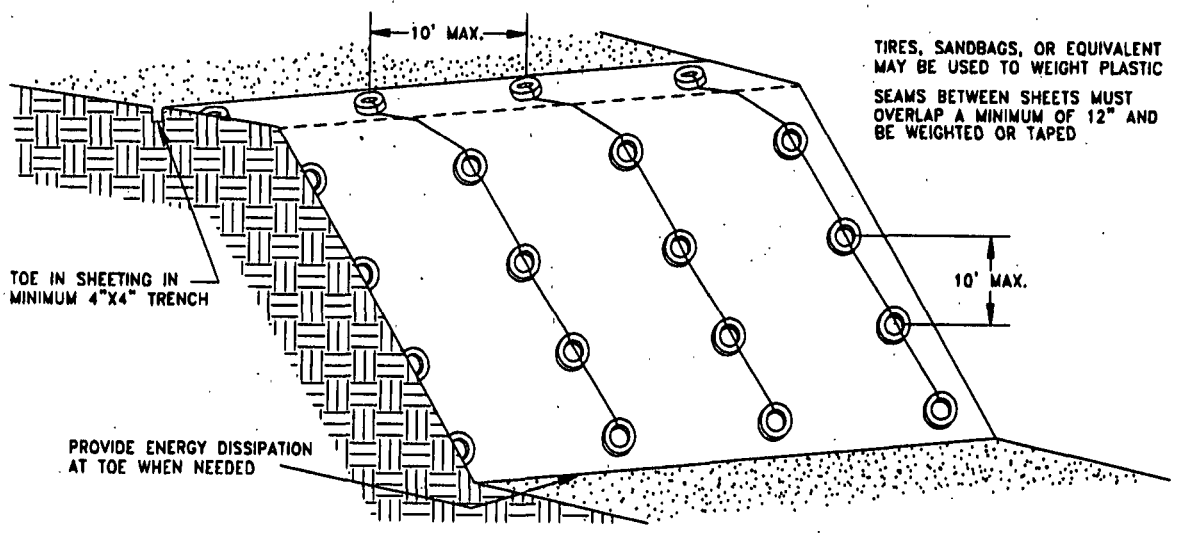
Design and Installation Specifications

1. See Figure 5.4.2.3A for detail.

2. Plastic sheeting shall have a minimum thickness of .06 mm

3. If erosion at the toe of slope is likely, a gravel berm, rip-rap, or other suitable protection shall be installed at the toe of slope in order to reduce the velocity of runoff.

FIGURE 5.4.2.3A PLASTIC COVERING



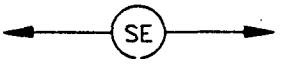
Maintenance Standards

1. Torn sheets must be replaced and open seams repaired.

2. If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.

3. When the plastic is no longer needed, it shall be completely removed.

5.4.2.4 TEMPORARY AND PERMANENT SEEDING

Code: SE Symbol: 

Purpose

To reduce erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

Conditions of Use

1. On disturbed areas that require seeding either because the area has reached final grade or because the area is to remain unworked for more than 30 days.

2. In vegetation-lined channels.

3. In retention/detention ponds as required.

4. At county discretion, seeding without mulch during the dry season is allowed even though it will take more than seven days to develop an effective cover. Mulch is, however, recommended at all times because it protects seeds from heat, moisture loss and transport due to runoff.

5. At the beginning of the wet season, all disturbed areas shall be reviewed to identify which ones can be seeded in preparation for the winter rains (Section 5.4.8). Disturbed areas shall be seeded within one week of the beginning of the wet season. A sketch map of those areas to be seeded and those areas to remain uncovered shall be submitted to the DDES inspector. The DDES inspector can require seeding of additional areas in order to protect surface waters, adjacent properties, or drainage facilities.

Design and Installation Specifications

1. **Time of Seeding** The best time to seed is April 1 through June 30 and September 1 through October 15. Areas may be seeded between July 1 and August 31, but irrigation may be required in order to grow adequate cover. Areas may also be seeded during the winter months, but it may take several months to develop a dense ground cover due to cold temperatures. The application and maintenance of mulch is critical for winter seeding.

2. **Site Preparation** To prevent seed from being washed away, confirm that all required surface water control measures have been installed.

3. **Seedbed Preparation** The seedbed should be firm, but not compacted because soils that are well-compacted will not vegetate as quickly or thoroughly. Slopes steeper than 3H:1V shall be surface roughened. Roughening can be accomplished in a variety of ways, but the typical method is track-walking, or driving a crawling tractor up and down the slope, leaving cleat imprints parallel to the slope contours.

4. **Fertilization** In general, 10-20-20 (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 250 lbs per acre. Slow-release fertilizers are preferred because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of

fertilizer needed. This will prevent the overapplication of fertilizer. Disturbed areas within 200 feet of water bodies and wetlands must use non-phosphorus fertilizer.

5. **Mulching** The following requirements apply to mulching:

   A. Mulch is always required for seeding slopes greater than 3H:1V (see Section 5.4.2.1).

   B. If seeding during the wet season, mulch is required.

   C. The use of mulch may be required during the dry season at the county's discretion if grass growth is expected to be slow, the soils are highly erodible due to soil type or gradient, there is a water body close to the disturbed area, or significant precipitation is anticipated before the grass will provide effective cover.

   D. Mulch can be applied on top of the seed or simultaneously by hydroseeding.

6. **Hydroseeding** Hydroseeding is allowed as long as tackifier is included. Hydroseeding with wood fiber mulch is adequate during the dry season. During the wet season, the application rate shall be doubled because the mulch and tackifier used in hydroseeding break down fairly rapidly. It may be necessary in some applications to include straw with the wood fiber, but this can be detrimental to germination.

7. **Soil Amendments** Areas to be permanently landscaped shall use soil amendments. The addition of stockpiled topsoil or compost reduces the need for fertilizer and improves the overall soil quality.

8. **Seed Mixes** The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 lbs/acre. This rate can be reduced if soil amendments or slow-release fertilizers are used.

	% Weight	% Purity	% Germination
Temporary Erosion Control Seed Mix			
Chewings or red fesque *Festuca rubra var. commutata* or *Festuca rubra*	40	98	90
Annual or perennial rye *Lolium multiflorum* or *Lolium perenn*	40	98	90
Redtop or colonial bentgrass *Agrostis alba* or *Agrostis tenuis*	10	92	85
White dutch clover *Trifolium repens*	10	98	90

This is the standard mix for those areas where just a temporary vegetative cover is required.

Landscaping Seed Mix			
Perennial rye blend *Lolium perenne*	70	98	90
Chewings and red fescue blend *Festuca rubra var. commutata* or *Festuca rubra*	30	98	90

This mix is provided as just one recommended possibility. Local suppliers should be consulted for their recommendations because the appropriate mix depends on a variety of factors, including exposure, soil type, slope, and expected foot traffic.

Bioswale Seed Mix (modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix)

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	68	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10	98	85
Meadow foxtail *Alepocurus pratensis*	10	90	80
Alsike clover *Trifolium hybridum*	6	98	90
Redtop *Agrostis alba*	6	92	85

This mix is recommended for bioswales and other intermittently wet areas. Sod shall generally not be used for bioswales because the seed mix is inappropriate for this application. Sod can be used for lining ditches to prevent erosion, but will provide little water quality benefit during the wet season.

Wetlands Seed Mix

Red fescue *Festuca rubra*	35	90	90
Redtop *Agrostis alba*	35	92	85
Meadow foxtail *Alepocurus pratensis*	30	90	80

This is a recommended low-growing, relatively non-invasive seed mix appropriate for wetlands where a temporary cover is desired while native plants are being established. Other mixes may be appropriate, depending on the soil type and hydrology of the wetland. Apply this mixture at a rate of 60 lbs/acre with additional sprigs or rhizomes of native wetland plants, such as bull rush (*Scirpus acutus, validus, or microcarpus*), creeping spike rush (*Eleocharis palustris*), slough sedge (*Carex obnupta*), or others as required by the county. Invasive plants such as cattail (*Typha latifolia*), reed canarygrass (*Phalaris arundinacea*), and purple loosestrife (*Lythrum salicaria*) shall not be used under any circumstances.

Meadow Seed Mix

Redtop or Oregon Bentgrass *Agrostis alba or Agrostis oregonensis*	40	92	85
Red Fescue *Festuca rubra*	40	90	90
White dutch clover *Trifolium repens*	20	98	90

This mix is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. Likely applications include rural road and utility right-of-ways. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. The appropriateness of clover in the mix may need to be considered as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

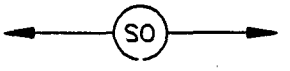
Maintenance Standards

1. Any seeded areas that fail to establish at least 80 percent cover within one month shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed.

2. After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.

3. Seeded areas shall be supplied with adequate moisture, but not watered to the extent that it causes runoff.

5.4.2.5 SODDING

Code: SO Symbol: 

Purpose

To establish permanent turf for immediate erosion protection and to stabilize drainageways where concentrated overland flow will occur.

Conditions of Use

1. Disturbed areas that require short-term or long-term cover.

2. Disturbed areas that require immediate vegetative cover.

3. All waterways, except biofiltration swales, that require vegetative lining. The seed mix used in most sod is not appropriate for biofiltration swales. Waterways may also be seeded, rather than sodded, and protected with a net or blanket (Section 5.4.2.2).

Design and Installation Specifications

The following steps are recommended for sod installation:

1. Shape and smooth the surface to final grade in accordance with the approved grading plan.

2. Fertilize as per supplier's recommendations. Disturbed areas within 200 feet of water bodies and wetlands must use non-phosphorus fertilizer.

3. Work lime and fertilizer into soil 1 to 2 inches deep and smooth the surface.

4. Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V.

5. Roll the sodded area and irrigate.

6. When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

7. Sod shall be free of weeds, of uniform thickness (approximately 1" thick), and shall have a dense root mat for mechanical strength.

Maintenance Standards

1. If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy ground cover. If it is impossible to establish a healthy ground cover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

5.4.3 PERIMETER PROTECTION

Minimum Requirement 3 Perimeter protection to filter sediment from sheetwash shall be located downslope of all disturbed areas and shall be installed prior to upslope grading. Perimeter protection includes the use of vegetated strips, as well as more conventional, constructed measures, such as silt fences. During the wet season, 50 linear feet of silt fence (and the necessary stakes) per acre of disturbed area must be stockpiled on-site.

Purpose The purpose of perimeter protection is to reduce the amount of sediment transported beyond the disturbed areas of the construction site. Perimeter protection is primarily a backup means of sediment control. Most, if not all, sediment-laden water is to be treated in a sediment trap or pond. The only circumstances in which perimeter control is to be used as a primary means of sediment removal is when the catchment is very small (see below).

When to Install Perimeter protection is to be installed prior to any upslope clearing and grading.

Measures to Use There are three perimeter protection measures in this section that can be used to satisfy the minimum requirement: silt fence, brush barriers, and vegetated strips. These measures can be used interchangeably. If surface water is collected by an interceptor dike/swale and routed to a sediment pond or trap, there is no need for the perimeter protection measures specified in this section.

Criteria for Use as Primary Treatment At the boundary of a site, perimeter protection may be used as the sole form of treatment when the flow path meets the criteria listed below. If these criteria are not met, perimeter protection shall only be used as a backup to a sediment trap or pond.

Average Slope	Flow Path Length
1.5H:1V or less	100 feet
2H:1V or less	115 feet
4H:1V or less	150 feet
6H:1V or less	200 feet
10H:1V or less	250 feet

5.4.3.1 SILT FENCE

Code: SF Symbol: X—X—X—X—X

Purpose

To reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Downslope of all disturbed areas.

2. Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstances in which overland flow can be treated solely by a silt fence, rather than by a sediment trap or pond, is where the area draining to the fence is small (see introduction to this section), and the average slope is not more than 1.5H:1V.

Design and Installation Specifications

1. See Figure 5.4.3.1A for detail.

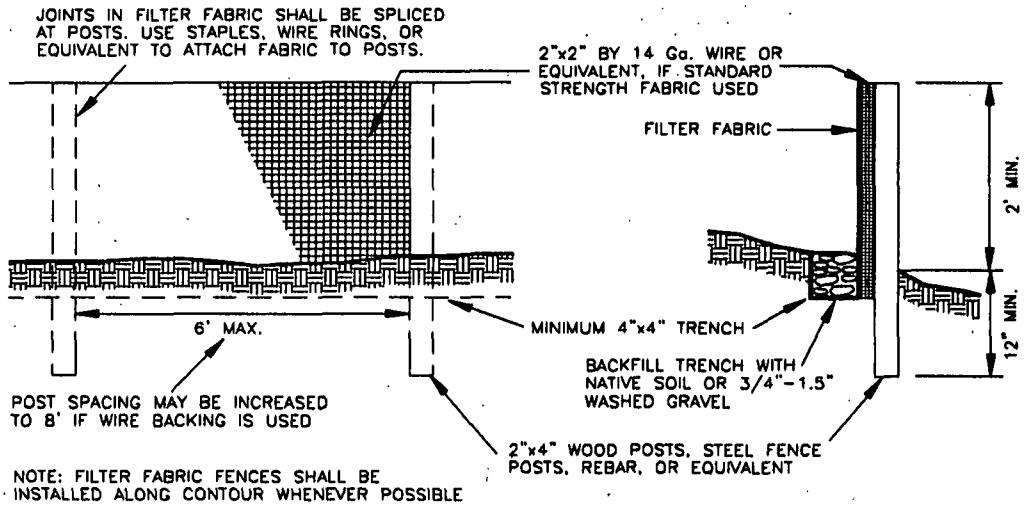
2. The geotextile used must meet the standards listed below. A copy of the manufacturer's fabric specifications must be available on-site.

AOS (ASTM D-4751)	=	30-100 sieve size (0.60-0.15 mm) for slit film 50-100 sieve size (0.30-0.15 mm) for other fabrics
Water Permittivity (ASTM D-4491)	=	0.02 sec^{-1} min.
Grab Tensile Strength (ASTM D-4632)	=	180 lbs min. for extra strength fabric 100 lbs min. for standard strength fabric
Grab Tensile Elongation(ASTM D-4632)	=	30% max.
Ultraviolet Resistance (ASTM D-4355)	=	70% min.

3. Standard strength fabric requires wire backing to increase the strength of the fence. Wire backing or closer post spacing may be required for extra strength fabric if field performance warrants a stronger fence.

4. Where the fence is installed, the slope shall be no steeper than 2H:1V.

FIGURE 5.4.3.1A SILT FENCE



Maintenance Standards

1. Any damage shall be repaired immediately.

2. If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment trap or pond.

3. It is important to check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence and/or remove the trapped sediment.

4. Sediment must be removed when the sediment is 6" high.

5. If the filter fabric has deteriorated due to ultraviolet breakdown, it shall be replaced.

5.4.3.2 BRUSH BARRIER

Code: BB Symbol:

Purpose

To reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Downslope of all disturbed areas.

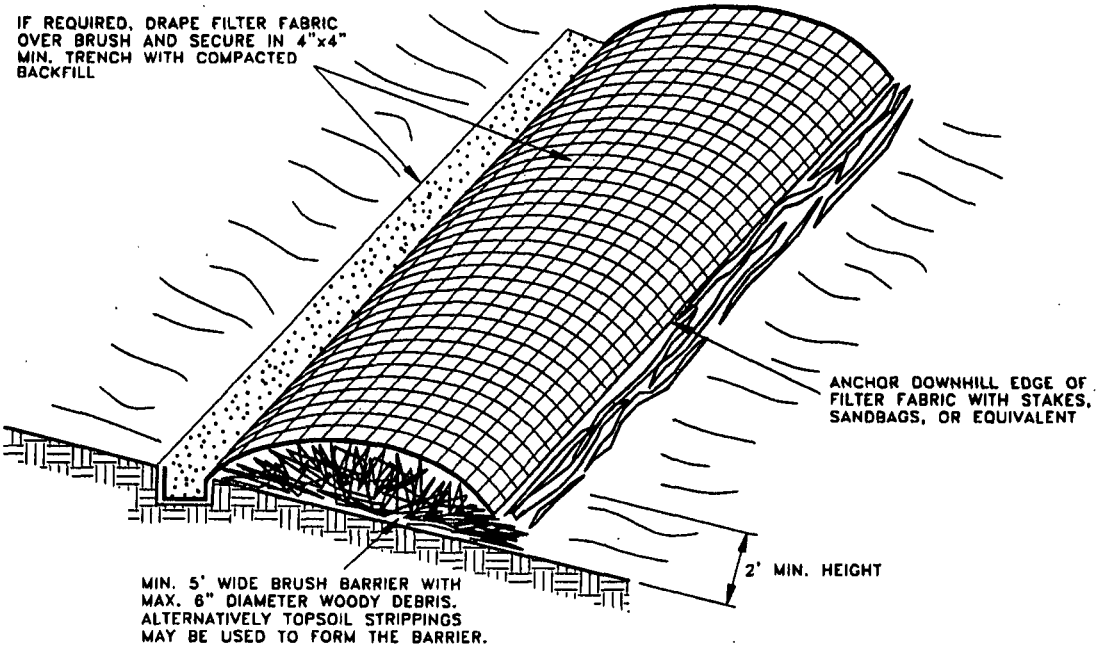
2. Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstances in which overland flow can be treated solely by a barrier, rather than by a sediment trap or pond, is where the area draining to the barrier is small (see introduction to this section) and the average slope is not more than 1.5H:1V.

Design and Installation Specifications

1. See Figure 5.4.3.2A for detail.

2. Filter fabric anchored over the brush berm may be required by King County to enhance the filtration ability of the barrier.

FIGURE 5.4.3.2A BRUSH BARRIER



Maintenance Standards

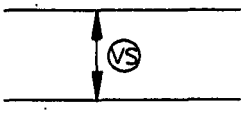
1. There shall be no signs of erosion or concentrated runoff under or around the barrier. If concentrated flows are bypassing the barrier, it must be expanded and/or augmented by toed-in filter fabric.

2. The dimensions of the barrier must be maintained.

5.4.3.3 VEGETATED STRIP

Code: VS

Symbol:



Purpose

To reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Downslope of all disturbed areas.

2. Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstances in which overland flow can be treated solely by a strip, rather than by a sediment trap or pond, is where the area draining to the strip is small (see introduction to this section) and the average slope is not more than 1.5H:1V.

Design and Installation Specifications

1. The vegetated strip shall consist of a 25-foot wide continuous strip of dense vegetation with a permeable topsoil. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.

2. The slope within the strip shall not exceed 4H:1V.

3. The uphill boundary of the vegetated strip shall be delineated with clearing limits as specified in Section 5.4.1.

Maintenance Standards

1. Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.

2. If more than 10 feet of the buffer width has had vegetation removed, sod must be installed.

3. If there are indications that concentrated flows are traveling across the buffer, surface water controls must be installed to reduce the flows entering the buffer, or additional perimeter protection must be installed.

5.4.4 TRAFFIC AREA STABILIZATION

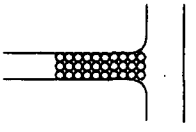
Minimum Requirement 4 Unsurfaced entrances, roads, and parking areas used by construction traffic shall be stabilized to minimize erosion and tracking of sediment off-site. Stabilized construction entrances shall be installed as the first step in clearing and grading. At the county's discretion, road and parking area stabilization is not required during the dry season (unless dust is a concern) or if the site is underlain by coarse-grained soils. Roads and parking areas shall be stabilized immediately after initial grading.

Purpose The purpose of traffic area stabilization is to reduce the amount of sediment transported off-site by construction vehicles and to reduce the erosion of areas disturbed by vehicle traffic. Sediment transported off-site onto paved streets is a significant problem because it is difficult to effectively remove, and any sediment not removed ends up in the drainage system. Additionally, sediment on public right-of-ways can pose a serious traffic hazard. Construction road and parking area stabilization is important because the combination of wet soil and heavy equipment traffic typically forms a slurry of easily erodible mud. Finally, stabilization also is an excellent form of dust control in the summer months.

When to Install The construction entrance is to be installed as the first step in clearing and grading. Construction road stabilization shall occur immediately after the construction roads and parking areas are graded.

Measures to Use There are two types of traffic area stabilization: (1) a stabilized construction entrance and (2) construction road/parking area stabilization. Both measures must be used as specified under "Conditions of Use" for each measure.

5.4.4.1 STABILIZED CONSTRUCTION ENTRANCE

Code: CE Symbol: 

Purpose

To reduce the amount of sediment transported onto paved roads by motor vehicles or runoff by constructing a stabilized pad of rock spalls at entrances to construction sites.

Conditions of Use

1. Wherever traffic will be leaving a construction site and traveling on paved roads or other paved areas within 1000 feet of the site.

Design and Installation Specifications

1. See Figure 5.4.4.1A for detail.

2. A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:

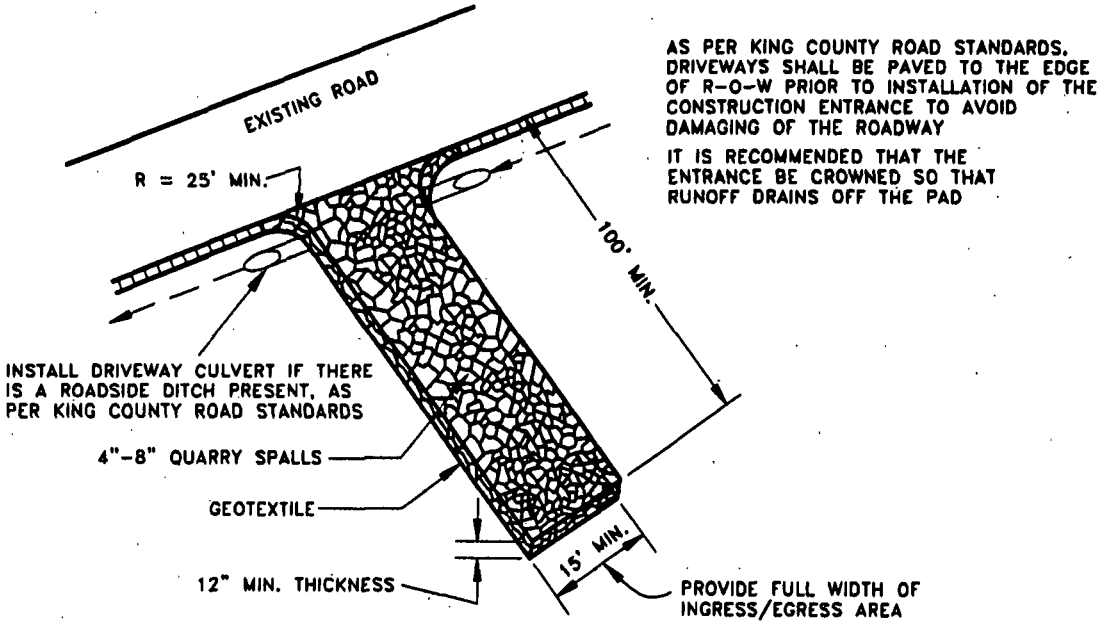
Grab Tensile Strength (ASTM D-4751)	=	200 psi min.
Grab Tensile Elongation (ASTM D-4632)	=	30% max.
Mullen Burst Strength (ASTM D-3786-80a)	=	400 psi min.
AOS (ASTM D-4751)	=	20-45 (U.S. standard sieve size)

3. Hog fuel may be substituted for or combined with quarry spalls in areas that will not be used for permanent roads. The effectiveness of hog fuel is highly variable, but it has been used successfully on many sites. It generally requires more maintenance than quarry spalls. The inspector may at any time require the use of quarry spalls if the hog fuel is not preventing sediment from being tracked onto pavement or if the hog fuel is being carried onto pavement. Hog fuel is prohibited from permanent roadbeds because organics in the sub-grade soils cause difficulties with compaction.

4. Fencing (Section 5.4.1) shall be installed as necessary to restrict traffic to the construction entrance.

5. Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

FIGURE 5.4.4.1A STABILIZED CONSTRUCTION ENTRANCE



Maintenance Standards

1. Quarry spalls (or hog fuel) shall be added if the pad is no longer in accordance with the specifications.

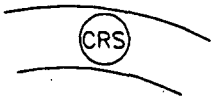
2. If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash. If washing is used, it shall be done on an area covered with crushed rock, and wash water shall drain to a sediment trap or pond.

3. Any sediment that is tracked onto pavement shall be removed immediately by sweeping. The sediment collected by sweeping shall be removed or stabilized on-site. The pavement shall not be cleaned by washing down the street, except when sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump shall be considered. The sediment would then be washed into the sump.

4. Any rock spalls that are loosened from the pad and end up on the roadway shall be removed immediately.

5. If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (Section 5.4.1) shall be installed to control traffic.

5.4.4.2 CONSTRUCTION ROAD/PARKING AREA STABILIZATION

Code: CRS Symbol: 

Purpose

To stabilize subdivision roads, parking areas, and other on-site vehicle transportation routes immediately after grading in order to reduce erosion caused by construction traffic or runoff.

Conditions of Use

1. Wherever roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

2. Fencing (Section 5.4.1) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

1. A 6" depth of 2"-4" crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4" course of asphalt treated base (ATB) may also be used or the road/parking area can be paved. It may also be possible to use cement or calcium chloride for stabilization. If the area will not be used for permanent roads, parking areas, or structures, a 6" depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade.

2. Temporary road gradients shall not exceed 15 percent. Roadways shall be carefully graded to drain transversely. Drainage ditches shall be provided on each side of the roadway in the case of a crowned section, or on one side in the case of super elevated section. Drainage ditches shall be designed in accordance with the standards given in Section 5.4.6.3 and directed to a sediment pond or trap.

3. Rather than relying on ditches, it may also be possible to grade the road so that runoff sheetflows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation, then it is generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include vegetated wetlands. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.

4. In order to control construction traffic, the county can require that signs be erected on-site informing construction personnel that vehicles, other than those performing clearing and grading, are restricted to stabilized areas.

Maintenance Standards

1. Crushed rock, gravel base, hog fuel, etc. shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.

5.4.5 SEDIMENT RETENTION

Minimum Requirement 5 Surface water collected from disturbed areas of the site shall be routed through a sediment pond or trap prior to release from the site. An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (Section 5.4.3). Also, if the soils and topography are such that no off-site discharge of surface water is anticipated up to and including the developed 2-year, 24-hour design storm, sediment ponds and traps are not required. No discharge up to and including the developed 10-year, 24-hour design storm shall be required if the project size, expected timing and duration of

construction, or downstream conditions warrant a higher level of protection (see below). At the county's discretion, sites may be worked during the dry season without sediment ponds and traps if there is some other form of protection of surface waters, such as a 100-foot, forested buffer between the disturbed areas and adjacent surface waters. Protection of catch basins is required for inlets that are likely to be impacted by sediment generated by the project and that do not drain to an on-site sediment pond or trap. Sediment retention facilities shall be installed prior to grading of any contributing area.

Purpose The purpose of sediment retention facilities is to remove sediment from runoff generated from disturbed areas.

When to Install The facilities shall be constructed as the first step in the clearing and grading of the site. The surface water conveyances can then be connected to the facilities as site development proceeds.

Measures to Use There are three sediment retention measures in this section. The first two, sediment traps and ponds, serve the same function, but for different size catchments. All runoff from disturbed areas must be routed through a trap or pond except for very small areas as specified in Section 5.4.3. The third measure is for catch basin protection. It is only to be used in limited circumstances and is not a primary sediment treatment facility. It is only intended as a backup in the event of failure of other systems on-site.

Use of Permanent Drainage Facilities All projects that are constructing permanent facilities for runoff quantity control are strongly encouraged to use the rough-graded or final-graded permanent facilities for ponds and traps. This includes combined facilities and infiltration facilities. When permanent facilities are used as temporary sedimentation facilities, the surface area requirements of sediment traps (for drainages less than 3 acres) or sediment ponds (more than 3 acres) must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as per the requirements for sediment ponds. Either a permanent control structure or the temporary control structure described in Section 5.4.5.2 can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond.

If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of two feet above final grade. Excavation should be done with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface. Additionally, any required pretreatment facilities shall be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavation are intended to prevent the clogging of soil with fines. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized (Section 5.4.11).

Selection of the Design Storm In most circumstances, the use of the standard 2-year, 24-hour design storm is sufficient for calculating surface area for ponds and traps and for determining exemptions to minimum requirements 5 and 6. In some circumstances, however, the 10-year, 24-hour storm should be used. Examples of such circumstances include:

- Sites that are in proximity to salmonid streams, Class 1 wetlands, and phosphorus-sensitive lakes, such as Lake Sammamish.
- Sites where major clearing and grading is likely to occur during the wet season.
- Sites with downstream erosion or sedimentation problems.

Natural Vegetation Whenever possible, sediment-laden water shall be discharged into on-site, relatively level, vegetated areas. This is the only way to effectively remove fine particles from runoff. This can be particularly useful after initial treatment in a sediment retention facility. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it because of the possibility of pump failure or runoff volume in excess of pump capacity.

5.4.5.1 SEDIMENT TRAP

Code: ST Symbol:

Purpose

To remove sediment from runoff originating from disturbed areas of the site. Sediment traps are typically designed to only remove sediment as small as medium silt (0.02 mm). As a consequence, they usually only result in a small reduction in turbidity.

Conditions of Use

1. A sediment trap shall be used where the contributing drainage area is 3 acres or less.

Design and Installation Specifications

1. See Figure 5.4.5.1A for detail.

2. If permanent runoff control facilities are part of the project, they should be used for sediment retention (see the introduction to this section).

3. To determine the trap geometry, first calculate the design surface area (SA) of the trap, measured at the invert of the weir . Use the following equation:

   $SA = FS(Q_2/V_s)$,

   where:

   Q_2 = Design inflow based on the peak discharge from the developed 2-year, 24-hour design storm from the contributing drainage area as computed in the hydrologic analysis. The 10-year, 24-hour design storm shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the rational method may be used (Section 4.3.3).

   V_s = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm^3 has been selected as the particle of interest and has a settling velocity (V_s) of 0.00096 ft/sec.

   FS = A factor of safety of 2 to account for non-ideal settling.

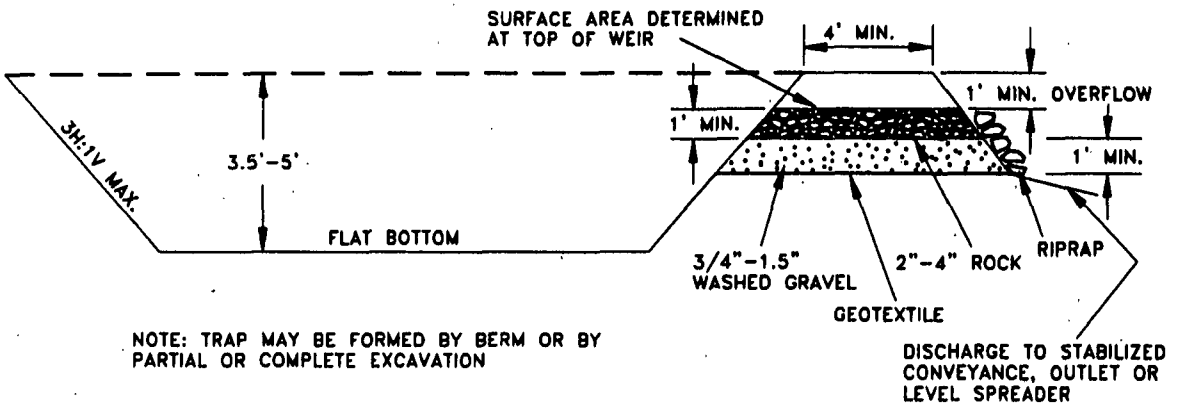
   Therefore, the equation for computing surface area becomes:

   $SA = 2 \times Q_2/0.00096$ or 2080 square feet per cfs of inflow

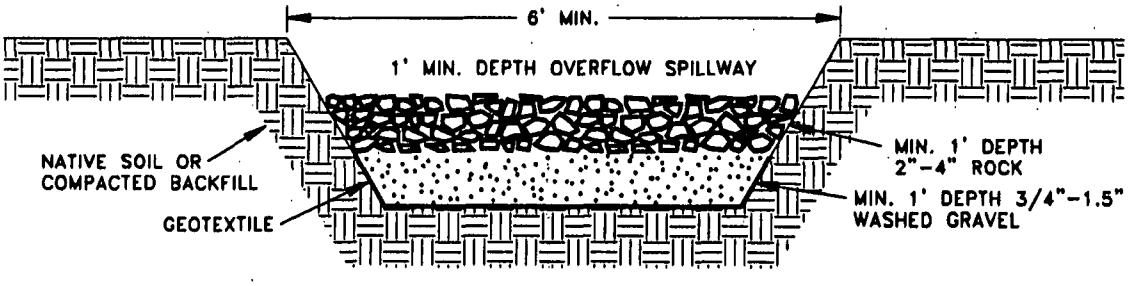
   NOTE: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

4. To aid in determining sediment depth, all traps shall have a staff gauge with a prominent mark 1 foot above the bottom of the trap.

FIGURE 5.4.5.1A SEDIMENT TRAP



CROSS-SECTION



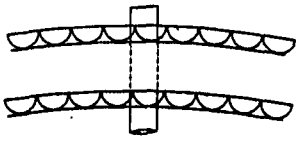
TRAP OUTLET

Maintenance Standards

1. Sediment shall be removed from the trap when it reaches 1 foot in depth.

2. Any damage to the trap embankments or slopes shall be repaired.

5.4.5.2 SEDIMENT POND

Code: SP Symbol: 

Purpose

To remove sediment from runoff originating from disturbed areas of the site. Sediment traps are typically designed to only remove sediment as small as medium silt (0.02 mm). As a consequence, they usually reduce turbidity only slightly.

Conditions of Use

1. A sediment pond shall be used where the contributing drainage area is 3 acres or more.

Design and Installation Specifications

1. See Figures 5.4.5.2A, 5.4.5.2B, and 5.4.5.2C for details.

2. If permanent runoff control facilities are part of the project, they should be used for sediment retention (see introduction to this section).

Determining Pond Geometry

1. Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year, 24-hour developed storm (Q_2). The 10-year, 24-hour design storm shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the rational method may be used (Section 4.3.3).

2. Determine the required surface area at the top of the riser pipe with the equation:

   $SA = 2 \times Q_2/0.00096$ or 2080 square feet per cfs of inflow

   See Section 5.4.5.1 for more information on the derivation of the surface area calculation.

3. The basic geometry of the pond can now be determined using the following design criteria:

   - Required surface area at top of riser.
   - Minimum 3.5' depth from top of riser to bottom of pond.
   - Maximum 3:1 interior side slopes and maximum 2:1 exterior slopes. The interior slopes can be increased to a maximum of 2:1 if fencing is provided at or above the maximum water surface.
   - One foot of freeboard between the top of the riser and the crest of the emergency spillway.
   - Flat-bottomed.
   - Minimum one foot deep spillway.
   - Length to width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms

Principal Spillway Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the pre-developed 10-year, 24-hour design storm (Q_{10}). Use Figure 4.4.7J to determine this diameter (h = one foot). Note that a permanent control structure may be used instead of a temporary riser.

Emergency Overflow Spillway Determine the required size and design of the emergency overflow spillway for the 100-year, 24-hour developed design storm using the procedure in Section 4.4.4 (Emergency Overflow Spillway subsection).

Dewatering Orifice Use the following steps to determine the size of the dewatering orifice:

1. Determine the size of the dewatering orifice(s) (minimum 1" diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. First, determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s(2h)^{0.5}}{10.6 \times 3600 Tg^{0.5}}$$

where: A_o = orifice area (square feet)

As = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

g = acceleration of gravity (32.2 feet/second^2)

2. Convert the required surface area to the required diameter of the orifice:

The orifice diameter (D) in inches is: $D = 24 \times \sqrt{\frac{A_o}{3.14}}$

3. The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. The size and number of performations in the tubing should be large enough so that the tubing does not restrict flow. The flow rate should be controlled by the orifice.

Additional Design Specifications

Pond Divider The pond shall be divided into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of 1 foot below the top of the riser. Wire-backed, 2-3 feet high, extra strength filter fabric (Section 5.4.3.1) supported by treated 4"x4"s can be used as a divider. Alternatively, staked straw bales wrapped with filter fabric may be used. If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

Depth Gauge To aid in determining sediment depth, one-foot intervals shall be prominently marked on the riser.

Embankment If an embankment of more than 6 feet is proposed, the pond must comply with the criteria for Berm Embankment/Slope Stabilization in Section 4.4.4.

FIGURE 5.4.5.2A SEDIMENT POND PLAN VIEW

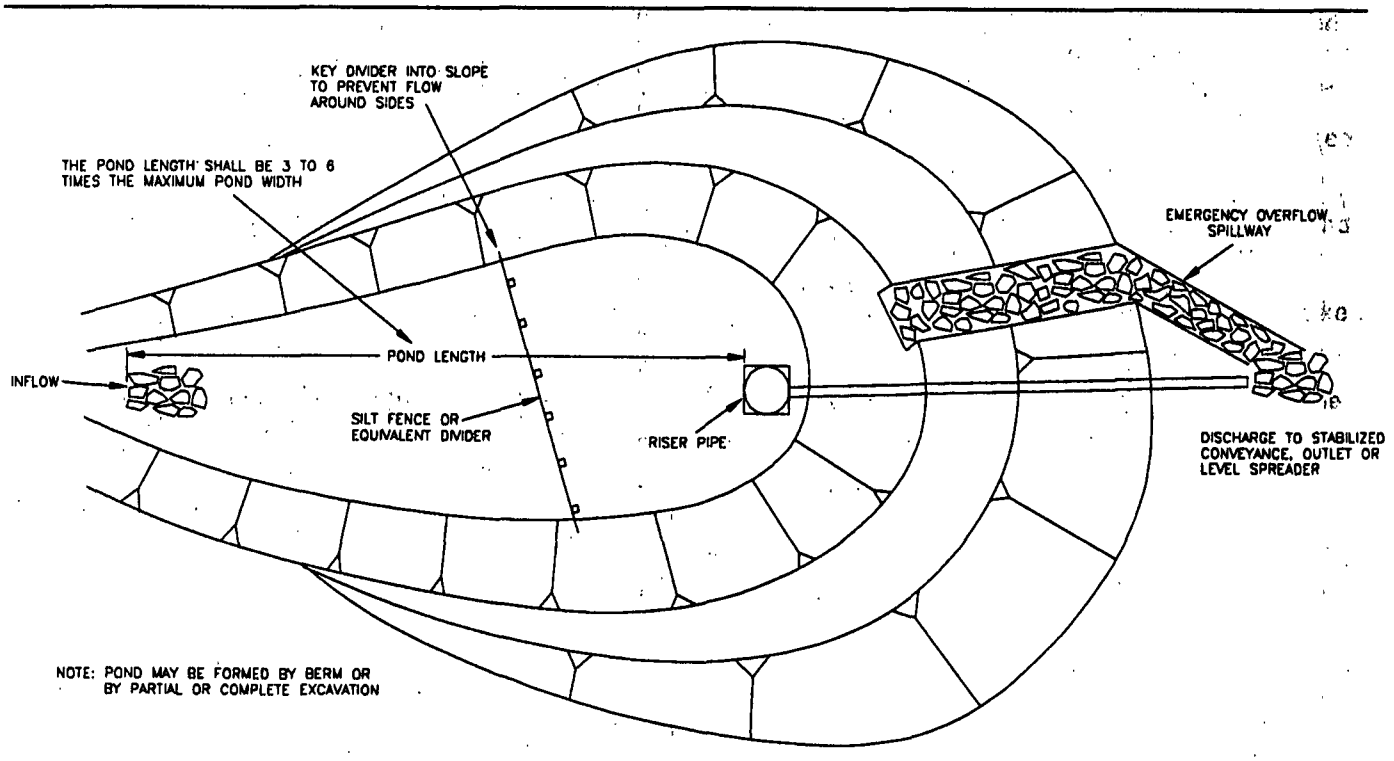


FIGURE 5.4.5.2B SEDIMENT POND CROSS-SECTION

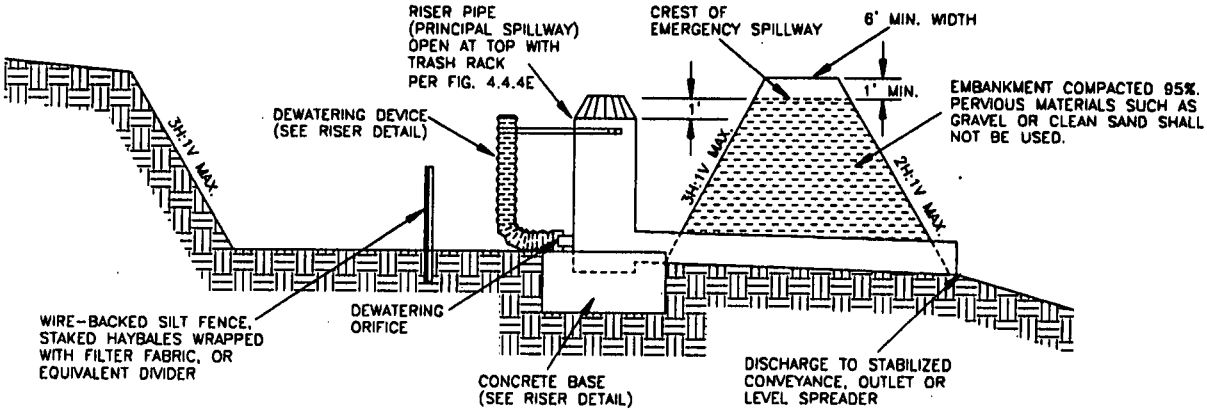
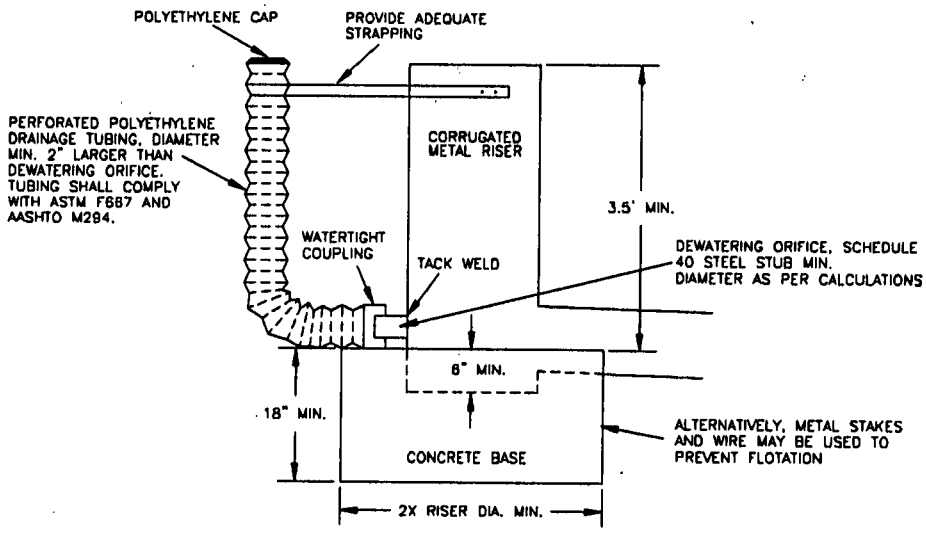


FIGURE 5.4.5.2C SEDIMENT POND RISER DETAIL



Maintenance Standards

1. Sediment shall be removed from the pond when it reaches 1 foot in depth.
2. Any damage to the pond embankments or slopes shall be repaired.

5.4.5.3 STORM DRAIN INLET PROTECTION

Code: FFP or CBI Symbol:

Purpose

To prevent coarse sediment from entering storm drainage systems.

Conditions of Use

1. All storm drain inlets downslope and within 500 feet of a disturbed area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap.

2. All storm drain inlets downslope and within 500 feet of a construction entrance, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap.

3. Inlet protection may be used anywhere at the applicant's discretion to protect the drainage system. This will, however, require more maintenance, and it is highly likely that the drainage system will still require some cleaning.

4. There are two options for protecting storm drain inlets: catch basin inserts and filter fabric protection. Catch basin inserts are manufactured devices that nest inside a catch basin. Filter fabric protection is filter fabric placed <u>over</u> the grate. Both options are much simpler to maintain than many other methods of storm drain inlet protection and are not a hazard to traffic. Both options provide adequate protection, but filter fabric is likely to result in ponding of water above the catch basin, while the insert will not. Thus, filter fabric is only allowed where ponding will not be a traffic concern and where slope erosion will not result if the curb is overtopped by ponded water.

5. It is sometimes possible to construct a small sump around the catch basin before final surfacing of the road. This is allowed because it can be a very effective method of sediment control.

NOTE: Trapping sediment in the catch basins is unlikely to improve the water quality of runoff if it is treated in a pond or trap because the coarse particles that are trapped at the catch basin settle out very quickly in the pond or trap. Catch basin protection normally only improves water quality where there is no treatment facility downstream. In these circumstances, catch basin protection is an important, last line of defense. It is not, however, a substitute for preventing erosion.

In addition, the use of catch basin protection has been severely scaled back and revised from previous versions of this manual due to field observations. The traditional method of protection has been placement of filter fabric under the grate of the catch basin. This method is very difficult to maintain, leads to ponding, and can cause substantial erosion because curbs can be overtopped, and concentrated runoff then erodes slopes. The placement of filter fabric <u>under</u> grates is therefore prohibited and the use of filter fabric over grates is strictly limited and discouraged.

Design Criteria/Specifications

1. See Figures 5.4.5.3A and 5.4.5.3B for details.

FIGURE 5.4.5.3A FILTER FABRIC PROTECTION

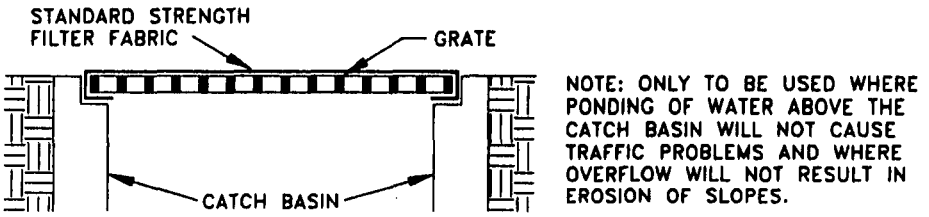
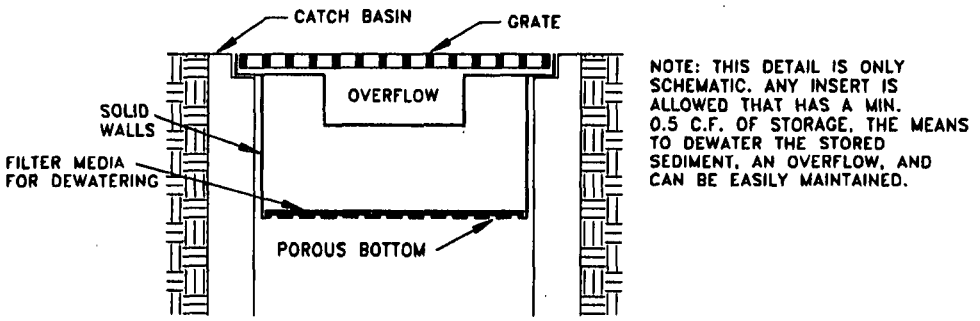


FIGURE 5.4.5.3B CATCH BASIN INSERT



Maintenance Standards

1. Any accumulated sediment on or around the filter fabric protection shall be removed immediately. Sediment shall not be removed with water, and all sediment must be disposed of as fill on-site or hauled off-site.

2. Any sediment in the catch basin insert shall be removed when the sediment has filled one-third of the available storage. The filter media for the insert shall be cleaned or replaced at least monthly.

3. Regular maintenance is critical for both forms of catch basin protection. Unlike many forms of protection that fail gradually, catch basin protection will fail suddenly and completely if not maintained properly.

5.4.6 SURFACE WATER CONTROL

Minimum Requirement 6 All surface water from disturbed areas shall be intercepted, conveyed to a sediment pond or trap, and discharged downslope of any disturbed areas. An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (Section 5.4.3). Also, if the soils and topography are such that no off-site discharge of surface water is anticipated up to and including the developed 2-year, 24-hour design storm, surface water controls are not required. No discharge up to and including the 10-year, 24-hour design storm shall be required if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection (see the introduction to Section 5.4.5). At the county's discretion, sites may be worked during the dry season without surface water controls, if there is some other form of protection of surface waters, such as a 100-foot, forested buffer between the disturbed areas and adjacent surface waters. Significant sources of upslope surface water that drain onto disturbed areas shall be intercepted and conveyed to a

stabilized discharge point downslope of the disturbed areas. Surface water controls shall be installed concurrently with rough grading.

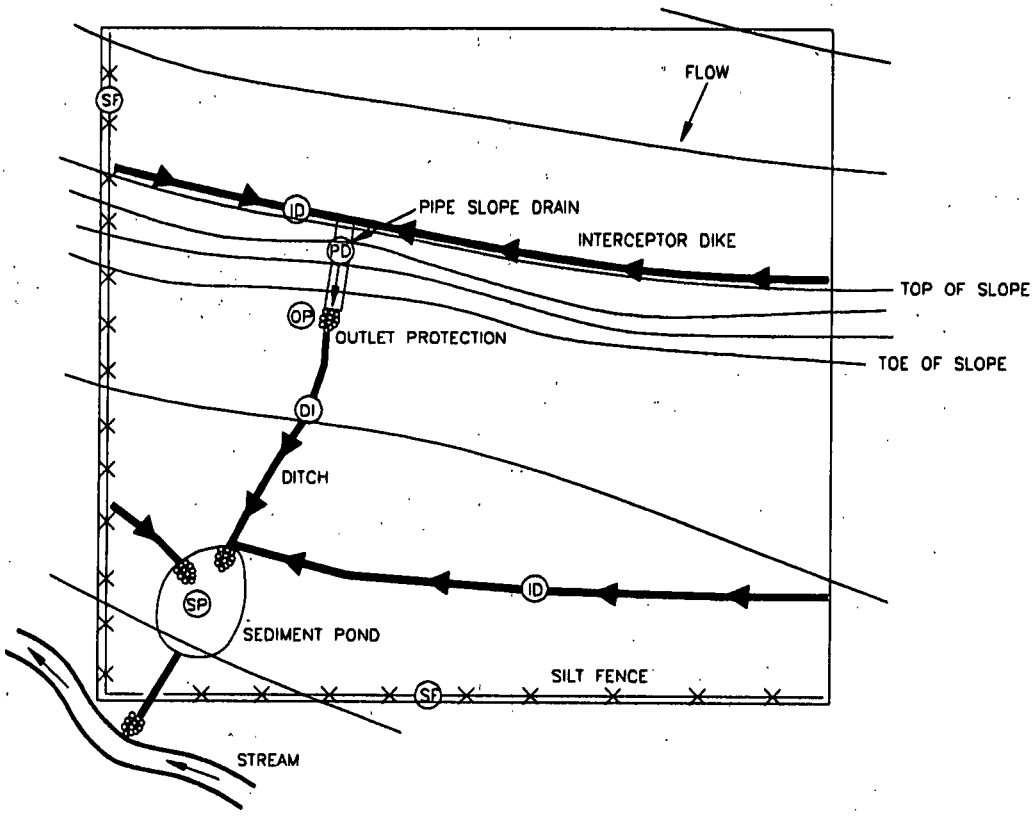
Purpose The purpose of surface water control is to collect and convey surface water so that erosion is minimized, and runoff from disturbed areas is treated by a sediment pond or trap. Surface water control essentially consists of three elements:

1. Interception of runoff on and above slopes.
2. Conveyance of the runoff to a sediment pond or trap (if the runoff was collected from a disturbed area).
3. Release of the runoff downslope of any disturbed areas.

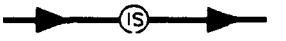
When to Install Surface water controls shall be constructed during the initial grading of an area and must be in place before there is any opportunity for storm runoff to cause erosion.

Measures to Install Interceptor dikes/swales intercept runoff, ditches and pipe slope drains convey the runoff, and riprap or level spreaders are used to release the runoff in a non-erosive manner. Each measure is to be used under different circumstances so there is very little overlap. However, the two options for releasing water in a non-erosive manner, outlet protection and level spreaders, can be somewhat interchangeable. See Figure 5.4.6A for a schematic drawing demonstrating the use of these measures.

FIGURE 5.4.6A SKETCH PLAN OF SURFACE WATER CONTROLS



5.4.6.1 INTERCEPTOR DIKE AND SWALE

Code: ID or IS Symbol: 

Purpose

To intercept storm runoff from drainage areas on or above disturbed slopes and convey it to a sediment pond or trap. Interceptor dikes and swales can also be used to intercept runoff from undisturbed areas and convey the runoff to a point below any exposed soils. Interception of surface water reduces the possibility of slope erosion. Interceptor dikes and swales differ from ditches (Section 5.4.6.3) in that they are intended to convey smaller flows along low-gradient drainageways to larger conveyances such as ditches or pipe slope drains.

Conditions of Use

1. This practice is required at the top of all slopes in excess of 3H:1V and with more than 20 feet of vertical relief.

2. It is required at intervals on any slope that exceeds the dimensions specified in this section for the horizontal spacing of dikes and swales.

Design and Installation Specifications

1. See Figure 5.4.6.1A for detail of interceptor dike and Figure 5.4.6.1B for detail of interceptor swale.

2. Horizontal spacing of interceptor dikes and swales:

Average Slope	Spacing
3-5%	300 feet
5-10%	200 feet
10-25%	100 feet
25-50%	50 feet

3. For slopes steeper than 2H:1V with more than 10 feet of vertical relief, benches may be constructed or closer spaced interceptor dikes or swales can be used. Whichever measure is chosen, the spacing and capacity of the measures must be designed by the engineer and the design shall include provisions for effectively intercepting the high velocity runoff associated with steep slopes.

4. If the dike or swale intercepts runoff from disturbed areas, it shall discharge to a stable conveyance that routes the runoff to a sediment pond or trap (Section 5.4.5). If the dike or swale intercepts runoff that originates from undisturbed areas, it shall discharge to a stable conveyance that will route the runoff downslope of any disturbed areas and release the water at a stabilized outlet.

5. Construction traffic over temporary dikes and swales shall be minimized.

FIGURE 5.4.6.1A INTERCEPTOR DIKE

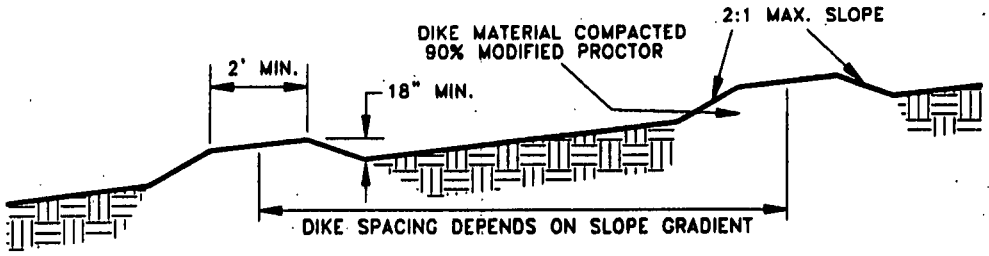
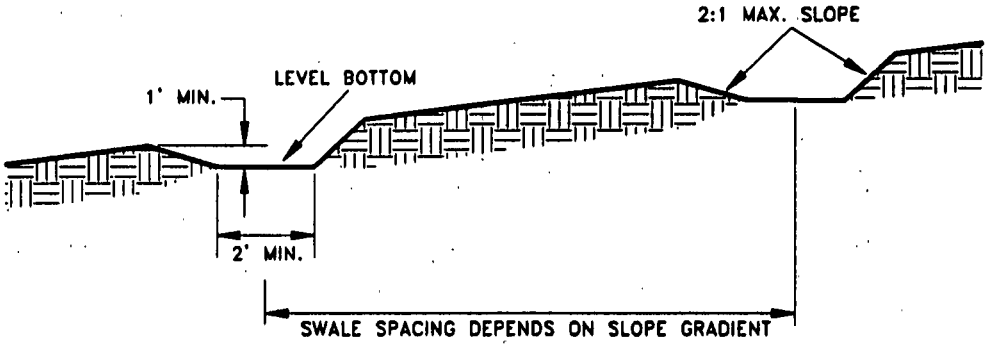


FIGURE 5.4.6.1B INTERCEPTOR SWALE

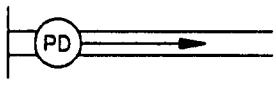


Maintenance Standards

1. Damage resulting from runoff or construction activity shall be repaired immediately.

2. If the facilities do not regularly retain storm runoff, the capacity and/or frequency of the dikes/swales shall be increased.

5.4.6.2 PIPE SLOPE DRAINS

Code: PD Symbol: 

Purpose

To carry concentrated runoff down steep slopes without causing erosion, or saturation of slide-prone soils.

Conditions of Use

1. On any slope with a gradient of 2H:1V or greater and with at least 10 feet of vertical relief.

2. Rock-lined ditches or other permanent, non-erosive conveyances may also be used to convey runoff down steep slopes.

Design and Installation Specifications

1. See Figure 5.4.6.2A for detail.

2. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10-year, 24-hour design storm. The peak flow may be computed using the rational method described in Section 4.3.3.

3. The maximum drainage area allowed per pipe is 10 acres. For larger areas, more than one pipe shall be used or a rock-lined channel shall be installed (see Section 4.3.7, Open Channels).

4. The soil around and under the pipe and entrance section shall be thoroughly compacted.

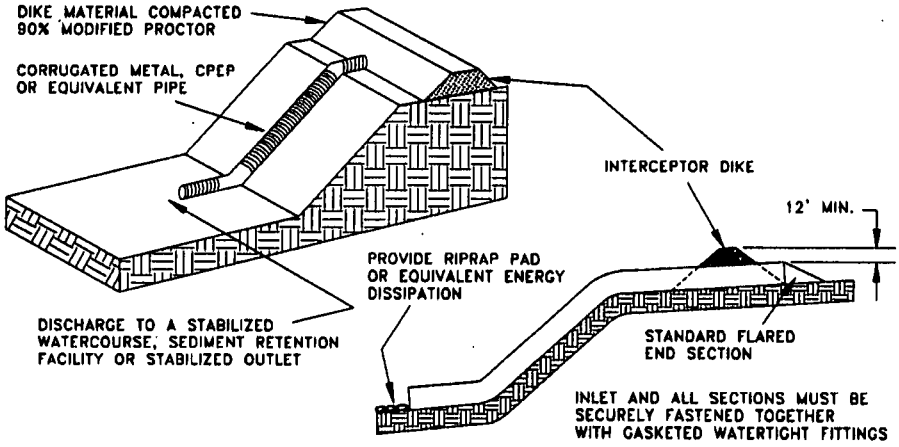
5. The flared inlet section shall be securely connected to the slope drain and have gasketed, watertight connecting bands.

6. Slope drain sections shall be securely fastened together with gasketed watertight fittings, and be securely anchored into the soil.

7. Where slope drains cross steep slope hazard areas or their associated buffers, the installation shall be accomplished with minimum alteration. In most circumstances, this requires that slope drains be constructed of HDPP and installed by hand (Section 4.3.6). Any area disturbed during installation or maintenance must be immediately stabilized.

8. If the pipe slope drain will convey sediment-laden runoff, the runoff must be directed to a sediment retention facility (Section 5.4.5). If the runoff is not from a disturbed area or is conveyed from a sediment trap or pond, it must be conveyed to a stabilized discharge point (Section 5.4.6.4).

FIGURE 5.4.6.2A PIPE SLOPE DRAIN

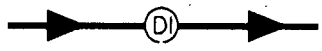


Maintenance Standards

1. The inlet shall not be undercut or bypassed by water. If there are problems, the head wall shall be appropriately reinforced.

2. No erosion shall occur at the outlet point. If erosion occurs, additional protection shall be added.

5.4.6.3 DITCHES

Code: DI Symbol: 

Purpose

To convey intercepted runoff from disturbed areas to and from sediment ponds/traps. Also, to convey runoff intercepted from undisturbed areas around the site to a non-erosive discharge point.

Conditions of Use

1. Anywhere that concentrated runoff is to be conveyed on or around the construction site. Temporary pipe systems can also be used to convey runoff.

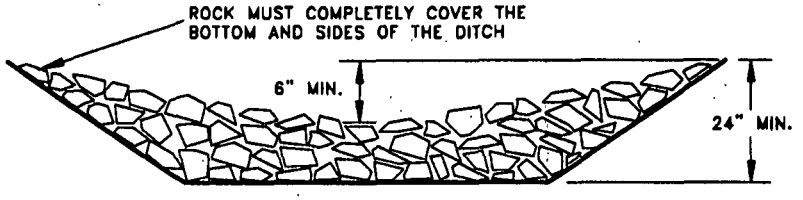
Design and Installation Specifications

1. Channels and ditches shall be sized to accommodate the peak flow from the 10-year, 24-hour design storm with 0.5 feet of freeboard . If no hydrologic analysis required the rational method may be used. (Section 4.3.3).

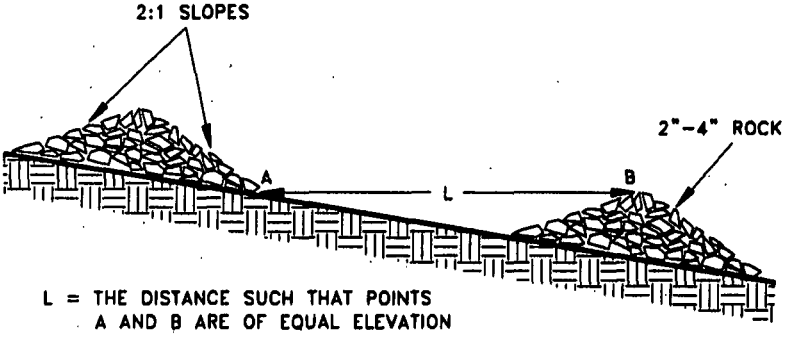
2. See Section 4.3.7 for requirements for open-channel design requirements.

3. The only exception to the requirements of Section 4.3.7 is the use of check dams, rather than grass-lining, for channels in which the design flow velocity does not exceed 5 fps. See Figure 5.4.6.3A for details on check dam installation.

FIGURE 5.4.6.3A CHECK DAMS



CROSS SECTION



CHECK DAM SPACING

Maintenance Standards

1. Any sediment deposition of more than 0.5 feet shall be removed so that the channel is restored to its design capacity.

2. If the channel capacity is insufficient for the design storm, it must be determined whether the problem is local (e.g., a constriction or bend) or the channel is underdesigned. If the problem is local, the channel capacity must be increased through construction of a berm(s) or by excavation. If the problem is underdesign, the design engineer shall be notified and the channel redesigned to a more conservative standard to be approved by King County.

3. The channel shall be examined for signs of scouring and erosion of the bed and banks. If scouring or erosion has occurred, affected areas shall be protected by rip-rap or an erosion control blanket or net.

5.4.6.4 OUTLET PROTECTION

Code: OP Symbol:

Purpose

To prevent scour at conveyance outlets.

Conditions of Use

1. At the outlets of all ponds, pipes, ditches, or other approved conveyances, and where runoff is conveyed to a natural or man-made drainage feature such as a stream, wetland, lake, or ditch.

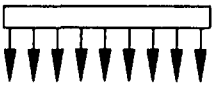
Design and Installation Specifications

1. Outlet protection shall meet the requirements of the Outfalls section of Core Requirement #4 and Section 4.3.6.

Maintenance Standards

1. If there is scour at the outlet, the eroded area shall be protected with more conservative measures proposed by the design engineer and approved by King County.

5.4.6.5 LEVEL SPREADER

Code: LS Symbol: 

Purpose

To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation.

Conditions of Use

1. Where runoff from undisturbed areas or sediment retention facilities is discharged. This practice applies only where the spreader can be constructed on undisturbed soil and the area below the level lip is vegetated and low gradient (see below).

NOTE: Level spreaders are conceptually an ideal way to release stormwater since the vegetation and soil allow for the removal of fines from runoff that cannot be removed by settling or filtration. Unfortunately, the performance record of spreaders in the field is dismal. They are frequently underdesigned and, despite the best installations, are rarely perfectly level, which results in the release of stormwater at a particular point. This concentrated runoff can result in catastrophic erosion downslope. Given such design failures, the use of spreaders is not encouraged. However, where slopes are gentle and the water volume is relatively low, spreaders may still be the best method. When proposing their use, the designer shall carefully evaluate the site for possible concerns.

Design and Installation Specifications

1. See Figure 5.4.6.5A for detail. Other designs may be used subject to county approval.

2. If runoff velocity as it enters the level spreader is more than 4 fps for the 10-year, 24-hour design storm, a rip-rap apron must be provided to dissipate energy before the runoff enters the spreader (Section 5.4.6.4).

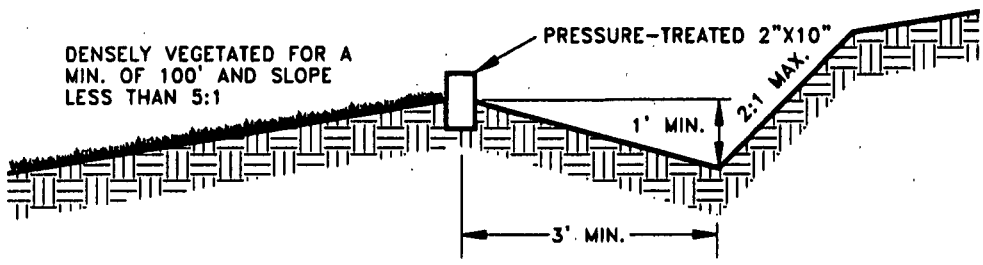
3. The total spreader length shall be at least the square root of the catchment area. The maximum length for an individual spreader is 50 feet, limiting the catchment area that a single spreader may serve to 2500 square feet. Although, this is very small, four 50-foot

spreaders next to one another could serve nearly an acre (40,000 square feet). Multiple spreaders shall not be placed uphill or downhill from one another in a configuration that would allow water released from one spreader to enter a downslope spreader.

