PLANNING COMMISSION
REGULAR MEETING
AGENDA

Thursday, August 20, 2015
7:00 p.m.

Council Chamber · Shoreline City Hall
17500 Midvale Ave North

		Estimated Time
1.	**CALL TO ORDER**	7:00
2.	**ROLL CALL**	7:01
3.	**APPROVAL OF AGENDA**	7:02
4.	**APPROVAL OF MINUTES** a. August 6, 2015 Meeting Minutes	7:03

Public Comment and Testimony at Planning Commission

During General Public Comment, the Planning Commission will take public comment on any subject which is not specifically scheduled later on the agenda. During Public Hearings and Study Sessions, public testimony/comment occurs after initial questions by the Commission which follows the presentation of each staff report. In all cases, speakers are asked to come to the podium to have their comments recorded, state their first and last name, and city of residence. The Chair has discretion to limit or extend time limitations and the number of people permitted to speak. Generally, individuals may speak for three minutes or less, depending on the number of people wishing to speak. When representing the official position of an agency or City-recognized organization, a speaker will be given 5 minutes. Questions for staff will be directed to staff through the Commission.

5.	**GENERAL PUBLIC COMMENT**	7:05
6.	**STUDY ITEM** a. Critical Areas Ordinance Update – General Provisions, Related Title 20 Changes, and Follow Up Items • Staff Presentation • Public Comment	7:10
7.	**DIRECTOR'S REPORT**	8:10
8.	**UNFINISHED BUSINESS**	8:20
9.	**NEW BUSINESS**	8:25
10.	**REPORTS OF COMMITTEES & COMMISSONERS/ANNOUNCEMENTS**	8:26
11.	**AGENDA FOR SEPTEMBER 3, 2015** a. Development Code Amendments Batch b. 145th Street Corridor Study	8:27
12.	**ADJOURNMENT**	8:30

The Planning Commission meeting is wheelchair accessible. Any person requiring a disability accommodation should contact the City Clerk's Office at 801-2230 in advance for more information. For TTY telephone service call 546-0457. For up-to-date information on future agendas call 801-2236

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DRAFT

CITY OF SHORELINE

SHORELINE PLANNING COMMISSION
MINUTES OF REGULAR MEETING

August 6, 2015 Shoreline City Hall
7:00 P.M. Council Chamber

Commissioners Present
Chair Scully
Vice Chair Craft
Commissioner Malek
Commissioner Maul
Commissioner Montero
Commissioner Mork
Commissioner Moss-Thomas

Staff Present
Rachael Markle, Director, Planning and Community Development
Steve Szafran, Senior Planner, Planning and Community Development
Lisa Basher, Planning Commission Clerk

CALL TO ORDER

Chair Scully called the regular meeting of the Shoreline Planning Commission to order at 7:00 p.m.

ROLL CALL

Upon roll call by the Commission Clerk the following Commissioners were present: Chair Scully, Vice Chair Craft and Commissioners Maul, Malek, Montero, Moss-Thomas and Mork.

APPROVAL OF AGENDA

The agenda was accepted as presented.

APPROVAL OF MINUTES

The minutes of July 16, 2015 were adopted as presented.

GENERAL PUBLIC COMMENT

No one indicated a desire to provide general comments.

PUBLIC HEARING: DEVELOPMENT CODE AMENDMENTS FOR SPLIT ZONING

Staff Presentation

Mr. Szafran reviewed that the purpose of Development Code amendments is to bring the development regulations into conformity with the Comprehensive Plan, to respond to changing conditions or needs of the City, and/or to comply with State Law. Code amendments are also necessary to reduce confusion, clarify existing language, respond to local policy changes, update references, and eliminate or modify inconsistent language.

Mr. Szafran explained that the current Development Code does not specifically address allowed uses on parcels with more than one zoning designation, and staff interprets this to mean that land uses are confined to the zoning designation even if there is more than one designation on a parcel. This interpretation has been problematic for commercial property owners who want to improve, redevelop and/or lease buildings for commercial uses that do not have the parcel size to accommodate their plans.

Mr. Szafran reported that staff prepared and analyzed a map that identifies the 48 split-zoned parcels in the City, which are zoned both residential and commercial. Based on this analysis, staff is recommending that the proposed amendment only apply to parcels that contain multiple commercial zoning districts that do not abut residential zones. As currently proposed, the amendment would only apply to two commercial properties that have split zoning (Mixed Business and Town Center).

Mr. Szafran reviewed that the proposed amendment would read:

> *"Where a zoning designation line divides a parcel which was in single ownership at the time of passage of the ordinance codified in this chapter and it contains more than one commercial zoning designation with no internal or abutting residential zoning designations, then the combination of the commercial zones allowed land uses shall be permitted throughout the entire parcel All other development standards apply to each zone separately."*

Mr. Szafran recommended that the Commission recommend approval of the proposed amendment as presented.

Public Testimony

No one in the audience indicated a desire to participate in the public hearing.

Planning Commission Deliberation and Action

COMMISSIONER MALEK MOVED THAT THE COMMISSION FORWARD THE PROPOSED DEVELOPMENT CODE AMENDMENT ON SPLIT ZONING TO THE CITY COUNCIL WITH A RECOMMENDATION OF APPROVAL AS RECOMMENDED BY STAFF. VICE CHAIR CRAFT SECONDED THE MOTION.

Commissioner Moss-Thomas asked if the proposed amendment would also apply to a split-zoned commercial property near Ballinger. Mr. Szafran clarified that the proposed amendment would not apply to this property as it abuts a residential zone.

Commissioner Maul asked how the City currently deals with properties with split zoning that abut residential zones. Mr. Szafran answered that the land uses allowed on the properties would be confined to each of the zoning designations.

Commissioner Moss-Thomas referred to Attachment 2 and pointed out that the Sky Nursery property is located across the street from a residential zone. Mr. Szafran agreed that the property is across the street from a residential zone, but it does not abut a residential zone. Therefore, the proposed amendment would apply. To provide additional clarification, Mr. Szafran explained that the proposed amendment would only apply to the property owned by Sky Nursery up to North 188th Street. However, he acknowledged that Sky Nursery owns other parcels in the vicinity.

Commissioner Moss-Thomas asked if changing the use on the property would require the property owner to choose between the Mixed Business or Town Center zoning. Mr. Szafran answered that either zoning designation could be applied to determine allowed uses. However, the applicable development regulations (height, setbacks, lot coverage, etc.) would still be applied to each of the separate zones.

Commissioner Moss-Thomas noted that land aggregation might occur elsewhere in the City, particularly along Aurora Avenue North, at some point in the future. She cautioned that it is important to consider any unintended consequences that might occur as a result. Mr. Szafran emphasized that the proposed amendment would not apply to properties that aggregate both commercial and residential properties. Nor would it apply to commercial properties that abut residential properties. In addition, the proposed amendment would only apply to split-zoned properties that existed prior to adoption of the amendment.

Chair Scully asked why staff is not proposing amendments to address split-zoned residential properties. Ms. Markle explained that some lots were split zoned in order to create transition when the properties were under King County's jurisdiction. Addressing these properties will require significantly more public process and notification. Chair Scully asked if the property owners requested the proposed amendment, and Mr. Szafran answered affirmatively. He explained that the City Manager and City Council directed staff to address the specific problems related to the all-commercial, split-zoned properties.

THE MOTION CARRIED UNANIMOUSLY.

Chair Scully closed the public hearing.

DIRECTOR'S REPORT

Ms. Markle reminded the Commissioners that their retreat is currently scheduled for August 14th. However, because two Commissioners will be unable to attend, she suggested that they consider rescheduling it to another date. She noted that the retreat discussion will focus on lessons learned from

the 185th Street Station Subarea Plan process in preparation for kicking off the 145th Street Station Subarea Plan process in 2016. The Commission agreed to postpone the retreat until October.

UNFINISHED BUSINESS

There was no unfinished business.

NEW BUSINESS

There was no new business.

REPORTS OF COMMITTEES AND COMMISSIONERS/ANNOUNCEMENTS

Commissioner Moss-Thomas noted that the Commissioners received a copy of the Planning Commission's Quarterly Survey, and she invited the staff to provide feedback.

AGENDA FOR NEXT MEETING

Chair Scully advised that the Commission's next meeting is August 20th. The topic of discussion will focus on the Critical Areas Ordinance in preparation for a public hearing on September 17th.

ADJOURNMENT

The meeting was adjourned at 7:18 p.m.

_____ _____

Keith Scully
Chair, Planning Commission

Lisa Basher
Clerk, Planning Commission

Planning Commission Meeting Date: August 20, 2015 Agenda Item

PLANNING COMMISSION AGENDA ITEM

CITY OF SHORELINE, WASHINGTON

AGENDA TITLE:	**Study of Critical Areas Ordinance Update – Subchapter 1-General Provisions, related Title 20 changes, and follow-up items**
DEPARTMENT:	**Planning & Community Development**
PRESENTED BY:	**Juniper Nammi, AICP, Associate Planner** **Paul Cohen, Planning Manager**

☐ **Public Hearing** ☒ **Study Session** ☐ **Recommendation Only**
☐ **Discussion** ☐ **Update** ☐ **Other**

INTRODUCTION

The City of Shoreline began the State required periodic update of the Critical Areas Ordinance (CAO) in Shoreline Municipal Code (SMC) Chapter 20.80 in May. This meeting is the fifth of six scheduled meetings with Planning Commission for review of the draft changes to these regulations. All of the CAO subchapters and related changes will be refined based on the meetings to date and put together in a revised version for public review and comment next month. **The Public Hearing on the whole CAO and related Title 20 changes is scheduled for the September 17, 2015, Planning Commission Meeting.**

The August 20, 2015, study session will review regulations for Critical Area General Provisions, as well as minor amendments to other sections of Title 20 for clarity and consistency.

The purpose of this study session is to:

- Review staff recommended code amendments for the following subchapters of Chapter 20.80 SMC Critical Areas:
    - Subchapter 1-General Provisions (SMC 20.80.010 through 20.80.130);
    - Related changes in Title 20 (SMC Chapter 20.30, 20.40, and 20.50); and
    - Associated Definitions (SMC Chapter 20.20).
- Review alternate amendment options for alterations of landslide hazard areas, in Subchapter 2-Geologic Hazard Areas, liability and special inspection regulatory tools, and GIS slope and landslide hazard data update costs as requested by Planning Commission.

- Review WA Department of Ecology information on alternatives for wetland compensatory mitigation in response to Planning Commission inquiry.

- Respond to questions.

- Receive feedback from the Commission on the proposed amendments.

- Determine what proposed changes may need more research or analysis.

- Develop recommended code amendments to the CAO General Provisions subchapter, related Title 20 changes, and associated definitions for the public hearing.

BACKGROUND

The Commission was introduced to the Critical Areas Ordinance periodic update requirements, as mandated by the Growth Management Act (GMA), on May 21, 2015. Proposed changes for subchapters for specific critical area types, critical areas regulations in the Shoreline Master Program, and related definitions and Title 20 code changes were presented at the June 4, June 18, and July 16, 2015, Planning Commission meetings. Information regarding these meetings can be found in the staff reports and agenda packets for those meeting dates.

The Planning Commission reviews and makes recommendations to Council on the critical area regulations because they are part of the Title 20 Development Code and include regulations that govern environmental protection, which is a stated purpose of the Planning Commission under SMC 2.20.010 and is a specific duty of the Planning Commission under SMC 2.20.060(B).

The decision criteria for Development Code amendments are found in SMC 20.30.350:

> ***B. Decision Criteria.*** *The City Council may approve or approve with modifications a proposal for the text of the Land Use Code if:*
>
> *1. The amendment is in accordance with the Comprehensive Plan; and*
>
> *2. The amendment will not adversely affect the public health, safety or general welfare; and*
>
> *3. The amendment is not contrary to the best interest of the citizens and property owners of the City of Shoreline.*

The City of Shoreline Comprehensive Plan was updated in December 2012 in compliance with the periodic update requirements of the Growth Management Act. The updated Comprehensive Plan added Element 6-Natural Environment as a new element specifically supporting the City's responsibility for protection of the natural environment. Many of the policies existed previously, but were deemed important enough to separate into their own element and expanded. The Comprehensive Plan goals and policies that support the regulation of land use to protect all types of critical areas can be found in the Element 6-Natural Environment of the Comprehensive Plan. Most of the relevant

goals and policies have been included for reference in previous CAO update staff reports to Planning Commission.

PROPOSAL & ANALYSIS

Proposal Summary

The focus of today's study session is the changes to Subchapter 1 - General Provisions of the Critical Areas Ordinance regulations, associated code changes to other chapters of Title 20 Development Code, and related definitions (**Attachment A**). Subchapter 1 applies general standards and provisions to all types of critical areas that are regulated. Minor revisions are also proposed to Chapters 20.30, 20.40, and 20.50 for accurate use of terms, cross references with the CAO, and update to decision criteria for development applications also in Attachment A. A few code sections and definitions that reference critical areas or are commonly used in the regulation of critical areas are included for reference, but no code changes are proposed at this time. These sections are highlighted grey in Attachment A, but will not be included in the revised draft for the September 17th public hearing.

The WA Department of Commerce (Commerce) provides guidance to cities for updating critical area regulations to integrate BAS. The Commerce guidance in *Critical Areas Assistance Handbook and Appendices (CTED, 2007)* includes Sample Code Provisions in Appendix A. This sample code appendix was included in the June 18th Planning Commission Agenda Packet as Attachment C and is being used by City staff for guidance in drafting updates to the critical area regulations. Sample code for general provisions can be found on Appendix pages A-1 through A-33 of that attachment.

Staff proposes the following changes and additions to the General Provisions, Subchapter 1, of the CAO:

- Reorganization of this subchapter to group related subsections together.
- Addition of subchapters to provide standards for:
  - preapplication meetings,
  - best available science,
  - mitigation plan requirements,
  - financial guarantee requirements, and
  - code enforcement for critical areas violations.
- Update of terms for consistency with changes to other subchapters, elimination of outdated terms, accuracy in responsibility, and correction of cross references.
- Changes to exemptions provisions to be clear on what is allowed without application of any of the Title 20 provisions in any type of critical area verses what is allowable without review of a critical area report but must still be reviewed for consistency with Chapter 20.80 Critical Areas.
- General provisions for critical area report and mitigation plan requirements added for clarity and predictability. Redundant draft regulations in other subchapters will be removed or edited to supplement these general requirements.

- Notice to title provisions revised to apply more broadly and native growth protection easement provisions to allow for more flexibility when a separate tract for critical areas does not make sense because development is still allowable within those critical areas.
- Add definitions that are currently not included in the CAO or delete definitions that duplicate or conflict with habitat area regulations.

Staff proposes the following changes and additions to Chapter 20.30 Procedures and Administration, Chapter 20.40 Zoning and Use Provisions, and Chapter 20.50 General Development Standards in SMC Title 20 Development Code:

- Updated terms such as “steep slopes” and “sensitive areas” for accuracy.
- Added or updated code cross references for consistency with changes to critical area chapter for clarity and accuracy.
- Added decision criteria for Critical Area Special Use Permits and Critical Area Reasonable Use Permits based on model code and for better incorporation of BAS.
- Revision to code enforcement provisions modifying civil penalties that apply to critical areas code violations.
- Relocation of exemption for invasive species removal in parks from Clearing and Grading regulations in SMC 20.50.310 to exemptions from Chapter 20.80 in SMC 20.80.030 and added cross reference for clearing and grading permit exemption.
- Added reference to national standards for pruning of protected trees and to allow for pruning to enhance views without removing or topping the tree.

SMC 20.20 Definitions

The purpose of this code section is to define terms as they shall be applied throughout the City of Shoreline. The definitions reviewed here are relevant to the regulation of development in critical areas generally. Proposed definitions to be added, deleted, or edited include:

Alteration – added
Best Available Science – added
Bond – edited for accuracy
Certified Arborist – edited for consistency with national certifications
Conservation Easement – added
Excessive Pruning – edited for clarity/BAS
Protected Tree/Protected Vegetation – edited for accuracy
Qualified Professional – edited to include specific minimum qualifications
Remediation – edited for term accuracy
Site Development Permit – edited to include critical area projects
Site Plan – edited to include critical area information
Substantial Development – deleted, located in SMP definitions

If there are other terms used in the code that would benefit from being defined, please let staff know so they can look for example language for those terms. A few definitions are included for reference (highlighted with grey or noted in comments), but no changes

are proposed. They are included to inform the CAO update process, but will not be included in the final ordinance if no changes are proposed.

Proposed Critical Area General Provisions Revisions

SMC Chapter 20.80 Critical Areas

Subchapter 1. Critical Areas – General Provisions

The general provisions subchapter serves to set the purpose and standards for regulation of development that apply to all types of critical areas. All of the existing general provisions sections are proposed for revision and five new sections are proposed to be added. Throughout the subchapter terms were updated for accuracy or clarity and cross references to relevant sections in other chapters of Title 20 were added. The following provides an overview of the substantive changes proposed.

The subchapter was reorganized to group related sections together. The first four sections identify the purpose and applicability of Chapter 20.80 in relation to the rest of Title 20 Development Code. Exemptions and activities allowed without a critical area report are next so these are easy to find before the details of procedure and standards for alteration of critical areas are addressed. Following the expanded critical area report and mitigation plan requirements, are six sections that provide protections for critical areas through notification, protection measures, financial guarantees, and code enforcement.

The key changes proposed to the General Provisions subchapter, intended to incorporate BAS, are:

1) Exemptions and partial exemptions are proposed to be modified, relocated, or deleted to eliminate unmitigated impacts to critical areas. The changes are intended to clarify what activities are completely exempt or only exempt from critical area report requirements.

2) Standards for critical area reports and related mitigation plans that apply for all types of critical areas and explicit provisions for what constitutes best available science and how it must be used are proposed.

Other changes to this subchapter would add clarity, predictability, and serve to better protect critical areas by improving notification of their presence and strengthening provisions that discourage unauthorized modification or ensure that mitigation is successfully completed. The specific changes proposed are included in more detail in the following sections of this staff report.

SMC 20.80.010 Purpose.

This section lays out the basis for critical areas regulation in the GMA (Chapter 36.70A RCW) and Shoreline Comprehensive plan identifies why they are regulated, and states the City's goals for regulation of critical areas. This section also cross references the administrative procedures in Chapter 20.30 SMC as applying to the application of this Chapter. Revision to this section is proposed for consistency of terms and explicit statement of no net loss as required by the

GMA. A provision regarding how this chapter should be administered is also added to help guide decisions where discretion must be applied.

SMC 20.80.015 Applicability. (formerly 20.80.025)
This section identifies when and how this chapter is applicable. These provisions were relocated to the beginning of the subchapter to be grouped with other provisions that identify what is regulated and how it is regulated relative to other chapters in the development code. Wording changes are proposed for clarity.

SMC 20.80.020 Relationship to other regulations. (formerly 20.80.045)
In addition to moving it, the changes proposed include addition of two provisions that clarify how this chapter relates to the State Environmental Policy Act regulations as well as other state and federal regulations. This is not new, but clarifies that compliance with the City's critical areas regulations do not constitute compliance with state and federal regulations and that the applicant is responsible for complying with those regulations in addition to Chapter 20.80 when applicable.

SMC 20.80.025 Critical area maps. (formerly 20.80.020)
Critical area maps are identified in the general provision SMC 20.80.020, which indicates that critical area maps are adopted by this chapter. The current CAO does not specifically identify or list those maps. The new mapping provisions in each of the subchapters are intended to identify sources of information for each type of critical area. Cross references to those new mapping sections in other subchapters are proposed.

SMC 20.80.030 Exemptions
This section is proposed to be reorganized and updated for incorporation of BAS. The following changes are proposed:

- One provision that applies to all of the exemptions in this section was moved to the beginning of the section.
- Titles for each type of exemption were added for ease of finding information.
- Grammatical corrections proposed for consistency.
- Provision added (A) to require mitigation of impacts in an emergency to facilitate no net loss and no increased risk to life and property.
- Provision added to (B) allow for maintenance of private connections to public utilities and permitted, private stormwater management facilities allowed in critical areas.
- Provision (C) revised to clarify alterations which are not exempted under this section and to facilitate restoration.
- At the request of the Parks department the provision for public recreation areas (D) revised to include modification and replacement, in addition to operation, maintenance, and repair. This is similar to exemption for utilities. Compliance with best practices to prevent impacts is still required.
- Two provisions for wetland and geologic hazard specific exemptions, previously reviewed, are proposed for deletion and are replaced with revisions in the critical area specific subchapters.

- Specific types of activities are proposed to be added to minor conservation and enhancement activities, now provision (E), to allow for invasive species removal and revegetation to a limited extent both on park property and on private property without requiring permit, critical area reports, monitoring and financial guarantees that can make this type of voluntary maintenance and restoration work cost prohibitive.
- Terms updated for non-imminent, hazard tree removal, now provision (G), for consistency with the forms, professionals, types of review, and replacement requirements. Tree replacement is proposed to be required to facilitate no net loss without requiring a mitigation plan prepared by a qualified professional.
- Tree pruning for health of tree and views that is not excessive, as allowed in 20.80.350(E), added as specifically being considered normal and routine maintenance, now provision (J), and exempt from 20.80.

SMC 20.80.040 Allowed activities. (formerly Partial exemptions)
This section is proposed to specifically exempt the listed activities from critical area reports and to require that best management practices be used to protect the critical areas. Previously, this section allowed revisions to nonconforming single family residences in existence prior to November 27, 1990, that could result in adverse impacts to critical areas without mitigation. The proposed revisions, previously reviewed with the wetlands and geologic hazards subchapters, eliminate allowance of adverse impacts without mitigation. This is in keeping with BAS and aligns with the provisions for legal nonconformance in SMC 20.30.280. Other allowed activities specific to each type of critical area were reviewed at previous meetings and would be in addition to these.

SMC 20.80.045 Critical areas preapplication meeting. (NEW)
SMC 20.30.080 requires a preapplication meeting for any project located within a critical area or its buffer. Historically, this requirement was sometimes missed because it is not cross referenced in the critical areas regulations. Clarification is proposed to when a preapplication meeting is required where critical areas might be impacted and this section is proposed to indicate what level of review and direction will be provided through this process by the City regarding critical area regulations and requirements.

The intention of these revisions is to ensure better customer service, advance notice to property owners and applicants of the limitations and requirements that apply to properties which have resources that are protected by the critical areas regulations, and better predictability in our permitting processes.

SMC 20.80.050 Alteration of critical areas. (formerly 20.80.070 and 20.80.080)
The current SMC 20.80.070 and 20.80.080 sections set standards for alteration of critical areas. These two sections are proposed to be combined into one as they are directly related. Clarification of how this section relates to required mitigation is proposed.

SMC 20.80.060 Best available science. (NEW)

The GMA requires that best available science be incorporated into critical areas regulations. Not only does this mean that the science used to shape the specific regulations be periodically reviewed, but the science used to identify and delineate critical areas, assess potential impacts and mitigate for them must meet the criteria of BAS. This new section is proposed to explicitly incorporate state language regarding what BAS is and is not and how to proceed when BAS is not available. By adding this directly to the City's regulations the requirements for the science to be used in critical area reports are laid out explicitly and applicants do not have to refer to state regulations to find this information.

SMC 20.80.070 Classification and rating of critical areas. (formerly 20.80.100)

This section is relocated to maintain proximity to critical area report requirements which are used to document the classification and rating of critical areas. One term change is proposed for consistency in this section.

SMC 20.80.080 Critical area reports - Requirements. (formerly 20.80.110)

Critical area reports are required under this section. Clarifying language is proposed to more accurately state when reports are required, who pays for them, and that more than one report may be required or allowed to meet the requirements of this section. The language proposed in this section comes directly from the Washington State Department of Commerce example code general provisions with adjustments to incorporate review processes unique to Shoreline.

The requirement that a critical area report be prepared by a qualified professional has been expanded and revised. Verification of qualifications will be handled at the time of review of a report (ideally at the preapplication meeting) rather than limiting qualified professionals to those who are pre-approved by the City. This expands the pool of professionals who can work in the City and eliminates an application step for professionals. This change is combined with adding the specific credentials and experience required for specific types of qualified professionals to the definition in SMC 20.20.042. These qualifications are added to the definition because qualified professionals are also required by other sections of the development code.

Clear thresholds for third party review of critical area reports by a City contracted or employed qualified professional are proposed for increased predictability of cost and time for most applications impacting critical areas. Director discretion is still available for unique circumstances but would rarely be needed.

This section adds the requirement that BAS consistent with the new section 20.80.060 shall be used. The proposed provisions then lay out what types of critical area reports or report sections may be required. Which sections/reports are required depends on the proximity and potential impacts of the proposed development to the critical area.

Standards are proposed for general information that would be required in all critical area reports. These will be supplemented by the critical area type specific requirements. The previously discussed report requirements in other subchapters will be reviewed and edited to eliminate duplication prior to the public hearing.

Provisions are also proposed for use of existing reports and sets a five year validity period for previous reports. Additionally, provisions are proposed that provide flexibility on the scope and content of a report in specific circumstances.

By providing clear report standards, combined with clarification to the qualified professional and third party review standards, staff expects to receive better report submittals with less review time or revision requirements. Third party review by a qualified professional contracted by the City adds cost and time to project reviews.

SMC 20.80.082 Mitigation plan requirements. (NEW)

Ensuring that mitigation is successfully implemented is necessary for adequate protection of ecosystem functions and values and to ensure no increased risk of hazards to life and property. Currently, the mitigation performance standards are in multiple subchapters and it is often unclear which performance standards are relevant to projects impacting specific critical areas.

Mitigation plans are the component of critical area reports where compensating for impacts to the critical areas is addressed. This new section is added to lay out the purpose and content required in mitigation plans. The language is based on the Commerce example code and modified to incorporate current City policy for mitigation plan requirements. This section is intended to add clarity and predictability to the critical area review and permitting process and to reduce the need for correction letters and revisions that add time and cost to the permit.

This section includes provisions for:

1. Mitigation goals;
2. Performance standards for quantifying successful projects;
3. Plan content requirements for construction, monitoring and contingency steps; and
4. Cost estimate requirements for calculating financial guarantees.

The mitigation standards currently drafted for the other critical area subchapters will be reviewed by staff prior to the public hearing to add missing standards for specific critical area types, eliminate redundancy, and to clarify where the drafts are confusing.

SMC 20.80.085 Pesticides, herbicides, and fertilizers on City-owned property.

This section was adopted with the 2006 update to incorporate the City's pesticide free parks policy. The proposed change would allow more flexibility where use of pesticides and herbicides has been scientifically determined to be the best method for managing invasive species when applied properly for the specific

species and location. This provision was added at the request of the Parks, Recreation, and Cultural Services department.

SMC 20.80.090 Buffer areas.
This section sets the basic requirements for buffer areas. The proposed revisions update the language regarding buffer width for consistency with the proposed changes in other subchapters and for consistency of terms related to required plans.

SMC 20.80.100 Notice to title. (formerly 20.80.050)
This section facilitates informing current and future property owners of the presence of critical areas and buffers as well as protecting critical areas permanently where subdivision, binding site plans, or other similar agreements are proposed. Tools used to put notification on title include recording a notice on title, creation of separate critical area tract(s), or recording of restrictions or easements on title or in a development agreement.

Notices to title inform a new owner of the critical area restrictions on a property at the time of purchase. This notification is intended to reduce the occurrence of unauthorized critical area alterations due to lack of knowledge. Some owners perceive the notice on title as reducing the potential resale value of their property even though the notice does not change the regulations that apply to a property. When there is no notice on title, owners are sometimes surprised to learn of the critical area restrictions on their property well after a purchase is completed, plans for alterations that cannot be permitted are drawn up, or when clearing of vegetation is already completed in violation of these regulations.

The current threshold for this notice to be recorded is when development is permitted in a critical area or its buffer. This is actually relatively rare because the critical areas regulations do not permit alteration within these areas most of the time. As such many projects are permitted without a notice to title informing of the critical area restrictions on the property. The current proposed revision would require that a notice be required, if not already recorded, any time a development permit is granted on property where there is a critical area or critical area buffer on the property. The basis for this proposed change is that anytime there are critical areas on or near a property, the City reviews the proposal for compliance with the critical areas regulations.

Staff requests direction from the Planning Commission regarding this threshold. Alternate to the existing standard or the proposed change the threshold could be when a critical area report is required, when a delineation of a critical area is required, or limiting the development permit threshold to permits that alter the building footprint or hardscape, exempting interior only work and repair work.

Another form of notice to title is a native growth protection area (NGPA) easement. This tool restricts development permanently in critical areas where subdivision, or other binding land division agreement, is not applicable. NGPA easements would also be useful where the size of the critical area is really too

small to require a separate tract. The proposed language is adapted from the Commerce example code and is a common tool used by other jurisdictions.

Provisions are also proposed that allow for relaxing the NGPA easement restrictions where development in the critical areas (such as seismic and erosion hazard areas) that meets applicable critical area regulations may be permitted.

SMC 20.80.110 Permanent field marking. (formerly 20.80.060)

The proposed revisions to this relocated section would eliminate outdated department name and phone number references that change periodically. This was previously presented with the development code batch amendments on June 4, 2015. The revisions also eliminate the need to print different signs for every type of critical area. The thresholds for when this field marking is required are proposed for adjustment to include when recommended by a qualified professional to adequately protect the critical area.

SMC 20.80.120 Financial guarantee requirements. (NEW)

Financial guarantee requirements are currently included in all subchapters for specific critical area types. This section is adapted from City of Edmonds code to standardize this requirement for all critical area types. The new provisions correct the way the financial guarantee is calculated for consistency with the City's financial guarantee policy and clearly indicate when a performance agreement and guarantee is required and/or a maintenance/defect/monitoring agreement and guarantee. This proposed section incorporates current policy and procedure into the code for consistency and predictability. The intention of this section is not to required financial guarantees when the project is voluntary restoration or enhancement work rather than required to mitigate or remediate impacts to the critical area.

SMC 20.80.130 Unauthorized critical area alterations and enforcement. (NEW)

This new section is proposed to better facilitate enforcement of the critical areas regulations by supplementing the provisions of Chapter 20.30, Subchapter 9 – Code enforcement. The language is adapted from the Commerce example code and incorporates penalties based on the City of Edmonds current and proposed critical areas civil penalties.

Standards for a restoration plan and performance standards are proposed in (B) and (C) to codify current policies for remediating critical area violations. Provision (D) proposes new penalties to replace the current economic benefit based penalties in SMC 20.30.770(D) when the violation is in a critical area or buffer. The $3.00 per square foot value and per tree penalty amounts are drawn from consultant recommendation in the City of Edmonds 2015 BAS Addendum prepared by Environmental Science Associates (ESA).

Future programmatic and regulatory options to consider for better code enforcement for critical areas include:

- Establish a critical area remediation permit for review and approval of restoration when the original alterations were not allowable. Separate permit type and process would facilitate calculation and collection of penalties tied to the review of the corrective action. A remediation permit would make clear that the City does not permit the original unauthorized activities. Rather that review is required to ensure remediation adequately restores the impacted functions and values or mitigates for increased risk to life and property.

- Develop a program and fund for restoration of critical areas altered illegally or alternate replacement of functions and values that cannot be restored. The idea behind this type of program would be to use penalties specifically collected for critical area violations to facilitate remediation of violations where the property owner is not cooperative or the cost is prohibitive for the owner. Additionally, sometimes the impacts are too severe or the critical area of a type that cannot successfully be restored. In those instances, penalties could be collected for the value of the impacts and off-site replacement or restoration could be funded in identified locations within the same basin or a nearby basin.

These two projects are outside the scope and available time for the current CAO update process, however staff recommends that they be explored as future Comprehensive Plan and City work plan items.

Related Revisions to Other Title 20 Chapters

The City of Shoreline critical areas regulations are part of the SMC Title 20 Development Code rather than being a standalone title in the municipal code. As such there are provisions in other chapters of the Development Code that contribute to the administration of or provide standard for Chapter 20.80 Critical Areas. Compliance with the critical areas regulations in Chapter 20.80 is also a requirement of the Development Code in project review and decision making criteria.

A few code sections are included for reference only. These are provisions that apply to critical areas regulation but do not require revision at this time. These sections are included to inform the discussion about the existing and proposed changes to critical area related regulations, but they will not be included in the final proposed ordinances. References to critical areas in the sections included for information only are highlighted with grey in Attachment A and noted in the comments when no changes are proposed.

The following sections of SMC Title 20 Development code are proposed for revision in addition to the critical areas specific changes in Chapter 20.80. The majority of these changes are additions of or updates to code references or out-of-date terms.

SMC Chapter 20.30 Procedures and Administration

Subchapter 3. Permit Review Procedures

20.30.080 Preapplication meeting.

The proposed revision of this section adds reference to the new critical area preapplication meeting requirements in SMC 20.80.045. Submittal requirements are updated to reflect the type of critical area documents that should be provided for a preapplication meeting.

Subchapter 5. Nonconforming Uses, Lots, and Structures

20.30.280 Nonconformance

Reference added to 20.80.040 Exemptions to ensure that modifications of structures nonconforming with regard to critical areas are only modified as allowed by Chapter 20.80 and to make a clear connection between these general nonconformance provisions and the critical area regulations.

Subchapter 6. Review and/or Decision Criteria

20.30.290 Deviation from the engineering standards (Type A action).
20.30.295 Temporary use.
20.30.310 Zoning variance (Type B action).
20.30.330 Special use permit-SUP (Type C action).
20.30.333 Critical areas special use permit (Type C action).
20.30.336 Critical areas reasonable use permit (Type C action).
20.30.353 Master development plan.
20.30.355 Development agreement (Type L).

The references in all these review and decision criteria provisions to the critical areas regulations are proposed to be standardized, so these regulations are referenced in a consistent manner that makes it clear which code sections apply. Minor punctuation and grammar edits and corrections to outdated terms are also proposed.

SMC 20.30.333 Critical areas special use permit and SMC 20.30.336 Critical areas reasonable use permit allow for development on property so encumbered by critical areas regulations that reasonable use or special public use could not be undertaken with strict application of the critical areas regulations. In addition to updating critical area type and classification references, new provisions are proposed to specify that mitigation is required using best available science and no net loss attempted. This is inferred when you apply the critical area regulations, however it is not explicitly stated in the current regulations.

Subchapter 7. Subdivisions

20.30.370 Purpose
20.30.410 Preliminary subdivision review procedures and criteria.

The changes proposed for both of these subdivision sections update the reference to the critical areas regulations for consistency and change the types of critical areas listed to use current terminology.

Subchapter 8. Environmental Procedures

20.30.560 Categorical exemptions – Minor new construction.

This subchapter section is included for reference only; no changes are proposed. Unless the project triggers State Environmental Protection Act (SEPA) review for another reason, the only type of critical areas that could trigger SEPA if altered are wetlands and streams. Alterations to the buffers of these critical areas would not trigger SEPA. There is no public notice requirement for alteration of critical areas unless SEPA review is required or the project requires public notice under some other provision of the Development Code, such as a subdivision.

Subchapter 9. Code Enforcement

20.30.730 General provisions.

Cross reference added specifically to the new enforcement provisions in SMC 20.80.130 to ensure that both sections are applied when critical area violations occur.

20.30.770 Enforcement provisions.

New civil penalties for critical areas violations are proposed in SMC 20.80.130(E) so a corresponding change is proposed to the civil penalties language in the general code enforcement section. The new penalties are proposed instead of the economic benefit equivalency penalty that currently applies to critical areas. Economic valuation of impacts critical areas is challenging to calculate and is not standardized. It is also difficult to defend legally. Without a clear and predictable dollar value to the penalty it is not currently serving as a deterrent to the violations. The current penalties provisions are left intact for the non-critical area violations to which these provisions also apply.

SMC Chapter 20.40 Zoning and Use Provisions

Subchapter 3. Index of Supplemental Use Criteria

20.40.230 Affordable housing.

Standardized critical area regulations reference added to this provision.

SMC Chapter 20.50 General Development Standards

Subchapter 1. Dimensions and Density for Development

20.50.020 Dimensional requirements.

This subchapter section is included for reference only; no changes are proposed. Public comment at past meetings asked whether critical areas are included in density calculations. This is the section which regulates what portions of a parcel may be included when calculating density. Only submerged lands such as tidelands, streams, and some wetlands are excluded from base density calculations. This is consistent with state requirement to protect submerged lands. It is also consistent with the City's Comprehensive Plan policy NE2 to "balance the conditional right of private property owners to develop and alter their land with protection of native vegetation and critical areas." While the allowable base density cannot necessarily be built within the critical areas and their buffers, this allows for clustered development that provides economic value from the property while still protecting the critical area(s).

20.50.040 Setbacks – Designation and measurement.
Update of terms for accuracy by removing “steep slopes” which is no longer critical area classification.

Subchapter 5. Tree Conservation, Land Clearing and Site Grading Standards

20.50.290 Purpose.
This subchapter section is included for reference only; no changes are proposed. This section states that part of the purpose of the Tree Conservation, Land Clearing and Site Grading Standards is to protect critical areas from the potential impacts of these activities.

20.50.300 General requirements.
This subchapter section is included for reference only; no changes are proposed. This section clearly states that clearing and grading activities within critical areas are subject both to Subchapter 5 - Tree Conservation, Land Clearing and Site Grading Standards and the critical areas regulations and that the standards providing greater protection shall apply.

20.50.310 Exemptions from permit.
A provision was added in 2010 to allow for minor enhancement projects in critical areas located within City parks without a permit. This type of work was exempted from the critical areas regulations under 20.80.030 as minor conservation and enhancement. The proposed change moves this specific permit exemption to the critical areas exemption section in 20.80.030 and add an exemption from clearing and grading permit requirements for all minor conservation and enhancement activities as exempted in 20.80.030(G).

20.50.320 Specific activities subject to the provisions of this subchapter.
Clearing and grading are narrowly defined in SMC 20.20. Revisions to provision (E) of this section are proposed to clarify that any land disturbing activity not explicitly exempted are subject to the provisions of this subchapter.

20.50.330 Project review and approval.
Standardized critical area regulations reference added to this provision and correction of outdate terms. Explicit requirement for clearing limit protection of critical areas and buffers is proposed.

20.50.350 Development standards for clearing activities.
Some provisions of this section are highlighted grey where critical areas are referenced but no changes are proposed. Code reference to critical areas regulations and outdate and inconsistent terms corrected.

New standards are proposed in provision (E) that add nationally accepted standard for pruning of trees for the benefit of the tree. Additionally, specific language is proposed to allow for tree pruning to facilitate views that does not result in excessive pruning such as topping. The pruning allowed in this section proposed for explicit inclusion in the critical areas exemptions in 20.80.030 as one type of normal and routine landscaping maintenance.

20.50.360 Tree replacement and site restoration.
Some provisions of this section are highlighted grey where critical areas are referenced but no changes are proposed. Inconsistent terms corrected. The provisions for performance assurances in (K) are clarified to indicate that when tree replacement is required within critical areas or due to a clearing violation on a single family lot, the guarantee requirement will not be waived. This is intended to eliminate contradicting provisions related to financial guarantees for violation remediation and critical areas when tree replacement is required.