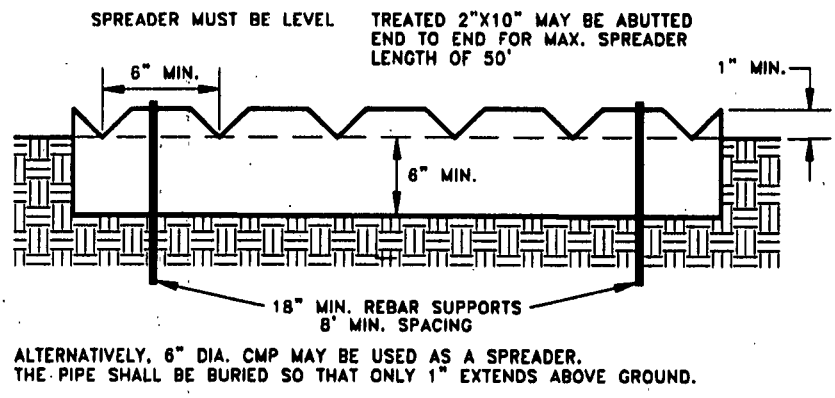
4. The area below the spreader for a horizontal distance of 100 feet shall not exceed 20 percent and shall be completely vegetated with no areas of instability or erosion. The topography for a horizontal distance of 50 feet below the spreader shall be uniform so that runoff is not funneled into a swale or channel immediately after its release.

5. The level spreader shall be seeded and mulched in accordance with Section 5.4.2.

FIGURE 5.4.6.5A LEVEL SPREADER



CROSS SECTION



DETAIL OF SPREADER

Maintenance Standards

1. Any damage to the spreader shall be immediately repaired.

2. The downslope area shall be checked for signs of erosion and to verify that the spreader is not functioning as a point discharge. Any eroded areas shall be immediately stabilized, and the cause determined and eliminated if possible. If the erosion is recurrent and the design, even when properly installed and maintained, is not adequate to prevent erosion, a new method of releasing runoff shall be installed in accordance with the standards of this chapter. Any new design must be approved by King County.

5.4.7 DUST CONTROL

Minimum Requirement 7 Preventative measures to minimize the wind transport of soil shall be taken when a traffic hazard may be created or when sediment transported by wind is likely to be deposited in water resources.

Purpose To prevent wind transport of dust from exposed soil surfaces onto roadways, drainageways, and surface waters.

When to Install When exposed soils are dry to the point that wind transport is possible and roadways, drainageways or surface waters are likely to be impacted.

Measures to Install Water is the most common dust control (or palliative) used in the area. When using water for dust control, the exposed soils shall be sprayed until wet, but runoff shall not be generated by spraying. Calcium chloride may also be used for dust control. Exposed areas shall be resprayed as needed. Oil shall not be used for dust control.

5.4.8 WET SEASON REQUIREMENTS

Minimum Requirement 8 Any site with exposed soils during the wet season (October 1 to March 31) shall be subject to the special provisions below. In addition to the cover requirements in minimum requirement 2, these provisions include covering any newly seeded areas with mulch and identifying and seeding as much disturbed area as possible the first week of October in order to provide grass cover for the wet season.

Wet Season Special Provisions

All of the following provisions are detailed in the referenced sections. These requirements are listed here for the convenience of the designer and the reviewer.

1. The allowed time that a disturbed area can remain unworked without cover measures is reduced to two days, rather than seven (Section 5.4.2).

2. Stockpiles and steep cut and fill slopes are to be protected if unworked for more than 12 hours (Section 5.4.2).

3. Cover materials sufficient to cover all disturbed areas shall be stockpiled on-site (Section 5.4.2).

4. All areas that are to be unworked during the wet season shall be seeded within one week of the beginning of the wet season (Section 5.4.2.4).

5. Mulch is required to protect all seeded areas (Section 5.4.2.4).

6. 50 linear feet of silt fence (and the necessary stakes) per acre of disturbance must be stockpiled on-site (Section 5.4.3).

7. Construction road and parking lot stabilization are required for all sites unless the site is underlain by coarse-grained soil (Section 5.4.4).

8. Sediment retention is required unless no off-site discharge is anticipated for the specified design storm (Section 5.4.5).

9. Surface water controls are required unless no off-site discharge is anticipated for the specified design storm (Section 5.4.6).

10. Phasing and more conservative BMPs must be evaluated for construction activity near surface waters (Section 5.4.9).

11. The frequency of maintenance review increases from monthly to weekly (Section 5.4.10).

5.4.9 SENSITIVE AREAS RESTRICTIONS

Minimum Requirement 9 Any construction that will result in disturbed areas on or within a stream or associated buffer, a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake shall be subject to the special provisions below. These provisions include, whenever possible, phasing the project so that construction in these areas is limited to the dry season. Also, more conservative BMPs shall be considered by the design engineer in order to protect surface water quality. The county may require more conservative BMPs, including more stringent cover requirements. Any project proposing work within 50 feet of a steep slope hazard area shall evaluate the need for diverting runoff that might flow over the top of the slope.

Sensitive Areas Special Provisions

Any project that disturbs areas on or within a stream or associated buffer, a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake has the potential to seriously damage water resources, even if the project is relatively small. While it is difficult to require specific measures for such projects because the TESC plan must be very site specific, the following recommendations shall be incorporated into the plan where appropriate:

1. Whenever possible, phase all or part of the project so that it occurs during the dry season. If this is impossible, November through February shall be avoided since this is the most likely period for large, high-intensity storms.

2. Any project shall be completed and stabilized as quickly as possible. Limiting the size and duration of a project is probably the most effective form of erosion control.

3. Where appropriate, sandbags or an equivalent barrier shall be constructed between the project area and the surface water in order to isolate the construction area from high water that might result due to precipitation.

4. Additional perimeter protection shall be considered to reduce the likelihood of sediment entering the surface waters. Such protection might include multiple silt fences, silt fences with a higher AOS, construction of a berm, or a thick layer of organic mulch upslope of a silt fence.

5. If work is to occur within the ordinary high water mark of a stream, most projects must isolate the work area from the stream by diverting the stream or by the construction of a coffer dam. Certain small projects that propose only a small amount of grading may not require isolation since diversions typically result in disturbance and the release of some sediment to the stream. For such small projects, the potential impacts from construction with and without a diversion must be weighed.

6. If a stream must be crossed, a temporary bridge shall be considered rather than allowing equipment to utilize the streambed for a crossing.

7. Any runoff generated by dewatering shall be treated through construction of a sediment trap and/or by releasing the water to a well-vegetated, gently sloping area. Since pumps are used for dewatering, it may be possible to pump the sediment-laden water well away from the surface water so that vegetation can be more effectively utilized for treatment.

8. For projects in or near a salmonid stream, it may be appropriate to monitor the composition of any spawning gravels within a quarter-mile of the site with a McNeil sampler before, during, and after construction. The purpose of such monitoring would be to determine if the fine content of the gravels increases as a result of construction impacts. Monitoring results could be used to guide erosion control efforts during construction and as a threshold for replacing spawning gravels if the fine content rises significantly.

5.4.10 MAINTENANCE REQUIREMENTS

Minimum Requirement 10 All TESC measures shall be maintained and reviewed on a regular basis as prescribed in the maintenance requirements for each BMP and this section. A TESC supervisor shall be designated by the applicant and shall be responsible for maintenance and review of TESC and for compliance with all permit conditions relating to TESC. The TESC supervisor must be available for rapid response to TESC problems. For minor projects, the applicant may serve as the TESC supervisor. The name, address, and phone number of the TESC supervisor shall be supplied to the county prior to the start of construction. A sign shall be posted at all primary entrances to the site identifying the TESC supervisor and their phone number. The requirement for a TESC supervisor does not relieve the applicant of ultimate responsibility for the project and compliance with county code.

The site shall be reviewed by the TESC supervisor at least once a month during the dry season, weekly during the wet season, and within 24 hours of significant storms. The county can require that a written record of these reviews be kept on-site with copies submitted to DDES within 48 hours. The county can also require that the applicant designate a TESC supervisor with demonstrated experience in TESC to perform these reviews and to be responsible for TESC.

TESC Supervisor For the vast majority of projects, the TESC supervisor shall be designated by the applicant and does not need to meet any specific qualifications. For highly sensitive sites, the county can, however, require that the applicant designate a TESC supervisor with demonstrated expertise in erosion and sediment control. The qualifications of such a person shall include at least several years of construction supervision or inspection and background in geology, soil science, or agronomy. Typically, if a geotechnical consultant is already a part of the project, the consultant can also be the designated TESC supervisor. The design engineer may also be qualified for this position. This requirement shall only be used for sensitive sites that pose an unusually high risk of impact to surface waters. At a minimum, the project site shall meet all of the following conditions in order to require the applicant to designate a TESC supervisor with demonstrated expertise in TESC:

- Alderwood soils or other soils of Hydrologic Group C or D.
- Five acres of disturbance.
- Large areas with slopes in excess of 10 percent.

Proximity to Class 1 or 2 streams or wetlands or phosphorus-sensitive lakes, such as Lake Sammamish, shall also be a factor in determining if a site warrants this requirement. However, proximity alone shall not be a determining factor because even projects that are a considerable distance from surface waters can result in significant impacts if there is a natural or constructed drainage system with direct connections to surface waters.

If DDES determines that the TESC measures on-site are frequently installed, located, or maintained inadequately, DDES can require the applicant to appoint a TESC supervisor with expertise in erosion and sediment control.

Documentation If DDES requires that a written record be maintained, a standard TESC Maintenance Report is included in the Reference section of this manual. A copy of all the required maintenance reports shall be kept on-site throughout the duration of construction. Detailed maintenance requirements for each TESC measure are provided in Sections 5.4.1 through 5.4.7.

Review Timing During the wet season, weekly reviews shall be carried out every 6 to 8 calendar days. During the dry season, monthly reviews shall be carried out within 3 days of the calendar day for the last inspection (e.g., if an inspection occurred on June 6, then the next inspection must occur between July 3 and July 9), Reviews shall also take place within 24 hours of significant storms. In general, a significant storm is one with more than 0.5 inches of rain in 24 hours or less. Other indications that a storm is "significant" is if the sediment ponds or traps are filled with water, or if gullies form as a result of the runoff.

Note The site is to be in compliance with the regulations of this chapter at all times. The requirement for periodic reviews does not remove the applicant's responsibility to have the site constantly in compliance with Core Requirement 5 and the requirements of this chapter. The

reviews are a mechanism to ensure that all measures are thoroughly checked on a regular basis and that there is documentation of compliance. The requirement for these reviews does not mean that TESC is to be ignored in between.

5.4.11 FINAL STABILIZATION

Minimum Requirement 11 Prior to obtaining final construction approval, the site shall be stabilized, the structural TESC measures, such as silt fences and sediment traps, removed, and drainage facilities cleaned. The removal of TESC measures is not required for those projects, such as plats, that will be followed by additional construction under a different permit. In these circumstances, the need for removing or retaining the measures must be evaluated on a site-specific basis.

To obtain final construction approval, the following conditions must be met:

1. All disturbed areas of the site shall be vegetated or otherwise permanently stabilized. At a minimum, disturbed areas shall be seeded and mulched (Section 5.4.2.4) with a high likelihood that sufficient cover will develop shortly after final approval. Mulch without seeding is not adequate to allow final approval of the permit, except for small areas of mulch used for landscaping. The only exceptions to these requirements are lots within a plat that are to be developed under an approved residential permit immediately following plat approval. In these cases, mulch and/or temporary seeding are adequate for cover.

2. Structural measures such as, but not limited to, silt fences, pipe slope drains, construction entrances, storm drain inlet protection, sediment traps and ponds, shall be removed from the site. Measures that will quickly decompose, such as brush barriers and organic mulches, may be left in place. In the case of silt fences, it may be best to remove fences in conjunction with the seeding, since it may be necessary to bring machinery back in to remove them. This will result in disturbed soils that will again require protection. The DDES inspector must approve an applicant's proposal to remove fencing prior to the establishment of vegetation. In some cases, such as residential building following plat development, it may be appropriate to leave some or all TESC measures for use during subsequent development. This shall be determined on a site-specific basis.

3. All permanent surface water facilities, including catch basins, manholes, pipes, ditches, channels, R/D facilities and water quality facilities shall be cleaned. Any off-site catch basin that required protection during construction (Section 5.4.5.3) shall also be cleaned.

4. If only the infrastructure of the site has been developed (e.g., subdivisions and short plats) with building construction to occur under a different permit, then the sensitive area buffers and Native Growth Protection Easements shall be clearly marked as per Section 5.4.1 in order to alert future buyers and builders.

5.5 ALTERNATIVE AND EXPERIMENTAL MEASURES

This manual generally only contains those BMPs that are standards of the local industry. There are a variety of other BMPs available that can also be used, even though they are not included in this chapter. Such alternatives may be approved without a variance if the alternative will produce a compensating or comparable result with the measures in this chapter. Variations on or modifications of the BMPs in this chapter can also be granted based on the same criteria. Technical support will be provided by SWM when requested by DDES.

A variance is only required for those products or techniques that are so new and untested as to be experimental. If the county determines that a proposed alternative is experimental, then an experimental variance must be obtained (Section 1.4.4). The intent of this requirement is not to discourage new techniques, but to insure that new techniques are monitored and documented for possible inclusion in subsequent versions of this manual. An example of a product that would have required an experimental variance prior to this version of the manual is the catch basin insert (Section 5.4.5.3) because it had no equivalence with any existing measure.

5.6 ROADS AND UTILITIES

Road and utility projects often pose difficult erosion control challenges because they frequently cross surface waters and because narrow right-of-ways constrain areas available to store and treat polluted water. In most cases, the standards of this chapter can be applied to such linear projects without modification. For instance, the ability to use perimeter control rather than a sediment retention facility for small drainage areas (Section 5.4.3) will apply to many of these projects. However, there may be some projects that cannot reasonably meet the standards of Core Requirement 5 and this chapter. In these cases, other measures may be proposed that will provide reasonable protection. A variance is not required for such projects, unless the county determines that measures proposed by the applicant fail to meet the intent of Core Requirement 5 and this chapter and that significant adverse impacts to surface water may result. Examples of other measures that may be taken in lieu of the standards of this chapter are:

1. Phasing the project so that the site is worked progressively from end to end, rather than clearing and grubbing the entire length of the project. This results in smaller exposed areas for shorter durations, thus reducing the erosion risk.

2. Mulching and vegetating cut and fill slopes as soon as they are graded. Frequently, this is done at the end of construction when paving or utility installation is complete. Vegetating these areas at the start of the project stabilizes those areas most susceptible to erosion.

3. Protecting all catch basin inlets with catch basin inserts when these do not drain to ponds or traps. This will not provide the same level of protection as a sediment pond or trap, but can remove most of the sand-sized material entrained in the runoff.

4. Phasing the project so that all clearing and grading in sensitive area buffers occurs in the dry season. This substantially reduces the chance of erosion and allows for rapid revegetation in the late summer and early fall.

5. Using flocculents to reduce the turbidity of water released from sediment ponds.

6. Hiring a private consultant with expertise in TESC to review and monitor the site.

If alternatives are used, it may be appropriate to develop a monitoring program that would monitor compliance with the performance standard of Core Requirement 5 and/or impacts to nearby water resources. Of particular concern are impacts to salmonid spawning gravels. McNeil sampling is a possible method of sampling to determine impacts to spawning gravels (see Section 5.4.9).

5.7 NPDES REQUIREMENTS

As part of the implementation of the National Pollutant Discharge Elimination System (NPDES), projects that will disturb more than five acres of total area must apply for coverage under the Washington State Department of Ecology's Baseline General Permit for Stormwater. The five acre threshold applies even if the five acres are to be disturbed in phases, as long as the construction is "part of a larger common plan of development or sale." In general, the erosion control plan required for this manual is equivalent to that required by the state through the Stormwater Management Manual for the Puget Sound Basin (DOE, 1982). The DOE stormwater permit application requires the filing of a Notice of Intent (NOI) at least 30 days prior to the start of construction. The only major requirement of the stormwater permit that is not included in this manual is a public notice requirement. Note that this public notice for Ecology's stormwater permit can be published concurrently with other public notices required for permits or SEPA. Contact the Department of Ecology at (206)407-7156 for complete information on permit thresholds, applications, and requirements.

5.8 REFERENCES

Goldman, S.J., Jackson, K., and T.A. Bursztynsky. 1986. Erosion and Sediment Control Handbook. McGraw-Hill Book Company, New York, New York.

King County Dept. of Public Works. 1993. Guidelines for Bank Stabilization Projects. Surface Water Management Division, Seattle, Wash.

Metropolitan Washington Council of Governments. 1990. Performance of Current Sediment Control Measures at Maryland Construction Sites. Washington, D.C. Prepared by T.R. Schueler and J. Lugbill.

Horner, R.R., Guedry, J., and Kortenhof, M.H.. 1990. Highway Construction Site Erosion and Pollution Control Manual. Washington State Transportation Center, Seattle, Wash. and Washington State Dept. of Transportation, Olympia, Wash. Report No. WA-RD 200.2.

DEFINITIONS

KING COUNTY, WASHINGTON
SURFACE WATER
DESIGN MANUAL

DEFINITIONS

Note: The following terms are provided for reference and use with this Manual. They shall be superseded by any other definitions for these terms adopted by ordinance.

"Adjacent steep slope" means slopes with a gradient of 15% or steeper within five hundred feet of the site.

"Anadromous" means fishes ascending rivers from the sea for breeding.

"Applicant" means the person who has applied for a development permit or approval.

"Appurtenances" means machinery, appliances, or auxiliary structures attached to a main structure, but not considered an integral part thereof, for the purpose of enabling it to function.

"Aquifer" means a geologic stratum containing groundwater that can be withdrawn and used for human purposes.

"As-Built Drawings" means engineering plans which have been revised to reflect all changes to the plans which occurred during construction.

"BALD" means the Building and Land Development Division of the King County Department of Parks, Planning and Resources. This division has been replaced by the Department of Development and Environmental Services (DDES).

"BSBL" means building set back line.

"Backwater" means water upstream from an obstruction which is deeper than it would normally be without the obstruction.

"Base Flood" means a flood having a one percent chance of being equaled or exceeded in any given year. This is also referred to as the 100 - year flood. The base flood is determined for existing conditions, unless a basin plan including projected flows under future developed conditions has been completed and adopted by King County, in which case these future flow projections shall be used. In areas where the Flood Insurance Study includes detailed base flood calculations, those calculations may be used until projections of future flows are completed and approved by King County.

"Base flood elevation" means the water surface elevation of the base flood. It shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD).

"Basin" means for the purposes of this document a drainage area which drains either to the Cedar, Green, Snoqualmie, Skykomish or White rivers, or the drainage areas which drain directly to Puget Sound.

"Basin Plan" means a plan and all implementing regulations and procedures including but not limited to land use management adopted by ordinance for managing surface and storm water management facilities and features within individual subbasins.

"Berm" means a constructed barrier of compacted earth.

"Biofiltration" means the process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.

"Bollard" means a post (may or may not be removable) used to prevent vehicular access.

"Bond" means a surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all King County requirements.

"Buffer" means a designated area adjacent to and a part of a steep slope or landslide hazard area which protects slope stability, attenuation of surface water flows, and landslide hazards reasonably necessary to minimize risk; or a designated area adjacent to or a part of a stream or wetland that is an integral part of the stream or wetland ecosystem. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from storm water runoff and precipitation, and erosion control.

"Building setback line" means a line measured parallel to a property, easement, drainage facility or buffer boundary, that delineates the area (defined by the distance of separation) where buildings, or other obstructions are prohibited (including decks, patios, outbuildings, or overhangs beyond 18 inches). Wooden or chain link fences and landscaping are allowable within a building setback line. In this Manual the minimum building setback line shall be 5 feet.

"CIP" means Capital Improvement Project.

"Capital Improvement Project or Program (CIP)" means a project prioritized and scheduled as a part of an overall construction program or the actual construction program.

"Catch line" means the point where a severe slope intercepts a different, more gentle slope.

"Channel" means a surface feature that conveys surface water and is open to the air.

"Channel, constructed" means channels or ditches constructed (or reconstructed natural channels) to convey surface water.

"Channel, natural" means streams, creeks or swales that convey surface/groundwater and have existed long enough to establish a stable route and/or biological community.

"Clearing" means the destruction and removal of vegetation by manual, mechanical or chemical methods.

"Closed depression" means an area of King County which is low-lying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin, with more than 5000 square feet of water surface area at overflow elevation.

"Coal Mine Hazard Areas" means those areas of King County underlain by abandoned mine workings such as adits, tunnels, drifts, and air shafts, or where mine tailings are present.

"Compensatory storage" means new excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe. Equivalent shall mean that the storage removed shall be replaced by equal volume between corresponding one foot contour intervals that are hydraulically connected to the floodway through their entire depth.

"Conveyance" means a mechanism for transporting water from one point to another, including pipes, ditches and channels.

"Conveyance system" means the drainage facilities, both natural and built, which collect, contain and provide for the flow of surface and storm water from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes and wetlands. The built elements of the conveyance system include gutters, ditches, pipes, channels and most retention/detention facilities.

"Critical depth" means the depth which minimizes the specific energy of flow (E).

"Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions which have resulted or will result from the cumulative impacts of development and urbanization,

that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98.

"Critical Flow" means flow at the critical depth and velocity.

"Culvert" means pipe or concrete box structure which drains open channels, swales or ditches under a roadway or embankment. Typically with no catch basins or manholes along its length.

"Current conditions" means the conditions (land use, impervious surfaces, topography, soils, and surface water flows) present at the time the analysis is conducted.

"DDES" means the Department of Development and Environmental Services.

"DNS" means determination of non-significance.

"Dead storage" means the volume available in a depression in the ground below any conveyance system, or surface drainage pathway, or outlet invert elevation that could allow the discharge of surface and storm water runoff.

"Dedication of land" refers to setting aside a portion of a property for a specific use or function.

"Department" means the Department of Public Works.

"Depression storage" means the amount of precipitation that is trapped in depressions on the surface of the ground.

"Design engineer" means the professional civil engineer who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.

"Design storm" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

"Detention" means release of surface and storm water runoff from the site at a slower rate than it is collected by the drainage facility system, the difference being held in temporary storage.

"Determination of Nonsignificance (DNS)" means the written decision by the responsible official of the lead agency that a proposal is not likely to have a significant adverse environmental impact, and therefore an EIS is not required.

"Development" means for the purposes of this document any activity that requires a permit or approval, including but not limited to a building permit, grading permit, shoreline substantial development permit, conditional use permit, unclassified use permit, zoning variance or reclassification, planned unit development, subdivision, short subdivision, master plan development, building site plan, or right-of-way use permit.

"Development Engineer" means the Building and Land Development Division employee authorized to oversee the review, conditioning, inspection and acceptance of right-of-way use permits, road and drainage projects constructed pursuant to permits administered by the Division. The development engineer or designee shall be a professional civil engineer registered and licensed under the laws of the State of Washington.

"Discharge" means runoff, excluding off-site flows, leaving the proposed development through overland flow, built conveyance systems, or infiltration facilities.

"Dispersed discharge" means release of surface and storm water runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodable underlying granular soils or flood downstream properties.

"Ditch" means a long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.

"Diversion" means a change in the natural discharge location or runoff flows onto or away from an adjacent downstream property. See Core Requirement 1.

"Drainage" refers to the collection, conveyance, containment, and/or discharge of surface and storm water runoff.

"Drainage area" means area draining to a location not bounded by property lines.

"Drainage channel" means a drainage pathway with well-defined bed and banks indicating frequent conveyance of surface and storm water runoff.

"Drainage course" means a pathway for watershed drainage characterized by wet soil vegetation; often intermittent in flow.

"Drainage easement" means a legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.

"Drainage facility" means the system of collecting, conveying and storing surface and storm water runoff. Drainage facilities shall include but not be limited to all surface and storm water runoff conveyance and containment facilities including streams, pipelines, channels, ditches, swamps, lakes, wetlands, closed depressions, infiltration facilities, retention/detention facilities, erosion/sedimentation control facilities, and other drainage structures and appurtenances, both natural and man-made.

"Drainage pathway" means the route that surface and storm water runoff, leaving any part of the site, follows downslope.

"Drainage review" means an evaluation by Building and Land Development Division staff of a proposed project's compliance with the drainage requirements in the Surface Water Design Manual.

"Dry Season" means April 1 to September 30.

"EIS" means Environmental Impact Statement.

"Easement" means the legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owners use of the land.

"Embankment" means a structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.

"Energy dissipator" means any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.

"Energy gradient" means the slope of the specific energy line (i.e., the sum of the potential and velocity heads).

"Engineering plan" means a plan prepared and stamped by a professional civil engineer. An engineering plan contains a Technical Information Report and Site Improvement Plans which are described in detail in the Surface Water Design Manual.

"Engineering review" means an evaluation by Building and Land Development Division staff of a proposed project's compliance with the drainage requirements in the Surface Water Design Manual. An engineering review also includes a BALD Division staff evaluation of a proposed project for compliance with other King County requirements.

"Enhancement" means to raise value, desirability, or attractiveness of an environment associated with surface water.

"Environmental Impact Statement (EIS)" means a document that discusses the likely significant adverse impacts of a proposal, ways to lessen the impacts, and alternatives to the proposal. They are required by the national and state environmental policy acts when projects are determined to have significant environmental impact.

"Equivalent area" means the tributary area tributary to the receiving water body equal to or less than the shortest, straight-line distance from the receiving water body (or regional facility) to the furthest point of the proposed project.

"Erodable granular soils" means soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

"Erosion" means detachment of soil or rock fragments by water, wind, ice and gravity.

"Erosion Hazard Areas" means those areas of King County containing soils which, according to the USDA Soil Conservation Service, King County Soils Survey dated 1973 and any subsequent revisions or additions thereto, may experience severe to very severe erosion hazard. The group of soils includes Alderwood gravelly sandy loan (AgD), Alderwood-Kitsap (AkF), Beausite gravelly sandy loam (BeD and BeF), Kitsap silt loam, (KpD), Ovall gravelly sandy loam (OvP and OvF), Ragnar fine sandy loam (Rad), Ragnar-Indianola Association (RdE), River Wash (Rh), and Coastal Beaches (Cb).

"Eutrophic" means a condition which describes that a water body has built up excess nutrients so that excess plant growth occurs. As a result, large amounts of plant material decay and consume dissolved oxygen while doing so. Thus, less dissolved oxygen is available to aquatic life. Eutrophication is the process by which this occurs.

"Eutrophication" refers to the process where nutrient overenrichment of water leads to excessive growth of aquatic plants.

"Evapotranspiration" means the collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.

"Existing off-site conditions" those present in the study area (except on the proposed project site) at the time of the analysis. See existing site conditions.

"Existing site conditions" depend on the presence of existing approved drainage systems. For sites with existing approved and build drainage systems, the existing on-site conditions are those that occur with the existing drainage facilities constructed per approved permits and engineering plans when required. For sites with no existing approved drainage systems, the existing on-site conditions are those that existed prior to May 1979 based primarily on aerial photographs and, if necessary, on knowledge of individuals familiar with the area. (See Core Requirement 3)

"FIRM" means Flood Insurance Rate Map.

"Fertilizer" means any material or mixture used to supply one or more of the essential plant nutrient elements.

"Flood fringe" means that portion of the flood plain outside of the floodway which is covered by floodwaters during the base flood; it is generally associated with standing water rather than rapidly flowing water.

"Flood Hazard Areas" means those areas of King County subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions.

"Flood Insurance Rate Map (FIRM)" is the official map on which the Federal Insurance Administration has delineated many areas of flood hazard, floodway, and the risk premium zones.

"Flood Insurance Study" means the official report provided by the Federal Insurance Administration that includes flood profiles and the FIRM.

"Flood plain" means the total area subject to inundation by the base flood including the flood fringe and floodway.

"Flood-proofing" means adaptations that ensure a structure is substantially impermeable to the passage of water below the flood protection elevation and resists hydrostatic and hydrodynamic loads and effects of buoyancy.

"Flood protection elevation" means an elevation that is one foot above the base flood elevation.

"Flood protection facility" means any levee, berm, wall, enclosure, raised bank, revetment, constructed bank stabilization or armoring, that is commonly recognized by the community as providing significant protection to a property from inundation by flood waters.

"Flood routing" means an analytical technique used to compute the effects of system storage and system dynamics on the shape and movement of flow represented by a hydrograph.

"Floodway" means the channel of the river or stream and those portions of the adjoining flood plains which are reasonably required to carry and discharge the base flood flow. The portions of the adjoining flood plains which are considered to be "reasonably required" is defined by the County flood hazard regulations.

"Freeboard" means the vertical distance between the design water surface elevation and the elevation of the barrier which contains the water.

"Geologist" means a person who has earned a degree in geology from an accredited college or university or who has equivalent educational training and has at least five years of experience as a practicing geologist or four years of experience and at least two years post-graduate study, research or teaching. The practical experience shall include at least three years work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers.

"Geometrics" means the mathematical relationships between points, lines, angles and surfaces used to measure and identify areas of land.

"Geotechnical professional civil engineer" means a practicing, geotechnical/civil engineer licensed as a professional Civil Engineer with the State of Washington who has at least four years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.

"Groundwater" means underground water usually found in aquifers. Groundwater usually originates from infiltration. Wells tap the groundwater for water supply uses.

"Gully" means a channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.

"Habitat" means the specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful contaminants.

"Hardpan" means a cemented or compacted and often clay-like layer of soil that is impenetrable by roots.

"Harmful pollutant" means a substance that has adverse effects to an organism including immediate death, chronic poisoning, impaired reproduction, cancer or other effects.

"Hydraulic gradient" means slope of the potential head relative to a fixed datum.

"Hydrograph" means a graph of runoff rate, inflow rate or discharge rate, past a specific point over time.

"Hydrologic cycle" means the circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation and transpiration.

"Hydrologic Soil Groups" means a soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties.

"Hyetograph" means a graph of percentages of total precipitation for a series of time steps representing the total time in which precipitation occurs.

"Impervious" means a surface which cannot be easily penetrated. For instance, rain does not readily penetrate paved surfaces.

"Impervious surface" means a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development, and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of surface and storm water runoff. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of this document. (See also new impervious surface.)

"Impoundment" means a natural or man-made containment for surface water.

"Improvement" means streets (with or without curbs or gutters), sidewalks, crosswalks, parking lots, water mains, sanitary and storm sewers, drainage facilities, street trees and other appropriate items.

"Infiltration facility" means a drainage facility designed to use the hydrologic process of surface and storm water runoff soaking into the ground, commonly referred to as percolation, to dispose of surface and stormwater runoff.

"Ingress/egress" means the points of access to and from a property.

"Inlet" means a form of connection between surface of the ground and a drain or sewer for the admission of surface and stormwater runoff.

"Insecticide" means a substance, usually chemical, that is used to kill insects.

"Isopluvial map" means a map with lines representing constant depth of total precipitation for a given return frequency.

"K.C.R.S." means King County Road Standards which are available from the King County Department of Public Works Map Counter.

"Lake" means an area permanently inundated by water in excess of two meters deep and greater than twenty acres in size as measured at the ordinary high water marks.

"Landslide" means episodic downslope movement of a mass of soil or rock that includes but is not limited to rockfalls, slumps, mudflows, and earthflows. For the purpose of these rules, snow avalanches are considered to be a special case of landsliding.

"Landslide Hazard Areas" means those areas of King County subject to a severe risk of landslide as defined in KCC 21.24.

"Lowest Floor" means the lowest enclosed area (including basement) of a structure. An area used solely for parking of vehicles, building access, or storage, in an area other than a basement area, is not considered a building's lowest floor, provided that the enclosed area meets all of the structural requirements of the flood hazard standards.

"MDNS" means a Mitigated Determination of Nonsignificance (See DNS and Mitigation).

"Mass Wasting" means the movement of large volumes of earth material down slope.

"Master Drainage Plan" means a comprehensive drainage control plan intended to prevent significant adverse impacts to the natural and man-made drainage system, both on and off-site.

"Metals" means elements, such as mercury, lead nickel, zinc and cadmium, that are of environmental concern because they do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations.

"Mitigation" means the use of any or all of the following actions that are listed in descending order of preference (KCC 21.04):

1. Avoiding the impact altogether by not taking a certain action or parts of an action; or
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts; or
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected sensitive area; or
4. Reducing or eliminating the impact over time by preservation or maintenance operations during the life of the development proposal; or
5. Compensating for the impact by replacing, enhancing, or providing substitute sensitive areas.
6. Monitoring the impact and taking appropriate corrective measures.

"Monitor" means to systematically and repeatedly measure something in order to track changes.

"Monitoring" means the collection and analysis of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on the biological, hydrologic, and geologic elements of such systems, and assessing the performance of mitigation measures imposed as conditions of development.

"NGPE" means Native Growth Protection Easement.

"NGVD" means National Geodetic Vertical Datum (see Base Flood elevation).

"NPDES" means National Pollutant Discharge Elimination System.

"National Pollutant Discharge Elimination System (NPDES)" means the part of the federal Clean Water Act, which requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and are administered by the Washington State Department of Ecology.

"Native Growth Protection Easements (NGPE)" means an easement granted to the County for the protection of native vegetation within a sensitive area or its associated buffer. The NGPE shall be recorded on the appropriate documents of title and filed with the King County Records and Election Division.

"Natural discharge location" means the location of the drainage pathway at the proposed project boundary at the time of analysis.

"New impervious surface" means any impervious surface proposed by a project that will increase the runoff curve number of that surface for existing site conditions (e.g. gravel to asphalt). See impervious surface.

"Normal Depth" means the depth of uniform flow. This is a unique depth of flow for any combination of channel characteristics and flow conditions. Normal depth is found from Mannings Equation.

"Nutrients" means essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and the growth of excessive numbers of algae. Some nutrients can be toxic at high concentrations.

"Off-site" means any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.

"Off-site flows" means runoff conveyed to a proposed project from adjacent properties.

"On-site" means the entire property that includes the proposed development.

"Ordinary High Water Mark" means the mark that will be found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water shall substitute. In any area where neither can be found, the channel bank shall be substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute shall be measured so as to include the entire stream feature.

"Orifice" means an opening with closed perimeter, usually sharp-edged, and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of such water.

"Overtopping" means to flow over the limits of a containment or conveyance element.

"Permeable Soils" means soil materials with a sufficiently rapid infiltration rate (10 minutes per inch or better) so as to greatly reduce or eliminate surface and storm water runoff. These soils are classified as SCS hydrologic soil type A.

"Perviousness" means related to the size and continuity of void spaces in soils; related to a soil's infiltration rate.

"Pesticide" means a general term used to describe any substance--usually chemical--used to destroy or control organisms; includes herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins which are extracted from plants and animals.

"pH" means a measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acid.

"Physiographic" means characteristics of the natural physical environment (including hills).

"Plat" means a map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.

"Point Discharge" means the release of collected and/or concentrated surface and storm water runoff from a pipe, culvert, or channel.

"Prediction" means for the purposes of this document an expected outcome based on the results of hydrologic modelling and/or the judgement of a trained professional civil engineer or geologist.

"Professional civil engineer" means a person registered with the State of Washington as a professional engineer in civil engineering.

"Project" means the proposed action of a permit application or an approval which requires a drainage review.

"R/D" means retention/detention facility.

"Reach" means a length of channel with uniform characteristics.

"Receiving Waters" means bodies of water or surface water systems receiving water from upstream man-made (or natural) systems. For the purpose of this document receiving waters are: Cedar River, Green/Duwamish River (below river mile 6.25, U.S. Army Corps of Engineers designation), Puget Sound, Lake Sammamish, Sammamish River, Skykomish River, and Snoqualmie River.

"Recharge" means the flow to groundwater from the infiltration of surface and stormwater runoff.

"Regional detention facility" means a stormwater quantity control structure designed to correct the existing excess surface water runoff problems of a basin or subbasin as defined by King County SWM Division. The area downstream has been previously identified by the SWM Manager as having existing or predicted significant and regional flooding and/or erosion problems.

"Release rate" means the computed peak rate of surface and storm water runoff for a particular design storm event and drainage area conditions.

"Retention" means the process of collecting and holding surface and stormwater runoff with no surface outflow.

"Retention/detention facility (R/D)" means a type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration and/or infiltration into the ground; or to hold surface and storm water runoff for a short period of time and then release it to the surface and stormwater management system.

"Retrofitting" means the renovation of an existing structure or facility to meet changed conditions or to improve performance.

"Rip rap" means a facing layer or protective mound of stones placed to prevent erosion or sloughing of a structure or embankment due to flow of surface and stormwater runoff.

"Riparian" means pertaining to the banks of streams, wetlands, lakes or tidewater.

"Rodenticide" means a substance used to destroy rodents.

"Runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

"SCS" means Soil Conservation Service, U.S. Department of Agriculture.

"SCS Method" means a hydrologic analysis based on the Curve Number method (National Engineering Handbook - Section 4: Hydrology, August, 1972) and using any acceptable analytical technology as delineated in the King County Surface Water Design Manual.

"SEPA" means State Environmental Policy Act.

"SWM" means the Surface Water Management Division of the King County Department of Public Works.

"Salmonid" means a member of the fish family Salmonidae. In King County, chinook, coho, chum, sockeye and pink salmon; cutthroat, , rainbow and steelhead salmon; brown trout; Dolly Varden and brook char, kokanee and whitefish.

"Scour" means erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.

"Sediment" means fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.

"Sedimentation" means the depositing or formation of sediment.

"Sensitive Areas Ordinance (SAO)" means the King County Ordinance and rules that identify environmentally sensitive areas (coal mine, erosion, flood, landslide, seismic, steep slope, and volcanic hazard areas, and streams, wetlands, and protective buffers) and supplement the development requirements contained in the various use classifications in the King County Code by providing for additional controls.

"Sensitive Areas Setback Area" means the area delineated on a site which contains wetlands, streams, steep slopes, hazard areas, landslide hazard areas, and required buffers.

"Sensitive Area Tract" means a separate tract that is created to protect the sensitive area and its buffer, whose ownership is assured as provided in KCC 21.24.

"Sheet erosion" means the relatively uniform removal of soil from an area without the development of conspicuous water channels.

"Sheet flow" means relatively uniform flow over plane surfaces without the concentration of water into conspicuous channels.

"Shoreline development" means the proposed projects as regulated by the Shoreline Management Act. Usually the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

"Siltation" means the process by which a river, lake, or other water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.

"Site" means the portion of a piece of property which is directly subject to development.

"Slope" means the gradient in feet per feet or expressed as percent.

"Sloughing" means the sliding of overlying material. It is the same effect as caving, but it usually occurs when the bank or an underlying stratum is saturated or scoured.

"Soil permeability" means the ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.

"Soil stabilization" means the use of measures such as rock lining, vegetation or other engineering structures to prevent the movement of soil when loads are applied to the soil.

"Specific energy" means the total energy within any system with respect to the channel bottom. Equal to the potential head plus velocity and pressure heads.

"State Environmental Policy Act (SEPA)" means the Washington State law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size and comprehensive plans. As part of this process, environmental documents are prepared and opportunities for public comment are provided.

"Steep slope" means those areas in King County on slopes 40% or steeper within a vertical elevation change of at least ten feet. A slope is delineated by establishing its toe and top and is measured by averaging the inclination over at least ten feet of vertical relief. For the purpose of this definition:

1. The toe of a slope is a distinct topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the toe of a steep slope is the lower most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet; and
2. The top of a slope is a distinct, topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the top of a steep slope is the upper most limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet.

"Storm drains" means the enclosed conduits that transport surface and stormwater runoff toward points of discharge (sometimes called storm sewers).

"Storm drain system" refer to the system of gutters, pipes, streams, or ditches used to carry surface and storm water from surrounding lands to streams, lakes, or Puget Sound.

"Stream classification" means the following stream classification which applies to all streams within King County:

1. Class 1 streams are all streams inventoried as Shorelines of the State under King County's Shoreline Master Program, KCC Title 25, pursuant to RCW Chapter 90:58.

2. Class 2 streams are all streams smaller than Class 1 streams that flow year around during years of normal rainfall, or those that are used by salmonids.

3. Class 3 streams are streams that are intermittent or ephemeral during years of normal rainfall and are not used by salmonids.

"Streams" means those areas of King County where surface waters produce a defined channel or bed. A defined channel or bed is an area which demonstrates clear evidence of the passage of water and includes, but is not limited to, bedrock channels, gravel beds, sand and silt beds, and defined-channel swales. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, storm water runoff devices or other entirely artificial watercourses unless they are used by salmonids or used to convey streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (i.e. swales) shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.

"Structure" means a catch basin or manhole in reference to a storm drainage system.

"Stub-out" means a short length of pipe provided for future connection to the storm drainage system.

"Subbasin" means a drainage area which drains to a water course or waterbody named and noted on common maps and which is contained within a basin as defined in K.C.C. 9.04.020.

"Subcritical flow" means flow at depths greater than the critical depth.

"Sub-division retention/detention facility" means a retention/detention facility which is both (1) located within or associated with a short or formal plat sub- division containing only single family or duplex residential structures located on individual lots; and 2) which is required to handle excess runoff generated by development of an area of which two-thirds or more is designated for single family or duplex residential structures located on individual lots.

"Supercritical flow" means flow at depths less than the critical depth.

"Surface and storm water" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

"Surface and storm water management system" means drainage facilities and any other natural features which collect, store, control, treat and/or convey surface and storm water.

"Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff design and analysis requirements, procedures and guidance which has been formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual will be available from the BALD Division permit center.

"Suspended solids" means organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles as well as solids in wastewater.

"Swale" means a shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.

"TESC" means Temporary Erosion and Sedimentation Control.

"Temporary Erosion and Sedimentation Control" means any temporary measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site.

"Threshold discharge area" means on-site area draining to a single natural discharge location or multiple natural discharge locations that combine within 1/4-mile downstream.

"Time of concentration" means the time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the tributary drainage area.

"Toxic" means poisonous, carcinogenic, or otherwise directly harmful to life.

"Tract" means a legally created parcel of property designated for special non-residential and non-commercial uses.

"Travel time" means the estimated time for surface water to flow between two points of interest.

"Tributary" means one that drains into, such as a drainage channel that flows into a larger drainage channel.

"Tributary area" means the geographical area (not constrained by property boundaries) that drains to the point of concern.

"Undisturbed buffer" means a zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and storm water drainage facility systems.

"Undisturbed low gradient uplands" means forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.

"Water quality swale" means an open vegetated drainage channel intended to optimize water quality treatment of surface and storm water runoff by following the specific design criteria described in the Surface Water Design Manual.

"Watershed" means the geographic region from which water drains to a particular point of interest.

"Wetponds" and "wetvaults" mean drainage facilities for water quality treatment that contain a permanent pool of water, usually four feet in depth, that are filled during the initial runoff from a storm event. They are designed to optimize water quality by providing retention time (on the order of a week or more) in order to settle out particles of fine sediment to which pollutants such as heavy metals absorb, and to allow biologic activity to occur that metabolizes nutrients and organic pollutants. For wetvaults the permanent

pool of water is covered by a lid which blocks sunlight from entering the facility, limiting photo-dependent biologic activity.

" Wetland" means those areas of King County that are inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (U.S. Army Corps of Engineers Regulation 33 CFR 328.3 (1988)). Wetlands in King County include all area waterward from the wetland edge. Where the vegetation has been removed, a wetland shall be determined by the presence of hydric soils, as well as other documentation of the previous existence of wetland vegetation such as aerial photographs.

"Wetland edge" means the line delineating the outer edge of a wetland established by using the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, January 10, 1989, jointly published by the U. S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the U.S. Soil Conservation Service.

"Wetland Rating System" means the following wetland rating system which is based upon the King County Wetlands Inventory, 1983 and the U.S. Fish and Wildlife Service's Classification of Wetlands and Deepwater Habitats of the United States, FWS/OBS-79/31 (December 1979):

1. Class 1 wetlands are assigned the Unique/Outstanding #1 rating in the inventory or are uninventoried wetlands which meet any one of the following criteria:
   a. presence of species recognized by the federal government or State of Washington as endangered, threatened, or the presence of critical or outstanding potential habitat for those species;
   b. wetlands having 40% to 60% open water in dispersed patches with two or more classes of vegetation, or
   c. wetlands equal to or greater than ten acres in size and having three or more wetland classes, one of which is open water.
   d. the presence of plant associations of infrequent occurrence. These include, but are not limited to, estuarine systems and bogs.

2. Class 2 wetlands are assigned the Significant #2 rating in the inventory or are uninventoried wetlands which meet any of the following criteria:
   a. wetlands greater than one acre in size;
   b. wetlands less than or equal to one acre in size and having three or more wetland classes;
   c. wetlands less than or equal to one acre in size which have a forested wetland class; or
   d. wetlands which have present heron rookeries or raptor nesting trees.

3. Class 3 wetlands are assigned the Low Concern #3 rating in the inventory or are uninventoried wetlands that are less than or equal to one acre in size and having two or fewer wetland classes.

"Wet Season" means October 1 to March 31.

APPENDICES

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

APPENDICES

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APPENDIX A
Maintenance Requirements for Privately Maintained Drainage Facilities

APPENDIX B
Master Drainage Plan Objective, Criteria Components and Review Process

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

APPENDIX A
MAINTENANCE REQUIREMENTS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

Section No.	Subject
1	Ponds
2	Infiltration
3	Closed Detention Systems
4	Control Structure/Flow Restrictor
5	Catch Basins
6	Debris Barriers
7	Energy Dissapators
8	Fencing
9	Gates
10	Conveyance Systems
11	Grounds
12	Access Roads/Easements

MAINTENANCE REQUIREMENTS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

NO. 1 - PONDS

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Poisonous Vegetation	Any poisonous vegetation which may constitute a hazard to County personnel or the public. Examples of poisonous vegetation include: tansy ragwort, poison oak, stinging nettles, devils club.	No danger of poisonous vegetation where County personnel or the public might normally be. (Coordination with Seattle/King County Health Department)
	Pollution	Oil, gasoline, or other contaminants of one gallon or more <u>or</u> any amount found that could: 1) cause damage to plant, animal, or marine life; 2) constitute a fire hazard; or 3) be flushed downstream during rain storms.	No contaminants present other than a surface film. (Coordination with Seattle/King County Health Department)
	Unmowed Grass/ Ground Cover	If facility is located in private residential area, mowing is needed when grass exceeds 18 inches in height. In other areas, the general policy is to make the pond site match adjacent ground cover and terrain as long as there is no interference with the function of the facility.	When mowing is needed, grass/ground cover should be mowed to 2 inches in height.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordination with Seattle/King County Health Department)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site.
	Tree Growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access, leave trees alone.	Trees do not hinder maintenance activities. Selectively cultivate trees such as alders for firewood.
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes should be stabilized by using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
Pond Dikes	Settlements	Any part of dike which has settled 4 inches lower than the design elevation.	Dike should be built back to the design elevation.
Emergency Overflow/Spillway	Rock Missing	Only one layer of rock exists above native soil in are five square feet or larger, or any exposure of native soil.	Replace rocks to design standards.

NO. 2 - INFILTRATION

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Poisonous Vegetation	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Pollution	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Unmowed Grass/ Ground Cover	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Rodent Holes	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Insects	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
Storage Area	Sediment	A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. If two inches or more sediment is present, remove.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
	Sheet Cover (If Applicable)	Sheet cover is visible and has more that three 1/4-inch holes in it.	Sheet cover repaired or replaced.
	Sump Filled with Sedmiment and Debris (If Applicable)	Any sediment and debris filling vault to 10% of depth from sump bottom to bottom of outlet pipe or obstructing flow into the connector pipe.	Clean out sump to design depth.
Filter Bags	Filled with Sedmiment and Debris	Sediment and debris fill bag more than 1/2 full.	Replace filter bag or redesign system.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Replace gravel in rock filter.
Side Slopes of Pond	Erosion	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
Emergency Overflow Spillway	Rock Missing	See "Ponds" Standard No. 1	
Settling Ponds and Vaults	Sediment	Remove when 6" or more.	

Note: Sediment accumulation of more than .25 inches per year may indicate excessive erosion is occurring upstream of the facility or that conveyance systems are not being properly maintained. The contributing drainage area should be checked for erosion problems or inadequate maintenance of conveyance systems if excessive sedimentation is noted in an infiltration facility.

Check twice a year during first 2 years of operation; once a year thereafter. Clean manholes/catch basins, repair damaged inlets/outlets, clean trash racks.

NO. 3 - CLOSED DETENTION SYSTEMS (PIPES/TANKS)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point with debris and sediment.	Vents free of debris and sediment.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any crack allowing material to be transported into facility.	All joints between tank/pipe sections are sealed.
	Tank/Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape.	Tank/pipe repaired or replaced to design.
Manhole	Cover not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying 80 pounds of lift. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	King County Safety Office and/or maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks.	Ladder meets design standards and allows maintenance persons safe access.
Catch Basins		See "Catch Basins" Standard No. 5	See "Catch Basins" Standard No. 5

NO. 4 - CONTROL STRUCTURE/FLOW RESTRICTOR

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash and Debris (Includes Sediment)	Distance between debris build-up and bottom of orifice plate is less than 1-1/2 feet.	All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall and outlet pipe structure should support at least 1,000 pounds of up or down pressure.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are watertight; structure repaired or replaced and works as designed.
		Any holes – other than designed holes – in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole		See "Closed Detention Systems" Standard No. 3.	See "Closed Detention Systems" Standard No. 3.
Catch Basin		See "Catch Basins" Standard No. 5.	See "Catch Basins" Standard No. 5.

NO. 5 - CATCH BASINS

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris (Includes Sediment)	Trash or debris of more than 1/2 cubic foot which is located immediately in front of the catch basin opening or is blocking capacity of basin by more than 10%.	No trash or debris located immediately in front of catch basin opening.
		Trash or debris (in the basin) that exceeds 1/3 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that would cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
		Deposits of garbage exceeding 1 cubic foot in volume.	No condition present which would attract or support the breeding of insects or rodents.
	Structural Damage to Frame and/or Top Slab	Corner of frame extends more than 3/4 inch past curb face into the street (if applicable).	Frame is even with curb.
		Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (intent is to make sure all material is running into the basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab.	Frame is sitting flush on top slab.
	Cracks in Basin Walls/Bottom	Cracks wider than 1/2 inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Cracks wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	No cracks more than 1/4 inch wide at the joint of inlet/outlet pipe.
	Settlement/ Misalignment	Basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards.
	Fire Hazard	Presence of chemicals such as natural gas, oil, and gasoline.	No flammable chemicals present.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Pollution	Nonflammable chemicals of more than 1/2 cubic foot per three feet of basin length.	No pollution present other than surface film.

NO. 5 - CATCH BASINS (Continued)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Catch Basin Cover	Cover Not In Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying 80 lbs. of lift; intent is keep cover from sealing off access to maintenance.	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (if applicable)		Grate with opening wider than 7/8 inch.	Grate openings meet design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface.	Grate free of trash and debris.
	Damaged or Missing	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

NO. 6 - DEBRIS BARRIERS (e.g. Trash Racks)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier clear to receive capacity flow.
Metal	Damaged/ Missing Bars	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier is missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Repair or replace barrier to design standards.

NO. 7 - ENERGY DISSIPATORS

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Replace rocks to design standard.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench must be redesigned or rebuilt to standard.
	Perforations Plugged	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Clean or replace perforated pipe.
	Water Flows Out Top of "Distributor" Catch Basin	Maintenance person observes water flowing out during any storm less than the design storm or it is causing or appears likely to cause damage.	Facility must be rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Posts, Baffles, Sides of Chamber	Structure dissipating flow deteriorates to 1/2 or original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Replace structure to design standards.
	Other Defects	See "Catch Basins" Standard No. 5	See "Catch Basins" Standard No. 5

NO. 8 - FENCING

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Missing or Broken Parts	Any defect in the fence that permits easy entry to a facility.	Parts in place to provide adequate security.
		Parts broken or missing.	Broken or missing parts replaced.
	Erosion	Erosion more than 4 inches high and 12-18 inches wide permitting an opening under a fence.	No opening under the fence that exceeds 4 inches in height.
Wire Fences	Damaged Parts	Posts out of plumb more than 6 inches.	Posts plumb to within 1-1/2 inches.
		Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
		Any part of fence (including posts, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place and holding fabric.
		Missing or loose barbed wire that is sagging more than 2-1/2 inches between posts.	Barbed wire in place with less than 3/4-inch sag between posts.
		Extension arm missing, broken, or bent out of shape more than 1-1/2 inches.	Extension arm in place with no bends larger than 3/4 inch.
	Deteriorated Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in Fabric	Openings in fabric are such that an 8-inch-diameter ball could fit through.	No openings in fabric.

NO. 9 - GATES

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Damaged or Missing Members	Missing gate or locking devices.	Gates and locking devices in place.
		Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.	Hinges intact and lubed. Gate is working freely.
		Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
		Missing stretcher bar, stretcher bands, and ties.	Stretcher bar, bands, and ties in place.
	Openings in Fabric	See "Fencing" Standard No. 8	See "Fencing" Standard No. 8

NO. 10 - CONVEYANCE SYSTEMS (Pipes & Ditches)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Pipes	Sediment & Debris	Accumulated sediment that exceeds 20% of the diameter of the pipe.	Pipe cleaned of all sediment and debris.
	Vegetation	Vegetation that reduces free movement of water through pipes.	All vegetation removed so water flows freely through pipes.
	Damaged	Protective coating is damaged; rust is causing more than 50% deterioration to any part of pipe.	Pipe repaired or replaced.
		Any dent that decreases the cross section area of pipe by more than 20%.	Pipe repaired or replaced.
Open Ditches	Trash & Debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes.	Trash and debris cleared from ditches.
	Sediment	Accumulated sediment that exceeds 20% of the design depth.	Ditch cleaned/flushed of all sediment and debris so that it matches design.
	Vegetation	Vegetation that reduces free movement of water through ditches.	Water flows freely through ditches.
	Erosion Damage to Slopes	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Rock Lining Out of Place or Missing (If Applicable)	Maintenance person can see native soil beneath the rock lining.	Replace rocks to design standard.
Catch Basins		See "Catch Basins" Standard No. 5	See "Catch Basins" Standard No. 5
Debris Barriers (e.g., Trash Rack)		See "Debris Barriers" Standard No. 6	See "Debris Barriers" Standard No. 6

NO. 11 - GROUNDS (Landscaping)

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Weeds (Nonpoisonous)	Weeds growing in more than 20% of the landscaped area (trees and shrubs only).	Weeds present in less than 5% of the landscaped area.
	Safety Hazard	Any presence of poison ivy or other poisonous vegetation.	No poisonous vegetation present in a landscaped area.
	Trash or Litter	Paper, can, bottles, totalling more than 1 cubic foot within a landscaped area (trees and shrubs only) of 1,000 square feet.	Area clear of litter.
Trees and Shrubs	Damage	Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	Trees and shrubs with less than 5% of the total foliage with split or broken limbs.
		Trees or shrubs that have been blown down or knocked over.	Tree or shrub in place free of injury.
		Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Tree or shrub in place and adequately supported; remove any dead or diseased trees.

NO. 12 - ACCESS ROADS/EASEMENTS

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet, i.e., trash and debris would fill up one standard size garbage can.	Trash and debris cleared from site.
	Blocked Roadway	Debris which could damage vehicle tires (glass or metal).	Roadway free of debris which could damage tires.
		Any obstructions which reduce clearance above road surface to less than 14 feet.	Roadway overhead clear to 14 feet high.
		Any obstructions restricting the access to a 10- to 12-foot width for a distance of more than 12 feet or any point restricting access to less than a 10-foot width.	Obstruction removed to allow at least a 12-foot access.
Road Surface	Settlement, Potholes, Mush Spots, Ruts	When any surface defect exceeds 6 inches in depth and 6 square feet in area. In general, any surface defect which hinders or prevents maintenance access.	Road surface uniformly smooth with no evidence of settlement, potholes, mush spots, or ruts.
	Vegetation in Road Surface	Weeds growing in the road surface that are more than 6 inches tall and less than 6 inches apart within a 400-square-foot area.	Road surface free of weeds taller than 2 inches.
Shoulders and Ditches	Erosion Damage	Erosion within 1 foot of the roadway more than 8 inches wide and 6 inches deep.	Shoulder free of erosion and matching the surrounding road.
	Weeds and Brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.

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APPENDIX B
MASTER DRAINAGE PLAN OBJECTIVE, CRITERIA COMPONENTS AND REVIEW PROCESS

APPENDIX B
MASTER DRAINAGE PLAN OBJECTIVE, CRITERIA AND COMPONENTS, AND REVIEW PROCESS

Objective

The objective of the Master Drainage Plan (MDP) is to propose specific drainage control systems that will prevent significant adverse impacts to the site's natural hydrologic system and to existing and planned off-site drainage systems. Significant adverse impacts are defined as follows:

(1) Any increase in flow rates and/or volumes that would result in flooding along the natural and/or constructed drainage system, or that would aggravate existing flooding problems, either on-site or downstream.

(2) An increase of flow rates and/or volumes, both on- and off-site that would de-stabilize the existing geomorphic balance of the natural drainage systems. Examples would include an increase in the rate or frequency of streambank erosion resulting in bank/slope failures along stream corridors, and downstream sedimentation reducing channel capacity.

(3) Alteration of natural topography and/or native vegetation that would result in unstable soil conditions, slopes, or embankments.

(4) Alteration of the natural hydrologic features that would reduce their functional ability to preserve water quality and quantity and/or in-stream and other aquatic habitat values.

(5) Alteration of ground water/interflow that would adversely change downstream base flows and/or impair existing water rights.

Criteria

The proposed drainage control system and impacts shall be supported by a detailed technical analysis and report as a part of the MDP. The report shall include appropriate geotechnical investigations, water quality and aquatic habitat analysis, and hydrologic computer modeling (see Section 3.2 in Chapter 3). The report shall also include maintenance and operation provisions for the existing natural drainage system and any on-site drainage facilities. Specific maintenance plans and agreements, identifying maintenance responsibilities, must be provided for any facility privately maintained.

The hydrologic and hydraulic analysis of the site, basin, and downstream system shall be done using the methods described in this Manual. Exceptions are for plans required to prepare hydrologic models using rainfall and stream gage data. Any upstream contributing systems or sub-basins shall be analyzed for both existing and future development conditions (as shown in the latest adopted Community Plan, the King County Comprehensive Plan, or other land use maps).

Components of Master Drainage Plans

The MDP shall consist of two major components: a technical report; and plans and mapping.

(1) <u>Technical Report</u>

The report shall provide a comprehensive analysis of existing and proposed surface and subsurface water quantity and quality conditions for both on- and off-site systems. Off-site systems may include upstream and downstream hydrology. Upstream analysis shall include the total drainage area contributing to the site. Downstream analysis shall extend to an acceptable receiving body of water.

The report should provide narrative descriptions of how the proposed system will meet the MDP objective, and shall contain all necessary technical data, including:

(a) All assumptions, parameters, and input data used in the hydrologic model. This includes the curve numbers, soils types, land use, areas, and times of concentration of all sub-basins.

(b) Hydraulic performance data (stage, storage, discharge) for all elements of the hydrologic system, whether existing or proposed, including lakes, ponds, and wetlands. This data shall be used to route inflow hydrographs to produce outflow hydrographs.

(c) Flow data for all existing and proposed conveyance facilities, including streams, swales, pipes, and ditches which will support the proposed system.

(d) Floodplain analysis identifying flows, velocities, and extent of flooding for the existing and proposed conditions. Other backwater analysis required to determine existing and proposed conveyance capacity within the MDP and downstream of the MDP.

(e) Erosion analysis of on-site and downstream open-drainage systems, identifying flows, velocities, areas of existing and future deposition and channel erosion, and characterization of sediment.

(f) Geotechnical analysis of the site and proposed improvements which specifically addresses soils and slope stability for proposed lakes/ponds, road alignments, channel/ravine conditions, building setbacks from steep slopes, vegetative preservation and controls, existing and proposed drainage facilities, and downstream system stability.

(g) Method and conceptual design for maintaining existing flow regimes in any swales/ravines that may be altered by the development.

(h) Method, conceptual design, and location of water quality compensating facilities that may be necessary to replace naturally occurring "biofiltration" functions of site vegetation, i.e. provision and/or preservation of vegetated swales.

(i) Description of maintenance design features and provisions that will ensure reliable and long-term facility operation.

(j) Ecological analysis to include the physical and biological features of the streams, lakes, wetlands and swales. The features identified shall be keyed to the map produced in item (2)(b), below.

(k) Input and output files from hydrologic and/or hydraulic computer models shall be included as an appendix.

(l) Provide construction phasing plan that will ensure stormwater/erosion control during development of individual subbasins.

(m) Establish a stream flow/rainfall gauging and stream cross section monitoring plan that will document any changes in the levels of flooding, erosion, and sedimentation, and identify responsible parties for necessary mitigation.

(2) Plans and Mapping

A conceptual or preliminary plan of the proposed drainage collection, detention and control systems, based upon accurate field topographic mapping and geologic data, should be provided, along with appropriate cross-sections and details necessary to identify system elements. Mapping must be of adequate scale and detail for accurate definition and location of all system elements, both on-site and off-site, and must provide support for hydrologic model characterization. In general, the following is required:

(a) Delineation of sub-basins of appropriate size/land use for computer model characterization and hydraulic analysis of all tributary flows.

(b) Location and size of all existing and proposed hydrologic features and facilities in the basins. This includes lakes, ponds, wetlands, swales, streams, pipes, and culverts.

(c) Overall plan/profile and cross-sections of conveyance systems and identification of the floodplain and floodway and frequency of flooding for existing and developed conditions.

(d) Identify areas of in-stream erosion, sedimentation and/or unstable slopes.

(e) Identify general required building setbacks, clearing limits and Native Growth Protection Easements in areas of steep slopes and drainage features.

(f) Site soils identification and preliminary analysis for controlling erosion during construction and for use in hydrologic modeling.

(g) Identify upstream and downstream habitat condition, i.e., spawning, rearing, and transport areas; pools, riffles, and other in-stream habitat features; and species and populations observed. Locations shall be keyed to the map produced in item (2)(b), above.

Review Process

Master Drainage Plans (MDPs) are submitted directly to the Department of Development and Environmental Services Division (DDES) for review. They must, however, be a part of a permit application that has been filed with DDES (see Section 1.1.1 in Chapter 1). The MDP process should commence concurrently with the SEPA process.

King County has prepared MDP guidelines entitled: "Master Drainage Planning for Large Site Developments - Process and Requirements", May 1995, which provide technical guidance to implement the requirements of Section 1.3.3 and this Appendix B. The MDP Guidelines may be obtained by contacting the SWM Division or DDES.

Prior to commencing preparation of the MDP, the applicant and design engineer (including the team that includes other design professionals such as geotechnical engineers and/or biologists, etc.) should request a MDP pre-application meeting for general information followed by a scoping meeting with DDES in order to coordinate the requirements for the hydrologic modeling and other special analysis which may be required. At these meetings, the applicant should present an outline for the proposed MDP that includes a description of the proposed project, a schedule for preparation of the MDP, and a description of any known environmental or regulatory issues related to the proposal.

DDES will review the components of the MDP as submitted, in a timely manner. The fees for review of the MDP will be determined from resources (consultant, staff, equipment) required and will be billed to the applicant by King County. Review fees shall be paid by the applicant to King County prior to receiving MDP plan approval.

Following approval in concept of all of the MDP components, the applicant will submit four complete final MDP packages to DDES for approval. Three copies will be kept by DDES, and one copy will be returned to the applicant for their records.

Any additional questions regarding the MDP review process should be directed to the reviewer in DDES.

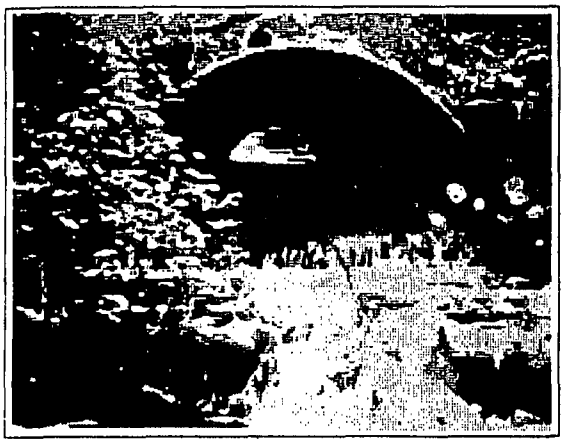
REFERENCE

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

NOTE:
Although some of the materials in this "Reference" section, such as the Sensitive Areas Ordinance and Rules, may have been adopted by administrative rule or by ordinance, the administrative rule that as adopted the Surface Water Design Manual has not formally adopted any of the materials in this section. All of the papers, forms, notes, equations, symbols, maps, rules, methods, requirements and other materials provided herein are for reference only.

King County assumes no responsibility for the completeness or current status of the materials contained in this section. It is the sole responsibility of each applicant to insure that the most current materials are used in preparing a permit application for their proposed project. Copies of these materials are available at the Building and Land Development Division office.

REFERENCE



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1-A Adopted Basin Plans - Requirements

1-B Adopted Community Plans - Requirements

2 Basin Reconnaissance Program Summary Reports

3 Critical Drainage Areas - Requirements

4 Overview of King County Surface Water Policies

5 Alternative Hydraulic Design Methods

6 Clearing and Grading Ordinance and Rules

7 Sensitive Areas Ordinance and Rules

8 King County Standard Map Symbols

9 Standard Plan Notes

10 Plan Review Procedures, Forms, and Worksheets

- A. Predesign Meeting Form
- B. TIR Worksheet
- C. R/D Summary Sheet
- D. Declaration of Covenant
- E. Bond Quantities Worksheet
- F. Drainage Release Covenant
- G. Drainage Easements
- H. Plan Review Procedures
- I. Variance Process Guidelines

11 Interim Changes to Requirements

- A. Blanket Variances
- B. Administrative Changes

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REFERENCE 1-A ADOPTED BASIN PLANS - REQUIREMENTS

BASIN PLAN	ADOPTED	SPECIFIC DRAINAGE REQUIREMENTS
Coal Creek	1/21/87	None that are not covered by other requirements and standards in this manual.
Soos/Jenkins Covington Creeks	1/13/92	Basin-wide and Area-specific recommendations (see Basin Plan)
Hylebos/Lower Puget Sound	1993	Basin-wide and Area-specific recommendations
East Lake Sammamish	11/8/93	Basin-wide and Area-specific recommendations
Issaquah/Tibbetts Creek	7/10/95	Basin-wide and Area-specific recommendations
Beaver Lake Management Plan	6/8/95	Basin-wide requirements
Cedar River	In process	

SPECIAL DRAINAGE REQUIREMENTS OF THE ISSAQUAH CREEK BASIN

BACKGROUND

This summary contains the special drainage requirements of the Issaquah Creek Basin Plan, adopted by the King County Council on July 10, 1995. The Basin Plan was written and adopted as a statement of King County policy; its requirements are administered through "Special Requirement #4" of the *King County Surface Water Design Manual* (1990).

The requirements that directly related to hydrologic/hydraulic analysis and design are included within this summary. The basin plan however contains additional development requirements which may indirectly affect the design of surface water facilities. Of most relevance is BW-3 which sets maximum allowable clearing limits on new and existing lots within the rural residential zones. By increasing levels of native growth retention, the detention and water quality requirements for new development can be reduced. Please refer to the complete Basin Plan dated September, 1994 for details on rural clearing restrictions.

Basin-Wide Conditions:

BW-1: Level-1 Flow Reduction Standard for On-Site Retention/Detention Facilities.

BW-2: Level-2 Flow Reduction Standard for On-Site Retention/Detention Facilities.

BW-3: Open-Space Retention Requirements for Subdivisions and Clearing Restrictions on Existing Lots (See September 1994 Basin Plan)

BW-4: Comprehensive TESC Program for Construction Sites (See September 1994 Basin Plan)

BW-5: Adoption of City of Issaquah Critical Areas Ordinance (See September 1994 Basin Plan)

BW-6: Adoption of Zoning Changes in Critical Resource and Sensitive Areas (See September 1994 Basin Plan)

BW-19: Water Quality Treatment Design Standards

REQUIREMENTS IN EFFECT BASIN-WIDE OR IN MULTIPLE SUBBASINS

BW-1: Establishment of Flow Reduction Standard for On-Site Retention/Detention Facilities

Authority: Amendment to the Design Manual *approved through adoption of the Issaquah Creek Basin Plan*

In the Issaquah basin (except for the subbasins listed in BW 2; see Figure 1), on-site retention/detention (R/D) facilities, where mandated by the *Design Manual*, shall be designed to control the post-development peak hourly flows to corresponding pre-development levels for all annual peak hourly flows from the 2-year up to the 10-year. Whenever allowed by the *Design Manual*, infiltration shall be used to achieve this goal.

At this time, either of three analysis techniques may be used:

The first technique is to use a modification to the Santa Barbara Urban Hydrograph (SBUH) method. A seven-day rainfall distribution based on actual storms in the Puget Sound Lowlands replaces the Soil Conservation Service (SCS) Type 1a distribution in the *Design Manual*. Additionally, the hydrographs for pervious and impervious surfaces are computed separately and added to obtain the total hydrograph for pervious and impervious segments. Travel time and time of concentration computations for pervious land segments are based on the sum of interflow, shallow concentrated flow, and open channel flow. Technical guidance for this modification is included in the reference section of the *Design Manual* as updated in August 1994. The calculated storage volume shall be increased by a safety factor of 30 percent.

The second technique uses the method of the 1990 *Design Manual* with modified release requirements as follows:

Post Development Storm Event	Pre-Development Flow Release Target
2-year	one-half of the 2-year
10-year	2-year
100-year	10-year

No safety factor is required for facilities using these release rates.

The third technique involves iterative design using a calibrated continuous flow hydrologic simulation model. The Hydrologic Simulation Program - Fortran (HSPF) model used for the analysis in this basin plan is an example of this type of model. The calculated storage volume shall be increased by a safety factor of at least 10 percent.

Other methods for designing detention ponds that meet the stated performance goal may be substituted by the King County Surface Water Management Division in the future.

BW 2: Establishment of Erosion Protection Standard for On-Site Retention/Detention Facilities in Especially Sensitive Basins

Authority: Amendment to the Design Manual *approved through adoption of the Issaquah Creek Basin Plan*

In subbasins where stream stability and habitat are highly sensitive to higher future flows, specifically the Upper Issaquah, Middle Issaquah, McDonald Creek subbasins and the Wetland 7 drainages of the North Fork (see Figure 1) on-site R/D facilities, where mandated by the *Design Manual*, shall be designed to reduce post-development flow durations to their pre-developed levels for all flows greater than 50 percent of the 2-year event and less than the 50-year event. Additionally, the 100-year post-development hourly peak flow shall be reduced to the pre-development level. Whenever allowed by the *Design Manual*, infiltration shall be used to achieve this goal.

At this time, either of two analysis techniques may be used. It is recommended that a calibrated continuous flow simulation model, such as HSPF, be used for this analysis. The calculated storage volume shall be increased by a safety factor of at least 10 percent.

Other methods for designing detention ponds that meet the stated performance goal may be substituted by the King County Surface Water Management Division in the future.

If a continuous model cannot be used, the method of the 1990 *Design Manual* shall be used with the 24-hour design event with the following release requirements.

Post-Development Storm Event	Pre-Development Flow Release Target
2-year	one-half of the 2-year
10-year	2-year
100-year	10-year

The calculated storage volume shall be increased by a safety factor of 30 percent.

BW 19: Water Quality Treatment Design Standards

Authority: Amendment to the Design Manual *approved through adoption of the Issaquah Creek Basin Plan*

New developments in the Issaquah Creek basin that require drainage facilities under the current *Design Manual* shall achieve phosphorus removal using one of the following options:

1. A wetpond or combined detention/wetpond with a permanent pool volume equal to 4.5 times the volume of runoff from the mean annual storm (VB/VR = 4.5).

The VB/VR ratio is the volume of the wetpond basin divided by the volume of the runoff from the mean annual storm. The mean annual storm is equal to 0.56 inches at Landsburg. Mean annual storm precipitation can be adjusted for intermediate locations using the 2-year, 24-hour isopluvials as a guide. Runoff shall be estimated using a runoff coefficient of 0.9 for impervious areas and 0.25 for pervious areas. Forested areas need not be included in the calculation for pond sizing (zero runoff is assumed). The SBUH model shall not be used for estimating mean storm runoff values.

Pond volumes can be reduced for forest retention above 25 percent, according to the following schedule:

% Forest	VB/VR Ratio
25	4.25
30	4.0
40	3.5
50	3.25
60	3.0

2. Forest retention of 60 percent or greater in addition to one of the following facilities: biofiltration swale, filter strip, wetpond, or combined detention/wetpond with a VB/VR of 3.0.

3. In addition to the above options, the use of two additional options involving sand filtration and infiltration are possible through a variance submitted to the SWM Division:

   A. A biofiltration swale, filter strip, or wetpond with a VB/VR of 3.0 followed by a sand filter: or a single large sand filter.

   B. Soil infiltration, if soils are suitable. Soils that are suitable for water quality treatment have relatively slow infiltration rates (less than or equal to 2.4 inches/hour), as well as specific characteristics of organic content, cation exchange capacity, or grain size distribution.

Finally, if it can be demonstrated by the applicant that an alternative facility or combination of facilities is equally effective for phosphorus removal, then a variance request from this requirement can be submitted to the SWM Division for approval. Guidance on facility design is available from the SWM Division.

REQUIREMENTS IN SPECIFIC SUBBASINS

EF 2 & NF 2 Factors for Evaluation of Master Planned Developments

Authority: Advisory to permitting agencies

The following factors should be considered by applicants and county review staff in scoping, preparation, and review of all proposed developments within the East Fork and North Fork subbasins that meet requirements for preparation of a Master Drainage Plan (MDP) or Environmental Impact Statement (EIS) under King County codes.

1. The impacts of site development on the diversity, productivity, resilience, or habitat value of North Fork Wetland 7.

2. The impacts of site development on phosphorous loading from the tributaries draining to the North and East Forks of Issaquah Creek.

3. The impacts of site development on stream-channel erosion and transport of sediment to the North and East Forks of Issaquah Creek or Patterson Creek.

4. The impacts of site development on diversity and abundance of anadromous fish in the North and East Forks of Issaquah Creek or Patterson Creek; and

5. The impacts of site development on the frequency and duration of flood flows in the North and East Forks of Issaquah Creek.

UI 2 Standards and Performance Goals for New Subdivisions and Segregations

Authority: Impervious surfaces — Amendment to KCC 21A.12.030 approved through adoption of the Issaquah Creek Basin Plan

Otherwise, language is advisory to permitting agencies.

All new subdivisions and segregations in the Upper Issaquah subbasin should comply with the following conditions in addition to those specified in UI 1 #2 and #3. Compliance should be ensured by DDES through permitting processes.

1. Impervious Surface: All subdivisions and short subdivisions in rural residential zones within the North Fork subbasin shall have a maximum impervious surface area of 8% of the gross acreage of the plat. Distribution of the allowable impervious area among the platted lots will be recorded on the face of the plat. Impervious surface of roads need not be counted towards the allowable impervious area. In cases where both lot- and plat-specific impervious limits apply, the more restrictive shall be required.

2. Lot Siting: Subdivisions and segregations should be designed to avoid siting of residential lots in the steep inner gorge of Carey Creek.

3. Road Crossings: New road crossings associated with subdivision or segregation development should utilize bridges that fully span the stream channels of Holder and Carey creeks.

4. MDP and EIS Requirements: In addition to the above requirements, all developments that are partially or wholly within this subbasin that meet requirements for preparation of a Master Drainage Plan (MDP) or Environmental Impact Statement (EIS) under King County codes should include the following elements within the scope of the MDP and/or EIS:

   A. The impact of development on natural hydrologic processes in the Holder and Carey Creek subbasins, as evaluated by predicted post-development changes in the magnitude and duration of high and low flows;

   B. The impact of development on natural hillslope-sediment processes in these subbasins, evaluated by predicted post-development changes in the quantity of hillslope erosion and the rate of sediment delivery into stream channels;

   C. The impact of development on water quality in Holder and Carey Creek and subbasin wetlands, evaluated by predicted post-development changes in water chemistry.

NF 3 Wetland 7 Management Area

Authority: Impervious surfaces--Amendment to KCC 21A.12.030 approved through adoption of the Issaquah Creek Basin Plan

Authority: R/D Standard--Amendment to the Design Manual *approved through adoption of the Issaquah Creek Basin Plan*

In order to prevent further degradation of North Fork Wetland 7, the largest riparian wetland in the Issaquah Creek basin, the following performance standards shall apply to all new subdivisions, short subdivisions, and Master Planned Developments in the area of the North Fork subbasin draining to the wetland:

1. All subdivisions and short subdivisions in rural residential zones within the North Fork subbasin shall have a maximum impervious surface area of 8% of the gross acreage of the plat. Distribution of the allowable impervious area among the platted lots will be recorded on the face of the plat. Impervious surface of roads need not be counted towards the allowable impervious area. In cases where both lot- and plat-specific impervious limits apply, the more restrictive shall be required.

2. For all lands draining to Wetland 7, on-site R/D facilities shall be designed to the standard specified in BW 2: Erosion Protection Standard. In addition, the stormwater conveyance, detention, and discharge facilities shall maximize infiltration potential to recharge the groundwater on which Wetland 7 depends. Whenever possible, the drainage system shall use perforated pipes in gravel trenches for stormwater conveyance and dispersal systems in undisturbed vegetation for stormwater discharge, and the detention ponds shall be designed to encourage infiltration.

T 2 Site Development Requirements

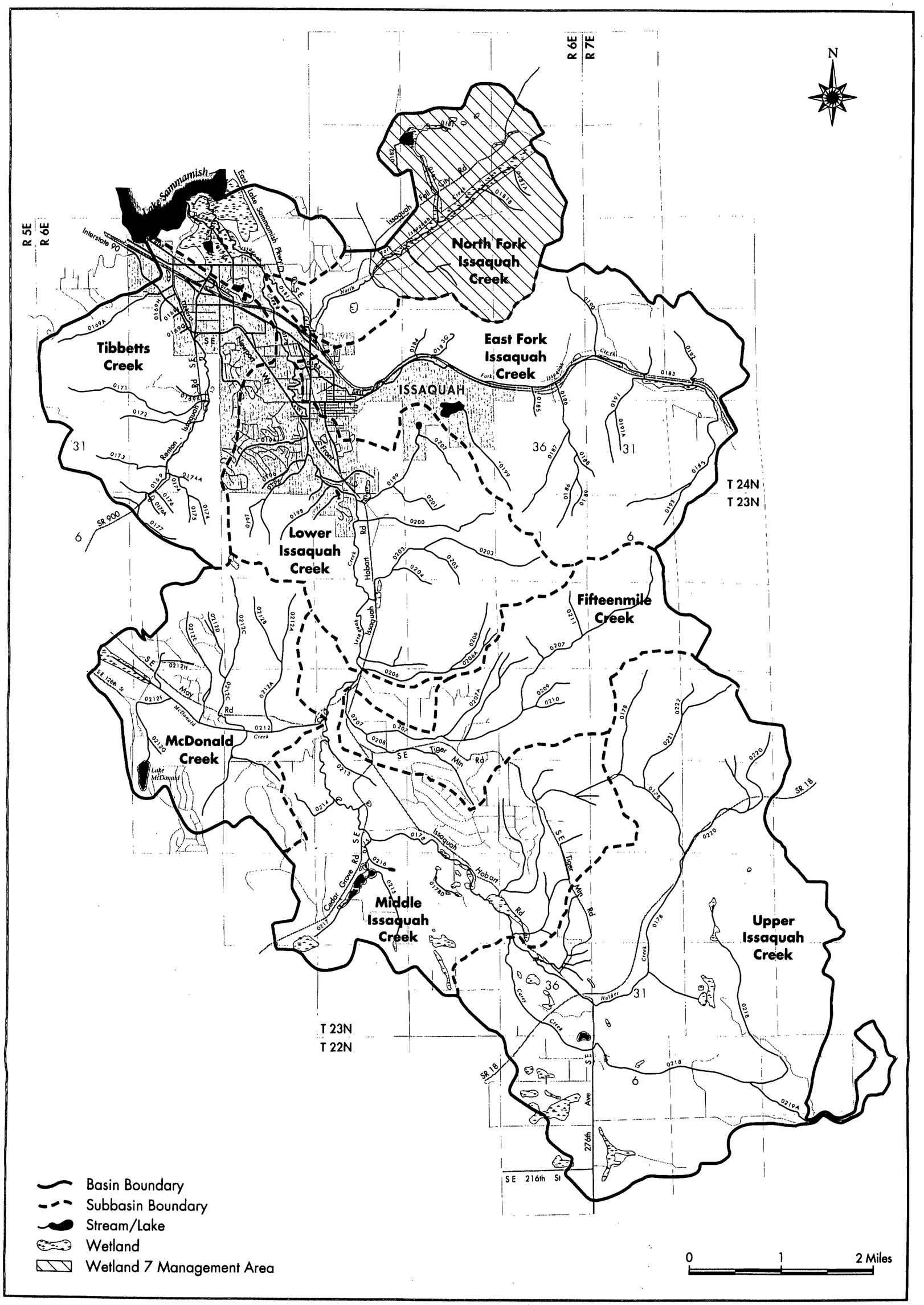
Authority: Amendment to the Design Manual *approved through adoption of the Issaquah Creek Basin Plan*

All new residential or mixed-use developments in the Tibbetts subbasin that meet requirements for preparation of a Master Drainage Plan (MDP) under King County drainage code shall comply with the following standards. Compliance shall be evaluated the SWM Division in the scoping, review, and approval of the MDP.

1. Stormwater discharges from developed areas must bypass the steep channel reaches of Cougar and Squak Mountains by continuous pipeline to the valley floor. Detention to the standards of BW 1: Flow Reduction Standard must also be provided.

2. In order to control erosion and sediment transport to downstream areas, no more than 60 percent of the site shall be cleared of its natural vegetation. Uncleared land shall be located in one or more open space tracts. No subsequent clearing of these tracts shall be allowed. In addition, a stringent temporary erosion and sediment control plan shall be initiated to minimize construction-related erosion.

3. Approval for the Master Drainage Plan shall be contingent on the completion of those downstream flood control and drainage projects that are deemed essential by SWM and the City of Issaquah to control current surface--water problems.



Issaquah Creek Basin

WATER FEATURES MAP

King County Surface Water Management
Everyone lives downstream

King County

Public Rules

Title	Document Code No
Beaver Lake Management Plan	PUT 8-7 (PR) KCC 9.08
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	June 8, 1995

King County
Public Rules and Regulations

Public Rules

RECEIVED
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CLERK
KING COUNTY COUNCIL

Title	Document Code No.
Beaver Lake Management Plan	PUT 8-7 (PR) KCC 9.08
Department/Issuing Agency Department of Public Works/Surface Water Management Division	Effective Date June 8, 1995
Approved 5/5/95	

1.0 SUBJECT TITLE: Beaver Lake Management Plan

1.1 EFFECTIVE DATE: The effective date of this Public Rule is thirty days after the filing date with the Clerk of the Council.

1.2 TYPE OF ACTION: NEW.

1.3 KEY WORDS: (1) Drainage; (2) Total Phosphorus Removal; (3) Permit Review; (4) Lake Management Plan; (5) Design Manual; (6) Surface Water Management Division; (7) Department of Development and Environmental Services.

2.0 PURPOSE: To designate the Beaver Lake watershed a special management area for total phosphorus loading control and to establish a standard procedure for evaluating drainage plans and related materials for applications of development within the Beaver Lake Watershed (within the East Lake Sammamish Drainage basin) for their conformance with an 80% total phosphorus loading reduction goal or AKART (all known, available, and reasonable methods of prevention, control and treatment) as applied to all new stormwater inputs.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of unincorporated King County, Beaver Lake watershed.

3.2 Applicants.

3.3 Department of Development and Environmental Services (DDES) or its successor agency.

3.4 Department of Public Works, Surface Water Management Division, or their successor agencies.

4.0 REFERENCES: King County Code 9.08.010 and 9.08.120; King County Code 2.98; Ordinance 11522; Surface Water Design Manual.

5.0 DEFINITIONS: In addition to the definitions listed in Section 5 of this Public Rule, all definitions included in the King County Surface Water Design Manual are hereby adopted by reference.

5.1 "AKART" means all known, available, and reasonable methods of prevention, control, and treatment.

5.2 "Eutrophic" means a trophic status characterized by moderately high algal productivity, more serious oxygen depletion in the bottom waters, some recreational use impairment, summer chlorophyll a concentration greater than 10 μg/l, a summer Secchi depth of <2 meters, and a winter total phosphorus concentration greater than 20 μg/l.

5.3 "Hypereutrophic" means a trophic status characterized by high algal productivity, intense algal blooms, fish kills due to oxygen depletion in the bottom waters, frequent recreational use impairment, summer chlorophyll a concentration greater than 10 μg /l, a summer Secchi depth generally less than 2 meters, and a winter total phosphorus concentrations greater than 30 μg/l.

5.4 "Lake Management Plan" means the plan (and supporting documents as appropriate) describing the lake management recommendations and requirements which are formally adopted by rule under procedures specified in K.C.C. 2.98.

5.5 "Mesotrophic" means a trophic status characterized by moderate algal productivity, oxygen depletion in the bottom waters, usually no recreational use impairment, summer chlorophyll a concentration averaging 4-10 μg/l, a summer Secchi depth of 2-5 meters, and a winter total phosphorus concentrations ranging from 10-20 μg/l.

5.6 "Oligotrophic" means a trophic status characterized by low algal productivity, algal blooms are rare, water clarity is high, all recreational uses unimpaired, summer chlorophyll a concentration average less than 4 μg/l, a summer Secchi depth greater than 5 meters, and a winter total phosphorus concentrations ranging from 0-10 μg/l.

5.7 "Phosphorus" means elemental phosphorus and for the purposes of this reule shall be measured as total phosphorus.

5.8 "Phosphorus Concentration" means the mass of phosphorus per liquid volume.

5.9 "Phosphorus Loading" means the total mass of phosphorus per time basis.

5.10 "Total Phosphorus" means the phosphorus concentration as determined by a state certified analytical laboratory using EPA 365.3 or SM 4500-P-B,E or an equivalent method.

5.11 "Trophic State Index" means a classification system which uses algal biomass as the basis for classification which can be independently measured by chlorophyll a, Secchi depth, and total phosphorus concentration.

5.12 "Trophic Status" means a classification which defines lake quality by the degree of biological productivity.

6.0 POLICIES

6.1 The Beaver Lake watershed as generally identified in the Beaver Lake Management Plan, which is available in summary to all Surface Water Design Manual subscribers or for purchase at the Surface Water Management Division or the Department of Development and Environmental Services, is a sensitive lake and is hereby designated a critical drainage area. This designation is:

6.1.1 Existing whole-lake total phosphorus concentration for the combined Beaver Lake system is 23 μg/l. Beaver Lake 1 and Beaver Lake 2, individually, have whole-lake total phosphorus concentrations of 36 ($\pm$2) μg/l and 20 ($\pm$1) μg/l, respectively;

6.1.2 Whole-lake total phosphorus concentration, chlorophyll a, and secchi depth indicate that the Beaver Lake system is bordering on eutrophic conditions;

6.1.3 Modeling of the Beaver Lake system's future trophic status indicates that the lake will become hypereutrophic with a whole-lake total phosphorus concentrations predicted to be 36 μg/l without additional phosphorus removal via stormwater treatment;

6.1.4 Maintaining existing trophic status is a management plan goal. To maintain existing trophic status, an 80 percent total phosphorus annual loading removal goal was established for new impervious surface development prior to stormwater discharges to Beaver Lake.

6.2 The standards specified in Policy 6.4 of this Public Rule shall apply to all development proposals located within the Beaver Lake watershed which require drainage review as specified in the King County Surface Water Design Manual.

6.3 Development proposals within the Beaver Lake watershed may be exempt from management plan requirements if they demonstrate to the satisfaction of the Department of Development and Environmental Services that on-site surface and stormwater runoff drainage does not in fact drain into the basin mapped in Appendix 9.1 of this Public Rule.

6.4 For projects which create greater than 5,000 sq. ft. of new impervious surface subject to vehicular use in the Beaver Lake watershed, the following conditions shall apply, unless the conditions identified in Policy 6.3 are documented to the satisfaction of the Department of Development and Environmental Services.

6.4.1 The proposed stormwater facilities shall be designed to remove 80 percent of all new total phosphorus loading on an annual basis due to new development (and associated stormwater discharges) in the Beaver Lake watershed where feasible or utilize AKART if unfeasible.

Currently the AKART standard or interim best management practices for phosphorus sensitive lakes can be fulfilled by the following stormwater treatment design criteria:

6.4.1.1 A wetpond or combined detention/wetpond with a permanent pool volume equal to 4.5 times the volume of runoff from the mean annual storm (VB/VR=4.5).

6.4.1.1.1 Mandatory roof downspout infiltration unless shown to be unfeasible, and maximization of forest or native vegetation retention.

6.4.1.1.2 Pond volume can be reduced by maximizing forest retention according to the following schedule:

Forest (%)	VB/VR ratio
25	4.25
30	4.00
40	3.50
50	3.25
60	3.00

6.4.1.1.3 Forest retention areas shall be in tracts dedicated to the County. Buffers without trails can be counted in the percent forest figure.

6.4.1.1.4 The VB/VR ratio is the volume of the wet pond basin divided by the volume of the runoff from the mean annual storm. The mean annual storm is equal to 0.46 inches at Seatac. Runoff can be estimated using a runoff coefficient of 0.9 for impervious area and 0.25 for all other pervious area. Forested areas in tracts dedicated to the County need not be included in the calculation of pond sizing (i.e. zero new runoff volume assumed). If this method is used in other areas, and Seatac precipitation statistics under-estimate the rainfall as judged by the isopluvial distribution of the 2-year 24-hour precipitation, the mean annual rainfall should be adjusted upward.

6.4.1.2 Although current King County SWM designs are not complete for sand filtration, incorporation of sand filters into stormwater treatment facility designs (i.e. treatment trains) can be pursued through the variance process to achieve additional total phosphorus removal. The proponent must demonstrate that equivalent or improved total phosphorus treatment can be expected with an alternative treatment system which incorporates sand filtration than by methods described in 6.4.1.1.

6.4.1.3 Where soil are suitable, on-site infiltration of storm water runoff can be pursued through the variance process as an AKART alternative. Soils are considered suitable for infiltration if at least two feet of soil exist where one of the following soil conditions are met: 1) the cation exchange capacity of the soil equals or is greater than five milliequivalents; 2) the organic content of the soil is equal to or greater than five percent; 3) the grain size distribution of site soils is equivalent to not more than 25 percent gravel by weight (75 percent passing the #4 sieve) and of that passing the #4 sieve, either a) 50 percent minimum passes the #40 sieve and two percent minimum passes the #100 sieve, or b) 25 percent minimum passes the #40 sieve and five percent minimum passes the #200 sieve; and 4) the infiltration rate is 2.4 inches/hour or less. Additionally, the proponent must demonstrate that equivalent or better phosphorus treatment can be expected with on-site infiltration than by methods described in 6.4.1.

6.4.1.4 As the King County Surface Water Design Manual is updated and additional treatment options and designs for total phosphorus removal become available, alternative treatment systems may be utilized if the AKART standard for phosphorus removal can be demonstrated.

6.4.2 Hydrologic analysis shall be determined using a continuous hydrologic model such as the Hydrologic Simulation Program-Fortran (HSPF), the King County Runoff Time Series program (KCRTS), the Santa Barbara Urban Hydrograph, or the VB/VR methodology . These methodologies may be revised or superseded by other methodologies

for achieving the same performance goal as stipulated by future revision to the Surface Water Design Manual.

6.5 This Public Rule will only be in effect until December 31, 1996 unless a Lake Management District has been formed for the Beaver Lake watershed in 1996.

6.6 If any portion of this Public Rule or its application to any person or property is held invalid, the remainder of this Public Rule or the application of the provision to other persons or property shall not be affected.

6.7 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objectives and purposes for which it was adopted.

7.0 PROCEDURES

Responsibility	Action	
DDES	7.1	Identifies that the project is in the Beaver Lake watershed.
DDES	7.2	Informs applicant that the project is located in the Beaver Lake Management Plan area.
Applicant	7.3	Submits additional information which either:
		7.3.1 Demonstrates that the project qualifies for the exemption in Policy 6.3; or
		7.3.2 Complies with Policy 6.4.
DDES	7.4	Reviews the materials submitted in step 7.3 and determines if it complies with the Beaver Lake Management Plan.
		7.4.1 Returns inadequate material to the applicant with specific instructions to comply with step 7.3.
		7.4.2 Forwards adequate engineering plans to be processed according to the established review process.

8.0 RESPONSIBILITIES

8.1 The Surface Water Management Division is responsible for:

8.1.1 Amending this Beaver Lake Management Plan Public Rule if requirements of the Beaver Lake Management Plan Public Rule warrant alteration.

8.1.2 Updating the Beaver Lake Management Plan Public Rule as new information becomes available.

8.2 The DDES is responsible for:

8.2.1 Identifying each project which is within the Beaver Lake Management Plan area.

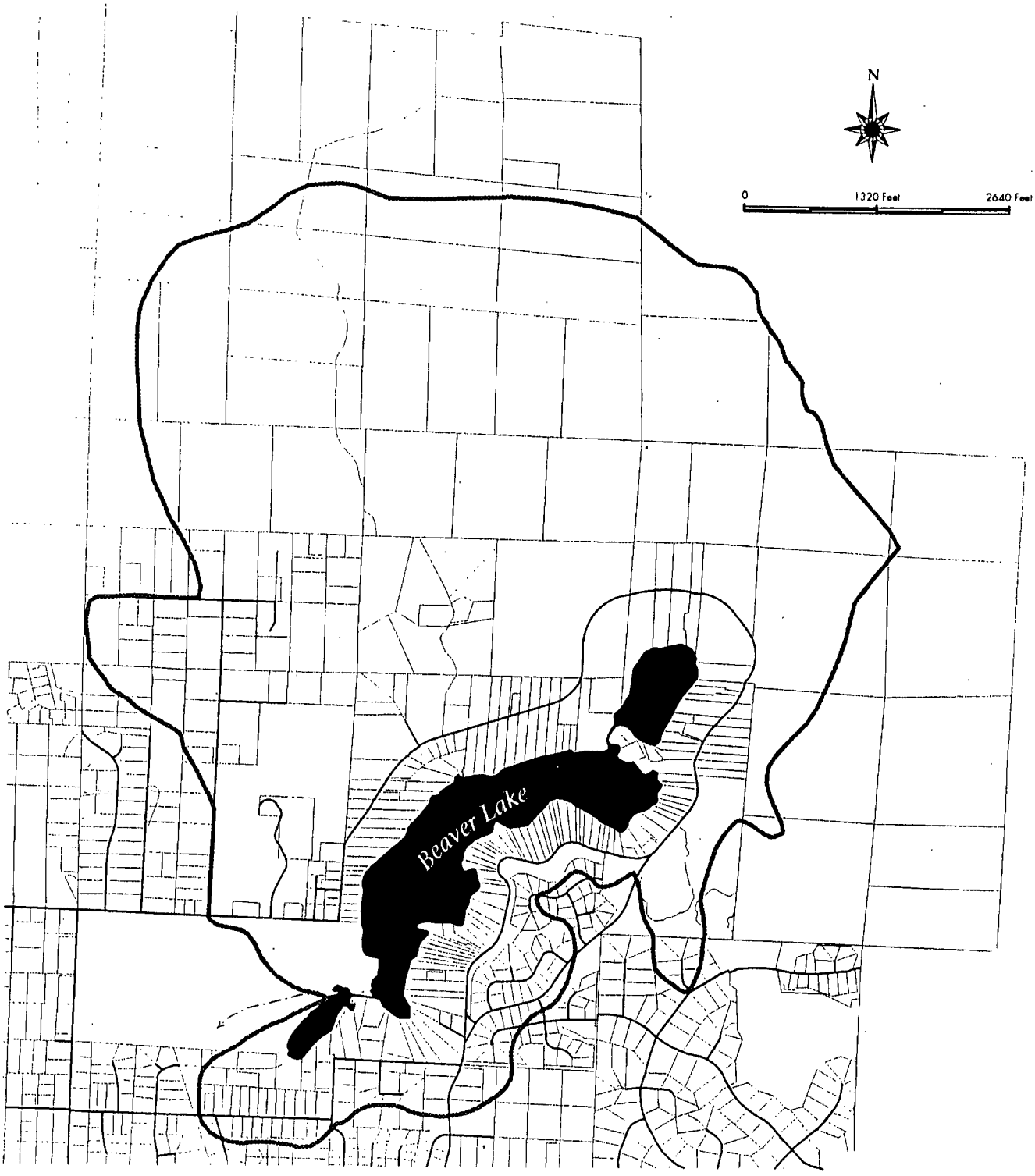
8.2.2 Determining if the material submitted by the applicant complies with either Policy 6.3 or Policy 6.4 of this Public Rule.

8.3 The applicant is responsible, at a minimum for:

8.3.1 Demonstrating that the project complies with Policy 6.3 or with the requirements in Policy 6.4 of this Public Rule.

9.0 APPENDICES

9.1 Map of the Beaver Lake Management Plan Area. Precise borders of this management area are indicated on the Beaver Lake Watershed Map at the DDES permit center.



Appendix 9.1

Beaver Lake Management Plan Area

King County Surface Water Management

Watershed Boundary
Parcel Boundary
Road
Lake
Lake Outlet

Sources: King County GIS Parcel Coverage, 1995; Aerial Photos, 7-22-89, 1:12,800; Aerial Photos, 9-14-89, 1:13,500; Aerial Photos, 4-11-89, 1:7,200; King County Wetland Notebooks, 1980; Field Survey, 11-95. Produced 12-95 FB

King County Surface Water Management

Everyone lives downstream

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 1-B
ADOPTED COMMUNITY PLANS - REQUIREMENTS

BASIN PLAN	ADOPTED	SPECIFIC DRAINAGE REQUIREMENTS
Bear Creek	2/17/89	(See Enclosed "P"-suffix drainage requirements)
Snoqualmie Valley	9/15/89	(See Enclosed "P"-suffix drainage requirements)
Soos Creek	12/17/91	(See Enclosed "P"-suffix drainage requirements)
Tahoma-Raven Heights	12/18/91	(See Enclosed "P"-suffix drainage requirements)
East Lake Sammamish	11/8/93	(See Enclosed "P"-suffix drainage requirements)

AREAWIDE P-SUFFIX CONDITIONS

The Bear Creek Community Plan calls for protection of areas prone to water-induced erosion, streams, other environmentally sensitive areas, and heritage sites. The Plan also calls for the development of a public equestrian trail system and for transportation improvements. To achieve these goals, conditions of site plan approval are applied to all properties in the Bear Creek planning area. A description of the conditions and maps of the areas where each of the conditions apply follows. The detailed maps in the **Zoning Maps** section shows a "P" suffix attached to the zone symbol for each zoning designation. The Building and Land Development Division has a parcel-specific record of which P-suffix conditions apply to each property.

P-SUFFIX CONDITIONS FOR BEAR CREEK STEEP SLOPE AREAS

The King County Comprehensive Plan designates the Snoqualmie Valley Rural. A major reason for this designation is to protect lands within the agricultural district from the impacts of surface water runoff caused by increased impervious surfaces (pavement) or development without special measures to avoid such problems. For this reason, the following "P" suffix conditions of site plan approval are applied to properties within areas considered to pose a threat to downstream development unless special measures are taken.

Steep slope areas in the Bear Creek planning area are extremely susceptible to water-induced erosion, which can result in rapid formation and growth of steep ravines. These ravines are capable of undercutting property and roads, and are a safety hazard. Existing natural drainage systems mitigate this danger through dispersing and slowing runoff in the areas tributary to these steep slope areas. Alteration of natural drainage systems serves to concentrate runoff flows and to accelerate the rate of runoff, both of which encourage rapid and severe stream-channel erosion.

Due to the extreme sensitivity of property in the indicated drainage areas to water-induced erosion and the resulting potential for danger to the safety of persons and property in these areas, the following conditions shall apply to all development in the indicated areas unless the applicant can demonstrate that their project is so categorized in error, because either:

1. Site drainage does not in fact drain over steep slopes,

2. The downstream drainage pathway is not underlain by erodable granular soil anywhere along its route, or

3. The site is underlain by permeable sediments that will infiltrate and dissipate runoff even after clearing and development.

If these exemptions are not met, a Drainage Control Plan shall be reviewed and approved by BALD for all development in this area whenever a proposed development requires a building permit, conditional use permit, unclassified use permit, variance, rezone, planned unit development, subdivision, short subdivision, right-of-way use permit, or grading permit. A list of exemptions, such as garden use of right-of-ways, will be developed to waive Drainage Control Plan requirements for proposed uses that will not impact surface water runoff quantities or rates. Once a drainage plan is approved through the subdivision or MPD process, individual building permits on the same property will not require another drainage plan.

Unless otherwise exempted, the following conditions shall apply:

1. Stormwater detention shall contain up to the 100-year/24-hour storm. Release shall be at 50% of the 2-year forested release rate up to and including the 2-year/24-hour storm, at the forested 2-year rate up to the 10-year/24-hour storm and at the forested 10-year rate for the 100-year/24-hour storm. These rate controls may be modified if discharge is via tightline to below the area of severe erosion potential.

2. Developed conditions will assume 100% removal of forest canopy, unless expressly prohibited by recorded easement or restriction; plus existing, proposed, and anticipated impervious surfaces.

3. Point discharge from detention systems will be only into drainage channels that convey surface water in the pre-development state. Dispersed discharge will be evaluated as a potential alternative.

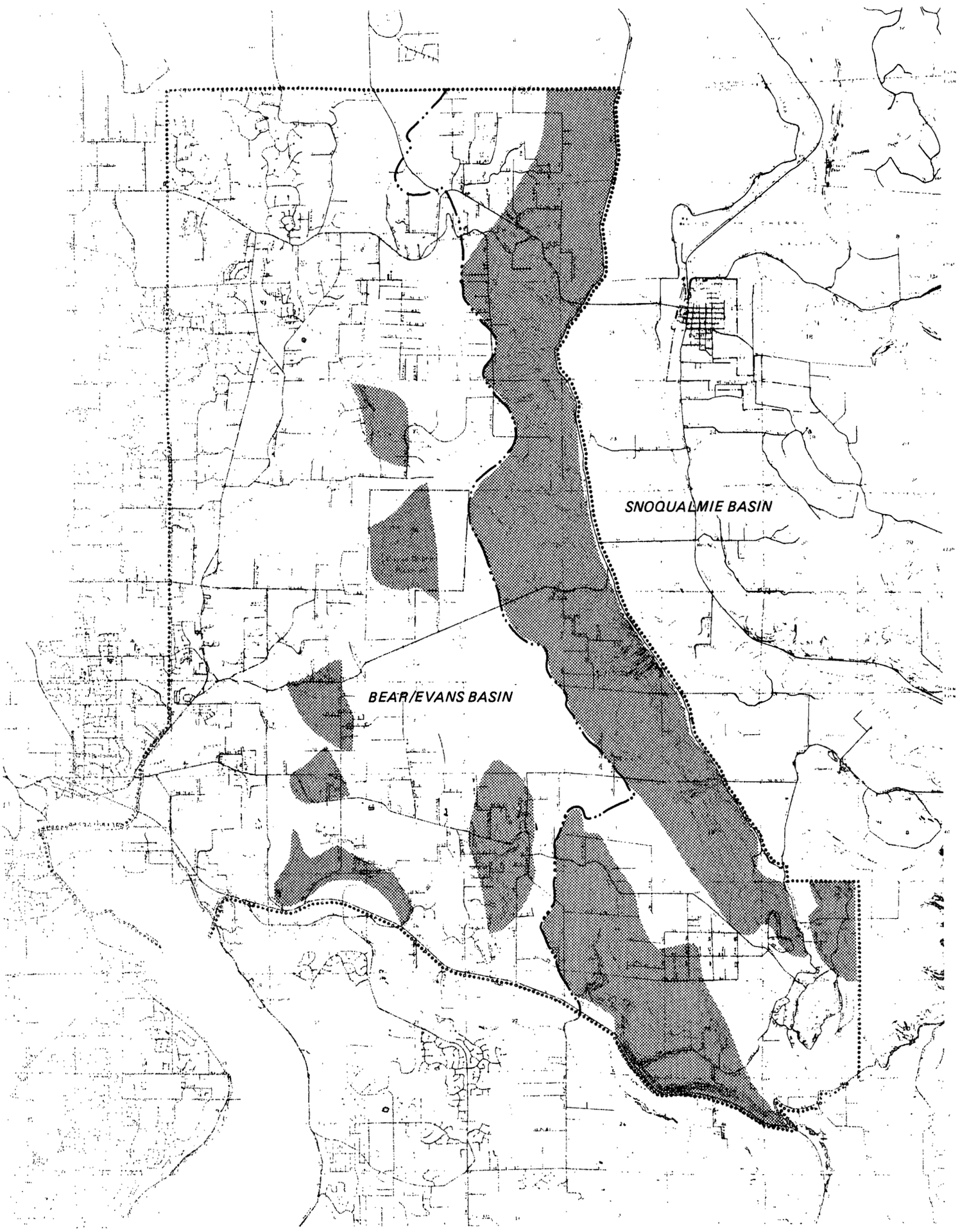
4. Drainage entering the site from developed upstream areas must be detained and released under the same criteria as runoff generated onsite.

5. Installation of the critical drainage control features, as scheduled and delineated in the Drainage Control Plan as approved by BALD, shall be installed prior to any land clearing, vegetation removal, site grading, road construction or utility installation. Only those activities associated with pre-development exploration, such as surveying and performance of soil tests and limited clearing and grading associated with construction of the drainage facilities, will be permitted prior to completion of the drainage control system.

6. In those situations where features of the drainage system or subsequent development make installation of the final drainage system impossible, a phased Drainage Control Plan will be developed which provides the required level of retention/detention to the entire site at all times.

These conditions are applied to all of the lands that lie on or drain onto slopes over 40% on the eastern edge of the Bear Creek planning area as shown on the **Steep Slope Areas/Basin Boundaries** map. The combination of very low residential density and special development conditions developed by the Resource Planning Section, the geologist at the Building and Land Development Division, the Surface Water Management Division and a water quality specialist from Metro are intended to reduce or eliminate major surface water runoff impacts of development in Bear Creek on the Snoqualmie Valley.

These special drainage conditions are also applied to some areas of the Bear Creek planning area outside the one home per ten-acre Rural area as shown on the **Steep Slope Areas/Basin Boundaries** map. These areas include steep portions of Union Hill and areas surrounding Patterson Creek. Again, the purpose of these conditions is to protect downstream properties and water quality from the impacts of increased impervious surfaces.



STEEP SLOPE AREAS/ BASIN BOUNDARIES

- Steep Slope Areas
- Drainage Basin Boundary

N

Miles

Bear Creek
Community Plan

P-SUFFIX CONDITIONS FOR STREAM CORRIDORS

All development within 150 feet of identified streams in the Bear Creek planning area (**Washington Department of Natural Resources Stream Types** map)* will be reviewed for impacts to streams. A sensitive area study will be prepared for any proposal that does not place required stream corridor easements in separate tracts, that proposes the use of streams for control or discharge of storm or surface water, or that proposes alterations of streams. Proposals that have no required corridor easement, that place stream corridor easements in a tract, that do not utilize streams for control or discharge of storm or surface water, and do not alter streams do not need to prepare a sensitive area study for streams. Other sensitive area special studies may still be required.

All sensitive area stream studies shall contain:

A. Map of the project area including:

1. reference streets and property lines;
2. existing and proposed easements, rights-of-way, and structures;
3. contours at the smallest readily available intervals;
4. hydrology: water movement into, through and off of the project area, including streams showing Department of Natural Resources (DNR) classification and wetlands showing King County inventory rating, and including seeps, springs, saturated soil zones, seasonal or intermittent swales and subsurface return flow zone. Streams noted as "unclassified" in the King County Sensitive Areas Map Folio or which do not appear in County or DNR maps should be labeled "unclassified." Wetlands not in the County inventory should be labeled "uninventoried."
5. tops and toes of slopes and embankments;
6. location of required buffer, corridor limits, and building setback lines (BSBL);
7. location of normal winter base flow edge;
8. location of all trees at least 8" diameter breast height (DBH) within 100' of the stream centerline but outside the proposed stream corridor;
9. the toe of any slope adjacent to or 25' or less from the stream;
10. the edge of any riparian wetland, and required buffer and BSBL;
11. proposed stream crossings for utilities, roads, walkways, or other purposes;
12. proposed trails within the stream corridor.

B. Written reports detailing:

1. how the study was performed;
2. description of the project site and its condition;
3. the proposed action and potential environmental impacts of the proposed project to the stream;
4. the measures proposed to avoid or lessen the project's impacts (during construction and permanently). When plantings are proposed, detail species to be used, timing, and planting techniques.
5. characterization of riparian vegetation;
6. discussion of soil types adjacent to the stream, based on Soil Conservation Service maps or site-specific soil analysis where available (indicate source);
7. documentation of the presence or absence of salmonids in Type V or unclassified streams, based on the State Department of Fisheries Catalogue of Streams and Salmon Utilizations, Metro Stream Resource Inventories, or State Game Department Game Fish Distribution in Selected Streams Within the Lake Washington Drainage Basin, #83-9. Electrofishing on site or the equivalent may

be necessary if no existing documentation is available.

8. when a stream crossing is proposed, discussion of salmonid use of the affected reach for spawning, rearing, or migration;
9. when restoration such as revegetation is discussed, documentation of vegetation, erosional, and landslide failures.

The following limitations and conditions on development in stream corridors will apply:

A. All stream corridors shall be designated as native growth protection easements (NGPE) in the following development processes:

Rezone, formal subdivison, planned unit development (PUD), master planned development (MPD), multifamily, residential or commercial building permits, variance, shoreline, conditional use and unclassified use.

The purpose of the NGPE is to prevent disturbance or removal of vegetation and to prohibit structures, fills, or obstructions.

B. In the following development processes each stream corridor designated as an NGPE also shall be placed in a separate tract.

Rezone, formal subdivision, planned unit development (PUD), master plan development (MPD), shoreline conditional use and unclassified use.

C. Extent of Corridors
Stream corridor NGPEs and tracts will be sized according to the following criteria: (Upon adoption of the Sensitive Areas Ordinance, the more stringent regulations shall apply.)

1. Streams unconstrained by adjacent hazardous areas (**Unconstrained Stream Corridors** figure):

   a. For all DNR Type I-IV streams and for DNR Type V streams which are shown to be habitat for salmonids, a minimum 100' buffer from the top-of-bank on both sides shall be provided and designated as a NGPE, and a 15' building setback line (BSBL) will extend landward from the edge of the tract.

   b. For Type V streams which are not salmonid habitat, a minimum 25' buffer from the stream center line on both sides shall be provided and designated as a NGPE, and a 15' BSBL will extend landward from the edge of the tract.

2. Streams constrained by riparian (streamside) wetlands (**Wetland Constrained Stream Corridor** figure): Existing sensitive areas requirements for wetlands shall apply unless stream corridor requirements are more restrictive.

3. Streams constrained by slopes 30% and greater (**Slope Constrained Stream Corridors** figure):

   a. For streams adjacent to or within 25' of the toe of slopes which are less than 100' in horizontal length, a buffer shall extend 25' beyond the top of slope and a 15' building setback line (BSBL) shall apply. The corridor shall be designated as NGPE. These requirements shall also apply if slopes are

variable, that is, having small benches or terraces but also having an overall slope of 30% or greater.

b. For streams adjacent to or within 25' of the toe of slopes which are greater than 100' in horizontal length, a buffer shall extend 125' beyond the top of bank or the water's edge and a 15' BSBL shall apply. The corridor shall be designated as NGPE. This requirement shall apply if slopes are variable, that is, having small benches or terraces but also having an overall slope of 30% or greater.

c. A minimum 100' buffer from the top of the bank on each side of the stream designated as NGPE and a 15' BSBL shall be provided for all streams.

D. The use of streams for discharge or control of storm or surface water is subject to the following conditions:

1. In approving the use of streams for storm or surface water control, BALD staff shall review drainage and stream studies and apply conditions which minimize impacts on the hydraulic regime of the stream and impacts to wildlife habitat and water quality. These conditions include:

a. No stormwater will be discharged directly or piped into a stream.

b. Discharge shall occur in a manner which mimics natural conditions, such as by meandering grass-lined swales, infiltration trenches, perforated pipe, sheet flow through the vegetation of the corridor or other designs which BALD approves and which eliminate the sediment load and dissipate the energy of inflows.

c. BALD may require construction of an on-site sedimentation and storage system which intercepts water entering the stream.

E. Alterations of streams and stream banks are subject to the following conditions:

1. Stream banks and their associated corridors shall not be altered without written review and approval by BALD and other pertinent agencies such as Washington Department of Game or Fisheries.

2. Streams may be placed in culverts only when no alternative exists to gain access to developable property.

3. Stream relocation is allowed only in DNR Type V streams and only when:

a. relocation is necessary to provide reasonable use of the property, and

b. reconstruction creates a new increase in both in-stream and riparian habitat over former conditions,

c. the new channel is designed to maximize fisheries habitat value,

d. revegetation of the new streamside uplands and banks provides for cooling shade, fish shelter, detritus inputs to the stream, bank stabilization, and stream channel protection from human and domestic animal intrusion.

e. new vegetation on the bank and adjacent uplands has been established for a full growing season prior to introduction of the new stream flows, and

f. the existing channel is not currently providing high quality habitat as determined by Washington State Fisheries or Game Department staff.

4. Trails may be located in stream corridors if they will not contribute to bank collapse or slope erosion or remove vegetation which shades or shelters the stream or anchors the bank. Trail access to the stream may be placed only at locations, that, in the Sensitive Areas Planner's judgement, can tolerate human traffic.

F. Stream Corridor Exemptions

If an applicant for a development proposal otherwise allowed under the applicable zone demonstates that establishment of an NGPE of the width required in Section C above, would deny all reasonable use of the property, the Director of the Parks, Planning and Resources Department or his or her designee may administratively reduce the width of the NGPE in order to allow the development where the applicant also demonstates:

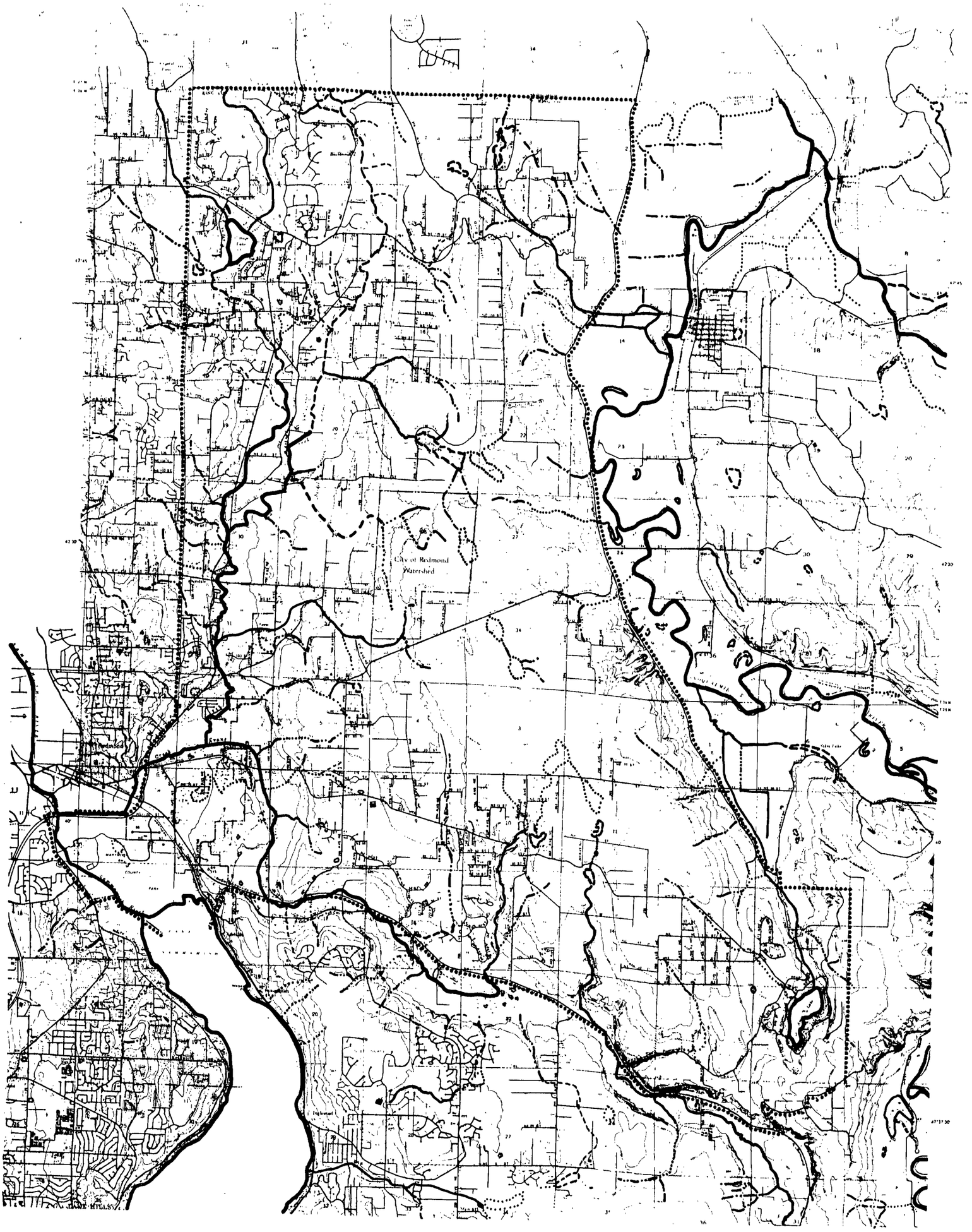
1. That no reasonable use with less impact on the sensitive area and its buffer is possible; and

2. That there will be no damage to nearby public or private property and no threat to the health or safety of people on or off the property. If a reduction of the required NGPE is granted, it shall in no event be greater than the minimum necessary to allow the applied for use.

Note: Detailed procedures for the request and consideration of a reduction in the required width of the NGPE shall be drafted by the Parks, Planning and Resources Department and be available from that department as an administrative rule.

* For comparitive purposes, the Washington Department of Natural Resources (DNR) stream classification system translates to the classification system used in the King County Sensitive Areas Ordinance (SAO) as follows:

DNR	SAO
Type I	Class I
Type II-IV	Class II
Type V (with salmonids)	Class II
Type V (no salmonids)	Class III



WASHINGTON DEPARTMENT OF NATURAL RESOURCES STREAM TYPES

- Type 1
- Type II
- Type III
- Type IV
- Type V
- Unclassified

1 1/2 0 1 2 Miles

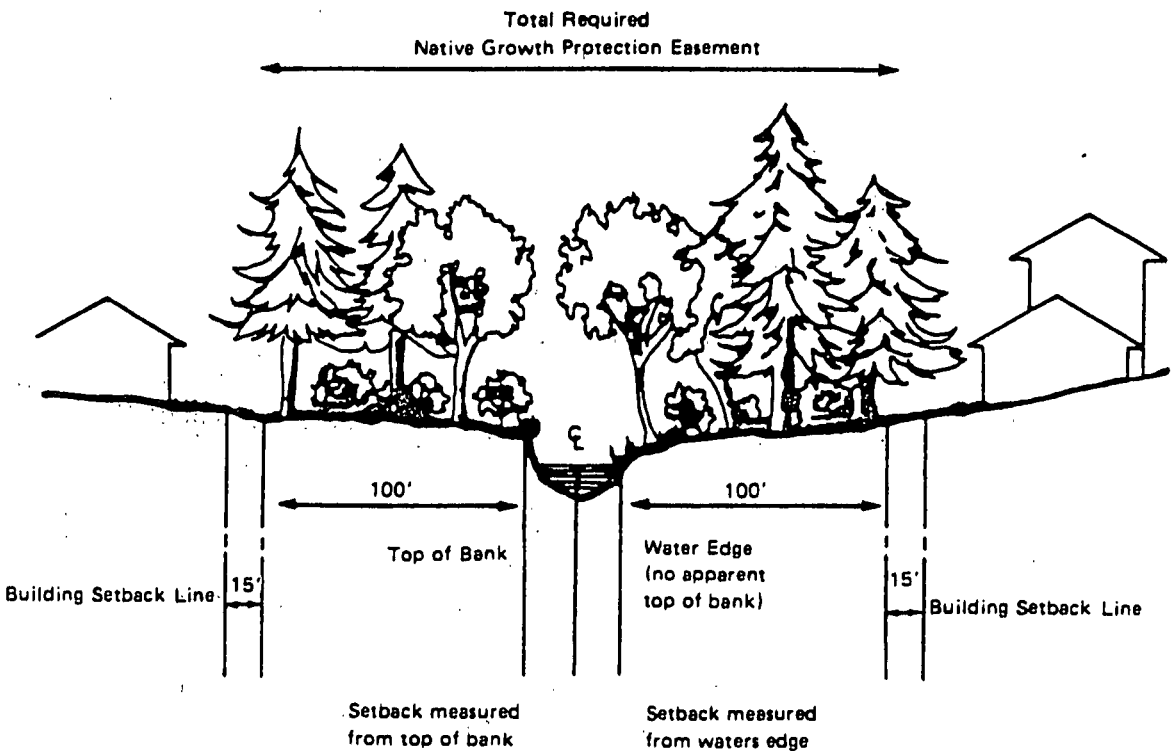
N

Bear Creek

Community Plan

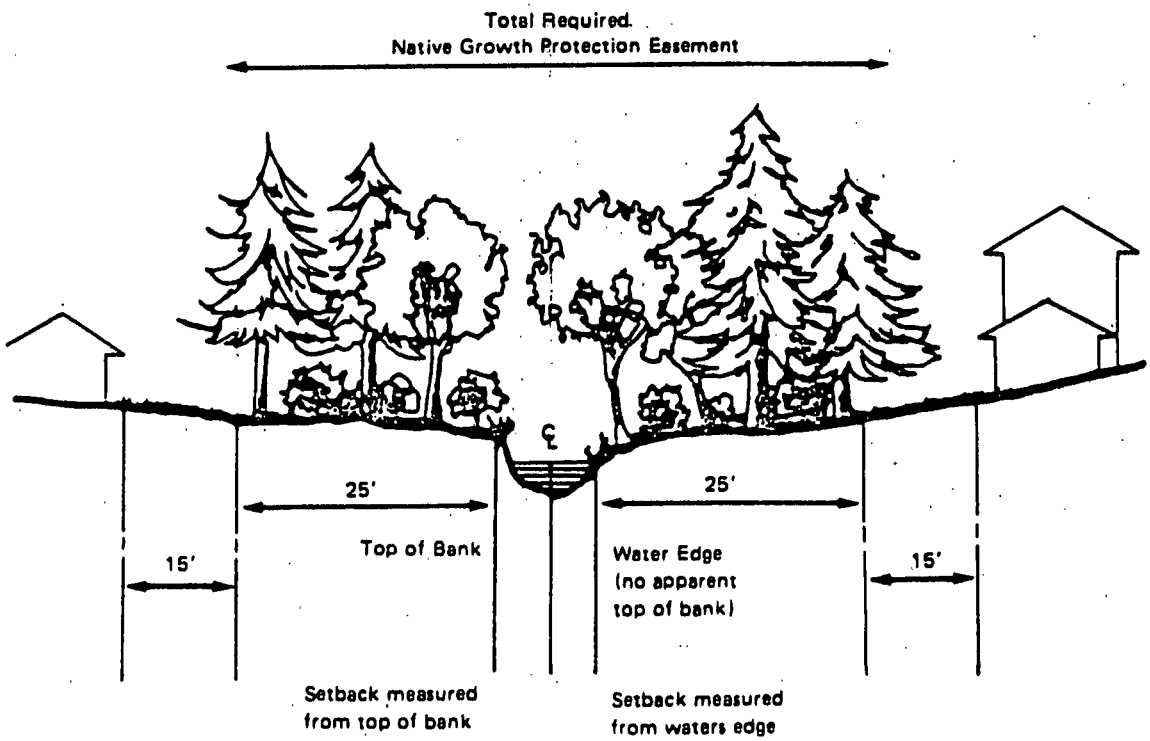
King County Planning and
Community Development Division

UNCONSTRAINED STREAM CORRIDORS



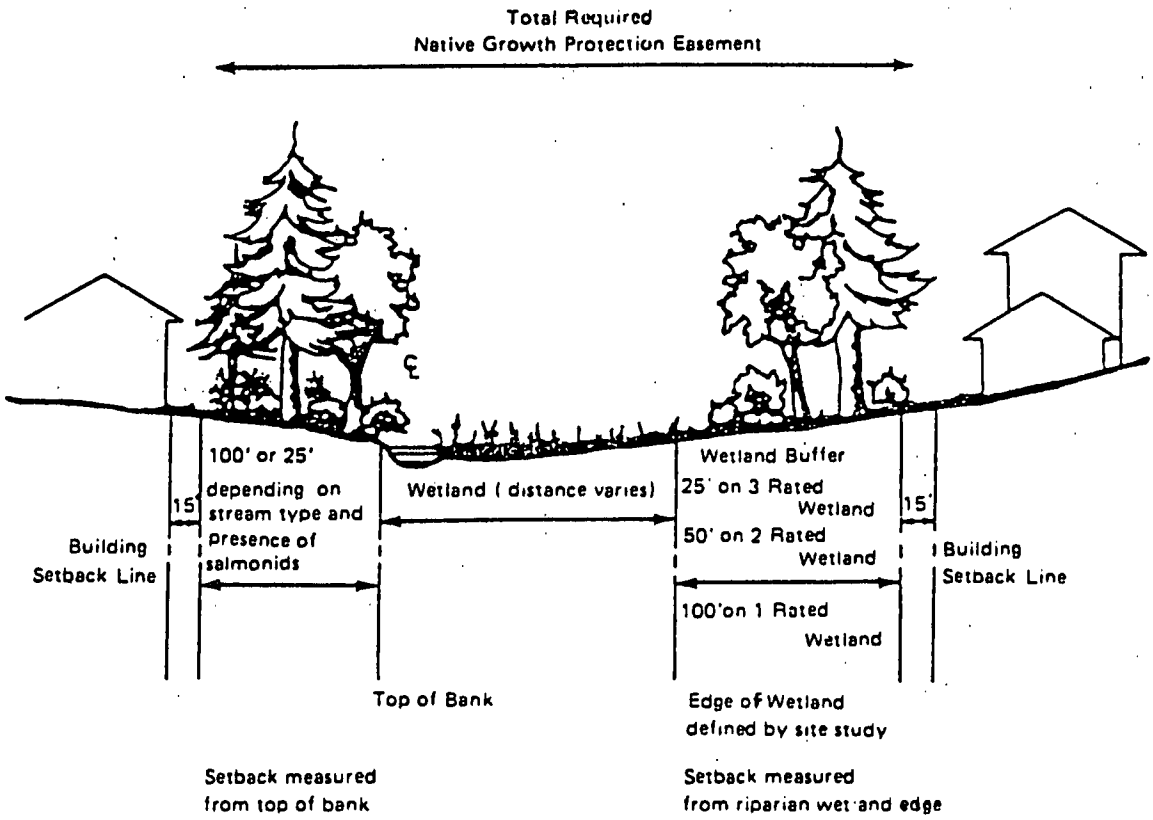
All year-round streams (DNR Types I-IV) and all intermittent streams (DNR Type V) with salmonid habitat

UNCONSTRAINED STREAM CORRIDORS

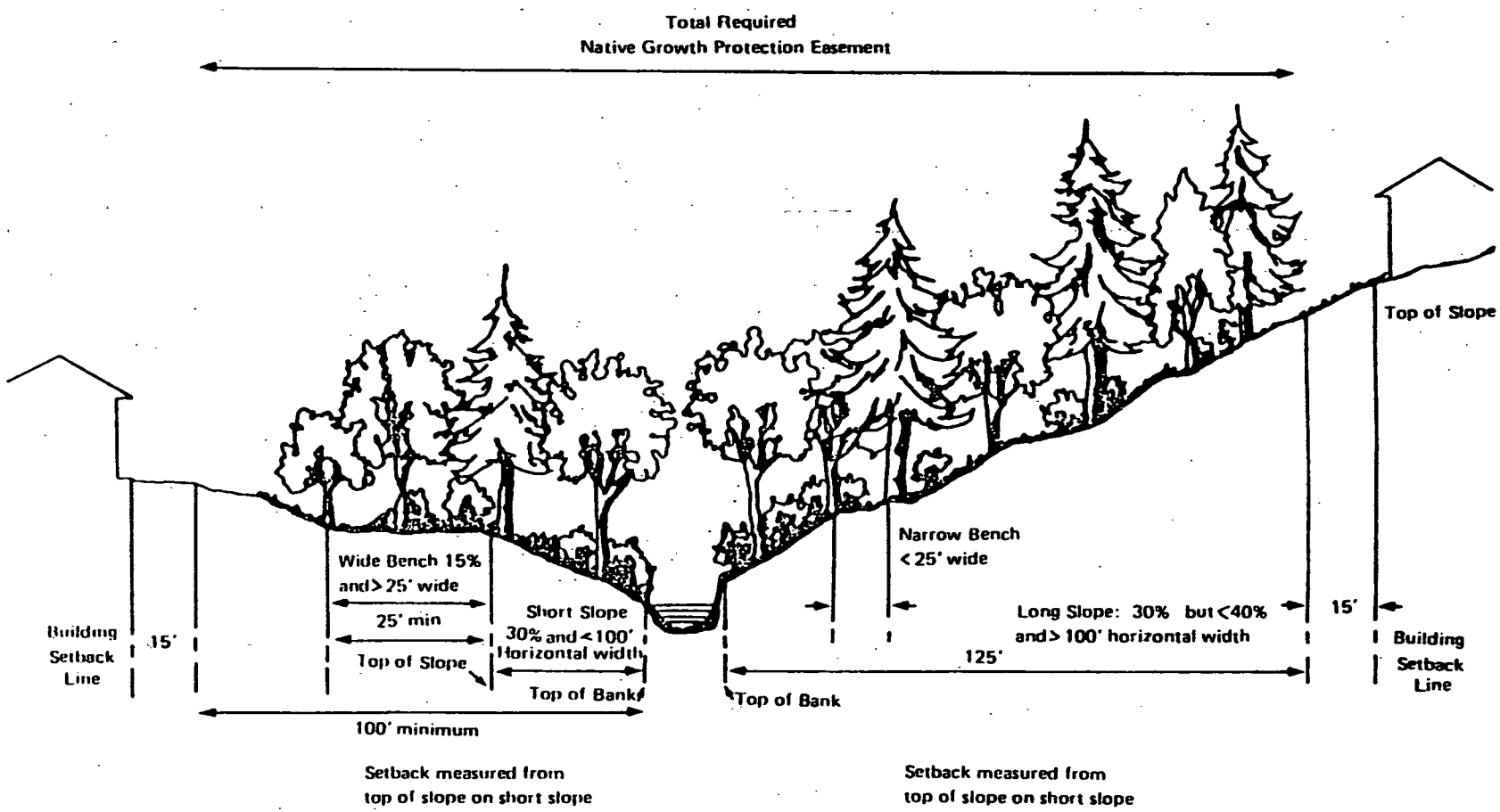


Intermittent Streams (DNR Type V) without salmonid (salmon,trout) habitat

WETLAND CONSTRAINED STREAM CORRIDORS



SLOPE CONSTRAINED STREAM CORRIDORS



P-SUFFIX CONDITIONS FOR BEAR/EVANS CREEK BASIN

Construction Controls: In the Bear/Evans Creek basins (see **Steep Slope Areas/Basin Boundaries** map) the best drainage controls feasible in light of size and circumstances of development as determined and approved by BALD, during its consideration of necessary grading permits, building permits or site design, subdivision or short subdivision review, shall be required in order to minimize construction damage to the sub-basin's drainage flows and quality. The controls shall be in place prior to the commencement of grading, utility location, site preparation or construction.