Additional Information

Geologic Hazard Areas follow-up

At previous Planning Commission meetings for the CAO update a few items that were discussed, related to geologic hazard areas, needed follow-up. For reference the items identified for follow-up include the following:

- Draft alternate amendment to proposed Geologic Hazards regulations for alteration of very high risk landslide hazard areas;
- Special inspection standards and special bonding requirement for contractors working in geologic/landslide hazard areas;
- Liability waiver to be recorded on title for projects in very high risk landslide hazard areas; and
- Example geologic hazard map updates and cost estimates that would improve the percent slope layer and create a new layer identifying areas of prior landslide activity.

Alternate Amendments – landslide hazard areas

Planning Commission requested that an alternate amendment be provided in response to public comment asking whether some slopes meeting the criteria of a very high risk landslide hazard area might actually be safe to alter or develop. Staff has drafted two alternate amendments to allow for alteration in very high risk landslide hazard areas based on language in the Commerce example code. These represent higher risk acceptance than the current and original draft changes to the geologic hazard area regulations.

Alternate Amendment 1- alteration of landslide hazard areas (**Attachment B**) proposes to allow any type of development activity in any classification of geologic hazard area if the specified factors of safety can be met. This approach relies entirely on accurate modeling of the slope stability before and after alteration and correct implementation of any mitigation measures necessary to meet the design criteria. This alternative allows the greatest flexibility to private property owners but a higher acceptance of risk that the design of the project may actually increase risk to life and property.

Alternate Amendment 2 – vegetation removal in very high risk landslide hazard areas (**Attachment C**) presents a more limited option for alteration of very high risk landslide hazard areas. This alternate amendment would allow for review and potential approval

of vegetation removal and replacement projects where the specific factors of safety can be demonstrate. It limits the alteration to vegetative solutions to re-stabilize the slope that do not require structures or grading. This approach is lower risk that alternate amendment 1, but does accept a higher level of risk than the current/proposed regulations. Meeting the design criteria may be problematic as natural vegetated slopes may not meet the same factors of safety typically used for engineered solutions. According to the City's consultant, many natural slopes will not have a factor of safety as high as 1.5 (but engineered structures should be designed for at least 1.5). Natural slopes could be maintained at 1.3 for static and greater than 1.0 for seismic. Or the City could say no decrease in slope stability, but then an applicant could determine the existing slope is only at 1.1 and they will not cause a decrease, but the City may not want any disturbance to a 1.1 slope, or the City might want to see improvement to 1.3.

The level of risk the City chooses to accept is a political decision. Best available science is incorporated through the critical area report process and design criteria that apply to any proposed alteration. Direction is requested from Planning Commission on how they would like staff to proceed on this topic.

Special requirements for alterations of landslide hazard areas

If Planning Commission recommends that one of the alternate amendments is proposed then they may also want to consider adopting additional provisions to require a waiver of liability, special inspections, and special bonding requirements for projects that alter very high risk landslide hazard areas to address both the greater risk and the extra care that is needed to ensure that the plans are correctly implemented.

Seattle has had much development and litigation experience with this topic. As a result they have adopted provisions that provide some relief from their development prohibition on Very High Hazard steep slopes. An application for relief from the regulations is conditional based on staff geotechnical review for specific development proposals. The required geotechnical report must show that no adverse impact will result. In addition, the steep slope situations that are exempt from the prohibition in steep slope areas are:

1. Downtown or high-rise zones;
2. New development proposed where existing development is located if the impact on the slopes is not altered or increase;
3. Steep slopes that were created by previous legal grading activity if no adverse impact has resulted;
4. Right-of-Way improvements;
5. Steep slopes that are less than 20 vertical feet and are separate by 30 feet from other steep slope areas; or
6. The Director determines that the prohibition on development in steep slopes presents necessary stabilization.
7. These areas are still considered critical areas and must meet other regulations regarding vegetation, drainage control, etc.

Seattle requires that the property owner sign a covenant with the city that acknowledges and accepts risks, waiver any rights to claims against the city, indemnifies and holds harmless the city against claims, losses and damages, duty to inform subsequent

successors of the property of the risks and the covenants, advisability of obtaining added insurance, and record the covenant on title.

Seattle also requires excavation and piling subcontractors to submit insurance documents that include coverage for subsidence and underground property damage, listing the City of Seattle as an additional insured because of the added risk during construction in vicinity of property lines within landslide areas, as well as geotechnical special inspections so that the owner's geotechnical engineer participates during the construction with significant ground-related hazards.

The City may also want to consider requiring neighborhood meetings when alteration of very high risk landslide hazard areas are proposed so that nearby property owners are aware of the proposed change and potential risks to adjacent properties and measures being taken to mitigate that risk.

Three additional best available science resources are included for reference with this packet and were used in the drafting of the geologic hazards alternate amendments and proposed tree pruning amendment in Chapter 20.50. An International Society of Arboriculture article on Tree Root Ecology in the Urban Environment is included as **Attachment D**, and addresses the role of tree roots in soil strength and stability. A King Conservation District paper on the geology of marine shorelines is included as **Attachment E**. A vegetation management guide for marine bluff property owners prepared by the Washington State Department of Ecology is included as **Attachment F**. Three informational handouts regarding vegetation and slope stability prepared by the Washington Coastal Training Program and Greenbelt Consulting are included as **Attachment G.**

Geologic hazard area map updates

Staff indicated at the June 18th Planning Commission meeting that update to the data layers used for identifying potential geologic hazard areas may be helpful to more accurately identify and protect these areas. There are three steps the City can take to improve these data layers:

1. Obtain new LiDAR layer for the City (~3,000 through consortium; ~13,000 independently) which is currently budgeted and underway for this year as part of the regional consortium.
2. Generate updated percent slope layer (estimated 40 hours of staff time or can be done by consultant).
3. Identification of areas of prior landslide activity through LiDAR interpretation (~8,000 to 10,000 by a qualified professional consultant).

Attachment H is an example of prior landslide activity mapping done for the City of Seattle. The City of Shoreline cannot accomplish the same level of detail and prediction of landslide probability because we do not have the same data source of historic landslide activity. With updated LiDAR a qualified professional could generate mapping of existing landforms that indicate prior landslide activity similar to the maps on pages 75 and 77 of the article by Schultz, et. al. (Schultz 2007).

Attachment I is an example of an updated percent slope map that can be generated from a Digital Elevation Modal (which is generated from LiDAR). This work can be done

by the City's GIS specialist or could be completed by a qualified professional through a contract and would take approximately 40 hours to complete.

Additional levels of study such as a detailed geologic survey of the city or landslide monitoring could be accomplished, but staff is uncertain as to how much additional certainty or detail would be provided for these much higher cost projects ($25,000 to $250,000 depending on level of detail and scale).

Wetlands Mitigation follow-up

At the June 4th Planning Commission meeting revisions to the Wetlands subchapter of the critical areas Chapter 20.80 were presented. Planning Commission inquired about whether provisions for mitigation through wetland mitigation bands or fee-in-lieu programs were included. The current draft of the wetlands subchapter changes does not include these options because known mitigation banks are located well outside of the WRIA 8 basin where Shoreline is located and would not benefit the sub-basins where impacts to wetlands could be proposed. Information from the WA Department of Ecology on these alternate wetland mitigation methods are included in **Attachment J** for reference. Staff does not currently recommend adding provisions for wetland mitigation banks or for fee-in-lieu programs because they would result in net loss of wetlands within the City of Shoreline.

Future consideration could be given to developing a locate wetland mitigation program which identifies projects within the City of Shoreline that could be undertaken for off-site or in-lieu mitigation when on site mitigation is not feasible. The City of Edmonds has developed a program and lists specific target sites for restoration that may be used when on site mitigation is not viable.

SMP Memo follow-up

At the July 16th Planning Commission meeting, staff was asked to provide a memo summarizing the pros and cons of updated the SMP to incorporate the revised critical areas regulations. This memo is still pending, but will be provided as soon as it is complete to Planning Commission.

Best Available Science

The following documents are included in the record by reference as the Best Available Science or analysis of BAS reviewed by the City to inform the update of the critical areas general provisions section of the CAO:

CTED. (Washington State Department of Community, Trade, and Economic Development). 2007. Critical Areas Assistance Handbook: Protecting Critical Areas within the Framework of the Washington Growth Management Act.

Day, S.D., 2010. Tree Root Ecology in the Urban Environment and Implications for a Sustainable Rhizosphere. Arboriculture & Urban Forestry, Scientific Journal of the International Society of Arboriculture, 36(5):193-205, September 2010. Downloaded 7/29/2015 from http://www.isa-arbor.com/education/resources/educ_Portal_RootGrowth2_AUF.pdf.

Ecology. 1993. Vegetation Management: A Guide for Puget Sound Bluff Property Owners. Prepared by Elliott Menashe, Greenbelt Consulting. Ecology Publication 93-31.

ESA. March 2015. Final City of Edmonds Critical Areas Ordinance Update: Best Available Science Addendum. Prepared by Environmental Science Associates.

Landry. P., 2006. Conservation Topic – Marine Shorelines: Geological Processes, Land Use Impacts & Conservation Practices. King Conservation District, May 2006.

Menashe, E. 1993. 4.4 Vegetation Management, excerpt from Shoreline Management and Stabilization Using Vegetation workshop materials, 1993. Prepared by Elliot Menashe of Greenbelt Consulting for the Washington Coastal Training Program.

Menashe, E. 2004. Trees, Soils, Geology, and Slope Stability. Handout from a workshop on Shoreline Management and Stabilization Using Vegetation. Prepared by Elliott Menashe of Greenbelt Consulting for the Washington Coastal Training Program.

Menashe, E. 2004. Value, Benefits and Limitations of Vegetation in Reducing Erosion. Handout from a workshop on Shoreline Management and Stabilization Using Vegetation. Prepared by Elliott Menashe of Greenbelt Consulting for the Washington Coastal Training Program.

Schulz, W.H., 2007. Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington. Engineering Geology, 89(2007):67-87, January 2007. Downloaded 8/13/2015 from http://landslides.usgs.gov/docs/schulz/lidar_enggeo.pdf.

Thorsen, G.W. and Menashe, E. 2004. Tree Removal on Steep Slopes of Puget Sound Shorelines. Handout from a workshop on Shoreline Management and Stabilization Using Vegetation. Prepared by Gerald W. Thorsen, Consulting Geologist, and Elliott Menashe of Greenbelt Consulting for the Washington Coastal Training Program.

Public Comment

Comments to Planning Commission were received July 15 and July 16 from representatives of two neighborhood groups. The letter to Planning Commission from the Richmond Beach Preservation Association is included for the public record in **Attachment K.** The letter and attached geotechnical engineering review memo from Eglick Kiker Whited law firm (EKW Law), on behalf of the Innis Arden Club, is attached for the public record in **Attachment L.** Both letters requested additional time for public review of the proposed critical areas regulations update. Staff added four weeks to the project schedule in response to these requests for more time. The City is still reviewing the other comments and content of these letters and will take them into consideration as the draft regulations are revised by staff for the public hearing.

A second comment letter was sent to Planning Commission by EKW Law on behalf of the Innis Arden Club on August 13, 2015, and is included as **Attachment M**. This letter proposes modifications to the geologic hazards regulations and includes suggested edits as attachments as well as including example code language from Bothell and Edmonds.

SCHEDULE

In response to public comment requesting more time for public review, staff extended the schedule for the Critical Areas Ordinance update by one month. The updated schedule for Planning Commission study sessions and public hearing is:

- *May 21 – Introduction and Overview*
- *June 4 – Wetlands and Shoreline Master Program*
- *June 18 – Geologic Hazard Areas*
- *July 16 – Fish & Wildlife Habitat, Flood Hazards, Aquifer Recharge Areas, and Streams (Current meeting)*
- ***August 20 – General Critical Area Provisions (added meeting)***
- *September 17 – Public Hearing and Recommendation*

The draft subchapters of the CAO were developed separately. The final draft of the entire CAO may change to remove legal or internal conflicts between subchapters. The final draft will be provided as soon as feasible prior to the staff report for the Public Hearing, currently scheduled for the September 17, 2015, Planning Commission meeting.

City Council review and adoption is now scheduled for October-November 2015, with staff updates to handouts, forms, processes, and permitting tools to follow thereafter.

The current proposed schedule for City Council study and adoption of the CAO update is:

- *October 5 – Study Session 1*
- *October 12 – Study Session 2*
- *November 2 - Adoption*

Due to the complexity of the proposed CAO changes, staff is recommending a delayed effective date for this ordinance of January 1, 2016. This would allow time for staff training, update of forms and handouts, and adjustment of projects being planned but not yet submitted. Based on a preliminary inquiry to the Washington Department of Commerce, it seems that delayed implementation would be compatible with the GMA compliance requirements so long as the delay was not too long.

The State deadline for completing these updates was June 30, 2015. While there are no immediate ramifications for not meeting the deadline, a number of State grant programs are tied to compliance with the GMA and cannot be awarded if we are not in compliance. Shoreline would be considered to be in compliance if we are not more than twelve months past the deadline and demonstrate substantive progress towards compliance.

This legislative action is subject to the State Environmental Policy Act (SEPA) and notification of the proposed changes must go to Commerce and DOE. The SEPA Determination and noticing was published August 3, 2015.

RECOMMENDATION

No decision is required of the Planning Commission at this time. Questions and feedback from Planning Commission on the proposed critical area general provisions

and related Title 20 amendments are requested at this time towards development of a recommended code update package for the public hearing on September 17, 2015. Direction is request from Planning Commission on how to proceed with the alternate amendments for landslide hazard areas presented today.

ATTACHMENTS

Attachment A – CAO 2015 Update_Subchapter 1-General Provisions and misc Title 20_August 2015
Attachment B – ALTERNATE AMENDMENT 1 - alteration of landslide hazard areas
Attachment C – ALTERNATE AMENDMENT 2 - vegetation removal in very high risk landslide hazard areas
Attachment D – Tree Root Ecology_Arboriculture & Urban Forestry 2010
Attachment E – Conservation Topic-Marine Shoreline Geological Processes
Attachment F – Vegetation Management Guide 1993
Attachment G – Coastal Training Program handouts 2004
Attachment H – Landslide Susceptibility Revealed by LIDAR in Seattle 2007
Attachment I – Example of Geohazard Map using Digital Elevation Models
Attachment J – Special Types of Compensatory Mitigation_Excerpts from Wetlands in WA Vol 2
Attachment K – RBPA comment letter, July 15, 2015
Attachment L – EKW Law comment letter and enclosure, July 16, 2015
Attachment M – EKW Law comment letter and enclosure, August 13, 2015

Title 20

DEVELOPMENT CODE

Division I. Unified Development Code

NOTE: Items highlighted grey are included for information only. No revisions proposed in these sections and they will not be included in the final critical areas update ordinances.

Chapter 20.20

Definitions*

Sections:

*Code reviser's note: Ordinance 238 provided all of the definitions initially set out in this chapter. History notes following definitions indicate amending ordinances only.

20.20.010 A definitions.

Alteration	Any human induced change in an existing condition of a critical area or its buffer. Alterations include, but are not limited to grading, filling, channelizing, dredging, clearing (vegetation), construction, compaction, excavation, or any other activity that changes the character of the critical area.

Comment [jn1]: Definition added based on Commerce example code.

20.20.012 B definitions.

Best Available Science	Current scientific information used in the process to designate, protect, mitigate impacts to, or restore critical areas, that is derived from a valid scientific process as defined by WAC 365-196-900 through 925.

Comment [jn2]: Definition added based on Commerce example code.

Binding Site Plan	A process that may be used to divide commercially and industrially zoned property, as authorized by State law. The binding site plan ensures, through written agreements among all lot owners, that the collective lots continue to function as one site concerning but not limited to: lot access, interior circulation, open space, landscaping and drainage; facility maintenance, and coordinated parking. It may include a plan drawn to scale, which identifies and shows the areas and locations of all streets, roads, improvements, utilities, open spaces, critical areas, parking areas, landscaped areas, surveyed topography, water bodies and drainage features and building envelopes. (Ord. 695 § 1 (Exh. A), 2014).

Comment [jn3]: Definition included for information only because it references critical areas. **No changes proposed and definition will not need to be included in the final CAO update.**

Bond	A financial guarantee in the form of a surety bond, cash deposit, escrow account

assignment of savings, irrevocable letter of credit or other means acceptable to, or required by, the Director to guarantee work is in compliance with all applicable requirements.

Buildable Area — The area of a lot remaining after the minimum yard and open space requirements of the Development Code have been met, not including critical areas and their buffers.

Comment [jn4]: This term is used commonly when discussing development constraints on a site, but is not directly used in the development code or critical areas ordinance anywhere. Included here for informational purposes because it references critical areas. **This definition will not be included in final proposed ordinance.**

20.20.014 C definitions.

Certified Arborist — A person or firm with specialized knowledge of the horticultural requirements of trees, certified by the International Society of Arboriculture or by the ~~National Arborist Association~~ American Society of Consulting Arborists as a registered consulting arborist.

Comment [jn5]: Definition updated for accuracy. The National Arborist Society does not certify or register arborists, but they do provide training for ISA certification. Added the other type of credential accepted by the City to be considered a qualified professional.

Clearing — The limbing, pruning, trimming, topping, cutting or removal of vegetation or other organic plant matter by physical, mechanical, chemical or other means.

Conservation Easement — A legal agreement that the property owner enters into to restrict uses of the land. Such restrictions can include, but are not limited to, passive recreation uses such as trails or scientific uses and fences or other barriers to protect habitat. The easement is recorded on a property deed, runs with the land, and is legally binding on all present and future owners of the property, therefore, providing permanent or long-term protection.

Comment [jn6]: Definition useful for any type of easement that would protect critical areas. Specifically required under new wetlands regulations and still mentioned in Buffers section for a means of protecting critical area buffers.

Consultant, Qualified — A person who is licensed to practice in the professional field of the requested consultation or who has equivalent educational training and at least four years of professional experience.

Comment [jn7]: This term was previously used in the critical areas ordinance as adopted in 2000, but the term was replaced by qualified professional in 2003 in the context of critical areas regulations. Not all instances of qualified consultant were replaced with professional at that time. The proposed revisions include this correction. This definition is included here for context, but will not be included in the final CAO update recommended by staff.

Qualified consultant is still applicable to preparation and review of environmental impact statements under SEPA review procedures and is not overridden by the CA standards.

20.20.016 D definitions.

Development — The division of a parcel of land into two or more parcels; the construction, reconstruction, conversion, structural alteration, relocation, or enlargement of any structure; any mining, clearing, or grading; changes to surface or ground waters; or any use, change of use, or extension of the use of land. (Ord. 324 § 1, 2003).

Comment [jn8]: Definition included for reference only. **No change proposed.**

20.20.018 E definitions.

Excessive Pruning — Pruning more than ~~four years of branch growth~~ 25 percent of the tree canopy in one growing season or over a five year period, unless necessary to restore the vigor of the tree or to protect life and property.

Comment [jn9]: Recommended edit based on general best practices for tree pruning.

20.20.022 G definitions.

Comment [jn10]: Definitions included for reference only. **No changes proposed.**

Grading — Any excavation, filling, removing the duff layer or any combination thereof.

Groundcover — Living plants designed to grow low to the ground (generally one foot or less) and intended to stabilize soils and protect against erosion.

20.20.026 I definitions.

Invasive Species	Any nonnative organisms that cause economic or environmental harm and are capable of spreading to new areas of the state. Invasive species do not include domestic livestock, intentionally planted agronomic crops, or nonharmful exotic organisms. Invasive species include but are not limited to noxious weeds.

Comment [jn11]: Definition added based on RCW 79A.25.310. Similar to but not the same as noxious weeds; defined separately. Commonly noxious weeds and invasive species are used interchangeably when applied to vegetation.

20.20.032 L definitions.

Landscape Architect	A person licensed by the State of Washington to engage in the practice of landscape architecture as defined by RCW 18.96.030.

Comment [jn12]: Definition included for reference only. **No change proposed.**

20.20.034 M definitions.

Marine Environment/Marine Waters	Aquatic lands and waters under tidal influence, including saltwaters and estuaries to the ordinary high water mark.
Monitoring	Evaluating the impacts of development proposals on biologic, hydrologic and geologic systems and assessing the performance of required mitigation through the collection and analysis of data for the purpose of understanding and documenting changes in natural ecosystems, functions and features including, but not limited to, gathering baseline data.

Comment [jn13]: Definition added per Planning Commissioner request. Language based on RCW 43.372 definition of marine waters.

Comment [jn14]: Definition included for reference only. **No change proposed.**

20.20.036 N definitions.

Native Vegetation, Native Plant(s)	~~A tree, shrub or groundcover plant of a species that is native to western Washington.~~ Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest, which reasonably could have been expected to naturally occur on the site.
Noxious Weed	Any plant which is highly destructive, competitive or difficult to control by cultural or chemical practices, limited to those plants on the State noxious weed list contained in Chapter 16-750 WAC.

Comment [jn15]: Update terminology and clarify definition for consistency with SMP and recommended CAO definitions.

Comment [jn16]: Definition included for reference only. **No change proposed.**

20.20.040 P definitions.

Practical Alternative	An alternative that is available and capable of being carried out after taking into consideration cost, existing technology, and logistics in light of overall project purposes, and has less adverse impacts to critical areas.
Private Stormwater Management Facility	A surface water control structure installed by a project proponent to retain, detain or otherwise limit runoff from an individual or group of developed sites specifically served by such structure.
Protected Tree/Protected Vegetation	A tree or area of understory vegetation identified on an approved tree protection and replacement plan (or other plan determined to be acceptable by the Director) to be retained and protected during construction and/or permanently protected by easement, tract, or covenant restriction. A protected tree may be

Comment [jn17]: Definition added based on Commerce example code. This term is in one of the criteria for Critical Area Special Use Permits.

Comment [jn18]: Definition included for reference only. **No change proposed.**

Comment [jn19]: Term updated for accuracy.

located outside or within a NGPA, ~~sensitive~~ critical area or ~~sensitive~~ critical area buffer.

Protection Measure — A practice or combination of practices (e.g., construction barriers, protective fencing, tree wells, etc.) used to control construction or development impacts to vegetation that is approved for protection.

Comment [jn20]: Definition included for reference only. **No change proposed.**

Protective Fencing — A temporary fence or other structural barrier installed to prevent permitted clearing or construction activity from adversely affecting vegetation which is designated for retention.

Comment [jn21]: Definition included for reference only. **No change proposed.**

20.20.042 Q definitions.

Qualified Professional — A person with the experience, training and competence in the pertinent discipline. A qualified professional must be licensed to practice in the State of Washington in the related professional field, if such field is licensed. If not licensed, a qualified professional must have a national certification in the pertinent field. If national certification in the field does not exist, the minimum qualification should be a bachelor's degree with 10 years of related professional work, or master's degree in the field and three years of related professional work. Minimum qualifications for specific fields of practice shall include but not be limited to the following:

Comment [jn22]: Updated to more clearly tie this definition to the administration of the CAO.

A. Arborists must be certified arborists as defined in SMC 20.20.014 and have a valid ISA Tree Risk Assessment Qualification (TRAQ).

B. Professionals for geologic hazard areas must be licensed in the State of Washington as a geotechnical engineer or engineering geologist as defined in SMC 20.20.018 and 20.20.022.

C. Professionals for streams and other fish and wildlife habitat must have a degree in biology, environmental planning, natural science, stream ecology or related field and the minimum years of experience, listed above, related to the subject habitat or species.

D. Professionals for vegetation restoration planning where specific expertise for wetlands, streams or other fish and wildlife habitat is not required, must have a degree in botany, environmental planning, natural science, ecology, landscape architecture or a related field and the minimum years of experience, listed above, with an emphasis on restoration ecology and vegetation management associated with critical areas and buffers. Professionals must demonstrate a minimum of three years of experience with the type of critical area or buffer for which the critical area report is being submitted.

E. Professionals for wetlands must be currently certified as a Professional Wetland

Scientist (PWS) with the Society of Wetland Scientists or meet the minimum education and years of experience, listed above, as a wetlands professional.

F. Minimum qualifications of professionals for other critical area related disciplines shall be determined by the Director consistent with the minimum qualifications defined above and specific to the discipline identified. (Ord. 324 § 1, 2003).

20.20.044 R definitions.

Reasonable Use — The minimum use to which a property owner is entitled under applicable State and Federal constitutional provision, including takings and substantive due process. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003).

Comment [jn23]: Definition included for reference only. **No change proposed.**

Remediation — To restore a site to a condition that ~~compiles~~ complies with ~~sensitive~~ critical area or other regulatory requirements as they existed when the violation occurred; or, for sites that have been degraded under prior ownerships, restore to a condition which does not pose a probable threat to the environment or to the public health, safety or welfare.

Comment [jn24]: Correction of terms. Remediation is restoration or other corrective action that corrects or mitigates impacts to a critical area or other site. Not just critical area specific.

Runoff — Water not absorbed by the soil in the landscape area to which it is applied.

Comment [jn25]: Definition included for reference only. **No change proposed.**

20.20.046 S definitions.

Site Development Permit — A permit, issued by the City, to develop, redevelop or partially develop a site exclusive of any required building or land use permit. A site development permit may include one or more of the following activities: paving, grading, clearing, tree removal, on-site utility installation, stormwater facilities, walkways, striping, wheelstops or curbing for parking and circulation, landscaping, critical area and buffer mitigation, enhancement, remediation, or restoration. (Ord. 439 § 1, 2006; Ord. 352 § 1, 2004).

Comment [jn26]: Language updated to include critical area work. This is the type of permit used when critical area work needs a permit but is being reviewed separate from or without a related building permit.

Site Plan — The development plan for one or more lots on which is shown the existing and proposed conditions of the lot, including topography, vegetation, drainage, flood plains, wetlands, ~~and~~ waterways, critical areas and critical area buffers; landscaping and open spaces; walkways; means of ingress and egress; circulation; utility services; structures and buildings; signs and lighting; berms, buffers, and screening devices; surrounding development; and any other information that reasonably may be required in order that an informed decision can be made by the approving authority.

Comment [jn27]: Critical areas added explicitly to list of things included on a site plan.

~~Substantial Development~~ — ~~Any extension, repair, reconstruction, or other improvement of a property, the cost of which equals or exceeds 50 percent of the fair market value of a property either before the improvement is started or, if the property has been damaged and is being restored, before the damage occurred.~~

20.20.048 T definitions.

Comment [jn28]: Tree definitions included for reference only. **No changes are currently planned to these definitions and they will not be in the final ordinance.**

Tree	A self-supporting woody plant characterized by one main trunk or, for certain species, multiple trunks, with a potential at maturity for a trunk diameter of two inches and potential minimum height of 10 feet.
Tree and Vegetation Removal	Removal of a tree(s) or vegetation, through either direct or indirect actions including, but not limited to, clearing, cutting, causing irreversible damage to roots or trunks; poisoning; destroying the structural integrity; and/or any filling, excavation, grading, or trenching in the dripline area of a tree which has the potential to cause irreversible damage to the tree, or relocation of an existing tree to a new planting location.
Tree Canopy	The total area of the tree or trees where the leaves and outermost branches extend, also known as the "dripline."
Tree, Hazardous	A tree that is dead, or is so affected by a significant structural defect or disease that falling or failure appears imminent, or a tree that impedes safe vision or traffic flow, or that otherwise currently poses a threat to life or property.
Tree, Significant	Any tree eight inches or greater in diameter at breast height if it is a conifer and 12 inches or greater in diameter at breast height if it is a nonconifer excluding those trees that qualify for complete exemptions from Chapter 20.50 SMC, Subchapter 5, Tree Conservation, Land Clearing, and Site Grading Standards, under SMC 20.50.310(A). (Ord. 669 § 1 (Exh. A), 2013).

20.20.050 U definitions.

Understory Vegetation	Small trees, shrubs, and groundcover plants, growing beneath and shaded by a significant tree which affect and are affected by the soil and hydrology of the area surrounding the significant tree roots.

Comment [jn29]: Vegetation definitions included for reference only. **No change proposed.**

20.20.052 V definitions

Vegetation	Any and all plant life growing at, below or above the soil surface.

Chapter 20.30

Procedures and Administration

Sections:

NOTE: Items highlighted grey are included for information only. No revisions proposed in these sections and they will not be included in the final critical areas update ordinances.

Subchapter 3.

Permit Review Procedures

20.30.080 Preapplication meeting.

A preapplication meeting is required prior to submitting an application for any Type B or Type C action and/or for an application for a project ~~located within~~ that may impact a critical area or its buffer consistent with SMC 20.80.045.

Comment [jn30]: Clarification added to cross referencing with 20.80 section. If not otherwise required, specific activities may be exempted from the preapplication meeting in Chapter 20.80.

Applicants for development permits under Type A actions are encouraged to participate in preapplication meetings with the City. Preapplication meetings with staff provide an opportunity to discuss the proposal in general terms, identify the applicable City requirements and the project review process including the permits required by the action, timing of the permits and the approval process.

Preapplication meetings are required prior to the neighborhood meeting.

The Director shall specify submittal requirements for preapplication meetings, which shall include a critical areas ~~checklist~~ worksheet and, if available, preliminary critical area reports. Plans presented at the preapplication meeting are nonbinding and do not "vest" an application. (Ord. 439 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. III § 4(a), 2000).

Subchapter 5.

Nonconforming Uses, Lots, and Structures

20.30.280 Nonconformance.

Comment [jn31]: This section applies to critical areas in combination with 20.80.040 so cross reference added for additional regulations.

A. Any use, structure, lot or other site improvement (e.g., landscaping or signage), which was legally established prior to the effective date of a land use regulation that rendered it nonconforming, shall be considered nonconforming if:

1. The use is now prohibited or cannot meet use limitations applicable to the zone in which it is located; or

2. The use or structure does not comply with the development standards or other requirements of this code;

3. A change in the required permit review process shall not create a nonconformance.

B. **Abatement of Illegal Use, Structure or Development.** Any use, structure, lot or other site improvement not established in compliance with use, lot size, building, and development standards in effect at the time of establishment shall be deemed illegal and shall be discontinued or terminated and subject to removal.

C. **Continuation and Maintenance of Nonconformance.** A nonconformance may be continued or physically maintained as provided by this code.

1. Any nonconformance that is brought into conformance for any period of time shall forfeit status as a nonconformance.

2. **Discontinuation of Nonconforming Use.** A nonconforming use shall not be resumed when abandonment or discontinuance extends for 12 consecutive months.

3. **Repair or Reconstruction of Nonconforming Structure.** Any structure nonconforming as to height or setback standards may be repaired or reconstructed; provided, that:

a. The extent of the previously existing nonconformance is not increased;

b. The building permit application for repair or reconstruction is submitted within 12 months of the occurrence of damage or destruction; and

c. The provisions of Chapter 13.12 SMC, Floodplain Management, are met when applicable.

4. **Modifications to Nonconforming Structures.** Modifications to a nonconforming structure may be permitted; provided, the modification does not increase the area, height or degree of an existing nonconformity. Single-family additions shall be limited to 50 percent of the use area or 1,000 square feet, whichever is lesser, and shall not require a conditional use permit in the MUR-45' and MUR-70' zones. Modification of structures that are nonconforming with regards to critical areas may only be permitted consistent with SMC 20.80.040.

D. **Expansion of Nonconforming Use.** A nonconforming use may be expanded subject to approval of a conditional use permit unless the indexed supplemental criteria (SMC 20.40.200) require a special use permit for expansion of the use under the code. A nonconformance with the development standards shall not be created or increased and the total expansion shall not exceed 10 percent of the use area.

E. **Nonconforming Lots.** Any permitted use may be established on an undersized lot, which cannot satisfy the lot size or width requirements of this code; provided, that:

1. All other applicable standards of the code are met; or a variance has been granted;

2. The lot was legally created and satisfied the lot size and width requirements applicable at the time of creation;

3. The lot cannot be combined with contiguous undeveloped lots to create a lot of required size;

4. No unsafe condition is created by permitting development on the nonconforming lot; and

5. The lot was not created as a “special tract” to protect critical area, provide open space, or as a public or private access tract.

Subchapter 6.

Review and/or Decision Criteria

Comment [jn32]: The terms used to cross reference the critical area regulations are not consistent and not included in all types of review decision criteria in Chapter 20.30. Proposed change would standardize so the code sections that apply are clear and consistent. SMP references also added for clarity.

20.30.290 Deviation from the engineering standards (Type A action).

B. Decision Criteria. The Director shall grant an engineering standards deviation only if the applicant demonstrates all of the following:

1. The granting of such deviation will not be materially detrimental to the public welfare or injurious or create adverse impacts to the property or other property(s) and improvements in the vicinity and in the zone in which the subject property is situated;

2. The authorization of such deviation will not adversely affect the implementation of the Comprehensive Plan adopted in accordance with State law;

3. The deviation is not in conflict with the standards of the critical areas regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II;

4. A deviation from engineering standards shall only be granted if the proposal meets the following criteria:

   a. Conform to the intent and purpose of the Code;

   b. Produce a compensating or comparable result which is in the public interest; and

   c. Meet the objectives of safety, function and maintainability based upon sound engineering judgement~~.~~;

~~4~~5. Deviations from road standards must meet the objectives for fire protection. Any deviation from road standards, which does not meet the International Fire Code, shall also require concurrence by the Fire Marshal~~.~~;

~~5~~6. Deviations from drainage standards contained in the Stormwater Manual and Chapter 13.10 SMC must meet the objectives for appearance and environmental protection~~.~~;

~~6~~7. Deviations from drainage standards contained in the Stormwater Manual and Chapter 13.10 SMC must be shown to be justified and required for the use and situation intended~~.~~;

~~7~~8. Deviations from drainage standards for facilities that request use of emerging technologies, an experimental water quality facility or flow control facilities must meet these additional criteria:

   a. The new design is likely to meet the identified target pollutant removal goal or flow control performance based on limited data and theoretical consideration~~.~~;

   b. Construction of the facility can, in practice, be successfully carried out; and

   c. Maintenance considerations are included in the design, and costs are not excessive or are borne and reliably performed by the applicant or property owner; and

~~8~~9. Deviations from utility standards shall only be granted if following facts and conditions exist:

   a. The deviation shall not constitute a grant of special privilege inconsistent with the limitation upon uses of other properties in the vicinity and in the zone in which the property on behalf of which the application was filed is located;

   b. The deviation is necessary because of special circumstances relating to the size, shape, topography, location or surrounding of the subject property in order to provide it with use rights and privileges permitted to other properties in the vicinity and in the zone in which the subject property is located; and

c. The granting of such deviation is necessary for the preservation and enjoyment of a substantial property right of the applicant possessed by the owners of other properties in the same zone or vicinity. (Ord. 531 § 1 (Exh. 1), 2009; Ord. 406 § 1, 2006; Ord. 238 Ch. III § 7(a), 2000).

20.30.295 Temporary use.

B. The Director may approve or modify and approve an application for a temporary use permit if:

1. The temporary use will not be materially detrimental to public health, safety, or welfare, nor injurious to property and improvements in the immediate vicinity of the subject temporary use; ~~and~~

2. The temporary use is not incompatible in intensity and appearance with existing land uses in the immediate vicinity of the temporary use; ~~and~~

3. Adequate parking is provided for the temporary use and, if applicable, the temporary use does not create a parking shortage for the existing uses on the site; ~~and~~

4. Hours of operation of the temporary use are specified; ~~and~~

5. The temporary use will not create noise, light, or glare which would adversely impact surrounding uses and properties: and

6. The temporary use is not in conflict with the standards of the critical areas regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II.

20.30.310 Zoning variance (Type B action).

B. Decision Criteria. A variance shall be granted by the City, only if the applicant demonstrates all of the following:

1. The variance is necessary because of the unique size, shape, topography, or location of the subject property;

2. The strict enforcement of the provisions of this title creates an unnecessary hardship to the property owner;

3. The subject property is deprived, by provisions of this title, of rights and privileges enjoyed by other properties in the vicinity and under an identical zone;

4. The need for the variance is not the result of deliberate actions of the applicant or property owner, including any past owner of the same property;

5. The variance is compatible with the Comprehensive Plan;

6. The variance does not create a health or safety hazard;

7. The granting of the variance will not be materially detrimental to the public welfare or injurious to:

   a. The property or improvements in the vicinity, or

   b. The zone in which the subject property is located;

8. The variance does not relieve an applicant from:

   a. Any of the procedural or administrative provisions of this title, or

   b. Any standard or provision that specifically states that no variance from such standard or provision is permitted, or

   c. Use or building restrictions, or

d. Any provisions of the critical areas ~~development standards~~ regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II;

9. The variance from setback or height requirements does not infringe upon or interfere with easement or covenant rights or responsibilities;

10. The variance does not allow the establishment of a use that is not otherwise permitted in the zone in which the proposal is located; or

11. The variance is the minimum necessary to grant relief to the applicant. (Ord. 324 § 1, 2003; Ord. 238 Ch. III § 7(c), 2000).

20.30.330 Special use permit-SUP (Type C action).

B. Decision Criteria. A special use permit shall be granted by the City, only if the applicant demonstrates that:

1. The use will provide a public benefit or satisfy a public need of the neighborhood, district or City;

2. The characteristics of the special use will be compatible with the types of uses permitted in surrounding areas;

3. The special use will not materially endanger the health, safety and welfare of the community;

4. The proposed location shall not result in either the detrimental over-concentration of a particular use within the City or within the immediate area of the proposed use, unless the proposed use is deemed a public necessity;

5. The special use is such that pedestrian and vehicular traffic associated with the use will not be hazardous or conflict with existing and anticipated traffic in the neighborhood;

6. The special use will be supported by adequate public facilities or services and will not adversely affect public services to the surrounding area or conditions can be established to mitigate adverse impacts;

7. The location, size and height of buildings, structures, walls and fences, and screening vegetation for the special use shall not hinder or discourage the appropriate development or use of neighboring properties;

8. The special use is not in conflict with the policies of the Comprehensive Plan or the basic purposes of this title; and

9. The special use is not in conflict with the standards of the critical areas ~~overlay~~ regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II. (Ord. 238 Ch. III § 7(e), 2000).

20.30.333 Critical area special use permit (Type C action).

Comment [jn33]: Updated for accuracy of terms and applicability.

A. **Purpose.** The purpose of the critical areas special use permit is to allow development by a public agency or utility when the strict application of the critical areas standards would otherwise unreasonably prohibit the provision of public services. This type of permit does not apply to flood hazard areas or within the shoreline jurisdiction.