P-SUFFIX CONDITIONS FOR VEGETATIVE COVERAGE AND IMPERVIOUS SURFACES

These conditions apply to all properties in the Bear Creek planning area.

The following conditions are interim regulations subject to modification by ordinance.

1. Impervious Surface Controls: All roofs, roof tops and covers to permanent structures greater than 250 square feet in area shall be attached to a drainage system terminating in splash blocks, french drains, dry wells, or some alternative stormwater infiltration control device approved by BALD. This requirement may be waived on lots of one acre or less where the applicant can demonstrate that its application would prohibit the siting of required on-site treatment systems, provided that in such instance the roof drainage is connected to an approved storm water management system where available.

2. Native Vegetative Coverage: Until repealed, the following conditions shall apply:

   All property is exempt from the following clearing limitations where the applicant can demonstrate compliance with the performance standard that for a storm of at least the 10-year frequency, post-development surface water flow release rates and durations will not substantially increase above pre-development conditions measured at the property edge or at any defined discharge to wetlands or streams. An applicant may satisfy this performance standard by providing detention or infiltration facilities designed and sized to be appropriate for the proposed development or clearing of native vegetation and that are demonstrated in an approved drainage plan, as defined by King County, to satisfy this standard.

   In addition to requirements and limitations set forth in other ordinances and regulations and provisions of the Bear Creek Community Plan and Area Zoning, no clearing, grading or alteration of the native vegetative cover will be allowed on a parcel of property except within a maximum of 3 separate areas covering in total no more than twenty five percent of the lot where the lot is up to one acre in size; not more then 9,000 square feet or twenty percent of the lot, which ever is greater, where the lot is greater than one acre but less than 2.5 acres in size; not more than 21,000 square feet or fifteen percent of the lot, whichever is greater, where the lot is greater than 2.5 acres but less than 5 acres in size; and not more than 26,250 square feet or ten percent of the lot, whichever is greater, where the lot is greater than 5 acres. This regulation shall not preclude the incidental removal of native vegetation necessary for protection of property or public health and safety, or the removal of native vegetation to be used in the celebration of recognized holidays.

   Any property that has been developed or contains an established and recognized use that existed prior to the effective date of the Bear Creek Community Plan

and Area Zoning will be exempt from the clearing limitations herein except that any new removal of native vegetation which covers more than 10% of the lot area and which is in excess of these limitations will be allowed only where an equal area of native vegetation is re-established at some other location on the property.

P-SUFFIX CONDITIONS FOR HERITAGE SITES

The Bear Creek Plan identifies 30 historic sites (see **Inventory of Heritage Sites** figures). To implement plan policies calling for preservation of these sites, the following P-Suffix conditions of site plan approval are applied:

1. An environmental checklist should be prepared for all historic properties identified by a P-suffix. (Historic resources are considered environmentally sensitive and therefore are not categorically exempt from threshold determinations and environmental impact statement requirements of the State Environmental Policy Act.)

2. All permit applications and site plans shall be circulated to the King County Historic Preservation Officer for comment on the impacts of the project on historic resources. This includes all permits for the following types of actions: alterations to the exterior of historic buildings, new construction on the same lot or adjacent lots under the same ownership or any other action requiring a permit which might affect the historic character of the site.

3. The Historic Preservation Officer may recommend approval, approval with conditions, or denial to the Manager of the Building and Land Development Division.

4. The Historic Preservation Officer may also propose that a site be considered for King County landmark designation according to procedures established in the Landmarks Ordinance (#4828). The ordinance provides that, based upon a preliminary evaluation, sites which appear to meet the criteria for designation shall be, for a period of up to six months, provided the same protection as if designated as a King County Landmark. A Certificate of Appropriateness would be required before making significant changes to the site. If the site is later designated as a King County Landmark, the Certificate of Appropriateness becomes a permanent requirement.

V. AREAWIDE P-SUFFIX CONDITIONS

The following development conditions are applied to properties that have similar developmental constraints or concerns that are areawide in nature. These areawide constraints and concerns include historic sites, erosion problem areas, stream corridors, laterally migrating rivers and forest practice permits. The development conditions discussed in this section will be applied to affected properties through the Building and Land Development Division's (BALD's) permit and developmental review process.

Areawide P-suffix conditions are noted for individual parcels in the planning area in the BALD Situs Data Base. The following abbreviations in the data base are described in more detail in this section.

BALD Situs Data Base abbreviations for Areawide P-suffix*

Item #	Abbreviation	P-Suffix Section
1.	Stream setbacks and NGPE's required per SVCP	Interim Stream Corridor Guidelines (p. AZ-49)
2.	Mapped Erosion Proplan Area: Special studies outlined in SVCP	Erosion Problem Areas (p. AZ-48)
3.	Designated Historic Site: See SVCP	Histroic Sites (p. AZ-46)
9.	Laterally Migrating Rivers: conditions in SVCP	Laterally Migrating Rivers (p. AZ-53)

* Other BALD Situs Data Base Abbreviations are noted in this document on the facing page next to the zoning map where the property is located.

HISTORIC SITES

The Snoqualmie Valley community planning area has a rich historic background. It is part of the traditional and current home land of the Snoqualmie Tribe, and archaeologists and historians have verified village sites throughout the planning area. The earliest white settlers came to the upper valley in 1858 from Seattle, and were drawn to the area because of the flat land and deep soils of the upper valley.

One of the goals of the community plan is to help promote historic and archaeological preservation in the planning area. Preservation of heritage sites help maintain aesthetic and cultural diversity and keeps alive the link with the area's historic and prehistoric past. One way to implement this goal is with the following areawide development conditions which require site plan approval before issuing building permits for the properties listed below. The requirement for site plan approval recognizes the development on a designated property may require special conditions to protect the public interest (K.C.C. 21.46.170). In this case, the areawide development conditions require that any development on designated Snoqualmie Heritage Sites be consistent with K.C.C. 20.62, the Landmarks Preservation Ordinance, and the heritage site policies of the King County Comprehensive Plan.

The following policy establishes the general direction for historic preservation efforts in the planning area:

SQP 118 THE PRESERVATION, RESTORATION, AND ADAPTIVE RE-USE OF HISTORIC, ARCHEOLOGICAL AND CULTURAL SITES IN THE SNOQUALMIE VALLEY COMMUNITY PLANNING AREA IS ENCOURAGED TO MAINTAIN THE CHARACTER OF EXISTING COMMUNITIES AND TO PRESERVE TANGIBLE REMINDERS OF THE PLANNING AREA'S HISTORY.

King County's Office of Historic Preservation has developed a list of historic sites of known or potential historical significance in the community planning area (see Community Plan Chapters, Historic Sites and Areas).

The King County Historic Sites Inventory survey file number, and when possible the site's address, appears on the detailed adopted Area Zoning maps and on the BALD Situs Data Base. The following conditions of site plan approval applies to properties containing historic structures:

- An environmental checklist should be prepared for all historic inventoried properties. (Historic resources are considered environmentally sensitive and therefore are not categorically exempt from threshold determinators and environmental impact statement requirements of the State Environmental Policy Act.)

- All permit applications and site plans shall be circulated to the County Historic Preservation Officer for comment on the impacts of the project on historic resources. This includes all permits for the following types of actions: alterations to the exterior of historic buildings, new construction on the same lot or adjacent lots under the same ownership or any other action requiring a permit which might affect the historic character of the site.

- The Historic Preservation Officer may recommend approval, approval with conditions, or denial to the Manager of the Building and Land Development Division.

- The Historic Preservation Officer may also propose that a site be considered for County Landmarks designation according to procedures established in the Landmarks Ordinance (#4828). The ordinance provides that, based upon a preliminary evaluation, sites which appear to meet the criteria for designation shall be, for a period of up to six months, provided the same protection as if designated as a County Landmark. A certificate of appropriateness would be required before making significant changes to the site. If the site is later designated as a County Landmark, the certificate of appropriateness becomes a permanent requirement. This ranking indicates local priorities but does not necessarily reflect priorities for Landmarks Commission consideration or protection. The Landmarks Commission must consider criteria of significance, physical integrity, geographic distribution and attrition rates in establishing its agendas.

EROSION PROBLEM AREAS

Steep slope areas (see Community Plan Map, Erosion Problem Areas) in the Snoqualmie Valley community planning area are extremely susceptible to water-induced erosion, which can result in rapid formation and growth of deep ravines. These ravines are capable of undercutting property and roads and are a safety hazard. Existing natural drainage systems mitigate this danger through dispersing and slowing runoff in the areas tributary to these steep slope areas. Alteration of natural drainage systems serves to concentrate runoff flows and to accelerate the rate of runoff, both of which encourage rapid and severe stream-channel erosion.

The following policy addresses "Erosion Problem Areas" in the Snoqualmie Valley community planning area:

SQP 21 PROPERTIES IN EROSION PRONE DRAINAGE BASINS ARE SUBJECT TO SPECIAL DEVELOPMENT CONDITIONS APPLIED TO PROTECT THE SAFETY AND PROPERTY OF COUNTY RESIDENTS AND PROPERTY OWNERS THROUGH REDUCING OR ELIMINATING THE OCCURRENCE OF GULLY FORMATION AND SEVER EROSION. THESE CONDITIONS MAY INCLUDE: (A) A DRAINAGE CONTROL PLAN: (B) INSTALLATION OF DRAINAGE CONTROL FEATURES PRIOR TO ANY LAND CLEARING, VEGETATION REMOVEL, SITE GRADING, ROAD CONSTRUCTION, OR UTILITY INSTALLATION: AND (C) RUN OFF CONTROL REQUIREMENTS. THE AREAS KNOWN TO HAVE THESE CONDITIONS ARE SHOWN ON THE EROSION PROBLEM AREA MAP. PROPERTIES CONTAINING THE CHARACTERISTICS OF EROSION PRONE DRAINAGE BASINS, BUT NOT IDENTIFIED ON THE EROSION PROBLEM AREA MAP ARE ALSO SUBJECT TO THESE SPECIAL DEVELOPMENT CONDITIONS TO PROTECT THE SAFETY AND PROPERTY OF COUNTY RESIDENTS AND PROPERTY OWNERS. TO IMPLEMENT THIS POLICY, KING COUNTY WILL REQUIRE DEVELOPMENT PROPOSALS TO PROVIDE STUDIES SUFFICIENT TO IDENTIFY SITES CONTAINING THESE CHARACTERISTICS OF EROSION PRONE DRAINAGE BASINS. MITIGATION SHALL BE REQUIRED CONSISTENT WITH THE INTENT OF THE AREAWIDE P-SUFFIX CONDITIONS FOR EROSION PRONE DRAINAGE BASINS AND THE KING COUNTY SENSITIVE AREAS ORDINANCE.

The following conditions are proposed for all of the lands either identified as being erosion problem areas based on the Erosion Problem Areas Map or properties that studies, required by BALD, identify as containing erosion problem areas. The combination of residential density and special development conditions developed by Resource Planning Section, the geologist at Building and Land Development Division, Surface Water Management Division and a water quality specialist from Metro are intended to reduce or eliminate major surface water runoff impacts of development in the Snoqualmie Valley community planning area.

Due to the extreme sensitivity of property in the indicated drainage areas to water-induced erosion, and the resulting potential for danger to the safety of persons and property in these areas, the following conditions shall apply to all development in the indicated areas unless the applicant can demonstrate that their project is so categorized in error, because either:

(1) Site drainage does not in fact drain over steep slopes.

(2) The downstream drainage pathway is not underlain with erodable granular sediment anywhere along its route, or

(3) The site is underlain by permeable sediments that will infiltrate and dissipate runoff even after clearing and development.

If these exemptions are not met, a Drainage Control Plan shall be required and reviewed and approved by BALD for all development in this area whenever a proposed development requires a building permit, conditional use permit, unclassified use permit, variance, rezone, planned unit development, subdivision, short subdivision, right-of-way use permit, or grading permit. A list of exemptions, such as garden use of rights-of-way, will be developed to waive Drainage Control Plan requirements for proposed uses that will not impact surface water runoff quantities or rates. Once a drainage plan is approved through the subdivision process, individual building permits on the same property will not require another drainage plan.

Unless otherwise exempted, the following conditions shall apply:

(1) Stormwater detention shall contain up to the 100-year/24-hour storm. Release shall be at the pre-development 2-year rate up to the 10-year storm and match the pre-development 100-year rate up to the 100-year storm. The pre- and post-development performances for a storm with one-half the two-year rainfall must also be matched. These rate controls may be modified if discharge is via tightline to below the area of severe erosion potential.

(2) Developed conditions will assume 100% removal of forest canopy, unless expressly prohibited by recorded easement or restriction; plus existing, proposed, and anticipated impervious surfaces.

(3) Point discharge from detention systems will be only into drainage channels that convey surface water in the pre-development state. Dispersed discharge will be evaluated as a potential alternative.

(4) Drainage entering the site from developed upstream areas must be detained and released under the same criteria as runoff generated onsite.

(5) Installation of the critical drainage control features, as scheduled and delineated in the Drainage Control Plan as approved by BALD, shall be installed prior to any land clearing, vegetation removal, site grading, road construction or utility installation. Only those activities associated with pre-development exploration, such as surveying and performance of soil tests and limited clearing and grading associated with construction of drainage facilities, will be permitted prior to completion of the drainage control system.

(6) In those situations where features of the drainage system or subsequent development make installation of the final drainage system impossible, a phased Drainage Control Plan will be developed which provides the required level of retention/detention to the entire site at all times.

INTERIM STREAM CORRIDOR GUIDELINES

Undisturbed stream corridors support wildlife habitat, protect water quality, provide opportunities for recreation, enhance fishery production and maintain open space, and are an important resource in the planning area. King County Comprehensive Plan and Snoqualmie Valley Community Plan policies recognize the importance of stream corridors and direct development to preserve an undisturbed corridor sufficient to maintain natural

functions of the stream. Countywide stream corridor guidelines are also under development at this time and will receive full public and Council review before adoption.

In the interim, the following minimum guidelines will be used to require new developments in the planning area to provide stream corridors.

These guidelines implement the following Snoqualmie Valley Community Plan policies:

SQP 8 A STREAM CORRIDOR WIDE ENOUGH TO MAINTAIN THE NATURAL BIOLOGICAL FUNCTIONS OF STREAMS DRAINING TO THE SNOQUALMIE RIVER OR ITS TRIBUTARIES SHALL BE PRESERVED IN ALL DEVELOPMENT PROPOSALS, BY THE USE OF NATIVE GROWTH PROTECTIVE EASEMENTS OR OTHER APPROPRIATE MECHANISMS. THE STREAM CORRIDORS SHALL BE PLACED IN SEPARATE TRACTS THROUGH THE SUBDIVISION AND SHORT SUBDIVISION PROCESS.

SQP 9 TO REDUCE DISRUPTION TO STREAMS AND THEIR BANKS, BRIDGES SHOULD BE USED WHEN STREAM CROSSINGS ARE NECESSARY. CROSSINGS SHOULD SERVE SEVERAL PROPERTIES. STREAM CHANNELS SHALL NOT BE PLACED IN CULVERTS UNLESS THERE IS NO OTHER WAY TO GET ACCESS TO A PARCEL OF LAND. WHEN CULVERTS ARE REQUIRED, OVERSIZED CULVERTS WITH GRAVEL BOTTOMS THAT MAINTAIN THE CHANNELS' WIDTH AND GRADE SHALL BE USED.

SQP 10 DURING THE DEVELOPMENT REVIEW PROCESS THE COUNTY MAY REQUIRE REHABILITATION OF (A) DEGRADED STREAM CHANNELS AND BANKS ADJACENT TO A STREAM, (B) WETLANDS OR (C) RIVER BANKS, AS CONDITIONS OF DEVELOPMENT TO ASSURE PUBLIC SAFETY, ENVIRONMENTAL QUALITY AND PROTECTION OF CRITICAL RESOURCE FUNCTIONS.

The following limitations and conditions on development in stream corridors will apply on an interim basis until the Sensitive Areas Ordinance is amended. At that time, the standards established by the Sensitive Areas Ordinance shall prevail.

A. All stream corridors shall be designated as native growth protection easements (NGPE) in the following development processes. The purposes of the NGPE is to prevent disturbance or removal of vegetation and to prohibit structures, fills, or obstructions. All stream corridors shall be designated as native growth protection easements (NGPE) in the following development processes.

   Rezone, Formal Subdivision, Planned Unit Development (PUD), Master Plan Development (MPD), Multifamily, Residential or Commercial Building Permit, Variance, Shoreline, Conditional Use, and Unclassified Use.

B. The following development processes each stream corridor designated as an NGPE also shall be placed in a separate tract:

   Rezone, Formal Subdivision, Planned Unit Development (PUD), Master Plan Development (MPD), Shoreline, Conditional Use, and Unclassified Use.

C. Extent of Corridors

   Stream corridor NGPEs and tracts will be sized according to the following criteria:

1. Streams unconstrained by adjacent hazardous areas: (page 23 Snoqualmie Community Plan map of surface water resources).

   a. For all streams which are shown to be habitat for anadromous salmonids, a minimum 100' corridor from the top-of-bank on both sides shall be provided and designated as a NGPE.

   b. For streams which are not anadromous salmonid habitat, a minimum 25' corridor from the stream center line on both sides shall be provided and designated as a NGPE.

2. Streams constrained by riparian (streamside) wetlands. Existing Sensitive areas requirements for wetland shall apply unless stream corridor requirements are more restrictive.

3. Streams constrained by slopes 30% and greater.

   a. For streams adjacent to or within 25' of the top of slopes which are less than 100' in horizontal length, a corridor shall extend 25' beyond the top of slope and a 15' building setback line (BSBL) shall apply. The corridor shall be designated NGPE. These requirements shall also apply if slopes are variable, that is, having small benches or terraces but also having an overall slope of 30% or greater.

   b. For streams adjacent to or within 25' of the top of slopes which are greater than 100' in horizontal length, a corridor shall extend 125' beyond the top-of-bank or the water's edge and a 15' BSBL shall apply. The corridor shall be designated as NGPE. This requirement shall apply if slopes are variable that is, having small benches or terraces but also having an overall slope of 30% or greater.

   c. A minimum 100' corridor designated as NGPE and a 15' BSBL shall be provided for all streams.

D. Stream Corridor Exemption

If an applicant for a development proposal otherwise allowed under the applicable zone demonstrates that establishment of an NGPE of the width required in Section C above, would deny all reasonable use of the property, the Director of the Department of Parks, Planning and Resources, or his or her designee, may administratively reduce the width of the NGPE in order to allow the development where the applicant also demonstrates:

1. That no reasonable use with less impact on the sensitive area and its buffer is possible; and

2. That there will be no damage to nearby public or private property and no threat to the health or safety of people on or off the property. If a reduction of the required NGPE is granted, it shall in no event be greater than the minimum necessary to allow the applied for use.

   NOTE: Detailed procedures for the request and consideration of reduction in the required width of the NGPE shall be drafted by the Department of Parks, Planning and Natural Resources and be available from that department as an administrative rule.

This stream corridor is a variable width conservancy strip which has minimum dimensions. The corridor protects the habitat functions of the stream during and after development. The minimum width of the corridor on each side of the stream may be increased according to site-specific conditions. This increased setback will be determined at the time of development approval by the Division of Building and Land Development. The following guidelines establish conditions under which the undisturbed corridor width may be expanded beyond the minimum requirements listed above.

1. The corridor width may be expanded to preserve existing vegetation which:

   a. Shades the stream during the midday hours from May through September to maintain cool water temperatures.

   b. Provides food and habitat for fish. Branches which overhang the stream provide physical shelter from fish predators. Furthermore, streamside vegetation provides food for fish in two ways. The foliage is habitat for insects which are the diet of many fish. Second, the leaves which fall into the stream are the food source for aquatic invertebrates which are critical food for fish.

   c. Protects streambanks with roots, stems or foliage. Streamside vegetation can break the force of flood water and anchor soil particles with dense root masses, armoring the bank naturally, and protecting against streambank erosion.

   d. Intercepts and filters runoff flowing toward the stream. Low ground cover such as grass and moss anchors soil above the streambank and filters silt-laden runoff which may flow toward the stream during construction. By trapping the silt and holding the soil, vegetation protects the gravel streambeds from siltation which can smother fish, fish eggs and their food sources, and fill-in spawning gravel beds.

2. Stream corridor widths shall be increased to include streamside wetlands which provide overflow storage for stormwater, feed water back to the stream during low flow, or provide shelter and food for fish.

3. The stream corridor width may be increased when steep slopes and erosive soils are adjacent to the stream channel. Increasing the undisturbed area will provide the buffer necessary to prevent streamside erosion and intercept silts from uphill erosion. The corridor may be expanded up to 50 feet from the top of the stream bank when there are slopes between 15-30 percent grade combined with soils rated as severely erosive by the U.S. Soil Conservation Service maps. The King County Conservation District may be consulted on the actual required width based on slope, soil type and existing vegetation. For slopes over 30 percent grade with severely erosive soils, the corridor may be extended to 15 feet beyond the first significant break in the slope. A significant break in the slope is defined as a bench at least 15 feet wide.

4. The corridor shall be dedicated as a separate tract during the platting process. Once land is subdivided into building lots, it is difficult to control clearing or disturbance of the stream corridor on those individual lots both during and after construction. This tract shall be maintained as a Native Growth Protection Tract (NGPT) area. The NGPT shall be fenced in all new plats and short plats to avoid disturbance of the buffer vegetation; provided that the type of fencing allows for wildlife movement between the stream corridor and the upland areas. Examples of suitable types include 3-strand wire, 36" 2/4 wire, 3 rail wood, and other low fences.

5. If a trail is to be constructed adjacent to a stream, it must be located so that it does not contribute to bank collapse or remove trees, shrubs, and understory vegetation which shades or shelters the stream or anchors the banks. Trails should be located away from streams with access points at locations which can tolerate human traffic.

LATERALLY MIGRATING RIVERS

Laterally migrating rivers in the Snoqualmie Basin presents a significant threat to life and property. The Snoqualmie Valley Community Plan calls for a study of the Tolt and Raging Rivers to accurately identify all such reaches that laterally migrate. The following interim regulations are in effect until regulations are adopted pursuant to the findings of the study. The following policy addresses protection of river corridors:

SQP 28 A STUDY OF THE TOLT AND RAGING RIVERS SHOULD BE PREPARED WHICH ACCURATELY ESTABLISHES AND MAPS THE LATERAL MIGRATION OF THESE RIVERS. THESE LATERALLY MIGRATING RIVERS AND TRIBUTARIES AND OTHER ASSOCIATED AREAS OF FLOOD-RELATED EROSION HAZARD SHOULD RECEIVE REGULATORY FLOODWAY WITH ADEQUATE SETBACKS OR PROHIBITIONS ON ALL NEW PERMANENT DEVELOPMENT WHERE REQUIRED.

SQP 29 UNTIL SUCH TIME AS DETAILED LATERAL MIGRATION STUDIES ARE COMPLETED AND ADOPTED, THE HISTORICAL LOCATION OF THESE RIVER CHANNELS SHOULD BE IDENTIFIED AND MAPPED, AND ADOPTED AS INTERIM REGULATORY FLOODWAYS.

P-Suffix Conditions along the Tolt and Raging Rivers:

Until the study establishing the limits of channel migration in the Tolt and Raging Rivers has been completed, property adjacent to the Tolt and Raging Rivers within the stretch of the rivers identified in the Snoqualmie Plan map of laterally migrating rivers and which is also identified within the 100-year floodplains of the rivers (as shown on the Federal Emergency Management Agency's Flood Insurance Rate Maps) are hereby designated regulatory floodways for County planning purposes and subject to all of the County restrictions of the 100-year floodway, in Section 21.54.060 of the King County Code.

FOREST PRACTICE PERMITS

The removal of timber through forest practice activities may cause erosion, slides and slumps, siltation of streams and loss of wildlife habitat. The Snoqualmie Valley Community Plan seeks to minimize environmental damage resulting from forest practice activities. The following policies address forest practice activities in the planning area:

SQP 18 KING COUNTY SHALL NOT PERMIT VEGETATION REMOVAL UNDER A CLASS IV GENERAL FOREST PRACTICES APPLICATION OR ANY APPLICABLE COUNTY CLEARING PERMIT, UNTIL STREAM CORRIDORS, WETLAND BUFFERS, SLOPE SETBACKS, AND OTHER ENVIRONMENTALLY SENSITIVE AREAS ARE MAPPED AND PROTECTED CONSISTENT WITH KING COUNTY CODE REQUIREMENTS.

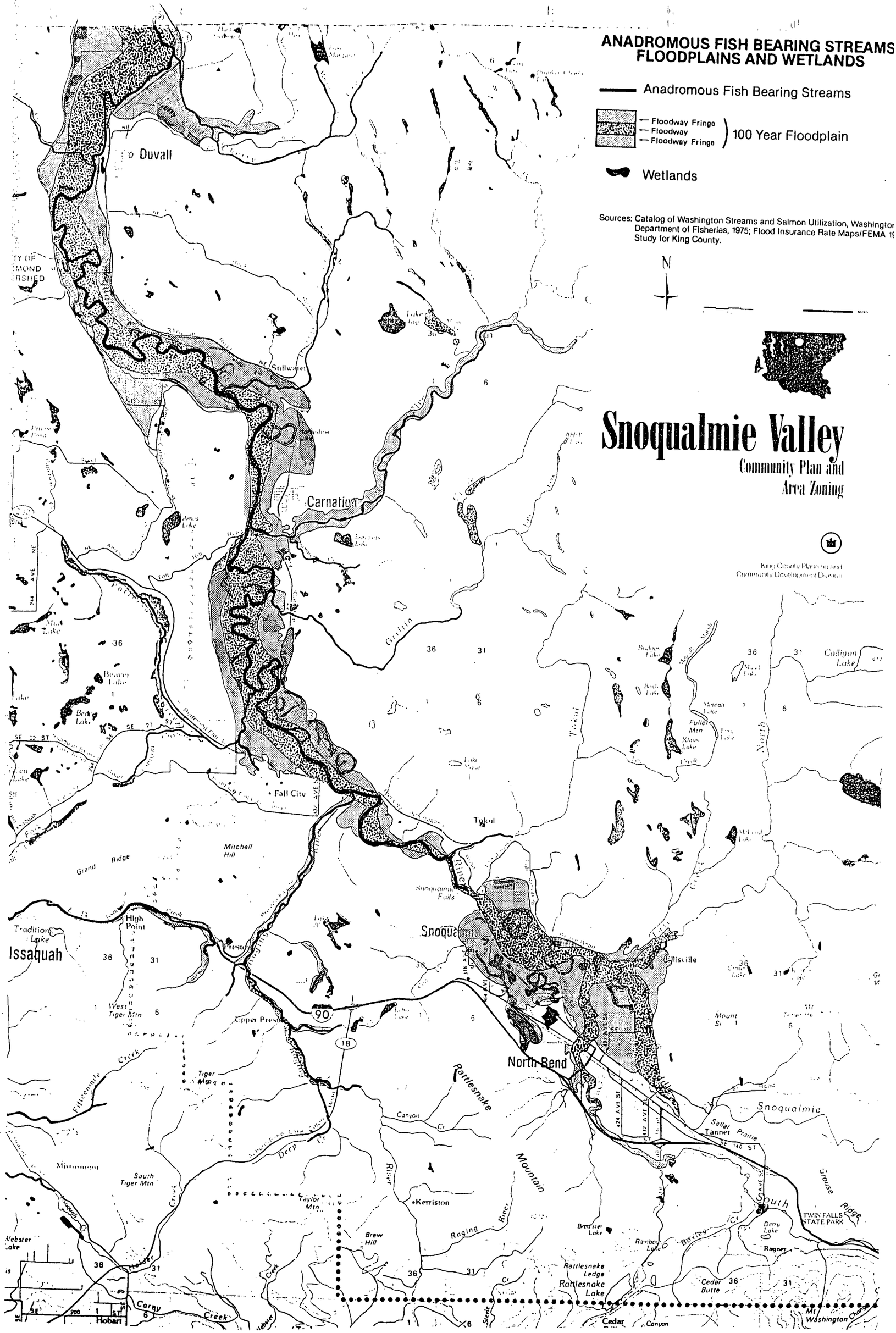
SQP 19 KING COUNTY SHALL OPPOSE VEGETATION REMOVAL UNDER A CLASS I, II OR III GENERAL FOREST PRACTICES APPLICATION IN AREAS OUTSIDE THE FOREST PRODUCTION DISTRICT THAT ARE SUSCEPTIBLE TO CONVERSION UNTIL STREAM CORRIDORS, WETLAND BUFFERS, SLOPE SETBACKS, AND

OTHER ENVIRONMENTALLY SENSITIVE AREAS ARE MAPPED AND PROTECTED CONSISTENT WITH KING COUNTY CODE REQUIREMENTS UNLESS THE APPLICANT COVENANTS NOT TO CONVERT THE PROPERTY FOR DEVELOPMENT FOR A 10 YEAR PERIOD.

In order to implement Snoqualmie Policies 18 and 19 and protect the drainage conditions of the Snoqualmie Basin, the following interim P-suffix conditions shall extend to all property within the Snoqualmie planning area.

P-suffix conditions for properties which have received Class I, II or III forest practice Permits:

Development proposals shall not be accepted by King County for any parcel of property on which a Class I, II or III forest practice activity has been initiated on or after June 15, 1983 until the applicant demonstrates to the satisfaction of the Manger of the Surface Water Management Division that drainage off-site from the parcel has been restored to eliminate the adverse drainage impacts of the forest practice activity. All necessary analysis by the applicant shall be conducted by a certified professional engineer. The requirement herein shall extend to all purchasers or successors of interest to the property who have had constructive notice prior to the acquisition of the property of the subject forest practice activity.


ANADROMOUS FISH BEARING STREAMS
FLOODPLAINS AND WETLANDS
Anadromous Fish Bearing Streams
Floodway Fringe
Floodway
Floodway Fringe
100 Year Floodplain
Wetlands
Sources: Catalog of Washington Streams and Salmon Utilization, Washington Department of Fisheries, 1975; Flood Insurance Rate Maps/FEMA 19 Study for King County.
N
Snoqualmie Valley
Community Plan and
Area Zoning
King County Planning and
Community Development Division
Duvall
Stillwater
Carnation
Griffin
Fall City
Tokul
Snoqualmie Falls
Snoqualmie
Ellisville
North Bend
Issaquah
Tradition Lake
High Point
Preston
Upper Preston
Mitchell Hill
Grand Ridge
West Tiger Mtn
Tiger Mtn
South Tiger Mtn
Taylor Mtn
Kerriston
Brew Hill
Rattlesnake Mountain
Rattlesnake Ledge
Rattlesnake Lake
Cedar Butte
Cedar
Tanner
Snoqualmie
Sallal Prairie
South
Grouse Ridge
TWIN FALLS STATE PARK
Ragner
Mt Washington Change
Hobart
Carey Creek
Webster Lake
Beaver Lake
Calligan Lake
Fuller Mtn
Mount Si
Fifteenmile Creek
Deep Cr
Canyon Cr
Raging River
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Cedar Canyon
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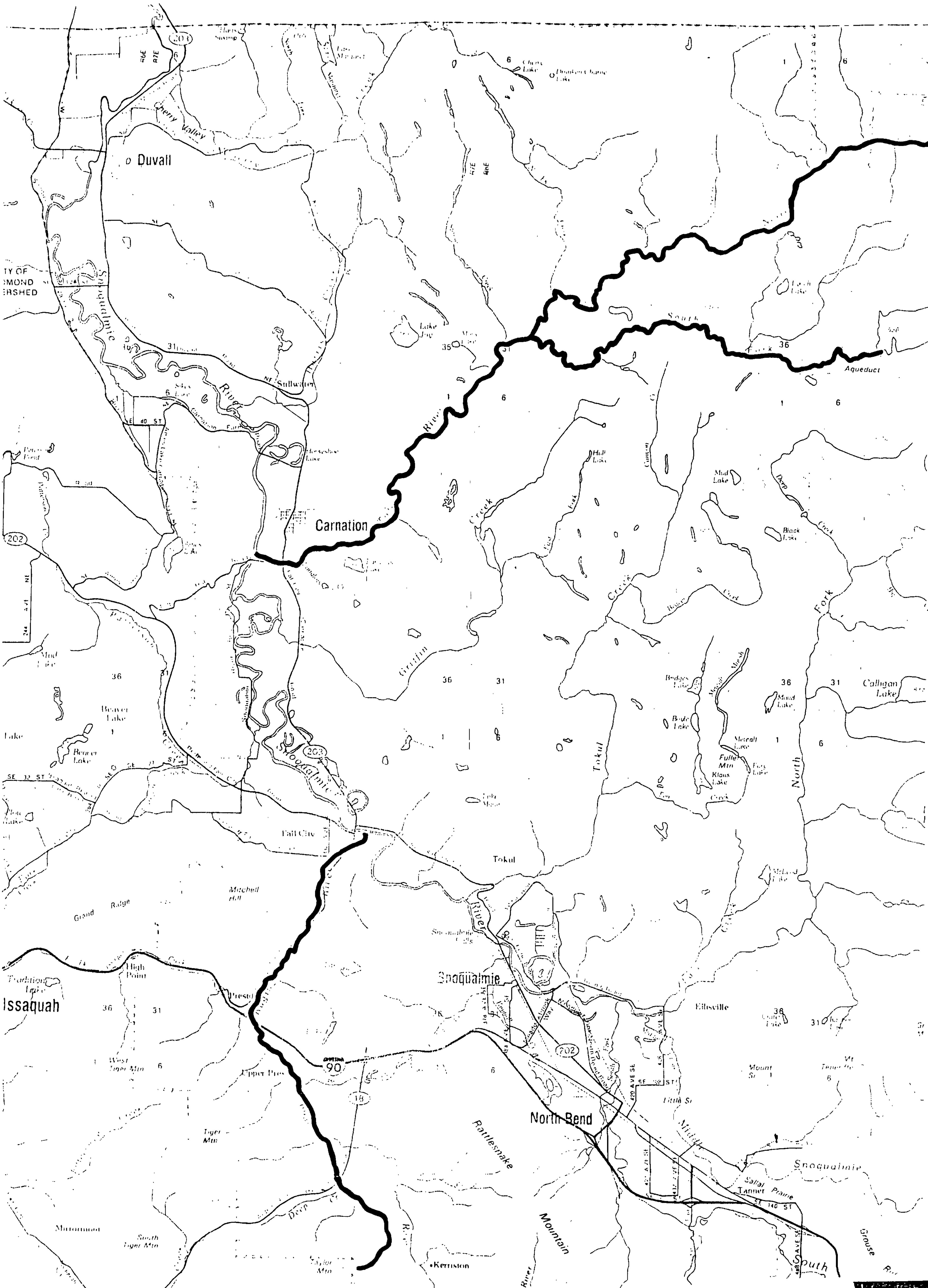
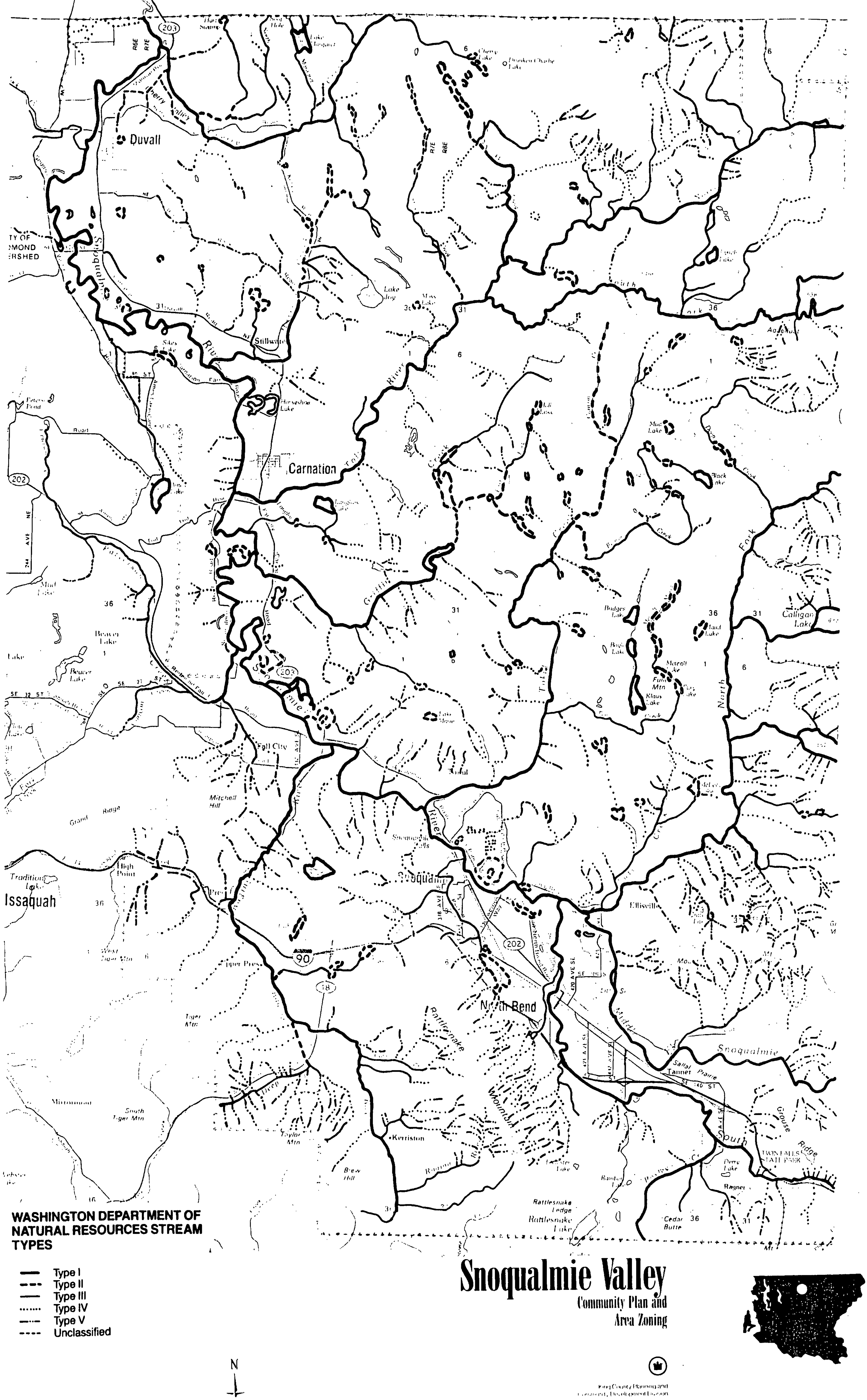


LATERALLY MIGRATING RIVERS

Snoqualmie Valley
Community Plan and
Area Zoning


WASHINGTON DEPARTMENT OF NATURAL RESOURCES STREAM TYPES
Type I
Type II
Type III
Type IV
Type V
Unclassified
Snoqualmie Valley
Community Plan and Area Zoning
N
Duvall
Carnation
Stillwater
Fall City
Snoqualmie
North Bend
Issaquah
Snoqualmie Falls
Cherry Valley
Lake Joy
Calligan Lake
Rattlesnake Ledge
Rattlesnake Lake
Rattlesnake Mountain
Mitchell Hill
Grand Ridge
High Point
Tiger Mtn
South Tiger Mtn
Taylor Mtn
Brew Hill
Kerriston
Cedar Butte
Grouse Ridge
Twin Falls State Park
Ellisville
Tanner
North Fork
Middle Fork
South Fork
Tolt River
Griffin Creek
Raging River
Mud Lake
Black Lake
Horseshoe Lake
Beaver Lake
Budges Lake
Boyle Lake
Klaus Lake
Fuller Mtn
Carlson Lake
Cherry Lake
Drunken Charlie Lake
Deer Lake
Moss Lake
Sikes Lake
Langlois Lake
Lake Marcel
Margaret Lake
Peters Pond
Traditional Lake
R6E
R7E
R8E
SE 140 ST
SE 32 ST
244 AVE NE
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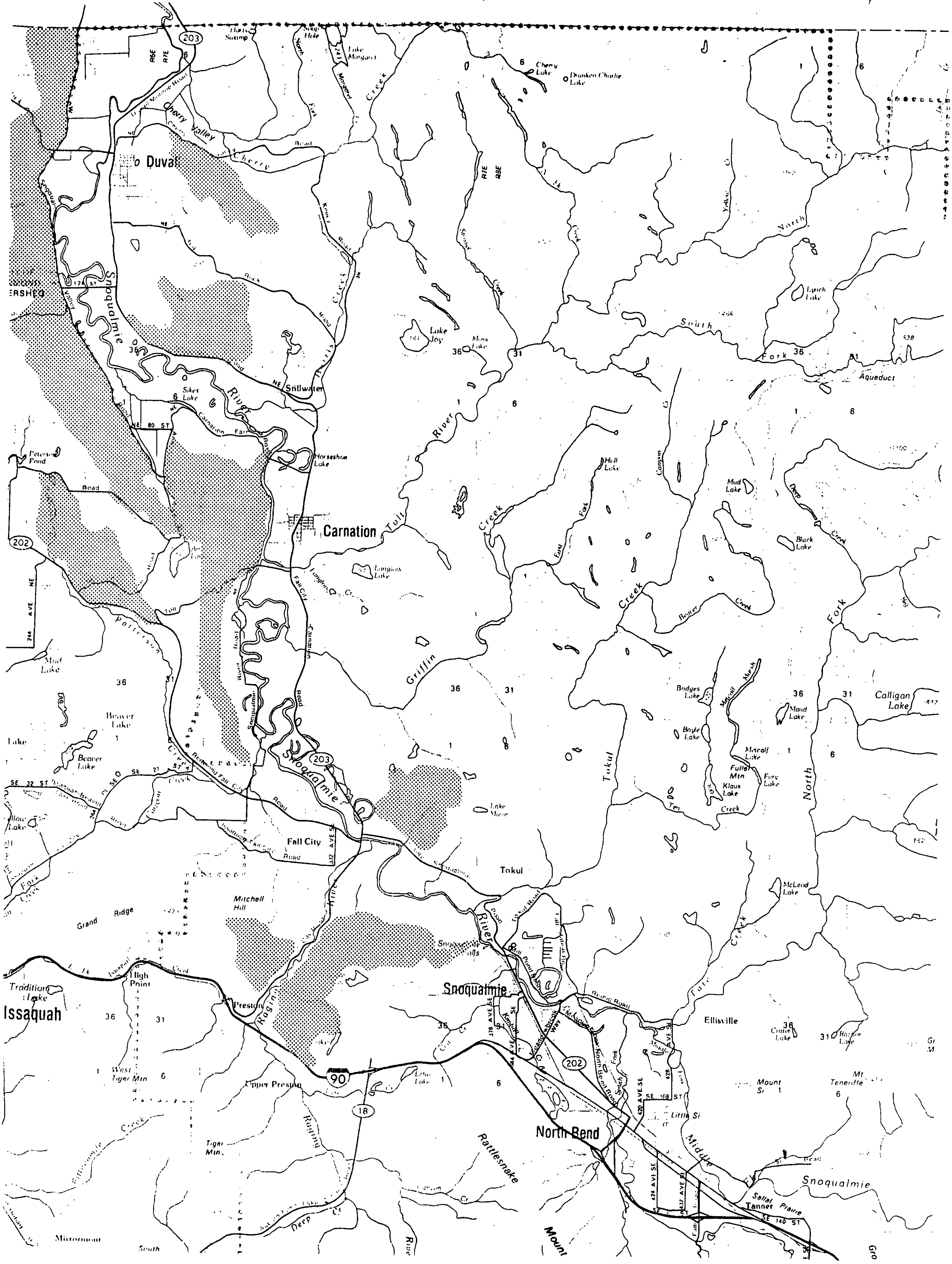


EROSION PROBLEM AREAS

Snoqualmie Valley
Community Plan and
Area Zoning

King County Planning and
Community Development Division

Soos Creek Basin Plan

P-Suffix Development Conditions

A P-suffix attached to a zone classification indicates that a particular property or area is conditionally suitable for the permitted use(s), provided that the property/area is designed and developed in accordance with guidelines, performance standards, permitted uses, or requirements specified in the area zoning. The purpose of a P-suffix in a community plan is to implement community plan policies at specific sites. The Zoning Code (and other County Codes) are used to apply development conditions on a County or areawide basis. P-suffix conditions also assure that the public interest is protected when development occurs, and assures compatibility within the community and with adjacent land uses.

I. Natural Systems

A. Soos Creek Basin Streams

The following P-suffix conditions apply to the SC-P within the urban portion of the Big Soos and Soosette sub-basins:

1. Clustering shall be required for all subdivision of property within the stream corridor. The reserve tract shall be retained in permanent open space retaining the natural vegetation. For properties adjacent to the streams, clustering shall occur on the portions of the property furthest away from the stream, fencing shall be required along the boundary of the reserve tract or along the edge of the stream buffer required by the Sensitive Area Ordinance, whichever is the greater distance from the stream.

2. To reduce the harmful effects of Suburban Cluster - Townhouse (SC-TN) zoning on significant salmon habitat in the Urban areas of the Soosette and Upper Big Soos Sub-basins:

   a. Impervious surfaces, as defined by the 1990 King County Surface Water Design Manual shall cover no more than 8 percent of the site. This percentage shall be calculated for the entire area covered by the development proposal, instead of on individual building lot.

   b. Building lots shall be clustered on 30 percent of the site. Clustering shall apply to parcels of two acres or more. For all parcels (including those of one acre or less), onsite structures shall be placed as far as physically possible from streams and wetlands.

   c. Seventy percent of all parcels shall be set aside in a permanent native growth protection tract. If the tract

does not contain a density of indigenous tree species that is typical of Lower Puget Sound forests, it shall be replanted with indigenous trees and vegetation according to a County-approved landscape planting and maintenance plan.

d. Keeping or grazing of livestock shall be prohibited.

e. No new road crossings of Class 1, 2, or 3 streams shall be constructed. Crossing of streams by public utilities shall be limited to existing road or utility rights-of-way except as provided by K.C.C. 21.54.050.

3. In the Big Soos Sub-basin, onsite retention/detention (R/D) facilities shall be designed to reduce post-development levels for all flows greater than 50 percent of the 2-year event and less than the 50-year event. Additionally, the 100-year post-development peak flow shall be reduced to pre-development levels.

A calibrated continuous flow simulation model, such as HSPF, is the preferred model to be used in designing these onsite R/D facilities. If a continuous model cannot be used, a modified 1990 King County Surface Water Design Manual method may be used. This modified method replaces the manual's SCS Type 1a distribution with a seven-day rainfall distribution based on actual storms in the Puget Sound Lowlands. In addition, the time of concentration shall be computed separately for pervious and impervious segment and added to obtain a net time of concentration. Travel time and time of concentration computations for existing or pervious land segments shall be based on the sum of the interflow, shallow concentrated flow, and open channel flow. The modified Design Manual method shall meet the following release goals:

Post-Development Event	Pre-Development Flows
2-year	1/2 the 2-year
10-year	2-year
100-year	10-year

These standards shall apply according to the procedures of the 1990 King County Surface Water Design Manual except that the threshold for drainage review shall be lowered to include proposals that will construct 300 square feet or more of new impervious surface where runoff is discharged onto soils other than the following Soil Conservation Service series soils: Arents ("An" only), Everett, Indianola, Klaus, Neilton, Pilchuck, Puyallup, or Ragnar. A soils report may be required to verify the soils series or to classify previous unmapped series.

NOTE: For onsite retention/detention requirements for the Soosette Sub-basin, please see the adopted Soos Creek Basin Plan.

The amount of land cleared for development and covered by impervious surfaces contributes substantially to storm water volumes, which in turn contribute to stream damage and flooding problems. The costs associated with such flooding problems are incurred by both private individuals and public agencies. Limitations on the amount of land covered by a building are one tool to help reduce this damage. Townhouse design also minimizes total lot coverage. Resulting reductions in dwelling unit size also enhance housing unit affordability.

The P-suffix condition for SC-P zoned land along stream corridors in the urban area of the Soos Creek Basin includes the following:

> Residential development is limited to townhouse design only. Dwelling unit footprints shall not exceed 1,000 square feet per unit, and the footprint for associated parking structures shall not exceed 400 square feet per dwelling unit. Total impervious surface coverage (buildings, parking areas, and drive ways) shall not exceed 8 percent. Total site clearing shall not exceed 30 percent. Where existing clearing already exists at greater than 30 percent of the total site, reforestation must be provided to restore forested cover to the site to achieve the 30 percent standard.

B. Clearing and Grading

As a general rule, the vegetation on a development site should be retained as long as possible to reduce impacts. Even after construction has begun, permanent retention of as much of the native vegetation as possible is important and contributes to mitigating the adverse impacts. Native vegetation is adapted to the conditions of the Northwest including summer drought, winter temperatures, insect pests, and diseases. Native vegetation provides food, shelter, and breeding sites to which local wildlife has adapted.

Clearing and grading should be limited to all short plats, plats, and commercial projects to protect water quality, limit surface water runoff and erosion and maintain wildlife habitat and visual buffers.

The following areawide P-suffix conditions implement policy NR-7. These areawide conditions shall apply. The conditions shall expire automatically upon the effective date of an adopted Countywide clearing ordinance.

1. Subdivisions, Short Subdivisions, and PUDs. The following conditions apply only to applications for subdivisions, short subdivisions, and PUDs. Deviations from these standards may be allowed based on a special study prepared by a qualified forester with expertise in windthrow or tree disease.

   a. Lot clearing during road and utility construction. The building envelop on each buildable lot shall be identified on the engineering plans. The following table specifies the maximum size of the building envelope based on actual average lot size:

Lot Size (in sq. ft.)	Building Envelope
Greater than 15,000	5,000 sq. ft.
9,001-15,000	35% of lot size
5,000-9,000	45% of lot size
Less than 5,000	55% of lots size

   b. Lot-by-lot clearing. In subdivisions, short subdivisions, and PUDs served by on-site septic systems, clearing on individual lots shall be postponed until the approval and issuance of the individual residential building permit for each lot. No clearing on the individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

   In subdivisions, short subdivisions and PUDs served by sewers, the applicant may opt to postpone clearing on individual building lots until the approval and issuance of the individual residential building permits for each lot. Under this option, no clearing on individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

C. Seasonal Clearing Restrictions

1. Seasonal restrictions. Clearing and grading shall not be permitted between November 1 and March 31. All bare ground must be fully covered or revegetated between these dates.

2. Exemptions. The following activities are exempt from the clearing and grading seasonal restriction:

a. Emergencies that threaten the public health, safety, and welfare.

b. Routine maintenance of public agency facilities.

c. Routine maintenance of existing utility structures as provided in the Sensitive Areas Ordinance, K.C.C. 21.54.030.D.

d. Clearing or grading where there is 100 percent infiltration of the surface water runoff within the site in approved and installed construction-related drainage facilities.

e. Clearing or grading where all state water quality standards are met including turbidity. The SWM Division shall develop an administrative process before such exemptions are allowed.

f. Landscaping of single-family residences.

g. Class II and III forest practices.

h. Quarrying or mining within sites with approved permits.

i. Clearing or grading for utility hook-ups on approved residential and commercial building permits.

j. Completion of any final clearing/grading work for construction activities which meet all applicable permit conditions and best management practices for a period of time (not to exceed two weeks in the month of November if dry weather conditions are present).

D. **Vegetation Coverage**

1. Separate tracts. In the rural zones listed below, 20 percent of each subdivision or short subdivision shall be placed in a separate tract to reduce surface water runoff:

   A-R 2.5
   A-R 5

2. Areas to be included. In meeting the percent requirement, the applicant may include all acreage set aside in sensitive areas tract except for wetlands and streams. Buffers for these sensitive areas may be included.

   When additional acreage beyond that occupied by the above features is necessary to meet the percent requirement, this land shall be included in the separate tract but the applicant shall receive full density credit for this land. The applicant

may reduce lot sizes below the minimum required for that zone to accommodate the transfer of density but they shall not change the residential uses permitted in the zone. Density transfers within the A-R classification shall be subject to the clustering provisions in the A-R zone.

The separate tract shall retain vegetation in large contiguous are rather than isolated patches, strips or individ ual trees. Forest or trees are the preferred vegetation type to be included in the tract, shrubs are the second preference and grasslands or pastures are least preferable.

II. Vegetation

B. Significant Tree Retention

1. Significant trees shall be retained on grading permits, subdivisions, and apartment, commercial, industrial, or institutional developments as follows:

a. All significant trees located within required perimeter landscaping area;

b. Five percent of the significant trees in the remaining site area including sensitive area buffers, of a commercial or industrial development;

c. Ten percent of the significant trees in the remaining site area including sensitive area buffers, of a multifamily or institutional development;

d. Ten percent of the significant trees on individual lots for single detached dwellings, if any portions of such lot contains erosion hazard areas.

e. Utility developments shall be exempt from the tree retention requirements of this chapter;

f. Fifty percent of the significant trees within sensitive areas or surface water management bio-filtration system areas may be used to satisfy the tree retention requirement;

g. Except as provided in subsection H, significant trees to be retained shall not include significant trees that are:

1) Damaged or diseased;
2) Safety hazards due to potential root, trunk, or limb failure.

V. Historic Preservation

Policies CR-1 and CR-2 state:

Historic resources are being lost at a rapid rate in the Soos Creek area through demolition, extreme alteration, or deterioration. An attrition survey of historic resources in the Soos Creek area was conducted in August 1989. The survey revealed that of the forty-four resources originally inventoried in unincorporated King County, only nineteen are still eligible as potential County Landmarks.

The policies, guidelines, and special recommendations contained in this chapter seek to strengthen the overall land use concept of the Soos Creek Community Plan. Protecting agricultural buildings and landscape features such as the Elliott Farm helps to preserve rural character in certain areas. Urban quality is also improved by retaining the best examples of past architectural design.

1. An environmental checklist shall be prepared for all historic resources identified by a P-suffic except where categorically exempt under King County SEPA guidelines.

2. All permit applications and site plans for a rezone, development proposal, or demolition permit, or other land use action shall be circulated to the County Historic Preservation Officer for comment on the impact of the project on historic resources. This includes all permits for the following types of actions: alterations to the exterior of historic buildings, or new construction in the same lot or adjacent lots under the same ownership or any other action requiring a permit which might affect the historic character of the resource.

   Additional information may be required including but not limited to:

   a. a vicinity map;

   b. a site plan showing the location of all existing and proposed buildings, structures, and landscape features;

   c. a brief description of the proposed project together with architectural drawings showing the existing condition of all buildings, structures, and landscape features and any proposed alterations to those buildings, structures, and landscape features over 40 years old;

   d. photographs of all buildings, structures, or landscape features on the site over 40 years old; and

   e. an environmental checklist.

3. The Historic Preservation Officer will provide information about available grant assistance and tax incentives for historic preservation. He/She may also provide the owner, developer, or other interested party with examples of comparable projects when historic resources have been restored or treated on a profit-making basis.

4. In the event of a conflict between the development proposal and adopted King County standards for preservation of historic resources, the Historic Preservation Officer will suggest alternatives to the owner/developer which achieve the goals of historic preservation.

5. The Historic Preservation Officer may:

   a. recommend approval, or approval with conditions to the Manager of Building and Land Development Division; or

   b. may propose that a resource be nominated for County Landmark designation according to procedures established in the Landmarks Preservation Ordinance (KCC 20.62).

VI. Urban Separators

The following P-Suffix conditions implement policies P-21 and P-22:

1. All subdivisions permitted under this plan, within the Urban Separator boundary (see Area Zoning map) shall link its open space with that of the adjacent properties unless conditions such as sensitive areas prevent reasonable linkage of open spaces.

2. All proposed road locations through or on the western ridge shall be reviewed to insure minimum grade disturbance and minimum cut-and-fill activity, particularly in those areas most visible due to slope, topographic or other conditions.

VII. Phasing Urban Development

A. Lake Desire Drainage Basin

Properties in the Lake Desire Drainage Basin shall meet all water quality and quantity requirements as outlined by the King County Surface Water Management Division. These requirements must be in compliance with the State Growth Management Act. Special attention should be given to increased retention/detention requirements and clearing restrictions on undeveloped parcels and stormwater treatments which will ensure that the quality of discharged waters shall be equal to or better than the current Lake Desire water quality.

B. Growth Reserve

A-13 Vacant and partially developed lands within the Phase 2 area will be designated Growth Reserve (GR-2.5) and remain at low densities until the area annexes to the Cities of Renton, Kent, or Auburn or a plan amendment applies urban densities.

Mandatory clustering shall be required. The applicant will demonstrate how urban densities can be achieved in the future through the submission of a shadow plat. Resubdivision of the reserve tract would be permitted following a plan update or the approval of urban zoning.

A-14 Requests for rezones in the Phase 2 area may be considered after December 31, 1994 if an application for a rezone in the phase 2 urban designated area meets all the criteria below. A rezone may be applied for and shall be considered under rules and procedures normally applied to the rezone process, and the rezone shall not be denied solely because of the zoning or phasing associated with the property.

a. The proposed project would be consistent with the King County Comprehensive Plan and the intent of the Growth Management Act by encouraging infill development; and

b. No probable significant adverse environmental impacts will occur as a result of appropriately designed development on the property; and

c. Restrictions established by the Community Plan and Area Zoning that are specific to the property are met; and

d. The property is served by all necessary utilities including water or sewer. Before urban density zoning may be applied, any needed service area boundary adjustments within the established LSA must be approved by King County; and

e. All necessary urban facilities including stormwater drainage, roads, and schools are available or can be made available to serve the development; and

f. Transportation capacity exists for the increased demands placed on the system by the development; and

g. The combined capacities of the city and the Phase 1 area within the respective urban growth boundary are shown to be insufficient to accommodate year 2000 forecasts as determined by the joint planning process between the city and county implementing the Growth Management Act.

VIII. Covington Urban Activity Center

The Covington Urban Activity Center was expanded to include all properties served by ULID 72-S. This includes properties west of

Jenkins Creek and east of Wax Road south of Southeast 267th. The additional area is zoned RM 900-P and is included in Phase 1.

The following P-suffix condition applies:

> "No multifamily development will be permitted on these properties due to the potential impacts of such uses on Jenkins Creek. Development on these properties will be coordinated in a manner to ensure a consolidated access point to SE Wax Road or 180th Ave. SE. An access plan shall be reviewed and approved by King County Public Works."

IX. Covington Master Drainage Plan (MDP):

Further degradation of the fishery found in the Soos Creek Basin will occur unless additional controls are applied to existing and future development in Covington Center.

The following P-suffix condition shall be applied to the area known as the Covington MDP.

Prior to the King County Council's adoption of the Covington Master Drainage Plan, applicants for new preliminary subdivisions or any non-single family construction permits (including grading permits) shall submit for approval to the surface water management division a site-specific drainage plan which mitigate the project and cumulative impacts of the development pursuant to the 1990 Drainage Manual standards.

XI. Meridian Valley Center

NR-13 Increased on-site retention/detention requirements, as recommended in the Soos Creek Basin Plan, should be adopted and implemented as an appendix to the King County Surface Water Design Manual.

P-suffix condition implementing NR-13. This condition applies to the Meridian Valley Neighborhood Center, which is defined as those areas contributing flow to Soos Creek Tributary 0091A, north of Southeast 256th Street. Prior to any development or project approval in the Meridian Valley Neighborhood Center requiring drainage review per King County Surface Water Design Manual, a drainage plan meeting enhanced detention requirements established by the SWM Division shall be approved by the Building and Land Development Division. Enhanced detention facilities shall be sized to at least maintain peak flows at or below existing peak flows for the 2-, 10-, and 100-year storm events, based on the King County SWM 7-day event. The enhanced requirements will minimize site-specific, or cumulative flooding and drainage problems for residences, businesses, and roads in the Meridian Valley Neighborhood Center. The requirement will be reevaluated when revisions to the 1990 Surface Water Design Manual area adopted. Prior to development of any commercial or residential projects in this

center, the King County SWM Division must determine that the Southeast 255th Street culvert improvement is installed as the SWM Division intended. The County will construct projects in the following area: adjacent to the intersection of Southeast 240th Street and 132nd Avenue Southeast; along 132nd Avenue Southeast, near Southeast 246th Street; at Southeast 255th Street, west of 144th Avenue Southeast; and at Southeast 256th Street east of 144th Avenue Southeast. The SWM Division shall design projects at these locations to reduce flooding in these areas for conditions up to the 100-year/24 hour event. These projects will be scheduled for completion in 1995.

XIII. Green River/Cedar River Valleys

Lands overlooking the Green River Gorge Upper Green River Valley and Cedar River Valley, face a unique hazard due to the instability and height of the gorge and valley walls. Soil failures and slides along these walls, which are vertical or nearly vertical at many points, can result in major earth movements, as the loosened material seeks a stable "angle of repose", which probably will not be steeper than one-to-one (height to horizontal distance between slope top and toe). A one-to-one, or 100 percent, slope in these circumstances may mean that extensive land on top of these walls may be unstable, since the walls are 200 to over 500 feet tall in many places. Therefore the review area for this hazard is set at 660 feet, which is the depth of a typical 10-acre parcel in the area, and the normal building setback required will be 100 feet, twice that required in the SAO for "steep" slopes, defined as those steeper than 40 percent.

NR-14 All development within 660 feet of the top of the Cedar River Valley and the Green River Valley walls, particularly along the bluffs south and west of the Lea Hill Plateau and south within the Lake Heights area, should be conditioned to avoid adverse impacts on the environment and risks to life and property.

The following P-Suffix conditions implement policy NR-14:

All development within 660 feet of the top of the slopes of the Green River Valley and Green River Gorge, the ridge line south and west of the Lea Hill Plateau including Olson Canyon and the Cedar River Valley walls including the ridge lines north and east of Lake Heights shall meet the following requirements. See map for the location of these areas.

A. General

The procedural requirements of the Sensitive Area Ordinance shall apply to all permit and land use approval applications within this area, except for a single-family residence or accessory structure constructed by an owner or lessee for his or her own use. Such residence or accessory structures shall still comply with the development standards of this section.

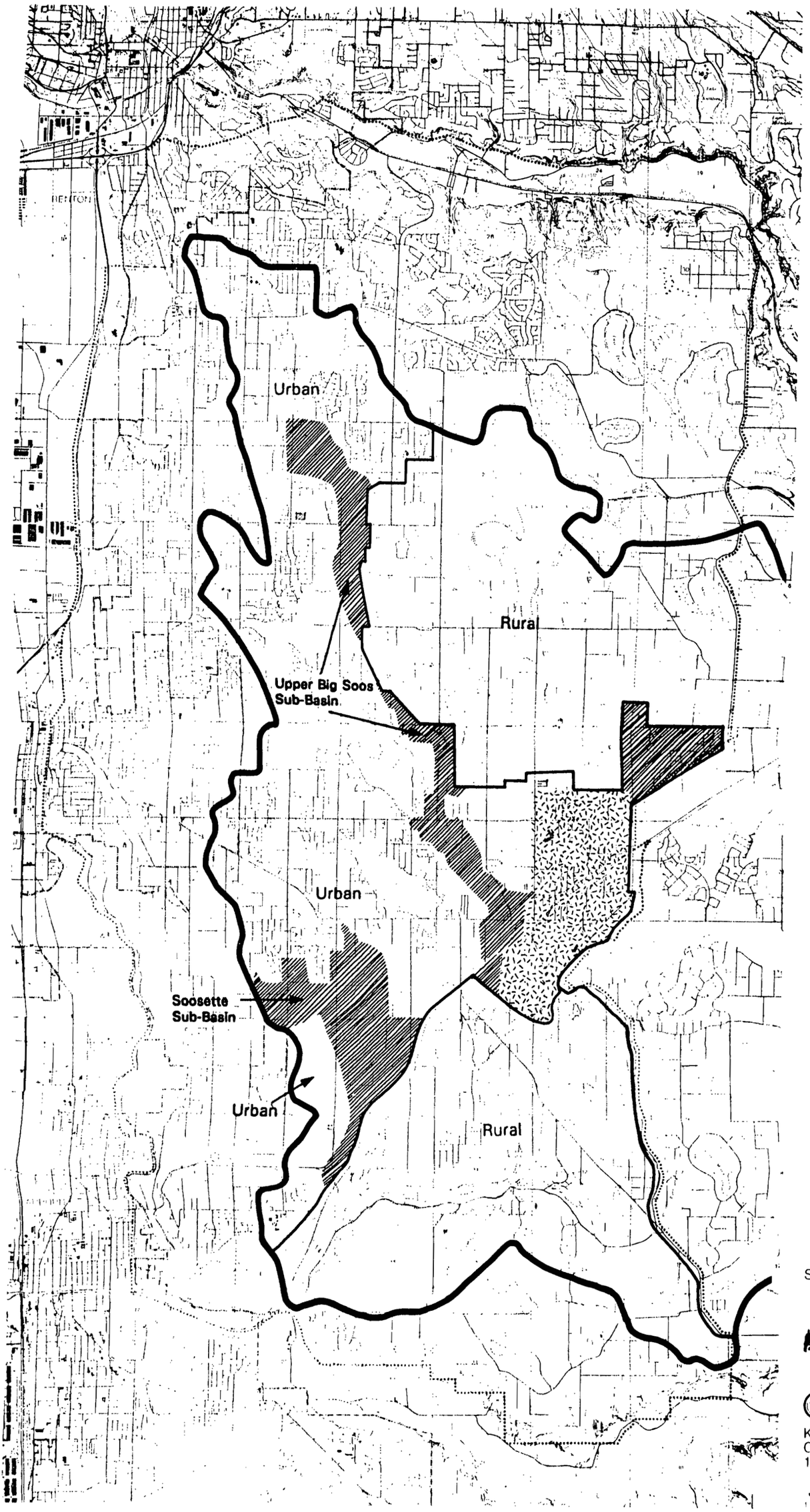
B. **Standards**

1. No discharge of water from any constructed drainage system shall be allowed onto valley or ravine side slopes, or into any swales which discharge onto these slopes. Discharge shall be carried in a tightline system which can be installed with a minimum of slope disturbance and which is sufficiently durable to withstand slope movements, tree fall, or other hazards. The tight line shall discharge to a non-erodable location at the tow of the slope.

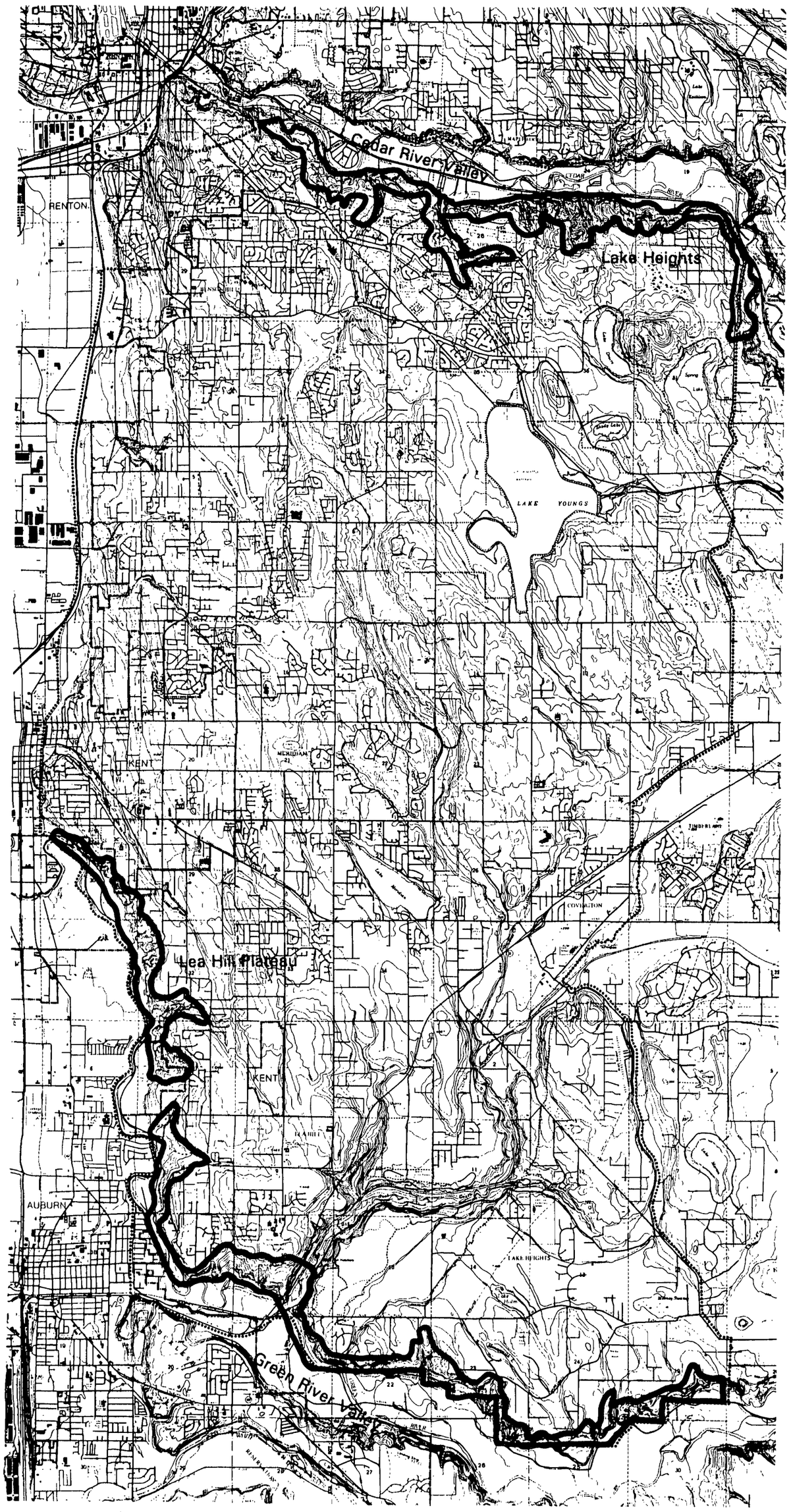
2. Building set-back lines (BSBLs) for residences shall be 100 feet from the top of slope over 15 percent in the direction of the Green River, Olson Creek, or Cedar River unless the applicant:

   a. shows that this requirement precludes any reasonable use of the property; and
   b. provides geotechnical studies showing conclusively that the normal BSBLs required by the Sensitive Areas Ordinance are sufficient to avoid any future instability caused by a major landslide on or near the subject property.

Soos Creek Basin Area



P-Suffix Map for Cedar River Valley, Olson Canyon and Green River Valley



Area of P-Suffix conditions

Soos Creek Community Planning Area

King County Planning and Community Development Division
1991

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SUBSTITUTE P-SUFFIX CONDITIONS
FOR
CLEARING AND GRADING
IN THE
TAHOMA RAVEN HEIGHTS COMMUNITY PLAN AMENDMENT

The following text should be substituted for the text in the Tahoma Raven Heights Community Plan Amendment beginning on pages 20 and 80.

Natural Systems

Environmental regulations which contribute to protecting natural systems in Soos Creek include the State Environmental Policy Act (SEPA), the King County Sensitive Areas Ordinance (SAO), and the King County Surface Water Design Manual. These are regulations which apply Countywide and may not account for the unique circumstances of different sites or drainage basins. The P-suffix conditions which follow address specific site clearing concerns within the Tahoma Raven Heights planning area. These conditions are taken from the Soos Creek Basin Plan, which also contains the scientific analysis and justification for the conditions. The conditions in Section A address clearing and grading in advance of subdivisions and building permit approval.

A. Clearing and Grading

As a general rule, the vegetation on a development site should be retained as long as possible to reduce impacts. Even after construction has begun, permanent retention of as much of the native vegetation as possible is important and contributes to mitigating the adverse impacts. Native vegetation is adapted to the conditions of the Northwest including summer drought, winter temperatures, insect pests, and diseases. Native vegetation provides food, shelter, and breeding sites to which local wildlife has adapted.

Temporary erosion control and drainage facilities are required to be in place prior to any clearing on a plat. Once the roads and utilities have been constructed and the plat has received final approval, the construction of individual homesites begins. The cumulative sedimentation from the construction of a number of single family homes without erosion control can be significant. Generally, individual single family residential homes fall below the threshold for drainage and erosion control plans pursuant to the Surface Water Design Manual. As a result, erosion and sedimentation control are needed for individual development.

In addition, tighter controls should be placed on the clearing that occurs during the platting process. Under present conditions, sites are often completely cleared very early in the development process, sometimes long before there are any building permits issued for a site. During the time between clearing and site development, substantial erosion and sedimentation can occur. Until there is a need to remove the existing vegetation for construction, the forest should remain in order to protect surface and ground water quality, and to provide wildlife habitat. When construction does occur, the surface water management facilities should be installed first, in order to control the increased surface water flows that will occur when the site is cleared.

Commercial property should not cleared until after approval of an individual site plan. This delay will allow for integrating the existing vegetation and trees on site into the overall landscape design.

The following policy reflects the recommendations of the Soos Creek Basin Plan as contained in BW-3 and BW-4 regarding retention of vegetation.

> **Clearing and grading should be limited on all short plats, plats, and commercial projects to protect water quality, limit surface water runoff and erosion and maintain wildlife habitat and visual buffers.**

The following P-suffix conditions implement the above policy. These conditions shall apply in the portions of the Soos Creek Basin covered by the Tahoma Raven Heights Plan. The conditions shall expire automatically upon the effective date of an adopted Countywide clearing ordinance.

1. Subdivisions, Short Subdivisions, and PUDs. The following conditions apply only to applications for subdivisions, short subdivisions, and PUDs. Deviations from these standards may be allowed based on a special study prepared by a qualified forester with expertise in windthrow or tree disease.

   a. Lot clearing during road and utility construction. The building envelope on each buildable lot shall be identified on the engineering plans. The following table specifies the maximum size of the building envelope based on actual average lot size:

Lot Size (in sq. ft.)	Building Envelope
Greater than 15000	5000 sq. ft.
9001-15000	35% of lot size
5000-9000	45% of lot size
Less than 5000	55% of lot size

   Except as provided in subsection 1.b., the clearing of building envelopes shall occur at the same time as the clearing for roads and utilities. The clearing limits for each building envelope shall be clearing marked of flagged on each lot and inspected prior to any clearing. Erosion and sedimentation controls shall be instituted on the building envelopes as required by the Surface Water Design Manual. The vegetation remaining after initial clearing of the building envelope may be preserved or cleared as deemed appropriate by the permittee of the residential building permit for that lot after its approval and issuance.

   b. Lot-by-lot clearing. In subdivisions, short subdivisions, and PUDs served by on-site septic systems, clearing on individual lots shall

be postponed until the approval and issuance of the individual residential building permit for each lot. No clearing on the individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

In subdivisions, short subdivisions, and PUDs served by sewers, the applicant may opt to postpone clearing on individual building lots until the approval and issuance of the individual residential building permits for each lot. Under this option, no clearing on individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

B. Seasonal Clearing Restrictions

Introduction of fine-grained sediment into stream channels is a significant cause of fish-habitat and water quality degradation in the Soos Creek Basin. This fine sediment clogs stream gravels, reduces the clarity of the water, and carries a substantial proportion of the urban contaminants into downstream water bodies. Based on numerous observations of existing development during the winters of 1988-89 and 1989-90, active construction and land-grading sites are one of the primary sources of observed turbidity problems in individual streams throughout the Soos Creek system.

The identification of November 1 through March 31 in Policy BW-4 is particularly important because of the amount of rain received by the County, and the extent of flooding which historically occurs between these months. The following policy is based on the BW-4 recommendation of the Soos Creek Basin Plan.

Within the Soos Creek Basin, bare ground associated with clearing, grading, utility installation, building construction, and other development activity should be covered or revegetated in accordance with King County Surface Water Design Manual Standards between November 1 and March 31 of each year. Earth moving and land-clearing activity should not occur during this period within the Soos Creek Basin except for regular maintenance for public facilities and public agency response to emergencies that threaten the public health, safety, and welfare. Landscaping of single-family residences, existing permitted commercial forestry and mining activities, and development sites with approved and

constructed drainage facilities that infiltrate 100 percent of surface runoff should be exempt from these restrictions.

The following P-suffix conditions implement the above policy. These conditions shall apply in the portions of the Soos Creek Basin covered by the Tahoma Raven Heights Plan. The conditions shall expire automatically upon the effective date of an adopted Countywide clearing ordinance.

1. Seasonal restrictions. Clearing and grading shall not be permitted between November 1 and March 31. All bare ground must be fully covered or revegetated between these dates.

2. Exemptions. The following activities are exempt from the clearing and grading seasonal restriction:

   a. Emergencies that threaten the public health, safety, and welfare.

   b. Routine maintenance of public agency facilities.

   c. Routine maintenance of existing utility structures as provided in the Sensitive Areas Ordinance, K.C.C. 21.54.030.D.

   d. Clearing or grading where there is 100 percent infiltration of the surface water runoff within the site in approved and installed construction-related drainage facilities.

   e. Clearing and grading where all state water quality standards are met including turbidity. The Surface Water Management Division shall develop administrative procedures before such exemptions are allowed.

   f. Landscaping of single-family residences.

   g. Class II and II forest practices.

   h. Quarrying or mining within sites with approved permits.

   i. Clearing or grading for utility hook-ups on approved residential and commercial building permits.

   j. Completion of any final clearing/grading work for construction activities which meet all applicable permit conditions and best management practices for a period of time (not to exceed two weeks) in the month of November if dry weather conditions are present.

C. Vegetation Coverage

Protection of natural vegetation coverage moderates surface water runoff and erosion and protects the integrity of stream channels. Removing forest cover increases the peak rate of surface runoff. Forest cover intercepts falling rain, absorbs water through roots and creates an absorbent duff layer on the forest floor. The following policy addresses retention of vegetation within the Soos Creek Basin and is based on recommendations BW-3, AS-10, and AS-15 of the Soos Creek Basin Plan.

> **For new subdivisions in the Rural Area of Soos Creek Basin in the Tahoma Raven Heights Planning Area, a minimum of 20 percent of the property should be retained as a separate tract of undisturbed indigenous vegetation except in areas mapped as Regionally Significant Areas where 35 percent should be retained.**

The following P-suffix conditions implement the above policy. These conditions shall apply in the portions of the Soos Creek Basin covered by the Tahoma Raven Heights Plan. The conditions shall expire automatically upon the effective date of an adopted Countywide clearing ordinance.

1. Separate tracts. In the rural zones listed below, 20 percent of each subdivision or short subdivision shall be placed in a separate tract to reduce surface water runoff, except in areas identified as Regionally Significant Areas where 35 percent shall be placed in the separate tract:

   A-R 2.5
   A-R 5
   A-R 10

2. Areas to be included. In meeting the percent requirement, the applicant may include all acreage set aside in sensitive areas tracts except for wetlands and streams. Buffers for these sensitive areas may be included.

   When additional acreage beyond that occupied by the above features is necessary to meet the percent requirement, this land shall be included in the separate tract but the applicant shall receive full density credit for this land. The applicant may reduce lot sizes below the minimum required for that zone to accommodate the transfer of density but they shall not change the residential uses permitted in the zone. Density transfers within the A-R classification shall be subject to the clustering provisions in the A-R zone.

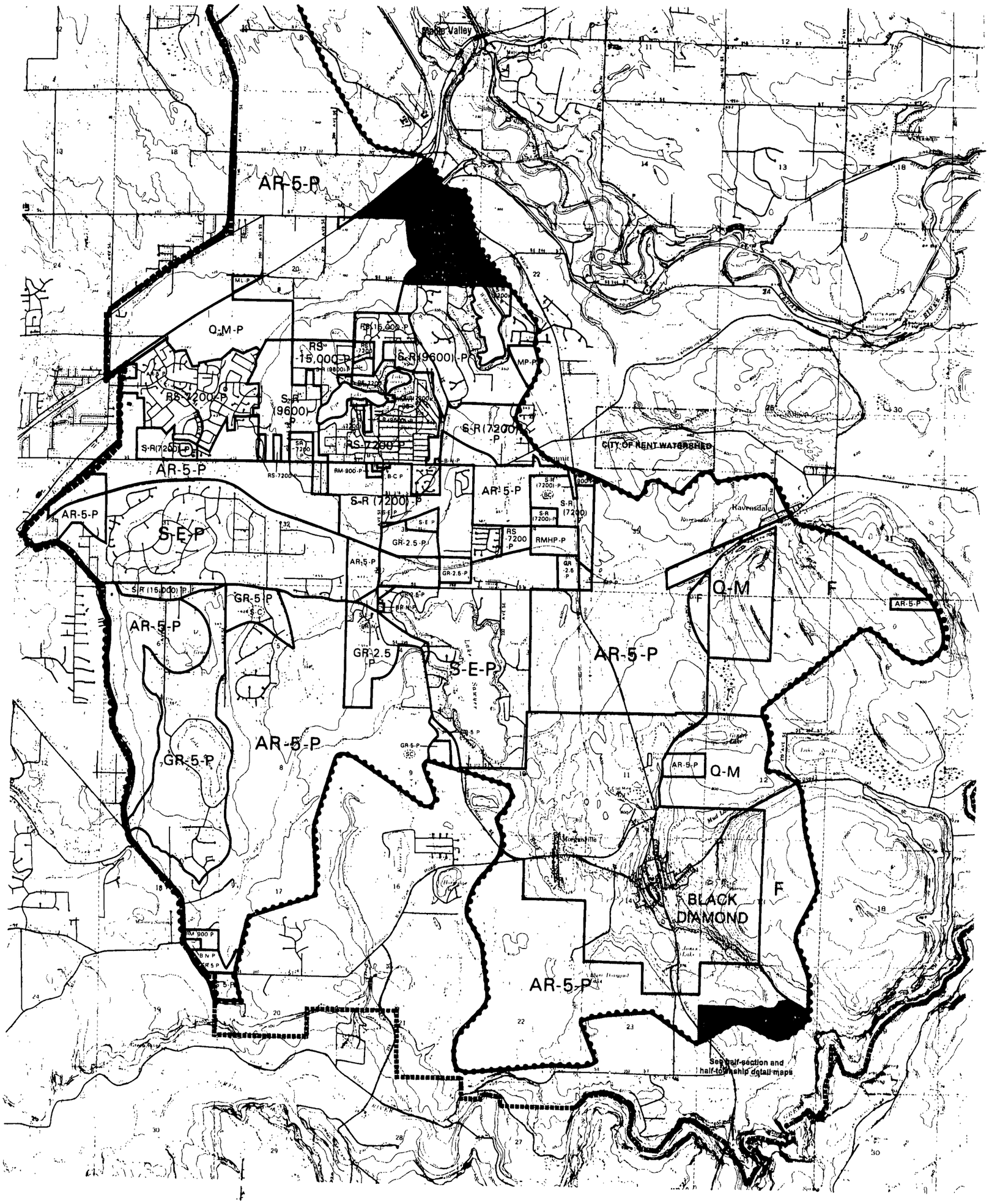
   The separate tract shall retain vegetation in large contiguous areas rather than isolated patches, strips, or individual trees. Forest or trees are the preferred vegetation type to be included in the tract, shrubs are the second preference, and grasslands or pastures are least preferable.

T/RH P-suffix conditions

	P-Suffix	Area of Application
1.	Clearing and Grading	Basinwide all urban/rural zones AR, GR-5, GR-5 (potential SC), GR-5 (potential SE), GR-5-P, G-5, RS 7200, SR 7200, SR 7200 (potential RM 2400, RS 15000, SR 9600, BC, B-C-P, B-N-P, RM-900P, ML, MP, and RMHP)
2.	Seasonal Clearing Restrictions	Basinwide all urban/rural zones
3.	Rural Vegetation Coverage	All designated rural residential areas including AR-5-P and G-5 zoned property

All properties in T/RH Study area (basinwide) get 1 and 2 rural and urban.

All properties in study area get 3 rural.



Plan Amendment Area Zoning

Tahoma / Raven Heights Communities
Plan Amendment Study Area

King County Planning and
Community Development Division
1991

N

•••••• Study Area Boundary

SPECIAL DRAINAGE REQUIREMENTS OF THE EAST LAKE SAMMAMISH BASIN

BACKGROUND

Herein are summarized the special drainage requirements of the *East Lake Sammamish Basin Plan*, adopted by the King County Council on November 8, 1993, and the *East Sammamish Community Plan*, adopted by the King Council on May 25, 1993. The Basin Plan was written and adopted as a statement of King County policy; its requirements are administered through "Special Requirement #4" of the *King County Surface Water Design Manual* (1990). The Community Plan was a policy statement but the adopted document also includes zoning changes that impose these drainage requirements through "P-suffix" conditions. Most of the special drainage requirements appear in both plans.

The following summarizes the special drainage requirements for use by permit applicants and reviewers. The background information on surface-water conditions in the East Lake Sammamish Basin, justification for the adopted requirements, and the public-funded programmatic programs and capital projects also recommended in the *Basin Plan* are omitted here but can be found in the *Final East Lake Sammamish Basin Plan* (December 1994).

Table 1 lists all of the special drainage requirements adopted as part of the East Lake Sammamish Basin Plan. Maps 1, 2, and 3, included in Attachment A, outline the parcels and areas where the geographic-specific requirements apply. Attachment B maps the detention standard in the basin. Attachment C maps the Wetland Management Areas. In addition to the area-specific requirements shown on the maps, two special requirements apply basin-wide (unless superseded by other area-specific requirements): BW-1, the Basinwide Onsite Detention Standard, and BW-26, Seasonal Clearing and Grading.

All applicable drainage requirements of the *King County Surface Water Design Manual* apply in full to any development project in this basin, unless specifically superseded by the requirements here.

Table 1
INDEX OF SPECIAL DRAINAGE REQUIREMENTS

RECOMMEND. NUMBER	PAGE	DESCRIPTION
BW-1	3	Onsite R/D: SCS 7-day storm
BW-2	4	Enhanced onsite R/D
BW-3	5-7	Ravine protection standard
BW-5	8	Wetland management areas (general)
BW-26	3-4	Seasonal clearing & grading
PH-2	7	Baseflow maintenance
PH-3	7-8	Reduced onsite R/D
I-2	8-9	Wetland management area (# 9)
T-2	9	Wetland management area (# 61)
PL-2	9-10	Wetland management area (# 30)
MH-2	7	Baseflow maintenance
MH-3	7-8	Reduced onsite R/D
MH-5	10-11	Wetland management area (# 58)
LJ-3	11	Wetland management area (#s 10,21,26,34,39)
LJ-4	15	Protection of LJ Lake floodplain
LJ-6	15	Ravine clearing & drainage
CP-58, CP-59[1]	15	Pine Lake phosphorus control
BLMP[2]	15	Beaver L. phosphorus control

[1] Amendments 58 and 59 of the adopted East Sammamish Community Plan
[2] Beaver Lake Management Plan

DRAINAGE REQUIREMENTS FOR NEW DEVELOPMENTS

1. *Basinwide Requirements*

Except where superseded by alternative requirements specified for particular areas in section 2., the following two recommendations apply to all property in the East Lake Sammamish Basin.

BW-1 **Basinwide Onsite Detention Standard**

To control downstream and downslope impacts of new development, including public and private streets and highways, onsite retention/detention (R/D) facilities in the East Lake Sammamish Basin shall be designed to control the post-development 2- and 10-year flows to corresponding pre-development levels. The calculated storage volume shall be increased by a safety factor of 30 percent.

Either of two alternative techniques may be used. The first is a calibrated continuous flow hydrologic simulation model. The Hydrologic Simulation Program—Fortran (HSPF) model used for the analysis in this basin plan is an example of this type of model.

The second alternative uses a modified King County *Surface Water Design Manual* (*Design Manual*) method. A modified seven-day rainfall distribution based on actual storms in the Puget Sound Lowlands replaces the Soil Conservation Service (SCS) Type I-a 24-hour rainfall distribution. Additionally, hydrographs for pervious and impervious surfaces are determined separately and then added together to obtain the total hydrograph for pervious and impervious segments. The total travel time and the time of concentration for pervious land segments are based on the sum of interflow, shallow concentrated flow, and open channel flow travel times. Specific guidance for this method can be found in the technical reference section of this Design Manual.

BW-26 **Seasonal Clearing and Grading Limits**

The following recommendation shall be implemented in the East Lake Sammamish Basin:

> During the period from October 1st to March 31st, bare ground associated with clearing, grading, utility installation, building construction, and other development activity shall be covered or revegetated in accordance with the *King County Surface Water Design Manual*. This limitation may be waived outside of designated Wetland Management Areas, however, if the property owner implements erosion control measures that meet the following conditions:
>
> 1. No significant silt-laden runoff leaves the construction site; and

2. The erosion and sediment control measures shown on an approved plan, or alternate best management practices as approved or required by the inspector or the Department of Development and Environmental Services (DDES), are installed and maintained throughout the course of construction.

Activities exempt from these requirements include routine maintenance of public facilities (including roads); public agency response to emergencies that threaten public health, safety, and welfare; typical landscaping of single-family residences; Class I and II forest practices; quarrying and mining within sites with approved permits; clearing and grading where there is 100 percent infiltration of surface water runoff within the site in approved and installed construction-related drainage facilities; and routine maintenance of utility structures as provided in K.C.C. 21.54.030.D.

2. *Area-Specific Requirements*

BW-2 **Stream Protection Onsite Detention Standard**

In subcatchments where higher future flows are expected to have significant adverse impacts on stream stability and habitat, onsite R/D facilities shall be designed to reduce post-development flow durations to their pre-developed levels for all flows greater than 50 percent of the 2-year event and less than the 50-year event. Additionally, the 100-year post-development peak flow shall be reduced to pre-development levels. *{Note: the boundaries of these areas correspond to the appropriate drainage divides of the indicated subcatchments.}*

It is recommended that a calibrated continuous flow simulation model, such as HSPF, be used for this analysis. If a continuous model cannot be used, the method of the 1990 *King County Surface Water Design Manual* may be used with the 24-hour design event with the following release requirements:

Post-Development Storm Event	Pre-Development Flow Release Target
2-year	one-half the pre-developed 2-year
10-year	pre-developed 2-year
100-year	pre-developed 10-year

The areas to which this standard apply are mapped in Attachment A for the East Lake Sammamish Basin and Attachment B for areas in the remaining portions of the East Sammamish Community Planning Area.

BW-3 **Ravine Protection Standard**

A. **Requirements.** The following requirements apply to the Panhandle subbasin, the Monohon subbasin, and any other areas tributary to a steep valley along the west slope of the East Lake Sammamish Basin that does not (or did not, in its predevelopment state) maintain a continuous surface-water channel from the base of the west slope to the flat surface of the plateau *{basis for the mapped boundaries are described in section A.2 below}*. In these areas, new development shall be held to the following standards:

NO-DISTUR-BANCE AREAS

1. A no-disturbance area shall be established on the western slope of the subbasin, to prevent damage from erosion in this extremely sensitive area. Land clearing or development shall not occur in this no-disturbance zone, except that necessary clearing for, and construction of, single-family residences on pre-existing building lots. Any clearing that does occur, as a result of single-family residential construction on pre-existing lots, shall be limited to the minimal area and duration of exposure necessary for construction.

2. The upslope boundary of this no-disturbance area lies at the first, obvious break in slope at the western edge of the upland plateau. The downslope boundary of this zone includes those areas designated as Erosion or Landslide Hazard Areas pursuant to the Sensitive Areas Ordinance. The Sensitive Areas Folio indicates the general location of these hazard areas but it cannot be used to specify the areas' precise boundaries. Single-family or multi-family residential density from the no-disturbance area may be fully reallocated onto the buildable portion of the site, in accord with K.C.C.21.54.080, or possibly transferred to other sites pursuant to a transfer of density credits program.

UPLAND AREAS

3. The drainage requirements listed in paragraphs A.4-A.9 below may be waived only for development proposals that meet any of the following criteria. These criteria substitute for the thresholds listed in section 1.1.1 of the 1990 *Surface Water Design Manual*:

a. Proposals that construct less than 2,000 square feet of impervious surface area. The applicable impervious area shall exclude the area of driveways for single-family residential building permits and short plats.

b. Proposals of any size that achieve 100 percent infiltration, evapotranspiration, and/or consumption of surface runoff from impervious and disturbed surfaces.

4. All runoff from newly constructed impervious surfaces must be retained on-site to the maximum extent feasible, as determined by DDES, consistent with underlying zoning[3].

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[3] The feasibility of on-site retention is determined by allowable infiltration as specified in Section 4.5 of the Design Manual.

5. Runoff from all development proposals that involve the parcels identified in Attachment A, except single-family building permits and those that achieve 100% on-site retention, must be conveyed down the western slope of the basin via continuous pipeline(s). Connection into one of these pipelines by subsequent downslope development projects is required, if determined feasible by DDES. *{The SWM Division is preparing a recommendation for action by the Metropolitan King County Council that this requirement be altered or dropped on all pipeline areas south of Main Street. Until action is taken, however, this requirement remains in effect.}*

PIPE-LINES

6. Before discharging into a natural stream or waterbody, runoff must receive water-quality treatment according to Core and Special Requirements in the King County *Surface Water Design Manual*, in order to meet the goals of the Lake Sammamish Water Quality Management Project which seek to maintain current phosphorus loading levels and to maintain groundwater recharge. Pretreatment of the Water-Quality Design Storm is required; it must be achieved by infiltration or other methods of on-site retention, if feasible and if permitted by drainage regulations. If on-site retention is not possible, alternative requirements include biofiltration (Core Requirement #3) and wetponds (for those projects meeting the threshold of Special Requirement #5) as specified by the *Design Manual*.

7. The discharge of the pipeline must be non-erosive, either into Lake Sammamish directly or to an engineered channel that is demonstrably stable from the point of discharge to the lakeshore. All outfalls must comply with existing Shoreline and wetland regulations; they must be designed and/or located to avoid disruption of shoreline spawning areas.

8. Pipeline installation shall be above ground wherever feasible and **must** be above ground over all designated Erosion or Landslide Hazard Areas pursuant to King County's Sensitive Areas Ordinance. Pipeline routes down the west slope of the basin shall avoid ravine valleys as much as possible.

9. Development projects in the Ravine Protection Area that cannot achieve 100% on-site stormwater retention and are not required to construct a new pipeline or connect to an existing one (under A.5. above) shall provide on-site detention to the level of the Stream-Protection Standard (BW-2).

B. Relationship to Other Drainage Codes and Standards. The Ravine Protection Standard is intended to supplement existing County drainage requirements and to work in consort with other recommendations of the East Lake Sammamish Basin Plan. In particular:

1. Peak rate runoff control (Core Requirement #3 of the *Design Manual*) is unnecessary for piped discharges, unless the discharge point is **not** Lake Sammamish, a designated "receiving water." All facilities must convey the 100-year 24-hour design storm.

2. All required treatment (including those in Core Requirement #3 and Special Requirements #5 and #6 of the *Design Manual*) must occur prior to final discharge.

3. Discharge of runoff at the natural location (Core Requirement #1 of the *Design Manual*) can be waived without need for a SWM variance for pipelines constructed in order to satisfy this recommendation.

4. The threshold for imposition of these drainage controls is lowered from those of the *Design Manual* to include all projects with 2000 square feet or more of impervious surface (excluding the area of driveways for single-family residential building permits and short plats).

5. Baseflow Maintenance (recommendations PH-2 and MH-2 of the Basin Plan) requires evaluation of infiltrative soils and/or clearing restrictions in many of the same areas covered by the Ravine Protection Standard.

PH-2
MH-2

Baseflow Maintenance

New development in the mapped areas shall be required to evaluate the suitability of onsite soils for infiltration. *{Note: the boundaries of these areas correspond to the drainage divides of the Panhandle and Monohon subbasins.}* All runoff from newly constructed impervious surfaces must be retained on-site to the maximum extent feasible, consistent with underlying zoning. Subdivisions and short subdivisions shall maintain undisturbed vegetation set aside in a Native Growth Protection Easement on at least 25 percent of the non-infiltrative area, defined as soils not among the eight infiltrative soils listed in Section 1.2.3 of the Design Manual. For the non-infiltrative area of all development applications, no more than 35 percent shall be covered by impervious surfaces, exclusive of stormwater facilities. For new subdivisions and short subdivisions, the maximum lot coverage allowed by this requirement shall be specified for subsequent residential building permits on individual lots.

PH-3
MH-3

Reduced Onsite Detention

Direct discharge of runoff into Lake Sammamish, *via* tightline or stable open channel, is an acceptable alternative to the recommended R/D standard for new development (the basinwide, BW-1; or stream protection, BW-2), if the discharge can be accomplished after appropriate biofiltration and other water-quality treatment.

BW-5 **Wetland Management Area Protection (Significant Resource Areas)**

Beyond the limits of Sensitive Areas Ordinance buffers, certain slopes and corridors adjacent to number-1-rated wetlands, and certain areas tributary to those wetlands, shall be maintained at low densities, have limited impervious area coverage, or a combination of these and other development conditions. The specific requirements are listed in this section, by subbasin, for each Wetland Management Area. The wetland management areas are mapped in Attachment A.

I-2 **Headwater Wetland Protection -- Wetland 9.**

Wetland Management Area protection (*see* BW-5) shall be provided for Wetland 9, with standards recommended for the following three management areas.

a. Area A: Eastern Tributary Area *{all area tributary to wetland upstream of 0144}*

1. Cluster new development on no more than 50 percent of the total lot area to maximize available buffers and to limit disturbance to the ground surface.

2. For subdivisions and short subdivisions of SC-zoned properties *{equivalent to R-1 zoning after 1/95}*, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

3. Retain at least 50 percent of new development sites in existing vegetative cover, preferably forest, and retain in a separate tract.

4. Using methods specified in the King County *Surface Water Design Manual*, infiltrate all stormwater runoff up to and including the 25-year event.

b. Area B: Southeast Slopes *{slopes ≥ 15 percent within Area A}*

This area is contained within Area A. Therefore, with the exception of Requirement A-4, all requirements for Area A apply. In addition, limit clearing and grading work to the period from May 1st through September 30th of each year. Also, the impervious-area restriction in a.2. above shall apply to the affected parts of the RS-7200-zoned parcels *{equivalent to R-6 or R-8 zoning after 1/95}* in this area.

c. Area C: Western Tributary Area *{area tributary to Wetland 9, 0144, or outlet to Wetland 59 upstream of 228th Avenue NE}*

Using methods specified in the King County *Surface Water Design Manual*, infiltrate all stormwater runoff up to and including the 25-year event.

T-2 **Headwater Wetland Protection** -- Wetland 61

Wetland Management Area protection (BW-5) shall be provided for the Wetland 61 system, with standards recommended for three areas tributary to the wetland.

a. Area A: Tributary Area *{area tributary to wetland}*

Provide stream protection detention standard (BW-2) for all new development in this area.

b. Area B: Adjacent Slope Areas *{slopes ≥ 6 percent adjacent to wetland as indicated on map}*

1. On the moderate slopes to the southeast and northeast of the wetland, cluster new development on no more than 50 percent of the total lot area farthest from the wetland to maximize available buffers and to limit disturbance of the land surface.

2. Limit clearing and grading activity to the five-month period from May 1st to September 30th of each year.

c. Area C: West Corridor

Cluster new development away from the axis of the corridor that follows tributary 0149 westward from Wetland 61.

PL-2 **Headwater Wetland Protection – Wetland 30**

Wetland 30 shall be provided with Wetland Management Area protection (BW-5). The following four management areas are outlined for this purpose.

a. Area A: Southern Tributary Sub-Area *{area tributary to south wetland edge west of 212th Avenue SE}*

1. For subdivisions and short subdivisions of SC-zoned properties *{equivalent to R-1 zoning after 1/95}*, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

2. Apply the stream protection detention standard (BW-2) for all new development in the sub-area.

3. Limit clearing and grading activity to the five-month period from (and including) May 1st through September 30th.

b. Area B: Southern Wetland Area *{currently grazed part of Wetland 30 proper}*

Along the boundary of the wetland in this area, erect a fence to exclude grazing activity and replant the area with appropriate wetland species.

c. Area C: North Swale *{axis of valley extending northwest through Wetland 29 to SE 24th Street}*

1. Cluster new development on no more than 50 percent of the lot area to maximize buffers around Wetland 29 and 30 and away from the axis of the swale that connects them.

2. For subdivisions and short subdivisions of SC-zoned properties *{equivalent to R-1 zoning after 1/95}*, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

3. Retain at least 50 percent of the land cover in forest or existing vegetation for all new development.

4. Provide stream protection detention standard (BW-2) for all new development in the sub-area.

MH-5 **Headwater Wetland Protection – Wetland 58**

Wetland 58 shall be provided with Wetland Management Area protection (BW-5). The following two management areas are outlined for this purpose.

a. Area A: Tributary Area *{area tributary to wetland}*

Apply the stream protection detention standard (BW-2) for all new developments in this area.

b. Area B: Eastern Swale *{valley axis extending east through Wetlands 32 and 33}*

1. Cluster new development on no more than 50 percent of the total lot area to maximize buffers around Wetlands 58, 32, 33, and the axis of the swale that connects them, in order to maximize the buffers that protect these wetlands.

2. Apply the stream protection detention standard (BW-2) for all new developments in this area.

LJ-3 Headwater Wetland Protection – Wetlands 10, 21, 26, 34, and 39

The protection measures listed below shall be applied to the following wetlands:

- **Wetland 10 Saddle Swamp**

Wetland 10 shall be provided with Wetland Management Area protection (BW-5). Specific management strategies for the three management areas are as follows.

a. Area A: Tributary area *{area tributary to wetland}*

1. For subdivisions and short subdivisions, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

2. Limit clearing and grading activity in the tributary area to the five-month period from (and including) May 1st through September 30th.

b. Area B: East Corridor

In order to maintain corridor connections between Wetland 10 and Wetland 21 to the east, cluster new development away from the designated map area (see "d" for Wetland 21, below).

c. Area C: Wetland Buffer

Beyond the SAO-mandated 100 foot buffer surrounding Wetland 10, maintain a low-impact zone of 200 feet:

1. Within this zone, retain at least 50 percent of new development sites in existing vegetative cover, preferably forest, and retain in a separate tract.

2. Cluster structures and impervious areas on those portions of the lots farthest from the wetland and its buffer.

- **Wetland 21**

Wetland Management Area wetland protection (BW-5) is required in the following four management areas:

a. Area A: Tributary Area *{area tributary to wetland}*

1. For subdivisions and short subdivisions of AR-5 and SC-zoned properties *{equivalent to RA-5 and R-1 zoning after 1/95}*, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

2. Retain at least 50 percent of new development sites in existing vegetative cover, preferably forest, and retain in a separate tract.

3. Apply the stream protection detention standard (BW-2) for all new development within the tributary area.

4. Limit clearing and grading activity in the tributary area to the five-month period from (and including) May 1st through September 30th.

b. Area B: East Swale *{axis of valley as mapped}*

In addition to the requirements for Area A, new development in the swale area shall be clustered away from the axis of the swale to preserve the hydrologic function.

c. Area C: Northwest Swale *{axis of valley as mapped}*

In addition to the requirements for Area A, new development in the swale area shall be clustered away from the axis of the swale to preserve the hydrologic function.

d. Area D: West Corridor

In order to maintain corridor connections between Wetland 10 and Wetland 21, cluster new development away from the axis of the corridor (see "b" for Wetland 10, above).

- **Wetland 26**

Wetland Management Area protection (BW-5) is provided this wetland. These recommendations are specified for five management areas. The three distinct sub-areas together encompass almost the entire tributary area of the wetland:

a. Area A: Northeast Tributary Sub-Area *{area tributary to wetland lying north of SE 24th Street and east of 236th Avenue SE}*

1. For subdivisions and short subdivisions of SC-zoned properties *{equivalent to R-1 zoning after 1/95}*, impervious surface coverage, including buildings and roadways/driveways, should be limited to a maximum of eight percent of the total area being subdivided, including common open space. Retention/detention facilities and off-site roads are excluded from this limitation. This condition should be waived only where unusual site access conditions make achievement infeasible, as determined by DDES.

2. Retain at least 50 percent of new development sites in existing vegetative cover, preferably forest, and retain in a separate tract.

3. Apply the stream protection detention standard (BW-2) for all new development within the sub-area.

4. Limit clearing and grading activity in the sub-area to the five-month period from May 1st through September 30th.

b. Area B: Southwest Tributary Sub-area *{area tributary to western lobe of wetland lying south of SE 24th Street}*

1. Retain at least 50 percent of new development sites in existing vegetative cover, preferably forest, and retain in a separate tract.

2. Apply the stream protection detention standard (BW-2) for all new development within the sub-area.

3. Limit clearing and grading activity in the sub-area to the five-month period from May 1st through September 30th.

c. Area C: Northwest Tributary Sub-area *{area tributary to wetland lying north of SE 24th Street and not included in Area A, above}*

Limit clearing and grading activity in the sub-area to the five-month period from May 1st through September 30th.

d. Area D: North Corridor *{centered on tributary 0144 to edge of Wetland 18}*

In order to maintain corridor connections to the north of Wetland 26, cluster new development away from the axis of the corridor.

e. Area E: South Corridor *{centered on tributary 0166 south to Wetland 39}*

In order to maintain corridor connections to the south of Wetland 26, cluster new development away from the axis of the corridor (see "a.1" for Wetland 39, below).

- **Wetland 34 (Queen's Bog)**

Much development already surrounds this wetland and precludes various measures applied to other systems. Nevertheless, Wetland Management Area protection shall be applied to the following three management areas of this wetland:

a. Area A: East Tributary Area *{area tributary to eastern boundary of wetland}*

Given the existing zoning for this sub-area, future development shall adhere to the following requirements:

1. Total effective impervious surface coverage in the sub-area should be minimized; roadway widths shall be as narrow as allowed by the King County Road Engineer.

2. Retain as much forest or other existing cover as possible.

3. Apply the stream protection detention standard (BW-2) for all new development within the sub-area.

b. Area B: North and South Buffers

Maintain the currently preserved buffer strips north and south of the wetland in 'Park/Open Space" zoning.

c. Area C: Eastern Swale *{valley axis of wetland east to 256th Avenue SE}*

This swale is wholly contained within Area A. In addition to the recommendations for Area A, the following standards shall apply in this area:

1. Cluster new development in the swale area away from the axis of the swale to preserve the hydrologic function.

2. Limit clearing and grading activity in the swale to the five-month period from May 1st through September 30th.

- **Wetland 39 (Laughing Jacob's Lake)**

Wetland Management Area protection (BW-5) is required for this wetland in two management areas. Standards for this wetland are as follows:

a. Area A: Northern Corridor *{centered on tributary 0166 north to Wetland 26}*

1. In order to maintain corridor connections to the north of Wetland 39, cluster new development away from the axis of the corridor (see "e" for Wetland 26, above).

2. On the slopes *(with inclination ≥ 15 percent)* to the west of the corridor, limit clearing and grading activity to the five-month period from May 1st through September 30th.

b. Area B: Southern Corridor *{centered on tributary 0166 to confluence with 0167}*

In order to maintain corridor connections to the south of Wetland 39, cluster new development away from the axis of the corridor.

LJ-4 **Protection of Laughing Jacobs Lake Floodplain**

A floodplain analysis of Laughing Jacobs Lake and tributary 0166 between the lake and SE 42nd Street is required for any development proposed within 10 vertical feet of the ordinary high water mark, measured at the lake cross-section nearest to the development. The floodplain analysis should include the determination of a "Zero-rise floodway" for future conditions as defined by the King County Sensitive Areas Ordinance.

LJ-6 **Ravine-Top Clearing and Drainage Standards** *{areas tributary to Laughing Jacobs Creek via slopes ≥ 15 percent between RM 0.5 and RM 1.0}*

To reduce hillslope erosion and slope failures, runoff from new development or clearing on ravine-top lands that discharge into Laughing Jacobs Creek between RM 0.5 and 1.00 of that creek should be detained according to the standard (BW-1 or BW-2) that is recommended for the area and tightlined to the base of the ravine before it is discharged with adequate energy dissipation to the stream.

CP-58
CP-59[4] **Pine Lake Phosphorus Control**

1. Clearing and grading shall be limited to the five-month period from and including May 1 through September 30, except for those activities exempted under Chapter IV of the *East Sammamish Community Plan*. Deviations from these standards may be allowed as provided for in that same chapter.

2. SWM shall require all known, available, and reasonable methods of prevention, control, and treatment for phosphorus control for all new development in the area draining to Pine Lake. Unless it can be demonstrated that a method or combination of methods is effective to prevent, control, and treat phosphorus, and is more feasible, the following shall be required until the *Drainage Manual* is revised to deal with phosphorus loading to small lakes, at which time the *Drainage Manual* requirements shall apply. If soils are suitable, SWM shall require infiltration to and including the 25-year event, for all new development. If soils are not suitable for infiltration, a grass-lined swale or constructed wetland shall be provided together with sand filtration.

[4] Amendments 58 and 59 of the adopted East Sammamish Community Plan

BLMP[5] **<u>Beaver Lake Phosphorus Control</u> (this requirement is currently inactive)**

Total phosphorus increases above background levels should be reduced by 80 percent through stormwater treatment and applied to all future development. All known and reasonable treatment for phosphorus control should be employed as the standard to achieve this goal.

{Note: The Metropolitan King County Council adopted an ordinance on October 3, 1994, authorizing the Surface Water Management Division to adopt the Beaver Lake Management Plan as an administrative rule. The Beaver Lake Management Plan contains the following recommendation for phosphorus removal (recommendation BL-2):

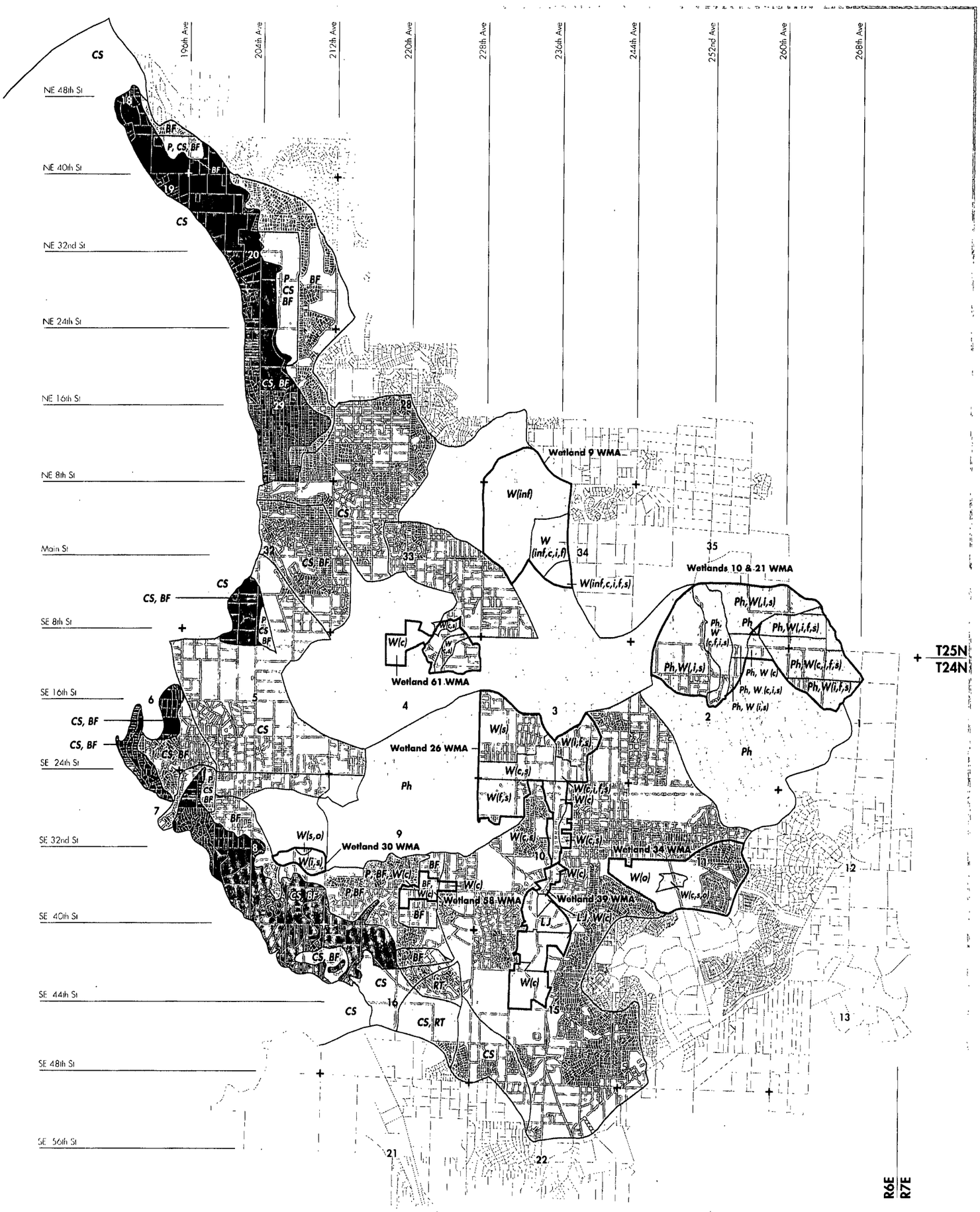
> *An 80 percent reduction of total phosphorus (above background levels) should be established as a stormwater treatment goal for all future development. AKART or "all known, available, and reasonable methods of prevention, control, and treatment" for phosphorus control should be employed as the standard to achieve this goal.*

The anticipated adoption of this administrative rule is January 1995.}

[5] Beaver Lake Management Plan

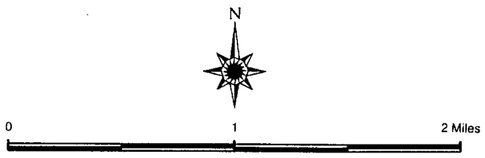
ATTACHMENT A

DEVELOPMENT CONDITIONS - EAST LAKE SAMMAMISH BASIN



East Lake Sammamish Basin

Development Conditions



- No Disturbance Area (BW-3) (includes CS & BF)
- Stream Protection Detention Standard (BW-2)
- Conventional Detention Standard (BW-1)
- **CS** Culvert Sizing Criteria (BW-45)
- **BF** Baseflow Maintenance (PH-2 & MH-2)
- **P** Pipeline Drainage Area (BW-3)
- **RT** Restrict Ravine-Top Clearing and Grading (LJ-6)
- **LJ** Protect Floodplain (LJ-4) (to SE 42nd St.)
- **Ph** Control Phosphorus (see plan)

+ 21 Section Corner & Section Number

- Condition Area Boundary
- Wetland Management Area (WMA) & Condition Area Boundary

Wetland Management Area Conditions

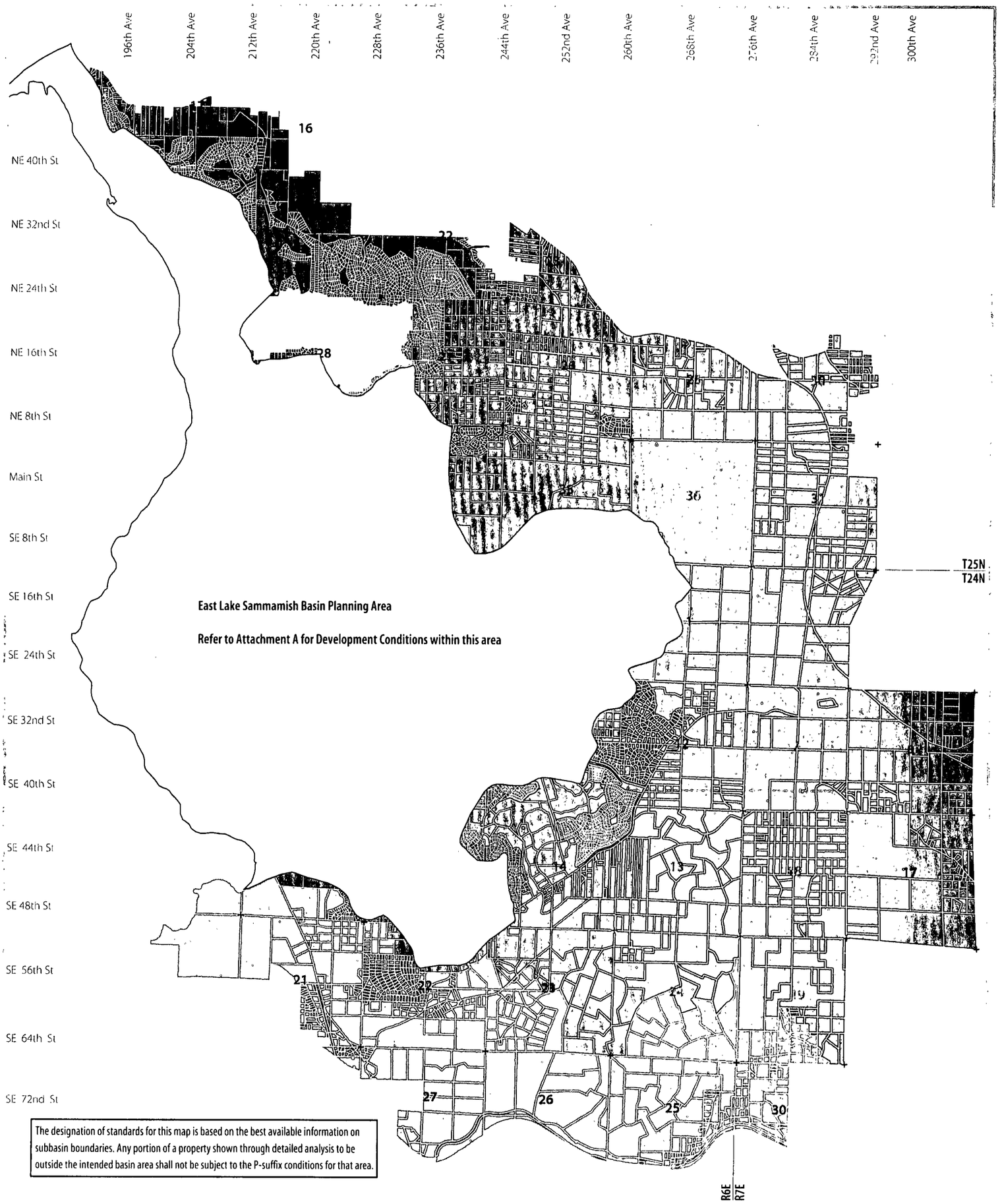
- **W** Wetland Management Area (BW-5 plus site specific requirements)
- ***f*** Retain 50% Forest or Other Existing Vegetation
- ***c*** Cluster New Development
- ***s*** Require Dry Season Clearing and Grading
- ***i*** Limit Impervious to 8% Site Area
- ***inf*** Require Infiltration of Stormwater Runoff
- ***o*** Other

Sources: King County Digital Parcels Coverage, Nov, 1991
USGS 1:24000 Topographic Maps
USGS Digital Elevation Model
Thomas Brothers Street Atlas
Field Surveys 3/94—8/94

Date: January 1995

ATTACHMENT B

DETENTION STANDARDS - EAST SAMMAMISH COMMUNITY PLANNING AREA



East Sammamish Community Planning Area

Development Condition 19A- Detention Standards

N

0 1 2 Miles

Notes: The Detention Standard area boundaries are based on the best available information as of February, 1994.

Detention Standard 2 (Stream Protection Standard)

Detention Standard 1 (Basinwide Protection Standard)

Unaffected Area

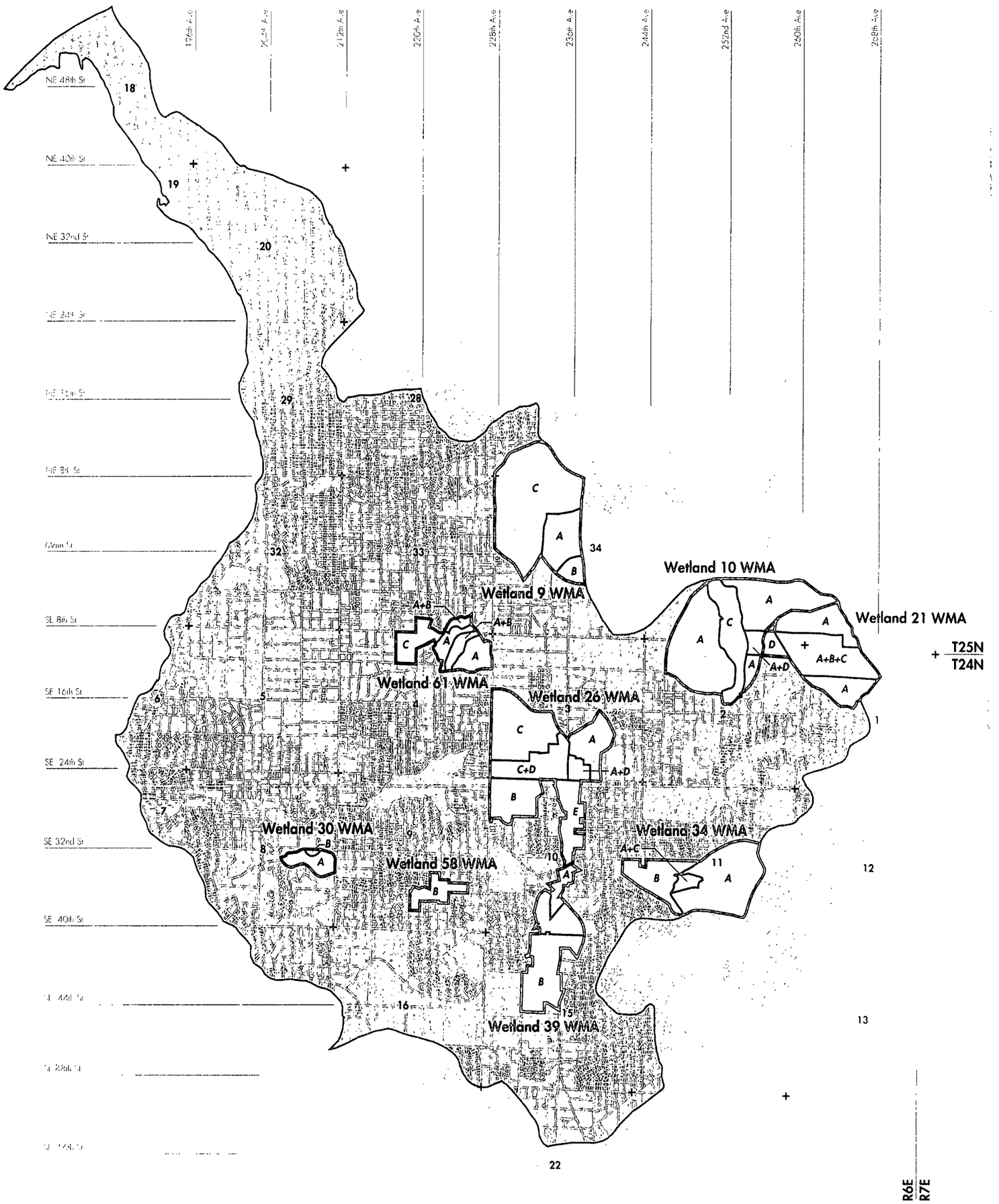
+ 26 Section Corner & Number

Sources: King County Digital Parcels Coverage, Nov, 1991
USGS 1:24000 Topographic Maps
USGS Digital Elevation Model
Thomas Brothers Street Atlas

Date: January 1995

ATTACHMENT C

WETLAND MANAGEMENT AREAS - EAST LAKE SAMMAMISH BASIN PLAN



East Lake Sammamish Basin

Wetland Management Areas

N

0 1 2 Miles

Basin Planning Area

Wetland Management Area

A+B+C Headwater Wetland Protection-Specific Requirements pp. 26 - 32

+ 21 Section Corner & Section Number

Sources: King County Digital Parcels Coverage, Nov, 1991
USGS 1:24000 Topographic Maps
USGS Digital Elevation Model
Thomas Brothers Street Atlas
Field Surveys 3/94—8/94

Date: January 1995

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 2
BASIN RECONNAISSANCE PROGRAM SUMMARY REPORTS

BASIN RECONNAISSANCE PROGRAM SUMMARY REPORTS

Reconnaissance studies have been completed for the following watersheds and are contained in the Basin Reconnaissance Program Summary volumes as noted:

Volume 1 Basins

Middle Puget Sound
Thornton Creek
Lake Washington
Sammamish River
Little Bear Creek
Big Bear Creek
Forbes Creek
Evans Creek

Volumes 2 Basins

West Lake Sammamish
East lake Sammamish
Tibbetts Creek
North Fork Issaquah Creek
East Fork Issaquah Creek
Issaquah Creek
Lower Cedar River
Soos Creek
Jenkins Creek
Covington Creek
Middle Green River

Volume 3 Basins

Lower Puget Sound
Duwamish River
Salmon Creek
Miller Creek
Des Moines Creek
Lower Green River
Black River
Hylebos Creek
Mill Creek
White River

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 3
CRITICAL DRAINAGE AREAS - REQUIREMENTS

TITLE	EFFECTIVE DATE
West Cedar River Valley Ridge	5/24/89
West Snoqualmie River Valley Ridge	5/24/89
Northshore	8/22/91
May Creek	4/22/93
MacDonald Creek	4/22/93

King County
Public Rules

Title	Document Code No.
WEST CEDAR RIVER VALLEY RIDGE CRITICAL DRAINAGE AREA DESIGNATION	KCPR 09.04.050.2
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	May 24, 1989

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King County
Public Rules and Regulations

Public Rules

Title	Document Code No
West Cedar River Valley Ridge Critical Drainage Area Designation	KCPR 09.04.050.2
Department/Issuing Agency: Department of Public Works/Surface Water Management Division	Effective Date: May 24, 1989

Approved: [signature]

1.0 SUBJECT TITLE: West Cedar River Valley Ridge Critical Drainage Area Designation

1.1 EFFECTIVE DATE: The proposed date for filing with the Clerk of the County Council is April 24, 1989.

1.2 TYPE OF ACTION: This is a new Public Rule.

1.3 KEY WORDS: (1) Critical Drainage Area Designation; (2) Drainage Problem; (3) West Cedar River Valley Ridge; (4) Cedar River; (5) Development Restriction

2.0 PURPOSE: To designate the West Cedar River Valley Ridge Critical Drainage Area and to establish a standard procedure for reviewing applications for development within this Critical Drainage Area in order to preserve the health, safety, and welfare of the general public.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of the West Cedar River Valley Ridge Critical Drainage Area

3.2 Developers

3.3 Department of Parks, Planning and Resources, Building and Land Development Division

3.4 Department of Public Works, Surface Water Management Division, Department of Public Works, Roads and Engineering Division

4.0 REFERENCES: King County Charter § 850; King County Code 2.16.040.B.4.g; King County Code 9.04, King County Code 2.98; King County Code 21.54; Surface Water Design Manual.

5.0 DEFINITIONS:

5.1 "Adjacent steep slope" means slopes with a gradient of 15% or steeper within five hundred feet of the site.

5.3 "Closed depression" means an area of King County which is low-lying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin, holding more than 5000 square feet of surface water at overflow.

5.4 "Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98. This designation is based on the observation or prediction, using standard hydrological methods, of one or more of the following concerns and the need for more specific regulations than the Countywide standards in order to mitigate the impacts of proposed developments.

5.4.1 Flooding Concerns:

5.4.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years; and/or

5.4.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years.

5.4.2 Erosion/sedimentation Concerns:

5.4.2.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road;

5.4.2.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow; and/or

5.4.2.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage.

5.5 "Design storm" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

5.6 "Detention" means release of surface and storm water runoff from the site at a slower rate than it is collected by the drainage facility system, the difference being held in temporary storage.

5.7 "Development," for the purposes of this document, means any activity that requires a permit or approval, including but not limited to a building permit, grading permit, shoreline substantial development permit, conditional use permit, unclassified use permit, zoning variance or reclassification, planned unit development, subdivision, short subdivision, master plan development, building site plan, or right-of-way use permit.

5.7 "Development" means, for the purposes of this document, any activity that requires a permit or approval, including but not limited to a building permit, grading permit, shoreline substantial development permit, conditional use permit, unclassified use permit, zoning variance or reclassification, planned unit development, subdivision, short subdivision, master plan development, building site plan, or right-of-way use permit.

5.8 "Dispersed discharge" means release of surface and storm water runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodable underlying granular soils.

5.9 "Drainage" refers to the collection, conveyance, containment, and/or discharge of surface and storm water runoff.

5.10 "Drainage channel" means a drainage pathway with well-defined bed and banks indicating frequent conveyance of surface and storm water runoff.

5.11 "Drainage facility" means the system of collecting, conveying and storing surface and storm water runoff. Drainage facilities shall include but not be limited to all surface and storm water runoff conveyance and containment facilities within the drainage area including streams, pipelines, channels, ditches, swamps, lakes, wetlands, closed depressions, infiltration facilities, retention/detention facilities and other drainage structures and appurtenances, both natural and manmade.

5.12 "Drainage pathway" refers to the route that surface and storm water runoff, leaving any part of a site, follows downslope.

5.13 "Drainage review" means an evaluation by Building and Land Development Division staff of a proposed project's compliance with the drainage requirements in the Surface Water Design Manual.

5.14 "Erodable granular soils" means soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Inc anola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

5.15 "Erosion" means detachment of soil or rock fragments by water, wind, ice and gravity.

5.16 "Erosion/sedimentation control facility" means a type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and storm water runoff directed to the facility to settle out so as to improve the quality of the runoff.

5.17 "Impervious surface" means a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development, and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of surface and storm water runoff. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of this Public Rule.

5.18 "Infiltration" means the hydrologic process of surface and storm water runoff soaking into the ground and is commonly referred to as percolation.

5.19 "Infiltration facility" means a drainage facility designed to use the hydrologic process of surface and storm water runoff soaking into the ground, commonly referred to as percolation, to dispose of surface and stormwater runoff.

5.20 "Manager" means the Manager of Building and Land Development Division of the King County Department of Parks, Planning, and Resources or his designee.

5.21 "Off-site" means any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.

5.22 "On-site" means the entire property that includes the proposed development.

5.23 "Permeable soils" means soil materials with a sufficiently rapid infiltration rate (10 minutes per inch or better) so as to greatly reduce or eliminate surface and storm water runoff. These soils are classified as SCS hydrologic soil type "A."

5.24 "Point discharge" means the release of collected and/or concentrated surface and storm water runoff from a pipe, culvert, or channel.

5.25 "Prediction" means an expected outcome based on the results of hydrologic modelling and/or the judgment of a trained professional civil engineer or geologist.

5.26 "Professional Civil Engineer" means a person registered with the State of Washington as a professional engineer in civil engineering.

5.27 "Release rate" means the computed peak rate of surface and storm water runoff for a particular design storm event and drainage area conditions.

5.28 "Retention/detention facility" means a type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration and/or infiltration into the ground; or to hold surface and storm water runoff for a short period of time and then release it to the natural watercourse.

5.28 "SCS" means Soil Conservation Service, U.S. Department of Agriculture.

5.29 "SCS Method" means a hydrologic analysis based on the Curve Number method (National Engineering Handbook - Section 4: Hydrology, August, 1972) and using any acceptable analytical technology as delineated in the King County Surface Water Design Manual.

5.30 "Sedimentation" means the depositing or formation of sediment.

5.31 "Site" means the portion of a piece of property that is directly subject to development.

5.32 "Steep slope" means slopes of 15% gradient or steeper.

5.33 "Surface and storm water runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

5.34 "Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff analysis and design requirements, procedures and guidance which is formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual will be available from the BALD permit center.

5.31 "Undisturbed buffer" means a zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and storm water drainage facility systems.

5.32 "Undisturbed low gradient uplands" means forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.

6.0 POLICIES

6.1 Those portions of the West Cedar River Valley Ridge drainage basin identified in the Critical Drainage Area map at the BALD permit center and generally indicated in the map in Appendix 9.1 of this Public Rule are hereby designated as a Critical Drainage Area because:

6.1.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road (Concern 5.3.2.1 of this Public Rule) and

6.1.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow (Concern 5.3.2.2 of this Public Rule).

6.2 Applications for development proposals within this Critical Drainage Area may be exempt from the more stringent Critical Drainage Area requirements if they demonstrate to the satisfaction of the Manager that the Critical Drainage Area mapping of the proposed development area is in error because one or more of these conditions exist:

6.2.1 On-site surface and storm water runoff (or off-site runoff entering the drainage facility system) does not in fact drain over steep slopes;

6.2.2 The drainage pathway is not underlain by erodable granular soils anywhere along its route within the Critical Drainage Area; and/or

6.2.3 The site is underlain by permeable soils that will infiltrate and dissipate surface and storm water runoff even after clearing and development, without risk of instability to any adjacent steep slopes.