B. **Decision Criteria.** A critical areas special use permit shall be granted by the City only if the utility or public agency applicant demonstrates that:

1. The application of the critical areas ~~development standards~~ regulations, Chapter 20.80 SMC, Critical Areas, would unreasonably restrict the ability of the public agency or utility to provide services to the public; ~~and~~

2. There is no other practical alternative to the proposal by the public agency or utility which would cause less impact on the critical area; ~~and~~

3. The proposed development does not create a health or safety hazard on or off the development site, will not be materially detrimental to the property or improvements in the vicinity; ~~and~~

4. This special use permit process shall not allow the use of the following critical areas for regional retention/detention facilities except where the Hearing Examiner makes a finding that the facility is necessary to protect public health and safety or repair damaged natural resources:

   a. Type ~~I~~ S or Type F-anadromous streams or buffers;

   b. ~~Type~~ Category I wetlands or buffers with plant associations of infrequent occurrence; or

   c. ~~Type~~ Category I or II wetlands or buffers which provide critical or outstanding habitat for herons, raptors or State or Federal designated endangered or threatened species unless clearly demonstrated by the applicant, using best available science, that there will be no impact on such habitat;

5. Any alterations permitted to the critical area are mitigated in accordance with SMC 20.80.082 and relevant mitigation standards for the impacted critical area(s);

6. The proposal attempts to protect the critical area functions and values consistent with the best available science and results in no net loss of critical area functions and values; and

7. The proposal is consistent with other applicable regulations and standards. (Ord. 641 § 4 (Exh. A), 2012; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(I), 2000. Formerly 20.80.090.).

C. **Permit Conditions.** The Director may condition the proposed activity as necessary to mitigate the impacts to critical areas and to conform to the standards required by Chapter 20.80 SMC, Critical Areas.

20.30.336 Critical areas reasonable use permit (Type C action).

A. **Purpose.** The purpose of the critical areas reasonable use permit is to allow development and use of private property when the strict application of the critical area ~~standards~~ regulations would otherwise deny all reasonable use of a property. This type of permit does not apply to flood hazard areas or within the shoreline jurisdiction.

B. **Decision Criteria.** A reasonable use permit shall be granted by the City only if the applicant demonstrates that:

1. The application of the ~~development standards~~ critical area regulations, Chapter 20.80 SMC, Critical Areas, would deny all reasonable use of the property; and

2. There is no other reasonable use of the property with less impact on the critical area; and

3. Any alterations to the critical area would be the minimum necessary to allow for reasonable use of the property; and

4. The proposed development does not create a health or safety hazard on or off the development site, will not be materially detrimental to the property or improvements in the vicinity, is consistent with the general purposes of this title and the public interest, and all reasonable mitigation measures have been implemented or assured; and

5. The inability to derive reasonable economic use is not the result of the applicant's action unless the action 1) was approved as part of a final land use decision by the City or other agency with jurisdiction; or 2) otherwise resulted in a nonconforming use, lot or structure as defined in this title;

5. Any alterations permitted to the critical area are mitigated in accordance with SMC 20.80.082 and relevant mitigation standards for the impacted critical area(s);

6. The proposal attempts to protect the critical area functions and values consistent with the best available science and results in no net loss of critical area functions and values; and

Comment [jn34]: References changed to match updated classifications/ratings and for consistency with new applicability language in CAO. Added clarifying provisions regarding the decision criteria for this type of permit.

Comment [jn35]: Updated for consistency with proposed Chapter 20.80 changes. This section is a required part of the CAO to meet GMA requirements. Added clarifying provisions regarding the decision criteria for this type of permit.

7. The proposal is consistent with other applicable regulations and standards.

C. **Development Standards.** To allow for reasonable use of property and to minimize impacts on critical areas the decision making authority may reduce setbacks by up to 50 percent, parking requirements by up to 50 percent, and may eliminate landscaping requirements. Such reductions shall be the minimum amount necessary to allow for reasonable use of the property, considering the character and scale of neighboring development.

D. **Priority.** When multiple critical areas and critical area buffers may be affected by the application, the decision making authority should consider exceptions to critical areas ~~standards~~ regulations that occur in the following order of priority with number 5 having the highest protection:

1. Geologic hazard area buffers;

2. Wetland buffers;

3. ~~Stream buffers;~~

~~4.~~ Fish and wildlife habitat conservation area buffers (excluding wetlands); and

~~5~~4. Geologic~~al~~ hazard areas, wetlands, ~~stream,~~ and fish and wildlife habitat conservation critical areas protection standards in the order listed above in items 1 through 4. (Ord. 641 § 4 (Exh. A), 2012; Ord. 352 § 1, 2004; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(L), 2000. Formerly 20.80.120.).

20.30.353 Master development plan.

B. **Decision Criteria.** A master development plan shall be granted by the City only if the applicant demonstrates that:

1. The project is designated as either campus or essential public facility in the Comprehensive Plan and Development Code and is consistent with goals and policies of the Comprehensive Plan.

2. The master development plan includes a general phasing timeline of development and associated mitigation.

3. The master development plan meets or exceeds the current ~~regulations for~~ critical areas regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II, if critical areas or their buffers are present or project is within the shoreline jurisdiction.

4. The proposed development uses innovative, aesthetic, energy efficient and environmentally sustainable architecture and site design (including low impact development stormwater systems and substantial tree retention) to mitigate impacts to the surrounding neighborhoods.

5. There is either sufficient capacity and infrastructure (e.g., roads, sidewalks, bike lanes) in the transportation system (motorized and nonmotorized) to safely support the development proposed in all future phases or there will be adequate capacity and infrastructure by the time each phase of development is completed. If capacity or infrastructure must be increased to support the proposed master development plan, then the applicant must identify a plan for funding their proportionate share of the improvements.

6. There is either sufficient capacity within public services such as water, sewer and stormwater to adequately serve the development proposal in all future phases, or there will be adequate capacity available by the time each phase of development is completed. If capacity must be increased to support the proposed master development plan, then the applicant must identify a plan for funding their proportionate share of the improvements.

7. The master development plan proposal contains architectural design (including but not limited to building setbacks, insets, facade breaks, roofline variations) and site design standards, landscaping, provisions for open space and/or recreation areas, retention of significant trees, parking/traffic management and multimodal transportation standards that minimize conflicts and create transitions between the proposal site and adjacent neighborhoods and between institutional uses and residential uses.

8. The applicant shall demonstrate that proposed industrial, commercial or laboratory uses will be safe for the surrounding neighborhood and for other uses on the campus.

C. **Amendments.** Minor amendments to an approved master development plan may be approved by the Director if the amendment meets the development standards and criteria applicable to the zoning and requirements set forth in this section. Minor amendments include any revision or modification of the previously approved master development plan that would result in any one or more of the following:

1. An increase in the square footage of any proposed building or structure by 10 percent or less; or

2. A change of 15 percent or less in the number of new parking spaces, parking spaces created by restriping existing parking areas and/or a combination of both except for an increase in parking spaces for bicycles or electric vehicles; or

3. A change in the original phasing timeline for mitigation of the master development plan; or

4. Changes to building placement when located outside of the required setbacks and any required ~~setbacks~~ buffers for critical areas; or

5. A cumulative increase in impervious surface of 10 percent or less or a cumulative decrease in tree cover of 10 percent or less; or

6. Other specific changes as noted in the master development plan.

Major amendments are changes that exceed the thresholds for a minor amendment or were not analyzed as part of an approved master development plan. Major amendments to an approved master development plan shall be processed as a new master development plan.

F. **Early Community Input.** Applicants are encouraged to develop a community and stakeholders consensus-based master development plan. Community input is required to include soliciting input from stakeholders, community members and any other interested parties with bubble diagrams, diagrammatic site plans, or conceptual site plans. The meeting notice shall be provided at a minimum to property owners located within 1,000 feet of the proposal, the neighborhood chair as identified by the Shoreline Office of Neighborhoods (note: if a proposed development is within 1,000 feet of adjacent neighborhoods, those chairs shall also be notified), and to the City of Shoreline Planning ~~and~~ & Community Development ~~Services~~ Department. Digital audio recording, video recording, or a court reporter transcription of this meeting or meetings is required at the time of application. The applicant shall provide an explanation of the comments of these entities to the City regarding the incorporation (or not) of these comments into the design and development of the proposal.

20.30.355 Development agreement (Type L).

C. **Decision Criteria.** A development agreement (general development agreement and development agreements in order to increase height above 70 feet) may be granted by the City only if the applicant demonstrates that:

1. The project is consistent with goals and policies of the Comprehensive Plan. If the project is located within a subarea plan, then the project shall be consistent with the goals and policies of the subarea plan.

2. The proposed development uses innovative, aesthetic, energy efficient and environmentally sustainable architecture and site design.

3. There is either sufficient capacity and infrastructure (e.g., roads, sidewalks, bike lanes) in the transportation system (motorized and nonmotorized) to safely support the development proposed in all future phases or there will be adequate capacity and infrastructure by the time each phase of development is completed. If capacity or infrastructure must be increased to support the proposed development agreement, then the applicant must identify a plan for funding their proportionate share of the improvements.

4. There is either sufficient capacity within public services such as water, sewer and stormwater to adequately serve the development proposal in all future phases, or there will be adequate capacity available by the time each phase of development is completed. If capacity must be increased to support the proposed

development agreement, then the applicant must identify a plan for funding their proportionate share of the improvements.

5. The development agreement proposal contains architectural design (including but not limited to building setbacks, insets, facade breaks, roofline variations) and site design standards, landscaping, provisions for open space and/or recreation areas, retention of significant trees, parking/traffic management and multimodal transportation improvements and other features that minimize conflicts and create transitions between the proposal site and property zoned R-4, R-6, R-8 or MUR-35'.

6. The project is consistent with the standards of the critical areas regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II.

Subchapter 7.

Subdivisions

20.30.370 Purpose.
Subdivision is a mechanism by which to divide land into lots, parcels, sites, plots, or tracts, for the purpose of sale. The purposes of subdivision regulations are:

A. To regulate division of land into two or more lots or tracts;

B. To protect the public health, safety and general welfare in accordance with the State standards;

C. To promote effective use of land;

D. To promote safe and convenient travel by the public on streets and highways;

E. To provide for adequate light and air;

F. To facilitate adequate provision for water, sewerage, stormwater drainage, parks and recreation areas, sites for schools and school grounds and other public requirements;

G. To provide for proper ingress and egress;

H. To provide for the expeditious review and approval of proposed subdivisions which conform to development standards and the Comprehensive Plan;

I. To adequately provide for the housing and commercial needs of the community;

J. To protect environmentally ~~sensitive~~ critical areas and their buffers as designated by ~~in the critical area overlay districts chapter,~~ Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II;

K. To require uniform monumenting of land subdivisions and conveyance by accurate legal description. (Ord. 695 § 1 (Exh. A), 2014; Ord. 238 Ch. III § 8(b), 2000).

20.30.410 Preliminary subdivision review procedures and criteria.
The short subdivision may be referred to as a short plat – Type B action.

The formal subdivision may be referred to as long plat – Type C action.

Time limit: A final short plat or final long plat meeting all of the requirements of this chapter and Chapter 58.17 RCW shall be submitted for approval within the time frame specified in RCW 58.17.140.

Review criteria: The following criteria shall be used to review proposed subdivisions:

A. **Environmental.**

1. Where environmental resources exist, such as trees, streams, ~~ravines~~ geologic hazards, or wildlife habitats, the proposal shall be designed to fully implement the goals, policies, procedures and standards of the critical areas regulations, Chapter 20.80 SMC, Critical Areas, and the tree conservation, land clearing, and site grading standards sections.

2. The proposal shall be designed to minimize grading by using shared driveways and by relating street, house site and lot placement to the existing topography.

3. Where conditions exist which could be hazardous to the future residents of the land to be divided, or to nearby residents or property, such as floodplains, ~~steep slopes~~ landslide hazards, or unstable soil or geologic conditions, a subdivision of the hazardous land shall be denied unless the condition can be permanently corrected, consistent with subsections (A)(1) and (2) of this section, Chapter 20.80 SMC Critical Areas, and Chapter 13.12 SMC, Floodplain Management.

Subchapter 8.

Environmental Procedures

20.30.560 Categorical exemptions – Minor new construction.

The following types of construction shall be exempt, except when: 1) undertaken wholly or partly on lands covered by water; 2) a rezone is requested; or 3) any license governing emissions to the air or discharges to water is required.

Comment [jn36]: Definition of "lands covered by water" proposed in SMC 20.20 based on state definition. Wetlands are lands covered by water so any alteration in a wetland is subject to SEPA, whether or not there is open standing water.

No changed proposed here, included for information only.

A. The construction or location of:

1. Any residential structures up to 30 dwelling units.

2. A multifamily structure with up to 60 dwelling units.

B. The construction of an office, school, commercial, recreational, service or storage building with 30,000 square feet of gross floor area, and with associated parking facilities designed for 90 automobiles.

C. The construction of a parking lot designed for 90 automobiles. This exemption includes stand-alone parking lots

D. Any landfill or excavation of 1,000 cubic yards throughout the total lifetime of the fill or excavation not associated with an exempt project in subsection A, B or C of this section and any fill or excavation classified as a Class I, II, or III forest practice under RCW 76.09.050 or regulations thereunder. (Ord. 660 § 1 (Exh. 1), 2013; Ord. 591 § 1 (Exh. A), 2010; Ord. 324 § 1, 2003; Ord. 299 § 1, 2002; Ord. 238 Ch. III § 9(h), 2000).

Subchapter 9.

Code Enforcement

20.30.730 General provisions.

A. For the purposes of this subchapter, any person who causes or maintains a code violation and the owner, lessor, tenant or other person entitled to control, use, or occupancy of property where a code violation occurs shall be identified as the responsible party and shall be subject to enforcement action as provided in this subchapter.

However, if a property owner affirmatively demonstrates that the action which resulted in the violation was taken without the owner's knowledge or consent by someone other than the owner or someone acting on the owner's behalf, that owner shall be responsible only for bringing the property into compliance to the extent reasonably feasible under the circumstances, as determined by the Director. Should the responsible party not correct the violation, after service of the notice and order, civil penalties and abatement costs may be assessed.

B. It shall be the responsibility of any person identified as a responsible party to bring the property into a safe and reasonable condition to achieve compliance. Payment of fines, applications for permits, acknowledgment of stop work orders and compliance with other remedies does not substitute for performing the corrective work required and having the property brought into compliance to the extent reasonably possible under the circumstances. The date set for compliance in the notice and order takes precedence over any date established for the expiration of any required permit(s) and will be subordinate only to written extension of the notice and order.

C. The responsible parties have a duty to notify the Director of any actions taken to achieve compliance. A violation shall be considered ongoing until the responsible party has come into compliance and has notified the Director of this compliance, and an official inspection has verified compliance and all assessed penalties and costs have been paid to the City.

D. The procedures set forth in this subchapter are not exclusive, specifically the provisions in SMC 20.80.130 apply to code enforcement of violations of Chapter 20.80 SMC, Critical Areas. These procedures shall not in any manner limit or restrict the City from remedying or abating code violations in any other manner authorized by law. (Ord. 669 § 1 (Exh. A), 2013; Ord. 515 § 1, 2008; Ord. 406 § 1, 2006; Ord. 391 § 4, 2005; Ord. 238 Ch. III § 10(b), 2000).

Comment [jn37]: Cross reference added to new CAO code enforcement section.

20.30.770 Enforcement provisions.

Comment [jn38]: New critical areas code enforcement provisions work together with this section.

A. **Infraction.** Whenever the Director has determined that a code violation has occurred, the Director may issue a Class 1 civil infraction, or other class of infraction specified in the particular ordinance violated, to any responsible party, according to the provisions set forth in Chapter 7.80 RCW.

B. **Misdemeanor.** Any person who willfully or knowingly causes, aids or abets a code violation by any act of commission or omission is guilty of a misdemeanor. Upon conviction, the person shall be punished by a fine not to exceed $1,000 and/or imprisonment in the County jail for a term not to exceed 90 days. Each week (seven days) such violation continues shall be considered a separate misdemeanor offense. A misdemeanor complaint or notice of infraction may be filed as an alternative, or in addition, to any other judicial or administrative remedy provided in this subchapter or by law or other regulation.

C. **Suspension, Revocation or Limitation of Permit.**

1. The Director may suspend, revoke or limit any permit issued whenever:

   a. The permit holder has committed a code violation in the course of performing activities subject to that permit;

   b. The permit holder has interfered with the Director in the performance of his or her duties relating to that permit;

c. The permit was issued in error or on the basis of materially incorrect information supplied to the City; or

d. Permit fees or costs were paid to the City by check and returned from a financial institution marked nonsufficient funds (NSF) or cancelled.

2. Such suspension, revocation or modification shall be carried out through the notice and order provisions of this subchapter and shall be effective upon the compliance date established by the notice and order. Such revocation, suspension or cancellation may be appealed to the Hearing Examiner using the appeal provisions of this subchapter. Notwithstanding any other provision of this subchapter, the Director may immediately suspend operations under any permit by issuing a stop work order.

D. **Civil Penalties.**

1. A civil penalty for violation of the terms and conditions of a notice and order shall be imposed in the amount of $500.00. The total initial penalties assessed for notice and orders and stop work orders pursuant to this section shall apply for the first 14-day period following the violation of the order, if no appeal is filed. The penalties for the next 14-day period shall be 150 percent of the initial penalties, and the penalties for the next 14-day period and each such period or portion thereafter shall be double the amount of the initial penalties.

2. Any responsible party who has committed a violation of the provisions of Chapter 20.50 SMC, General Development Standards (tree conservation, land clearing and site grading standards), or Chapter 20.80 SMC, Critical Areas, will not only be required to restore unlawfully removed trees or damaged critical areas, insofar as that is possible and beneficial, as determined by the Director, but will also be required to pay civil penalties in addition to penalties under subsection (D)(1) of this section, for the redress of ecological, recreation, and economic values lost or damaged due to the violation. Civil penalties will be assessed according to the following factors:

a. Inside critical areas and required buffers, an amount determined pursuant to SMC 20.80.130(E); or

b. Outside of critical areas, ~~A~~an amount determined to be equivalent to the economic benefit that the responsible party derives from the violation measured as the total of:

i. The resulting increase in market value of the property; and

ii. The value received by the responsible party; and

iii. The savings of construction costs realized by the responsible party as a result of performing any act in violation of the chapter; and

~~b~~c. A penalty of $2,000 if the violation has severe ecological impacts, including temporary or permanent loss of resource values or functions.

3. An additional penalty of $2,000 if the violation was deliberate, the result of knowingly false information submitted by the property owner, agent, or contractor, or the result of reckless disregard on the part of the property owner, agent, or their contractor. The property owner shall assume the burden of proof for demonstrating that the violation was not deliberate.

4. A repeat violation means a violation of the same regulation in any location within the City by the same responsible party, for which voluntary compliance previously has been sought or any enforcement action taken, within the immediate preceding 24-consecutive-month period, and will incur double the civil penalties set forth above.

5. Under RCW 59.18.085, if, after 60 days from the date that the City first advanced relocation assistance funds to displaced tenants, the landlord does not repay the amount of relocation assistance advanced by the City, the City shall assess civil penalties in the amount of $50.00 per day for each tenant to whom the City has advanced a relocation assistance payment.

Comment [jn39]: Cross reference added to penalties section to replace existing language with new provisions for violations in critical areas.

6. The responsible parties have a duty to notify the Director of any actions taken to achieve compliance with the notice and order. For purposes of assessing civil penalties, a violation shall be considered ongoing until the responsible party has come into compliance with the notice and order and has notified the Director of this compliance, and an official inspection has verified compliance and all assessed penalties and costs have been paid to the City.

7. a. Civil penalties will be waived by the Director or will be reimbursed to the payer by the Director, with the concurrence of the Administrative Services Director, under the following documented circumstances:

i. The notice and order were issued in error; or

ii. The civil penalties were assessed in error; or

iii. Notice failed to reach the property owner due to unusual circumstances.

b. Civil penalties accrued under subsection (D)(1) of this section will be reduced by the Director to 20 percent of accrued penalties if voluntary compliance is achieved and the City is reimbursed its reasonable staff and professional costs incurred in enforcing the notice and order.

E. **Abatement.**

1. All public nuisances are subject to abatement under this subchapter.

2. **Imminent Nuisance and Summary Abatement.** If a condition, substance, act or nuisance exists which causes a condition, the continued existence of which constitutes an immediate and emergent threat to the public health, safety or welfare or to the environment, the City may summarily and without prior notice abate the condition. Notice of such abatement, including the reason for the abatement, shall be given to the person responsible for the property and the violation as soon as reasonably possible after the abatement. The Director shall make the determination of a condition, substance, act or other occurrence constituting an imminent nuisance requiring summary abatement. Costs, both direct and indirect, of the abatement may be assessed as provided in this chapter.

3. In the case of such unfit dwellings, buildings, structures, and premises or portions thereof, the Director, as an alternative to any other remedy provided in this subchapter, may abate such conditions by demolition, repair, removal, or securing the site and have abatement costs collected as taxes by the King County Treasury pursuant to SMC 20.30.775. If an occupied rental dwelling or its premises are declared unfit and required to be vacated by a notice and order, and the landlord fails to pay relocation assistance as set forth in RCW 59.18.085, the City shall advance relocation assistance funds to eligible tenants in accordance with RCW 59.18.085.

F. **Additional Enforcement Provisions.** The enforcement provisions of this section are not exclusive, and may be used in addition to other enforcement provisions authorized by the Shoreline Municipal Code or by State law, including filing for injunctive relief or filing of a civil action. (Ord. 669 § 1 (Exh. A), 2013; Ord. 631 § 1 (Exh. 1), 2012; Ord. 581 § 1 (Exh. 1), 2010; Ord. 466 § 2, 2007; Ord. 406 § 1, 2006; Ord. 391 § 4, 2005; Ord. 251 § 2(D), 2000; Ord. 238 Ch. III § 10(c), 2000. Formerly 20.30.740).

Chapter 20.40

Zoning and Use Provisions

Sections:

Subchapter 3.

Index of Supplemental Use Criteria

20.40.230 Affordable housing.

A. Provisions for density bonuses for the provision of affordable housing apply to all land use applications, except the following which are not eligible for density bonuses: (a) the construction of one single-family dwelling on one lot that can accommodate only one dwelling based upon the underlying zoning designation, (b) provisions for accessory dwelling units, and (c) projects which are limited by the critical areas ~~requirements~~ regulations, Chapter 20.80 SMC, Critical Areas, or Shoreline Master Program, SMC Title 20, Division II.

Chapter 20.50

General Development Standards

Sections:

Subchapter 1. Dimensions and Density for Development

Subchapter 5. Tree Conservation, Land Clearing and Site Grading Standards

NOTE: Items highlighted grey are included for information only. No revisions proposed in these sections and they will not be included in the final critical areas update ordinances.

Subchapter 1.

Dimensions and Density for Development

20.50.020 Dimensional requirements.

Comment [jn40]: Section included for information only. No changes proposed.

B. **Base Density Calculation.** The base density for an individual site shall be calculated by multiplying the site area (in acres) by the applicable number of dwelling units. When calculation results in a fraction, the fraction shall be rounded to the nearest whole number as follows:

1. Fractions of 0.50 and above shall be rounded up except for lots less than 14,400 square feet in R-6 zones. See Exception (7) to Table 20.50.020(1).

2. Fractions below 0.50 shall be rounded down.

Example #1 – R-6 zone, 2.3 acres site: 2.3 x 6 = 13.8
The base density for this site would be 14 dwelling units.

Example #2 – R-24 zone, 2.3 acres site: 2.3 x 24 = 55.2
The base density for the site would be 55 dwelling units.

Example #3 – R-6 zone, 13,999-square-foot site: (13,999/43,560 = .3214 acres) so .3214 X 6 = 1.92. The base density for single-family detached dwellings on this site would be one unit.

Example #4 – R-6 zone, 14,400-square-foot site (14,400/43,560 = .331 acres) so .331 X 6 = 1.986. The base density for the site would be two units.

C. All areas of a site may be used in the calculation of base density, except that submerged lands shall not be credited toward base density calculations.

Comment [jn41]: Submerged lands differ in definition to lands covered by water and requires an area of open water that creates an ordinary high water mark. So this technically excludes areas like Puget Sound tidelands, streams, and private portions of open water wetlands from the base density calculation. Privately owned wetlands with open water currently only exist on one property on Echo Lake and a few on Hidden Lake (which may change if the lake is eliminated). **Section included for reference only. No changes proposed and will not be included in final ordinance.**

D. When a lot is divided by a zone boundary, the following rules shall apply:

1. When a lot contains both residential and nonresidential zoning, the zone boundary between the zones shall be considered a lot line for determining permitted building height and required setbacks on the site.

2. When a lot contains residential zones of varying density, the following shall apply:

a. Any residential density transfer within the lot shall be allowed from the portion with the lesser residential density to that of the greater residential density.

b. Residential density transfer from the higher density zone to the lower density zone may be allowed only when:

- The transfer enhances the efficient use of needed infrastructure;
- The transfer contributes to preservation of critical areas, or other natural features; and
- The transfer does not result in significant adverse impacts to adjoining lower-density properties.

Example: A development site is 3.8 acres. 1.5 acres is zoned R-12 and 2.3 acres is zoned R-24. The base density for the R-12 portion: 1.5 x 12 = 18 dwelling units, for the R-24 portion: 2.3 x 24 = 55.2 rounded to 55 dwelling units. The overall base density for the site is 18 + 55 = 73 dwelling units. (Ord. 706 § 1 (Exh. A), 2015; Ord. 695 § 1 (Exh. A), 2014; Ord. 682 § 1 (Exh. A), 2014; Ord. 654 § 1 (Exh. 1), 2013; Ord. 560 § 4 (Exh. A), 2009; Ord. 536 § 1, 2009; Ord. 531 § 1 (Exh. 1), 2009; Ord. 500 § 1, 2008; Ord. 462 § 1, 2006; Ord. 439 § 1, 2006; Ord. 352 § 1, 2004; Ord. 299 § 1, 2002; Ord. 293 §§ 1,2, 2001; Ord. 266 § 1, 2001; Ord. 238 Ch. V § 1(B-1), 2000).

20.50.040 Setbacks – Designation and measurement.

F. **Allowance for Optional Aggregate Setback.** For lots with unusual geometry, flag lots with undesignated setbacks, or site conditions, such as ~~steep slopes~~ critical areas, an existing cluster of significant trees, or other unique natural or historic features that should be preserved without disturbance, the City may reduce the individual required setbacks, however, the total of setbacks shall be no less than the sum of the minimum front yard, rear yard, and side yards setbacks. In order to exercise this option, the City must determine that a public benefit is gained by relaxing any setback standard. The following criteria shall apply:

1. No rear or side yard setback shall be less than five feet.

2. The front yard setback adjacent to street shall be no less than 15 feet in R-4 and R-6 and 10 feet in all other zones. (See Exception 20.50.070(1).)

Subchapter 5.

Tree Conservation, Land Clearing and Site Grading Standards

20.50.290 Purpose.

The purpose of this subchapter is to reduce the environmental impacts of site development while promoting the reasonable use of land in the City by addressing the following:

A. Prevention of damage to property, harm to persons, and environmental impacts caused by excavations, fills, and the destabilization of soils;

B. Protection of water quality from the adverse impacts associated with erosion and sedimentation;

C. Promotion of building and site planning practices that are consistent with the City's natural topography and vegetative cover;

D. Preservation and enhancement of trees and vegetation which contribute to the visual quality and economic value of development in the City and provide continuity and screening between developments;

E. Protection of critical areas from the impacts of clearing and grading activities;

F. Conservation and restoration of trees and vegetative cover to reduce flooding, the impacts on existing drainageways, and the need for additional stormwater management facilities;

G. Protection of anadromous fish and other native animal and plant species through performance-based regulation of clearing and grading;

H. Retention of tree clusters for the abatement of noise, wind protection, and mitigation of air pollution;

I. Rewarding significant tree protection efforts by granting flexibility for certain other development requirements;

J. Providing measures to protect trees that may be impacted during construction;

K. Promotion of prompt development, effective erosion control, and restoration of property following site development; and

L. Replacement of trees removed during site development in order to achieve a goal of no net loss of tree cover throughout the City over time. (Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(A), 2000).

20.50.300 General requirements.

A. Tree cutting or removal by any means is considered a type of clearing and is regulated subject to the limitations and provisions of this subchapter.

B. All land clearing and site grading shall comply with all standards and requirements adopted by the City of Shoreline. Where a Development Code section or related manual or guide contains a provision that is more restrictive or specific than those detailed in this subchapter, the more restrictive provision shall apply.

C. Permit Required. No person shall conduct clearing or grading activities on a site without first obtaining the appropriate permit approved by the Director, unless specifically exempted by SMC 20.50.310.

D. When clearing or grading is planned in conjunction with development that is not exempt from the provisions of this subchapter, all of the required application materials for approval of tree removal, clearing and rough grading of the site shall accompany the development application to allow concurrent review.

E. A clearing and grading permit may be issued for developed land if the regulated activity is not associated with another development application on the site that requires a permit.

F. Replacement trees planted under the requirements of this subchapter on any parcel in the City of Shoreline shall be regulated as protected trees under SMC 20.50.330(D).

G. Any disturbance to vegetation within critical areas and their corresponding buffers is subject to the procedures and standards contained within the critical areas chapter of the Shoreline Development Code, Chapter 20.80 SMC, Critical Areas, in addition to the standards of this subchapter. The standards which result in the greatest protection of the critical areas shall apply. (Ord. 640 § 1 (Exh. A), 2012; Ord. 406 § 1, 2006; Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(B), 2000).

20.50.310 Exemptions from permit.

Comment [jn42]: Edits made to cross reference these exemptions with CA exemptions for consistency about when a permit is required because activity is in a critical area.

A. **Complete Exemptions.** The following activities are exempt from the provisions of this subchapter and do not require a permit:

1. Emergency situation on private property involving danger to life or property or substantial fire hazards.

   a. **Statement of Purpose.** Retention of significant trees and vegetation is necessary in order to utilize natural systems to control surface water runoff, reduce erosion and associated water quality impacts, reduce the risk of floods and landslides, maintain fish and wildlife habitat and preserve the City's natural, wooded character. Nevertheless, when certain trees become unstable or damaged, they may constitute a hazard requiring cutting in whole or part. Therefore, it is the purpose of this section to provide a reasonable and effective mechanism to minimize the risk to human health and property while preventing needless loss of healthy, significant trees and vegetation, especially in critical areas and their buffers.

   b. For purposes of this section, "Director" means the Director of the Department and his or her designee.

   c. In addition to other exemptions of SMC 20.50.290 through 20.50.370, a request for the cutting of any tree that is an active and imminent hazard such as tree limbs or trunks that are demonstrably cracked, leaning toward overhead utility lines or structures, or are uprooted by flooding, heavy winds or storm events. After the tree removal, the City will need photographic proof or other documentation and the appropriate application approval, if any. The City retains the right to dispute the emergency and require that the party obtain a clearing permit and/or require that replacement trees be replanted as mitigation.

2. Removal of trees and/or ground cover by the City and/or utility provider in situations involving immediate danger to life or property, substantial fire hazards, or interruption of services provided by a utility. The City retains the right to dispute the emergency and require that the party obtain a clearing permit and/or require that replacement trees be replanted as mitigation.

3. Installation and regular maintenance of public utilities, under direction of the Director, except substation construction and installation or construction of utilities in parks or ~~environmentally sensitive~~ critical areas.

4. Cemetery graves involving less than 50 cubic yards of excavation, and related fill per each cemetery plot.

5. Removal of trees from property zoned NB, CB, MB and TC-1, 2 and 3, and MUR-70' unless within a critical area of critical area buffer.

6. Removal and restoration of vegetation within critical areas or their buffers consistent with the provisions of SMC 20.80.030(E) or removal of tree consistent with SMC 20.80.030(G).~~Within City-owned property, removal of noxious weeds or invasive vegetation as identified by the King County Noxious Weed Control Board in a wetland buffer, stream buffer or the area within a three-foot radius of a tree on a steep slope is allowed when:~~

   ~~a. Undertaken with hand labor, including handheld mechanical tools, unless the King County Noxious Weed Control Board otherwise prescribes the use of riding mowers, light mechanical cultivating equipment, herbicides or biological control methods; and~~

~~b. Performed in accordance with SMC 20.80.085, Pesticides, herbicides and fertilizers on City-owned property, and King County best management practices for noxious weeds and invasive vegetation; and~~

~~c. The cleared area is revegetated with native vegetation and stabilized against erosion in accordance with the Department of Ecology 2005 Stormwater Management Manual for Western Washington; and~~

~~d. All work is performed above the ordinary high water mark and above the top of a stream bank; and~~

~~e. No more than 3,000 square feet of soil may be exposed at any one time.~~

B. **Partial Exemptions.** With the exception of the general requirements listed in SMC 20.50.300, the following are exempt from the provisions of this subchapter, provided the development activity does not occur in a critical area or critical area buffer. For those exemptions that refer to size or number, the thresholds are cumulative during a 36-month period for any given parcel:

1. The removal of up to a maximum of six significant trees (excluding trees greater than 30 inches DBH per tree) in accordance with Table 20.50.310(B)(1) (see Chapter 20.20 SMC, Definitions).

Table 20.50.310(B)(1) – Exempt Trees

Lot size in square feet	Number of trees
Up to 7,200	3
7,201 to 14,400	4
14,401 to 21,780	5
21,781 and above	6

2. The removal of any tree greater than 30 inches DBH, or exceeding the numbers of trees specified in the table above, shall require a clearing and grading permit (SMC 20.50.320 through 20.50.370).

3. Landscape maintenance and alterations on any property that involves the clearing of less than 3,000 square feet, or less than 1,500 square feet if located in a special drainage area, provided the tree removal threshold listed above is not exceeded. (Ord. 706 § 1 (Exh. A), 2015; Ord. 695 § 1 (Exh. A), 2014; Ord. 640 § 1 (Exh. A), 2012; Ord. 581 § 1 (Exh. 1), 2010; Ord. 560 § 4 (Exh. A), 2009; Ord. 531 § 1 (Exh. 1), 2009; Ord. 434 § 1, 2006; Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(C), 2000).

20.50.320 Specific activities subject to the provisions of this subchapter.
All activities listed below must comply with the provisions of this subchapter. For those exemptions that refer to size or number, the thresholds are cumulative during a 36-month period for any given parcel:

A. The construction of new residential, commercial, institutional, or industrial structures or additions.

B. Earthwork of 50 cubic yards or more. This means any activity which moves 50 cubic yards of earth, whether the material is excavated or filled and whether the material is brought into the site, removed from the site, or moved around on the site.

C. Clearing of 3,000 square feet of land area or more or 1,500 square feet or more if located in a special drainage area.

D. Removal of more than six significant trees from any property.

E. Any clearing, ~~or~~ grading, or other land disturbing activity within a critical area or buffer of a critical area unless otherwise exempt from the provisions of this subchapter in SMC 20.50.310.

Comment [jn43]: Revised for consistency with existing and proposed exemptions.

F. Any change of the existing grade by four feet or more.

G. Repealed by Ord. 640.

H. Any land surface modification not specifically exempted from the provisions of this subchapter.

I. Development that creates new, replaced or a total of new plus replaced impervious surfaces over 1,500 square feet in size, or 500 square feet in size if located in a landslide hazard area or special drainage area.

J. Any construction of public drainage facilities to be owned or operated by the City.

K. Any construction involving installation of private storm drainage pipes 12 inches in diameter or larger.

L. Any modification of or construction which affects a stormwater quantity or quality control system. (Does not include maintenance or repair to the original condition.)

M. Applicants for forest practice permits (Class IV – general permit) issued by the Washington State Department of Natural Resources (DNR) for the conversion of forested sites to developed sites are also required to obtain a clearing and grading permit. For all other forest practice permits (Class II, III, IV – special permit) issued by DNR for the purpose of commercial timber operations, no development permits will be issued for six years following tree removal. (Ord. 640 § 1 (Exh. A), 2012; Ord. 531 § 1 (Exh. 1), 2009; Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(D), 2000).

20.50.330 Project review and approval.

A. Review Criteria. The Director shall review the application and approve the permit, or approve the permit with conditions; provided, that the application demonstrates compliance with the criteria below.

1. The proposal complies with SMC 20.50.340 through 20.50.370, or has been granted a deviation from the Engineering Development Manual.

2. The proposal complies with all standards and requirements for the underlying permit.

3. If the project is located in a critical area or buffer, or has the potential to impact a critical area, the project must comply with the critical areas ~~standards~~ regulations, Chapter 20.80 SMC, or Shoreline Master Program, SMC Title 20, Division II.

4. The project complies with all requirements of the Engineering Development Manual and SMC 13.10.200, Surface Water Management Code and adopted standards.

5. All required financial guarantees or other assurance devices are posted with the City.

B. Professional Evaluation. In determining whether a tree removal and/or clearing is to be approved or conditioned, the Director may require the submittal of a professional evaluation and/or a tree protection plan prepared by a certified arborist at the applicant's expense, where the Director deems such services necessary to demonstrate compliance with the standards and guidelines of this subchapter. Third party review of plans, if required, shall also be at the applicant's expense. The Director shall have the sole authority to determine whether the professional evaluation submitted by the applicant is adequate, the evaluator is qualified and acceptable to the City, and whether third party review of plans is necessary. Required professional evaluation(s) and services may include:

1. Providing a written evaluation of the anticipated effects of proposed construction on the viability of trees on a site;

2. Providing a hazardous tree assessment;

3. Developing plans for, supervising, and/or monitoring implementation of any required tree protection or replacement measures; and/or

4. Conducting a post-construction site inspection and evaluation.

C. Conditions of Approval. The Director may specify conditions for work at any stage of the application or project as he/she deems necessary to ensure the proposal's compliance with requirements of this subchapter, critical area ~~standards~~ regulations, Chapter 20.80 SMC, or Shoreline Master Program, SMC Title 20, Division II, the Engineering Development Manual, the adopted stormwater management regulations, and any other section of the Shoreline Development Code, or to protect public or private property. These conditions may include, but are not limited to, hours or seasons within which work may be conducted, or specific work methods.

D. Designation of Protected Trees.

1. For the following areas, the retention and planting plan and any application and permit plans shall show all trees designated for protection: areas designated as "protected trees," "native growth protection areas," "~~sensitive~~ critical areas," "~~sensitive~~ critical area buffers," or such other designation as may be approved by the Director. Protected vegetation, including protected trees, shall not be modified, harmed or removed except as provided in this subchapter.

Comment [jn44]: Update of terms, not previously revised.

2. The Director may require that protected trees be permanently preserved within a tract, easement or other permanent protective mechanism. When required, the location, purpose, and limitation of these protected areas shall be shown on the face of the deed, plat, binding site plan, or similar document and shall be recorded with the King County ~~Department of~~ Recorder's Office ~~and Elections~~ or its successor. The recorded document shall include the requirement that the protected areas shall not be removed, amended or modified without the written approval of the City.

E. Preconstruction Meeting Required. Prior to the commencement of any permitted clearing and grading activity, a preconstruction meeting shall be held on-site with the permittee and appropriate City staff. The project site shall be marked in the field as follows:

1. The extent of clearing and grading to occur;

2. Delineation and protection with clearing limit fencing of any critical areas and critical area buffers;

Comment [jn45]: Added to ensure that clearing limit fencing is installed to protect clearing limits prior to preconstruction inspection.

3. Trees to be removed and retained; and

4. Property lines. (Ord. 631 § 1 (Exh. 1), 2012; Ord. 531 § 1 (Exh. 1), 2009; Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(E), 2000).

20.50.350 Development standards for clearing activities.

A. No trees or ground cover shall be removed from critical area or buffer unless the proposed activity is consistent with the critical area standards.