6.3 Development proposals in this Critical Drainage Area must be submitted with a drainage plan prepared by a professional civil engineer that meets each of the following conditions, unless the conditions identified in Policy 6.2 are documented to the satisfaction of the Manager:

6.3.1 Surface and storm water runoff detention shall be computed using a SCS-based hydrograph method (or other method as subsequently approved by King County). The performance of proposed detention facilities (as illustrated in Appendix 9.2) shall be such that discharge from the developed area shall be no more than:

6.3.1.1 Fifty percent of the forested two-year/24-hour release rate for design storm events up to and including the two-year/24-hour design storm event;

6.3.1.2 The forested two-year/24-hour release rate for design storm events greater than the two year/24-hour design storm event and up to and including the 10-year/24-hour design storm event; and

6.3.1.3 The forested ten-year/24 hour release rate for design storm events greater than the 10-year/24-hour design storm event and up to and including the 100-year/24-hour design storm event.

These rate controls may be modified if discharge is conveyed via continuous welded storm pipe to a suitably stabilized release point, with adequate energy dissipation, below the area of severe erosion potential.

6.3.2 For purposes of the computations required in Policy 6.3.1, pre-development conditions will be assumed to be totally forested and developed conditions will assume 100% removal of forest canopy within the area of the development (unless expressly prohibited by recorded easement or restriction) as well as existing, proposed, and anticipated impervious surfaces. Detention facilities must be located to accommodate surface and storm water runoff from all areas of planned or potential clearing and/or construction.

6.3.3 Point discharge from detention systems will be only into drainage channels that previously conveyed surface and storm water runoff in the predevelopment state. No point discharge shall be permitted onto or upstream of steep slopes where erodable granular soils lie downstream of that point discharge. Dispersed discharge, onto undisturbed low-gradient uplands may be evaluated as a potential alternative. An undisturbed buffer between the dispersed discharge and the steep sideslopes must be adequate to ensure infiltration of surface and storm water runoff into the ground.

Determining and documenting that adequacy to the satisfaction of the Manager is the responsibility of the applicant's professional civil engineer.

6.3.4 Surface and storm water runoff entering any component of the on-site drainage facility system from developed upstream areas must be detained and released under the same criteria as surface and storm water runoff generated on-site.

6.4 If any portion of this Public Rule or its application to any person or property is held invalid, the remainder of this Public Rule or the application of the provision to other persons or property shall not be affected.

6.5 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objectives and purposes for which it was adopted.

7.0 GENERAL PROCEDURES

Responsibility	Action
BALD	7.1 Identifies that the proposed development is in a Critical Drainage Area.
BALD	7.2 Informs applicant that the proposed development is in a Critical Drainage Area.
Applicant	7.3 Submits additional application information which either:
	7.3.1 Demonstrates that the application qualifies for the exemption in Policy 6.2; or
	7.3.2 Complies with Policy 6.3.
BALD	7.4 Reviews the materials submitted in step 7.3 and determines if it complies with this Critical Drainage Area Public Rule.
	7.4.1 Returns inadequate material to the applicant with specific instructions to comply with step 7.3.
	7.4.2 Forwards adequate application to be processed according to the established review process.

8.0 RESPONSIBILITIES

8.1 The Surface Water Management Division is responsible for:

8.1.1 Amending this Critical Drainage Area Public Rule if requirements of this Critical Drainage Area Public Rule warrant alteration.

8.1.2 Updating the Critical Drainage Area map as new information becomes available.

8.2 The Building and Land Development Division is responsible for:

8.2.1 Identifying each development application which is within a Critical Drainage Area.

8.2.2 Determining if the material submitted by the applicant complies with either Policy 6.2 or Policy 6.3 of this Public Rule.

8.3 The applicant is responsible, at a minimum, for:

8.3.1 Demonstrating that the area of the proposed development complies with Policy 6.2 or with the requirements in Policy 6.3 of this Public Rule.

9.0 APPENDICES

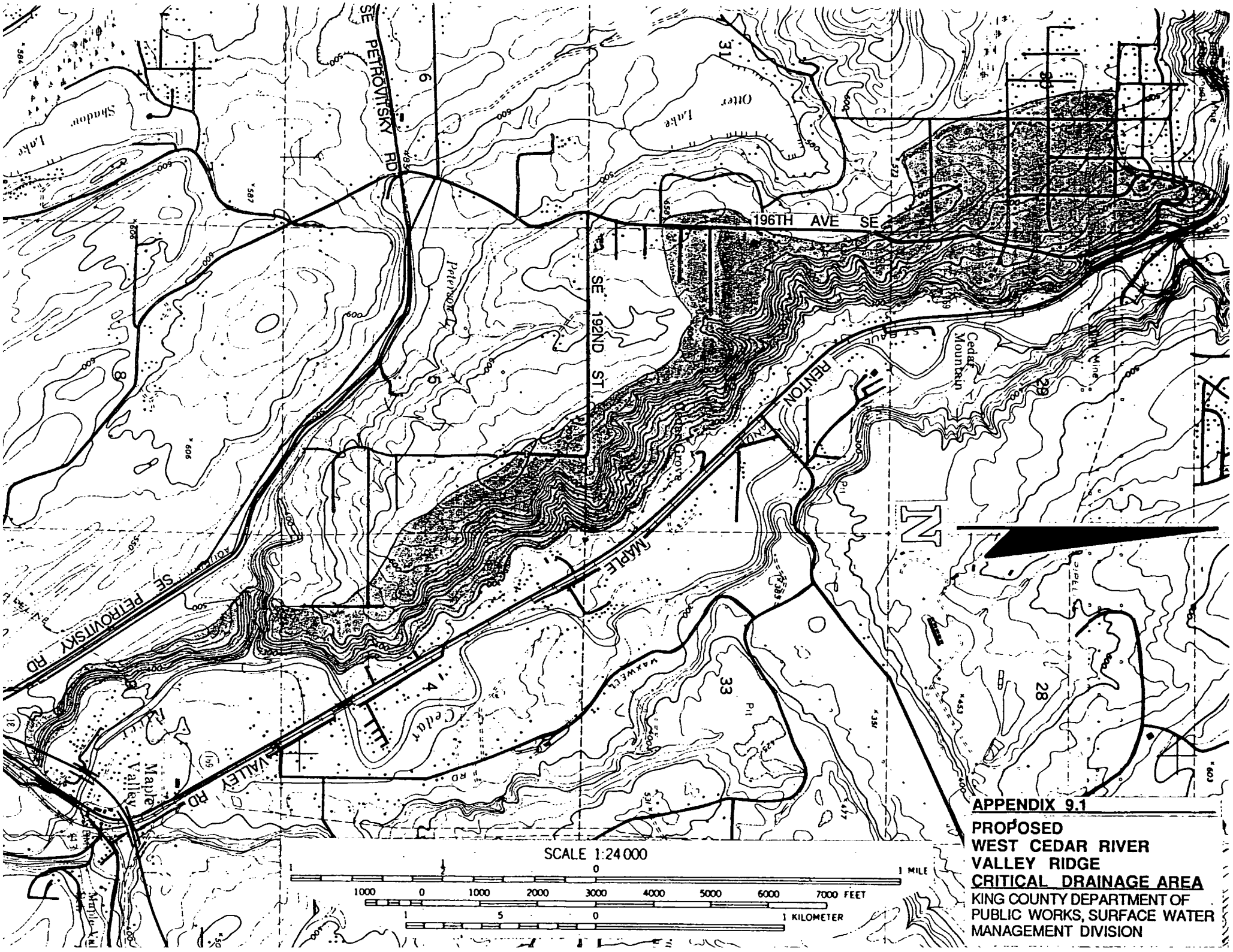
9.1 Map of the West Cedar River Valley Ridge Critical Drainage Area. Precise borders of this Critical Drainage Area are indicated on the Critical Drainage Area map at the BALD permit center.

9.2 Illustration of Policy 6.3.1.

APPENDIX 9.1

MAP OF WEST CEDAR RIVER VALLEY RIDGE CRITICAL DRAINAGE AREA

(1-PAGE MAP ATTACHED)



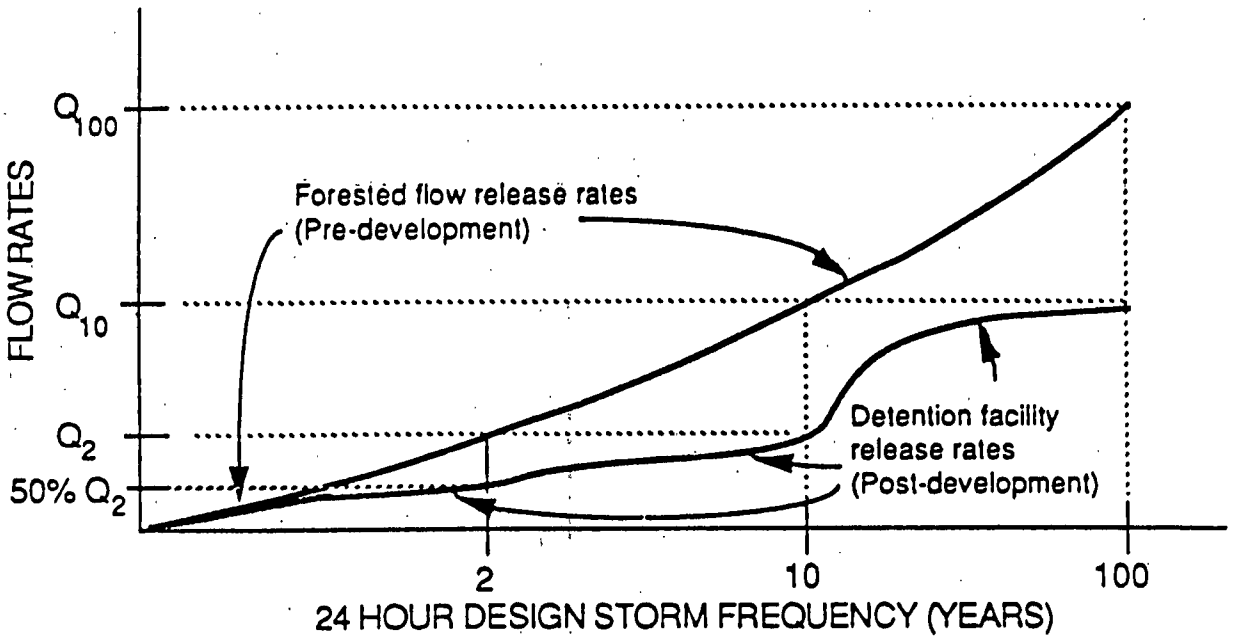
APPENDIX 9.1

PROPOSED WEST CEDAR RIVER VALLEY RIDGE CRITICAL DRAINAGE AREA

KING COUNTY DEPARTMENT OF PUBLIC WORKS, SURFACE WATER MANAGEMENT DIVISION

APPENDIX 9.2

DETENTION FACILITY PERFORMANCE REQUIREMENTS



* Note, detention facility hydrographic analysis is only required for the 2-, 10-, and 100-year/24-hour duration design storms (SCS Type 1A distribution)

King County
Public Rules

Title	Document Code No
WEST SNOQUALMIE VALLEY RIDGE CRITICAL DRAINAGE AREA DESIGNATION	KCPR 09.04.050.1
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	May 24, 1989

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KING COUNTY COUNCIL

King County
Public Rules and Regulations

Public Rules

Title	Document Code No
West Snoqualmie Valley Ridge Critical Drainage Area Designation	KCPR 09.04.050.1
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	May 24, 1989

Approved

1.0 SUBJECT TITLE: West Snoqualmie Valley Ridge Critical Drainage Area Designation

1.1 EFFECTIVE DATE: The proposed date for filing with the Clerk of the County Council is April 24, 1989.

1.2 TYPE OF ACTION: This is a new Public Rule.

1.3 KEY WORDS: (1) Critical Drainage Area Designation; (2) Drainage Problem; (3) West Snoqualmie Valley Ridge; (4) Snoqualmie River; (5) Development Restriction

2.0 PURPOSE: To designate the West Snoqualmie Valley Ridge Critical Drainage Area and to establish a standard procedure for reviewing applications for development within this Critical Drainage Area in order to preserve the health, safety, and welfare of the general public.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of the West Snoqualmie Valley Ridge Critical Drainage Area

3.2 Developers

3.3 Department of Parks, Planning and Resources, Building and Land Development Division

3.4 Department of Public Works, Surface Water Management Division, Department of Public Works, Roads and Engineering Division

4.0 REFERENCES: King County Charter § 850; King County Code 2.16.040.B.4.g; King County Code 9.04, King County Code 2.98; King County Code 21.54; Surface Water Design Manual.

5.0 DEFINITIONS:

5.1 "Adjacent steep slope" means slopes with a gradient of 15% or steeper within five hundred feet of the site.

5.2 "BALD" means the Building and Land Development Division of the King County Department of Parks, Planning and Resources.

5.3 "Closed depression" means an area of King County which is low-lying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin, holding more than 5000 square feet of surface water at overflow.

5.4 "Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98. This designation is based on the observation or prediction, using standard hydrological methods, of one or more of the following concerns and the need for more specific regulations than the Countywide standards in order to mitigate the impacts of proposed developments.

5.4.1 Flooding Concerns:

5.4.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years; and/or

5.4.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years.

5.4.2 Erosion/sedimentation Concerns:

5.4.2.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road;

5.4.2.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow; and/or

5.4.2.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage.

5.5 "Design storm" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

5.6 "Detention" means release of surface and storm water runoff from the site at a slower rate than it is collected by the drainage facility system, the difference being held in temporary storage.

5.7 "Development," for the purposes of this document, means any activity that requires a permit or approval, including but not limited to a building permit, grading permit, shoreline substantial development permit, conditional use permit, unclassified use permit, zoning variance or reclassification, planned unit development, subdivision, short subdivision, master plan development, building site plan, or right-of-way use permit.

5.8 "Dispersed discharge" means release of surface and storm water runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodable underlying granular soils.

5.9 "Drainage" refers to the collection, conveyance, containment, and/or discharge of surface and storm water runoff.

5.10 "Drainage channel" means a drainage pathway with well-defined bed and banks indicating frequent conveyance of surface and storm water runoff.

5.11 "Drainage facility" means the system of collecting, conveying and storing surface and storm water runoff. Drainage facilities shall include but not be limited to all surface and storm water runoff conveyance and containment facilities within the drainage area including streams, pipelines, channels, ditches, swamps, lakes, wetlands, closed depressions, infiltration facilities, retention/detention facilities and other drainage structures and appurtenances, both natural and manmade.

5.12 "Drainage pathway" refers to the route that surface and storm water runoff, leaving any part of a site, follows downslope.

5.13 "Drainage review" means an evaluation by Building and Land Development Division staff of a proposed project's compliance with the drainage requirements in the Surface Water Design Manual.

5.14 "Erodable granular soils" means soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

5.15 "Erosion" means detachment of soil or rock fragments by water, wind, ice and gravity.

5.16 "Erosion/sedimentation control facility" means a type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and storm water runoff directed to the facility to settle out so as to improve the quality of the runoff.

5.17 "Impervious surface" means a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development, and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt

paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of surface and storm water runoff. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of this Public Rule.

5.18 "Infiltration" means the hydrologic process of surface and storm water runoff soaking into the ground and is commonly referred to as percolation.

5.19 "Infiltration facility" means a drainage facility designed to use the hydrologic process of surface and storm water runoff soaking into the ground, commonly referred to as percolation, to dispose of surface and stormwater runoff.

5.20 "Manager" means the Manager of Building and Land Development Division of the King County Department of Parks, Planning, and Resources or his designee.

5.21 "Off-site" means any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.

5.22 "On-site" means the entire property that includes the proposed development.

5.23 "Permeable soils" means soil materials with a sufficiently rapid infiltration rate (10 minutes per inch or better) so as to greatly reduce or eliminate surface and storm water runoff. These soils are classified as SCS hydrologic soil type A.

5.24 "Point discharge" means the release of collected and/or concentrated surface and storm water runoff from a pipe, culvert, or channel.

5.25 "Prediction" means an expected outcome based on the results of hydrologic modelling and/or the judgment of a trained professional civil engineer or geologist.

5.26 "Professional Civil Engineer" means a person registered with the State of Washington as a professional engineer in civil engineering.

5.27 "Release rate" means the computed peak rate of surface and storm water runoff for a particular design storm event and drainage area conditions.

5.28 "Retention/detention facility" means a type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration and/or infiltration into the ground; or to hold surface and storm water runoff for a short period of time and then release it to the natural watercourse.

5.29 "SCS" means Soil Conservation Service, U.S. Department of Agriculture.

5.30 "SCS Method" means a hydrologic analysis based on the Curve Number method (National Engineering Handbook - Section 4: Hydrology, August, 1972) and using any acceptable analytical technology as delineated in the King County Surface Water Design Manual.

5.31 "Sedimentation" means the depositing or formation of sediment.

5.32 "Site" means the portion of a piece of property that is directly subject to development.

5.33 "Steep slope" means slopes of 15% gradient or steeper.

5.34 "Surface and storm water runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

5.35 "Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff analysis and design requirements, procedures and guidance which is formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual will be available from the BALD permit center.

5.36 "Undisturbed buffer" means a zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and storm water drainage facility systems.

5.37 "Undisturbed low gradient uplands" means forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.

6.0 POLICIES

6.1 Those portions of the West Snoqualmie Valley Ridge drainage basin identified in the Critical Drainage Area map at the BALD permit center and generally indicated in the map in Appendix 9.1 of this Public Rule are hereby designated as a Critical Drainage Area because:

6.1.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road (Concern 5.3.2.1 of this Public Rule),

6.1.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow (Concern 5.3.2.2 of this Public Rule), and

6.1.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage (Criteria 5.3.2.3 in this Public Rule).

6.2 Applications for development proposals within this Critical Drainage Area may be exempt from the more stringent Critical Drainage Area requirements if they demonstrate to the satisfaction of the Manager that the Critical Drainage Area mapping of the proposed development area is in error because one or more of these conditions exist:

6.2.1 On-site surface and storm water runoff drainage (or off-site surface and storm water runoff entering the drainage facility system) does not in fact drain over steep slopes;

6.2.2 The drainage pathway is not underlain by erodable granular soils anywhere along its route within the Critical Drainage Area; and/or

6.2.3 The site is underlain by permeable soils that will infiltrate and dissipate surface and storm water runoff even after clearing and development, without risk of instability to any adjacent steep slopes.

6.3 Development proposals in this Critical Drainage Area must be submitted with a drainage plan prepared by a professional civil engineer that meets each of the following conditions, unless the conditions identified in Policy 6.2 are documented to the satisfaction of the Manager:

6.3.1 Surface and storm water runoff detention shall be computed using a SCS based hydrograph method (or other method as subsequently approved by King County). The performance of proposed detention facilities (as illustrated in Appendix 9.2) shall be such that discharge from the developed area shall be no more than:

6.3.1.1 Fifty percent of the forested two-year/24-hour release rate for design storm events up to and including the two-year/24-hour design storm event;

6.3.1.2 The forested two-year/24-hour release rate for design storm events greater than the two year/24-hour design storm event and up to and including the 10-year/24-hour design storm event; and

6.3.1.3 The forested ten-year/24-hour release rate for design storm events greater than the 10-year/24-hour design storm event and up to and including the 100-year/24-hour design storm event.

These rate controls may be modified if discharge is conveyed via a continuous welded storm pipe to a suitably stabilized release point, with adequate energy dissipation below the area of severe erosion potential.

6.3.2 For purposes of the computations required in Policy 6.3.1, predevelopment conditions will be assumed to be totally forested and developed conditions will assume 100% removal of forest canopy within the area of the development (unless expressly prohibited by recorded easement or restriction) as well as existing, proposed, and anticipated impervious surfaces. Detention facilities must be located to accommodate surface and storm water runoff from all areas of planned or potential clearing and/or construction.

6.3.3 Point discharge from detention systems will be only into drainage channels that previously conveyed surface and storm water runoff in the predevelopment state. No point discharge shall be permitted onto or upstream of steep slopes where erodable granular deposits lie anywhere downstream of that point discharge. Dispersed discharge, onto undisturbed low-gradient uplands may be evaluated as a potential alternative. An undisturbed buffer between the

dispersed discharge and the steep sideslopes must be adequate to ensure infiltration of surface and storm water runoff into the ground. Determining and documenting that adequacy to the satisfaction of the Manager is the responsibility of the applicant's professional civil engineer.

6.3.4 Surface and storm water runoff entering any component of the on-site drainage facility system from developed upstream areas must be detained and released under the same criteria as runoff generated on-site.

6.4 If any portion of this Public Rule or its application to any person or property is held invalid, the remainder of this Public Rule or the application of the provision to other persons or property shall not be affected.

6.5 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objectives and purposes for which it was adopted.

7.0 GENERAL PROCEDURES

Responsibility	Action
BALD	7.1 Identifies that the proposed development is in a Critical Drainage Area.
BALD	7.2 Informs applicant that the proposed development is in a Critical Drainage Area.

Applicant

7.3 Submits additional application information which either:

7.3.1 Demonstrates that the application qualifies for the exemption in Policy 6.2; or

7.3.2 Complies with Policy 6.3.

BALD

7.4 Reviews the materials submitted in step 7.3 and determines if it complies with this Critical Drainage Area Public Rule.

7.4.1 Returns inadequate material to the applicant with specific instructions to comply with step 7.3.

7.4.2 Forwards adequate application to be processed according to the established review process.

8.0 RESPONSIBILITIES

8.1 The Surface Water Management Division is responsible for:

8.1.1 Amending this Critical Drainage Area Public Rule if boundaries or requirements of this Critical Drainage Area Public Rule warrant alteration.

8.1.2 Updating the Critical Drainage Area map at the BALD permit center as new information becomes available.

8.2 The Building and Land Development Division is responsible for:

8.2.1 Identifying each development application which is within a Critical Drainage Area.

8.2.2 Determining if the material submitted by the applicant complies with either Policy 6.2 or Policy 6.3 of this Public Rule.

8.3 The applicant is responsible, at a minimum, for:

8.3.1 Demonstrating that the area of the proposed development complies with Policy 6.2 or with the requirements in Policy 6.3 of this Public Rule.

9.0 APPENDICES

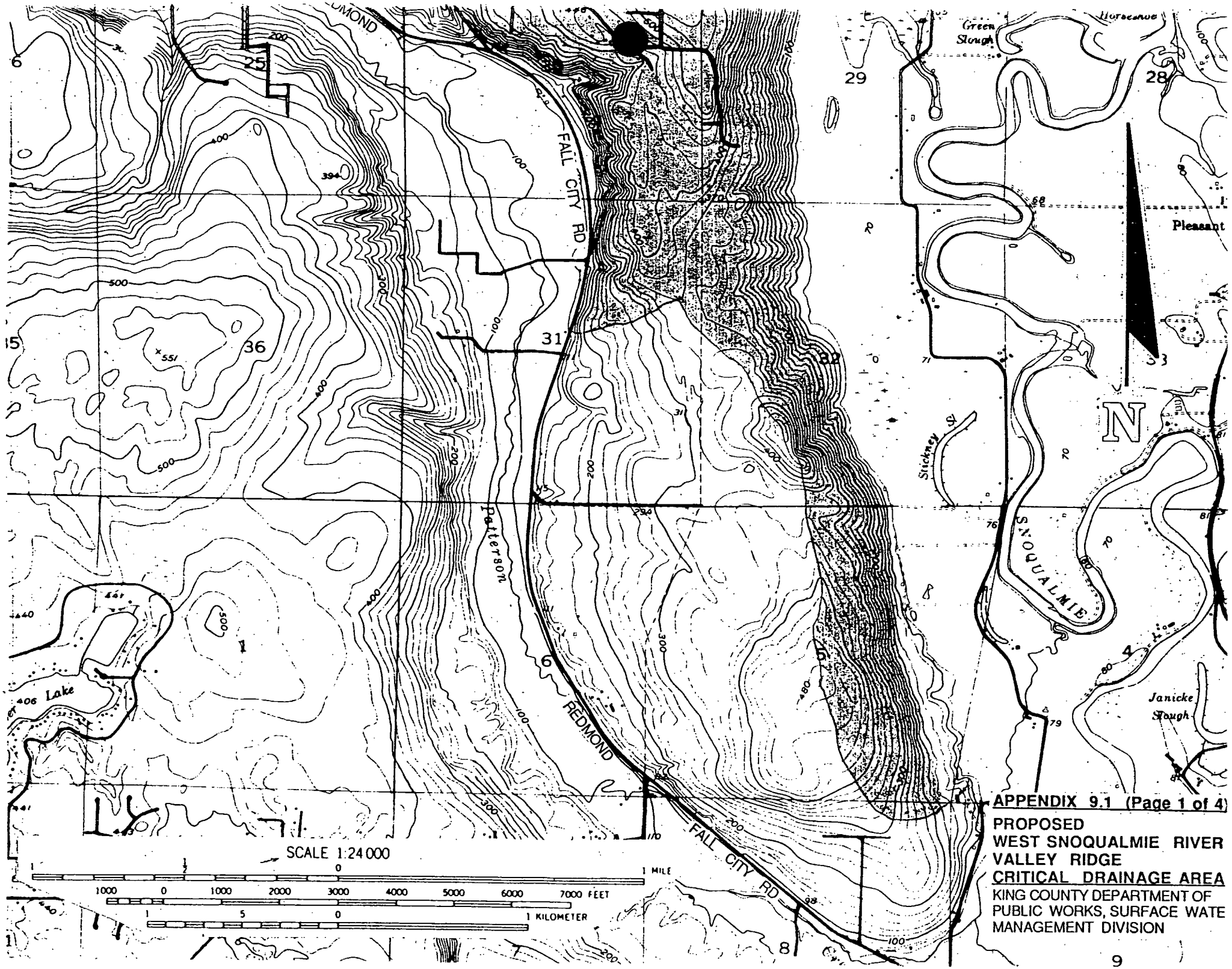
9.1 Map of the West Snoqualmie Valley Ridge Critical Drainage Area. Precise borders of this Critical Drainage Area are indicated on the Critical Drainage Area map at the BALD permit center.

9.2 Illustration of Policy 6.3.1.

APPENDIX 9.1

MAP OF THE WEST SNOQUALMIE VALLEY RIDGE CRITICAL DRAINAGE AREA

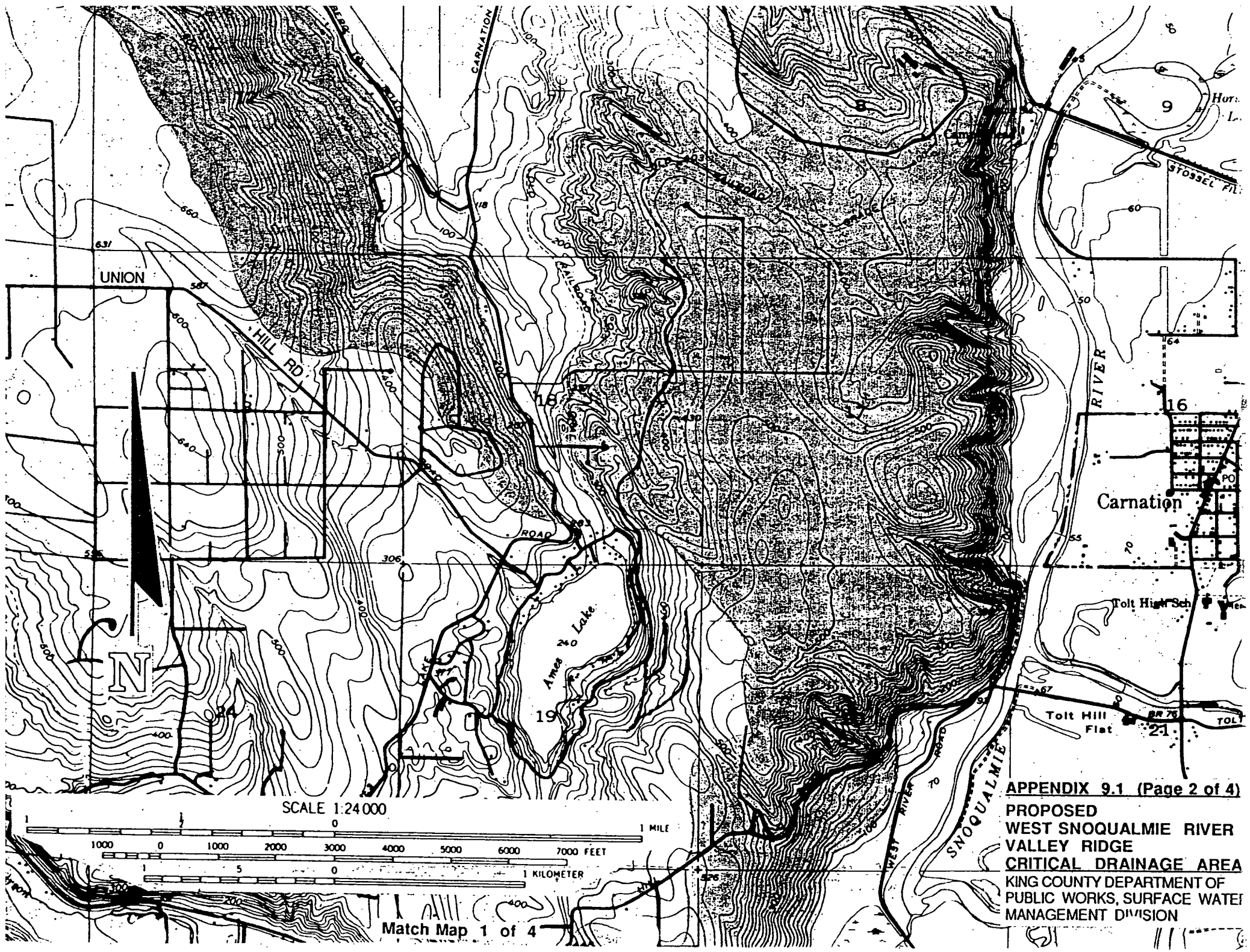
(4-PAGE MAP ATTACHED)



APPENDIX 9.1 (Page 1 of 4)

PROPOSED
WEST SNOQUALMIE RIVER
VALLEY RIDGE
CRITICAL DRAINAGE AREA

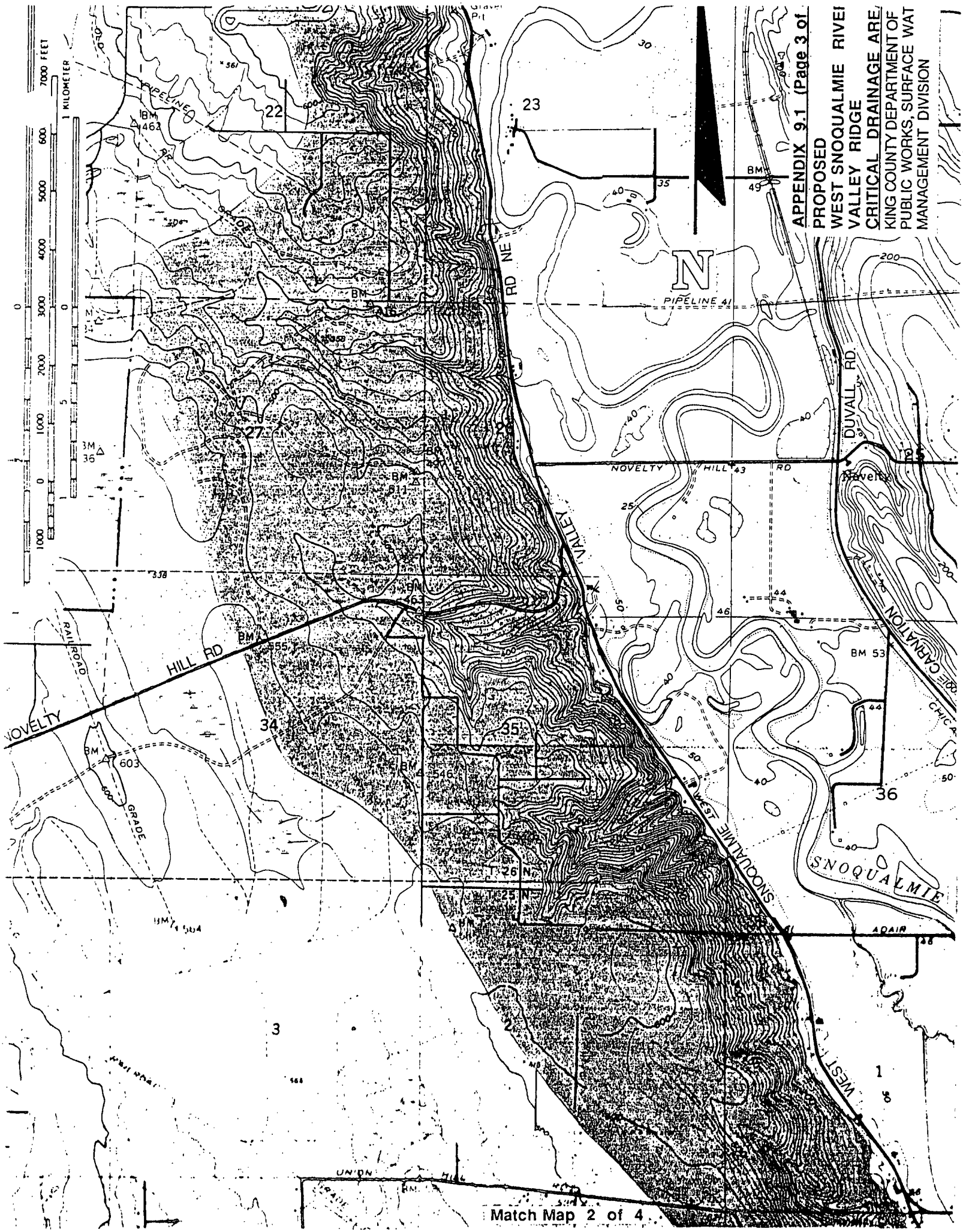
KING COUNTY DEPARTMENT OF
PUBLIC WORKS, SURFACE WATE
MANAGEMENT DIVISION



APPENDIX 9.1 (Page 2 of 4)

PROPOSED WEST SNOQUALMIE RIVER VALLEY RIDGE CRITICAL DRAINAGE AREA

KING COUNTY DEPARTMENT OF PUBLIC WORKS, SURFACE WATER MANAGEMENT DIVISION


APPENDIX 9.1 (Page 3 of
PROPOSED
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VALLEY RIDGE
CRITICAL DRAINAGE ARE
KING COUNTY DEPARTMENT OF
PUBLIC WORKS, SURFACE WAT
MANAGEMENT DIVISION
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1 KILOMETER
PIPELINE
PIPELINE 41
NOVELTY HILL RD
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DUVALL RD.
Novelty
VALLEY RD NE
WEST SNOQUALMIE
CARNATION
SNOQUALMIE
RAILROAD
GRADE
ADAIR
UNION HILL
T 26 N
T 25 N
22
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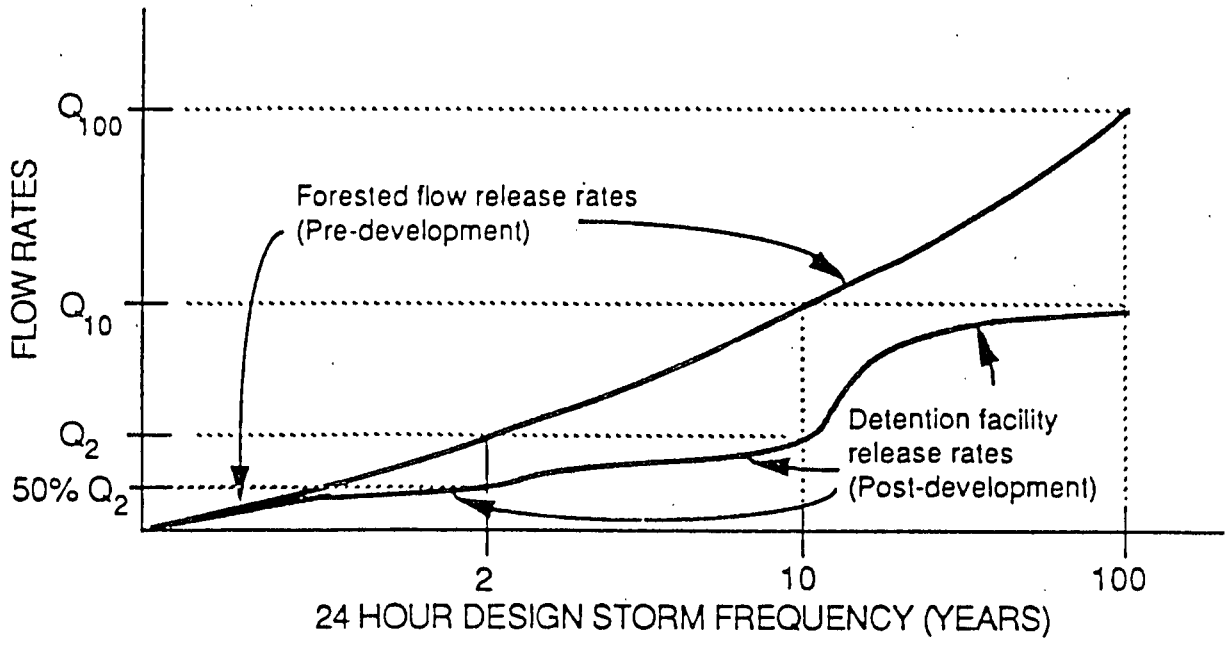
Match Map 2 of 4

APPENDIX 9.1 (Page 4 of 4)
PROPOSED
WEST SNOQUALMIE RIVER
VALLEY RIDGE
CRITICAL DRAINAGE AREA
KING COUNTY DEPARTMENT OF
PUBLIC WORKS, SURFACE WATER
MANAGEMENT DIVISION
N
SNOHOMISH CO
KING CO
NE WOODINVILLE DUVALL RD
SNOQUALMIE VALLEY RD NE
WEST
Big Bend
Cherry Valley School
DUVALL
Gravel Pit
Ring Hill
Tuck Creek
Creek
HIGH BRIDGE
1 KILOMETER
7000 FEET
Match Map 3 of 4

APPENDIX 9.2

DETENTION FACILITY PERFORMANCE REQUIREMENTS



* Note, detention facility hydrographic analysis is only required for the 2-, 10-, and 100-year/24-hour duration design storms (SCS Type 1A distribution)

King County
Public Rules

Title
Northshore Critical Drainage Area Designation

Document Code No
PUT 8-4 (PR)
09.04.050

Department/Issuing Agency
Department of Public Works/Surface Water Division

Effective Date
August 22, 1991

Title	Document Code No
Northshore Critical Drainage Area Designation	PUT 8-4 (PR) KCPR 09.04.050. Page 1 of 10
Department/Issuing Agency Department of Public Works/Surface Water Management Division	Effective Date August 22, 1991
Approved	

1.0 SUBJECT TITLE: Northshore Critical Drainage Area Designation

1.1 EFFECTIVE DATE: August 22, 1991

1.2 TYPE OF ACTION: This is a new Public Rule.

1.3 KEY WORDS: (1) Critical Drainage Area Designation; (2) Drainage Problem; (3) Northshore Community Planning Area; (4) East Lake Washington; (5) Development Restriction; (6) Juanita Creek; (7) Sammamish River.

2.0 PURPOSE: To designate the Northshore Critical Drainage Area and to establish a standard procedure for reviewing applications for development within this Critical Drainage Area in order to preserve the health, safety, and welfare of the general public. The intent of this Rule is to limit the magnitude and duration of post-development flows to their pre-development levels.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of the Northshore Critical Drainage Area.

3.2 Developers

3.3 Department of Parks, Planning and Resources, Building and Land Development Division

3.4 Department of Public Works, Surface Water Management Division, Roads and Engineering Division

4.0 REFERENCES: King County Charter § 850; King County Code 2.16.040.B.4.g; King County Code 9.04; King County Code 2.98; King County Code 21.54; Surface Water Design Manual; Bear Creek Basin Plan.

5.0 DEFINITIONS:

5.1 "BALD" means the Building and Land Development Division of the King County Department of Parks, Planning and Resources.

5.2 "Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98. This designation is based on the observation or prediction, using standard hydrological methods, of one or more of the following concerns and the need for more specific regulations than the Countywide standards in order to mitigate the impacts of proposed developments.

5.2.1 Flooding Concerns:

5.2.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years; and/or

5.2.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years.

5.2.2 Erosion/sedimentation Concerns:

5.2.2.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road;

5.2.2.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow; and/or

5.2.2.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage.

5.3 "Design storm event" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

5.4 "Detention" means release of surface and storm water runoff from the site at a slower rate than it is collected by the drainage facility system, the difference being held in temporary storage.

5.5 "Development" means any activity that requires a permit, included but not limited to a building permit, a grading permit, a shoreline substantial development permit, a conditional use permit, an unclassified use permit, a variance, a zone reclassification, a planned unit development, a subdivision, a short subdivision, a master plan development, a building site plan, or a right-of-way use permit.

5.6 "Drainage" refers to the collection, conveyance, containment, and/or discharge of surface and storm water runoff.

5.7 "Drainage channel" means a drainage pathway with well-defined bed and banks indicating frequent conveyance of surface and storm water runoff.

5.8 "Drainage facility" means the system of collecting, conveying and storing surface and storm water runoff. Drainage facilities shall include but not be limited to all surface and storm water runoff conveyance and containment facilities within the drainage area including streams, pipelines, channels, ditches, swamps, lakes, wetlands, closed depressions, infiltration facilities, retention/detention facilities and other drainage structures and appurtenances, both natural and manmade.

5.9 "Drainage review" means an evaluation by Building and Land Development Division staff of a proposed project's compliance with the drainage requirements in the Surface Water Design Manual.

5.10 "Erosion" means detachment of soil or rock fragments by water, wind, ice, and gravity.

5.11 "Erosion/sedimentation control facility" means a type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and storm water runoff directed to the facility to settle out so as to improve the quality of the runoff.

5.12 "Impervious surface" means a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development, and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of surface and storm water runoff. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of this Public Rule.

5.13 "Manager" means the Manager of Building and Land Development Division of the King County Department of Parks, Planning, and Resources or his designee.

5.14 "On-site" means the entire property that includes the proposed development.

5.15 "Prediction" means an expected outcome based on the results of hydrologic modeling and/or the judgment of a trained professional engineer or geologist.

5.16 "Professional Civil Engineer" means a person registered with the State of Washington as a professional engineer in civil engineering.

5.17 "Release rate" means the computed peak rate of surface and storm water runoff for a particular design storm event and drainage area conditions.

5.18 "Retention/detention facility" means a type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration and/or infiltration into the ground; or to hold surface and storm water runoff for a short period of time and then release it to the natural watercourse.

5.19 "SCS" means Soil Conservation Service, U.S. Department of Agriculture.

5.20 "SCS Method" means a hydrologic analysis based on the "Curve Number" method (National Engineering Handbook - Section 4: Hydrology, August, 1972) and using any acceptable analytical technology as delineated in the King County Surface Water Design Manual.

5.21 "Sedimentation" means the depositing or formation of sediment.

5.22 "Site" means the portion of a piece of property that is directly subject to development.

5.23 "Surface and storm water runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

5.24 "Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff analysis and design requirements, procedures and guidance which is formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual is available from the BALD permit center.

6.0 POLICIES

6.1 Those portions of the Northshore drainage basin identified in the Critical Drainage Area map at the BALD permit center and generally indicated in the map in Appendix 9.1 of this Public Rule are hereby designated as a Critical Drainage Area because:

6.1.1 Erosion/sedimentation has caused and is predicted to cause a blockage or washout of an arterial road (Concern 5.2.2.1 of this Public Rule),

6.1.2 Erosion/sedimentation has caused or is predicted to cause flooding of a residential or commercial structure (Concern 5.2.2.2 of this Public Rule), and

6.1.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage (Concern 5.2.2.3 of this Public Rule).

6.2 Applications for development proposals within this Critical Drainage Area may be exempt from the more stringent Critical Drainage Area requirements if they demonstrate to the satisfaction of the Manager that :

6.2.1 The Critical Drainage Area mapping of the proposed development area is in error because on-site surface and storm water runoff drainage does not in fact drain into the erodible drainage basins mapped in Appendix 9.1 as part of the Northshore Community Planning Area; or

6.2.2 The proposed development will add less than 5,000 square feet of impervious surface to a single dwelling lot and clear less than one-half acre of existing native vegetation.

6.3 Development proposals in this Critical Drainage Area must be submitted with a drainage plan prepared by a professional civil engineer that meets each of the following conditions (6.3.1 to 6.3.6) unless the conditions identified in Policy 6.2 are documented to the satisfaction of the Manager.

6.3.1 The proposed stormwater facilities must meet one of the following three standards:

6.3.1.1 Surface and storm water runoff detention shall be computed using a SCS-based hydrograph method (or other method as subsequently approved by King County). The performance of proposed detention facilities shall be such that discharge from the developed area shall be no more than seventy percent of the pre-development two-year/24-hour release rate for design storm events up to and including the 100-year/24-hour design storm event;

OR

6.3.1.2 Discharge from the developed site shall not exceed pre-development flow peaks and flow durations for all discharges greater than or equal to one-half of the two-year pre-development discharge, as determined by hydrologic analysis using a continuous hydrologic model such as the Hydrologic Simulation Program - Fortran (HSPF);

OR

6.3.1.3 Discharge shall be conveyed via a continuous welded storm pipe to a suitably stabilized release point, with adequate energy dissipation, below the area of severe erosion potential.

6.3.2 The volume of all facilities designed to this standard must be sufficient to contain the 100-year/24-hour storm event.

6.3.3 A drainage control system, as approved by BALD, shall be installed prior to any unrelated land clearing, vegetation removal, site-grading, road construction or utility installation. Only those activities associated with pre-development exploration, such as surveying and performance soil tests and limited clearing and grading associated with construction of drainage facilities, will be permitted prior to construction of the drainage control system.

6.3.4 In those situations where features of the drainage system or subsequent development make installation of the final drainage system impossible, a phased drainage control plan shall be developed. This phased plan shall provide the level of retention/detention set forth in the applicable detention standard for the entire site at all times.

6.3.5 For purposes of the computation required in Policy 6.3.1, pre-development conditions will be assumed to be totally forested and developed conditions will assume 100 percent removal of forest canopy within the area of the development (unless expressly prohibited by recorded easement or restriction) as well as existing, proposed, and anticipated impervious surfaces. Detention facilities must be located to accommodate surface and storm water runoff from all areas of planned or potential clearing and/or construction.

6.3.6 Point discharge from detention systems will be only into drainage channels that previously conveyed surface and storm water runoff in the pre-development state. No point or dispersed discharge shall be permitted onto or upstream of steep slopes where erodible granular deposits lie anywhere downstream of that discharge.

6.4 If any portion of this Public Rule or its application to any person or property is held invalid, the remainder of this Public Rule or the application of the provision to other persons or property shall not be affected.

6.5 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objectives and purposes for which it was adopted.

7.0 GENERAL PROCEDURES

Responsibility	Action
BALD	7.1 Identifies that the proposed development is in a Critical Drainage Area.
BALD	7.2 Informs applicant that the proposed development is in a Critical Drainage Area.
Applicant	7.3 Submits additional application information which either:
	7.3.1 Demonstrates that the application qualifies for the exemption in Policy 6.2; or
	7.3.2 Complies with Policy 6.3.
BALD	7.4 Reviews the materials submitted in step 7.3 and determines if it complies with this Critical Drainage Area Public Rule.
	7.4.1 Returns inadequate material to the applicant with specific instructions to comply with step 7.3.
	7.4.2 Forwards adequate application to be processed according to the established review process.

8.0 RESPONSIBILITIES

8.1 The Surface Water Management Division is responsible for:

8.1.1 Amending this Critical Drainage Area Public Rule if requirements of this Critical Drainage Area Public Rule warrant alteration.

8.2 The Building and Land Development Division is responsible for:

8.2.1 Identifying each development application which is within a Critical Drainage Area.

8.2.2 Determining if the material submitted by the applicant complies with either Policy 6.2 or Policy 6.3 of this Public Rule.

8.3 The applicant is responsible, at a minimum, for:

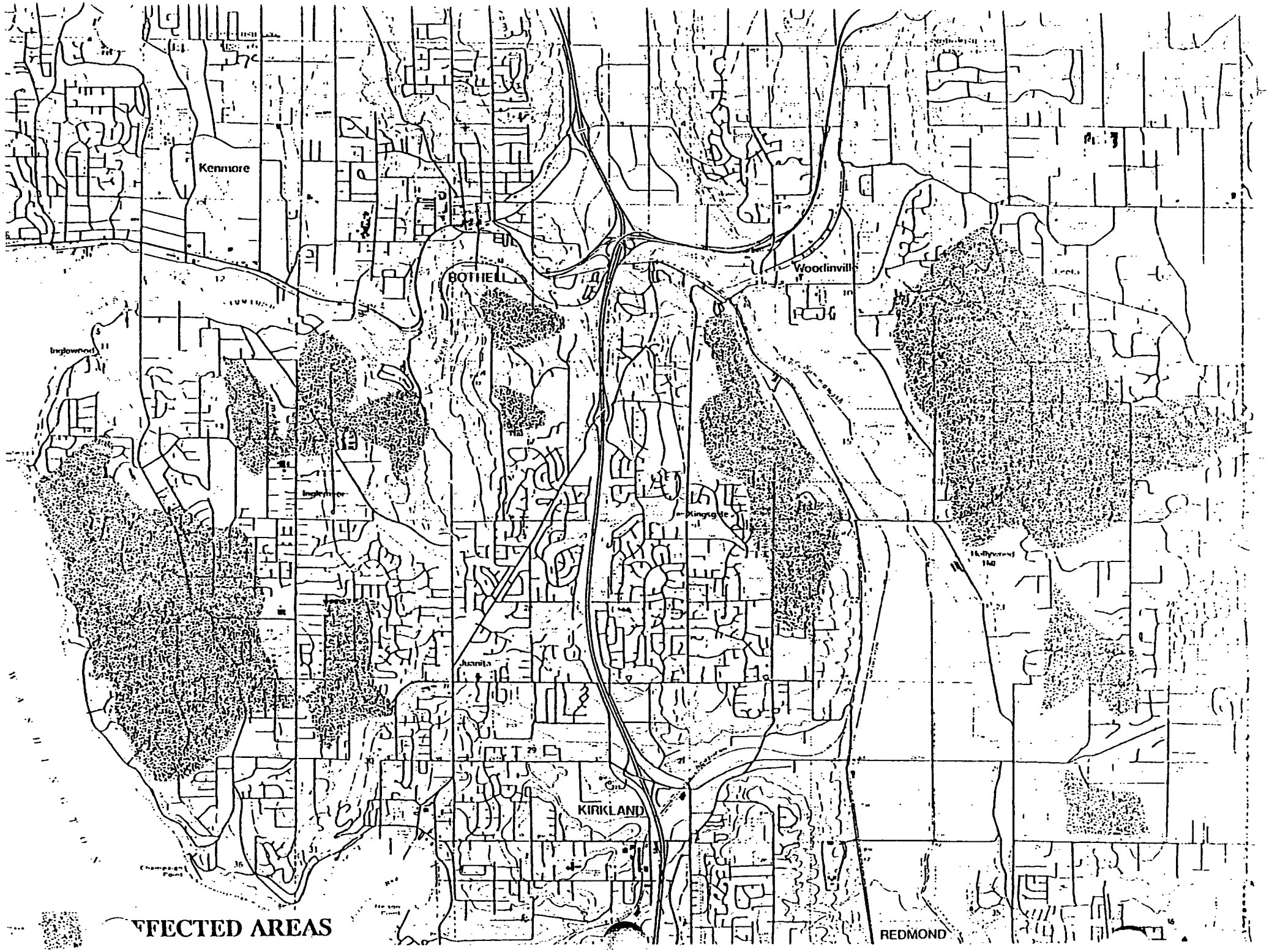
8.3.1 Demonstrating that the area of the proposed development complies with Policy 6.2 or with the requirements in Policy 6.3 of this Public Rule.

9.0 APPENDICES

9.1 Map of the Northshore Critical Drainage Area. More precise borders of this Critical Drainage Area are indicated on the Critical Drainage Area map at the BALD permit center.

APPENDIX 9.1

MAP OF THE NORTHSHORE CRITICAL DRAINAGE AREA


Kenmore
BOTHELL
Woodinville
Inglewood
Juanita
Kingsgate
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REDMOND
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CLERK
KING COUNTY COUNCIL

King County
Public Rules

Title	Document Code No.
MAY CREEK CRITICAL DRAINAGE AREA	KCPR09.04.050 PUT 8-6 (PR)
Department/Issuing Agency	**Effective Date**
DEPT. of PUBLIC WORKS/ SURFACE WATER MANAGEMENT DIVISION	April 22, 1993

King County
Public Rules and Regulations

Public Rules

Title	Document Code No.
MAY CREEK Critical Drainage Area	KCPR 09.04.050 PUT 8-6 (PR)
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	April 22, 1993
Approved 3/18/93	

1.0 SUBJECT TITLE: MAY CREEK Critical Drainage Area

1.1 EFFECTIVE DATE: Thirty days after filing with the Clerk of the King County Council.

1.2 TYPE OF ACTION: This is a new Public Rule.

1.3 KEY WORDS: (1) Critical Drainage Area Designation; (2) Drainage Problem; (3) Development Restriction; (4) May Creek; (5) Coal Creek/Newport Hills; (6) Newcastle Community Plan

2.0 PURPOSE: To designate the May Creek Critical Drainage Area and to establish a standard procedure for reviewing applications for development within this Critical Drainage Area in order to preserve the health, safety and welfare of the general public.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of the May Creek Critical Drainage Area

3.2 Developers

3.3 Department of Development and Environmental Services

3.4 Department of Parks, Planning and Resources

3.5 Department of Public Works: Surface Water Management Division, Roads and Engineering Division, Solid Waste Division

4.0 REFERENCES: King County Charter section 850; King County Code 2.16.040.B.4.g; King County Code 9.04, King County Code 2.98; King County Code 21.54; Surface Water Design Manual.

5.0 DEFINITIONS: In addition to the definitions listed in Section 5 of this Public Rule, all definitions included in the King County Surface Water Design Manual are hereby adopted by reference.

5.1 "Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98. This designation is based on the observation or prediction, using standard hydrological methods, of one or more of the following concerns and the need for more specific regulations than the Countywide standards in order to mitigate the impacts of projects.

5.1.1 Flooding Concerns:

5.1.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years; and/or

5.1.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years.

5.1.2 Erosion/sedimentation Concerns:

5.1.2.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road;

5.1.2.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow; and/or

5.1.2.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage.

5.2 "DDES" means the Department of Development and Environmental Services.

5.3 "Design storm event" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

5.4 "Director" means the Director of the Department of Development and Environmental Services or the Director's designee.

5.5 "Drainage control system" means a temporary drainage system which provides the level of retention/detention specified in Policy 6.4 for the entire site at all times during construction.

5.6 "Drainage plan" means a plan for receiving, transporting and discharging surface and storm water runoff as specified in the Surface Water Design Manual.

5.7 "Infiltration" means the hydrologic process of surface and storm water runoff soaking into the ground and is commonly referred to as percolation.

5.8 "On-site" means the entire property that includes the project.

5.9 "Surface and storm water runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

5.10 "Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff analysis and design requirements, procedures and guidance which is formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual is available from the DDES permit center.

6.0 POLICIES

6.1 The MacDonald Creek drainage basin, generally identified on the Critical Drainage Area map at the DDES permit center and the map (Appendix 9.1) of this Public Rule, is hereby designated as a Critical Drainage Area because:

6.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years (Concern 5.1.1.1 of this Public Rule).

6.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years (Concern 5.1.1.2 of this Public Rule).

6.1.3 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road (Concern 5.1.2.1 of this Public Rule).

6.1.4 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow (Concern 5.1.2.2 of this Public Rule).

6.1.5 Erosion/sedimentation has caused or is predicted to cause significant habitat damage (Concern 5.1.2.3 of this Public Rule).

6.2 The standards specified in Policy 6.4 of this Public Rule apply to all development proposals which require drainage review as specified in the King County Surface Water Design Manual. Unless otherwise specified in this Public Rule, all Surface Water Design Manual thresholds apply.

6.3 Development proposals within this Critical Drainage Area may be exempt from these Critical Drainage Area requirements if they demonstrate to the satisfaction of the Director that on-site surface and storm water runoff drainage does not in fact drain into the basin mapped in Appendix 9.1 of this Public Rule.

6.3.1 Development proposals within this Critical Drainage Area are exempt from the standards specified in Policy 6.4 if the project will add less than 5,000 square feet of impervious surface to a lot intended for single-family residential use.

6.4 Engineering plans for projects located within this Critical Drainage Area must meet the following conditions, unless the conditions identified in Policy 6.2 are documented to the satisfaction of the Director.

6.4.1 The proposed storm water facilities must meet one of the following standards:

6.4.1.1 Surface and storm water runoff detention shall be computed using an SCS-based hydrograph method (or other method as subsequently approved by King County). The performance of proposed detention facilities shall be such that discharge from the developed area shall be no more than one-half (50 percent) of the pre-development two-year/24-hour release rate for design storm events up to and including the two-year/24-hour design storm event, the pre-development two-year/24-hour release rate for all design storm events up to and including the ten-year/24-hour design storm event and the pre-development ten-year/24-hour release rate for all design storm events up to and including the 100-year/24-hour design storm event. The storage volume so calculated shall be increased by a safety factor of 30 percent as required by the King County <u>Surface Water Design Manual</u>;

OR

6.4.1.2 As determined by hydrologic analysis using a continuous hydrologic model such as the Hydrologic Simulation Program - Fortran (HSPF), post-development flow durations shall not exceed pre-development flow durations for all flows greater than one-half (50 percent) of the two-year event and less than the 50-year event. In addition, the 100-year post-development peak flow rate shall not exceed pre-development levels.

6.4.2 The detention standards in 6.4.1 will terminate upon adoption of the May Creek Basin Plan.

6.5 A drainage control system, as approved by the Department of Development and Environmental Services, or, in the case of public works facilities, as approved by the Surface Water Management Division, shall be installed prior to any land clearing, vegetation removal, site grading, road construction, or utility installation, except that those activities associated with pre-development exploration, such as surveying and performing soil tests, and limited clearing and grading associated with construction of drainage facilities, will be permitted prior to construction of the drainage control system.

6.6 In those situations where features of the final drainage system or subsequent development make installation of the final drainage system impossible, a phased drainage control plan shall be developed. This phased plan shall provide the level of retention/detention set forth in the applicable detention standard for the entire site at all times.

6.7 Point discharge from detention systems shall be only into drainage channels that previously conveyed surface and storm water runoff in the pre-development state. No point or dispersed discharge shall be permitted onto or upstream of steep slopes where erodible granular deposits lie anywhere downstream of that discharge.

6.8 All commercial, subdivision, and short plat permits for projects located on rural zoned lands within this Critical Drainage Area must impose a clearing limitation for hydrologic, erosion, and water quality control such that a maximum of 35 percent of the total project area may be cleared and a minimum of 65 percent of the total project area must be retained in existing vegetative cover. These clearing limitations will terminate upon adoption of the May Creek Basin Plan.

6.9 The clearing restrictions in Policy 6.8 may be waived by the Director to provide for needed public services and facilities to accommodate growth. In such instances, on-site detention must be provided in accordance with the standards specified in Policies 6.4.1.1 or 6.4.1.2

6.10 If any portion of this Public Rule or its application to any person or property is held invalid, the remainder of this Public Rule or the application of the provision to other persons or property shall not be affected.

6.11 This Public Rule is exempt from the rule of strict construction and shall be liberally construed to give full effect to the objectives and purposes for which it was adopted.

7.0 GENERAL PROCEDURES

Responsibility		Action
DDES	7.1	Identifies that the project is in a Critical Drainage Area.
DDES	7.2	Informs applicant that the project is in a Critical Drainage Area.
Applicant	7.3	Submits additional information which either:
	7.3.1	Demonstrates that the project qualifies for the exemption in Policy 6.3; or
	7.3.2	Complies with Policy 6.4.
DDES	7.4	Reviews the materials submitted in step 7.3 and determines if it complies with this Critical Drainage Area Public Rule.
	7.4.1	Returns inadequate material to the applican with specific instructions to comply with step 7.3.
	7.4.2	Forwards adequate engineering plans to be processed according to the established review process.

8.0 RESPONSIBILITIES

8.1 The Surface Water Management Division is responsible for:

8.1.1 Amending this Critical Drainage Area Public Rule if requirements of this Critical Drainage Area Public Rule warrant alteration.

8.1.2 Updating the Critical Drainage Area map as new information becomes available.

8.2 The DDES is responsible for:

8.2.1 Identifying each project which is within a Critical Drainage Area.

8.2.2 Determining if the material submitted by the applicant complies with either Policy 6.3 or Policy 6.4 of this Public Rule.

8.3 The applicant is responsible, at a minimum, for:

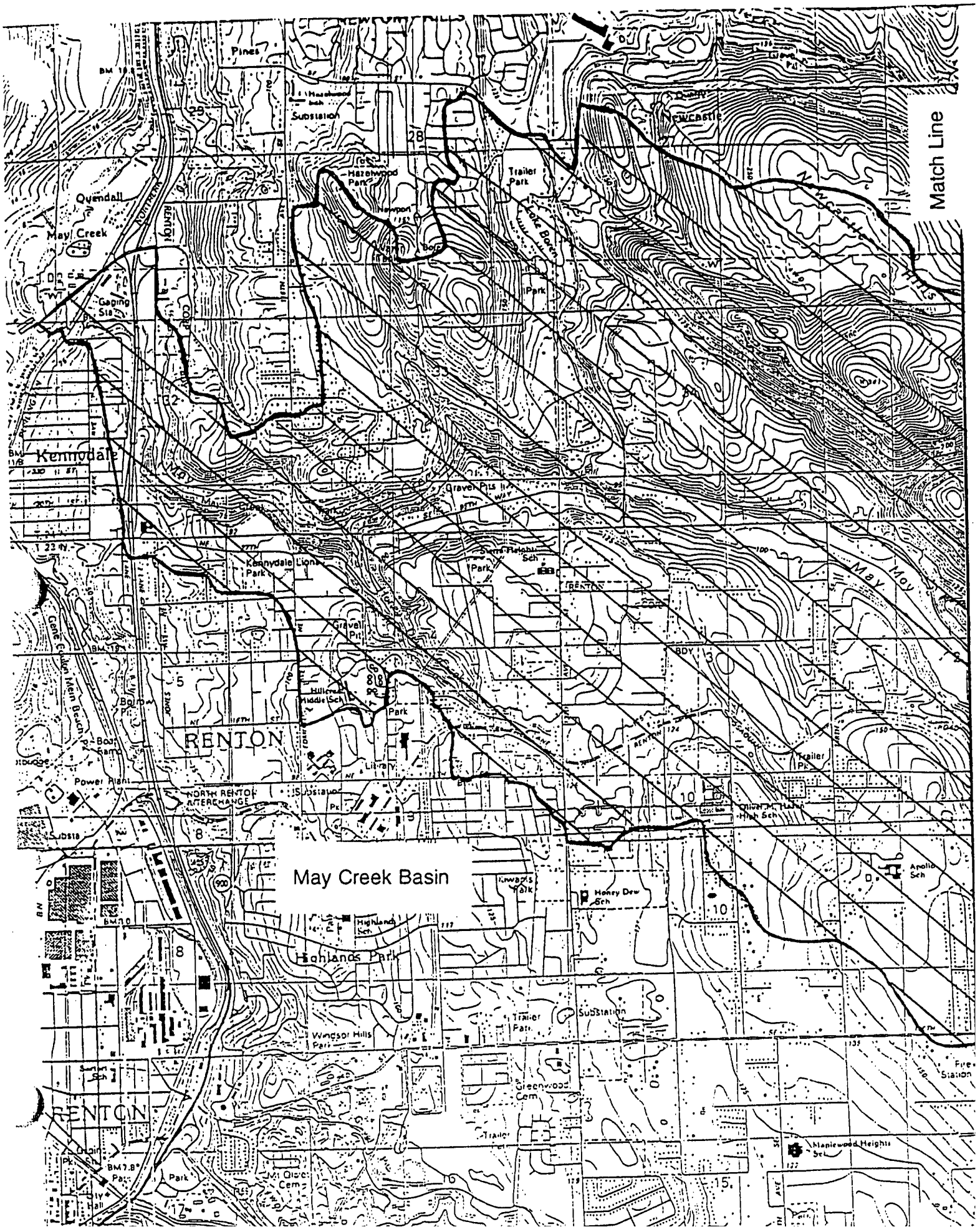
8.3.1 Demonstrating that the project complies with Policy 6.3 or with the requirements in Policy 6.4 of this Public Rule.