B. Minimum Retention Requirements. All proposed development activities that are not exempt from the provisions of this subchapter shall meet the following:

1. At least 20 percent of the significant trees on a given site shall be retained, excluding critical areas, and critical area buffers, or

2. At least 30 percent of the significant trees on a given site (which may include critical areas and critical area buffers) shall be retained.

3. Tree protection measures ensuring the preservation of all trees identified for retention on approved site plans shall be guaranteed during development through the posting of a performance bond equal to the value of the installation and maintenance of those protection measures.

4. The minimum amount of trees to be retained cannot be removed for a period of 36 months and shall be guaranteed through an approved maintenance agreement.

5. The Director may require the retention of additional trees to meet the stated purpose and intent of this title, as required by the critical areas ~~standards~~ regulations, Chapter 20.80 SMC, or Shoreline Master Program, SMC Title 20, Division II, or as site-specific conditions demand using SEPA substantive authority.

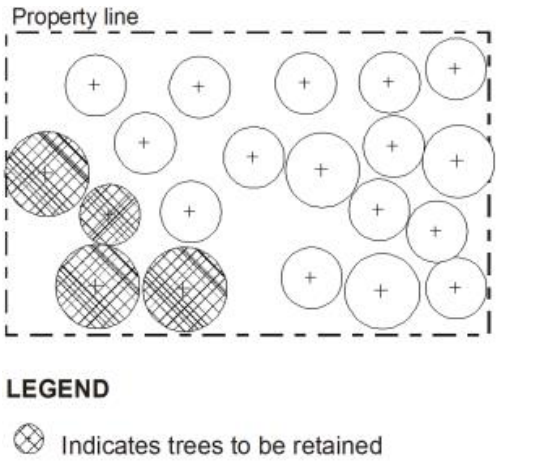


Figure 20.50.350(B)(1): Demonstration of the retention of 20 percent of the significant trees on a site containing no critical areas.

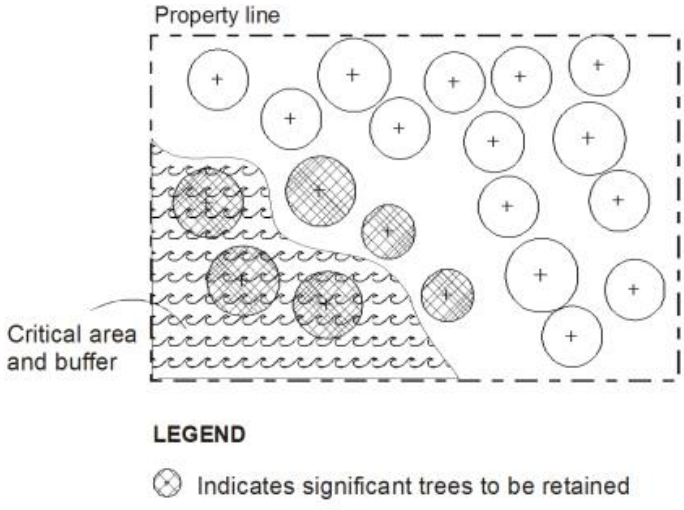


Figure 20.50.350(B)(2): Demonstration of the retention of 30 percent of the significant trees on a site containing a critical area.

Exception 20.50.350(B):

1. The Director may allow a reduction in the minimum significant tree retention percentage to facilitate

preservation of a greater number of smaller trees, a cluster or grove of trees, contiguous perimeter buffers, distinctive skyline features, or based on the City's concurrence with a written recommendation of an arborist certified by the International Society of Arboriculture and approved by the City that retention of the minimum percentage of trees is not advisable on an individual site.

2. *In addition, the Director may allow a reduction in the minimum significant tree retention percentage if all of the following criteria are satisfied: The exception is necessary because:*

   - *There are special circumstances related to the size, shape, topography, location or surroundings of the subject property.*
   - *Strict compliance with the provisions of this Code may jeopardize reasonable use of property.*
   - *Proposed vegetation removal, replacement, and any mitigation measures are consistent with the purpose and intent of the regulations.*
   - *The granting of the exception or standard reduction will not be detrimental to the public welfare or injurious to other property in the vicinity.*

3. *If an exception is granted to this standard, the applicant shall still be required to meet the basic tree replacement standards identified in SMC 20.50.360 for all significant trees removed beyond the minimum allowed per parcel without replacement and up to the maximum that would ordinarily be allowed under SMC 20.50.350(B).*

4. *In addition, the applicant shall be required to plant four trees for each significant tree removed that would otherwise count towards the minimum retention percentage. Trees replaced under this provision shall be at least 12 feet high for conifers and three inches in caliper if otherwise. This provision may be waived by the Director for restoration enhancement projects conducted under an approved vegetation management plan.*

C. **Incentives for Higher Levels of Tree Protection.** The Director may grant reductions or adjustments to other site development standards if the protection levels identified in subsection (B) of this section are exceeded. On a case-by-case review, the Director shall determine the balance between tree protection that exceeds the established minimum percentage and variations to site development requirements. If the Director grants adjustments or reductions to site development standards under this provision, then tree protection requirements shall be recorded on the face of the plat, as a notice to title, or on some other legal document that runs with the property. Adjustments that may be considered are:

1. Reductions or variations of the area, width, or composition of required open space and/or landscaping;
2. Variations in parking lot design and/or any access driveway requirements;
3. Variations in building setback requirements;
4. Variations of grading and stormwater requirements.

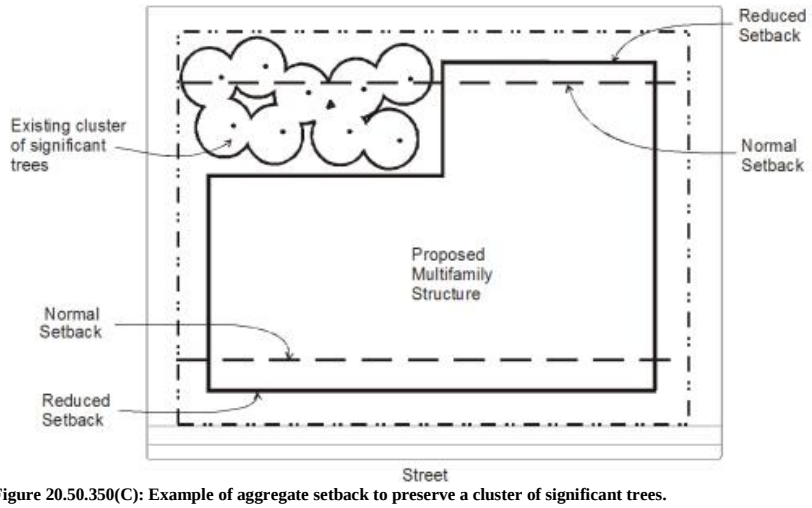


Figure 20.50.350(C): Example of aggregate setback to preserve a cluster of significant trees.

D. Site Design. Site improvements shall be designed and constructed to meet the following:

1. Trees should be protected within vegetated islands and stands rather than as individual, isolated trees scattered throughout the site.

2. Site improvements shall be designed to give priority to protection of trees with the following characteristics, functions, or location:

   - Existing stands of healthy trees that have a reasonable chance of survival once the site is developed, are well shaped to withstand the wind and maintain stability over the long term, and will not pose a threat to life or property.
   - Trees which exceed 50 feet in height.
   - Trees and tree clusters which form a continuous canopy.
   - Trees that create a distinctive skyline feature.
   - Trees that have a screening function or provide relief from glare, blight, commercial or industrial harshness.
   - Trees providing habitat value, particularly riparian habitat.
   - Trees within the required yard setbacks or around the perimeter of the proposed development.
   - Trees having a significant land stability function.
   - Trees adjacent to public parks, open space, and ~~sensitive~~ critical area buffers.
   - Trees having a significant water-retention function.

3. Building footprints, parking areas, roadways, utility corridors and other structures shall be designed and located with a consideration of tree protection opportunities.

4. The project grading plans shall accommodate existing trees and avoid alteration to grades around existing significant trees to be retained.

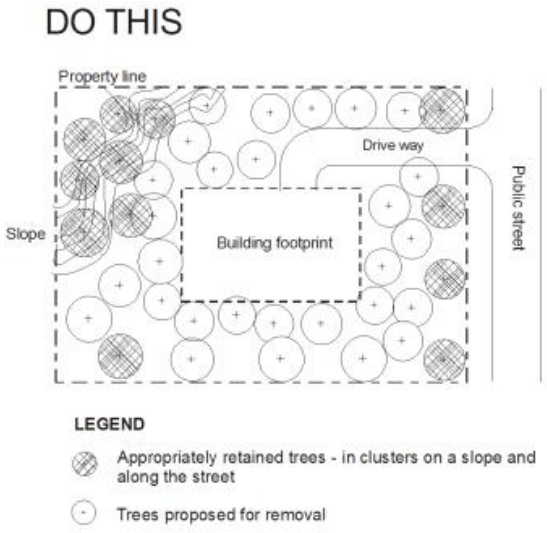
5. Required open space and recreational space shall be designed and located to protect existing stands of trees.

6. The site design and landscape plans shall provide suitable locations and adequate area for replacement trees as required in SMC 20.50.360.

7. In considering trees for protection, the applicant shall avoid selecting trees that may become hazardous because of wind gusts, including trees adjacent to utility corridors where falling trees may cause power outages or other damage. Remaining trees may be susceptible to blow downs because of loss of a buffer from other trees, grade changes affecting the tree health and stability and/or the presence of buildings in close proximity.

8. If significant trees have been removed from a closed, forested situation, an adequate buffer of smaller trees shall be retained or planted on the fringe of such significant trees as determined by a certified arborist.

9. All trees located outside of identified building footprints and driveways and at least 10 feet from proposed structures shall be considered as eligible for preservation. However, all significant trees on a site shall be considered when calculating the minimum retention percentage.



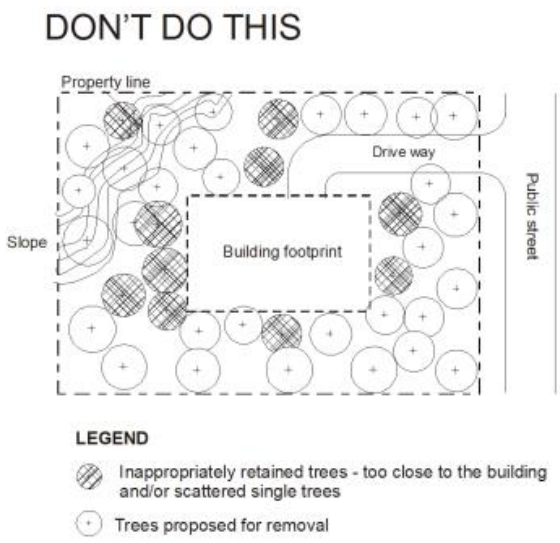


Figure 20.50.350(D): Example of the application of tree retention site design standards. Appropriate retention of a cluster of trees on a slope and frontage trees are shown above. Inappropriate retention of scattered single trees and trees near structures are shown below.

E. Cutting and Pruning of Protected Trees. Trees protected under the provisions of this section shall not be topped. Pruning and maintenance of protected trees shall be consistent with best management practices in the field of arboriculture, such as the American National Standard for Tree Care Operations – Tree, Shrub, and Other Wood Plant Maintenance- Standard Practices (ANSI A300) or similar, and further the long-term health of the tree. Excessive pruning, including topping, stripping, or imbalances, shall not be allowed unless necessary to protect life and property. Protected trees may be pruned to enhance views including methods such as windowing, interlimbing, or skirting up, when completed by a qualified professional arborist and consistent with best management practices.

F. Landmark Trees. Trees which have been designated as landmark trees by the City of Shoreline because they are 30 inches or larger in diameter or particularly impressive or unusual due to species, size, shape, age, historical significance and/or are an outstanding row or group of trees, have become a landmark to the City of Shoreline or are considered specimens of their species shall not be removed unless the applicant meets the exception requirements of subsection (B) of this section. The Director shall establish criteria and procedures for the designation of landmark trees. (Ord. 640 § 1 (Exh. A), 2012; Ord. 406 § 1, 2006; Ord. 398 § 1, 2006; Ord. 238 Ch. V § 5(G), 2000).

20.50.360 Tree replacement and site restoration.

A. Plans Required. Prior to any tree removal, the applicant shall demonstrate through a clearing and grading plan, tree retention and planting plan, landscape plan, critical area report ~~protection and~~ mitigation or restoration plans, or other plans acceptable to the Director that tree replacement will meet the minimum standards of this section. Plans shall be prepared by a qualified person or persons at the applicant's expense. Third party review of plans, if required, shall be at the applicant's expense.

B. The City may require the applicant to relocate or replace trees, shrubs, and ground covers, provide erosion control methods, hydroseed exposed slopes, or otherwise protect and restore the site as determined by the Director.

C. Replacement Required. Trees removed under the partial exemption in SMC 20.50.310(B)(1) may be removed

Comment [jn46]: Many jurisdictions in the region require compliance with this ANSI A300. The ISA also has guidelines they have developed for their members that are based on the ANSI standards. Both require organizational memberships to be able to access the specific standards so staff is recommending adding them as examples of best practices rather than requiring specific adherence to these standards.

Comment [jn47]: Proposed language to allow for pruning within critical areas for health of tree and to allow for view through the tree without excessive pruning or topping.

per parcel with no replacement of trees required. Any significant tree proposed for removal beyond this limit should be replaced as follows:

1. One existing significant tree of eight inches in diameter at breast height for conifers or 12 inches in diameter at breast height for all others equals one new tree.

2. Each additional three inches in diameter at breast height equals one additional new tree, up to three trees per significant tree removed.

3. Minimum size requirements for trees replaced under this provision: deciduous trees shall be at least 1.5 inches in caliper and evergreens six feet in height.

Exception 20.50.360(C):

1. No tree replacement is required when the tree is proposed for relocation to another suitable planting site; provided, that relocation complies with the standards of this section.

2. The Director may allow a reduction in the minimum replacement trees required or off-site planting of replacement trees if all of the following criteria are satisfied:

- *There are special circumstances related to the size, shape, topography, location or surroundings of the subject property.*
- *Strict compliance with the provisions of this Code may jeopardize reasonable use of property.*
- *Proposed vegetation removal, replacement, and any mitigation measures are consistent with the purpose and intent of the regulations.*
- *The granting of the exception or standard reduction will not be detrimental to the public welfare or injurious to other property in the vicinity.*

3. The Director may waive this provision for site restoration or enhancement projects conducted under an approved vegetation management plan.

D. The Director may require that a portion of the replacement trees be native species in order to restore or enhance the site to predevelopment character.

E. The condition of replacement trees shall meet or exceed current American Nursery and Landscape Association or equivalent organization's standards for nursery stock.

F. Replacement of removed trees with appropriate native trees at a ratio determined by the Director will be required in critical areas.

G. The Director may consider smaller-sized replacement plants if the applicant can demonstrate that smaller plants are more suited to the species, site conditions, and to the purposes of this subchapter, and are planted in sufficient quantities to meet the intent of this subchapter.

H. All required replacement trees and relocated trees shown on an approved permit shall be maintained in healthy condition by the property owner throughout the life of the project, unless otherwise approved by the Director in a subsequent permit.

I. Where development activity has occurred that does not comply with the requirements of this subchapter, the requirements of any other section of the Shoreline Development Code, or approved permit conditions, the Director may require the site to be restored to as near preproject original condition as possible. Such restoration shall be determined by the Director and may include, but shall not be limited to, the following:

1. Filling, stabilizing and landscaping with vegetation similar to that which was removed, cut or filled;

2. Planting and maintenance of trees of a size and number that will reasonably assure survival and that replace functions and values of removed trees; and

3. Reseeding and landscaping with vegetation similar to that which was removed, in areas without significant trees where bare ground exists.

J. Significant trees which would otherwise be retained, but which were unlawfully removed or damaged or destroyed through some fault of the applicant or their representatives shall be replaced in a manner determined by the Director.

K. **Performance Assurance.**

1. The Director may require a performance bond for tree replacement and site restoration permits to ensure the installation of replacement trees, and/or compliance with other landscaping requirements as identified on the approved site plans.

2. A maintenance bond shall be required after the installation of required site improvements and prior to the issuance of a certificate of occupancy or finalization of permit and following required landscape installation or tree replacement. The maintenance bond and associated agreement shall be in place to ensure adequate maintenance and protection of retained trees and site improvements. The maintenance bond shall be for an amount not to exceed the estimated cost of maintenance and protection measures for a minimum of 36 months or as determined by the Director.

3. The Director shall exempt individual single-family lots from a maintenance bond, except where a clearing violation has occurred or tree replacement is located within critical areas or critical area buffers.

L. **Monitoring.** The Director may require submittal of periodic monitoring reports as necessary to ensure survival of replacement trees. The contents of the monitoring report shall be determined by the Director.

M. **Discovery of Undocumented Critical Areas.** The Director may stop work authorized by a clearing and grading permit if previously undocumented critical areas are discovered on the site. The Director has the authority to require additional studies, plans and mitigations should previously undocumented critical areas be found on a site. (Ord. 640 § 1 (Exh. A), 2012; Ord. 406 § 1, 2006; Ord. 398 § 1, 2006; Ord. 299 § 1, 2002; Ord. 238 Ch. V § 5(H), 2000).

Chapter 20.80

Critical Areas

Sections:

Subchapter 1. Critical Areas – General Provisions

Comment [jn48]: Reorganized for clarity and consistency. Double strike through or double underlined show moved sections.

Subchapter 1.

Critical Areas – General Provisions

20.80.010 Purpose.

A. The purpose of this chapter is to establish supplemental standards for the protection of critical areas in compliance with the provisions of the Washington Growth Management Act of 1990 (Chapter 36.70A RCW) and consistent with the goals and policies of the Shoreline Comprehensive Plan in accordance with the procedures of Chapter 20.30 SMC.

B. By identifying and regulating development and alterations to critical areas and their buffers, it is the intent of this chapter to:

1. Protect the public from injury, loss of life, property damage or financial losses due to flooding, erosion, landslide, seismic events, or soils subsidence ~~or steep slope failure~~;

2. Protect unique, fragile and valuable elements of the environment;

3. Reduce cumulative adverse environmental impacts to water quality, wetlands, streams and other aquatic resources, fish and wildlife habitat, ~~steep slopes~~ landslide hazards and other geologically unstable features and prevent the overall net loss of the area, functions, and values of wetlands, streams and other fish and wildlife habitat areas and their buffers;

4. Ensure the long-term protection of ground and surface water quality;

5. Alert members of the public, including appraisers, assessors, owners, potential buyers, or lessees, to the development limitations of critical areas and their required buffers;

6. Serve as a basis for exercise of the City's substantive authority under the State Environmental Policy Act (SEPA) and the City's Environmental Procedures (Chapter 20.30 SMC, Subchapter 8); and comply with the requirements of the Growth Management Act (Chapter 36.70A RCW) and its implementing rules;

7. Establish standards and procedures that are intended to protect ~~environmentally~~ critical areas while accommodating the rights of property owners to use their property in a reasonable manner; and

8. Provide for the management of critical areas to maintain their functions and values and to restore degraded ecosystems. (Ord. 641 § 5 (Exh. A), 2012; Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(A), 2000).

C. This Chapter is to be administered with flexibility and attention to site-specific characteristics. It is not the intent of this Chapter to make a parcel of property unusable by denying its owner reasonable economic use of the property or to prevent the provision of public facilities and services necessary to support existing development and planned for by the community without decreasing current service levels below minimum standards.

20.80.02~~2~~15 Applicability.

A. Unless explicitly exempted, the provisions of this chapter shall apply to all lands, all land uses, development activity and all structures and facilities within all zoning designations in the City of Shoreline, whether or not a permit or authorization is required. All persons within the City shall comply with the requirements of this chapter.

B. The City shall not approve any permit or otherwise issue any authorization to alter the condition of any land, water or vegetation or to construct or alter any structure or improvement without first assuring compliance with the requirements of this chapter.

C. Approval of a permit or development proposal pursuant to the provisions of this chapter does not discharge the obligation of the applicant to comply with the provisions of this chapter.

Comment [jn49]: Subchapter reorganized to group related general provisions together for clarity and consistency.

Comment [jn50]: This reference indicates administrative procedures are in 20.30 rather than included specifically in the CAO. Authority is granted for all of Title 20 in Chapter 20.10.

Comment [jn51]: Identified as gap in existing critical area regulations. Required by the state to have goal of no net loss.

Comment [jn52]: Suggested provision from Commerce example code for direction on application/interpretation of the Chapter.

D. The provisions of this chapter shall apply to any forest practices over which the City has jurisdiction pursuant to Chapter 76.09 RCW and WAC Title 222. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(E), 2000. Formerly 20.80.050.).

20.80.045~~2~~0 Relationship to other regulations.

A. These critical area regulations shall apply as an overlay and in addition to zoning, land use, and other regulations established by the City of Shoreline. In the event of any conflict between these regulations and any other regulations of the City, the regulations which provide greater protection to the ~~environmentally~~ critical areas shall apply.

B. Areas characterized by particular critical areas may also be subject to other regulations established by this chapter due to the overlap or multiple functions of some critical areas. ~~Wetlands, for example, may be defined and regulated according to the provisions for fish and wildlife habitat conservation areas contained in this chapter, as well as provisions regulating wetlands.~~ In the event of any conflict between regulations for particular critical areas in this chapter, the regulations which provide greater protection to ~~environmentally~~ critical areas shall apply.

C. These critical areas regulations shall apply concurrently with review conducted under the State Environmental Policy Act (SEPA), as necessary and locally adopted.

D. Compliance with the provisions of this Chapter does not constitute compliance with other federal, state, and local regulations and permit requirements (for example, Shoreline Substantial Development Permits, Hydraulic Permit Act (HPA) permits, Section 106 of the National Historic Preservation Act, U.S. Army Corps of Engineers Section 404 permits, National Pollution Discharge Elimination System permits). The applicant is responsible for complying with these requirements, apart from the process established in this Chapter. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(K), 2000. Formerly 20.80.110.).

20.80.020~~5~~ Critical areas maps.

A. The approximate location and extent of identified critical areas within the City's planning area are shown on the critical areas maps adopted as part of this chapter, including but not limited to the maps identified in sections SMC 20.80.222, 20.80.272 and 20.80.322. These maps shall be used for informational purposes only to assist property owners and other interested parties. Boundaries and locations indicated on the maps are generalized. Critical areas and their buffers may occur within the City which have not previously been mapped.

B. The actual presence or absence, type, extent, boundaries, and classification of critical areas shall be identified in the field by a qualified professional, and determined by the City, according to the procedures, definitions and criteria established by this chapter. In the event of any conflict between the critical area location or designation shown on the City's maps and the criteria or standards of this chapter, the criteria and standards shall prevail.

C. The critical areas maps shall be periodically updated by the City and shall reflect any permit activity, results of special studies and reports reviewed and approved by the City, amendments to the Comprehensive Plan ~~Environmental~~ Natural Environment Element, and Department identified errors and corrections. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(D), 2000. Formerly 20.80.040.).

~~**20.80.025 Applicability.**~~

~~A. Unless explicitly exempted, the provisions of this chapter shall apply to all land uses and within all zoning designations in the City of Shoreline. All persons within the City shall comply with the requirements of this chapter.~~

~~B. The City shall not approve any permit or otherwise issue any authorization to alter the condition of any land, water or vegetation or to construct or alter any structure or improvement without first assuring compliance with the requirements of this chapter.~~

~~C. Approval of a development proposal pursuant to the provisions of this chapter does not discharge the obligation~~

Comment [jn53]: Moved. Formerly 20.80.045. Provisions for concurrency with SEPA and compliance with other regulations added based on Commerce example code for clarity.

Comment [jn54]: Added reference to new mapping sections and corrected Comprehensive Plan element reference. Section number changed for reorganization.

Comment [jn55]: Moved to 20.80.015.

~~of the applicant to comply with the provisions of this chapter.~~

~~D. The provisions of this chapter shall apply to any forest practices over which the City has jurisdiction pursuant to Chapter 76.09 RCW and WAC Title 222. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(E), 2000. Formerly 20.80.050.).~~

20.80.030 Exemptions.

Notwithstanding the exemptions provided by this section, any otherwise exempt activities occurring in or near a critical area or critical area buffer shall meet the purpose and intent of SMC 20.80.010 and shall consider on-site alternatives that avoid or minimize impacts. To be exempt from this Chapter does not give permission to degrade a critical area or ignore risk from natural hazards. Any incidental damage to, or alteration of, a critical area that is not a necessary outcome of the exempted activity shall be restored, rehabilitated, or replaced at the responsible party's expense. The following activities shall be exempt from the provisions of this chapter, but are not exempt from applicable permits:

Comment [jn56]: Moved from former subsection N below and additional language added based on Commerce example code. Applies to all exemptions of this section.

Comment [jn57]: Clarification to reduce confusion.

A. **Emergencies.** Alterations in response to emergencies which threaten the public health, safety and welfare or which pose an imminent risk of damage to private property as long as any alteration undertaken pursuant to this subsection is reported to the City as soon as possible. Only the minimum intervention necessary to reduce the risk to public health, safety, or welfare and/or the imminent risk of damage to private property shall be authorized by this exemption. The City shall confirm that an emergency exists and determine what, if any, additional applications and/or measures shall be required to protect the environment consistent with the provisions of this chapter, and to repair any damage to a preexisting resource. If the Director determines that the action taken, or any part of the action taken, was beyond the scope of an allowed emergency action, then enforcement provisions of SMC 20.80.130 Unauthorized critical area alterations and enforcement shall apply.

After the emergency, the person or agency undertaking the action shall fully fund and conduct necessary restoration and other mitigation for any impacts to the critical area and buffers resulting from the emergency action in accordance with an approved critical area report and restoration/mitigation plan. The person or agency undertaking the action shall apply for review, and the alteration, critical area report, and mitigation plan shall be reviewed by the City in accordance with the review procedures contained herein. Mitigation activities must be initiated under permit within one (1) year of the date of the emergency;

Comment [jn58]: This is currently policy but not explicitly included in current code. Language from Commerce example code. Restoration is one type of mitigation. Mitigation

B. **Utility Operation, Maintenance, Repair, or Replacement.** Public water, electric and natural gas distribution, public sewer collection, cable communications, telephone, utility and related activities undertaken pursuant to City-approved best management practices, and best available science with regard to protection of threatened and endangered species, as follows:

1. Normal and routine maintenance or repair of existing utility structures or rights-of-way;

2. Relocation of electric facilities, lines, equipment or appurtenances, not including substations, with an associated voltage of 55,000 volts or less, only when required by the City of Shoreline, which approves the new location of the facilities;

3. Replacement, operation, repair, modification or installation or construction in an improved City road right-of-way or City-authorized private roadway of all electric facilities, lines, equipment or appurtenances, not including substations, with an associated voltage of 55,000 volts or less;

4. Relocation of public sewer local collection, public water local distribution, natural gas, cable communication or telephone facilities, lines, pipes, mains, equipment or appurtenances, only when required by the City of Shoreline, which approves the new location of the facilities; ~~and~~

5. Replacement, operation, repair, modification, relocation, installation or construction of public sewer local collection, public water local distribution, natural gas, cable communication or telephone facilities, lines, pipes, mains, equipment or appurtenances when such facilities are located within an improved public right-of-way or City-authorized private roadway; and

6. Repair and maintenance of existing private connections to public utilities and private stormwater management facilities consistent with best practices. Revegetation of disturbed areas is required to be native vegetation, unless the existing, non-native vegetation is re-established with no change to type or extent.

Comment [jn59]: Provision added to facilitate repair and maintenance of existing private utility connections and facilities that are located within critical areas or critical area buffers.

C. **Roadway Operation, Maintenance, Repair, or Replacement.** Maintenance, operation, repair, modification or replacement of publicly improved roadways or City authorized private roadway, and associated stormwater drainage systems as long as any such alteration does not involve the expansion of roadways or related improvements into previously unimproved rights-of-way or portions of rights-of-way and does not alter a wetland or watercourse, such as culverts or bridges, or result in the transport of sediment or increased stormwater. Retention and replanting of native vegetation shall occur wherever possible along the right-of-way improvement and resulting disturbance;

Comment [jn60]: Updated for consistency with best practices and Commerce example code.

D. **Recreation Areas Operation, Maintenance, Repair, or Replacement.** Maintenance, operation, ~~or~~ repair, modification, or replacement of exiting publicly improved recreation areas as long as any such activity does not involve the expansion ~~of uses and/or~~ facilities and existing improvements into a previously unimproved portion of ~~a preexisting area~~ critical areas or required buffers. Maintenance, operation, ~~and~~ repair, modification, and replacement of publicly improved recreation areas within designated fish and wildlife habitat areas shall be permitted if all activities are performed consistent with the development standards of this chapter, best available science or adaptive management plans as recognized by the City. Retention and replanting of native vegetation shall occur wherever possible along the right-of-way improvement and resulting disturbance;

Comment [jn61]: Section revised at request of parks department to include modification and replacement similar to utilities and right-of-way exemptions above.

~~E. Activities affecting isolated Type IV wetlands which are individually smaller than 1,000 square feet;~~

~~F. Activities occurring in areas which may be considered small steep slopes (areas of 40 percent slope or greater with a vertical elevation change of up to, but not greater than 20 feet), such as berms, retaining walls, excavations and small natural slopes, and activities on steep slopes created through prior legal grading activity may be exempted based upon City review of a soils report prepared by a qualified geologist or geotechnical engineer which demonstrates that no adverse impact will result from the exemption;~~

Comment [jn62]: Provision is not consistent with BAS and confusing because these slopes allow alteration similar to Moderate to High Risk Landslide Hazard areas. Exemption still requires critical area report. Replaced with revision to classifications of landslide hazard areas in SMC 20.80.220(B)

~~G~~E. **Minor Conservation and Enhancement.** Minor conservation and enhancement of critical areas that does not alter the location, dimensions or size of the critical area or buffer, and results in improvement of the critical area functions, including the following invasive species removal activities:

1. Within City-owned property, removal of noxious weeds or invasive vegetation as identified by the Washington State or King County Noxious Weed Control Boards in a wetland buffer, ~~stream~~ a fish and wildlife habitat conservation area or its buffer or a geologic hazard area (excluding very high risk landslide hazard areas and their buffers), or the area within a three-foot radius of a tree ~~on a steep slope~~ in a very high risk landslide hazard area and buffer is allowed when:

   a. Undertaken with hand labor, including handheld mechanical tools, unless the Washington State or King County Noxious Weed Control Boards otherwise prescribes the use of riding mowers, light mechanical cultivating equipment, herbicides or biological control methods; ~~and~~

   b. Performed in accordance with SMC 20.80.085, Pesticides, herbicides and fertilizers on City-owned property, and King County best management practices for noxious weeds and invasive vegetation; ~~and~~

   c. The cleared area is revegetated with native vegetation and stabilized against erosion in accordance with the ~~Department of Ecology 2005~~ adopted Stormwater ~~Management~~ Manual ~~for Western Washington; and~~

   d. All work is performed above the ordinary high water mark and above the top of a stream bank; and

   e. No more than 3,000 square feet of soil may be exposed at any one time~~s~~; or

2. Within private property, removal of noxious weeds or invasive vegetation as identified by the

Comment [jn63]: Moved from SMC 20.50.310(A)(6). Replaced with cross reference for exemption of these activities from site development or clearing and grading permit requirements.

Washington State or King County Noxious Weed Control Boards in a wetland buffer, a fish and wildlife habitat conservation area or its buffer or a geologic hazard area (excluding very high risk landslide hazard areas and their buffers), or the area within a three-foot radius of a tree in a very high risk landslide hazard area and buffer is allowed when:

a. Undertaken with hand labor, including hand-held mechanically tools, unless the Washington State or King County Noxious Weed Control Board otherwise prescribe the use of riding mowers, light mechanical cultivating equipment, herbicides, or biological control methods with permit approval from the City for the alternate treatment methods;

b. Not more than 500 square feet of area may be cleared, as calculated cumulatively over one (1) year, on private property without a permit and critical area report prepared by a qualified professional;

c. All removed plant material shall be taken away from the site and disposed of appropriately;

d. Plants that appear on the Washington State Noxious Weed Control Board list of noxious weeds or the King County Noxious Weed List must be handled and disposed of according to best practices appropriate to that species and approved by the City when permit review is applicable; and

f. Revegetation with appropriate native species at natural densities is required in conjunction with removal of invasive plant species and stabilized against erosion in accordance with the adopted Stormwater Manual; or

3. Vegetation management consistent with a previously approved critical area mitigation, restoration, remediation, or enhancement plan that requires ongoing maintenance and vegetation management beyond final inspection and the required monitoring period for the permitted project;

~~H~~F. **Active Hazard Trees.** Removal of active or imminent hazardous trees in accordance with SMC 20.50.310(A)(1)(c);

~~I~~G. **Nonimminent Hazard Trees.** Removal of not active or imminent hazardous trees in accordance with the following:

1. For hazardous circumstances that are not active or imminent, such as suspected tree rot or diseased trees or less obvious structural wind damage to limbs or trunks, a permit exemption request form must be submitted by the property owner together with a ~~risk assessment~~ tree evaluation form prepared by a qualified professional arborist as defined in SMC 20.20.042. Both the permit exemption request form and ~~risk assessment~~ tree evaluation form shall be provided by the Director;

2. The permit exemption request form shall include a grant of permission for the Director and/or ~~his~~ qualified professionals under contract with the City to enter the subject property to evaluate the circumstances. Attached to the permit exemption request form shall be a risk assessment form that documents the hazard and which must be signed by a certified arborist or professional forester;

3. No permit exemption request shall be approved until the Director reviews the submitted forms and conducts a site visit. The Director may ~~direct that a peer review~~ require third party review of the request be performed by a qualified professional under contract with the City at the applicant's ~~cost~~ expense, and may require that the subject tree(s) and vegetation be cordoned off with yellow warning tape during the review of the request for exemption;

4. Approval to cut or clear trees may only be given upon recommendation of the ~~City approved~~ qualified professional arborist that the condition constitutes an actual threat to life or property in homes, private yards, buildings, public or private streets and driveways, sidewalks, improved utility corridors, or access for emergency vehicles and any trail as proposed by the property owner and approved by the Director for purposes of this section;

5. The Director shall authorize only such alteration to existing trees and vegetation as may be necessary to

eliminate the hazard and shall condition authorization on means and methods of removal necessary to minimize environmental impacts, including replacement of any significant trees. The arborist shall include an assessment of whether a portion of the tree suitable for a snag for wildlife habitat may safely be retained. All work shall be done utilizing hand-held implements only, unless the property owner requests and the Director approves otherwise in writing. The Director may require that all or a portion of cut materials be left on site;

6. The trees shall be replaced within one year consistent with the provisions of SMC 20.50.360. Where nonsignificant trees are approved for removal as hazardous, replacement shall be one tree for each tree removed. Replacement tree may be planted at a different, nearby location if it can be determined that the planting in the same location would create a new hazard or potentially damage the critical area; and

7. If a tree to be removed provides priority habitat, such as an eagle perch, a qualified professional shall be consulted to determine timing and methods of removal that will minimize and mitigate impacts.

~~J~~H. **Site Investigation.** Site investigative work and studies necessary for preparing land use applications, including soils tests, water quality studies, wildlife studies and similar tests and investigations; provided, that any disturbance of the critical area shall be the minimum necessary to carry out the work or studies;

~~K~~I. **Passive Outdoor Activities.** When it can be demonstrated that there will be no undue adverse effect, the following activities may be allowed within critical areas and their buffers: educational activities, scientific research, and outdoor recreational activities, including but not limited to interpretive field trips, bird watching, public beach access including water recreation-related activities, bicycling and hiking, that will not have an undue adverse effect on the critical area;

~~L~~J. **Normal Maintenance.** Normal and routine maintenance and operation of existing landscaping and gardens~~, provided they comply with all other regulations in this chapter~~ including pruning, beneficial to the tree, of protected trees consistent with SMC 20.50.350(E);

~~M~~K. **Minor Activities.** Minor activities not mentioned above and determined by the City to have minimal impacts to a critical area;

~~N. Notwithstanding the exemptions provided by this section, any otherwise exempt activities occurring in or near a critical area should meet the purpose and intent of SMC 20.80.010 and should consider on-site alternatives that avoid or minimize impacts;~~ and

~~O~~L. **Utility Mitigation Projects.** Mitigation projects related to utilities construction in critical areas or their buffers. (Ord. 640 § 1 (Exh. A), 2012; Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(G), 2000. Formerly 20.80.070.).

20.80.040 ~~Partial exemptions~~Allowed activities.

A. ~~The following are exempt from the provisions of this chapter except for the notice to title provisions and the flood hazard area provisions, if applicable.~~ **Critical Area Report.** Activities allowed under this section shall have been reviewed and permitted or approved by the City/county or other agency with jurisdiction, but do not require submittal of a separate critical area report, unless such submittal was required previously for the underlying permit. The Director may apply conditions to the underlying permit or approval to ensure that the allowed activity is consistent with the provisions of this Chapter to protect critical areas.

B. **Best Management Practices.** All allowed activities shall be conducted using the best management practices that result in the least amount of impact to the critical areas. Best management practices shall be used for tree and vegetation protection, construction management, erosion and sedimentation control, water quality protection, and regulation of chemical applications. The City shall observe the use of best management practices to ensure that the activity does not result in degradation to the critical area. Any incidental damage to, or alteration of, a critical area shall be restored, rehabilitated, or replaced at the responsible party's expense.

C. **Allowed Activities.** The following activities are allowed:

Comment [jn64]: Provisions 6 and 7 recommended to offset cumulative adverse impacts to critical areas consistent with BAS, while still allowing for removal of hazardous trees without extensive permitting and critical area report requirements. The language proposed is modified from City of Edmonds code.

Comment [jn65]: Applies to all exemptions so moved to beginning of 20.80.030.

1. **Modifications to Existing Structures within Critical Areas.** Structural modification of, addition to, maintenance, repair, or replacement of legally nonconforming structures consistent with SMC 20.30.280~~, except single detached residences, in existence before November 27, 1990~~, which do not meet the building setback or buffer requirements for wetlands, ~~streams~~ fish and wildlife habitat conservation areas, or ~~steep slope~~ geologic hazard areas if the modification, addition, replacement or related activity does not increase the existing building height, footprint of the structure, or area of hardscape lying within the ~~above-described building setback area, sensitive~~ critical area or buffer. Where nonconforming structures that are partially located within critical areas or their buffers additions are allowed with a critical area report delineating the critical area(s) and required buffers showing that the addition is located entirely outside the critical area or buffer;

~~2. Structural modification of, addition to, or replacement of single detached residences in existence before November 27, 1990, which do not meet the building setback or buffer requirements for wetlands, streams or steep slope hazard areas if the modification, addition, replacement or related activity does not increase the existing footprint of the residence lying within the above-described buffer or building setback area by more than 750 square feet over that existing before November 27, 1990, and no portion of the modification, addition or replacement is located closer to the critical area or, if the existing residence is within the critical area, extend farther into the critical area; and~~

~~3. Maintenance or repair of structures which do not meet the development standards of this chapter for landslide or seismic areas if the maintenance or repair does not increase the footprint of the structure and there is no increased risk to life or property as a result of the proposed maintenance or repair.~~

2. **Demolition.** Demolition of structures located within critical areas or their buffers subject to approval of a stormwater pollution prevention plan consistent with the adopted stormwater manual and clearing limits that will adequately protect the critical area.

~~B~~3. **Permit Requests Subsequent to Previous Critical Area Review.** A permit or approval sought as part of a development proposal for which multiple permits are required is exempt from the provisions of this chapter, except for the notice to title provisions, as applicable if:

~~1~~a. The City of Shoreline has previously reviewed all critical areas on the site; and

~~2~~b. There is no material change in the development proposal since the prior review; and

~~3~~c. There is no new information available which may alter previous critical area review of the site or a particular critical area; and

~~4~~d. The permit or approval under which the prior review was conducted has not expired or, if no expiration date, no more than five years have lapsed since the issuance of that permit or approval; and

~~5~~e. The prior permit or approval, including any conditions, has been complied with. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(H), 2000. Formerly 20.80.080.).

20.80.045 Critical areas preapplication meeting.

A. A preapplication meeting, pursuant to SMC 20.30.080, is required prior to submitting an application for development or use of land or prior to starting a development activity or use of the land that may be regulated by the provisions of this Chapter unless specifically exempted in SMC 20.80.030.

B. A determination may be provided through the preapplication meeting regarding whether critical area reports are required, and if so what level of detail and what elements may be necessary for the proposed project. This determination does not preclude the Director from requiring additional critical area report information during the review of the project. After a site visit and review of available information for the preapplication meeting the Director may determine:

Comment [jn66]: Section added to support and clarify the existing requirement in SMC 20.30.080 for preapplication meetings when a critical area might be impacted.

Comment [jn67]: This section is added based on Commerce example code as means for applicant to find out what the critical area report requirements for a project would be. Intended to support the new provisions in 20.80.080. Other jurisdictions have a preliminary Critical Area Identification process required prior to any development permits. These provisions come from that process, without requiring an additional review/approval process.

1. **No Critical Areas Present.** If the Director's analysis indicates that the project area is not within or adjacent to a critical area or buffer and that the proposed activity is unlikely to degrade the functions or values of a critical area, then the Director shall determine that the critical area review is complete and note in the preapplication meeting summary letter the reasons that no further review is required.

2. **Critical Areas Present, But No Impact.** If the Director determines that there are critical areas within or adjacent to the project area, but that the best available science shows that the proposed activity is unlikely to degrade the functions or values of the critical area, the Director may waive the requirement for a critical area report. A waiver may be granted if there is substantial evidence that all of the following requirements will be met:

   a. There will be no alteration of the critical area or buffer;

   b. The development proposal will not impact the critical area in a manner contrary to the purpose, intent, and requirements of this Chapter; and

   c. The proposal is consistent with other applicable regulations and standards.

   A summary of this analysis and the findings shall be included in the preapplication meeting summary letter and any staff report or decision on the underlying permit.

3. **Critical Areas May Be Affected by Proposal.** If the Director determines that a critical area or areas may be affected by the proposal, then the Director shall notify the applicant that a critical area report(s) must be submitted prior to further review of the project, and indicate each of the critical area types that should be addressed in the report. Additionally, the Director may indicate the sections or report types that must be included in the critical report(s) consistent with SMC 20.80.080.

20.80.07~~5~~0 Alteration of critical areas.

A. Critical areas shall be maintained in their natural state or current legally established condition, including undisturbed, native vegetation to maintain the functions, values, resources, and public health and safety for which they are protected. Alteration of critical areas, including their established buffers, may only be permitted subject to the criteria and standards in this chapter, and compliance with any Federal and/or State permits required. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(A), 2000. Formerly 20.80.160.).

~~**20.80.080 Alteration or development of critical areas - Standards and criteria.**~~

B. This section applies to mitigation required with all critical areas reviews, approvals, and enforcement pursuant to this ~~c~~Chapter. This section is supplemented with specific measures under subchapters for particular critical areas. Mitigation for specific development proposals may include a combination of the measures below. The ~~proponent~~ applicant for a project involving critical areas shall avoid, minimize and mitigate the impacts to the critical areas through actions that occur in the following priority sequence:

   ~~A~~1. Avoiding the impact altogether by not taking a certain action or parts of actions;

   ~~B~~2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation;

   ~~C~~3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

   ~~D~~4. Reducing or eliminating the impact over time through preservation and maintenance operations during the life of the action;

   ~~E~~5. Compensating for the impact by replacing or providing substitute resources or environments; and/or

   ~~F~~6. Monitoring, measuring and reporting the impact to the ~~Planning~~ Director and taking appropriate corrective measures. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(B), 2000. Formerly 20.80.170.).

20.80.060 Best available science.

Comment [jn68]: New section. Incorporation of best available science required in both formulation of regulations and in review of specific proposals. Inclusion of code language articulating requirements for demonstrating best available science is used strengthens reliability of critical area reports and clarity of what meets requirements for BAS incorporation. Proposed code is slightly modified from Commerce example code.

Language regarding special consideration to anadromous fish is a state mandate and is required in consideration of best available science for any critical area type.

A. **Protect Functions and Values of Critical Areas With Special Consideration to Anadromous Fish.** Critical area reports and decisions to alter critical areas shall rely on the best available science to protect the functions and values of critical areas and required buffers and must give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fish, such as salmon and bull trout, and their habitat, where applicable.

B. **Best Available Science to be Consistent With Criteria.** The best available science is that scientific information, obtained through a valid scientific process, that is applicable to the critical area prepared by local, state, or federal natural resource agencies, a qualified scientific professional, or team of qualified scientific professionals that is consistent with criteria established in WAC 365-195-900 through WAC 365-195-925 and RCW 36.70A.172.

C. **Characteristics of a Valid Scientific Process.** In the context of critical areas protection, a valid scientific process is one that produces reliable information useful in understanding the consequences of a local government's regulatory decisions, and in developing critical areas policies and development regulations that will be effective in protecting the functions and values of critical areas and buffers. To determine whether information received during the permit review process is reliable scientific information, the Director shall determine whether the source of the information displays the characteristics of a valid scientific process. Such characteristics are as follows:

1. **Peer Review.** The information has been critically reviewed by other persons who are qualified scientific experts in that scientific discipline. The proponents of the information have addressed the criticism of the peer reviewers. Publication in a refereed scientific journal usually indicates that the information has been appropriately peer-reviewed;

2. **Methods.** The methods used to obtain the information are clearly stated and reproducible. The methods are standardized in the pertinent scientific discipline or, if not, the methods have been appropriately peer-reviewed to ensure their reliability and validity;

3. **Logical Conclusions and Reasonable Inferences.** The conclusions presented are based on reasonable assumptions supported by other studies and consistent with the general theory underlying the assumptions. The conclusions are logically and reasonably derived from the assumptions and supported by the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained;

4. **Quantitative Analysis.** The data have been analyzed using appropriate statistical or quantitative methods;

5. **Context.** The information is placed in proper context. The assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge; and

6. **References.** The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information.

D. **Nonscientific Information.** Nonscientific information, such as anecdotal observations, non-expert opinion, and hearsay, may supplement scientific information, but it is not an adequate substitute for valid and available scientific information.

E. **Absence of Valid Scientific Information.** Where there is an absence of valid scientific information or incomplete scientific information relating to a critical area leading to uncertainty about the risk to critical area function of permitting an alteration of or impact to the critical area, the Director shall:

1. Take a "precautionary or a no-risk approach," that strictly limits development and land use activities until

the uncertainty is sufficiently resolved; and

2. Require application of an effective adaptive management program that relies on scientific methods to evaluate how well regulatory and nonregulatory actions protect the critical area. An adaptive management program is a formal and deliberate scientific approach to taking action and obtaining information in the face of uncertainty. An adaptive management program shall:

a. Include secure funding for the research component of the adaptive management program;

b. Change course based on the results and interpretation of new information that resolves uncertainties; and

c. Commit to the appropriate timeframe and scale necessary to reliably evaluate regulatory and nonregulatory actions affecting protection of critical areas and anadromous fisheries.

20.80.~~1~~070 Classification and rating of critical areas.

Comment [jn69]: Moved. Formerly 20.80.100.

To promote consistent application of the standards and requirements of this chapter, critical areas within the City of Shoreline shall be rated or classified according to their characteristics, function and value, and/or their sensitivity to disturbance. Classification of critical areas shall be determined by the City using the following tools:

A. Application of the criteria contained in these regulations;

B. Consideration of the ~~technical~~ critical area reports submitted by qualified professionals in connection with applications subject to these regulations; and

C. Review of maps adopted pursuant to this chapter. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(E), 2000. Formerly 20.80.200.).

20.80.~~1~~080 Critical areas reports ~~required~~ - Requirements.

A. If uses, activities, or developments are proposed within, adjacent to, or are likely to impact critical areas or their buffers, an applicant shall provide site-specific ~~information and analysis~~ critical area report(s) as determined by the City. Critical area reports for two or more types of critical areas must meet the report requirements for each type of critical area. The expense of preparing the critical area report(s) shall be borne by the applicant. ~~The site-specific information must be obtained by expert investigation and analysis.~~ This provision is not intended to expand or limit an applicant's other obligations under WAC 197-11-100. ~~Such site-specific reviews shall be performed by qualified professionals, as defined by SMC 20.20.042, who are approved by the City or under contract to the City.~~

B. **Preparation by Qualified Professional.** Critical area report(s) shall be prepared by qualified professional(s) as defined in SMC 20.20.042, with the required training and experience specific to the type(s) of critical area(s) present consistent with the requirements of SMC 20.80.240, 20.80.290, and 20.80.340. Proof of licensing, credentials, and resume of the qualified professional(s) preparing the report must be submitted for review by the City to determine if the minimum qualifications are met.

C. **Third Party Review of Critical Area Reports.** Review of required critical area reports by a qualified professional under contract with or employed by the City will be required by the Director, at the applicant's expense, in any of the following circumstances:

1. The project requires a critical area reasonable use permit, critical area special use permit, or shoreline variance application; or

2. Third party review is specifically required by the provisions of this chapter for the critical area(s) or critical area buffer(s) potentially being impacted; or

3. When the Director determines such services are necessary to demonstrate compliance with the standards

and guidelines of this Chapter.

D. **Best Available Science.** Critical area reports shall use standards for best available science in SMC 20.80.060. The critical areas report shall evaluate the proposal and all probable impacts to critical areas in accordance with the provisions of this Chapter.

E. **Critical Area Report Types or Sections.** Critical area reports may be met in stages through multiple reports or combined in one report. A critical are report may include one or more of the following sections or report types depending on the information required by the director and the extent of the potential critical area impacts. The scope and location of the proposed project will determine which report(s) alone or combined are sufficient to meet the critical area report requirements for the impacted critical area type(s). The typical sequence of potentially required sections or reports that may in part or in combination fulfill the requirements of this section include:

1. **Reconnaissance.** Reconnaissance or identification report documenting the existence, general location, and type of critical areas in the vicinity (within 300 feet for wetlands and fish and wildlife habitat conservation areas and within 200 feet for geologic hazards, shorelines, flood plains, and aquifer recharge areas) of a project site;

2. **Delineation.** Delineation or mapping report documenting the extent, boundaries, rating or classification, and applicable standard buffers of critical areas where the project area could potentially impact the critical area or its buffer including an assessment of the characteristics of or functions and values of the critical area and buffers identified;

3. **Analysis.** Analysis of the proposal and impact assessment report documenting the potential project impacts to the critical area and buffers including a discussion of the efforts taken to avoid, minimize, or reduce potential impacts to those areas;

4. **Mitigation or Restoration.** Mitigation plan or report documenting the potential impacts and mitigation measures designed to meet the requirements of this Chapter in SMC 20.80. 082 Mitigation plan requirements and for the specific critical areas impacted, including but not limited to adjustments to required buffer sizes, best practices to minimize impacts, and critical area or buffer enhancement, restoration, or preservation plans. Mitigation plans may be called restoration plans if they are used to remediate violations or to voluntarily restore critical areas and buffers legally altered or impacted due to proximity to development, but the restoration is not required for a proposed development project; and

5. **Maintenance and Monitoring.** Maintenance, monitoring, and contingency plan documenting the goals of the mitigation proposed, performance standards for success, monitoring methods and reporting schedule, maintenance methods and schedule, and contingency actions.

F. **Minimum Report Contents.** At a minimum critical area reports shall contain the following:

1. The name and contact information of the applicant, a description of the proposal, and identification of the permit requested;

2. A copy of the site plan for the development proposal including:

   a. A map to scale depicting critical areas, buffers, the development proposal, and any areas to be altered; and

   b. A description of the proposed stormwater pollution prevention plan for the development and consideration of impacts to drainage alterations;

3. The dates, names, and qualifications of the qualified professional(s) preparing the report and documentation of any fieldwork performed on the site;

4. Identification and characterization of all critical areas, wetlands, water bodies, shorelines, and buffers within the vicinity of the proposed project area (within 300 feet for wetlands and fish and wildlife habitat conservation areas and within 200 feet for geologic hazards, shorelines, flood plains, and aquifer recharge areas);

5. A statement specifying the accuracy of the report and all assumptions made and relied upon;

6. A description of the methodologies used to conduct the critical areas investigation, including references;

7. An assessment of the probable impacts to the critical areas resulting from the proposed development of the site;

8. A description of reasonable efforts made to apply mitigation sequencing pursuant to SMC 20.80.050, Alteration of critical areas, to avoid, minimize, and mitigate impacts to critical areas;

9. Plans for adequate mitigation, as needed and allowed, to offset any critical areas impacts, in accordance with subsection J below and the corresponding mitigation sections of this Chapter and including a discussion of the applicable development standards and cost estimates for determination of financial guarantee requirements.

10. Report requirements specific to each critical area type as indicated in the corresponding sections of this Chapter;

G. **Existing reports.** Unless otherwise provided, a critical areas report may incorporate, be supplemented by or composed, in whole or in part, of any reports or studies required by other laws and regulations or previously prepared for and applicable to the development proposal site, as approved by the director. At the discretion of the director, reports previously compiled or submitted as part of a proposal for development may be used as a critical areas report to the extent that the requirements of this section and the report requirements for each specific critical area type are met. Critical areas reports shall be considered valid for five years; after such date the city shall determine whether a revision or additional assessment is necessary.

I. **Modifications to report requirements.**

1. **Limitations to Study Area.** The director may limit the required geographic area of the critical areas report as appropriate if:

   a. The applicant, with assistance from the city of Shoreline, cannot obtain permission to access properties adjacent to the project area; or

   b. The proposed activity will affect only a limited part of the subject site.

2. **Modifications to Required Contents.** The applicant may consult with the Director prior to or during preparation of the critical areas report to obtain approval of modifications to the required contents of the report where, in the judgment of a qualified professional, more or less information is required to adequately address the potential critical area impacts and required mitigation.

3. **Additional Information Requirements.** The Director may require additional information to be included in the critical areas report when determined to be necessary to the review of the proposed activity in accordance with this title. Additional information that may be required includes, but is not limited to:

   a. Historical data, including original and subsequent mapping, aerial photographs, data compilations and summaries, and available reports and records relating to the site or past operations at the site;

   b. Grading and drainage plans; and

   c. Information specific to the type, location, and nature of the critical area. (Ord. 581 § 1 (Exh. 1),

2010; Ord. 515 § 1, 2008; Ord. 406 § 1, 2006; Ord. 398 § 1, 2006).

20.80.082 Mitigation plan requirements.

When mitigation is required, the applicant shall submit for approval by the City a mitigation plan as part of the critical area report. The mitigation plan shall include:

A. **Environmental Goals and Objectives.** The mitigation plan shall include a written report identifying environmental goals and objectives of the compensation proposed and including:

1. A description of the anticipated impacts to the critical areas and the mitigating actions proposed and the purposes of the compensation measures, including the site selection criteria; identification of compensation goals; identification of resource functions; and dates for beginning and completion of site compensation construction activities. The goals and objectives shall be related to the functions and values of the impacted critical area;

2. A review of the best available science supporting the proposed mitigation and a description of the report author's experience to date in restoring or creating the type of critical area proposed.

B. **Performance Standards.** The mitigation plan shall include measurable specific criteria for evaluating whether or not the goals and objectives of the mitigation project have been successfully attained at the end of the required monitoring period and whether or not the requirements of this Chapter have been met.

C. **Detailed Construction Plans.** The mitigation plan shall include written specifications and descriptions of the mitigation proposed, such as:

1. The proposed construction sequence, timing, and duration;

2. Grading and excavation details;

3. Erosion and sediment control features;

4. A planting plan specifying plant species, quantities, locations, size, spacing, and density; and

5. Measures to protect and maintain plants until established.

These written specifications shall be accompanied by detailed site diagrams, scaled cross-sectional drawings, topographic maps showing slope percentage and final grade elevations, and any other drawings appropriate to show construction techniques or anticipated final outcome.

D. **Monitoring Program.** The mitigation plan shall include a program for monitoring construction of the mitigation project and for assessing a completed project. A protocol shall be included outlining the schedule for site monitoring (for example, monitoring shall occur in years 1, 3, 5, and 7 after site construction), and how the monitoring data will be evaluated to determine if the performance standards are being met. A monitoring report shall be submitted as needed to document milestones, successes, problems, and contingency actions of the mitigation project. The mitigation project shall be monitored for a period necessary to establish that performance standards have been met, but not for a period less than five (5) years.

E. **Contingency Plan.** The mitigation plan shall include identification of potential courses of action, and any corrective measures to be taken if monitoring or evaluation indicates project performance standards are not being met.

F. **Cost Estimates.** The mitigation plan shall include cost estimates that will be used by the City to calculate the amounts of financial guarantees, if necessary, to ensure that the mitigation plan is fully implemented. Financial guarantees ensuring fulfillment of the compensation project, monitoring program, and any contingency measures shall be posted in accordance with SMC 20.80.120 Financial guarantee requirements.

20.80.045 Relationship to other regulations.

Comment [jn70]: Moved to 20.80.020.

A. These critical area regulations shall apply as an overlay and in addition to zoning, land use and other regulations established by the City of Shoreline. In the event of any conflict between these regulations and any other regulations of the City, the regulations which provide greater protection to the environmentally critical areas shall apply.

B. Areas characterized by particular critical areas may also be subject to other regulations established by this chapter due to the overlap or multiple functions of some critical areas. Wetlands, for example, may be defined and regulated according to the provisions for fish and wildlife habitat conservation areas contained in this chapter, as well as provisions regulating wetlands. In the event of any conflict between regulations for particular critical areas in this chapter, the regulations which provide greater protection to environmentally critical areas shall apply. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(K), 2000. Formerly 20.80.110.).

20.80.050 Notice to title.

Comment [jn71]: Revision based on commerce example code and in response to comments from property owners wishing they knew a property had a critical area on it before purchase.

A. To inform subsequent purchasers of real property of the existence of critical areas, when development is permitted in an identified critical area or its associated buffer, a notice to title applicable to the property shall be filed with the King County Department of Records. The notice shall state that critical areas or buffers have been identified on the property and the fact that limitations on actions in or affecting the critical area or buffer may exist. The notice shall run with the land. This notice shall not be required for development by a public agency or public or private utility when:

1. Within a recorded easement or right-of-way; or

2. On the site of a permanent public facility.

B. Subdivisions, short subdivisions, development agreements, and binding site plans shall establish a separate tract (a critical areas tract) as a permanent protective measure for wetlands, streams, fish and wildlife habitat, landslide hazard areas and their buffers. The plat or binding site plan for the project shall clearly depict the critical areas tract, and shall include all of the subject critical area and any required buffer, as well as additional lands, as determined by the developer. Restrictions to development within the critical area tract shall be clearly noted on the plat or plan. Restrictions shall be consistent with this chapter for the entire critical area tract, including any additional areas included voluntarily by the developer. Should the critical area tract include several types of critical areas, the developer may wish to establish separate critical areas tracts. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(M), 2000. Formerly 20.80.130.).

20.80.060 Permanent field marking.

A. All critical areas tracts, easements or dedications shall be clearly marked on the site using permanent markings, placed every 300 feet, which include the following text:

This area has been identified as a <<INSERT TYPE OF CRITICAL AREA>> by the City of Shoreline. Activities, including clearing and grading, removal of vegetation, pruning, cutting of trees or shrubs, planting of nonnative species, and other alterations may be prohibited. Please contact the City of Shoreline Department of Development (206) 546-1811 for further information.

B. It is the responsibility of the landowner to maintain and replace if necessary all permanent field markings. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(N), 2000. Formerly 20.80.140.).

20.80.070 Alteration of critical areas.

Comment [jn72]: Moved to 20.80.050

Alteration of critical areas, including their established buffers, may only be permitted subject to the criteria in this chapter, and compliance with any Federal and/or State permits required. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(A), 2000. Formerly 20.80.160.).

~~20.80.080 Alteration or development of critical areas – Standards and criteria.~~

~~This section applies to mitigation required with all critical areas reviews, approvals and enforcement pursuant to this chapter. This section is supplemented with specific measures under subchapters for particular critical areas. The proponent for a project involving critical areas shall avoid, minimize and mitigate the impacts to the critical areas through actions that occur in the following sequence:~~

~~A. Avoiding the impact altogether by not taking a certain action or parts of actions;~~

~~B. Minimizing impacts by limiting the degree or magnitude of the action and its implementation;~~

~~C. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;~~

~~D. Reducing or eliminating the impact over time through preservation and maintenance operations during the life of the action;~~

~~E. Compensating for the impact by replacing or providing substitute resources or environments; and/or~~

~~F. Monitoring, measuring and reporting the impact to the Planning Director and taking appropriate corrective measures. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(B), 2000. Formerly 20.80.170.).~~

20.80.085 Pesticides, herbicides and fertilizers on City-owned property.

Pesticides, herbicides and fertilizers which have been identified by State or Federal agencies as harmful to humans, wildlife, or fish, shall not be used in a City-owned riparian corridor, shoreline habitat or its buffer, wetland or its buffer, except as allowed by the Director for the following circumstances:

A. When the Director determines that an emergency situation exists where there is a serious threat to public safety, health, or the environment and that an otherwise prohibited application must be used as a last resort.

B. Compost or fertilizer may be used for native plant revegetation projects in any location.

C. Limited pesticide and herbicide use may be applied pursuant to the King County Noxious Weed Control Board best management practices specific to the species needing control when that is determined to be the best method of control for the location. (Ord. 398 § 1, 2006)

20.80.090 Buffer areas.

The establishment of buffer areas shall be required for all development proposals and activities in or adjacent to critical areas. In all cases the standard buffer ~~(i.e., the maximum buffer required by the City)~~ shall apply unless the Director determines that no net loss of functions and values will occur or the Director determines that additional buffer width is necessary to ensure no net loss of functions and values consistent with the provisions of this chapter and the recommendations of a qualified professional. The purpose of the buffer shall be to protect the integrity, function, value and resource of the subject critical area, and/or to protect life, property and resources from risks associated with development on unstable or critical lands. Buffers shall consist of an undisturbed area of native vegetation established to achieve the purpose of the buffer. If the buffer area has previously been disturbed, it shall be revegetated pursuant to an approved ~~planting~~ mitigation or restoration plan. Buffers shall be protected during construction by placement of a temporary barricade if determined necessary by the City, on-site notice for construction crews of the presence of the critical area, and implementation of appropriate erosion and sedimentation controls. Restrictive covenants or conservation easements may be required to preserve and protect buffer areas. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(C), 2000. Formerly 20.80.180.).

~~20.80.050~~**100 Notice to title.**

A. **Notice to Title.** A notice to title is required when development is permitted on any property containing a critical area or buffer. The purpose is ~~T~~to inform subsequent purchasers of real property of the existence of critical areas and associated buffers.~~, when development is permitted in an identified critical area or its associated buffer, a~~ A notice to title applicable to the property shall be prepared by the City and filed by the property

Comment [jn73]: Moved to 20.80.055

Comment [jn74]: Reference to best management practices added at request of Parks Department. Sometimes correctly applied chemical treatment is the most effective and least impactful method for removal.

Comment [jn75]: Revision based on commerce example code and in response to comments from property owners wishing they knew a property had a critical area on it before purchase.

Comment [jn76]: Notice to Title is currently required ONLY when development is permitted within a critical area or its buffer, which is a very small number of properties. The proposed revision would require a notice on title any time a permit is issued for development on a property where there is a critical area or buffer on the property. Alternately, the threshold could be when a critical area report is required, or when specific types of development are proposed.

owner with the King County ~~Department of~~ Recorder's Office. The notice shall state that critical areas or buffers have been identified on the property and the fact that limitations on actions in or affecting the critical area or buffer may exist. The notice shall run with the land. This notice shall not be required for development by a public agency or public or private utility when:

1. Within a recorded easement or right-of-way; or

2. On the site of a permanent public facility.

B. **Critical Area Tract.** Subdivisions, short subdivisions, development agreements, and binding site plans shall establish a separate tract (a critical areas tract) as a permanent protective measure for wetlands, ~~streams,~~ fish and wildlife habitat conservation areas, and landslide hazard areas and their buffers. The plat or binding site plan for the project shall clearly depict the critical areas tract, and shall include all of the subject critical area and any required buffer, as well as additional lands, as determined by the developer. Restrictions to development within the critical area tract shall be clearly noted on the plat or plan. Restrictions shall be consistent with this chapter for the entire critical area tract, including any additional areas included voluntarily by the developer. Should the critical area tract include several types of critical areas, the developer may wish to establish separate critical areas tracts.

C. **Native Growth Protection Area.** Unless otherwise required in this Chapter, native growth protection area (NGPA) easements shall be recorded on title for all affected parcels prior to issuance of the site development or building permit when two (2) or more dwelling units and/or nonresidential development are proposed on one parcel to delineate and protect those contiguous wetlands, fish and wildlife habitat conservation, and landslide hazard critical areas and their buffers. NGPA easements shall be required on a property where no subdivision, short subdivision, development agreement, or binding site plan is proposed or required. The easement to be recorded shall clearly depict the critical area and the limits of the NGPA easement and shall include all of the subject critical area(s) and any required buffer(s). Restrictions to development with in the NGPA easement shall be clearly noted in the easement and shall include the following:

1. An assurance that native vegetation will be preserved for the purpose of preventing harm to property and the environment, including, but not limited to, controlling surface water runoff and erosion, maintaining slope stability, buffering, and protecting plants, fish, and animal habitat; and

2. The right of the City to enforce the terms of the restriction.

D. **Modifications and Waivers.** Where the standards in this chapter allow for development within the identified critical areas, the Director may modify the language or dimensions of the required critical area tract or native growth protection area easement for consistency with the extent of the development to be permitted.

E. The applicant shall submit proof that the notice has been recorded on title before the City approves any development permit for the property or, in the case of subdivisions, short subdivisions, binding site plans, master plans, or development agreements, at or before recording (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(M), 2000. Formerly 20.80.130.).

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20.80.~~060~~110 Permanent field marking.

A. All critical areas tracts, easements, ~~or~~ and dedications, or as recommended by a qualified professional, shall be clearly marked on the site using permanent markings, placed every 300 feet, which include the following text:

~~This area has been identified as a <<INSERT TYPE OF CRITICAL AREA>> by the~~ City of Shoreline Designated Critical Area. Activities, including clearing and grading, removal of vegetation, pruning, cutting of trees or shrubs, planting of nonnative species, and other alterations may be prohibited. Help protect and care for this area. Please contact the City of Shoreline ~~Department of Development (206) 546-1811 for further information~~ with questions or concerns.

B. It is the responsibility of the landowner to maintain and replace if necessary all permanent field markings. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 1(N), 2000. Formerly 20.80.140.).

~~**20.80.100 Classification and rating of critical areas.**~~

~~To promote consistent application of the standards and requirements of this chapter, critical areas within the City of Shoreline shall be rated or classified according to their characteristics, function and value, and/or their sensitivity to disturbance. Classification of critical areas shall be determined by the City using the following tools:~~

~~A. Application of the criteria contained in these regulations;~~

~~B. Consideration of the technical reports submitted by qualified professionals in connection with applications subject to these regulations; and~~

~~C. Review of maps adopted pursuant to this chapter. (Ord. 398 § 1, 2006; Ord. 324 § 1, 2003; Ord. 238 Ch. VIII § 2(E), 2000. Formerly 20.80.200.).~~

Comment [jn77]: Moved to 20.80.070.

~~**20.80.110 Critical areas reports required.**~~

~~If uses, activities or developments are proposed within critical areas or their buffers, an applicant shall provide site-specific information and analysis as determined by the City. The site-specific information must be obtained by expert investigation and analysis. This provision is not intended to expand or limit an applicant's other obligations under WAC 197-11-100. Such site-specific reviews shall be performed by qualified professionals, as defined by SMC 20.20.042, who are approved by the City or under contract to the City. (Ord. 581 § 1 (Exh. 1), 2010; Ord. 515 § 1, 2008; Ord. 406 § 1, 2006; Ord. 398 § 1, 2006).~~

Comment [jn78]: Moved to 20.80.080.

20.80.120 Financial guarantee requirements. Financial guarantees and associated Performance Agreements or Maintenance/Defect/Monitoring agreements shall be required for projects with required mitigation or restoration of impacts to critical areas or critical area buffers consistent with the following:

Comment [jn79]: Provision added based on City of Edmonds bonding regulations and modified from current requirements in SMC 20.80.250(G)(2) and other similar existing requirements for other types of critical areas.

A. A Performance agreement and bond or other acceptable financial guarantee is required from the applicant when mitigation required pursuant to a development proposal is not completed prior to final permit approval, such as final plat approval or final building inspection. The amount of the performance bond(s) shall equal 125 percent of the cost of the mitigation project (after City mobilization is calculated).

B. A Performance agreement and bond or other acceptable financial guarantee is required from the applicant when restoration is required for remediation of a critical area violation. The amount of the performance bond(s) shall equal 125 percent of the cost of the mitigation project (after City mobilization is calculated).

C. A Maintenance/Defect/Monitoring agreement and bond or other acceptable financial guarantee is required to ensure the applicant's compliance with the conditions of the approved mitigation plan pursuant to a development proposal or restoration plan for remediation of a violation. The amount of the maintenance bond(s) shall equal 25 percent of the cost of the mitigation project (after City mobilization is calculated) in addition to the cost for monitoring for a minimum of five years. The monitoring portion of the financial guarantee may be reduced in proportion to work successfully completed over the period of the bond. The bonding period shall coincide with the monitoring period.

20.80.130 Unauthorized critical area alterations and enforcement.

A. When a critical area or its buffer has been altered in violation of this Chapter, all ongoing development work shall stop and the critical area shall be restored. The City shall have the authority to issue a stop work order to cease all development, and order restoration measures at the owner's or other responsible party's expense to remediate the impacts of the violation of provisions of this Chapter.

B. **Requirement for Restoration Plan.** All development shall remain stopped until a restoration plan is prepared by the responsible party and an approved permit is issued by the City. Such a plan shall be prepared by a qualified professional using the best available science and shall describe how the actions proposed meet the

minimum requirements described in subsection (C). The Director may, at the responsible party's expense, seek expert advice, including but not limited to third party review by a qualified professional under contract with the City, in determining if the plan meets the minimum performance standards for restoration. Submittal, review, and approval of required restoration plans for remediation of violations of Chapter 20.80 SMC, Critical Areas shall be completed through a site development permit application process.

Comment [jn80]: The City may want to consider creation of a separate remediation permit for review of plans that correct for code violations to facilitate application of code enforcement provisions. This is outside the scope of the CAO update process this year. Current permit process for restoration of violations is currently adapted internally from the generic site development permit application.

C. **Minimum Performance Standards for Restoration.**

1. For alterations to aquifer recharge areas, flood hazard areas, wetlands, and habitat conservation areas, the following minimum performance standards shall be met for the restoration, provided that if the violator can demonstrate that greater functional and habitat values can be obtained, these standards may be modified:

   a. The pre-violation structural and functional values of the affected critical areas and buffers shall be restored, including water quality and habitat functions;

   b. The pre-violation soil types and configuration shall be replicated;

   c. The critical area and buffers shall be replanted with native vegetation that replicates the vegetation historically, or pre-violation, found on the site in species types, sizes, and densities. The pre-violation functions and values should be replicated at the location of the alteration; and

   d. Information demonstrating compliance with the requirements in Section 20.80.082 Mitigation Plan Requirements and the applicable mitigation sections for the affected type(s) of critical area(s) and their buffer(s) shall be submitted to the Director with a complete site development permit application.

2. For alterations to flood and geological hazards, the following minimum performance standards shall be met for the restoration of a critical area, provided that, if the violator can demonstrate that greater safety can be obtained, these standards may be modified:

   a. The hazard shall be reduced to a level equal to, or less than, the pre-violation hazard;

   b. Any risk of personal injury resulting from the alteration shall be eliminated or minimized; and

   c. The hazard area and buffers shall be replanted with native vegetation sufficient to minimize the hazard.

D. **Site Investigations.** The Director is authorized to make site inspections and take such actions as are necessary to enforce this Chapter. The Director shall present proper credentials and make a reasonable effort to contact any property owner before entering onto private property.

E. **Penalties.** Any responsible party violating of any of the provisions of this Chapter shall be subject any applicable penalties per SMC 20.30.770 plus the following:

1. A square footage cost of three dollars ($3.00) per square foot of impacted critical area and critical area buffer; and

2. A per tree penalty in the amount of $3,000 per non-significant tree and $9,000 per significant tree for trees removed from a critical area or critical area buffer in violation of the provisions of this Chapter.

Comment [jn81]: Suggested language based on proposed code language developed by the City of Edmonds. Easier to determine than determining the economic value of the ecological functions and values impacted, but still proportional to the area impacted. City of Edmonds consultant for their CAO update provided basis for value of $3.00 per square foot impacted in 2015 BAS Addendum. Penalties for tree removal in critical areas added based on current tree removal penalties used in Edmonds.

ALTERNATE AMENDMENT 1 – ALTERATION OF LANDSLIDE HAZARD AREAS

20.80.224 GEOLOGIC HAZARDS – Development standards.

A. Activities and uses shall be prohibited in geologic hazard areas and their required buffers except as provided for in this Title.

B. **Activities allowed in all geologic hazard areas and buffers.** The activities listed below are allowed in the identified geologic hazard areas types pursuant to SMC 20.80.0XX Allowed Activities. Additional exemptions are listed in SMC 20.80.030 and 20.80.040, but do not apply within the shoreline jurisdiction. These activities do not require submission of a critical area report.

1. All exempt activities per SMC 20.80.040, unless critical area report is required for the exemption;

2. Installation of fences as allowed without a building permit in Chapter 20.50 Development standards; and

3. Non-structural interior remodel, maintenance, or repair of structures which do not meet the standards of this chapter, if the maintenance or repair does not increase the footprint or height of the structure and there is no increased risk to life or property as a result of the proposed maintenance or repair.

4. **Landslide and Seismic Hazard Areas.** No additional activities allowed without submission of a critical area report in landslide and seismic hazard areas.

5. **Erosion Hazard Areas.** If the site does not contain another type of critical area or critical area buffer and does not exceed any other threshold contained in SMC 20.50.320, then up to 1,500 square feet may be cleared on any lot in an erosion hazard area without a permit.

C. **Alteration.** The City shall approve, condition, or deny proposals in a geologic hazard area as appropriate based upon the effective mitigation of risks posed to property, health and safety. The objective of mitigation measures shall be to render a site containing a geologic hazard as safe as one not containing such hazard. Conditions may include limitations of proposed uses, modification of density, alteration of site layout, and other appropriate changes to the proposal. Where potential impacts cannot be effectively mitigated to eliminate a significant risk to public health, safety and property, or important natural resources, the proposal shall be denied.

D. **Alteration of Landslide Hazards.**
Alterations of a landslide hazard area and/or buffer may only occur for activities for which a hazards analysis is submitted and certifies that:

1. The development will not increase surface water discharge or sedimentation on site or to adjacent properties beyond pre-development conditions;

2. The development will not decrease slope stability on the site or on adjacent properties;

3. Such alterations will meet other critical areas regulations; and

4. The design criteria in subsection (E) are met.

E. **Design Criteria for Alteration of Landslide Hazard Areas.** Development within a landslide hazard area and/or buffer shall be designed to meet the following basic requirements unless it can be demonstrated that an alternative project design provides greater short and long-term slope stability while meeting all other provisions of this Chapter. The requirement for long-term slope stability shall exclude designs that require regular and periodic maintenance to maintain their level of function. The basic development design criteria are:
1. The proposed development shall not decrease the factor of safety for landslide occurrences below the limits of 1.5 for static conditions and 1.2 for dynamic conditions. Where the existing conditions are below these

Comment [jn1]: Wavy underline is the alternate amendment language for proposed SMC 20.80.224.

limits the proposed development shall increase the factor of safety to these limits. Analysis of dynamic conditions shall be based on the seismic event as established by the current version of the International Building Code;

2. New structures and improvements shall be clustered to avoid geologically hazardous areas and other critical areas;

3. New structures and improvements shall minimize alterations to the natural contour of the slope, and foundations shall be tiered where possible to conform to existing topography;

4. New structures and improvements shall be located to preserve the most critical portion of the site and its natural landforms and vegetation;

5. The proposed development shall not result in greater risk or a need for increased buffers on neighboring properties;

6. Where the existing natural slope area cannot be retained undisturbed with native vegetation, the use of retaining walls that allow the maintenance of existing natural slope area is preferred over graded artificial slopes; and

7. Development shall be designed to minimize impervious lot coverage.

F. **Alteration of Seismic Hazard Areas.** Avoidance of alterations in seismic hazard areas per SMC 20.80.080(A) is not required. Development activities and uses that result in impact to seismic hazard areas may be permitted, consistent with SMC 20.80.055(B-F), in accordance with an approved geologic hazards critical area report prepared by a qualified professional. The report must provide assurances that the risk of damage from the proposal, both on-site and off-site, are minimal subject to the conditions set forth in the report, that the proposal will not increase the risk of occurrence of the potential hazard, and that measures to eliminate or reduce risks have been incorporated into the report's recommendations. The report must include the following:

1. For one-story and two-story residential detached structures and all nonstructural projects, a qualified professional shall conduct an evaluation of site response and liquefaction potential based on current mapping, site reconnaissance, research of nearby studies; or

2. For all other proposals, the applicant shall conduct an evaluation of site response and liquefaction potential including sufficient subsurface exploration to determine the site coefficient for use in the static lateral force procedure described in the International Building Code.

G. **Alteration of Erosion Hazard Areas.** Development activities and uses in erosion hazard areas can be permitted, not subject to 20.80.055(A), based on review of a critical area report prepared by a qualified professional demonstrating that the project is consistent with SMC 20.80.055(B-F) and the following provisions:

1. All development proposals on sites containing erosion hazard areas shall include a stormwater pollution prevention plan consistent with the requirements of the adopted Stormwater Manual and a revegetation plan to ensure permanent stabilization of the site. Specific requirements for revegetation plans shall be determined on a case-by-case basis during permit review and administrative guidelines shall be developed by the Department. Critical area revegetation plans may be combined with required landscape, tree retention, and/or other critical area mitigation plans as appropriate.