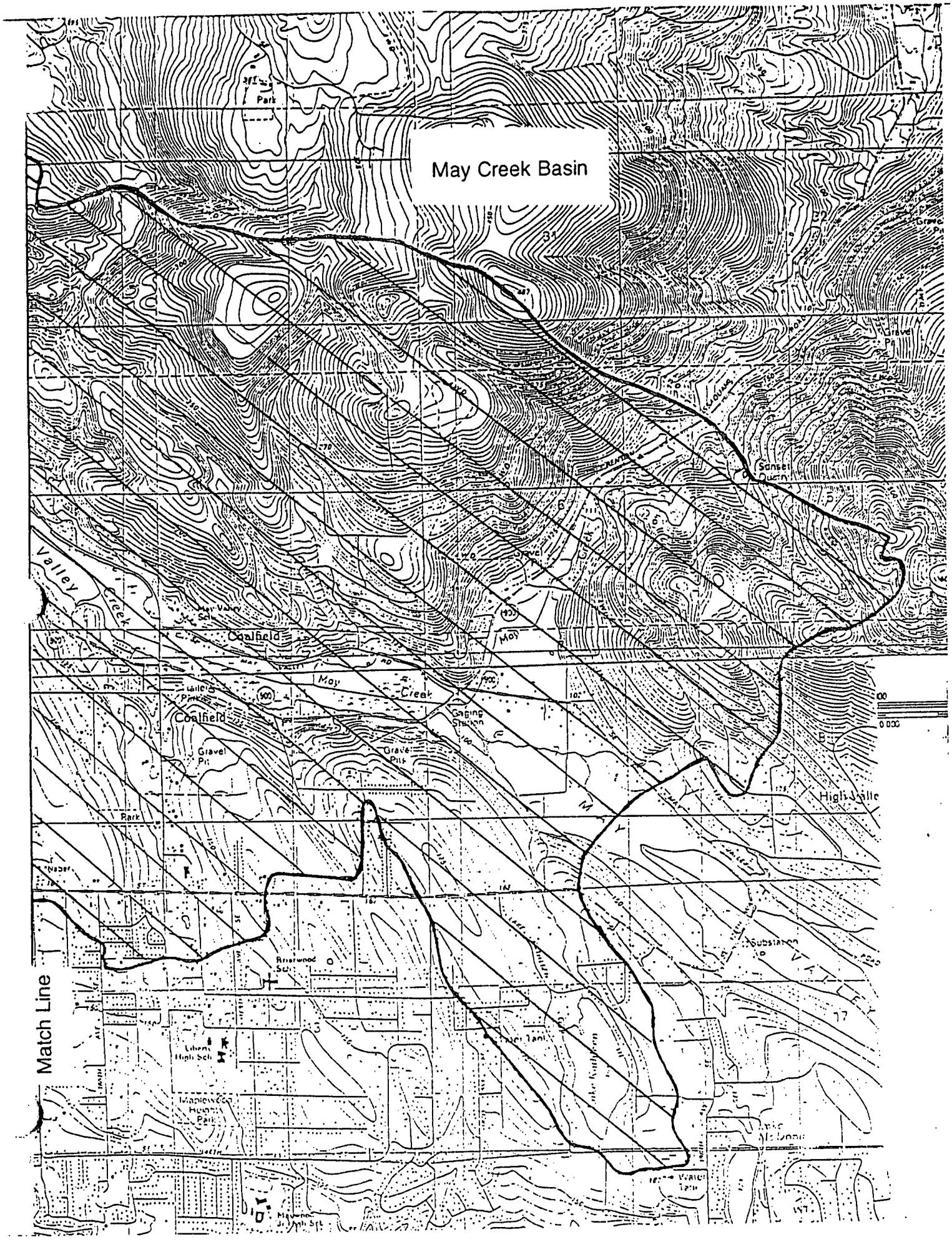
9.0 APPENDICES

9.1 Map of the May Creek Critical Drainage Area. Precise borders of this Critical Drainage Area are indicated on the Critical Drainage Area map at the DDES permit center.

APPENDIX 9.1

MAP


Match Line
May Creek Basin
Kennydale
RENTON
Highlands Park
Newcastle
Quendall
May Creek
Pines
Hazelwood Park
Trailer Park
Lake Boren
Gravel Pits
Kennydale Lions Park
Gravel Pit
Hillcrest Middle Sch
Library
Power Plant
NORTH RENTON INTERCHANGE
Substation
Honey Dew Sch
Apollo Sch
Highlands Sch
Windsor Hills Park
Greenwood Cem
Maplewood Heights Sch
Mt Olivet Cem
Gene Coulon Mem Beach
Gaging Sta
Newport
Park


May Creek Basin
Match Line
Coalfield
Coalfield
May Creek
Valley Creek
Gravel Pit
Gravel Pits
Gaging Station
Sunset Quarry
High Valle
Substation
Park
Briarwood Sch
Liberty High Sch
Maplewood Heights Park
Water Tank

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King County
Public Rules

Title	Document Code No.
MacDONALD CREEK CRITICAL DRAINAGE AREA	PUT 8-5 (PR) KCPR09.04.050
Department/Issuing Agency	**Effective Date**
DEPT. of PUBLIC WORKS/ SURFACE WATER MANAGEMENT DIVISION	April 22, 1993

King County
Public Rules and Regulations

Public Rules

Title	Document Code No.
MacDONALD CREEK Critical Drainage Area	PUT 8-5 (PR) KCPR 09.04.050
Department/Issuing Agency	**Effective Date**
Department of Public Works/Surface Water Management Division	April 22, 1993

Approved 3/18/93

1.0 SUBJECT TITLE: MacDONALD CREEK Critical Drainage Area

1.1 EFFECTIVE DATE: Thirty days after filing with the Clerk of the King County Council.

1.2 TYPE OF ACTION: This is a new Public Rule.

1.3 KEY WORDS: (1) Critical Drainage Area Designation; (2) Drainage Problem; (3) Development Restriction; (4) MacDonald Creek; (5) Coal Creek/Newport Hills; (6) Newcastle Community Plan

2.0 PURPOSE: To designate the MacDonald Creek Critical Drainage Area and to establish a standard procedure for reviewing applications for development within this Critical Drainage Area in order to preserve the health, safety and welfare of the general public.

3.0 ORGANIZATIONS AFFECTED:

3.1 Landowners and residents of the MacDonald Creek Critical Drainage Area

3.2 Developers

3.3 Department of Development and Environmental Services

3.4 Department of Parks, Planning and Resources

3.5 Department of Public Works: Surface Water Management Division, Roads and Engineering Division, Solid Waste Division

4.0 REFERENCES: King County Charter section 850; King County Code 2.16.040.B.4.g; King County Code 9.04, King County Code 2.98; King County Code 21.54; Surface Water Design Manual.

5.0 DEFINITIONS: In addition to the definitions listed in Section 5 of this Public Rule, all definitions included in the King County Surface Water Design Manual are hereby adopted by reference.

(E/AD:PRR4)

5.1 "Critical Drainage Area" means an area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in K.C.C. 2.98. This designation is based on the observation or prediction, using standard hydrological methods, of one or more of the following concerns and the need for more specific regulations than the Countywide standards in order to mitigate the impacts of projects.

5.1.1 Flooding Concerns:

5.1.1.1 First-floor flooding of a residential or commercial structure occurs or is predicted to occur more frequently than once every ten years; and/or

5.1.1.2 Flooding of an arterial road or over one foot of flooding on a residential or commercial access road occurs or is predicted to occur more frequently than once every ten years.

5.1.2 Erosion/sedimentation Concerns:

5.1.2.1 Erosion/sedimentation has caused or is predicted to cause a blockage or wash-out of an arterial road, residential or commercial access road;

5.1.2.2 Erosion/sedimentation has caused or is predicted to cause flooding or displacement of a residential or commercial structure by way of a landslide and/or debris flow; and/or

5.1.2.3 Erosion/sedimentation has caused or is predicted to cause significant habitat damage.

5.2 "DDES" means the Department of Development and Environmental Services.

5.3 "Design storm event" means a rainfall (or other precipitation) event or pattern of events for use in analyzing and designing drainage facilities.

5.4 "Director" means the Director of the Department of Development and Environmental Services or the Director's designee.

5.5 "Drainage control system" means a temporary drainage system which provides the level of retention/detention specified in Policy 6.4 for the entire site at all times during construction.

5.6 "Drainage plan" means a plan for receiving, transporting and discharging surface and storm water runoff as specified in the Surface Water Design Manual.

5.7 "Infiltration" means the hydrologic process of surface and storm water runoff soaking into the ground and is commonly referred to as percolation.

5.8 "On-site" means the entire property that includes the project.

5.9 "Surface and storm water runoff" means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water.

5.10 "Surface Water Design Manual" means the manual (and supporting documents as appropriate) describing surface and storm water runoff analysis and design requirements, procedures and guidance which is formally adopted by rule under the procedures specified in K.C.C. 2.98. The Surface Water Design Manual is available from the DDES permit center.

6.0 POLICIES

6.1 The MacDonald Creek drainage basin, generally identified on the Critical Drainage Area map at the DDES permit center and the map (Appendix 9.1) of this Public Rule, is hereby designated as a Critical Drainage Area because:

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6.1.5 Erosion/sedimentation has caused or is predicted to cause significant habitat damage (Concern 5.1.2.3 of this Public Rule).

6.2 The standards specified in Policy 6.4 of this Public Rule apply to all development proposals which require drainage review as specified in the King County Surface Water Design Manual. Unless otherwise specified in this Public Rule, all Surface Water Design Manual thresholds apply.

6.3 Development proposals within this Critical Drainage Area may be exempt from these Critical Drainage Area requirements if they demonstrate to the satisfaction of the Director that on-site surface and storm water runoff drainage does not in fact drain into the basin mapped in Appendix 9.1 of this Public Rule.

6.3.1 Development proposals within this Critical Drainage Area are exempt from the standards specified in Policy 6.4 if the project will add less than 5,000 square feet of impervious surface to a lot intended for single-family residential use.

6.4 Engineering plans for projects located within this Critical Drainage Area must meet the following conditions, unless the conditions identified in Policy 6.2 are documented to the satisfaction of the Director.

6.4.1 The proposed storm water facilities must meet one of the following standards:

6.4.1.1 Surface and storm water runoff detention shall be computed using an SCS-based hydrograph method (or other method as subsequently approved by King County). The performance of proposed detention facilities shall be such that discharge from the developed area shall be no more than one-half (50 percent) of the pre-development two-year/24-hour release rate for design storm events up to and including the two-year/24-hour design storm event, the pre-development two-year/24-hour release rate for all design storm events up to and including the ten-year/24-hour design storm event and the pre-development ten-year/24-hour release rate for all design storm events up to and including the 100-year/24-hour design storm event. The storage volume so calculated shall be increased by a safety factor of 30 percent as required by the King County Surface Water Design Manual;

OR

6.4.1.2 As determined by hydrologic analysis using a continuous hydrologic model such as the Hydrologic Simulation Program - Fortran (HSPF), post-development flow durations shall not exceed pre-development flow durations for all flows greater than one-half (50 percent) of the two-year event and less than the 50-year event. In addition, the 100-year post-development peak flow rate shall not exceed pre-development levels.

6.4.2 The detention standards in 6.4.1 will terminate upon adoption of th MacDonald Creek Basin Plan.

6.5 A drainage control system, as approved by the Department of Development and Environmental Services, or, in the case of public works facilities, as approved by the Surface Water Management Division, shall be installed prior to any land clearing, vegetation removal, site grading, road construction, or utility installation, except that those activities associated with pre-development exploration, such as surveying and performing soil tests, and limited clearing and grading associated with construction of drainage facilities, will be permitted prior to construction of the drainage control system.

6.6 In those situations where features of the final drainage system or subsequent development make installation of the final drainage system impossible, a phased drainage control plan shall be developed. This phased plan shall provide the level of retention/detention set forth in the applicable detention standard for the entire site at all times.

6.7 Point discharge from detention systems shall be only into drainage channels that previously conveyed surface and storm water runoff in the pre-development state. No point or dispersed discharge shall be permitted onto or upstream of steep slopes where erodible granular deposits lie anywhere downstream of that discharge.

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6.9 The clearing restrictions in Policy 6.8 may be waived by the Director to provide for needed public services and facilities to accommodate growth. In such instances, on-site detention must be provided in accordance with the standards specified in Policies 6.4.1.1 or 6.4.1.2

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9.0 APPENDICES

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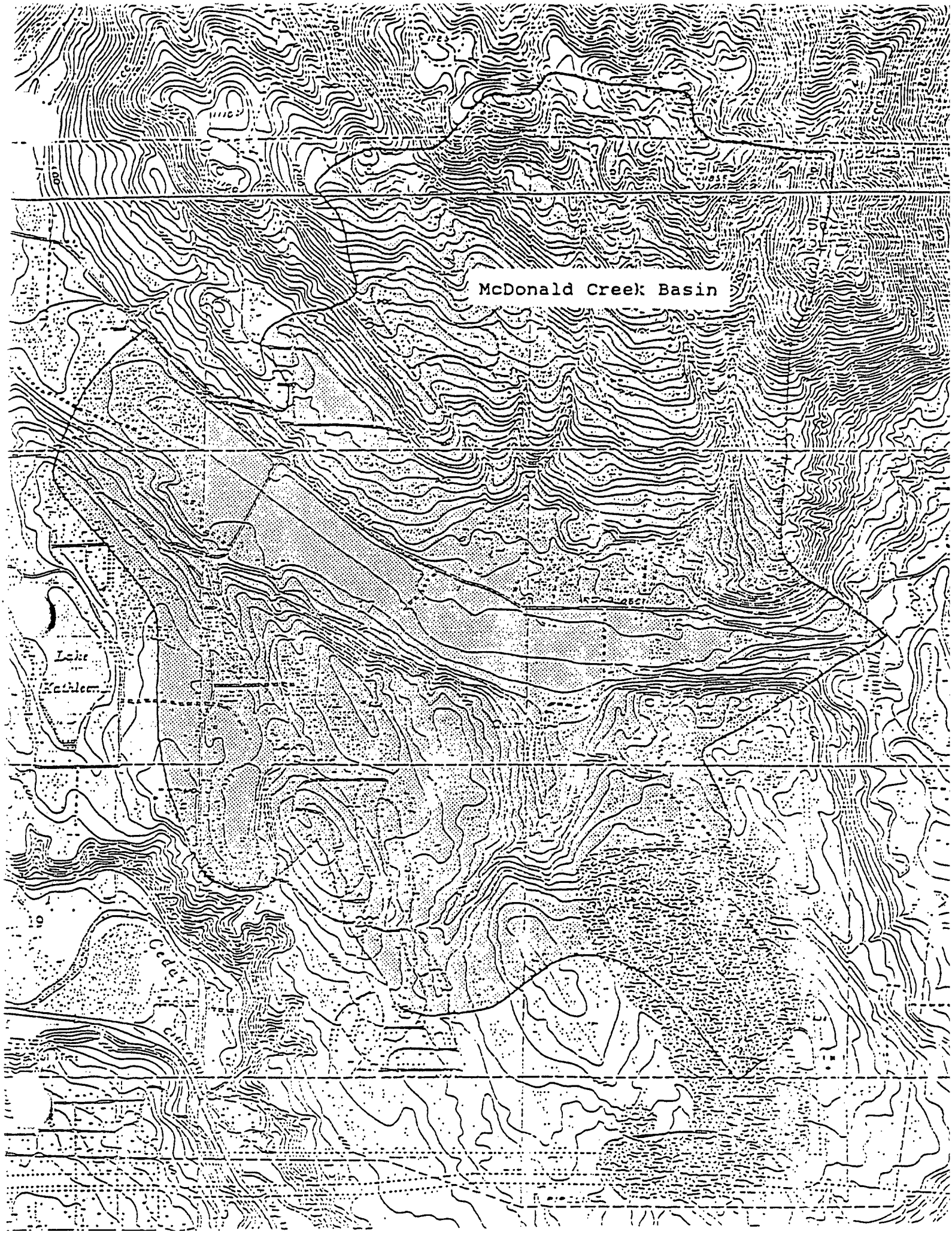
APPENDIX 9.1

MAP


McDonald Creek Basin
Lake
Kathleen
Cedar

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 4
OVERVIEW OF KING COUNTY SURFACE WATER POLICIES

OVERVIEW OF KING COUNTY SURFACE WATER POLICIES

This paper is provided for reference to the readers and users of the Surface Water Design Manual. Its purpose is to inform the reader as to some of the background policies from which the Manual was developed. It includes a summary of the King County Comprehensive Plan Policies related to and affecting surface water management, and the Surface Water Management Division's surface water system planning policies for new development and surface water quantity and quality control policies. A major objective in the preparation of the Surface Water Design Manual has been to provide the regulatory and technical means to implement these policies.

Several departments within King County have responsibility for development and implementation of surface water management policies. The Surface Water Management Division (SWM) of the Department of Public Works prepares Basin Plans and other policies to address issues of regional facilities planning and engineering, and the development and enforcement of drainage regulations. The Building and Land Development Division (BALD) of the Parks, Planning and Resources Department (Planning) performs the actual review of drainage plans for new development. The Natural Resources and Parks Division of Planning assists SWM in surface water management and assists the Planning and Community Development Division of Planning in the preparation of Community Plans. Basin Plans and Community Plans provide specific policies on which requirements are based. Community Plans provide detailed land use plans for local geographic areas. At the time of this printing, King County has established sixteen such geographic areas (see Figure 1). The Road Division publishes standards for drainage facilities constructed in King County road right-of-way.

Five major river basins are situated completely or partially in King County. These basins subdivide into sixty-seven subbasins (see Figure 2). In the basins with adopted Basin Plans, the drainage requirements may differ from standard King County requirements because of special geographic conditions and special solutions. In addition to providing special drainage requirements, the Basin Plans may include information useful in the preparation of drainage plans.

KING COUNTY COMPREHENSIVE PLAN

King County's Comprehensive Plan (Comp Plan) was adopted in 1985, setting forth the County's vision for land use in the County. The major policies directing land use are presented in the Comp Plan along with a series of maps identifying areas for which special requirements have been developed. Comp Plan policies which direct surface water management are presented in Chapter 4 of the Comp Plan. The Comp Plan provides the broadest definitions and direction for King County surface water management policy. As a result, many of the policies on which the requirements in this Manual are based originated in the Comp Plan. The Comp Plan is available for review in the BALD Division office.

The Comp Plan's overall approach to environmental protection encourages growth and development patterns compatible with natural features, and discourages alteration of natural features. Land use designations that realistically show natural constraints give an accurate indication of development potential, and allow public agencies to plan for services.

The following section describes the specific Comp Plan policies related to surface water management and requiring special consideration in land use decisions, as well as to those which reduce hazards and prevent adverse environmental impacts.

Comp Plan on General Environment

Policy E-301: Land use plans and zoning should reflect natural constraints.

Policy E-302: When environmentally sensitive features are discovered through technical review of a development proposal, the need to protect the sensitive features should be factored into site planning.

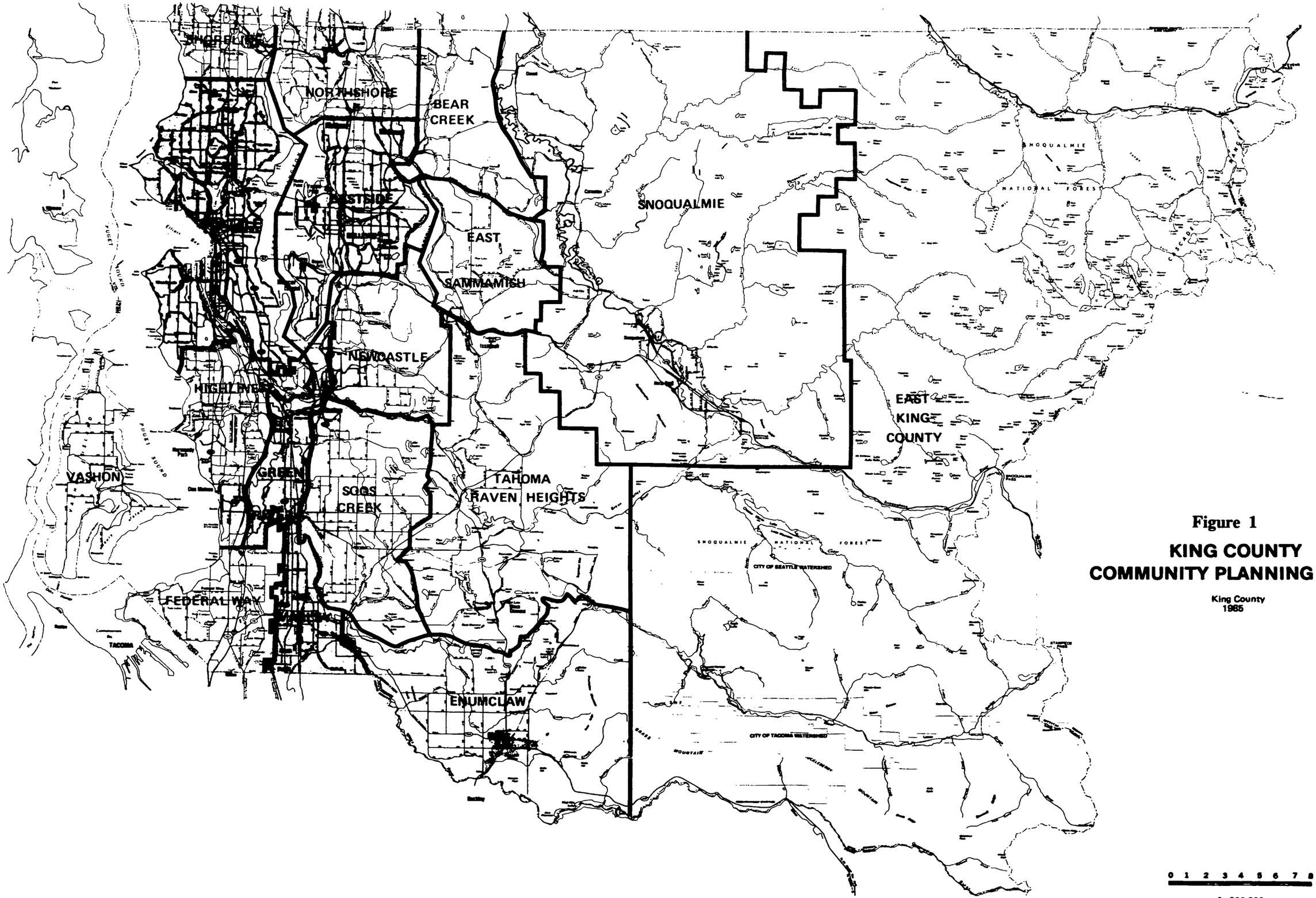


Figure 1

KING COUNTY COMMUNITY PLANNING AR

King County
1985

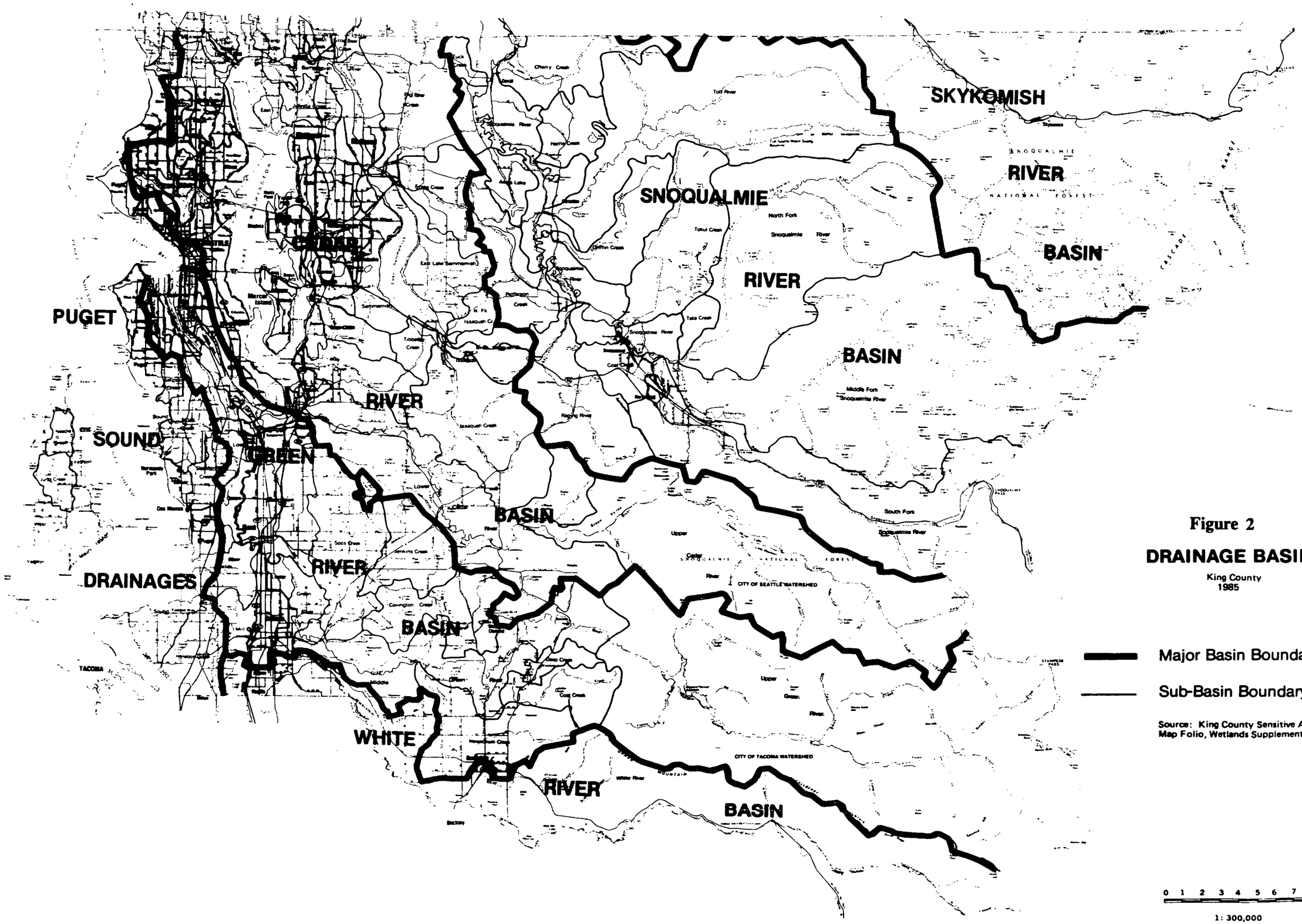


Figure 2

DRAINAGE BASINS

King County
1985

Major Basin Boundary

Sub-Basin Boundary

Source: King County Sensitive Areas Map Folio, Wetlands Supplement

Development plans should ensure that structures locate on unconstrained portions of the site and that clustering, if approved, is compatible with surrounding land uses. These considerations may result in a reduction in density from that otherwise allowed by the zoning.

Policy E-303: Wildlife should be maintained through preservation and enhancement of wildlife habitat. Habitat for species which have been identified as endangered or threatened should not be reduced, and should be preserved through acquisition, incentives, and other techniques.

Comp Plan on Steep Slopes, Landslides and Erosion Hazards

Policy E-304: Land uses on steep slopes should be designed to prevent property damage and environmental degradation, and enhance greenbelt and wildlife habitat values.

Policy E-305: As slope increases, development intensity, site coverage and vegetation removal should decrease to mitigate problems of drainage, erosion, siltation and landslides. Slopes of 40 percent or more should be retained in a natural state, free of structures and roads.

Policy E-307: In areas subject to erosion hazards, native ground cover should be retained or replaced after construction, special construction practices should be used, and allowable site coverage may need to be reduced to prevent erosion and sedimentation. Limitations on the time when site work can be done may also be appropriate.

Comp Plan on Water Quality

Policy E-311: Water quality should be protected and enhanced. Land use plans and land development should preserve the amenity and ecological functions of water features.

Policy E-312: Water resources should be managed for multiple uses -- including recreation, fish and wildlife, flood protection, erosion control, water supply, energy production, and open space. Use of water resources for one purpose should, to the fullest extent possible, preserve opportunities for other uses.

Comp Plan on Drainage Systems

Policy E-313: Surface water management plans should consider entire watersheds, with responsibility shared between King County, other counties, and the incorporated cities within a watershed . . .

Policy E-314: Natural drainage systems should be maintained and enhanced to protect water quality, reduce public costs and prevent environmental degradation. Public improvements and private developments should not alter natural drainage systems without acceptable mitigating measures which eliminate the risk of flooding or negative impacts to water quality.

Policy E-315: Natural surface water storage sites that help regulate stream flows and recharge groundwater should be preserved and their water quality protected.

Policy E-316: Water quality and natural drainage systems should be protected by controlling the quality and quantity of stormwater runoff.

Policy E-317: New development should not increase peak stormwater runoff. In critical drainage, erosion or flood hazard areas, new development should not increase total runoff quantity.

Policy E-318: Site plans and construction practices should be designed to minimize on-site erosion and sedimentation during and after construction.

Policy E-319: Stormwater runoff from new development next to steep hillsides or ravines should be routed so it does not cause gully erosion or landslides. Runoff also should be sufficiently diffused so that flows do not create erosion of ravines or steep hillsides.

Policy E-320: Resource industries should use management practices that prevent erosion and sedimentation, and prevent pollutants from entering ground or surface waters .

Comp Plan on Rivers, Streams, and Waterbodies

Policy E-321: Water quality, natural drainage, fish and wildlife habitat and aesthetic functions of rivers, streams, lakes and Puget Sound should be protected.

Policy E-322: New development adjacent to rivers, streams, lakes and Puget Sound should preserve an undisturbed corridor wide enough to maintain natural functions.

Policy E-323: Natural stream channels should be preserved, protected and enhanced for their hydraulic, ecological and aesthetic functions through development regulations, land dedications, easements, incentives, acquisition, and other means.

Policy E-324: River and stream channels should not be placed in culverts unless absolutely necessary for property access. Bridges are preferred for river and stream crossings, and crossings should serve several properties, to reduce disruption to rivers, streams, and their banks. When culverts are necessary, oversized culverts with gravel bottoms that maintain the channel's width and grade should be used.

Policy E-325: Degraded stream and river channels and banks should be rehabilitated by public programs and new development, to maintain water quality and prevent future erosion problems. Where conditions permit, the banks and channels should be restored to a natural state.

Policy E-326: Private development and public actions should maintain adequate flows in rivers and streams to protect fisheries and recreation resources.

Policy E-327: Development within designated shoreline environments should:

a. Preserve the resources and ecology of the water and shorelines;

b. Avoid natural hazards;

c. Promote visual and physical access to the water; and

d. Preserve navigation rights.

Comp Plan on Wetlands

Policy E-328: Wetlands important for flood control, drainage, water quality, aquifer recharge, visual or cultural values or habitat functions should be preserved or enhanced.

Policy E-329: New development adjacent to a unique,outstanding, or significant wetland should preserve or enhance the wetland and provide an undisturbed buffer around the wetland adequate to protect its natural functions. Encroachments into significant wetlands may be allowed when no feasible alternative exists and enhancements are provided to replace the lost wetland's functions.

Policy E-330: Water level fluctuations in wetlands used as storm water detention sites should be similar to the fluctuations under natural conditions, unless plants in the wetland can adapt to new levels.

Policy E-331: Public access to wetlands for scientific and recreational use is desirable when sensitive habitats are protected. Careful planning of access trails, for example, can allow public enjoyment of wetlands while preventing safety and environmental problems.

Policy E-332: Development on existing or former wetlands should occur only after careful soils analysis shows that construction measures can successfully mitigate potential hazards of unstable soil and drainage problems.

Comp Plan On Floodplains

Policy E-333: The natural flood storage function of floodplains should be preserved. Non-structural methods should be emphasized in planning for flood prevention and damage and should be designed to maintain natural flood storage functions and minimize hazards.

Policy E-334: One-hundred-year floodplains should be protected by restricting residential development to rural residential densities, locating roads and structures above the 100-year flood level, and requiring new development to replace existing flood storage capacity lost due to filling.

Policy E-335: Due to the risks associated with deep and fast-flowing waters, no permanent structures should be located in the floodway. Land uses in a floodway should not divert water from the floodway, change flood elevation or obstruct natural flow. Development in the flood fringe must not reduce existing flood storage capacity.

Policy E-336: Along small streams for which the floodway has not been identified, the entire floodplain should be treated as a floodway, and no permanent structures, grading or filling should be allowed.

Comp Plan on Aquifers

Policy E-337: Groundwater recharge areas should be identified and protected to ensure that groundwater resources are protected from potential pollution.

Comp Plan on Open Space

Policy E-202: Lands preserved for public parks or open space should provide multiple open space benefits whenever possible. Multiple benefits include but are not limited to, active or passive recreation opportunities, scenic vistas, fish or wildlife habitat, many of which can be provided by natural surface water drainage systems, including wetlands.

SURFACE WATER SYSTEM PLANNING POLICIES FOR NEW DEVELOPMENT

A variety of approaches exist for the design of surface water systems used in the mitigation of a new development impacts. Each system design must consider the hydrology, hydraulics, and environmental constraints of both the on- and off-site systems. Knowing the system alternatives, site limitations, and environmental constraints is critical early in the development planning process to avoid costly surprises and delays due to design changes, as well as adverse impacts. The design engineer should focus on details of the development design while simultaneously focusing on the project in the larger context of King County goals for managing surface water while protecting environmental quality.

Design engineers are expected to consider the variety of available surface water system alternatives before beginning system design. Generally, systems incorporating water quality protection and low-maintenance system components with gravity control are required by King County. In some cases, multi-use facilities may be appropriate, such as a passive recreation area located within a detention pond, but approval of these facilities will be dependent on maintenance and liability considerations.

Protection of existing natural drainage features is required by the King County Sensitive Areas Ordinance and Rules. In the situations where alteration of the natural system is allowed, provisions are usually required for the re-establishment of the natural system functions. These functions include water quality benefits, biofiltration, groundwater recharge and wildlife habitat.

In general, King County requires the use of on-site drainage controls and storage facilities which are intended to reduce the problem of increased runoff quantity at the source by replicating the existing predevelopment runoff rates. While the effectiveness of on-site controls warrants their continued use in King County, particularly for water quality control, the SWM Division is continuing to investigate a regional approach which would integrate the on-site controls with a larger, basin-wide program through the Basin Planning Program.

Other alternatives to on-site runoff quantity controls may be effective in meeting King County's goals of preserving and protecting natural drainage systems. For example, it may be more hydraulically efficient to discharge stormwater without detention if the site is located close to an acceptable receiving body or a regional facility designed to receive the runoff from the site, and the conveyance system to the water body is adequate and water quality protection measures will be constructed.

SURFACE WATER QUANTITY CONTROL POLICY

The primary means for King County to minimize the impacts of new development on natural and constructed drainage systems downstream is to require on-site detention facilities to limit the peak rates of runoff from design storm events to levels which exist in the undeveloped state. In most cases, the detention performance curve (described below) will control runoff from most newly developed sites without the need to directly address the increased volume of runoff which results due to the addition of impervious surface. This, however, will not be the case with some sites, for example, where the site discharges to a closed depression or where there is severe downstream erosion potential.

Detention Performance Curve

The concept of a detention performance curve was formulated to limit downstream flooding and accelerated erosion resulting from new development. This concept was based on a review of the goals of peak runoff rate controls applied to design storm events of specified return frequencies. Traditionally, control of the less frequent, but higher magnitude, events were addressed in order to prevent downstream flooding. It has now been acknowledged that an even more prevalent, and equally destructive, drainage problem occurs as the result of new development. This is the accelerated erosion of natural and manmade conveyance systems which occurs from all storms. This is particularly the case for runoff generated from more frequent storms due to the cumulative "increased work" they apply to the conveyance systems. The "increased work" is the product of the increased flow levels times the extended duration of time which runoff occurs.

Hydrograph Methods

In order to apply the concept of detention performance as well as the other hydrologic and hydraulic analytical tools, it is essential to have a means of representing the runoff of water leaving a basin at a specific point, over a period of time. The hydrograph method serves this function and, thus, characterizes the surface water runoff from a basin, and from which can be extracted numerical values useful in analysis and design. These values include the total volume, peak rate of runoff, and other values developed from processing the hydrograph through other analytical models such as those representing storage or stream channel routing. The utility of this representation has dictated its selection as the primary tool in estimating the existing and proposed developed runoff characteristics of sites in King County.

Design Storm Event Method

The method of designing facilities based on hydrographs generated from the application of design storm events has been retained for analyzing existing and designing new drainage facilities. It is acknowledged that methods based on calibrated models utilizing continuous rainfall and streamflow records yield the most accurate results and are essential to analyzing certain complex hydrologic problems. Currently, the data requirements and the complexity and level of effort does not warrant the use of continuous models for the design of most on-site drainage systems in King County.

Since the SWM Division is using a continuous model (HSPF, Hydrologic Simulation Program Fortran) for preparing Basin Plans, in all likelihood the use of continuous modeling for design of on-site drainage systems will be phased in over time as Basin Plans are adopted or as special projects arise, in particular very large projects such as Master Drainage Plans.

Hydrograph Method Selection

There were a number of objectives sought in the selection of a "yard stick" methodology for generating runoff hydrographs. The major objectives are listed below:

- The method must utilize the design storm event concept.
- The method must be easily understandable by practicing civil engineers and BALD Division drainage review staff.
- The method is preferably known, at least in part, by current practicing civil engineers in King County.
- The method must have easily definable and readily obtainable runoff parameters.
- The method must generate consistent, reasonable results through the range of basin areas, and existing and developed runoff characteristics.
- The method should be executable manually (although likely much more efficiently through the use of programmable calculators and computers).
- The method must produce hydrographs which may be readily processed by other algorithms applying concepts such as storage routing.

The combination of the Santa Barbara Urban Hydrograph (SBUH) Method using the Soil Conservation Service (SCS) curve numbers was found to most closely meet these objectives and therefore was selected as the "bench mark" hydrograph methodology.

SURFACE WATER QUALITY CONTROL POLICY

State-of-the-art measures intended to preserve existing water quality or reduce potential pollutant loadings have been incorporated into many of the requirements of this Manual. These measures include design criteria and requirements such as detention facility performance to control erosive discharges from detention basins, detention basin designs that promote controlled sedimentation, and special water quality controls and vegetation-lined channels for biofiltration. A "Background" discussion is provided at the end of this section which describes some of the research, problems, and regulatory direction on the issues of protecting urban runoff quality.

Detention Facility Performance

Retention/Detention (R/D) facilities provide flow control by detaining, buffering and attenuating flows. These attributes also provide some level of pollution control by detaining the flow long enough for pollutant removal by physical and/or biochemical processes. They are designed to minimize pollutant discharge so that downstream fisheries, habitat and water quality will be preserved. Because of the direct relationship urban sediment has with pollutants and toxic chemicals, R/D facility design criteria provide control of sediment-laden water and downstream erosion.

Control of the 2-year 24 hour duration storm events is needed to provide protection from the cumulative impacts that result in downstream erosion. The need for this protection is supported by recent literature indicating that the level of erosion in a channel is directly proportional to the "work" performed on the channel by flowing water. The dominant flow, defined as channel dominant discharge, is the most effective in performing this "work" and has been found to be in the range of a 1 - 2 year return frequency flow, or an approximate bank-full channel condition.

Results of recent studies have demonstrated that substantial removals of pollutants in urban stormwater can be achieved by gravity sedimentation if turbulent mixing can be avoided and the detention time is long. The pollutants most susceptible to removal are Total Suspend Solids (TSS), hydrocarbons, lead, Biological Oxygen Demand (BOD), and total phosphates. Trap efficiencies of 70 percent of TSS, hydrocarbons and lead; 50 percent of BOD and phosphates; and at least 33 percent of chemical Oxygen

Demand (COD), Total Organic Carbon (TOC), and Total Nitrogen (TN) were reported in the studies. TSS is particularly susceptible to removal by sedimentation and can also be representative of the amount of general pollution due to their affinity for absorbing numerous other pollutants.

The most important feature for water quality R/D facility design is to promote siltation by providing maximum detention time of the ponded urban runoff. The hydrologic performance concept for R/D design described previously is primarily for controlling downstream erosion and flood events, but its inherent design also provides long detention times and is therefore ideally suited for water quality control. Computer model test cases run by SWM staff for average development conditions resulted in detention times of approximately 30 hours for the 2-year, 24-hour storm.

Additional R/D facility design features generally required to promote sedimentation, infiltration, and biofiltration include:

- Utilization of long, narrow pond configurations. The minimum required length/width ratio is two; larger ratios are encouraged.
- Installation of inlet and outlet structures at extreme ends of the pond.
- Flat pond and tank/vault bottoms provide for minimum flow velocity to promote settlement and biofiltration (in ponds).
- Provision of water tolerant, stable vegetative ground cover on pond bottom and sides controls erosion and provides biofiltration.
- Provision of 6-inch-deep sediment sump (dead storage) over pond and tank/vault bottom area.
- Two-cell pond design.

Special Water Quality Controls

There are two types of special water quality control facilities provided in this Manual to treat surface water runoff. These are wet ponds and vaults, and water quality swales. They are primarily required to treat runoff from developed areas prior to discharge to sensitive natural drainage features such as wetlands, lakes and streams (when not treated by a retention/detention pond), and prior to infiltration. Both of these types of facilities utilize sedimentation, biofiltration and biologic activity as the mechanisms for removal of pollutants from surface water runoff and have been demonstrated to provide substantial water quality improvements by a number of studies. The SWM Division will continue to participate in on-going programs to further substantiate and quantify the benefits these facilities provide, as well as refine the analytic methods and criteria for their design.

Vegetation-Lined Swales and Native Growth Areas

Vegetation-lined swales (often referred to a grass-lined channels), when properly designed, have been proven effective as "biofiltration" mechanisms for the removal of sediments, heavy metals, and some nutrients from stormwater leaving developed areas. Suspended particles can settle out if the velocity of flow is slowed over an adequate length of channel and, depending on soil type, infiltration will also provide water quality benefits. The optimum design of vegetation-lined swales minimizes water depth and velocity to promote maximum water contact with channel vegetation and infiltration.

The preservation of native growth areas is also very important in preserving water quality, as well as environmental features necessary to protect valuable natural resources and maintain stable slopes. Water quality benefits from these native growth areas are both direct and indirect by providing for pollutant reduction or elimination, and provide physical protection of aesthetics and wildlife habitat. For example, natural vegetative corridors along streams or around wetlands provide biofiltration to incoming pollutants and preserve the aquatic and wildlife habitat along the water's edge.

Background

Discharge of stormwater runoff into surface water can result in water quality degradation of the natural surface water system. For example, the Bellevue National Urban Runoff Program (Pitt and Bissonnette, 1984) stated the following stormwater related impacts to a local stream in an urbanizing area:

- Reduction in diversity of aquatic species.
- Physiological damage to fish populations
- Periodic fish kills associated with dumping of toxic substances into the drainage system
- Higher water temperature
- Channel instability and increased sediment transport
- Increased fecal coliform bacteria populations
- Reduced aesthetic value

Water quality degradation may be acute or chronic. A fishkill is an acute reaction to dumping of a toxic substance (such as antifreeze) into a catchbasin discharging to a stream. Chronic degradation may also include the gradual accumulation of pollutants (including combustion engine by-products such as cadmium, zinc, and lead) which in turn may contribute to a reduction in the diversity of species and physiological damage to the species that remain.

Pollutants in urban runoff are usually attached to sediments. In addition, sediments clog and cement spawning gravels and reduce the capacity of conveyance systems. Control of sediment during all phases of urbanization (construction through full development) is therefore critical to reducing the discharge of pollutants to the County's surface waters. Consequently, the County requires all new development to prepare a plan for the control erosion and sedimentation both during and after construction, (see Requirement #5).

In the coming years, there will be growing local state and federal emphasis on the control of water quality. The recently completed 1987 Puget Sound Water Quality Plan, underscores the need for basin planning and controlling the discharge of stormwater pollutants at the source. During the next 5 years the Environmental protection Agency and the State of Washington Department of Ecology will be preparing the requirements for a County-wide permit (under the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) program) which will set acceptable levels of stormwater pollutants discharged into the County's surface waters. In response to these programs and King County's own goals for enhancement and preservation of environmental quality, King County will continue to review and update its requirements for the protection of water quality to ensure environmental preservation of our water resources.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 5
ALTERNATIVE HYDRAULIC DESIGN METHODS

- Modified SBUH (Barker) Method
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METHODOLOGY FOR USING THE "BRUCE BARKER" OR MODIFIED SBUH, 7-DAY STORM DETENTION METHODOLOGY

-- Revised Guidance --

July 15, 1994

The King County HYD program has been modified to directly compute hydrographs for the "Bruce Barker" or modified SBUH 7-day storm methodology. In addition, the pervious times of concentration for pasture cover have been revised from those published in previous guidance documents for this methodology. People familiar with the Santa Barbara Urban Hydrograph and the King County Surface Water Design Manual should find this modified method easy to use. This outline presents the basic steps for calculating hydrographs with this methodology.

Note: the phrase "the design manual" refers to the King County Surface Water Design Manual, 1990.

The modified SBUH methodology with a modified 7-day design storm (the Bruce Barker methodology) shall only be used for conversions of till and wetland soils. The table below defines which SCS soil series should be considered till soils for the purpose of this methodology. Projects built on deep outwash soils should not use this methodology, but should continue to use the standard of the design manual.

Step one. Isopluvials.

Establish precipitation amounts for the appropriate location and design storms using the Bruce Barker, et al., 7-day isopluvial maps at the end of this package.

Step two. Compute Hydrographs with Option #3, "Modified SBUH Methodology", of the King County HYD Program.

Hydrographs for pervious and impervious surfaces are determined separately and then added together. This eliminates problems associated with a composite time of concentration when the individual times of concentration are very different. In option #3, the HYD program will ask you first for the curve number and time of concentration for pervious soils, and then ask you for the curve number and time of concentration for impervious surfaces.

Determine the curve numbers (CN values) as specified in the design manual.

<u>Times of concentration for pervious soils</u> are to be computed separately. The time of concentration shall be a summation of "interflow or sheet flow, shallow concentrated flow, and open channel flow," (Barker, 1992). However, sheet flow calculations should only be

used for impervious areas. Do not use sheet flow formulas for pervious land cover. Instead, use the times of concentration for pervious areas specified in Table 2.

TABLE 2 CALIBRATED TIME OF CONCENTRATION VALUES FOR TILL/WETLAND SOILS	
Cover/Slope	**Time of Concentration (minutes)**
Wetland/All	1495
Grass/Steep*	0
Grass/Flat*	0
Grass/Steep**	545
Grass/Flat**	1255
Forest/Steep	530
Forest/Flat	1125
Pasture/Steep	495
Pasture/Flat	1155

* Calibrated to surface component of runoff. Use for applications where peak flow is critical, such as conveyance design.

** Calibrated to interflow component of runoff. Use for applications where runoff volume is critical, such as detention design.

Flat: Average slope of 15% or less.
Steep: Average slope greater than 15%.

Outwash soils: For sites predominantly outwash use standard 24-hr hydrograph method in the design manual.

For R/D Analysis: Use interflow calibrated Tc for both existing and developed condition hydrograph.

For Conveyance/Overflow Analysis: Use standard SCS Type I-A 24-hr rainfall distribution and time-of-concentration as defined in the design manual.

Times of concentration for impervious surfaces are calculated as specified in the design manual.

Table 1

Conversion of SCS Soil Types to Till, Outwash, and Wetland Classifications

SCS Soil Type	SCS Hydrologic Soil Group	Modified SBUH Group	Notes
Alderwood (AgB, AgC, AgD)	C	Till	
Arents, Alterwood Material (AmB, AmC)	C	Till	
Arents, Everett Material (An)	B	Outwash	1
Beausite (BeC, BeD, BeF)	C	Till	2
Bellingham (Bh)	D	Till	3
Briscot (Br)	D	Till	3
Buckley (Bu)	D	Till	4
Earlmont (Ea)	D	Till	3
Edgewick (Ed)	C	Till	3
Everett (EvB, EvC, EvD, EwC)	A/B	Outwash	1
Indianola (InC, InA, InD)	A	Outwash	1
Kitsap (KpB, KpC, KpD)	C	Till	
Klaus (KsC)	C	Outwash	1
Neilton (NeC)	A	Outwash	1
Newberg (Ng)	B	Till	3
Nooksack (Nk)	C	Till	3
Norma (No)	D	Till	3
Orcas (Or)	D	Wetland	
Oridia (Os)	D	Till	3
Ovall (OvC, OvD, OvF)	C	Till	2
Pilchuck (Pc)	C	Till	3
Puget (Pu)	D	Till	3
Puyallup (Py)	B	Till	3
Ragnar (RaC, RaD, RaC, RaE)	B	Outwash	1
Renton (Re)	D	Till	3
Salal (Sa)	C	Till	3
Sammamish (Sh)	D	Till	3
Seattle (Sk)	D	Wetland	
Shalcar (Sm)	D	Till	3
Si (Sn)	C	Till	3
Snohomish (So, Sr)	D	Till	3
Sultan (Su)	C	Till	3
Tukwila (Tu)	D	Till	3
Woodinville (Wo)	D	Till	3

1. Where outwash soils are saturated or underlain at shallow depth (<5 ft) by glacial till, they should be treated as till soils.

2. These are bedrock soils, but calibration of HSPF by King County SWM shows bedrock soils to have similar hydrologic response to till soils.

3. These are alluvial soils, some of which are underlain by glacial till or which have a seasonally high water table. In the absence of detailed study, these soils should be treated as till soils.

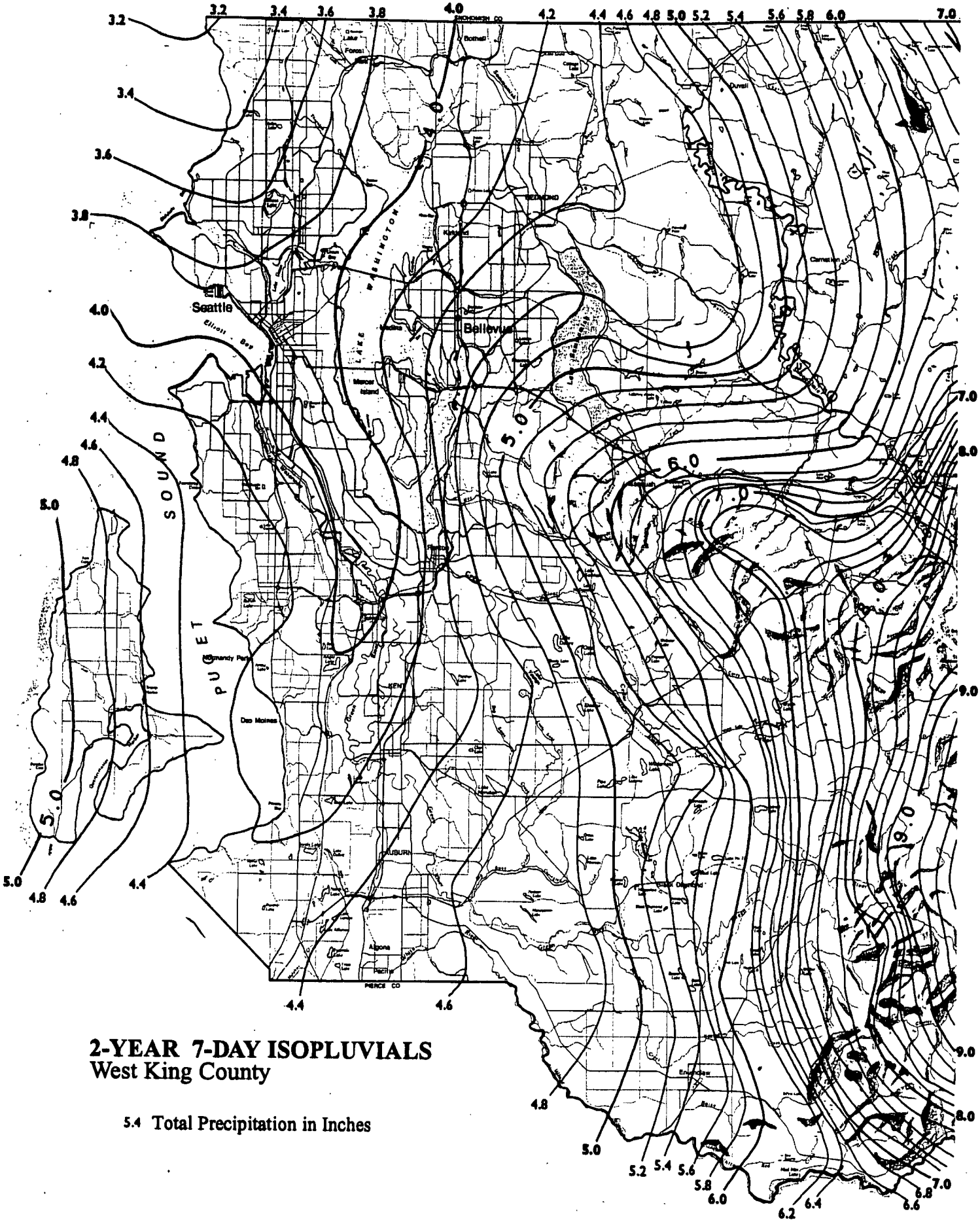
4. Buckley soils are formed on the low permeability Osceola mudflow. Hydrologic response is assumed to be similar to that for till soils.

When using the modified SBUH method to create a hydrograph for only pervious or only impervious areas, still include a CN and Tc for both as asked by the program, but set the area of the unwanted CN to zero.

Step three. Routing.

Same procedure as in the design manual.

If you have questions or comments, please contact Jeff Burkey, Kelly Whiting, or Rhett Jackson at (206) 296-6519.

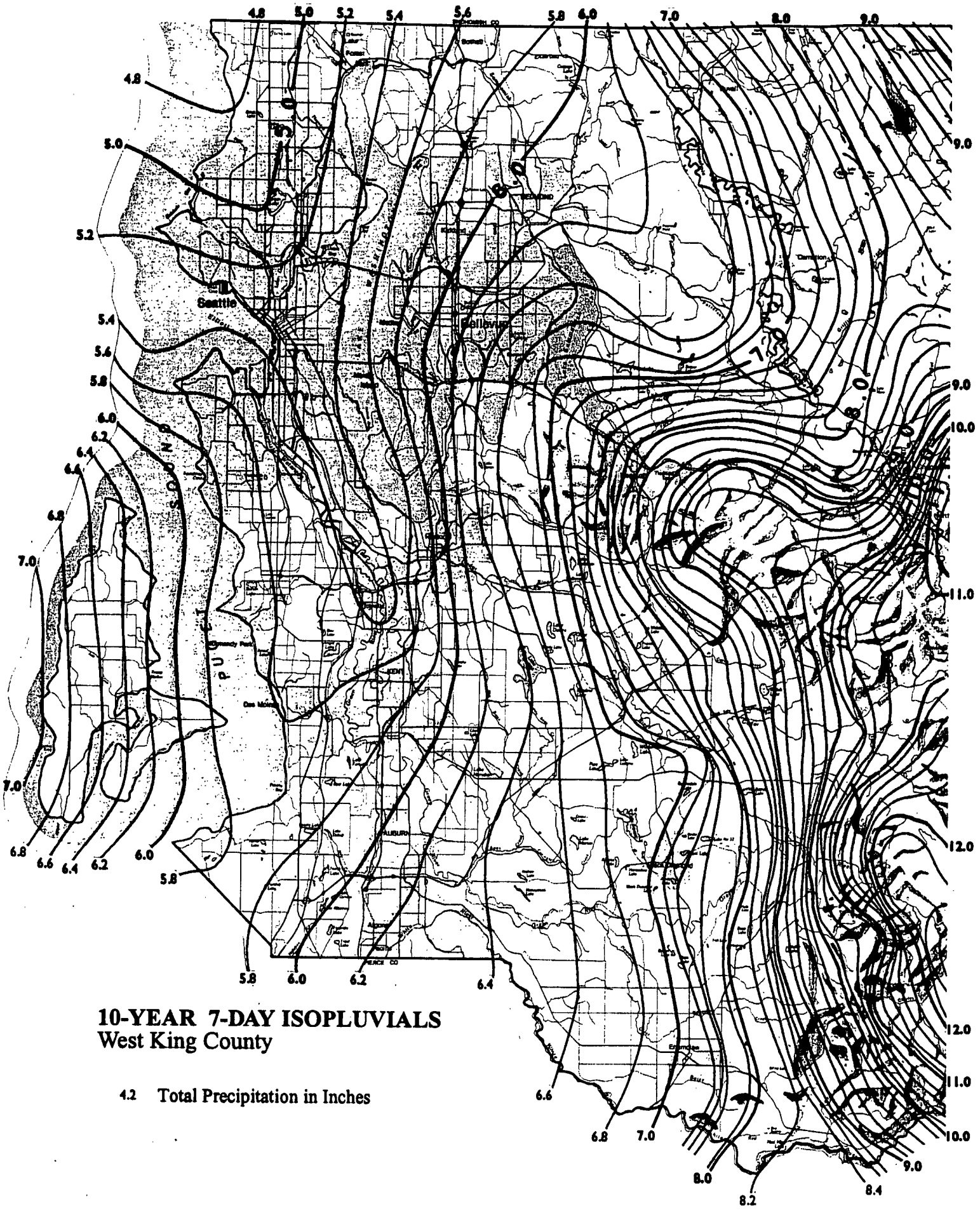


2-YEAR 7-DAY ISOPLUVIALS
West King County

5.4 Total Precipitation in Inches

0 1 2 3 4 5 6 7 8 Miles

1: 300,000

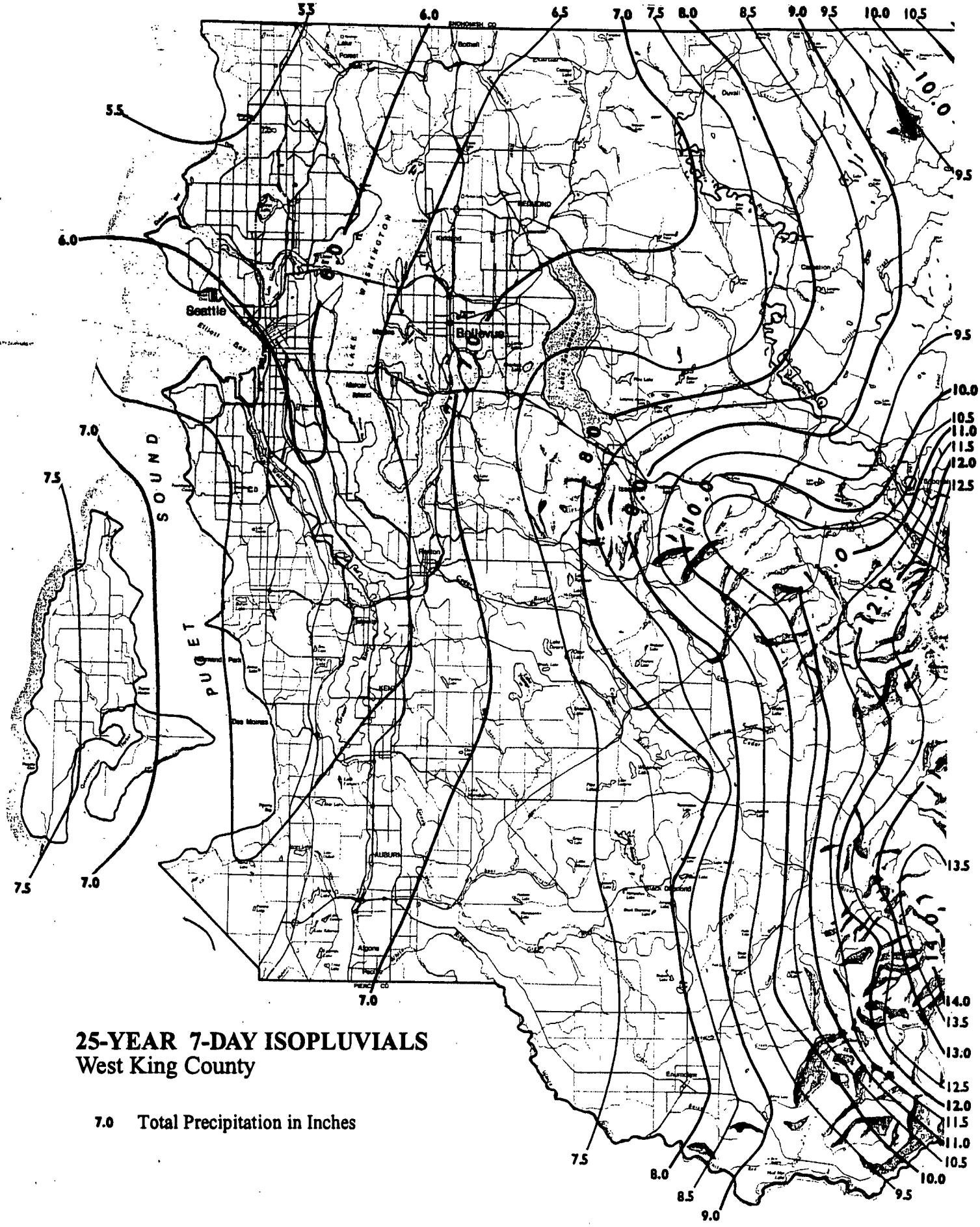


10-YEAR 7-DAY ISOPLUVIALS
West King County

4.2 Total Precipitation in Inches

0 1 2 3 4 5 6 7 8 Miles

1: 300,000

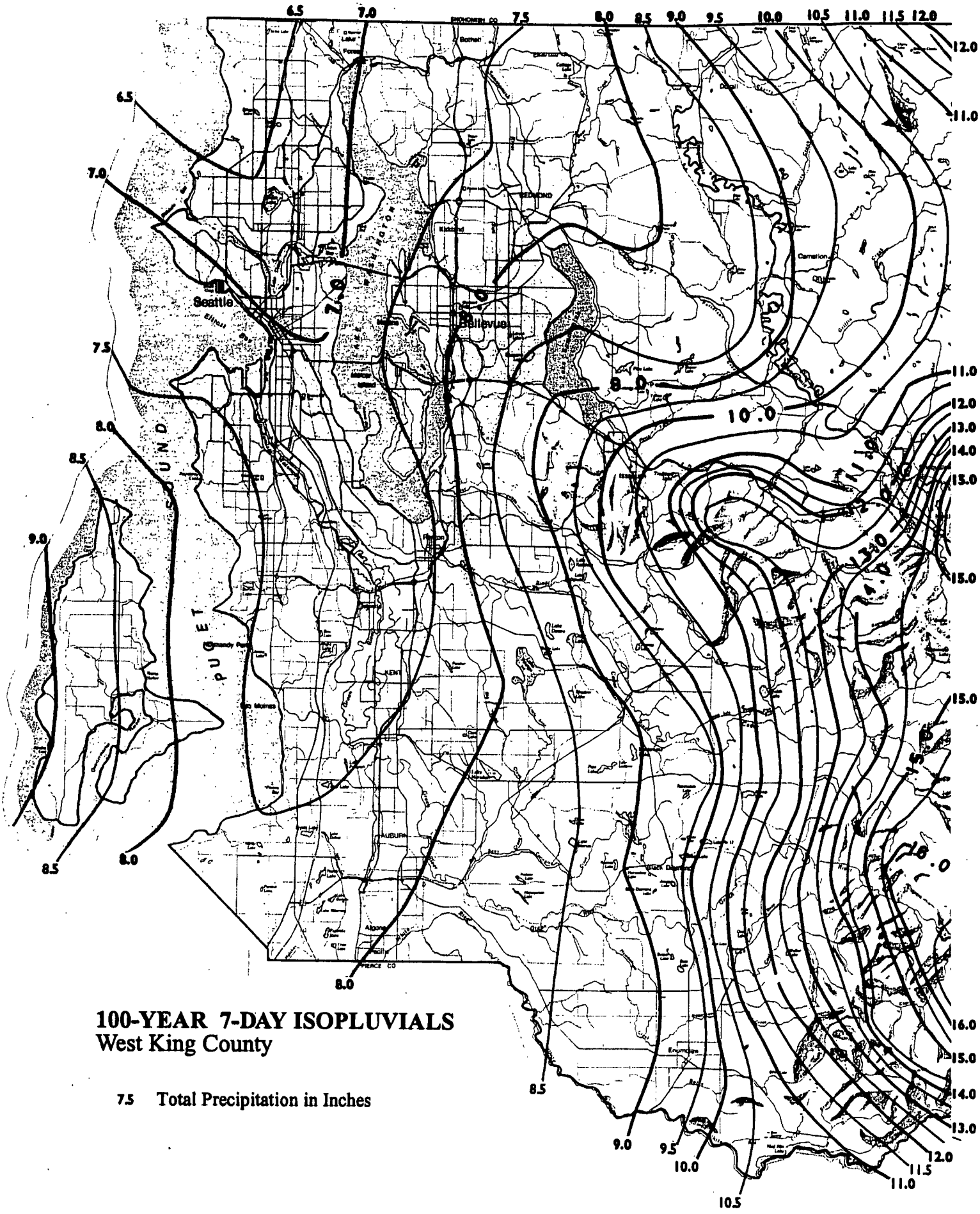


25-YEAR 7-DAY ISOPLUVIALS
West King County

7.0 Total Precipitation in Inches

0 1 2 3 4 5 6 7 8 Miles

1: 300,000



100-YEAR 7-DAY ISOPLUVIALS
West King County

7.5 Total Precipitation in Inches

0 1 2 3 4 5 6 7 8 Miles

1: 300,000

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 6
CLEARING AND GRADING ORDINANCE AND RULES

(Not included at this time.)

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 7
SENSITIVE AREAS ORDINANCE AND RULES

(Not included at this time.)