2. All subdivisions, short subdivisions or binding site plans on sites with erosion hazard areas shall comply with the following additional requirements:

a. Except as provided in this section, existing vegetation shall be retained on all lots until building permits are approved for development on individual lots;

b. If any vegetation on the lots is damaged or removed during construction of the subdivision infrastructure, the applicant shall be required to implement the revegetation plan in those areas that have been impacted prior to final inspection of the site development permit or the issuance of any building permit for the subject property;

c. Clearing of vegetation on individual lots may be allowed prior to building permit approval if the City of Shoreline determines that:

i. Such clearing is a necessary part of a large scale grading plan,

ii. It is not feasible to perform such grading on an individual lot basis, and

iii. Drainage from the graded area will meet established water quality standards.

3. Where the City of Shoreline determines that erosion from a development site poses a significant risk of damage to downstream receiving water, the applicant shall be required to provide regular monitoring of surface water discharge from the site. If the project does not meet water quality standards, the City may suspend further development work on the site until such standards are met.

4. The City may require additional mitigation measures in erosion hazard areas, including, but not limited to, the restriction of major soil-disturbing activities associated with site development between October 1st and April 30th to meet the stated purpose contained in SMC 20.80.010 and 20.80.210.

5. The use of hazardous substances, pesticides and fertilizers in erosion hazard areas may be prohibited by the City of Shoreline.

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ALTERNATE AMENDMENT 2 – VEGETATION REMOVAL IN VERY HIGH RISK LANDSLIDE HAZARD AREAS

20.80.224 GEOLOGIC HAZARDS – Development standards.

A. Activities and uses shall be prohibited in geologic hazard areas and their required buffers except as provided for in this Title.

B. **Activities allowed in all geologic hazard areas and buffers.** The activities listed below are allowed in the identified geologic hazard areas types pursuant to SMC 20.80.0XX Allowed Activities. Additional exemptions are listed in SMC 20.80.030 and 20.80.040, but do not apply within the shoreline jurisdiction. These activities do not require submission of a critical area report.

1. All exempt activities per SMC 20.80.040, unless critical area report is required for the exemption;

2. Installation of fences as allowed without a building permit in Chapter 20.50 Development standards; and

3. Non-structural interior remodel, maintenance, or repair of structures which do not meet the standards of this chapter, if the maintenance or repair does not increase the footprint or height of the structure and there is no increased risk to life or property as a result of the proposed maintenance or repair.

4. **Landslide and Seismic Hazard Areas.** No additional activities allowed without submission of a critical area report in landslide and seismic hazard areas.

5. **Erosion Hazard Areas.** If the site does not contain another type of critical area or critical area buffer and does not exceed any other threshold contained in SMC 20.50.320, then up to 1,500 square feet may be cleared on any lot in an erosion hazard area without a permit.

C. **Alteration.** The City shall approve, condition, or deny proposals in a geologic hazard area as appropriate based upon the effective mitigation of risks posed to property, health and safety. The objective of mitigation measures shall be to render a site containing a geologic hazard as safe as one not containing such hazard. Conditions may include limitations of proposed uses, modification of density, alteration of site layout, and other appropriate changes to the proposal. Where potential impacts cannot be effectively mitigated to eliminate a significant risk to public health, safety and property, or important natural resources, the proposal shall be denied.

D. **Alteration of Moderate to High Risk Landslide Hazards.**
Development activities and uses that result in unavoidable alterations may be permitted in moderate to high risk landslide hazard areas or their buffers in accordance with an approved geologic hazard critical area report prepared by a qualified professional. The recommendations contained within the critical area report shall be incorporated into the proposed alteration of the landslide hazard area or their buffers.

The qualified professional preparing the report shall provide assurances that the risk of damage from the proposal, both on-site and off-site, are minimal subject to the conditions set forth in the report, that the proposal will not increase the risk of occurrence of the potential landslide hazard, and that measures to eliminate or reduce risks have been incorporated into the report's recommendations.

E. **Alteration of Very High Risk Landslide Hazard Areas.**
Development shall be prohibited in very high risk landslide hazards areas or their buffers except as granted by a critical areas special use permit, a critical areas reasonable use permit per SMC 20.30.333 and 20.30.336, unless otherwise allowed by the exemptions or allowed activities provisions of this Title, or subject to the provisions of the Shoreline Master Program, SMC Title 20, Division II, where the proposed development activity is located within the shoreline jurisdiction. Additionally, the following activities within Very High Risk Landslide Hazard Areas and recommended buffers may be allowed based upon City review of a geologic hazards critical area

Comment [jn1]: Wavy underline is the alternate amendment language for proposed SMC 20.80.224.

report and site development permit application.

1. **Vegetation Clearing and Revegetation.** Vegetation clearing, including tree removal, within very high risk landslide hazard area and/or recommended buffers may only occur for vegetation removal and replacement activities for which a hazards assessment and analysis of proposal is submitted as part of a critical area report consistent with SMC 20.80.240 and certifies that:

   a. The vegetation clearing and replacement will not increase surface water discharge, erosion, or sedimentation on site or to adjacent properties beyond pre-development conditions;

   b. The vegetation clearing and replacement will not decrease slope stability on the site or on adjacent properties, and will not cause erosion of the slope;

   c. Such vegetation clearing and replacement will meet other critical areas regulations; and

   d. The design standards in subsection (2) are met.

2. **Design Criteria for Vegetation Removal and Replacement within Very High Risk Landslide Hazard Areas.** Proposals for vegetation removal, including tree removal, and replacement within a very high risk landslide hazard area and/or recommended buffer shall be designed to meet the following basic requirements unless it can be demonstrated that an alternative design that provides greater short and long-term slope stability while meeting all other provisions of this Chapter. The requirement for long-term slope stability shall exclude project designs that require regular and periodic maintenance to maintain their level of function. The basic vegetation removal and replacement design criteria are:

   a. The proposed vegetation removal and replacement shall not decrease the factor of safety for landslide occurrences below the limits of 1.5 for static conditions and 1.2 for dynamic conditions. Where the existing conditions are below these limits the proposed project shall increase the factor of safety to these limits. Analysis of dynamic conditions shall be based on the seismic event as established by the current version of the International Building Code;

   b. Vegetation removal and replacement plans shall not require the installation of structures to maintain the short- and long- term stability of the landslide hazard area;

   c. Vegetation removal and replacement shall not require or include alterations to the natural contour of the slope;

   d. All replacement vegetation must be native species and must be consistent with the tree replacement requirements and site restoration standards in SMC 20.50.360;

   e. The proposed vegetation removal and replacement shall not result in greater risk or a need for increased buffers on neighboring properties;

   f. No new structures or hardscape may replace vegetation proposed to be removed; and

   g. The vegetation removal and replacement proposal must meet the requirements of SMC 20.80.240 Geologic Hazards – Critical area report requirements and of SMC 20.80.250 Geologic Hazards – Mitigation performance standards and requirements.

F. **Alteration of Seismic Hazard Areas.** Avoidance of alterations in seismic hazard areas per SMC 20.80.080(A) is not required. Development activities and uses that result in impact to seismic hazard areas may be permitted, consistent with SMC 20.80.055(B-F), in accordance with an approved geologic hazards critical area report prepared by a qualified professional. The report must provide assurances that the risk of damage from the proposal, both on-site and off-site, are minimal subject to the conditions set forth in the report, that the proposal will not increase the risk of occurrence of the potential hazard, and that measures to eliminate or reduce risks have been incorporated into the report's recommendations. The report must include the following:

Comment [t2]: Many natural slopes will not have an FS as high as 1.5 (but engineered structures should be designed for at least 1.5). Natural slopes could be maintained at 1.3 for static and greater than 1.0 for seismic. Or the City could say no decrease in slope stability, but then an applicant could claim the existing slope is only at 1.1 and they will not cause a decrease, but the City may not want any disturbance to a 1.1 slope, or the City might want to see improvement to 1.3.

1. For one-story and two-story residential detached structures and all nonstructural projects, a qualified professional shall conduct an evaluation of site response and liquefaction potential based on current mapping, site reconnaissance, research of nearby studies; or

2. For all other proposals, the applicant shall conduct an evaluation of site response and liquefaction potential including sufficient subsurface exploration to determine the site coefficient for use in the static lateral force procedure described in the International Building Code.

G. **Alteration of Erosion Hazard Areas.** Development activities and uses in erosion hazard areas can be permitted, not subject to 20.80.055(A), based on review of a critical area report prepared by a qualified professional demonstrating that the project is consistent with SMC 20.80.055(B-F) and the following provisions:

1. All development proposals on sites containing erosion hazard areas shall include a stormwater pollution prevention plan consistent with the requirements of the adopted Stormwater Manual and a revegetation plan to ensure permanent stabilization of the site. Specific requirements for revegetation plans shall be determined on a case-by-case basis during permit review and administrative guidelines shall be developed by the Department. Critical area revegetation plans may be combined with required landscape, tree retention, and/or other critical area mitigation plans as appropriate.

2. All subdivisions, short subdivisions or binding site plans on sites with erosion hazard areas shall comply with the following additional requirements:

   a. Except as provided in this section, existing vegetation shall be retained on all lots until building permits are approved for development on individual lots;

   b. If any vegetation on the lots is damaged or removed during construction of the subdivision infrastructure, the applicant shall be required to implement the revegetation plan in those areas that have been impacted prior to final inspection of the site development permit or the issuance of any building permit for the subject property;

   c. Clearing of vegetation on individual lots may be allowed prior to building permit approval if the City of Shoreline determines that:

      i. Such clearing is a necessary part of a large scale grading plan,

      ii. It is not feasible to perform such grading on an individual lot basis, and

      iii. Drainage from the graded area will meet established water quality standards.

3. Where the City of Shoreline determines that erosion from a development site poses a significant risk of damage to downstream receiving water, the applicant shall be required to provide regular monitoring of surface water discharge from the site. If the project does not meet water quality standards, the City may suspend further development work on the site until such standards are met.

4. The City may require additional mitigation measures in erosion hazard areas, including, but not limited to, the restriction of major soil-disturbing activities associated with site development between October 1st and April 30th to meet the stated purpose contained in SMC 20.80.010 and 20.80.210.

5. The use of hazardous substances, pesticides and fertilizers in erosion hazard areas may be prohibited by the City of Shoreline.

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Arboriculture & Urban Forestry 2010. 36(5): 193–205

Tree Root Ecology in the Urban Environment and Implications for a Sustainable Rhizosphere

Susan D. Day, P. Eric Wiseman, Sarah B. Dickinson, and J. Roger Harris

Abstract. This review examines current understandings of how the belowground characteristics of urban settings affect tree roots as well as how tree roots contribute to biogeochemical processes in this belowground environment. Soil characteristics common to the urban environment include soil compaction and other physical impediments to root exploration, elevated pH, altered temperature and moisture patterns, and the presence of contaminants. These conditions may alter the growth dynamics, morphology, and physiology of roots. At the same time, roots have a profound effect on the soil environment, with trees directing 40%–73% of assimilated carbon below ground. Urban rhizosphere ecology is a topic of renewed interest for research not only because of its critical role in the urban ecosystem, but also because of its role in global environmental issues. In addition to its obvious contribution to aboveground growth, root exploration of the soil environment can influence environmental sustainability through root contributions to soil structure and drainage. Root influence is further mediated by the intimate role of roots in soil biological activity and thus carbon storage and nutrient cycling. Current advances and implications for emerging research are discussed.

Key Words. Heavy Metals; Road Salt; Root Periodicity; Soil Compaction; Soil Structure; Urban Hydrology; Urban Infrastructure.

The root-soil environment—the urban rhizosphere—is critical not only to tree health, but to urban ecosystem function as well. The performance of urban trees depends upon the ability of their root systems to acquire resources and provide anchorage. However, conditions prevalent in the built environment, such as compacted soils, underground infrastructure, chemical contamination, and excessive heat, create a unique and often unaccommodating environment that may impair root growth and development. In addition, practices associated with establishing and maintaining a landscape, such as transplanting large trees and employing irrigation systems, can alter tree root growth dynamics. In turn, tree roots alter the belowground environment through their influence on biological, physical, and chemical soil properties. This urban rhizosphere ecology has implications for both establishing trees in cities, and for assessing potential ecosystem services that trees, and their root systems in particular, provide to society. The scope of this review includes root responses to environmental elements typical of urban settings (for example, soil compaction) and root interactions with that environment through carbon deposition and other means. This paper avoids discussion of root architecture and specific root management practices (e.g., directing roots with barriers or planting space designs, root pruning, fertilization), and instead focuses on root ecological interactions with the environment. These interactions include growth periodicity; root response to physical constraints and soil chemical and biological properties; and root contributions to characteristics of the belowground environment that relate to contemporary discussions of environmental sustainability, such as carbon sequestration, erosion control, and soil hydrological processes. The purpose of this paper is to provide a review of the literature in this emerging area of inquiry in the context of arboriculture and urban forestry that will help identify knowledge gaps and inform future research.

ROOT GROWTH PERIODICITY—RESPONSES TO TRANSPLANTING, SOIL TEMPERATURE, AND SEASON

Root growth, especially fine root production and mortality, is a dominant feature of the belowground ecosystem where trees are present. In arboriculture and urban forestry, the question "When do tree roots grow?" has been largely addressed in the context of transplanting (Harris et al. 2001; Harris et al. 2002; Richardson-Calfee et al. 2007; Richardson-Calfee et al. 2008), where tree establishment depends upon root exploration of the new site (Harris 2007) and can be influenced considerably by transplant time (Richardson-Calfee et al. 2004).

Mathematical modeling of root growth periodicity has shown that resource limitation feedback between shoot and root growth results in a balance between the two processes that is favorable to tree growth in the particular environment where it is located (Thornley 1972; Thaler and Pagés 1998). Investigators have reported that many temperate woody plants exhibit pronounced periods of root elongation in autumn and spring, although activity level will decline during shoot expansion as resources are allocated to aboveground parts (Stone and Schubert 1959; Stone et al. 1962; Cripps 1970 Roberts 1976; Deans 1979; Dell and Wallace 1983; Wargo 1983; Deans and Ford 1986; Harris et al. 1995; Harris and Fanelli 1999). Although root growth is clearly linked to shoot growth by endogenous signals (Richardson 1958; Larson and Whitmore 1970; Farmer 1975), climate, local weather, and soil conditions are key factors controlling these root growth periods. In particular, root growth is strongly influenced by soil temperature and moisture (Lyr and Hoffman 1967). Each species has a different amplitude, or "ideal" range, of soil temperature that is suitable for root growth. This range usually corresponds to the climate of the region where the species (or species ecotype) is native. The typical temperature range that permits root growth

for temperate zone species is between 2°C and 25°C (Lyr and Hoffman 1967). Root elongation of many temperate species is severely limited when soil temperatures fall below 10°C (Harris et al. 1995; Harris et al. 1996). In contrast to their shoots, which have a dormant period that can only be overcome by chilling, the roots of many temperate zone trees do not exhibit an easily identified period of innate dormancy (Richardson 1958; Taylor and Dumbroff 1975), and can respond quickly to warming soil. However, Arnold and Young (1990) found evidence with several *Malus* (apple) species that an innate root dormancy satisfied by low temperature exposure may exist in some tree species. Lack of moisture suppresses root growth in two ways: first by restricting water uptake that drives cell expansion, and second by increasing soil strength (see *Compacted Soil as a Permeable Impediment*). For trees in tropical areas, water availability is the main environmental determinant for periodic root growth patterns (Borchert 1994), and root biomass is strongly correlated with soil moisture across tropical moisture gradients (Green et al. 2005; McGroddy and Silver 2009). In temperate species, soil moisture dynamics influence root growth periodicity within the confines of temperature controls (Tesky and Hinkley 1981; Kuhns et al. 1985).

ROOT RESPONSE TO PHYSICAL CONSTRAINTS

The ability of roots to explore the belowground environment in urban settings influences tree health, stability, and longevity. However, few studies have addressed rooting response of urban trees to specific characteristics of the belowground environment (for a general view of root architecture in urban settings, see Day et al. 2010). In a study encompassing seven German cities, 20- to 40-year-old *Tilia* spp. (lindens, species not identified) were excavated in an attempt to identify belowground factors that influenced root penetration and proliferation (Krieter 1986). One unusual facet of this large-scale study was the excavation of potential rooting spaces under streets and sidewalks. Root penetration and fine root proliferation were influenced by soil type. Both pure sands and gravel layers (no fine materials) as well as highly compacted loamy and clayey soils restricted or prevented root penetration (see also *Soil Compaction*). Greater fine root proliferation was observed within irrigated areas, around utility and irrigation lines, in areas with coarse gravel and debris mixed with finer materials (clay and silt), and at curb interfaces and similar structures where a physical "dam" was created that may have collected water. Even with this large-scale study, however, variation was considerable, and the root responses observed may have been unique to German street tree installation practices, to the northern European climate, or to the particular tree species.

As this study demonstrates, there are multiple physical constraints that dictate root exploration of the subterranean urban environment. These constraints can be broadly classified into two types: solid impediments such as building foundations, roads, and rocks; and permeable impediments, such as compacted soils. Root exploration of these physical obstructions may further depend upon moisture content.

Urban Infrastructure as a Solid Impediment

In urban conditions, tree root systems may be confined by belowground infrastructure that is essentially impenetrable unless seams, cracks, or other openings are present. Studies in urban and landscape settings documenting tree root growth in and around this infrastructure are extremely limited. Nonetheless, the following examples illustrate the potential for roots to navigate minute fissures in the urban underground complex. In a case study describing management of root–infrastructure conflicts, Schroeder (2005) published a photo of *Acer pseudoplatanus* (sycamore maple) fibrous roots penetrating through mortar joints into an underground utility room and extending 1 m or more through the air inside the chamber. Root interactions with sewer pipes have been reviewed by Randrup et al. (2001), who documented numerous intrusions by roots into unsealed pipes. Although tree roots may successfully explore belowground urban infrastructure, this does not necessarily mean that adequate nutrients and water can be obtained, and spatial availability of these resources can have a profound effect on root distribution (Mou et al. 1997).

Because research in urban settings is limited, we must rely on studies in analogous situations to provide additional insight into root response to physical constraints. For example, trees adapted to arid, rocky conditions may grow roots through very small cracks (less than 0.3 cm wide) in rock up to 9 m deep in order to access the water table (Saunier and Wagle 1967). In southwestern Oregon, U.S., roots were found in rock fissures as small as 100 µm (Zwieniecki and Newton 1995). While the stele retains its regular shape under such confined conditions, the root cortex may become flat, creating wing-like structures on the sides of the stele (Saunier and Wagle 1967; Stone and Kalisz 1991; Zwieniecki and Newton 1995). These structures have been measured at up to 0.75 mm across with root hairs only occurring on the edges of the structures (Zwieniecki and Newton 1995). These studies illustrate how roots might penetrate minute fissures in concrete, masonry, or other urban infrastructure and adapt anatomically to the space. Documented observations in urban environments are few, and the conditions necessary for this adaptive growth are unknown. In some cases, tree roots will grow around physical obstacles. For example, *Platanus* × *acerifolia* roots were observed to partially or completely encapsulate 2 cm limestone gravel that was a component of a structural soil mix (Bassuk 2008).

Compacted Soil as a Permeable Impediment

Soil compaction arising from urban land development and use is a more pervasive cause of root restriction for landscape trees. Compaction occurs as soil is compressed, which degrades structure, diminishes porosity, and increases strength—the soil's physical resistance to penetration. Soil compaction in urban areas is widespread. In a study of 48 sites in Moscow, Idaho, and Pullman, Washington, recently developed sites were found to have higher soil bulk densities than older sites (Scharenbroch et al. 2005), presumably due to more stringent engineering standards and more effective compaction equipment. Site development practices often entail removal of upper soil horizons (especially O and A) during grading (Jim 1998), leaving denser subsoil at the surface, and the soil underlying pavement is typically compacted to provide structural support. Thus urban tree root systems are likely to encounter compacted soil. These restricted root systems are commonly shallower, confined by dense soil underlying pavement or planting pits, or exhibit less extensive soil exploration than would be possible in uncompacted soil. Root systems in compacted soil are more highly branched and consist of thicker, stubbier roots, which often results in shallower rooting depth (Tackett and Pearson 1964; Voorhees et al. 1975; Gilman et al. 1987; Materechera et al. 1991).

Although bulk density indicates the degree of compaction for a particular soil, it does not provide a complete picture of root inhibition for that soil. Soil texture and moisture must also be considered along with bulk density, because these properties in combination determine soil strength (Taylor and Gardner 1963; Taylor and Ratliff 1969; Zisa et al. 1980; Daddow and Warrington 1983; Day et al. 2000). In their classic study, Daddow and Warrington (1983) used an in-depth survey of forest soil compaction research to create a chart depicting root-growth-limiting bulk density for each soil texture (i.e., the bulk density at which root growth would essentially halt for a given soil texture). As they note, this serves as a useful proxy for soil resistance to penetration, but does not account for other factors that affect soil strength, particularly moisture.

Soil strength is a function of bulk density and moisture content. As bulk density increases due to compaction, the frictional and cohesive forces between soil particles increase and thus soil strength increases (Greacen and Sands 1980). As soil strength increases, root elongation rate decreases due to resistance of soil particles to displacement (Clark et al. 2003). The critical soil strength (measured with a cone penetrometer) above which woody plant root elongation is severely restricted is in the vicinity of 2.3 MPa, depending on soil type and plant species (Day and Bassuk 1994). Soil moisture can alleviate excessive soil strength by lubricating soil particles and the elongating root tip. However, the moisture content required to alleviate excessive soil strength is progressively greater as bulk density increases. In sandy loam soil, the volumetric moisture content at which soil strength fell below the critical limit was about 20% at a bulk density of 1.18 g/cm^3 versus about 30% at a bulk density of 1.26 g/cm^3 (Siegel-Issem et al. 2005).

In compacted soil, the combination of increased volumetric water content, and decreased macroporosity limits gas diffusion and may cause root aeration stress. In silty loam soil compacted to 1.44 g/cm^3, root growth of shortleaf pine (*Pinus echinata*) is limited above 35% volumetric water content due to poor aeration (Siegel-Issem et al. 2005). In a loam soil compacted to 1.5 g/cm^3, root growth of *Cornus florida* (flowering dogwood) is depressed in very moist soils (matric tension of 0.006 MPa and oxygen diffusion rates <0.5 mg cm^{-2} min), while roots of *Acer saccharinum* (silver maple) are not (Day et al. 2000). However, poor aeration due to low macroporosity in compacted soil may not be an issue in unsaturated soil (Day et al. 1995; Aust et al. 1998; Day et al. 2000).

Species vary in their ability to elongate roots in compacted soils. This is not simply attributable to differential ability to exert pressure on the soil, although slight differences have been demonstrated among species in controlled laboratory environments. For example, Materechera et al. (1991) evaluated root penetration of 22 crop species at an extreme soil strength of 4.2 MPa and found that all species had root elongation reduced between 92 and 98% and that the ability of a given species to penetrate strong soil was positively correlated with root diameter. At lower soil strength levels, species differences in root response to compaction can be easier to discern. For example, when soil strength is increased from 0 to 1.0 MPa, root elongation of peanuts is reduced by only 29% while elongation of cotton roots is reduced by 62% (Taylor and Ratliff (1969). However, low soil strengths such as these are unlikely to be encountered in the field except under wet conditions. These data illustrate that root growth of woody plants will be restricted with *any* increase in soil strength, rather than growing "normally" until a certain threshold is reached. In a recent study with native Australian *Eucalyptus* spp., root penetration decreased linearly as soil bulk density was increased from 1.0 to 1.4 g/cm^3 (soil texture not described), further demonstrating the immediate reduction in root penetration when soil compaction increases (Skinner et al. 2009).

Variation in species tolerance of soil compaction is currently conceived to be a complex response to the whole rooting environment. The strongest hypothesis for explaining the ability of certain tree species to tolerate compacted soil is the "root growth opportunity" hypothesis, which states that tree species tolerant of wet soils (e.g., bottomland species) can grow roots during wet periods when soil strength is low, while species less tolerant of wet soils (i.e., soil hypoxia) cannot. Thus bottomland species may be expected to have a greater root growth opportunity when soil strength is low, and thus be more adapted to soil compaction, such as is found in urban areas. Generalized models addressing this root growth opportunity were initially developed to integrate the limits of soil strength with the limits of soil water content into a single descriptor for evaluating soil quality for crop production (Letey 1985), and were eventually described as the Least Limiting Water Range (da Silva et al. 1994). Day et al. (2000) presented a similar hypothesis for urban trees and evaluated the root growth opportunity in the context of species tolerances via a study of silver maple (*Acer sacharrinum*) and flowering dogwood (*Cornus florida*). Siegel-Issem et al. (2005) further developed this approach as a measure of forest soil productivity. These last experiments evaluated the influence of soil strength, bulk density, soil moisture, and oxygen diffusion rate on seedling root growth, providing support for this hypothesis as an explanation for species response to compacted soils (Day et al. 2000; Siegel-Issem et al. 2005). Yet, response to compacted soils is influenced by a host of environmental and genetic factors and species differences are not always easily explained (Bassett et al. 2005).

ROOT RESPONSE TO SOIL CHEMISTRY AND CONTAMINANTS

Urban soils typically have very different environmental inputs than rural or forested landscapes. These include anything related to intense human activity, such as de-icing salts, tire residue, engine oil, construction debris, landscape mulches, and lawn clippings. Many of these items alter soil chemistry. In addition, brownfields—land previously used for industrial, or sometimes other commercial, purposes that may have environmental contaminants—are prevalent in many countries (Oliver et al. 2005). Decisions concerning brownfield development receive more attention as land becomes more scarce (e.g., Altherr et al. 2007), and the numerous economic, social, and environmental benefits of urban greenspaces are better appreciated. In a Canadian study, uncertainty about the effects of soil contamination and approaches to its mitigation was ranked as the most important noneconomic barrier to developing these areas as greenspace (De Sousa 2003). Chemical contaminants are also common beyond brownfields. These include de-icing salt as well as heavy metals such as Cu, Pb, and Zn that are by-products of automobile traffic (Pouyat et al. 1995; Irvine et al. 2009). Thus, there is increasing need to broaden our knowledge of root interactions with chemically altered urban soils.

Adverse Soil pH

While some instances of slightly lower pH in forested lands near urban cores have been documented (Pouyat et al. 1995), disturbed urban soils are rarely too acidic for satisfactory tree growth. Instead, soil alkalinity is a more common consequence of urbanization and therefore a more common impediment to tree health. The use of concrete and other calcareous construction materials is nearly universal in urban areas and the removal of topsoil and horizon mixing facilitates the increase in soil pH. In Hong Kong, China, soils sampled from 100 locations around the city core had a mean pH of 8.68 (Jim 1998). Sampling of soil pH in the top 10 cm of mineral soil around the Virginia Tech central campus in Blacksburg, VA, by students during laboratory exercises in horticulture and forestry classes taught by two authors of this review revealed soil pH is always above 7.0 and as high as 8.3, whereas nearby relatively undisturbed sites has surface soil pH of 5.9–6.2 and nearby disturbed roadside ditches a pH of 6.8–7.3 (Harris et al. 2008). A study of six urban landscapes in Moscow, ID, and Pullman, WA, found average pH ranges from 6.64 to 7.32 (Scharenbroch et al. 2005).

At higher soil pH, many tree species suffer from micronutrient deficiencies (B, Cu, Fe, Mn, and Zn) because these nutrients exist in insoluble forms that are unavailable to the plant (Mengel and Kirkby 2001). Availability of P is also reduced in alkaline soil. Elevated pH may also alter the composition and abundance of endomycorrhizal fungi that inhabit soil (Porter et al. 1987), which could influence root system colonization and therefore nutrient uptake capacity. On the other hand, soil alkalinity also reduces the solubility of certain elements such as Al and Pb, which are toxic to tree roots.

Sensitivity to alkalinity-induced nutrient deficiencies differs among tree species. In even slightly alkaline soils, sensitive species such as *Quercus palustris* (pin oak) and *Quercus phellos* (willow oak) may develop interveinal chlorosis in response to Fe and Mn deficiency while others remain unaffected [e.g., *Ulmus americana* (American elm) and *Platanus* × *acerifolia* (London plane)] (Dirr 1998). Root adaptations have been identified in some tolerant species that enhance Fe uptake, one example being the production of a specialized enzyme to reduce Fe (Moog and Brüggemann 1994). An evaluation of olive tree cultivars and rootstocks indicated that tolerance of calcareous soils was conferred by the rootstock rather than the scion (Alcántara et al. 2003).

Because of the ubiquity of alkaline soils in urban settings and the varied sensitivity of tree species to these soils, lists have been published to assist practitioners in selecting tree species and cultivars that tolerate particular soil pH levels (e.g., Appleton and Chaplin 2001; Bassuk et al. 2009). These lists are based partly, although certainly not exclusively, on practitioner experience since research reports are limited on many trees. In orchard trees, a clear asymptotic relationship is apparent between extractable Fe in the soil and leaf chlorosis: leaf greenness increases rapidly with increasing extractable Fe until a maximum level is reached, at which point the relationship levels off (de Santiago et al. 2008). However, in some urban trees, iron deficiency chlorosis has not shown a strong relationship with soil pH (Watson and Himelick 2004) and therefore likely not with the associated variable of extractable soil Fe either, although this last relationship has not been reported. A host of root system stresses – including root severance can negatively affect Fe uptake by urban tree roots. This has real consequences for urban trees since Fe or Mn deficiency impairs photosynthetic capacity (Abadía et al. 1999), which may diminish tree growth and stress tolerance.

Salt Contamination

Salt contamination of soils can stunt or kill tree roots depending upon species sensitivity, environmental variables (soil physical and chemical properties, precipitation, light intensity, temperature), duration and timing of exposure, and severity of contamination (Headley and Bassuk 1991; Bernstein and Kafkafi 2002). Salt contamination can arise from meltwater or spray from deicing salts (Kayama et al. 2003), from saltwater intrusion into groundwater, from sea salt blown ashore in coastal areas, or even from repeated applications of sewage sludge (Usman et al. 2004). De-icing salt is a common soil contaminant in colder climates. NaCl is the most widely-available, cost-effective material for de-icing streets, sidewalks, and parking lots, although other formulations such as $CaCl_2$ and K_2CO_3 are used. In Denmark, high road salt concentrations were found in soils within 2 m of roadways, but quickly dissipated at greater distances (Pedersen et al. 2000). When precipitation is abundant, salt does not persist in the top layers of soil and eventually leaches down to subsoil horizons and groundwater (for a review of the environmental effects road salt, including effects on vegetation, see Priority Substances List Assessment: Road Salt 2001).

Because of its agronomic importance, salt stress has been the subject of considerable research. Nonetheless, the physiological mechanisms for tolerance are varied and complex and likely represent expressions of multiple genes as well as other adaptive responses (for reviews, see Cheeseman 1988). Root growth is usually less sensitive to salt stress than shoot growth, resulting in a higher root:shoot ratio in salt-stressed plants (Cheeseman 1988). However, in landscape situations, tree roots can be subjected to acute salt shock when large amounts of roadside deicing salt are applied (Headley and Bassuk 1991). High levels of salinity impose two types of stress on roots; first, osmotic stress results from lowered water potential in the soil solution (desiccation), and second, ionic stress results from changes in concentrations of specific ions in the soil solution and inside growing tissues (toxicity). Root systems vary in their ability to tolerate salts; tolerant species may be able to selectively exclude salt ion uptake (Lloyd et al. 1987). However, few generalizations can be made. For example, in a study of grafted *Citrus* spp. (lemon trees), salinity reduced growth of some rootstocks more than others and in some cases physiological stress was governed primarily by toxic levels of Na^+ and Cl^- in leaf tissue (Gimeno et al. 2009). Salinity can also alter the symbiotic relationship between the roots of woody plants and mycorrhizal fungi, but this is not well understood at this time (Tian et al. 2004; Porras-Soriano et al. 2009). Because of the economic importance of salt tolerance in food crops, research is quickly identifying plant mechanisms of salt tolerance and their genetic control (e.g., Papdi et al. 2009).

Trace Elements and Heavy Metals

Numerous trace elements are essential or beneficial for plant function, including B, Cu, Fe, Mn, Mo, and Zn (essential); Cl and Ni (sometimes essential); and Co, I, Na, Si, and V (beneficial) (Marschner 1996; Mengel and Kirkby 2001). However, all these elements can be toxic when their concentrations are too high (Hagemeyer and Breckle 2002). Heavy metals are commonly

found in urban soils. They persist in the environment and can accumulate over time to levels toxic to plants. Besides industry, vehicular traffic is the main source of metal pollutants. The highest levels occur near roads (Jim 1998) and levels decrease with distance from the roadside (Birch and Scollen 2003; Fakayode and Olu-Owolabi 2003). Although modern regulations have reduced Pb emitted from vehicles, it persists in the environment and may remain elevated in roadsides. Zinc from tires is another major contaminant associated with vehicular traffic (Roberts et al. 2006).

Excessive concentrations of trace elements or heavy metals cause phytotoxicity through several mechanisms, including changes in cell membrane permeability, interference with metabolic processes, and replacement of essential ions (Patra et al. 2004). In roots, metals inhibit growth by interfering with cell division or cell elongation (Hagemeyer and Breckle 2002). These negative effects on roots may translate directly to negative effects on aboveground physiological function. For example, Hg toxicity symptoms of spruce seedlings such as decreased transpiration and lowered chlorophyll content were attributed primarily to root injury (Godbold and Hutterman 1988). Enhanced lateral root formation and compact, dense root branching habit have been observed in response to increasing concentrations of Pb, Zn, Mn, Cd, and Cu (Kahle 1993; Hagemeyer and Breckle 2002). It is thought that injury to the root apex by metals diminishes apical dominance, thereby increasing lateral root primordia. Lead also interferes with root hair formation. For example, root hair formation in *Fagus sylvatica* (European beech) was strongly inhibited by Pb at a concentration of 44 ppm and was completely eliminated at 283 ppm (Kahle 1993). Although a reduction in root hair density is an adaptive response for decreasing absorption of heavy metals, absorption of water and nutrients will also likely be reduced. In addition, nutrient uptake may be further reduced because of direct ion competition from heavy metals. For example, Kahle (1993) found lower nutrient concentrations in roots of numerous tree species exposed to heavy metals due to both reduced uptake and increased membrane leakage. Thus heavy metals commonly found in urban areas may both reduce root exploration of the soil and restrict uptake of nutrients and water. For a discussion of heavy metal threshold concentrations that reduce root growth, see Kahle (1993). Metal phytotoxicity is tempered in soils with high pH, CEC, clay content, and organic matter because these conditions lower metal bioavailability (for reviews, see Kahle 1993; Sieghardt et al. 2005).

Tolerance of heavy metals

Plant tolerance of heavy metal toxicity varies among species and genotypes, and tolerance of one metal does not imply tolerance of all metals. Because of their relatively long life span, trees can accumulate large amounts of toxic elements when growing on contaminated soils. Moreover, they often lack the morphological and physiological adaptations possessed by herbaceous plants that regulate internal concentrations of toxic trace elements (Hagemeyer and Breckle 2002). Heavy metals are likely not uniformly accumulated in the root system. Violina et al. (1999), for example, found that Pb concentrations in grapevine (*Vitis* spp.) were highest in fine absorbing roots and much lower in older, woody roots. Trees that can survive on metal-rich sites may rely on phenotypic plasticity, which enables roots to avoid areas of high contamination (Lepp 1991; Turner and Dickinson 1993; Hagemeyer and Breckle 2002). On the other hand, tolerant ecotypes of some genera, such as *Betula* spp. (birch) and *Salix* spp. (willow), may exhibit multiple survival strategies, including synthesis of phytochelatins that immobilize metal ions within the plant, rapid root turnover, and metal ion exclusion (Kahle 1993), and can become dominant species on metal contaminated sites (Gallagher et al. 2008). *Salix* spp. are frequently employed in phytoremediation of soils, where plants are selected for their ability to accumulate heavy metals or other contaminants from the soil and later harvested and safely disposed (Pulford and Watson 2003).

Organic Pollutants and Pesticides

There are a number of synthetic organic compounds (commonly pesticides and industrial compounds/by-products) that are potential pollutants in urban settings, and some may persist in the environment. Toxic levels of industrial organics usually are a concern on sites that have historic industrial activity, but may also occur at accident "hotspots" such as along roadways and railways. Some pesticides can have a negative impact on nontarget soil organisms (Bunemann et al. 2006) and may therefore adversely affect root growth. Mycorrhizae, for example, are sensitive to certain pesticides, particularly fungicides. Container-grown *Liriodendron tulipifera* (tulip-poplar) inoculated with arbuscular mycorrhizal fungi and subsequently soil-drenched with benomyl fungicide had reduced growth and mycorrhizal colonization compared to their non-drenched counterparts (Verkade and Hamilton 1983).

ROOT CONTRIBUTIONS TO ENVIRONMENTAL SUSTAINABILITY

Tree roots have the potential to positively influence soil quality, hydrology, and biogeochemistry in urban settings. More specifically, the roots of trees improve soil physical properties; maintain or enhance soil organic matter, N_2 fixation, and nutrient uptake from below the reach of crop roots; increase water infiltration and storage; decrease loss of nutrients to erosion and leaching; decrease soil acidity; and improve soil biological activity (Young 1997).

Soil Structure

There are many factors in the urban environment that contribute to degradation of soils and in particular, soil structure (see *Compacted Soil as a Permeable Impediment*). Thus, the potential of tree roots to influence soil structure is of considerable interest. Tree roots are primary contributors to the development of soil structure and, in the longer term, soil formation. This new appreciation of the influence of roots on soil is redefining and enlarging our concept of rhizosphere: the area where soil interacts directly with living roots (Richter et al. 2007). Tree root contributions to soil structure not only affect plant growth, but a host of other soil functions that provide ecosystem services such as stormwater runoff mitigation through enhanced soil permeability (Bramley et al. 2003; Bartens et al. 2008).

Tree roots form soil macropores

Tree roots aid in improving soil structure in several ways. One of the most significant plant-induced changes in soil structure is the formation of continuous macropores (i.e., channels) by penetrating roots (Angers and Caron 1998). A large proportion of pores formed by roots fall into the macropore range (>30 μm) (Gibbs and Reid 1988). These macropores facilitate soil aera-

tion and water percolation and storage as well as create zones of failure, which help fragment the soil, form aggregates, and decrease resistance for further root growth. Roots form macropores by creating compressive and shear stresses when growing through the soil matrix (Goss 1991). Radial pressure exerted by growing roots compresses adjacent soil (Dexter 1987), which enlarges existing pores and creates new ones. Bartens et al. (2008) demonstrated that live roots can create channels through compacted soils and vastly increase water infiltration, although flow may be greater once roots die and decay (Mitchell et al. 1995). As root decay occurs, tissue remnants and associated microflora coat pore walls, which may enhance water transport efficiency (Barley 1954; Yunusa et al. 2002).

Tree roots aid in soil aggregate formation

Aggregate stability, an indicator of soil structure, results from soil particle rearrangement, flocculation, and cementation; it is mediated by soil organic carbon, biota, ionic bridging, clay, and carbonates (Bronick and Lal 2005). Rhizosphere soil has been found to have greater aggregate stability than nonrhizosphere soil (Angers and Caron 1998), and is influenced by rhizosphere deposition as well as a number of root system attributes, including root length, mass, density, size distribution, turnover rate, and hyphal growth (Caravaca et al. 2002). Dorioz et al. (1993) observed that adsorption of water by roots promoted reorganization of the clay, characterized by oriented and compacted clay particles, and that this environment was very rich in root mucilage. "The outstanding effect of the rhizosphere on soil structure can be related to the rhizosphere as being the privileged site for growth for a wide range of microorganisms at various sizes, each of them organizing the material at its own scale" (Dorioz et al. 1993).

Tree roots can directly enhance aggregation by releasing a variety of compounds that have a cementing effect on soil particles (Bronick and Lal 2005). For example, polysaccharides from root tips can penetrate and impregnate surrounding soil up to 50 µm while bacteria polysaccharides penetrate less than 1 µm (Dorioz et al. 1993). Research suggests that the root exudate polygalaturonic acid (PGA) stabilizes soil by increasing strength of bonds between particles and decreasing wetting rate of soil via water repellency at the soil surface (Czarnes et al. 2000). Tree roots also indirectly contribute to soil aggregate formation and stability because their exudates are a food source for soil organisms, which in turn release their own exudates that contribute to soil aggregation (Tisdall et al. 1978). These exudates are also a food source for earthworms (Angers and Caron 1998), which create macropores as they burrow through the soil (Edwards et al. 1989).

Soil strength and stability

Tree root systems form part of a complex matrix that can stabilize soil and reduce erosion, both important contributions to environmental sustainability. Soil inhabited by plants dries more quickly due to transpiration; as a result, the soil has greater shear and tensile strength and the root/soil tangential resistance to slipping will be increased (Waldron and Dakessian 1982). Lower soil water content resulting from the presence of plants may also help soils resist compaction (Horn and Dexter 1989; Lafond et al. 1992). Deep-rooted woody vegetation extracts more water from greater soil depths than grassy vegetation (Bethlahmy 1962; Rogerson 1976; McColl 1977). This deep water extraction and resulting wetting and drying cycles can cause shrinkage and strengthening of the soil.

In addition to drying soil, tree roots increase soil stability via mechanical reinforcement (Waldron and Dakessian 1981; Waldron and Dakessian 1982; Abe and Iwamoto 1986; Mamo and Bubenzer 2001a; Mamo and Bubenzer 2001b; Wynn and Mostaghimi 2006). Construction of highways and other infrastructure alters the natural terrain, often resulting in steep, barren slopes that pose a landslide hazard. Tree roots have been used as tools for slope reinforcement, either alone (Norris 2005), or in combination with engineered approaches (Naoto et al. 2008). Although herbaceous vegetation may provide more immediate cover and soil stabilization, woody plants may provide greater reinforcement strength. In a study comparing the shear resistance of soil inhabited by different plants, alfalfa and grass had a more immediate effect on sheer resistance than yellow pine, but the older pine roots were clearly superior to young alfalfa roots, and shearing resistance was proportional to the number and diameter of pine roots (Waldron and Dakessian; Waldron et al. 1983).

Trees can also play an important role in stream bank stabilization (Docker and Hubble 2008; Pollen-Bankhead et al. 2009). In urban areas, stormwater runoff results in widely fluctuating water levels in streams, leading to channel erosion and impaired water quality (Schoonover et al. 2006). An *in situ* study of vegetated stream banks showed that an increase in the volume of roots with diameters of 2–20 mm was correlated with reduced soil erodability (Wynn and Mostaghimi 2006). Wynn et al. (2004) compared root distribution and density in stream banks inhabited by both herbaceous and woody vegetation. Their findings suggest riparian forests may provide better protection against stream bank erosion than herbaceous buffers.

Hydrology

Impervious surfaces, soil compaction, and stormwater drains prevent dispersed infiltration of stormwater in the built environment, decreasing groundwater levels and stream baseflow (Kaye et al. 2006). Even unpaved urban soils can have much reduced infiltration rates compared to undeveloped land (Gregory et al. 2006). In vegetated areas, only 5%–15% of rainwater runs off the ground and the rest evaporates or infiltrates into the soil, whereas about 60% of rainfall in urban areas is exported through storm drains (Bolund and Hunhammar 1999). Older stormwater systems are often connected to sewers and when these stormwater systems overflow, untreated sewage pollutes surface waters. Even if storm drains are not connected to sewers, stormwater is still concentrated and not allowed to infiltrate in a dispersed fashion, thereby reducing the influence of plants and soil on water chemistry and increasing stream temperatures when stormwater is directly deposited into surface waters (Kaye et al. 2006).

Urban trees are well recognized as effective tools for mitigating urban runoff (Xiao et al. 2000; Xiao and McPherson 2003), but the specific role of the root system is largely unrecognized. Root systems aid in dispersal of stormwater into the soil by guiding stormwater along root channels, playing a primary role in base flow (Dasgupta et al. 2006; Johnson and Lehmann 2006), aiding in water infiltration (Bramley et al. 2003; Bartens et al. 2008), and absorbing water (Wullschleger et al. 1998; Szabo et al. 2001). In addition, hydraulic lift by tree roots may improve survival of other plant species in dry climates, thus enhancing the contribution of

the plant community as a whole (Dawson 1993; Dawson 1996). In addition to "lifting" water, trees may redistribute water into deeper soil regions, possibly improving groundwater recharge (Burgess et al. 1998; Burgess et al. 2001). Tree roots may also have indirect effects on the hydrologic cycle through their role in nutrient and carbon cycling and improvements in soil structure.

Nutrient Cycling

Plant nutrient content of urban soils can range from highly deficient due to interrupted nutrient cycles and disturbed soils to overly abundant due to misapplication of fertilizers and other anthropogenic sources. Nitrogen deposition from the atmosphere has increased considerably over the past 150 years, and the consequences of this change are still uncertain (Holland et al. 2005). Urban ecosystems have been identified as sources of nutrient pollution to receiving waters (Boyer et al. 2002), particularly N and P. Urban and suburban watersheds have much higher N losses than completely forested watersheds (Groffman et al. 2004). The input of reactive N compounds in urban areas is also much higher than surrounding, less populated areas, with sources ranging from automobile engines and excessive N fertilization to pet urine and feces (Zhu et al. 2004). Rates of denitrification in urban areas can be very high compared to other ecosystems and N distribution is influenced by stormwater capture systems (Zhu et al. 2004). The effect of such nutrient hotspots on urban tree root systems is poorly documented. However, tree roots can help regulate nutrient cycles by influencing the supply and availability of nutrients in the soil via root turnover, root exudates, and nutrient uptake.

Trees can affect nutrient export by reducing stormwater runoff and soil erosion (see *Hydrology*); stormwater may carry nutrients as well as sediment laden with nutrients that may be tightly bound to soil (e.g., P). Trees can influence nutrient supply in the rhizosphere by biological N fixation, extracting nutrients – especially nitrate – from below the root zone of other plants, and reducing nutrient losses from processes such as leaching and erosion (Buresh and Tian 1997; Jama et al. 1998). Roots influence a complex set of nitrogen transformations that regulate production, flow, and loss of N in ecosystems (Fornara et al. 2009). In a Jamaican study, proximity to *Casuarina cunninghamiana* (river sheoak) trees increased N, NO_3, organic matter, P, Mg, K, Ca, pH, and CEC (Zimpfer et al. 1999). The researchers attributed this response to a complex symbiotic relationship with particular mycorrhizal species. On a global scale, nutrient cycling by plants alters vertical distribution of nutrients within the soil profile, keeping nutrients available nearer the soil surface (Jobbágy and Jackson 2001). For example, sloughed root cells and mucilage contain substantial amounts of soluble C and N (Jones et al. 2004), which is a source of energy for rhizosphere flora and fauna that in turn contribute to a consistent supply of N for plants.

Carbon Cycling, Soil Organic Material, and C Sequestration

Urban regions are large contributors to atmospheric CO_2 enrichment because of both high emissions and fuel use and minimal C sequestration (Kaye et al. 2006). In addition, daily average atmospheric CO_2 concentrations in city centers can exceed 500 ppm, whereas global mean concentrations are 379 ppm (Pataki et al. 2007; Lorenz and Lal 2009). Higher CO_2 concentrations enhance plant growth (Gregg et al. 2003), and trees fix this CO_2 via photosynthesis and sequester it into the soil through litter and root inputs. Urban soils have the potential to store large amounts of root-supplied soil organic carbon (SOC) and therefore to contribute to mitigation of increased atmospheric CO_2 concentrations (Lorenz and Lal 2009). The amount of SOC that can be stored is highly variable – the SOC pool at 0.3-m depth may range between 16 and 232 Mg/ha and between 15 and 285 Mg/ ha at 1-m depth (Lorenz and Lal 2009). SOC storage is also dependent on the local climate, land use, and parent material. For example, the cool, wet climate of northeastern United States favors higher accumulation of soil organic carbon than dry, rocky, arid climates (Pouyat et al. 2006).

The role of urban tree root systems in carbon storage has received limited attention, and research rests primarily on results from other ecosystems and laboratory studies. However, the potential for carbon storage through root deposition is considerable. Besides the deliberate incorporation of organic matter, carbon enters soil from plant litter, the release of carbon-rich root exudates, and root death along with associated mycorrhizae (i.e., turnover) (Grayston et al. 1997; Young 1998; Farrar et al. 2003). It has been estimated 2%–4% of net fixed C in plants may be directly deposited into the soil via root exudates (for a review, see Jones et al. 2004). These carbon compounds can also be taken back up by the plant in a controlled fashion (Farrar et al. 2003). Trees direct a greater proportion of their fixed carbon below ground when compared to annual plants, with rates from 40%–73% of assimilated C being demonstrated in studies with trees (Grayston et al. 1997). Up to 47% of carbon allocated to fine roots and mycorrhizae is deposited into soils through root turnover (Fogel and Hunt 1983). Not only does SOC increase activity of microorganisms, but the presence of the microorganisms can initiate a feedback system that increases root exudation (Meharg and Killham 1991). Carbon from plant roots therefore exerts a large control on the soil microbial community and consequently on overall soil health (Brant and Myrold 2006).

As previously discussed, urban soils are often very inhospitable to root growth. Stripping urban land of its vegetation and topsoil, coupled with elevated temperatures, also depletes soil organic matter and consequently decreases soil microbial populations, particularly in newly disturbed soils (McDonnell et al. 1997; Scharenbroch et al. 2005). Soil microorganisms are very important to tree growth because they are critical drivers of nutrient cycling, N fixation, nitrification, and the aggregation of clay particles (i.e., building of soil structure) (Lee and Pankhurst 1992). Urban sites in Colorado, U.S., that were fertilized and irrigated had greater microbial biomass than adjacent agricultural land that was not fertilized or irrigated (Kaye et al. 2005). Takahashi et al. (2008) compared soil C concentrations of different land uses [turf, trees "with management" (weed and litter removal), and trees "without management" in urban parks], and found that at 0–10 cm soil depth there were similar soil C concentrations, but at 10–30 cm, average C concentrations were lower for turf than they were for trees "with management." Trees "without management" resulted in far greater soil C concentrations than the other land uses.

CONCLUSIONS AND FUTURE RESEARCH

This review has focused on the ecophysiology of tree roots in the urban environment and how they interact with this human-dominated world. There are many unanswered questions that relate to management of urban tree root systems,

but comments here are confined to basic research questions that can provide a greater understanding of the role of the tree root system in the ecology of the urban rhizosphere. The following are proposed as possible areas of future research:

1. Biological community in the larger rhizosphere. Evidence is abundant that tree root systems cannot be fully understood separately from the microorganisms that inhabit the larger rhizosphere. Yet, we know little about these communities and how they develop in urbanized settings. The interactions that occur within the larger rhizosphere may not only influence tree growth, but also play a role in certain ecosystem services that trees provide, such as treatment of stormwater, that are now taking on a heightened importance.

2. Soil contamination. Urban infill development is growing in importance as societies seek to protect increasingly scarce agricultural and forested land from development and to rehabilitate previously developed land. Thus, professionals who work with urban trees will be increasingly faced with managing trees on sites that are undergoing rehabilitation, such as brownfields. Although considerable information concerning tree roots and contaminated soils is available from phytoremediation and mine spoils research, this work focuses on maximizing extraction of contaminants by trees and other plants with the intention of eventually harvesting the plant and safely disposing of it. Little is known about long-term challenges to growing trees in contaminated soils and the long-term effects of tree roots on contaminated soils.

3. Climate change. There is a growing body of scientific evidence demonstrating that global temperature is increasing, atmospheric CO_2 levels are rising, N deposition from the atmosphere is increasing, and urban heat islands are generating ground-level ozone. All of these factors affect root growth and development either directly or indirectly through mediation from the aboveground portion of the plant. What will be the responses of tree root systems in this altered environment?

The urban ecosystem is under increasing scrutiny as society strives to manage the environment in a sustainable way. Urban trees play a critical role in the urban environment on many levels. As we increase our understanding of the complex processes at play in the rhizosphere, we will not only be able to better manage landscape trees, but also more fully benefit from their role in urban ecosystem processes.

Acknowledgments. We are grateful to many people for their contributions to this project, including Julia Bartens, Francesco Ferrini, Greg McPherson, Paul Markworth, Tang Dai, Gary Watson, and Lisa Richardson-Calfee. We also thank the reviewers for many improvements to the manuscript. This project was supported in part by the International Society of Arboriculture and is a part of the ISA Literature Review Series.

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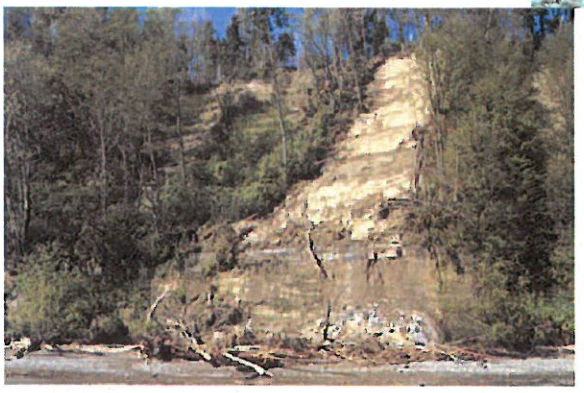
King Conservation District

Conservation Topic

Marine Shorelines: Geological Processes, Land Use Impacts & Conservation Practices



Acknowledgment

Special acknowledgment and thanks is given to Hugh Shipman of the Washington State Department of Ecology for use of photos and text taken from Coastal bluffs and sea cliffs on Puget Sound, Washington (2004), included in the body of this information paper. Utilization of portions of the cited paper aided significantly in the timely and efficient production of this paper.

Prepared by: Peter Landry, P.E., L.G. May, 2006

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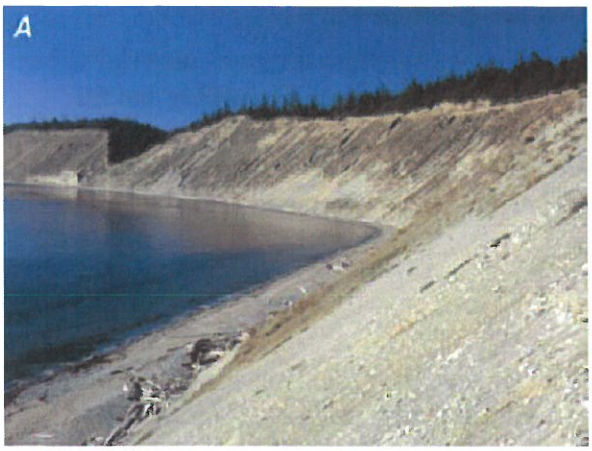
INTRODUCTION

When people think of shorelines they often think of expansive sand beaches backed by low lying lands stretching for miles behind them, sometimes with dunes and beach grasses separating the beach from the woodlands and communities which lie inland. This image, while representing much of the temperate coastal landscape including some of the Pacific Northwest Coast, does not reflect well the landscape of our Puget Sound Shoreline. In the Puget Sound region coastal bluffs and gravel beaches are the landscape most often encountered when one explores the shores of our beautiful inland marine waters.

Unfortunately, population growth in the region has significantly increased development along the shoreline. As much of the low-lying shores were already developed as ports and cities early in the last century, much of the current development is occurring along coastal bluffs. Much of this development has occurred with little awareness of the risks associated with erosion and landsliding, or the importance of these systems in maintaining the geological and biological integrity of Puget Sound's beaches and ecology with serious ramifications to public health and safety and the environment. The purpose of this text is to review some of the current knowledge of the coastal bluffs and beaches around Puget Sound, the processes that shape them, and some recently acknowledged management techniques that can aid coastal landowners in supporting and restoring their ongoing health.



Uniform slope of sand and gravel

Complex bluff profile of varied composition

In contrast, bluffs consisting solely of glacial till or marine drift may form near-vertical banks. Most bluffs, however, are cut through a sequence of sedimentary units, each with distinct slope forming properties. This can lead to complex bluff profiles containing both steep and gradual segments depending on the geologic, hydrologic, and mechanical properties of individual units. Poorly consolidated sands and gravels become slope-forming units, whereas glacial till and ancient lake bed silts and clays are often cliff-forming. The presence of distinct stratigraphic elements also impacts hydrologic characteristics that influence mass-wasting mechanisms, leading to more complex profiles. For example, many high bluffs on Puget Sound are marked by a mid-slope bench that forms at the contact between permeable advance outwash deposits and underlying impermeable lakebed clays. Saturation along this contact drives upslope failures that result in more rapid retreat of the top of the slope than the base, causing the bench to widen. These benches, which can vary from a few tens of feet to hundreds of feet in width, may exhibit highly irregular topography as a result of their origin in landslides from the upper cliff.

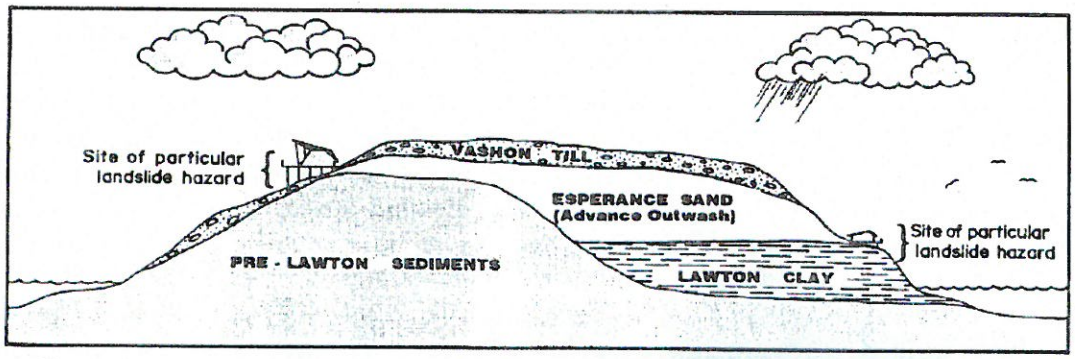


Figure 12. Sketch of a typical Seattle hill showing slope stability relations (modified from Tubbs, 1974).

Typical King County bluff profiles showing geologic composition.

HILLSLOPE AND LANDSLIDE PROCESSES

The most visible event associated with buff retreat occurs through landsliding. Slope failures can range from shallow slides a few tens of feet across to deep-seated landslides many hundreds of feet in size. It is important to realize that landsliding or "mass-wasting" is a natural part of the coastal system. Movement of material from the bluffs to the beaches is necessary for the nourishment of the beaches themselves. It is also important to realize that not all landslides are inherently hazardous. Many landslides represent the slow ongoing processes of weathering of slope sediment, and the transport of soil and woody debris to the beach where both are crucial to the existence and ecology of our unique Puget Sound shorelines.

Raveling

Poorly consolidated deposits of glacial outwash sands and gravels may erode primarily through raveling or surface erosion of the bluff face. Failures tend to be progressive, beginning with undercutting at the toe by wave action, then gradually extending upslope. Raveling tends to occur in areas where loose sediments are eroding rapidly enough so that protective soil binding vegetation cannot become established. If and when sufficient sediment moves downslope to protect and buttress the slope, vegetation can become reestablished and can protect the slope from surface erosion.

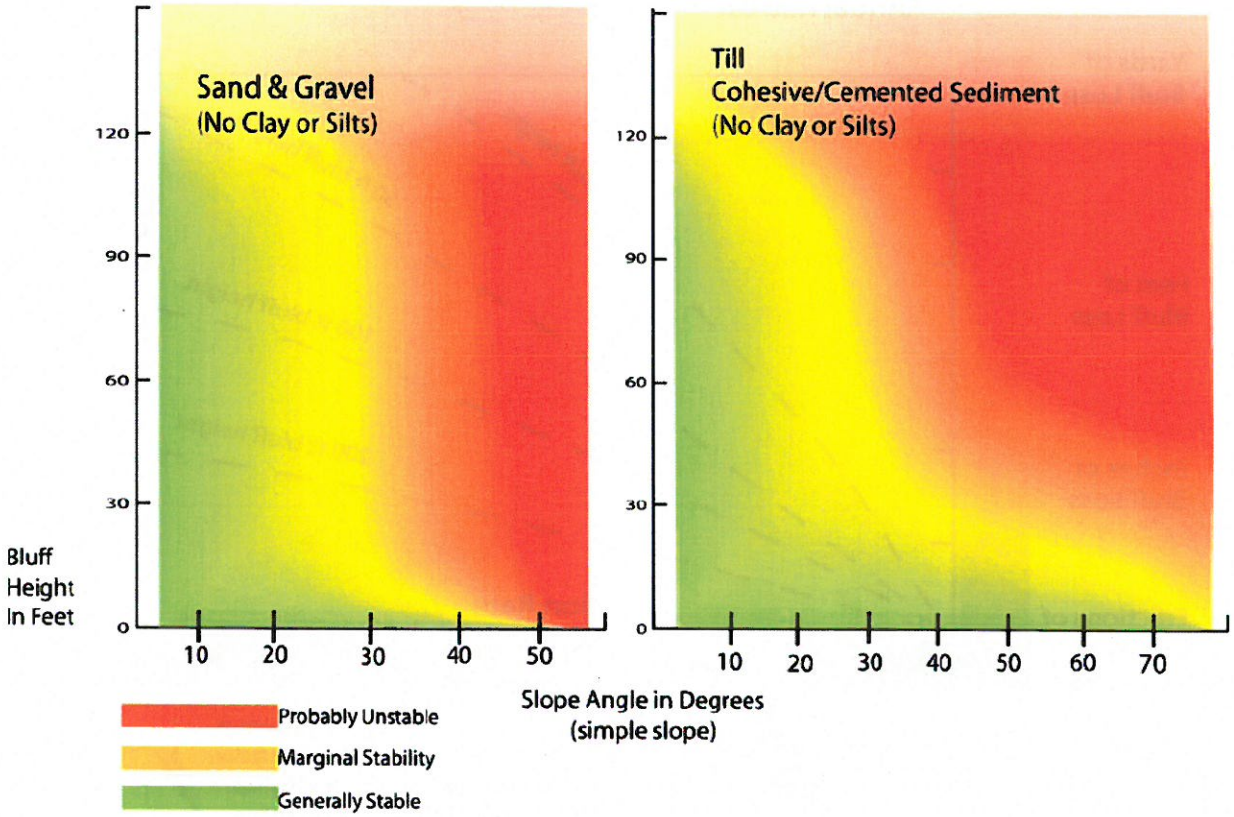
Shallow Landslides

Most landslides that occur on Puget Sound bluffs consist of shallow landslides and debris slides. Shallow landsliding is pervasive along many shoreline reaches, although any one site may slide only once every 30 or 40 years. These landslides typically involve only a thin layer of soil and associated vegetation generally involving the top 3 to 6 feet of the soil profile. Some extend the entire height of the bluff, but others only affect a portion of the slope. Shallow failures may occur as small slumps, debris slides, or as topples of overlying glacial till. Single slides may occur by several mechanisms — for example, a block failure of glacial till high on a bluff may develop into a larger landslide as it moves downslope. Shallow slides are usually triggered by heavy rainfall over a period of hours to days. They are easily caused by drainage failures or modest redirection of surface drainage.

Large Slumps and Landslides

Puget Sound is subject to occasional, much larger, landslides that may involve many thousands of cubic yards of material. These slides are much less common than shallower slides, but would be devastating if they occurred in a developed area. Understanding of the geologic conditions that give rise to these large slides is limited, but such slides seem to be associated with higher bluffs and have been triggered both by elevated groundwater levels and by earthquakes. Coherent geologic units, such as glacial till and glacial marine drift, tend to fail as blocks on near-vertical slopes. When basal support is lost, through direct undermining by waves or by erosion of underlying units, failures occur along joints or tension cracks that form parallel to the bluff face. Block failures are typically a meter or less in thickness, although faces with greater relief seem capable of generating thicker failures.

The figure shown below shows the basic relationship between bluff height, slope angle, geologic composition and general slope stability. Relating to bluffs without significant structural defects such as clay at the bluff base, this figure is provided to give the reader a basic understanding of the interplay of these elements. Due to the complexity of geotechnical evaluation techniques this figure is not meant as a alternative to consultation with qualified professionals. Always consult with your local government and qualified professional consultant before making important decisions regarding any critical area slope.



Relationships between bluff height, slope angle, geologic composition and general slope stability

RATE OF BLUFF RECESSION

Long-term bluff recession rates on Puget Sound reflect three primary factors, including wave action, bluff geology, and beach characteristics. Waves provide the energy necessary to erode the toe of the bluff and to remove eroded sediment from the site. Geology determines the resistance of the bluff to erosion and its susceptibility to landslides that deliver erodible material to the base of the slope. The width of the beach and the height of the beach berm control the frequency and intensity with which waves can reach the bluff toe. The highest erosion rates measured on Puget Sound and in the Georgia Strait occur in fairly loose sediments where wave exposure is high. Galster and Schwartz (1990) found that erosion rates of bluffs west of Port Angeles were as much as one meter per year before the shoreline was armored. Keuler (1988) determined rates of over 30 cm/yr on the western shore of Whidbey Island with significant exposures along the Strait of Juan de Fuca. These rates are not typical, however, and in most areas recession rates appear more

erosion rate can give an indication of the long-term bluff recession rate.

COASTAL DEVELOPMENT

Pressure to build along coastal bluffs is rising rapidly with increasing population growth and urbanization in the Puget Sound region. Much of the shoreline lies within a short distance of the major metropolitan centers of Seattle, Tacoma, and Everett. These areas have seen a significant shift in the character of shoreline development from small seasonal retreats and retirement cabins to large primary residences. The demand for waterfront and bluff property is driven primarily by access to the water and unimpeded views of the Sound and nearby mountains. Development along bluffs most commonly occurs at the top of the bluff. The distance a building is set back from the bluff edge depends on local regulations, the history and age of the structure, the topography of the site, lot lines, and the original property owner's concept of risk and their desire for views. Property owners often build as close to the edge as allowed, in large part to maximize views in an otherwise forested area. The risk to bluff top homes is relatively low as a consequence of slow erosion rates, although a property owner's perception of danger may be greatly enhanced by periodic landslides or related bluff failures.

Since the early days of European settlement, development has occurred at the base of steep coastal bluffs. In some cases, homes are built on spits, stream deltas, or related depositional landforms waterward of the bluff toe. In other cases, development occurred on artificial fill placed across the backshore or beach. In several locales residential developments were created in the 1950s and 1960s by constructing bulkheads on the beach below a high bluff and then using hydraulic methods to wash bluff material in as landfill. The legacy of such development is rows of homes at water level, constructed on non-engineered hydraulic fill, and located at the base of unstable bluffs 100-200 feet high. In some locations, homes (and in the case of Tacoma's Salmon Beach, an entire community) were constructed on piles over the beach at the base of high bluffs. Such development would not be allowed today for many safety and environmental reasons, but where it already exists, we observe regular conversion of small cabins into large homes and periodic slide damage to homes. Although the steeper coastal bluffs largely preclude development on the slopes themselves, development can and does occur in less extreme situations. Building is common on more gradually sloping portions of complex coastal slopes, and in particular, on the mid-slope benches that characterize many bluff shorelines. These areas often appear to offer prime building sites in otherwise difficult to build areas. Unfortunately, these benched slopes often reflect unstable geologic conditions. Another circumstance where building occurs on the slopes themselves is in areas where property lines, old unregulated building practices, or modern heavily engineered development have led to homes being constructed on piles or multilevel foundations either above or into the face of steep slopes.

HUMAN IMPACTS ON SHORELANDS

Humans are in themselves an agent of bluff erosion, at least in their capacity to trigger landslides or increase erosion through careless or imprudent development practices. The occurrence of landslides and the continued erosion of coastal bluffs is a natural process, but humans, primarily through their propensity to modify natural hydrology, can easily exacerbate unstable conditions or trigger slides. Puget Lowland is a heavily forested area with high precipitation. Surface runoff and subsurface saturation are highly sensitive to the abundance and type of vegetation. Land

Bulkheads

Shoreline bulkheads are often used on Puget Sound to address wave-induced toe erosion. Numerous materials are used, including concrete, wood, and rock, and a variety of designs are employed, including gravity walls, riprap revetments, and sheet pile walls. The most commonly built structure is a steep rock bulkhead or rockery. These structures are typically less than 6 feet high and are required by regulations to be located as close to the bluff toe as possible. The effectiveness of bulkheads varies considerably. The wave environment in most of Puget Sound is sufficiently protected that structures need not be massive to address local wave conditions. Bulkheads are often seen as a panacea for coastal slope stability problems, however they are an approach that overemphasizes the role of waves in determining overall slope stability.

On many shoreline bluffs the slope is already over-steepened and more likely to fail during a heavy rainfall than during high wave conditions. Many of the landslides during the heavy rainstorms of 1996-97 occurred on slopes where bulkheads had protected the toe for many decades. Although bulkheads are commonly used to protect the toe of slopes from wave action, in some cases (for example, after a failure of a coastal bluff already protected by a bulkhead) property owners have built multiple-stage retaining walls, reinforced soil embankments, or have otherwise modified the geometry of the entire bluff. In the case of deeper sliding, larger rock toe buttresses have been constructed, but regulations preventing encroachment across the beach increasingly discourage such solutions. Biotechnical stabilization methods have received much interest in recent years, in part because of their potential for addressing slope stability problems in environmentally sensitive areas, but their actual application has been limited.

Special Foundations

Sometimes the use of deep or pile foundations can provide an additional margin of safety for structures built close to certain types of coastal bluffs. Over the last few decades pile foundations have become more frequently employed by engineers to protect structures from possible shallow slope movement and settling. It is also possible to retrofit existing homes with foundations that can lessen risks associated with the movement of bluff sediment.

Environmentally Sustainable Approaches to Bluff and Property Protection

There are a limited number of landuse and protective measures which can reduce the amount of impact we have on a bluff system, and protect both property and the environment. These measures include the following:

- Minimize impervious surfaces near bluffs
- Preserve and enhance native bluff and near-bluff trees and vegetation whenever possible
- Detain and properly convey stormwater to safe discharge point and dissipate flow energy
- Conduct risk assessment and set back buildings accordingly
- Preserve natural shoreline protection elements such as driftwood, berms, and beach grasses
- Avoid and discourage use of bulheads and groins, which can have adverse impacts on beaches
- Utilize special foundations to protect structures instead of bulkheads where practical

Vegetation Management: A Guide for Puget Sound Bluff Property Owners

May, 1993
Publication 93-31

Vegetation Management: A Guide for Puget Sound Bluff Property Owners

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This manual is funded in part by the National Oceanic and Atmospheric Administration. The views expressed herein are those of the author and do not necessarily reflect the view of NOAA or any of its sub-agencies.

The recommended bibliographic citation for this publication is: Menashe, Elliot. 1983. *Vegetation Management: A Guide for Puget Sound Bluff Property Owners*. Shorelands and Environmental Assistance Program, Washington Department of Ecology. Olympia.

Publication 93-31

Contents

Preface

This publication has been prepared to provide property owners and others with information about the role, benefits, and management of existing vegetation common to steep, often unstable shore sites in the Puget Sound area. It will also identify and discuss the limitations of plant cover under some conditions. The focus of this guide is on vegetation management during site development with an emphasis on reducing the hazard of surface and mass soil erosion (landslides).

It is beyond the scope of this publication to deal with the effects, advisability, or design of shoreline armoring structures such as bulkheads. Refer to *Marine Shoreline Erosion: Structural Property Protection Methods* in "Recommended Reading." The subject of vegetative restoration of slopes will be discussed in a companion publication, *Slope Stabilization and Erosion Control Using Vegetation*, that will be published concurrently with this guide. Issues regarding sealevel rise, beach nourishment, regulatory management of shorelands and other important topics are likewise not addressed here.

Vegetation management is a crucial element of an overall shoreline management strategy. The Shorelands and Environmental Assistance Program (Shorelands) of the Washington State Department of Ecology (D.O.E.), in an effort to deal with coastal and Puget Sound erosion concerns, has been exploring a multiplicity of issues for several years. The Coastal Erosion Management Strategy (CEMS) project, initiated in 1992, is a comprehensive effort to coordinate research, assessment, and monitoring of beach processes and erosion control measures. For more information on the CEMS project, or to order the Department of Ecology publication listed in "Recommended Reading," contact:

Shorelands and Environmental Assistance Program
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Acknowledgements

I am indebted to the Washington State Department of Ecology for providing the opportunity to research and write this guide. In particular I would like to thank Jim Scott, Hugh Shipman, and Douglas Canning for their technical expertise and willingness to answer innumerable questions. A special thanks to Jim Scott for his layout and formating of the manuscript. Thanks also to Beverly Huether, Contracts Coordinator.

Individuals who have been especially tireless in technical review and suggestions include Gerald Thorsen, Consulting Geologist; Clayton Antieau, Ebasco Environmental; Jim Fox, Fox's Tree Service; Lisa Lewis, Hood Canal Ranger District of Olympic National Forest; Shelley Farber, Washington State Department of Natural Resources; Karen Kerwin, Snohomish County Public Works; and Island County personnel, Mike Morton, Dave Bonvouloir, and Jim Hossley.

I would like to acknowledge the following people for their generocity in providing me with valuable technical doucuments during the manuscript preparation: D.N. Swanston, USDA Forest Service, Juneau Forest Sciences Laboratory; J.W. Schwab, British Columbia Ministry of Forests, Smithers, B.C.; Will Carr, Terrasol, Vancouver, B.C.; and Ken Russell, Washington State Department of Natural Resources, Olympia, Washington; and Don Minore, USDA Forest Service, Corvallis Forest Sciences Laboratory, Corvallis, Oregon.

The patient assistance of Abbey Carpenter and Janie Pulsifer was invaluable in editing, proofing, and preparation of this manuscript. Thanks to the illustrator, John M. Dispenza for rendering my rough sketches presentable, and to the Island County Beach Watchers for the phrase "Living on the Edge."

Although many people and publications have helped in preparing this guide, I take responsibility for the content and accuracy of the information presented.

Elliott Menashe

Greenbelt Consulting

A Word of Caution

There is a lack of detailed research on vegetation management for Puget Sound bluff sites. The information and recommendations provided here have been gathered from a variety of published and unpublished sources in forestry, fisheries, geology, horticulture, soil science, and arboriculture. Many of the observations and suggestions are based on the experience of the author and from conversations with researchers and land managers from the United States and Canada.

This guide is not intended as a substitute for professional assistance. Readers are advised to become familiar with any federal, state, county and/or municipal ordinances that may apply to development of shoreline sites. Neither the author nor the Washington State Department of Ecology assumes responsibility for any results or consequences that arise from the treatments or techniques mentioned in this guide.

Readers who have additional information, pertinent bibliographic citations, or management suggestions are invited to submit their comments to the Washington State Department of Ecology's Shorelands and Environmental Assistance Program or to the author at:

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Introduction

Imagine you have just bought the property in Illustration 1. You are going to build your dream house here. Note the stand of trees on the uplands, the brush and trees growing on the crest, and the scattered growth on the face of the bluff. The information in the guide will help the following unfortunate scenario from happening to you.

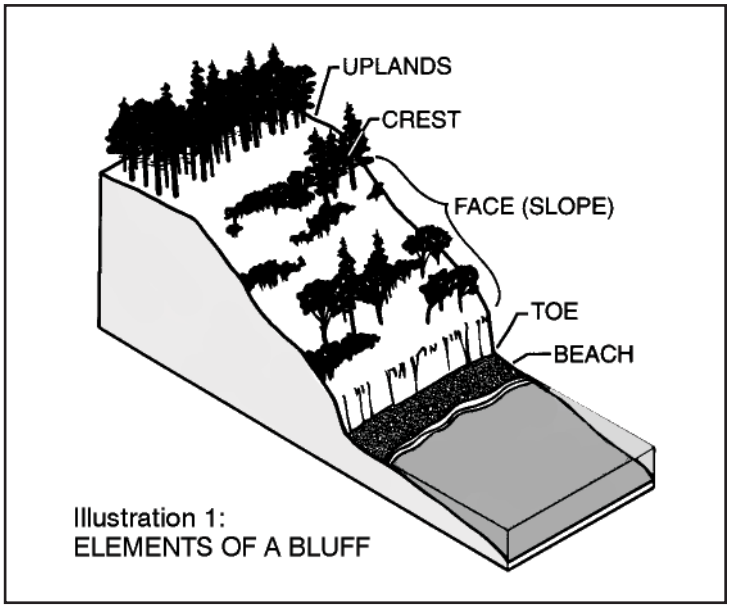


Illustration 1:
ELEMENTS OF A BLUFF

Heavy equipment clears the brush and small trees from the uplands. Trees on the bluff top are cut; their stumps and roots are pulled and pushed over the crest. Clearing debris are piled and burned or join the stumps over the bluff edge. Trees on the slope and crest are removed or topped to open up the view. The top of the bluff is graded to remove topographic irregularities and allow free access to the edge.

The home is sited as close to the crest as possible to obtain the most dramatic panorama. The septic system is installed. Excavations for foundation footings are dug. Trenches for water, power, and waste lines are dug. Roof and footing drains are installed. Construction of the residence is begun. The house takes shape quickly. As construction proceeds, a stairway is built to the beach and more trees and brush are removed from the slope.

The area surrounding the house has been repeatedly scraped, graded, and subjected to traffic. Soil has become compacted and fairly impervious to water. It is doubtful that it will support a lawn. A landscaper is called in. Topsoil is brought in and the lawn is installed. Flower beds are built and ornamental trees are planted. In neglected corners of the clearing thickets of alder, thistle, and Scot's broom grow in the disturbed soil.

After several years some irritating problems begin to worry you. The lawn dries out in the summer and requires frequent watering. In the winter the yard is soggy and puddled. The few trees left on the bluff top have blown down, died, or the tops of some have broken in the wind. The brush below the crest has grown too tall to see over

and young alders have begun to obscure the view. The trees that were topped are also in the way again and make you nervous when the wind blows. The trees you planted don't seem to be doing well; they are brown and dead-looking on the seaward side.