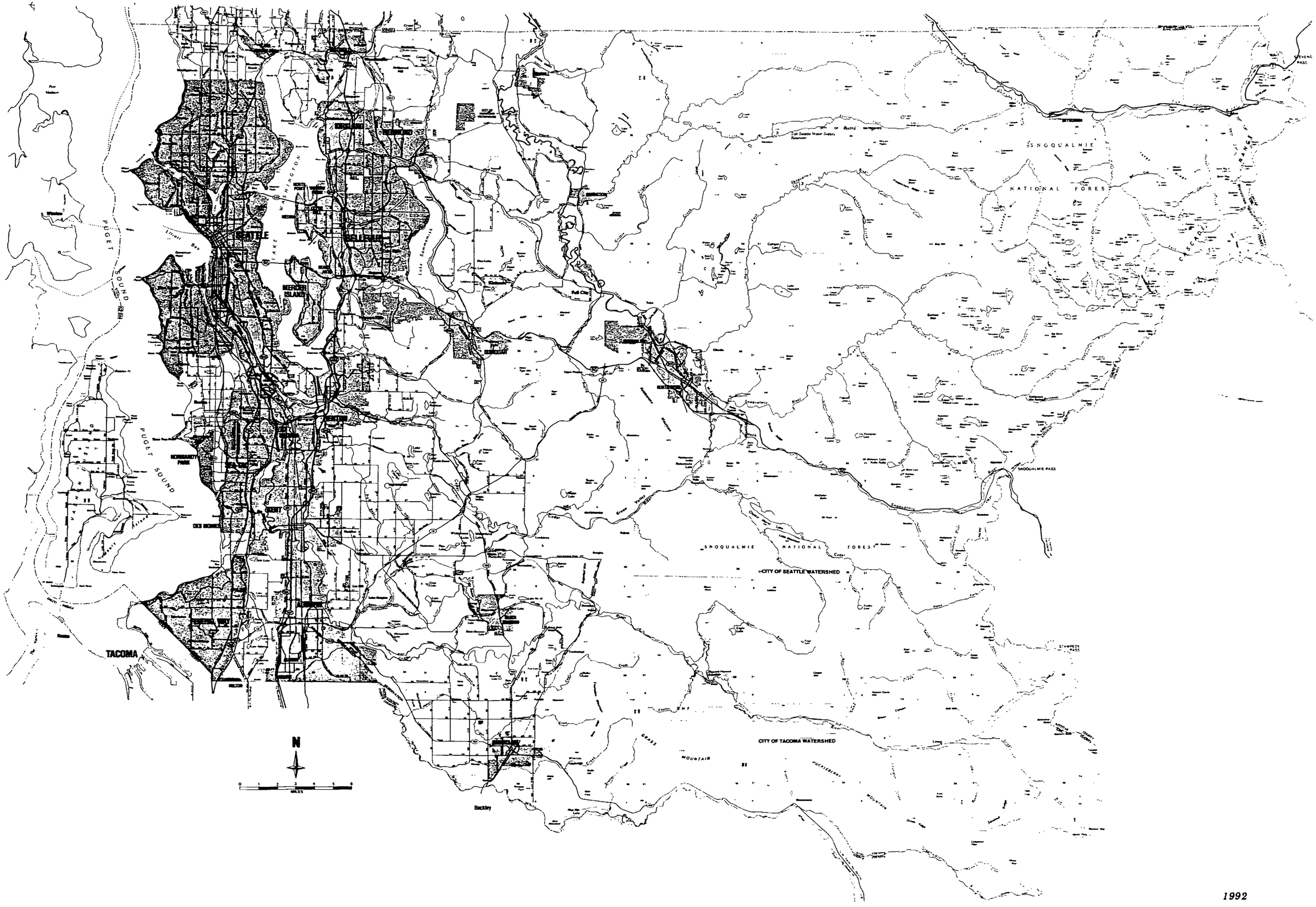
KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 8
KING COUNTY STANDARD MAP SYMBOLS

KING COUNTY
STANDARD MAP SYMBOLS

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE - 9
STANDARD PLAN NOTES


SEATTLE
BELLEVUE
MERCER ISLAND
RENTON
KENT
TACOMA
PUGET SOUND
LAKE WASHINGTON
SNOQUALMIE NATIONAL FOREST
CITY OF SEATTLE WATERSHED
CITY OF TACOMA WATERSHED
SNOQUALMIE PASS
STEVENS PASS
STAMPEDE PASS
CASCADE RANGE
GRASS MOUNTAIN
HUCKLEBERRY MOUNTAIN
Buckley
N
MILES

1992

KING COUNTY
STANDARD PLAN NOTES

The standard plan notes must be included on all plans. At the applicant's discretion, notes which in no way apply to the project may be omitted; however, the remaining notes must not be renumbered. For example, if General Note #3 were omitted, the remaining notes should be numbered 1, 2, 4, 5, 6, etc.

GENERAL NOTES

(1) All construction shall be in accordance with the King County Code (KCC), Road Standards (KCRS), and the King County Council's conditions of preliminary subdivision approval. It shall be the sole responsibility of the applicant and the professional civil engineer to correct any error, omission, or variation from the above requirements found in these plans. All corrections shall be at no additional cost or liability to King County.

(2) The design elements within these plans have been reviewed according to the King County Department of Development and Environmental Services (DDES) Engineering Review checklist. Some elements may have been overlooked or missed by the DDES plan reviewer. Any variance from adopted standards is not allowed unless specifically approved by King County prior to construction.

(3) Approval of this road, grading, and drainage plan does not constitute an approval of any other construction (e.g. domestic water conveyance, sewer conveyance, gas, electrical, etc.)

(4) Before any construction or development activity, a preconstruction meeting must be held between the DDES's Development Inspection Unit, the Applicant, and the Applicant's Construction Representative.

(5) A copy of these approved plans must be on the job site whenever construction is in progress.

(6) Construction noise shall be limited as per King County Code (Section 12.88); normally, this is 7 a.m. to 10 p.m. weekdays and 9 a.m. to 10 p.m. on weekends.

(7) It shall be the applicant's/contractor's responsibility to obtain all construction easements necessary before initiating off-site work within the road rights-of-way.

(8) Franchised utilities or other installations that are not shown on these approved plans shall not be constructed unless an approved set of plans that meet all requirements of KCRS Chapter 8 are submitted to the DDES's Development Inspection Unit three days prior to construction.

(9) Datum shall be KCAS unless otherwise approved by DDES.

(10) Groundwater system construction shall be within a right-of-way or appropriate drainage easement, but not underneath the roadway section. All groundwater systems must be constructed in accordance with Section B1 3.02 of the APWA Standard Specifications.

(11) All utility trenches shall be backfilled and compacted to 95 percent density.

(12) All roadway subgrade shall be backfilled and compacted to 95 percent density (WSDOT 2-06.3).

(13) Open cutting of existing roadways is not allowed unless specifically approved by DDES and noted on these approved plans. Any open cut shall be restored in accordance with KCRS 8.03(B)3.

(14) The Contractor shall be responsible for providing adequate safeguards, safety devices, protective equipment, flaggers, and any other needed actions to protect the life, health, and safety of the public, and to protect property in connection with the performance of work covered by the contractor. Any work within the traveled right-of-way that may interrupt normal traffic flow shall require at least one flagger for each lane of traffic affected. All sections of the WSDOT Standard Specifications 1-07.23 - Traffic Control, shall apply.

DRAINAGE NOTES

(1) Proof of liability insurance shall be submitted to DDES prior to the preconstruction meeting (KCC 9.04.100.D).

(2) All pipe and appurtenances shall be laid on a properly prepared foundation in accordance with WSDOT 7-02.3(1). This shall include leveling and compacting the trench bottom, the top of the foundation material, and any required pipe bedding, to a uniform grade so that the entire pipe is supported by a uniformly dense unyielding base.

(3) Steel pipe shall be galvanized and have asphalt treatment #1 or better inside and outside (KCRS 7.03).

(4) All drainage structures, such as catch basins and manholes, not located within a traveled roadway or sidewalk, shall have solid locking lids. All drainage structures associated with a permanent retention/detention facility shall have solid locking lids (KCRS 7.05).

(5) All catch basin grates shall conform to KCRS drawing numbers 2-013, 2-018, 2-019, or 2-020, which includes the stamping "OUTFALL TO STREAM, DUMP NO POLLUTANTS" and "Property of King County" (KCRS 7.05).

(6) All driveway culverts located within King County right-of-way shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sections to match the side slope (KCRS 7.03(L), Drawing No. 2-001).

(7) Rock for erosion protection of roadway ditches, where required, must be of sound quarry rock, placed to a depth of 1 foot, and must meet the following specifications: 4"-8"/40%-70% passing; 2"- 4" rock/30%-40% passing; and -2" rock/10%-20% passing. Installation shall be in accordance with KCRS 7.02(B) drawing number 2-024.

(8) Drainage outlets (stub-outs) shall be provided for each individual lot, except for those lots approved for infiltration by King County. Stub-outs shall conform to the following:

a) Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved stormwater conveyance system or to an approved outfall location.

b) Outlets on each lot shall be located with a five-foot-high, 2" x 4" stake marked "storm" or "drain". The stub-out shall extend above surface level, be visible, and be secured to the stake.

c) Pipe material shall conform to underdrain specifications described in KCRS 7.04 and, if non-metallic, the pipe shall contain wire or other acceptable detection.

d) Drainage easements are required for drainage systems designed to convey flows through individual lots.

e) The applicant/contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g. power, gas, telephone, television).

f) All individual stub-outs shall be privately owned and maintained by the lot home owner.

TEMPORARY EROSION AND SEDIMENTATION CONTROL NOTES

(1) Approval of this temporary erosion and sedimentation control (TESC) plan does not constitute an approval of permanent road or drainage design (e.g. size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.)

(2) The implementation of these TESC plans and the construction, maintenance, replacement, and upgrading of these TESC facilities is the responsibility of the applicant/TESC supervisor until all construction is approved.

(3) The boundaries of the clearing limits shown on this plan shall be clearly flagged by a continuous length of survey tape (or fencing, if required) prior to construction. During the construction period, no disturbance beyond the clearing limits shall be permitted. The clearing limits shall be maintained by the applicant/TESC supervisor for the duration of construction.

(4) The TESC facilities shown on this plan must be constructed prior to or in conjunction with all clearing and grading so as to ensure that the transport of sediment to surface waters, drainage systems, and adjacent properties is minimized.

(5) The TESC facilities shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, these TESC facilities shall be upgraded as needed for unexpected storm events and modified to account for changing site conditions (e.g., additional sump pumps, relocation of ditches and silt fences, etc.).

(6) The TESC facilities shall be inspected daily by the applicant/TESC supervisor and maintained to ensure continued proper functioning. Written records shall be kept of weekly reviews of the TESC facilities during the wet season (Oct. 1 to March 31) and of monthly reviews during the dry season (April 1 to Sept. 30).

(7) Any areas of exposed soils, including roadway embankments, that will not be disturbed for two days during the wet season or seven days during the dry season shall be immediately stabilized with the approved TESC methods (e.g., seeding, mulching, plastic covering, etc.).

(8) Any area needing TESC measures, not requiring immediate attention, shall be addressed within fifteen (15) days.

(9) The TESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within 48 hours following a storm event.

(10) At no time shall more than one (1) foot of sediment be allowed to accumulate within a catch basin. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment-laden water into the downstream system.

(11) Stabilized construction entrances and roads shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures, such as wash pads, may be required to ensure that all paved areas are kept clean for the duration of the project.

(12) Any permanent retention/detention facility used as a temporary settling basin shall be modified with the necessary erosion control measures and shall provide adequate storage capacity. If the permanent facility is to function ultimately as an infiltration system, the temporary facility must be graded so that the bottom and sides are at least one foot above the final grade of the permanent facility.

(13) Where straw mulch for temporary erosion control is required, it shall be applied at a minimum thickness

STRUCTURAL NOTES

(1) These plans are approved for standard road and drainage improvements only. Plans for structures such as bridges, vaults, and retaining walls require a separate review and approval by DDES prior to construction (KCC 16.04. 16.70, 14.20).

(2) Rockeries are considered to be a method of bank stabilization and erosion control. Rockeries shall not be constructed to serve as retaining walls. All rockeries shall be constructed in accordance with KCRS drawing numbers 5-004, 5-005, 5-006, and 5-007.

RECOMMENDED CONSTRUCTION SEQUENCE

(1) Pre-construction meeting.
(2) Flag or fence clearing limits.
(3) Post sign with name and phone number of TESC supervisor.
(4) Install catch basin protection if required.
(5) Grade and install construction entrance(s).
(6) Install perimeter protection (silt fence, brush barrier, etc.).
(7) Construct sediment ponds and traps.
(8) Grade and stabilize construction roads.
(9) Construct surface water controls (interceptor dikes, pipe slope drains, etc.) simultaneously with clearing and grading for project development.
(10) Maintain erosion control measures in accordance with King County standards and manufacturer's recommendations.
(11) Relocate erosion control measures or install new measures so that as site conditions change the erosion and sediment control is always in accordance with the King County TESC minimum requirements.
(12) Cover all areas that will be unworked for more than seven days during the dry season or two days during the wet season with straw, wood fiber mulch, compost, plastic sheeting or equivalent.
(13) Stabilize all areas that reach final grade within seven days.
(14) Seed or sod any areas to remain unworked for more than 30 days.
(15) Upon completion of the project, all disturbed areas must be stabilized and bmps removed if appropriate.

TESC MAINTENANCE REPORT

Performed By: _____
Date: _____
Project Name: _____
DDES Permit #: _____

Clearing Limits			
Damage	OK ____	Problem	_____
Visible	OK ____	Problem	_____
Intrusions	OK ____	Problem	_____
Other	OK ____	Problem	_____
Mulch			
Rills/Gullies	OK ____	Problem	_____
Thickness	OK ____	Problem	_____
Other	OK ____	Problem	_____
Nets/Blankets			
Rills/Gullies	OK ____	Problem	_____
Ground Contact	OK ____	Problem	_____
Other	OK ____	Problem	_____
Plastic			
Tears/Gaps	OK ____	Problem	_____
Other	OK ____	Problem	_____
Seeding			
Percent Cover	OK ____	Problem	_____
Rills/Gullies	OK ____	Problem	_____
Mulch	OK ____	Problem	_____
Other	OK ____	Problem	_____
Sodding			
Grass Health	OK ____	Problem	_____
Rills/Gullies	OK ____	Problem	_____
Other	OK ____	Problem	_____
Silt Fence			
Damage	OK ____	Problem	_____
Sediment Build-up	OK ____	Problem	_____
Concentrated Flow	OK ____	Problem	_____
Other	OK ____	Problem	_____
Brush Barrier			
Damage	OK ____	Problem	_____
Sediment Build-up	OK ____	Problem	_____
Concentrated Flow	OK ____	Problem	_____
Other	OK ____	Problem	_____
Vegetated Strip			
Damage	OK ____	Problem	_____
Sediment Build-up	OK ____	Problem	_____
Concentrated Flow	OK ____	Problem	_____
Other	OK ____	Problem	_____
Construction Entrance			
Dimensions	OK ____	Problem	_____
Sediment Tracking	OK ____	Problem	_____
Vehicle Avoidance	OK ____	Problem	_____
Other	OK ____	Problem	_____
Construction Road			
Stable Driving Surf.	OK ____	Problem	_____
Vehicle Avoidance	OK ____	Problem	_____
Other	OK ____	Problem	_____
Sediment Trap/Pond			
Sed. Accumulation	OK ____	Problem	_____
Overtopping	OK ____	Problem	_____
Inlet/Outlet Erosion	OK ____	Problem	_____
Other	OK ____	Problem	_____
Catch Basin Protection			
Sed. Accumulation	OK ____	Problem	_____
Damage	OK ____	Problem	_____
Clogged Filter	OK ____	Problem	_____
Other	OK ____	Problem	_____

TESC MAINTENANCE REPORT

Interceptor Dike/Swale

Damage	OK ____	Problem _____
Sed. Accumulation	OK ____	Problem _____
Overtopping	OK ____	Problem _____
Other	OK ____	Problem _____

Pipe Slope Drain

Damage	OK ____	Problem _____
Inlet/Outlet	OK ____	Problem _____
Secure Fittings	OK ____	Problem _____
Other	OK ____	Problem _____

Ditches

Damage	OK ____	Problem _____
Sed. Accumulation	OK ____	Problem _____
Overtopping	OK ____	Problem _____
Other	OK ____	Problem _____

Outlet Protection

Scour	OK ____	Problem _____
Other	OK ____	Problem _____

Level Spreader

Damage	OK ____	Problem _____
Concentrated Flow	OK ____	Problem _____
Rills/Gullies	OK ____	Problem _____
Sed. Accumulation	OK ____	Problem _____
Other	OK ____	Problem _____

Miscellaneous

Wet Season Stockpile	OK ____	Problem _____
Other	OK ____	Problem _____

Comments:

Actions Taken:

Problems Unresolved:

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10
PLAN REVIEW PROCEDURES, FORMS AND WORKSHEETS

10-A	Predesign Meeting Form
10-B	Technical Information Report (TIR) Worksheet
10-C	Retention/Detention Summary Sheet and Sketch
10-D	Declaration of Covenant
10-E	Bond Quantities Worksheets
10-F	Drainage Release Covenant
10-G	Drainage Easements
10-H	Plan Review Procedures
10-I	Variance Process Guidelines

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-A
PREDESIGN MEETING FORM

DRAINAGE PLAN SUBMITTAL

PRE-DESIGN MEETING FORM

Project Title _____

Site Address _____

County Project No. _____

Subdivision ☐ Short Subdivision ☐ Commercial ☐ Grading ☐

Other ☐ _____

Date: _____ Time: _____

Meeting Attendees: _____

_____

_____

_____

MEETING AGENDA

- Introduction . . . . . Plan Review
- Project Description . . . . . Design Engineer
- Site Characteristics . . . . . Design Engineer
- General Considerations . . . . . Plan Reviewer
- Worksheet Overview . . . . . Plan Reviewer
- Other _____ . . . . . Meeting Attendees

  _____
- General Discussion

MEETING NOTES

Is a public hearing required for this project? _____ Yes _____ No
Date of public hearing _____

Has the King County Council approved the hearing examiner's conditions?
_____ Yes _____ No

Hearing Examiner's Final Report Date _____
is attached.

Conditions No.'s _____ related to drainage review and
are circled on the attached report.

- Is the project in a Critical Drainage Basin? _____ Yes _____ No

  Reference/Source _____

  _____

  _____

  _____

- Are off-site drainage basins contributing to on-site flows?
  _____ Yes _____ No

  Reference/Source _____

  _____

  _____

  _____

- Is the Site located within a Community Planning Area?

  _____ Yes _____ No

_____

_____

_____

On-site Features

Steep slopes _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Wet areas, springs, seeps _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Streams, Creeks, Drainage Swales, Springs _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Natural Drainage Features Onsite to be altered _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Mitigations for Altered Natural Features

_____

_____

_____

Sensitive Areas Review

Class III Landslide Hazards _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Class III Seismic Hazards _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Erosion Hazards _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Wetlands _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Anadromous Fish-Bearing Waters _____ Yes _____ No

Reference/Source _____

_____

_____

_____

100-year Flood Plain _____ Yes _____ No

Reference/Source _____

_____

_____

_____

Coal Mine Hazards _____ Yes _____ No

Reference/Source _____

_____

_____

_____

- Is a Soils Report Required? _____ Yes _____ No

_____

_____

_____

Detention Required? _____ Yes _____ No

Additional storage requirements for critical basin, for on-site depression, wetlands, downstream hazard.

_____

_____

_____

Specific Type of Detention

Manmade

_____

_____

_____

Natural Drainage Features

_____

_____

_____

100-year Flood Plain _____ Yes _____ No

_____

_____

_____

Outfall Location(s)

_____

_____

_____

- Downstream Analysis - Capacity of Erosion Problems?

_____

_____

_____

- Is a State Fisheries Hydraulic Permit Application Required?

  _____ Yes _____ No

_____

_____

_____

- Is a Flood Plain Analysis Required? _____ Yes _____ No

_____

_____

_____

- Is a Native Growth Protection Easement Required?

  _____ Yes _____ No

Other Easements _____

_____

_____

_____

All subdivision, Short Subdivision, Commercial and Grading plans must be designed to King County Road Standards, and King County Storm Drainage Guidelines and Requirements. All storm drainage materials and concepts must comply with these standards. Direction given to applicants is based upon the best information available on or before the meeting. Should site circumstances change or new information become available the direction provided by King County representatives may be revised in accordance with the newer circumstances or conditions. Hearing Examiner's conditions as adopted by Council are binding. Where conflicts occur those conditions adopted by the King County Council will apply. The permittee is ultimately responsible for providing a plan design that conforms to all King County Codes, Regulations and Policies.

_____
King County Staff/Position/Date

_____
Developer's Representative/Firm

_____
Developer's Representative/Firm

_____
Developer's Representative/Firm

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-B
TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

King County Building and Land Development Division

TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

PART 1 PROJECT OWNER AND PROJECT ENGINEER

Project Owner _____
Address _____
Phone _____
Project Engineer _____
Company _____
Address Phone _____

PART 2 PROJECT LOCATION AND DESCRIPTION

Project Name _____
Location
Township _____
Range _____
Section _____
Project Size _____ AC _____
Upstream Drainage Basin Size _____ AC _____

PART 3 TYPE OF PERMIT APPLICATION

- ☐ Subdivision
- ☐ Short Subdivision
- ☐ Grading
- ☐ Commercial
- ☐ Other _____

PART 4 OTHER PERMITS

- ☐ DOF/G HPA
- ☐ COE 404
- ☐ DOE Dam Safety
- ☐ FEMA Floodplain
- ☐ COE Wetlands
- ☐ Shoreline Management
- ☐ Rockery
- ☐ Structural Vaults
- ☐ Other
- ☐ HPA

PART 5 SITE COMMUNITY AND DRAINAGE BASIN

Community _____

Drainage Basin _____

PART 6 SITE CHARACTERISTICS

- ☐ River _____
- ☐ Stream _____
- ☐ Critical Stream Reach
- ☐ Depressions/Swales
- ☐ Lake _____
- ☐ Steep Slopes _____
- ☐ Lakeside/Erosion Hazard
- ☐ Floodplain _____
- ☐ Wetlands _____
- ☐ Seeps/Springs
- ☐ High Groundwater Table
- ☐ Groundwater Recharge
- ☐ Other _____

PART 7 SOILS

Soil Type	Slopes	Erosion Potential	Erosive Velocities

☐ Additional Sheets Attatched

King County Building and Land Development Division

TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

PART 8 DEVELOPMENT LIMITATIONS

REFERENCE	LIMITATION/SITE CONSTRAINT
☐ Ch. 4 - Downstream Analysis	
☐	
☐	
☐	
☐	
☐	
☐ Additional Sheets Attatched	

PART 9 ESC REQUIREMENTS

MINIMUM ESC REQUIREMENTS DURING CONSTRUCTION	MINIMUM ESC REQUIREMENTS FOLLOWING CONSTRUCTION
☐ Sedimentation Facilities	☐ Stabilize Exposed Surface
☐ Stabilized Construction Entrance	☐ Remove and Restore Temporary ESC Facilities
☐ Perimeter Runoff Control	☐ Clean and Remove All Silt and Debris
☐ Clearing and Grading Restrictions	☐ Ensure Operation of Permanent Facilities
☐ Cover Practices	☐ Flag Limits of NGPES
☐ Construction Sequence	☐ Other
☐ Other	

PART 10 SURFACE WATER SYSTEM

☐ Grass Lined Channel	☐ Tank	☐ Infiltration	Method of Analysis
☐ Pipe System	☐ Vault	☐ Depression	
☐ Open Channel	☐ Energy Dissapator	☐ Flow Dispersal	Compensation/Mitigation of Eliminated Site Storage
☐ Dry Pond	☐ Wetland	☐ Waiver	
☐ Wet Pond	☐ Stream	☐ Regional Detention	

Brief Description of System Operation _____

Facility Related Site Limitations ☐ Additional Sheets Attatched

Reference	Facility	Limitation

PART 11 STRUCTURAL ANALYSIS
(May require special structural review)

- ☐ Cast in Place Vault
- ☐ Retaining Wall
- ☐ Rockery > 4' High
- ☐ Structural on Steep Slope
- ☐ Other

PART 12 EASEMENTS/TRACTS

- ☐ Drainage Easement
- ☐ Access Easement
- ☐ Native Growth Protection Easement
- ☐ Tract
- ☐ Other

PART 14 SIGNATURE OF PROFESSIONAL ENGINEER

I or a civil engineer under my supervision have visited the site. Actual site conditions as observed were incorporated into this worksheet and the attatchments. To the best of my knowledge the information provided here is accurate.

_____
Signed/Date

OFF-SITE ANALYSIS DRAINAGE SYSTEM TABLE
Surface Water Design Manual, Core Requirement #2

Basin: **Subbasin Name:** **Subbasin Number:**

Symbol	Drainage Component Type, Name, and Size	Drainage Component Description	Slope	Distance from site discharge	Existing Problems	Potential Problems	Observations of field inspector resource reviewer, or resident
see map	Type: sheet flow, swale, stream, channel, pipe, pond; Size: diameter, surface area	drainage basin, vegetation, cover, depth, type of sensative area, volume	%	1/4 mi = 1,320 ft	constrictions, under capacity, ponding, overtopping, flooding, habitat or organism destruction, scouring, bank sloughing, sedimentation, incision, other erosion		tributary area, likelihood of problem, overflow pathways, potential impacts.

OFF-SITE ANALYSIS DRAINAGE SYSTEM TABLE
Surface Water Design Manual, Core Requirement #2

Basin: Crystal Drainage Basin **Subbasin Name:** Clear Creek **Subbasin Number:** AA

Symbol	Drainage Component Type, Name, and Size	Drainage Component Description	Slope	Distance from site discharge	Existing Problems	Potential Problems	Observations of field inspector resource reviewer, or resident
see map	Type: sheet flow, swale, stream, channel, pipe, pond; Size: diameter, surface area	drainage basin, vegetation, cover, depth, type of sensative area, volume	%	1/4 mi = 1,320 ft	constrictions, under capacity, ponding, overtopping, flooding, habitat or organism destruction, scouring, bank sloughing, sedimentation, incision, other erosion		tributary area, likelihood of problem, overflow pathways, potential impacts.
A	Site Discharge Location	Crystal Drainage Basin		0'			
A - B	Natural Swale	Natural, dense vegetation	2%	0 - 240'	None	None	Swale has capacity; no erosion exists.
B - C	12" CMP	Under private drive	3%	240' - 260'	None	Under capacity	No erosion exists
C - D	Draw	Natural, dense vegetation	8%	260' - 500'	Erosion	Further erosion	Tributary area about 650 - 1900 acres
D - E	18" CMP	Under 57th Street	6%	500' - 660'	None	Under capacity	Overtopping is unlikely. If culvert were plugged, drainage would flow toward roadside ditch.
E - F	Seasonal stream	Natural, dense vegetation with gravel and sand at the flow line	5%	660' - 860'	None	None	No erosion exists.
G - H	36" RCP	Under 15th Street	5%	860' - 1010'	None	Under capacity	No erosion exists.
H - I	36" RCP	Under I-22	3%	1010' - 1160'	None	Under capacity	No erosion exists.
I - J	36" RCP	Adjacent to Smith Street	1.5%	1160' - 1310'	Flooding and Sedimentation	Under capacity	No erosion exists.
J - K	Clear Creek	Type 2 Stream	1.5%	1310' - 1610'	Erosion	Further erosion	No erosion exists.
K - L	Wetland CL21	Type 2 Wetland		1610' - 1660'			Tributary area 15 sq. mi.
L - M	Crystal Lake			1660'			

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-C
RETENTION/DETENTION
SUMMARY SHEET AND SKETCH

RETENTION/DETENTION SUMMARY SHEET

Development _____ Date _____

Location _____

ENGINEER
Name _____
Firm _____
Address _____
_____
Phone _____

DEVELOPER
Name _____
Firm _____
Address _____
_____
Phone _____

- Developed Site _____acres Number of Lots _____
- Number of Detention Facilities On Site _____
- Detention provided in regional facility ☐
  Regional Facility location _____
- No detention required ☐
  Acceptable receiving waters _____
- Downstream Drainage Basins

	Immediate	Major Basin
Basin A		
Basin B		
Basin C		
Basin D		

	TOTAL	INDIVIDUAL BASIN			
		A	B	C	D
Drainage Basin(s)					
Onsite Area					
Offsite Area					
Type of Storage Facility					
Live Storage Volume					
Predeveloped Runoff Rate	2 year				
	10 year				
Postdeveloped Runoff Rate	100 year				
	2 year				
	10 year				
Developed Q	100 year				
Type of Restriction					
Size of Orifice/Restriction					
Orifice/Restriction	No.1				
	No.2				
	No.3				
	No.4				
	No.5				

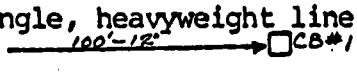
RETENTION/DETENTION SUMMARY SHEET SKETCH

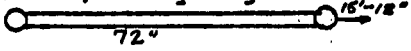
All retention/detention summary sheets must include a sketch prepared to the following criteria:

1. Heading for the drawings should be located at the top of the sketch, preferably at the top right hand corner.

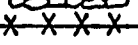
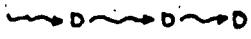
   The heading should contain:
   - North arrow point up or to the left
   - D9#
   - Plat name or Short Plat number
   - Date drawn or updated
   - Address (nearest the site)
   - Thomas Brothers page and grid number
   - Maintenance Division number

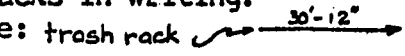
2. Label CB's and MH's with the plan and profile designation.
   Label the control structrue in writing or abbreviate with C.S. or O.W.S.

3. Pipes - indicate:
   - Pipe size
   - Pipe lenghth
   - Flow direction
   - Use a single, heavyweight line
     Example: 

4. Tanks - use a double, heavyweight line and indicate the size
   Example: 

5. Access Roads
   - Outline the limits of the road
   - Fill the outline with dots if the road is gravel. Label in writing if it is another surface

6. Other Standard Symbols:
   - Bollards
   - Rip Rap 
   - Fences 
   - Ditches

7. Label trash racks in writing.
   Example: 

8. Label all streets with the actual street sign designation. If you don't know the actual street name, consult the plat map.

9. Include easements and lot lines or tract limits when possible.

10. Arrange all the labeling or writing to read from left to right or from bottom to top with reference to a properly oriented heading.

11. Indicate driveways or features that may impact our access, maintenance or replacement.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-D
DECLARATION OF COVENANT

After recording return to:

_____
_____
_____

DECLARATION OF COVENANT

IN CONSIDERATION OF the approved King County _____ _____ permit for application No. _____ relating to real property legally described as follows: _____

_____

_____

_____.

The undersigned as Grantor(s), declares that the above described property is hereby subject an easement for a natural or constructed conveyance system and hereby dedicates, covenants and agrees as follows:

1. King County shall have the right to ingress and egress over those portions not contained in Exhibit "A" to access such easement area for inspection of and to reasonably monitor the system for performance, operational flows, or defects in accordance with and [as presented in King County Code Section 9.04.120].

2. If King County determines that maintenance or repair work is required to be done to the system, the Manager of the Surface Water Management Division of the Department of Public Works shall give notice of the specific maintenance and/or repair required pursuant to K.C.C. 9.04.030. The Manager shall also set a reasonable time in which such work is to be completed by the Grantor(s), its heirs, successors or assigns. If the above required

maintenance and/or repair is not completed within the time set by the Manager, the County may perform the required maintenance and/or repair. Written notice will be sent to the Grantor(s) stating the County's intention to perform such maintenance. Maintenance work will not commence until at least seven (7) days after such notice is mailed. If, within the sole discretion of the Surface Water Management Division Manager, there exists an imminent or present danger, said seven (7) day notice period will be waived and maintenance and/or repair work will begin immediately.

3. If at any time King County reasonably determines that any existing retention/detention system creates any of the conditions listed in K.C.C. 9.04.030 and herein incorporated by reference, the Surface Water Management Division Manager may take measures specified therein.

4. The Grantor(s) shall assume all responsibility for the cost of any maintenance and for repairs to the system. Such responsibility shall include reimbursement to the County within thirty (30) days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate as liquidated damages. If legal action ensues, the prevailing party is entitled to costs or fees.

5. The Grantor(s) is (are) hereby required to obtain written approval from the Surface Water Management Division Manager of the King County Department of Public Works prior to filling, piping, cutting, or removing vegetation (except in routine landscape maintenance) in open vegetated drainage facilities (such as swales, channels, ditches, ponds, pond, etc.), or performing any alterations or modifications to the drainage facilities contained within said drainage easement. Any notice or consent required to be given or

otherwise provided for by the provisions of this Agreement shall be effective upon personal delivery, or three (3) days after mailing by Certified Mail, return receipt requested.

6. This Agreement constitutes the entire agreement between the parties, and supersedes all prior discussions, negotiations, and all agreements whatsoever whether oral or written.

This covenant is intended to protect the value of desirability of the real property described above, and shall insure to the benefit all the citizens of King County, and shall be binding on all heirs, successors and assigns.

_____
OWNER

_____
OWNER

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this date personally appeared before me:

_____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of _____, 199____.

_____
NOTARY PUBLIC in and for the State of Washington, residing at _____.
My Commission Expires: _____.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-E
BOND QUANTITIES WORKSHEET

Commercial/Multifamily Group
Subdivision Products Section

King County Department of Development and Environmental Services
3600 136th Place Southeast
Bellevue, Washington 98006-1400

SITE IMPROVEMENT BOND QUANTITY WORKSHEET

Project Name: _____ SIERRA Project No.: _____ Date: _____

Location: _____ Sierra Activity No. _____

	Unit Price	Unit	FOR ENTIRE PROJECT Quantity	Price
EROSION/SEDIMENT CONTROL				
Fence, silt	$ 1.30	LY		
Hydroseeding	.40	SY		
Jute Mesh	1.00	SY		
Mulch, by hand, straw, 2" deep	.35	SY		
Mulch, by machine, straw, 1" deep	.40	SY		
Rock Constr Entrance, 50' x 15' x 1'	1,030.00	Each		
Rock Constr Entrance, 100' x 15' x 1'	1,800.00	Each		
Seeding, by hand	.35	SY		

ESC SUBTOTAL _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
GENERAL ITEMS																
Clear/Remove Brush, by hand	.24	SY														

SUBTOTAL FOR PAGE _____ _____ _____ _____ _____ _____ _____

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
GENERAL ITEMS (Con't.)																
Clearing/Grubbing/Removal, trees	6,150.00	Acre														
Excavation - bulk	1.10	CY														
Excavation - trench	3.00	CY														
Backfill & Compaction - embankment	3.60	CY														
Backfill & Compaction - trench	5.70	CY														
Fill & Compact - common barrow	11.10	CY														
Fill & Compact - gravel base	15.60	CY														
Fill & Compact - screened topsoil	15.40	CY														
Grading, fine, with grader	.70	SY														
Grading, fine, by hand	1.30	SY														
Fencing, cedar, 6' high	25.00	LF														
Fencing, chain link, 6' high	9.20	LF														
Fencing, chain link, gate, 20'	880.00	Each														
Fencing, temporary (NGPE)	1.10	LF														
Sod	4.82	SY														
Monuments, 3' long	84.00	Each														
Surveying, lot location/lines	630.00	Acre														
Surveying, line & grade	510.00	Day														
Trail, 4" crushed cinder	6.50	SY														
Trail, 4" top course	6.00	SY														
Gabion, 3' thick, no earthwork	97.00	SY														
Wall, retaining, rockery w/earthwork	21.00	SF														

SUBTOTAL FOR PAGE _____ _____ _____ _____ _____ _____ _____

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
ROAD IMPROVEMENTS																
AC Grinding, 4' machine	7.00	SY														
AC Removal/Disposal/Repair	80.00	SY														
Barricade, type III	30.00	LF														
Barricade, type I	20.00	LF														
Curb, extruded asphalt	1.80	LF														
Curb, extruded concrete	1.80	LF														
Curb & Gutter, rolled	9.30	LF														
Curb & Gutter, vertical	6.80	LF														
Demolition/Disposal, curb & gutter	10.30	LF														
Demolition/Disposal, sidewalk	22.50	SY														
Sawcut, asphalt, 3" depth	1.30	LF														
Sawcut, concrete, per 1" depth	1.10	LF														
Sealant	.70	LF														
Shoulder, AC, see AC Road	.	SY														
Shoulder, gravel	6.40	SY														
Sidewalk, 4" thick, vertical curb	20.80	SY														
Sidewalk, 5" thick, rolled curb	23.80	SY														
Striping, 4" reflectorized line	.20	LF														
Striping, per parking stall	2.90	Each														
Thickened Edge	4.70	LF														
ROAD SURFACING (4" rock = 2.5 base & 1.5" top course)																
AC Overlay, 1.5" AC	5.40	SY														
AC Overlay, 2" AC	6.50	SY														
SUBTOTAL FOR PAGE																

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
ROAD SURFACING (Con't.)																
AC Road, 2", 4" rock, First 2500 SY	13.70	SY														
AC Road, 2", 4" rock, Qty. over 2500 SY	9.10	SY														
AC Road, 3", 4" rock, First 2500 SY	16.50	SY														
AC Road, 3", 4" rock, Qty. over 2500 SY	11.00	SY														
AC Road, 5", First 2500 SY	16.30	SY														
AC Road, 5", Qty. over 2500 SY	10.80	SY														
AC Road, 6", First 2500 SY	19.10	SY														
AC Road, 6", Qty. over 2500 SY	12.70	SY														
Asphalt Treated Base (ATB) (Assume 2.05 ton/cyd)	30.00	Ton														
Gravel Road, 4" rock, First 2500 SY	7.20	SY														
Gravel Road, 4" rock, Qty. over 2500 SY	4.70	SY														
PCC Road, 5", no base	14.30	SY														
PCC Road, 6", no base	16.60	SY														
DRAINAGE																
(CPP = Corrugated Plastic Pipe, N-12 or equivalent)																
Access Road, R/D	9.30	SY														
Bollards - fixed	290.00	Each														
Bollards - removable	475.00	Each														
(CBs include frame and lid)																
CB Type I	850.00	Each														
CB Type IL	1,000.00	Each														
CB Type II, 48" diameter	1,300.00	4' deep														
for additional depth over 4'	+320.00	+1' depth														

SUBTOTAL FOR PAGE _____ _____ _____ _____ _____ _____ _____

C/84-4:M136 - 12/8/84

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
DRAINAGE (Con't.)																
CB Type II, 54" diameter	1,450.00	4' deep														
for additional depth over 4'	+370.00	+1' depth														
CB Type II, 60" diameter	1,600.00	4' deep														
for additional depth over 4'	+410.00	+1' depth														
CB Type II, 72" diameter	2,200.00	4' depth														
for additional depth over 4'	+520.00	+1' depth														
Through-curb Inlet Framework (Add)	225.00	Each														
Cleanout, PVC, 4"	86.00	Each														
Cleanout, PVC, 6"	115.00	Each														
Cleanout, PVC, 8"	142.00	Each														
Culvert, PVC, 4"	4.50	LF														
Culvert, CPP, 6"	9.30	LF														
Culvert, PVC, 6"	6.40	LF														
Culvert, CMP, 8"	9.50	LF														
Culvert, concrete, 8"	12.90	LF														
Culvert, CPP, 8"	10.00	LF														
Culvert, PVC, 8"	8.00	LF														
Culvert, CMP, 12"	14.60	LF														
Culvert, concrete, 12"	17.90	LF														
Culvert, CPP, 12"	16.50	LF														
Culvert, CMP, 15"	18.70	LF														
Culvert, concrete, 15"	22.50	LF														
Culvert, CPP, 15"	18.50	LF														
Culvert, CMP, 18"	21.90	LF														

SUBTOTAL FOR PAGE _____ _____ _____ _____ _____ _____ _____

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
DRAINAGE (Con't.)																
Culvert, concrete, 18"	27.60	LF														
Culvert, CPP, 18"	22.00	LF														
Culvert, CMP, 24"	30.30	LF														
Culvert, concrete, 24"	39.80	LF														
Culvert, CPP, 24"	29.00	LF														
Culvert, CMP, 30"	38.60	LF														
Culvert, concrete, 30"	64.70	LF														
Culvert, CMP, 36"	62.80	LF														
Culvert, concrete, 36"	83.20	LF														
Culvert, CPP, 36"	39.00	LF														
Culvert, concrete, 42"	101.80	LF														
Culvert, CMP, 48"	80.60	LF														
Culvert, concrete, 48"	113.00	LF														
Culvert, CMP, 60"	112.00	LF														
Culvert, concrete, 60"	164.00	LF														
Ditching, bare, roadside	5.40	CY														
Flow Dispersal Trench	1,100 base + 15.00	LF														
French Drain	12.30	LF														
Mid-tank Access Riser, 36"	700.00	Each														
Pond Overflow Spillway	4.70	SY														
Restrictor/Oil Separator, 12"	785.00	Each														
Restrictor/Oil Separator, 15"	885.00	Each														
Restrictor/Oil Separator, 18"	1,035.00	Each														

SUBTOTAL FOR PAGE _____ _____ _____ _____ _____ _____ _____

Sierra Project No. _____

			EXISTING RIGHT-OF-WAY		FUTURE PUBLIC ROAD IMPROVEMENTS		PRIVATE IMPROVEMENTS		R/D FACILITIES AND CONVEYANCE SYSTEMS		BOND REDUCTIONS 1		2		3	
	Unit Price	Unit	Quantity	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity Complete	Price	Quantity Complete	Price	Quantity Complete	Price
DRAINAGE (Con't.)																
Riprap, placed	28.00	CY														
Tank End Reducer	400.00	Each														
Trash Rack, 12"	160.00	Each														
Trash Rack, 15"	185.00	Each														
Trash Rack, 18"	210.00	Each														
Trash Rack, 21"	240.00	Each														
PARKING LOT SURFACING																
2" A.C., 2" top course rock & 4" select borrow	8.10	SY														
1.5" top course rock & 2.5" base course	4.70	SY														
4" select borrow	1.75	SY														
WRITE-IN ITEMS																
SUBTOTAL (SUM ALL PAGES):																
30% CONTINGENCY & MOBILIZATION:																
TOTAL:											(A)		(B)		(C)	

Sierra Project No. _____

Quantities above were completed by:

Signature: _____ Date: _____

PE Registration Number: _____ Telephone Number: _____

Firm Name: _____

Address: _____

_____

_____

This section to be completed by King County

BOND COMPUTATIONS:

	PERFORMANCE BOND AMOUNTS	MAINTENANCE BOND AMOUNT	DEFECT BOND AMOUNT
Stabilization/Erosion Sediment Control (ESC)	(D)_____		
Existing Right-of-Way Improvements	(E)_____		
Future Public Road Improvements	(F)_____	(E+F) x 0.25 = _____	
Private Improvements	_____		
R/D Facilities and Conveyance Systems	_____	- - - - - - - - - - - - - - - - - -	x 0.15 = _____
TOTAL PERFORMANCE BOND AMOUNT	(T)_____		
RIGHT-OF-WAY & SITE RESTORATION BOND (First $7,500 of bond shall be cash.)	(D+E)_____		
PERFORMANCE BOND TOTAL AFTER BOND REDUCTIONS (T-A,B OR C)	#1_____		
	#2_____		
	#3_____		

NOTE: The word "bond" is used to represent any financial guarantee acceptable to King County.

Original bond computations prepared by: _____ Date: _____

Signature of Person Preparing Bond Reduction

#1_____ Date

#2_____ Date

#3_____ Date

NOTE: Total bond amounts remaining after reduction shall not be less than 30% of the original amount or the sum of the maintenance and defect amounts shown above, whichever is greater.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-F
DRAINAGE RELEASE COVENANT

After recording return to:

_____
_____
_____

DRAINAGE RELEASE COVENANT

This agreement made this _____ day of _____, 19____, _____, hereinafter called the GRANTOR, and KING COUNTY, a political subdivision of the State of Washington, hereinafter called the GRANTEE, and whereas GRANTOR represents and warrants that it is the owner in fee of that certain parcel of land, described as follows:

_____
_____
_____
_____
_____

and whereas the GRANTEE is implementing an approved drainage plan for a project known as _____, permit no. _____, on lands located at the above description, which said plan shall divert surface and storm waters from its natural course so as to cause them to flow (onto)/(away from) the lands of GRANTOR; NOW THEREFORE in consideration of either GRANTEE approval of diversion of said plan and/or other valuable consideration, receipt of which is hereby acknowledged, the GRANTOR hereby willfully acknowledges, agrees and consents to the diversion of surface and storm waters (onto)/(away from) its lands and to hold and release GRANTEE

harmless for any damage that may be caused by such diversion of flow. This release shall be a covenant running with the land and shall be binding upon GRANTOR and its heirs, successors and assigns forever.

IN WITNESS THEREOF, the parties hereto have hereunto set their hands:

_____
GRANTOR

_____
GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this date personally appeared before me:

_____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of _____, 199____.

_____
NOTARY PUBLIC in and for the State of Washington, residing at _____.
My Commission Expires: _____.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-G
DRAINAGE EASEMENTS

Public Drainage Easement
Private Drainage Easement

After recording return to:

_____
_____
_____

DRAINAGE EASEMENT

For a valuable consideration, receipt of which is hereby acknowledged, the GRANTOR(s), _____

_____

_____

the owner(s) in fee of that certain parcel of land, legally described as follows:

_____

_____

_____

_____

hereby grant and convey a(an) [exclusive/non-exclusive] easement (attached and incorporated as Exhibit "A") to King County, a political subdivision of the State of Washington, (GRANTEE) for the purpose of conveying, storing, managing and facilitating storm and surface water per an engineering plan approved by King County for the project known as: _____

_____,

together with the right for King County to reasonably [ingress and egress to] enter said drainage easement for the purpose of operating, maintaining, repairing, and improving the drainage facilities contained herein.

The GRANTOR(s) of said parcel, is (are) required to obtain prior written approval from the Surface Water Management Division of the King County Department of Public Works prior to filling, piping, cutting, removing vegetation or substantially modifying or altering the intended use of the drainage facility contained within the easement above described (except for seasonal, routine landscape maintenance).

This easement is intended to facilitate reasonable access to the drainage facilities. It is binding upon the GRANTOR(s), its heirs, successors and assigns.

_____
GRANTOR

_____
GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this date personally appeared before me:

_____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of _____, 199____.

_____
NOTARY PUBLIC in and for the State of Washington, residing at _____.
My Commission Expires: _____.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-H
PLAN REVIEW PROCEDURES

PLAN REVIEW PROCEDURES

This reference section details the required procedures for the submittal of the drainage aspects of engineering plans as part of a permit application to the King County Building and Land Development (BALD) Division. Taking care that your plans comply with these formats and plan specifications will help secure a prompt review and approval, with a minimum of time-consuming corrections and resubmittals.

The intent of these procedures is to present consistent formats for the engineering plans and the technical support data required to develop the plans. These conventions are necessary to review engineering plan designs for compliance with King County ordinances and regulations and that the intent of the plan is easily understood and implemented in the field. Properly drafted engineering plans and supporting information will also facilitate the construction, operation and maintenance of the proposed system long after its review and approval.

Please note that this reference section primarily describes how to submit drainage plans for review - what must be submitted, in what formats, at what times, to what offices. The design requirements that these plans must address are contained in Chapter 1 "Summary and Guide to All Requirements." The specific design methods and standards to be used are contained in Chapters 3, 4 and 5.

Several key forms used in the Plan review process are reproduced in this reference section. The review process and submittal requirements for Master Drainage Plans are contained in Appendix B.

BUILDING AND LAND DEVELOPMENT DIVISION REVIEW PROCESS

The BALD Division is responsible for the review of all engineering aspects on private development proposals. Drainage review is a primary concern of engineering design. This section outlines the processes involved in submitting engineering plans to the BALD Division.

The steps in the review process vary with the type of development permit which occasioned the drainage review. The two main plan review processes are illustrated in the two flow charts, Figures A and B. Figure A represents the procedures required for a Subdivision, Short Plat, Master Planned Development or Planned Unit Development (PUD). Figure B represents the procedures required for a Commercial Building Permit or a Grading Permit. The reader should note that the processes illustrated apply to fairly complex proposals. The review procedures for simpler permits are correspondingly simpler. For detailed information on specific requirements on any permit type, please refer to the Development Assistance Bulletins prepared by the BALD Division for this purpose.

Submittals - All Subdivisions, Short Plats, Planned Unit Developments, Master Planned Developments, Binding Site Plans, and right-of-way use permit applications should be submitted to the BALD Subdivision Products Section. All Commercial Building and Grading Permit applications should be submitted to the Commercial/Multi-Family Products Section. All Conditional Use and Shoreline Permit applications should be submitted to the Land Use Control Section. All Special Use Permit applications should submitted to the Real Property Division.

The initial submittal of any type of permit application shall include:

(1) documentation on how the Core and Special Requirements apply to the project;
(2) a downstream analysis (Core Requirement #2: Off-Site Analysis); AND
(3) environmental checklist.

All preliminary and engineering plans and specifications must be stamped by a professional civil engineer registered in the State of Washington. All reproductions of site improvement plans and the cover page of copies of the Technical Information Report submitted must be signed and dated by the professional civil engineer approving the design.

All land boundary surveys used, and legal descriptions prepared, for preparing preliminary and engineering plans must be stamped by a professional land surveyor registered in the State of Washington. Topographic survey data and mapping prepared specifically for a proposed project may be performed by the professional

civil engineer stamping the engineering plans as allowed by the Washington State Board of Registration for Professional Engineers and Land Surveyors.

PRELIMINARY PLANS SUBMITTAL

Preliminary plans are submitted as part of the initial application.

Used for public review and evaluation, the preliminary plans for regular Subdivisions (i.e., "Plats"), Master Planned Developments and Planned Unit Developments must show lot layout, building locations, road alignments and right-of-way, tracts, site topography and other site features. In addition, the supporting documents specified in Section 2.2.1 must accompany the preliminary plans for these developments.

For Subdivisions, Master Planned Developments and Planned Unit Developments, the BALD Division may also require a conceptual drainage design to address any drainage concerns (such as wetlands, steep slopes, floodplains, etc.) identified on the plan or through site visits. The components of this design will vary from project to project, but always will consist of elements of the Technical Information Report, such as "Project Overview", "Off-site Analysis", "Conveyance System Analysis and Design", etc., described in Section 2.2. These elements will be determined by the conclusion of the SEPA Threshold Determination, if not earlier.

Preliminary plans for Short Plats are simpler, requiring only a plot plan showing the configuration of the lots, access and other tracts. Conceptual drainage designs are never required for Short Plats.

Preliminary plans are not required at all for Commercial Building, Conditional Use, Grading, Residential Building, Right-of-Way Use, Shorelines Management or Special Use Permits. For these permits the initial submittal to the BALD Division is a set of engineering plans.

ENGINEERING PLANS SUBMITTAL

An engineering plan will be required if:

- a hydrologic, geotechnical, or soils analysis is required; OR
- new drainage facilities must be constructed, or existing drainage facilities modified; OR
- site restrictions (such as building setback lines, floodplain limits and drainage easements) are required.

The drainage portion of engineering plans shall consist of:

- a Technical Information Report . (TIR)
  (specified in Section 2.3.1) and
- a set of Site Improvement Plans
  (specified in Section 2.3.2)

Exemption: Less stringent requirements apply to certain individual Residential Building Permits and to Short Plats, as described in Section 2.3.

Subdivisions, Planned Unit Developments, and Master Plan Developments must receive preliminary approval prior to submitting engineering plans for approval. The plans shall be submitted at least 60 days prior to the expiration of the preliminary approval. (see Figure A)

Commercial Building Permits and Grading Permits requiring engineering site plan review require engineering plans at the time of application. (see Figure B)

Refer to the Development Assistance Bulletins for specific details as to the number of copies and other requirements, such as the expiration periods set for each type of permit application.

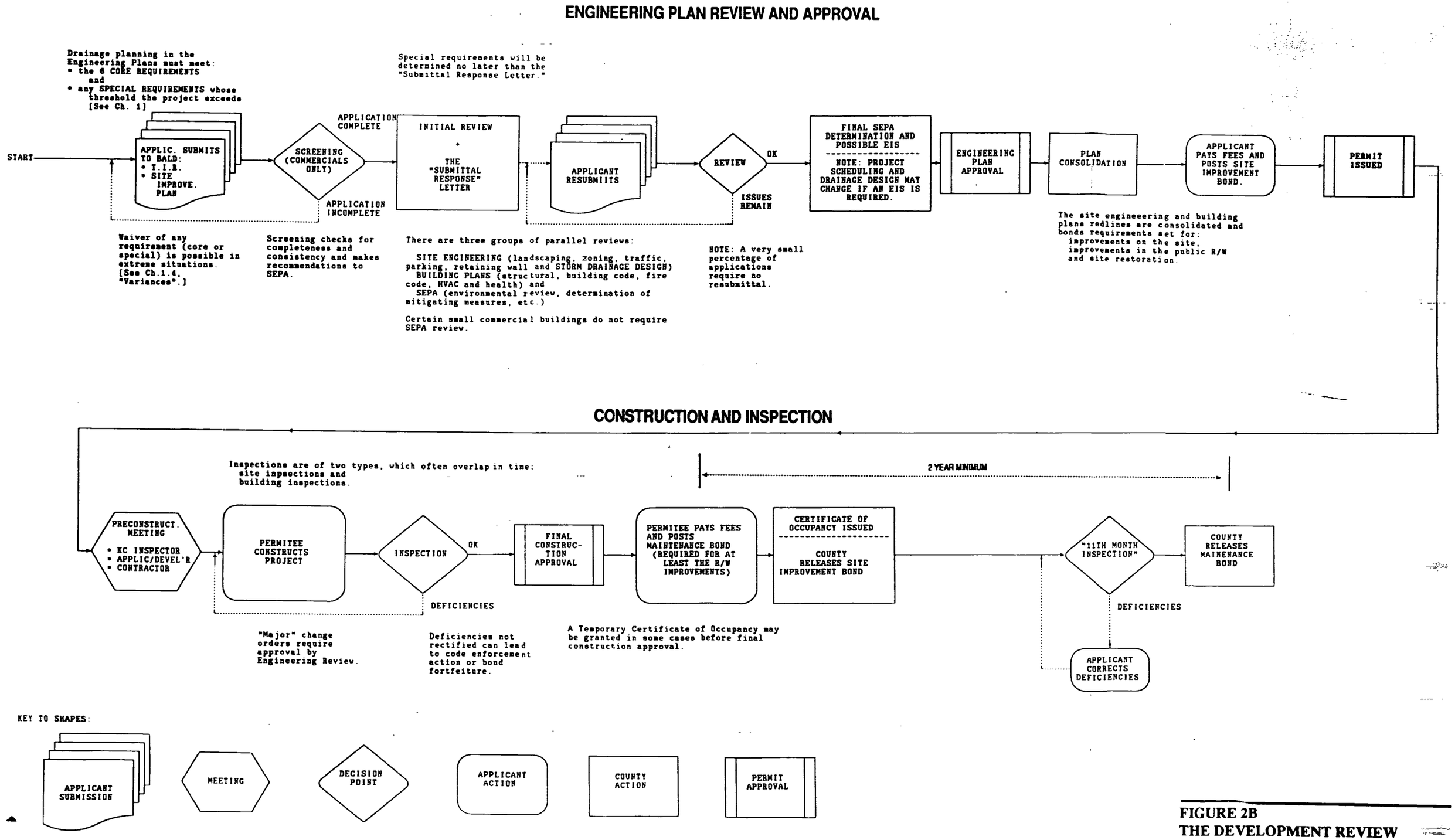
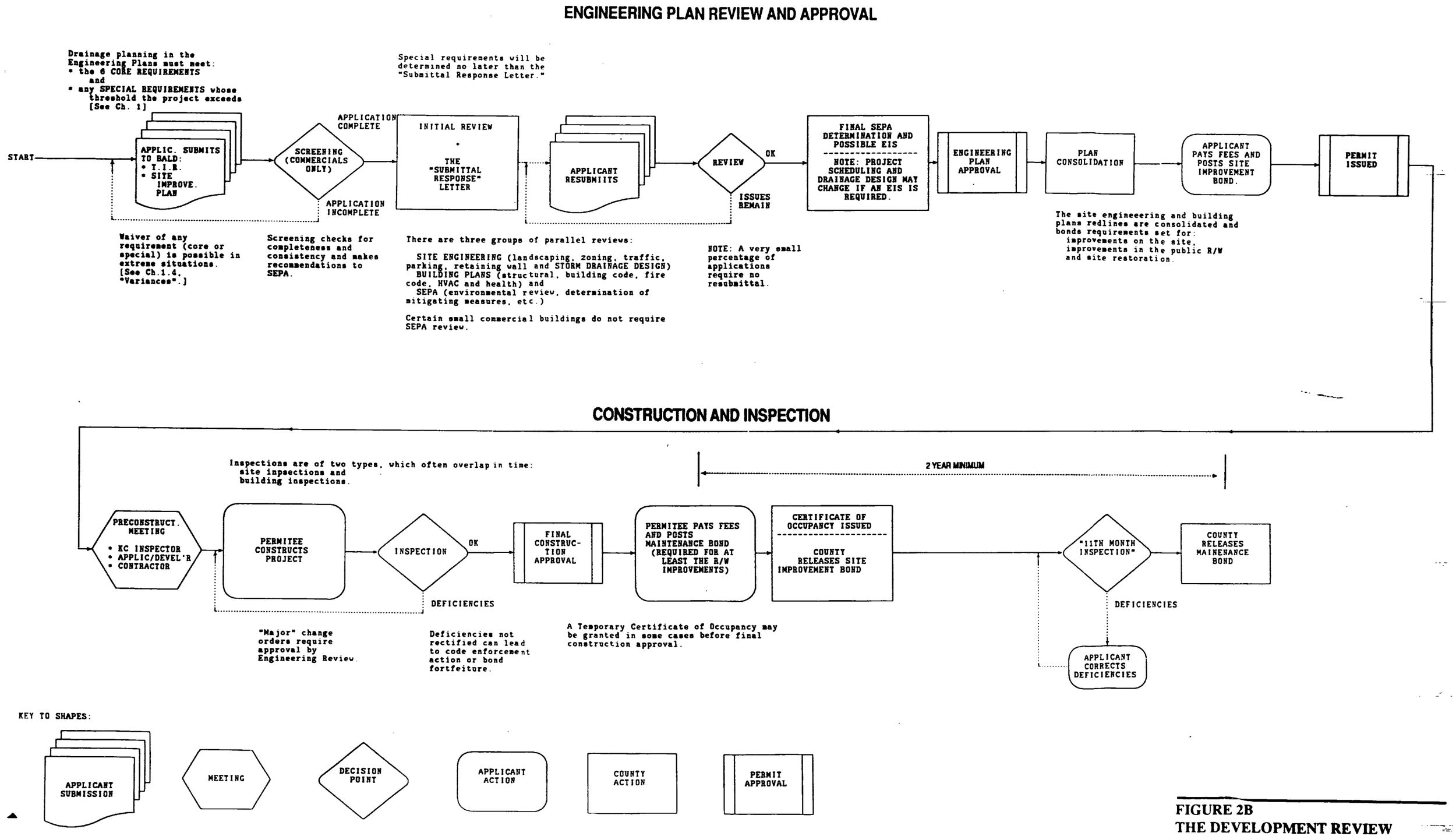


FIGURE 2B
THE DEVELOPMENT REVIEW PROCESS WITH DRAINAGE REVIEW ELEMENTS SHOWN
(Commercial Building Permits and Grading Permits)



NOTE: BALD WILL UPDATE THIS PROCESS FROM TIME TO TIME. THE APPLICANT SHOULD BE SURE TO REFER TO THE CURRENT REVISION.

FIGURE 2B
THE DEVELOPMENT REVIEW PROCESS WITH DRAINAGE REVIEW ELEMENTS SHOWN
(Commercial Building Permits and Grading Permits)

All applicable review fees shall be paid at the time of plan submittal and/or approval. Please refer to the current fee ordinance for the specific fees.

Following Plan approval of any Subdivision, Planned Unit Development, Binding Site Plan or Short Plat plan, the BALD Division will make a set of reproducible plans, cost to be paid by the applicant, and return the original set to the applicant's engineer. The BALD Division will retain this reproducible, utilizing it to make copies for public inspection, distribution and base reference as required. At the time the development construction is approved by King County, the BALD Division set of reproducibles shall be replaced by the corrected original set for permanent public records at the Department of Public Works map counter, 9th floor, King County Administration Building.

PLAN CHANGES AND REVISIONS AFTER PERMIT ISSUANCE

If changes or revisions to the originally approved plans require additional review, the revised plans shall be submitted to the BALD Division for approval prior to construction. The plan change submittals shall be accompanied by:

- the appropriate Plan Change Order form(s)
- one copy of the revised TIR
- three sets of the engineering plans

Proposed changes shall be highlighted, and the page/sheet shall include a revision title block. The revision block shall include the change or revision number, description, the date and initials of the person making the revisions, and the date and professional civil engineer's initials and space for approval initials. The change order number shall also be shown in a small triangle next to the revision on the plan and/or report sheet/page. If a project has held a pre-construction conference and begun construction, all changes or revisions shall be initiated through the field inspector. Plan changes and revisions shall be prepared, reviewed and processed as described above for engineering plan submittals.

FINAL CORRECTED PLAN SUBMITTAL

During the course of construction, changes to the approved plan are often required to address unforeseen field conditions or plan design improvements. Once construction is completed, it is the applicants responsibility to submit to the BALD Division, a "Final Corrected Plan" which is an engineering drawing that accurately represents the project as constructed. These corrected drawings must be professionally drafted revisions applied to the original approved plan and include all changes made during the course of construction, except that the erosion/sedimentation control plan should not be included. The final corrected plan must be stamped, signed and dated by a civil engineer registered in the State of Washington.

FINAL RECORDING SUBMITTAL

Any Subdivision or Planned Unit Development to be "finaled", thereby completing the subdivisions process and legally forming the new lots, requires a final plat submittal for approval and recording. Any Binding Site Plans also require a final submittal for approval and recording. The final plat or map page, shall contain the elements summarized in Section 2.4 and specified in detail in Development Assistance bulletins published by the BALD Division. Submittals shall be accompanied with appropriate fees as prescribed by ordinance.

Final submittals shall be allowed only after the approval of preliminary plans and any required engineering plans and after the construction of any required drainage facilities. Final applications for Short Plats may be submitted along with engineering plan submittals.

Final submittals shall be submitted at least 60 days prior to expiration of preliminary approval, as modified by any written approved extension.

The final recording is allowed when the preliminary plan, (and engineering plan, when required) and all conditions of preliminary approval are satisfied. Exception: a developer may be allowed to record a

subdivision prior to completing all site improvements provided a bond or other surety is posted which guarantees all site improvements will be completed within one year from recording.

All final plat map sheets and pages shall be prepared by a professional land surveyor registered in the State of Washington and shall conform with all state and local statutes.

No permit other than a Subdivision or Planned Unit Development will require submittal of a final plat for recording.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 10-I
VARIANCE PROCESS GUIDELINES

1 Preapplication Variance

2 Experimental Design Variance

3 Fee Reduction

REFERENCE 10-I
VARIANCE PROCESS GUIDELINES

1.0 PREAPPLICATION VARIANCE PROCESS

This process is used when the applicant needs a variance decision to determine if a project is feasible or the results are needed to determine if a project is viable before funding a full application. Preapplication variance requests will be accepted when 1) an issue is raised or a potential constraint is identified at a preapplication conference with DDES, and 2) sufficient engineering information to evaluate the request is provided. A higher preapplication variance fee will apply to these requests, and any unused variance fee will be credited towards the permit application fee.

Steps in the processing of a preapplication variance shall include:

- A DDES preapplication conference is scheduled at which the applicant provides justification that a decision on the variance will effect viability of the project. An example could include a need to divert flows due to a downstream problem.

- Additional information and site visits may be requested due to the limited data and lack of prior project review by King County.

- A preapplication deposit is required and fee for review will be an hourly rate billing applied against the deposit. Any unused fees could be returned to the applicant. Any fees in excess of the deposit must be paid prior to the issuance of a decision.

- For approved preapplication variance, the applicant can apply that approval to the applied for permit proposal provided conditions of the approval are met, the proposal has not substantially changed and the applicable regulations have not changed. This will be determined by DDES.

The criteria for granting a preapplication variance are the same as for a Standard or Complex variance. However, preapplication variances will be tied by condition to the project proposal presented at the preapplication meeting. The appeal process is also the same as for a Standard variance or a Complex variance. This approval will expire 1 year after the approval date, unless a complete permit application is submitted and accepted.

2.0 EXPERIMENTAL DESIGN VARIANCE PROCESS

This process is used for proposing new designs or methods different from those in the manual, that are not site specific, and where data sufficient to establish functional equivalence does not exist. Experimental design proposals will be submitted to DDES for processing review and recommendations and forwarded to SWM for review. These variances will incur a special review fee as adopted in the King County DDES fee ordinance. Experimental variances should be submitted prior to development permit application since they may take longer than a typical variance to review.

Upon approval of the variance by the SWM Division Manager, the applicant can use the design or method in a development proposal without applying for a site specific variance. This type of variance is provided to encourage innovation on the part of the development community. It also can expedite the review and development of alternative designs for incorporation in future Manual updates.

Steps in the application for an Experimental Design Variance will include:

- The application for variance is preferably submitted prior to engineering plan review due to the extended review period that may occur. However, it may occur at any permit stage prior to final plan approval. If the review time is to exceed the time outlined in Section 1.4, staff will provide an estimate of the additional time necessary to complete the review within 10 working days of submittal of the variance.

- Review will follow the Standard or Complex variance procedure. DDES may forward to SWM without a recommendation.

- DDES will process and bill the applicant.

- Justification supporting comparable performance of the proposed system to a standard design is required. Where uncertainty or lack of supportive literature or performance testing exists, monitoring may be applicable with joint participation and funding between King County and the applicant.

Only a limited number of experimental variances for a particular facility or method will be granted. If the design proves successful, SWM and DDES may establish a blanket variance for the design until such time as it can be incorporated in the Design Manual by formal update. The appeal process is also the same as for a Standard variance or a Complex variance.

3.0 FEE REDUCTION PROCESS

This process is used for variances that are determined to meet either of the conditions A or B identified below. The DDES Director or designee shall be responsible for making the determination for a fee reduction.

A. Minor variance requests which are defined as issues that require no engineering review to determine appropriateness. These include:

- New or revised standard specifications for engineering and construction which are cited in the Manual (e.g., APWA standard specifications for public works construction, WSDOT standard specifications),
- Minor design alternatives that meet the stated intent in the Manual,
- Identified errors in the Manual.

B. Blanket Variances (See Reference Section 11A Blanket Variances, for approved Blanket Variances).

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REFERENCE 11
INTERIM CHANGES TO REQUIREMENTS

11-A Blanket Variances
11-B Administrative Changes

(Not included at this time.)

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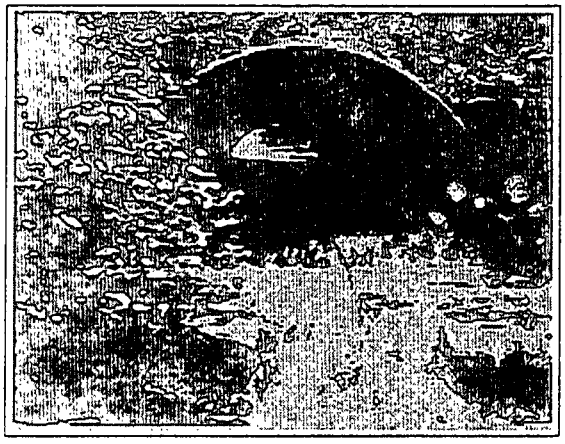

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