A tree trimmer tops the trees again and cuts the brush and alder so your view is back. He mentions that some of the old stumps from the initial view-clearing are becoming undermined by erosion and the rootwads that were pushed over the edge made it difficult to work. They have been sliding downslope and have caused some small landslides. He also remarks that in places the edge of the bluff is undermined and seems unsafe. He notices that there are several patches of bare ground and signs of mudslides. You are surprised and concerned. You don't remember seeing bare spots the last time you used the stairway to the beach, though you have not been down there since a washout made it unsafe.

After the tree trimmer's visit you decide to call a geologist. Her investigations indicate that the slope shows signs of serious surface erosion, soil slumpage and the potential of a landslide. She also notes the undermined crest and suggests it be fenced off from use. She says that bluff retreat has accelerated and advises that perhaps the house be moved further back from the edge in the near future. You are understandably unhappy and wonder how your dream house could become such a nightmare.

The scenario above is rather dismal. While often the situation is not this bleak, these problems nevertheless occur all too often in the Puget Sound area. Many of the problems property owners experience in regard to surface erosion and slope failure can be attributed to ill-advised clearing of vegetation. It can sometimes take years for the consequences to become evident. Thus it is crucial that property owners understand the role of vegetation in the shoreline environment and how proper management and planning during development of shore and bluff sites can benefit the land and protect your investment.

Vegetation management should be incorporated into your site development plans before you begin construction. This requires that you understand the role of vegetative cover and its ability to protect a site in relation to topography, drainage patterns, soil type, and natural shore processes such as wave attack. Also, before you alter the shoreline environment, it is wise to first learn how it was formed and the processes that are continually shaping it.

Keep in mind that vegetation alone cannot protect against erosion in all cases. Vegetation cannot withstand wave attack at the toe of a slope, nor will it prove effective in stabilizing a slope already subject to deep-seated mass soil movements. If you suspect problems of this nature, seek the services of a geologist who is familiar with conducting geotechnical site investigations before you build.

Could the difficulties our hypothetical homeowner suffer have been avoided? What could have been done differently? Would careful clearing and tree trimming rather that removal have made a difference? There are no "cookbook" recipes for maintaining the stability of dynamic shorelands, but a knowledgeable property owner is less likely to make mistakes that could have been avoided. The purpose of this guide is to give you the the resources to make informed choices.

Chapter 1: The Shoreline Environment

Living on the Edge

Beaches and shorelands are dynamic zones between land and water, an intricate landscape continually shaped by water and wind. Where water meets land, land changes, and though the glaciers receded long ago, water continues to shape the shores of Puget Sound. Sometimes the changes are gradual, almost imperceptible. At other times one winter storm brings drastic changes in a matter of hours. Consider the following a primer on how our shores were formed and the processes at work today.

Glacial Origins

Much of Puget Sound's uplands are comprised of and underlain by glacial and interglacial deposits of sand, gravel, silt, and clay. Repeated glaciations have sculpted, compacted, transported, and deposited these materials. The most recent of these, together with stream and shoreline processes, formed the landscape we see today. This landscape is generally characterized by steep, eroding bluffs of glacial and interglacial sediments, and narrow beaches. In places such as the northern end of Whidbey Island, and the islands of Skagit, Whatcom, and San Juan Counties, bedrock is exposed and the beaches are commonly discontinuous.

Factors Affecting Bluff Stability

Several geologic, topographic, and watershed-related characteristics can determine general slope stability and the type, rate, and severity of erosion common to shorelands comprised of glacial and interglacial materials. (Rocky shores and sites of exposed bedrock are not discussed specifically but much of the information on the role and management of vegetation will apply.) The Coastal Zone Atlas (see "Recommended Reading") for your county is a valuable source of information. County planning and engineering offices usually have a copy available for the public. Property owners should become familiar with the characteristics of their land before beginning clearing or grading.

Soil Type, Bluff Materials and Stratigraphy

Soil types vary greatly depending on the kind of materials they are formed of, the plants that have grow and died within them, their composition, and many other factors. A detailed discussion of soil types can be found in the Soil Survey for your county. (See "Recommended Reading" or contact your Soil Conservation Service Office.) For the purposes of this guide, we will be discussing the basic properties of soils that dictate how much water they can hold, how well they grow plants, whether they can support and anchor trees and how susceptible they are to erosion. Simply put, soil is the upper layer of "dirt" we are all familiar with. It has characteristics of texture, color, depth, moisture, and fertility. Soil is what our hypothetical landowner scraped away with the brush during land clearing.

Bluff materials refer to the sand, gravel, clay, silt, and glacial till that comprise many Puget Sound bluffs. Their characteristics and properties can influence the extent to which a site may be prone to erosion and slope instability.

Stratigraphy, the sequence of bluff materials in a particular shore profile, can influence whether your property is well-drained or boggy, if your trees are prone to blowing down, or whether you should move your house site back another fifty feet.

The **properties** of bluff materials vary depending on

whether they are generally coarse or fine textured. Soil types derived from bluff materials will have many properties in common, but will differ in factors such as depth, organic material (humus), and mixing of coarse and fine textured materials. For example, soils with high percentages of clay materials will be more prone to compaction than sandy soils, and soils with high humus content hold water better than purely mineral soils. The properties and characteristics that property owners need to know are outlined below.

Coarse-textured materials (sand, gravel)

- Readily permeable to water infiltration
- Highly susceptible to wave action
- Soils prone to surface erosion
- Soils readily penetrated by plant roots
- Soil less subject to compaction

Fine-textured materials (clays, silts)

- Resist water infiltration
- Become slick when wetted
- Somewhat resistant to surface erosion
- Resistant to penetration of plant roots
- Susceptible to wave action
- Clay soils highly susceptible to compaction

Glacial till (wide range of textures)

- Resistant to water infiltration
- Resistant to surface erosion
- Moderately resistant to wave action
- Soil resistant to further compaction

Glacial till (or hardpan) is usually comprised of combinations of the above and is characterized by being very hard and compact.

The materials that make up Puget Sound bluffs can be extremely diverse in composition. There will often be mixtures of the coarse and fine-textured soils within one layer and the thickness of individual layers can vary considerably. The stratigraphy of these soils can also be complex. Each combination and configuration responds differently to wind, water, and the force of gravity. For instance, glacially compacted materials are harder and denser than those sediments deposited later.

Topography

The presence of swales, gullies, or drainage channels on or adjacent to a shore site can affect surface water movement. These features can direct surface water flow towards or away from the bluff face and slope. They also affect the accumulation of sub-surface water and groundwater. The sometimes steep sides of such features can concentrate and accelerate runoff, increasing surface erosion. These features often indicate the site of past erosion or landslides. Modifications of existing topography should not be undertaken lightly.

Steepness of Slope

The tendency of bluff materials to fall, slide, or flow downslope depends on the force of gravity, other factors being constant. For example, sand and gravel banks are stable at around 30 to 40 degrees. If the slope is modified by wave attack or other means, that material will seek a new equilibrium causing a mass soil movement. Many vegetated slopes in Puget Sound are at or beyond this equilibrium point. The removal of vegetation can tip the balance of forces.

Steep, almost vertical bluffs composed of glacial till are common in the area and can sometimes stand for years if undisturbed. When subjected

to wave attack and erosion, however, they may collapse.

The importance of slope gradient in determining stability must be assessed in conjunction with factors such as soil characteristics, stratigraphy, topography, and watershed characteristics. These factors are greatly influenced by the shore processes discussed below.

Causes of Erosion

Natural Processes

The erosive agents of water and weather act on bluffs in several ways (Illustration 2). As mentioned, these processes occur constantly, altering and modifying shorelands over time.

Beach processes, in particular the transport of beach materials along the shore by the combined action of waves, currents, and wind, can create a protective area between the waters of the Sound and the toe of a bluff. This area is called a backshore and is generally stable and dry from year to year. These are the beaches we walk on at high tide in the middle of winter when most others are inaccessible. Often they support the growth of vegetation and are above the drift line where logs accumulate. The result of net accumulations of sand and gravel, they are termed "accretional beaches" and they are relatively rare in an area where most beaches are erosional (that is, the result of net removals of sand and gravel). They are significant in terms of bluff stability because they offer a natural buffer from the erosive forces of wave activity. The shore shown in Illustration 2 has no protective backshore and thus is subject to wave attack.

Water is widely regarded as the most important force at work on shore sites. It can be misleading to discuss water-related processes separately; they often act in combination. Property owners should be cautious when attempting to control one problem because they may create other hazardous situations.

Wave action on shorelines with narrow beaches can attack the base of bluffs, eroding the toe, steepening the slope, and decreasing bluff support. This process is most active during winter months when storm-generated waves increase in size, and storms in frequency.

While wave attack is often an important cause of mass soil failures, it is not always a precipitating factor. Other factors, such as surface erosion or groundwater may actually be the cause of a bluff failure. The construction of traditional erosion control structures such as bulkheads, seawalls, and other devices designed to protect the toe of shore slopes

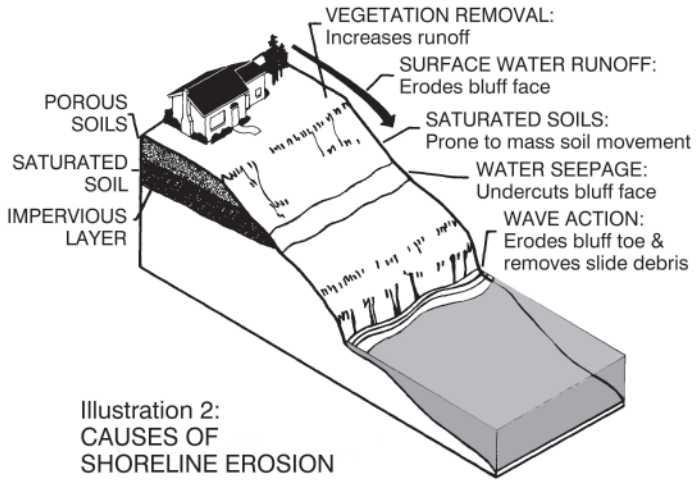


Illustration 2:
CAUSES OF
SHORELINE EROSION

from erosion can be expensive and ineffective. Current research has indicated that, in some cases, they will actually aggravate unstable situations by directing or deflecting wave energy that can result in outflanking or undermining the structure. For a thorough discussion of this subject refer to the "Recommended Reading."

Remember that bluffs undergoing active erosion from wave attack cannot be protected by the presence of vegetation. If you determine that your bluff is actively eroding, it is wise to site upland structures far enough back from the slope so they are not in jeopardy. In many Puget Sound counties there are bluff setback requirements in the zoning ordinance to guide homeowners. Prudent setbacks allow natural beach processes to occur without the need for disruptive and expensive engineering solutions.

Groundwater influences bluff properties in a variety of ways. The extent to which a particular site is subject to groundwater problems is a function of bank materials, stratigraphy, and our wet winter weather (though rainfall varies greatly within Puget Sound). During the winter, rainstorms are frequent and of long duration while evaporation from the ground is reduced due to increased humidity. Like wave action, groundwater impacts increase during the winter.

Much of the rain falling on the land soaks into the ground. If the upper layers are coarse-textured and permeable, the water percolates down until it reaches a layer of lower permeability such as the denser clays. This interruption of groundwater movement is often referred to as perched water; its subsequent lateral movement and discharge on exposed bluffs is commonly observed as seeps or springs.

The two influences of increased groundwater on slopes are shown in Illustration 2. When the soils above the impermeable layer become saturated, they are subject to landslides in the form of slumps, earthflows, and debris avalanches. This movement on a previously stable site is the result of a drastic reduction of the soil's ability, when wet, to resist the force of gravity (Illustration 6). This is the most common way groundwater affects slope stability.

Where seeps appear on bluff faces, the discharged water erodes the soil below, causing the upper unsupported layers to fall or slide. This can be a problem where bank materials below the seep discharge are erodible sand or gravel.

Vegetation can play an important role in maintaining stability in these situations. The removal of groundcovers and trees from uplands and bluff faces is a major contributing factor in triggering these events. (This will be discussed at length in Chapter 2.) However, vegetation alone cannot prevent occurrences of this nature if they are precipitated by other factors. Unusually heavy rains can often increase local groundwater influences (such as saturated soils) and initiate serious mass soil movements. Clearing of adjacent property can exacerbate these problems on your land.

Surface water runoff and the sediments it carries as it flows have been perceived as relatively unimportant as an erosional hazard in the Puget Sound area. However, while its effects are not as dramatic as landslides or bluff collapse caused by wave action, surface erosion can become a serious problem that is difficult to repair. Aside from the impacts to water quality, marine life, and soil productivity, soil erosion by surface water can have serious implications for bluff property owners.

The two most serious initiators of surface erosion on shore properties are clearing of ground and tree cover and the compaction or disturbance of shallow soils by construction-related activities such as grading. The role vegetation plays in reducing and guarding against surface erosion is discussed in detail in Chapter 2. The subject of construction-related surface erosion is touched upon in Chapter 4, "Vegetation Management: Other Commonly Asked Questions."

Illustration 3 shows the process of surface erosion and the damage it can cause. The process is initiated by the force of **raindrops** striking bare ground and dislodging soil particles. Once dislodged they are transported and become agents of further erosion. **Sheet erosion** occurs when the ground can no longer absorb water or the rate of flow exceeds the percolation rate (like filling a coffee filter too fast). More soil is dislodged and joins the flow. Topographic features concentrate the flow and are deepened, developing into **rills and gullies**.

Governing the severity and rate of surface erosion are slope, topography, and the properties of the affected soils. Obviously the steeper the slope, the faster the water flows and the greater its erosive capacity. Topographic features such as ditches and swales direct the flow. Soils such as sand and gravel are more prone to surface erosion than denser fine-textured soils.

Weathering of shore landforms by wind, rain, and freeze/thaw cycles is constantly occurring. Wind can be a cause of substantial erosion on sandy bluffs exposed to heavy gales if there is no vegetative cover. Rainwater falling on undisturbed sites causes some weathering but is not an important consideration when vegetative cover is present. The freeze/thaw cycle levers and breaks up the surface of exposed bluff faces and contributes to weathering, even on rocky slopes, but is rarely of concern in the Puget Sound area.

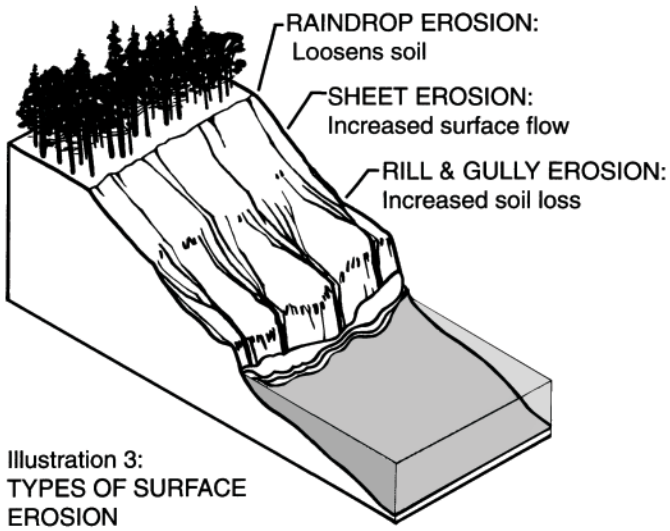


Illustration 3:
TYPES OF SURFACE EROSION

Human impacts

Human impacts that modify the factors and causes discussed above can potentially initiate or accelerate erosion and mass soil movements. Many of the problems encountered by our hypothetical owner in the Introduction could have been avoided or minimized. Below is a list of alterations and modifications common during site development. Their impacts should be considered carefully.

- hydrologic changes, both surface water and groundwater flow

- topographic changes due to excavation or filling
- vegetation removal
- construction or road building in marginally stable areas
- soil compaction by heavy equipment

Questions to Answer Before You Begin

The key to maintaining a stable bluff lies in recognizing the natural forces at work on your site. We have discussed the major processes that contribute to unstable situations and the factors that need to be considered. Obviously, some properties and bluff sites are difficult or impossible to develop while maintaining stability. It is important to recognize these sites and to avoid the expense and frustration of attempting to develop them. If you are considering the purchase of bluff property, these questions will be valuable guidelines for what to avoid. If you already own a problem site the questions below will serve as a checklist to help you make decisions.

- Is the bluff presently stable?
- Are there signs of past instability (landslides)?
- Can you determine when the last one occurred?
- Is the bluff toe subject to wave attack?
- If subject to wave attack, what is the nature and frequency of such action?
- Is the shoreline accreting or eroding?
- If eroding, what is the rate of bluff retreat?
- Would a greater setback of structures from the edge be practical?
- What materials comprise the bluff?
- What is the stratigraphic sequence of the sediments making up the bluff?
- What are the soil moisture and groundwater conditions?
- Is there surface water drainage over the bluff on or adjacent to the property?
- What is the angle of the bluff?
- What vegetation is present?
- Is the property large enough for your purposes (i.e., required setback, driveway, septic, yard, and home)?
- Can the property be developed successfully without initiating or aggravating erosion?

Some of these questions cannot be answered adequately by the homeowner and require the help of a geotechnical expert.

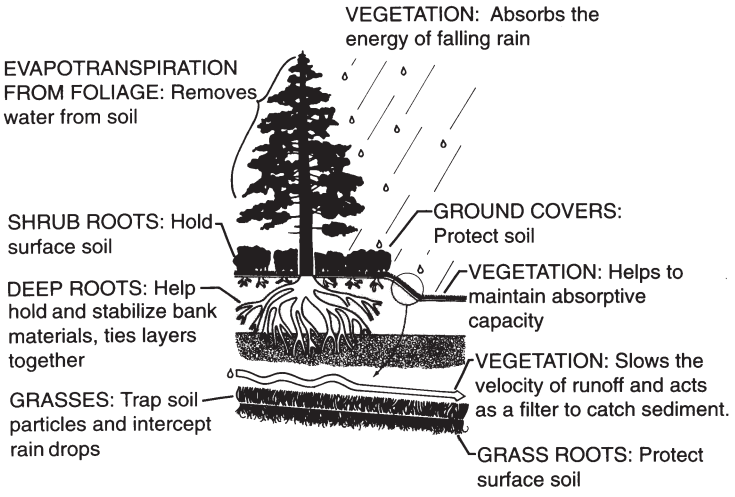


Illustration 4:
EFFECTS OF VEGETATION IN MINIMIZING EROSION

Chapter 2: Vegetation on Shore Bluffs

When property owners become aware of the dynamic and fragile nature of shore areas through an understanding of the landscape's origins and the processes continually shaping it, they are better able to answer some of the questions listed at the end of Chapter 1. A knowledge of the nature and functions of the vegetation growing on these sites is no less important if they are to avoid the sometimes disastrous consequences of ill-advised development practices.

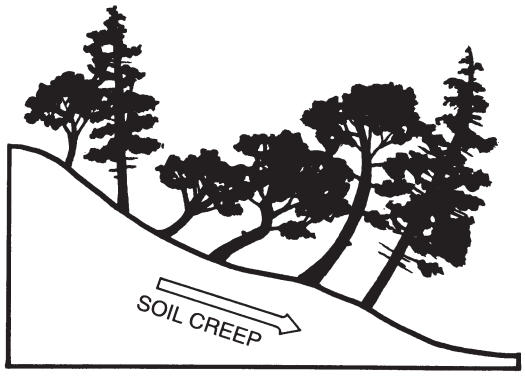
The Role of Vegetation in Minimizing Erosion

Illustration 4 shows ways vegetation protects soil from surface erosion. Live plant foliage and forest litter (partly decomposed leaves, twigs, etc.) break the force of falling rain and reduce the impact of raindrops, which can loosen soil and transport it downslope. Absorptive capacity of the soil is increased substantially by the presence of forest litter, which acts as a sponge by holding water and releasing it slowly over an extended period. Low-growing plants catch and slow rainfall and allow some moisture to evaporate from leaf surfaces. Groundcovers and forest litter also help reduce surface water runoff velocity and act as a filtering system for soil particles in suspension. Plants draw water up through their stems or trunks and branches to their leaves and into the air by the mechanism of transpiration, thereby removing water from the soil.

Plant roots, especially the smaller feeder roots, provide a fibrous web that stabilizes and anchors soil. They function much like reinforcing steel in concrete structures, increasing the cohesive strength within a soil horizon. The roots of many brush and tree species penetrate deeply across the contact zone between two soil layers, thus increasing the soil's shear strength and reducing risk of shallow landslides.

Several layers of plant foliage multiply the benefits discussed above. Ideally, a site will support low groundcovers, small shrubs, taller shrubs, and small and large trees.

Vegetation, though more effective in protecting against surface erosion than in controlling mass soil movements triggered by groundwater, can still be valuable in sustaining slope stability. As mentioned, many bluff sites are barely stable and the removal of vegetation on some slopes can precipitate a landslide or re-activate an old one. Due to the complex root network formed by trees and shrubs, potentially unstable slopes are held together and the resistance of the soil to slipping, sliding, and washing away is increased. Slopes susceptible to soil creep (Illustration 5) are also held in check to some degree by the presence of vegetation.



Soil creep causes districtive curved form of tree trunks over time.

Illustration 5:
INDICATIONS OF SOIL CREEP

The ability of plants to absorb water and slow its velocity also allows time for soils to "meter" the absorption and discharge of water more effectively.

Vegetation Indicators of Slope History and Stability

The type, age, health, and abundance of vegetation growing on a shoreline bluff site can offer valuable clues to determine slope stability. Even the presence of stumps and fallen trees can tell a story to a knowledgeable observer. This section discusses these clues and what they may indicate. Vegetative indicators are best interpreted in combination with soil and geological data.

Curved Trunks

Trees on a slope curved as shown in Illustration 5 are usually the result of a slow, gradual soil creep. Care should be exercised in clearing sites like this because you may de-stabilize an already marginally stable area.

"Jackstrawed" Trees

Illustration 6 shows the jumbled appearance of trees after a slump or earthflow. In situations like this, groundwater problems can cause a mass of soil and the vegetation on it to move downslope. If the trees are dead, this may indicate that the roots were sheared or broken loose.

Trees Tipped Downslope

On sites with shallow soils and steep slopes, this may indicate mechanical shifting of materials and signal the potential for a slope failure.

Groups of Trees Growing Across the Slope in a Line

Lines of trees growing across a slope may indicate two conditions. If the trees are species such as Red alder or willow, a slide may have caused bare ground in the recent past, subsequently offering a site for germination and growth of these fast-growing trees. Chances are good that the slide is active and periodic. The age of trees growing in this manner can be a clue to when the slide occurred.

A line of trees may also indicate an area of perched water or groundwater seepage that in turn may indicate a layer of impervious material underlying a deposit of sandy soil (Illustration 7). These sites usually are unstable and should be investigated geologically.

Bluff Faces Without Vegetation

Shorelands with slopes or sections of bluffs devoid of vegetation can indicate many different situations. Generally, a bare bluff face suggests a site is either too steep to support vegetation or that recurrent

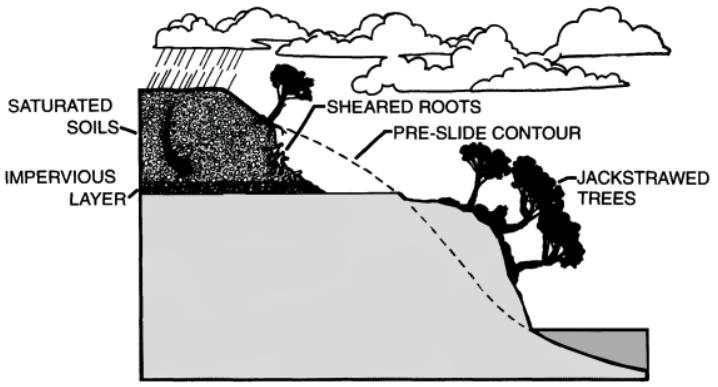


Illustration 6:
INDICATION OF EARTH SLUMP, DEBRIS AVALANCHE CAUSED BY GROUNDWATER INFLUENCES

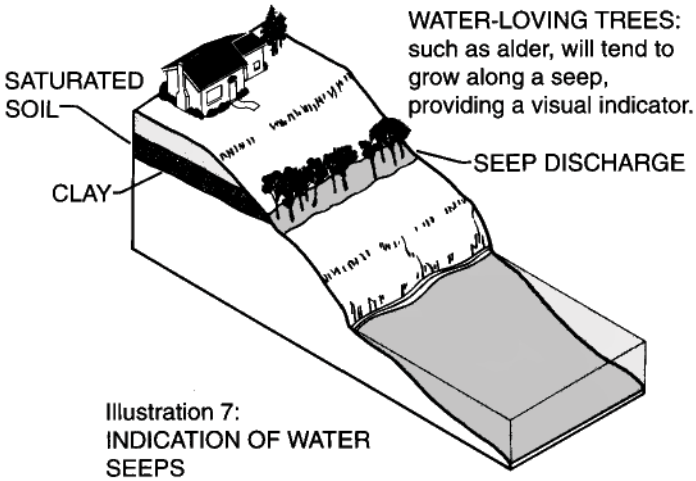


Illustration 7:
INDICATION OF WATER
SEEPS

erosion precludes the establishment of plants (Illustration 2). The first case is common on exposed bluff faces comprised of glacial till. These sites are often vertical. They are difficult places for vegetation to become established. Of more concern to property owners are steep, erodible sandy bluffs that are actively eroding or retreating. These sites are usually not able to be stabilized by vegetation.

Bare areas may also be indicative of recent or active slope failure. These sites are usually obvious. If the toe of the slope is protected from wave action, signs of debris will be seen. However, wave action will often remove the evidence of erosion.

Old Stumps

Stumps from past logging and clearing are often found on shoreline sites. These remnants can offer much information about the stability of a site and the history of an area. Most shorelines were logged off by the turn of the century. Old-growth trees were often eight feet or more in diameter and they were usually two hundred or more years old when they were cut. Thus, an old-growth stump found today indicates that a site has probably experienced no appreciable mass movement for at least three hundred years. This, of course, is not an inflexible rule and does not always mean the site is currently or permanently stable. All indicators should be used in context with other available information.

Partially buried old-growth stumps can indicate soil movement from up slope in the form of debris avalanches.

Downed Trees

The presence of downed trees may indicate several things. In sites where rooting is shallow, wind may cause trees to blow down. Shallow rooting can be the result of wet soils like those found in wetlands, or can be caused by shallow soils underlain by impervious layers that resist penetration of roots.

Fallen trees may also result from adjacent clearing or excessive tree removal within the stand, which often exposes previously stable trees to unusual wind stresses. In some cases, diseases such as root rot may cause substantial windthrow on a site. Another potential and common cause of downed trees is a slope disturbance such as excavation of the toe, or previous thinning, which leads to local erosion undermining downslope portions of the rootmass. This condition becomes obvious when bare roots and “caves” are observed under trees.

Whatever the cause of fallen trees, the results are similar: accelerated erosion, de-stabilization of the slope, and substantial disturbance to

the area. These sites should be examined carefully to determine the cause, impact and severity of a disturbance. Any remedial actions deemed necessary should be accomplished quickly.

Single Dominant Species and Even-aged Stand

Occurrence of a predominantly single-species, even-aged stand of Red alder or willow accompanied by understory vegetation such as stinging nettle or bracken fern, can indicate a fairly recent, large-scale, mass soil movement. A plant community similar to that described above, though apparently indicating a stable site, hints at the presence of recurrent large scale disturbances. Linear down-slope "stripes" of such vegetation commonly mark the paths of debris avalanches.

These vegetation types are sometimes associated with high water tables, shallow soils, and marginally stable slopes. They are often adjacent to wetlands and underlain by impervious soils. They are extremely difficult to manage successfully for most residential development. It is often impossible to attain shoreline amenities such as a view on these sites because they are predominantly deciduous and even when fully vegetated are barely stable. In many cases attempts at forest thinning can cause blowdown and subsequent erosion.

Single-age stands can also indicate past clearing or tree removal. Look for old stumps and note size and condition to estimate how long ago the trees were removed. Tree rings can tell you how old the trees were when cut.

Recently Cleared Areas

Partial clearing of uplands and slopes to allow access for prospective buyers and reveal views can cause modifications that could precipitate erosion. Seldom has the clearing been planned and executed with long-range slope stability in mind. Since the impacts of clearing may take several years to become evident, an unwitting buyer may purchase a potentially unstable site. Though this is not always the case, previous clearing will reduce your options for site development.

Dead/Dying Trees

Properties with large numbers of dead or dying trees indicate that there is cause for concern. Look for insect or disease incidence, signs of past wildfire, changes in local hydrology, or other probable causes. Healthy vegetation is important to your property's long-term stability.

Multi-species, Multi-age Vegetation

A site that has a wide variety of vegetation of various ages, is usually stable. A variety of vegetation (groundcovers, shrubs, and trees of deciduous and evergreen species) often indicates the site has not been recently disturbed and that local soil movements are likely to be stabilized naturally by the surrounding vegetation.

Each plant, from the smallest herb to the largest tree, contributes a stabilizing influence to the soil through its rootmass. Some plants have shallow, fibrous roots; others have deep roots. Together they form a strong mat that resists erosional stresses.

As a result of the inherently stable nature of a diverse vegetative community, your management options are increased.

Low-growing Brush May Hide Problems

Because many brush species grow fast and luxuriantly, a slope face that appears fully vegetated may be actively or potentially unstable. Many brush species found on logged slopes in the Puget Sound area can hide signs of old slides or the clues that would indicate

an inherently unstable site. It is sometimes necessary to investigate beneath this vegetation to inspect for signs of seepage, soil movement, or surface erosion. Sites with extensive cover of Himalayan blackberry or salmonberry should be carefully inspected.

Factors Influencing the Vegetation Found on Shore Sites

If you explore Puget Sound by boat or walk the beaches you will notice a wide variety of trees, shrubs, and other plants growing along the shores and bluffs. In some places the slopes are densely wooded with evergreens and broad-leaved trees while other places support mostly brush or herbaceous plants such as ferns and foxglove. There are places where madrone and salal line the shores and others where barely anything grows. What causes this variety and variability? What are the implications for site development and slope stability? Property owners need to be familiar with the interactions between what grows on their land and the environmental conditions that influence that growth.

In previous sections of the guide we have discussed the geologic origins and natural processes shaping much of Puget Sound. We have described some of the clues that help explain the recent geologic history of shore properties and how to recognize unstable situations. Now we will explore some of the general factors that influence the shoreline vegetation. Keep in mind that invariably more than one factor will influence the growth and variety of vegetation on any given site. Refer to the tables in the Appendix, "Plants Commonly Found on Puget Sound Shorelands."

Steepness

The steepness of a slope is often a controlling factor influencing its stability. On steep slopes prone to mass soil movements plants may never become established and large mature trees are scarce. The effect of slope gradient on vegetation establishment is strongly related to soil type, stratigraphy, and hydrology. Many steep slopes remain stable and well-vegetated until some critical factor is altered.

Examples:

Stable sites offering good rooting conditions will support densely wooded slopes with great vegetative diversity.

Unstable sites will show obvious slide paths and have a high proportion of species such as alder, willow and wild cherry which are relatively short-lived but readily colonize disturbed areas.

Soil types

Soil type and development influence plant growth and vigor, rooting depth, and available moisture.

Examples:

Deep, porous soils that have a high humus content are more productive and hold water better than soils that are mostly mineral.

Poor or recently disturbed soils will often be colonized by species such as Scot's broom and Himalaya blackberry, which thrive in poor soils.

Deep, productive soils will support mature, diverse plant communities comprised of conifers, broad-leaved trees, various shrubs, and herbaceous growth.

Shallow or saturated soils may support a wide range of brush species such as salmonberry, gooseberry, thimbleberry, and elderberry, but trees requiring solid rooting such as Douglas-fir may be absent.

Hydrology

Hydrology is always a factor to consider. Plants are

sensitive to both saturated and droughty soil conditions. Some plants can tolerate wide extremes of soil moisture while others cannot.

Examples:

Shore pine can be found on both wet and dry sites, butterfly bush is common on dry sites, and Black cottonwood is an indicator of wet sites.

Aspect

Aspect, the orientation of a slope face in relation to the sun, influences the vegetation growing on shore sites in several important ways. It determines the amount and duration of sun exposure, temperature, and the severity and type of environmental stresses, especially wind, that plants are subjected to.

A south-facing slope is generally hotter and dryer than a north-facing one. A steep east-facing slope will receive full sun in the morning during summer but be in shade by afternoon. A slope oriented towards the west will be exposed to the sun throughout the afternoon and evening during long summer days. The influence of aspect is complicated by topographic features such as canyons and stream courses, causing complex local microclimates that can support radically different plant communities within a small geographical area.

Examples:

East-facing slope: Bigleaf maple with sword fern

West-facing slope: Grand fir and Shore pine

South-facing slope: Oceanspray and snowberry

North-facing slope: Red cedar, hemlock, and salal

Microclimate

Microclimate is a word that refers to the existence of localized conditions of shade, wind, air temperature, and humidity that can combine to influence plant occurrence and growth and which can vary from the general conditions existing on a slope. The effects of factors such as steepness, soil type, hydrology, and aspect can be locally modified by microclimate influences such as fog and frost pockets and the movement of cold air down canyons and stream channels.

Microhabitat

Microhabitats are created by these microclimate conditions and the presence of localized differences in soil, topography, and hydrology. Microhabitats are places within a larger area that support plants or communities of plants different from those more generally found on a site.

An awareness of these factors will help you to understand and explain the sometimes complex nature of the plant communities seen on Puget Sound shorelands.

Environmental stresses

Environmental stresses influence the type of vegetation and its position on a slope. Drought, periods of cold, intense rain, heat, and exposure to wind can reduce plant vigor. Some plants have a broad natural adaptability and can thrive under a wide range of conditions, while others are more limited in the stresses they can withstand. If conditions change slowly over a long period of time, most species can adapt. When natural and human-caused environmental stresses combine to rapidly alter microclimate and habitat characteristics, plant communities change as less-adaptive species weaken and are replaced by plants more able to adjust to new conditions.

Listed below are common conditions to which species found around Puget Sound have adapted.

Drought: Oregon white oak, Western white pine

Saturated soil: alder, willow, salmonberry, Devil's club, Black cottonwood

Hot, exposed sites: wild rose, Oregon white oak, Western white pine

Cool, wet sites: Western red cedar, Grand fir, Sword fern

Full sun: Douglas-fir, alder, Pacific madrone

Shade: Western hemlock, maple, Pacific yew, Evergreen huckleberry

Wind: Pacific madrone, Sitka spruce, Grand fir

Salt spray: Pacific madrone, Sitka spruce

Many of our common plants are adapted so well to various conditions that they can be found almost anywhere. Pacific madrone, Red alder, willows, oceanspray, and Himalayan blackberry (an invasive, non-native) are a few of these.

Site Disturbance

Site disturbance, whether caused by natural processes or human impacts, affects the nature of plant communities and how long they have had to develop and mature. Below, we discuss the causes of site disturbance.

Natural processes contributing to site disturbance include erosion (both surface and mass soil movements), fire, extreme episodes of wind, rain or cold, seismic activity, and unusual tidal/storm events that de-stabilize the toe of slopes.

Human impacts that can cause severe site disturbance include logging, clearing, road building, and grading of shore areas.

The impact of removing mature trees from a site, while not as disruptive as clearing and grading, can severely alter microclimate conditions. Many smaller native trees and shrub species have adapted to the low-light conditions under forest cover. When large trees such as Douglas-fir, Western hemlock, Western red cedar, Sitka spruce, and Grand fir are removed these understory plants suffer from light increases and may die and be replaced by less desirable brush species.

Salal, Evergreen huckleberry, Oregon grape and Pacific yew are all valuable native species that supply wildlife habitat, erosion control benefits and are easily maintained. They are all, to some extent, adapted to flourish under the shade provided by tree canopies.

Species such as Sword fern, Vine maple, snowberry, and Red huckleberry are also valuable native species. They are more adaptive and able to survive environmental modifications.

Many of the shrub and herbaceous plants that thrive in full sun or increased light conditions are less beneficial than those above because they have inferior erosion control abilities, are extremely invasive, and/or create maintenance problems. They respond to increased light by height increases and by rapid spread. The worst of these for view and access management on bluff crests include Himalaya blackberry, English ivy, salmonberry, Devil's club, nettle, oceanspray, and Scot's broom.

Succession is a term used by ecologists to describe the natural development of plant communities over time. Starting with bare soil, certain highly-adaptive plants such as alder, willow, and fireweed will colonize the disturbed soil if nearby seed sources are present. These **pioneer species** are often short-lived and contribute organic material to the bare soil, and allow various other species, such as Evergreen huckleberry, Oregon grape, Salal, and Western hemlock to become established under their shade.

Factors such as soil type, hydrology, aspect, and local climate all influence the

composition of various plant communities and how well they develop. Natural plant succession can require many years to produce a heavily wooded site. Generally, a plant community that is composed of a wide variety of evergreen and deciduous trees and shrubs is more resistant to environmental stresses and erosional processes than a "younger" plant community.

Often, though, plant species from other parts of the world, such as English ivy, Scot's broom, Himalaya blackberry, and Butterfly bush have been introduced and become well-established here. They are termed "non-native" and "exotic" plants and can compete successfully with the native pioneer species that form the first link in the succession towards a stable plant community.

They are called "invasive" when they colonize sites and spread to surrounding areas, often at the expense of native plants. In the case of Himalaya blackberry and English ivy the erosion control capabilities of these plants are inferior to the natives they dispossess. Himalaya blackberry has a deep root system but does not hold or bind soil well. English ivy creates a dense mat that discourages other species growth and establishment. Both of these invasive exotics grow extremely fast and rob the soil of nutrients. Scot's broom offers good erosion control but reduces the establishment of evergreen and hardwood species. Butterfly bush and foxglove, while exotics, do not displace natives and offer wildlife benefits.

Many exotics spread readily by seed or plant parts. They can be inadvertently introduced to a site in loads of structural fill and topsoil Once established they can be very difficult to control and they compete with landscape plantings.

Off-site influences

Off-site influences can impact the plants growing on your property and indirectly increase the potential for erosion in various ways. Adjacent clearing can modify the hydrologic and drainage characteristics on your property. Sudden increases or decreases in surface and sub-surface water can subject the vegetation (especially evergreen trees) to environmental stresses that can weaken them. Madrone, our only broad-leaved evergreen tree, can be rapidly killed by even minimal increases in summer soil moisture.

Off-site clearing can also remove wind protection or change wind patterns. It is difficult to generalize, but frequently windthrow or blow-down of nearby trees results.

In some areas salt-laden wind has affected barrier trees (trees between the wind and an inland stand of trees) over many years and they have adapted to the prevailing conditions. They protect the trees and shrubs to leeward (behind them). These barrier trees are often misshapen, broken, and gnarled, but they have developed root systems that have allowed them to withstand many winter storms. If they are removed, the trees to leeward are exposed to stresses they are not adapted to. Windthrow and damage from salt often result.

Summary

We have discussed the value of vegetation in minimizing and reducing erosion and described the vegetative clues for diagnosing slope stability. Some of the factors that influence why certain plants grow where they do have been examined and the concept of a constantly changing plant community has been introduced. See if you can use this information to answer the questions posed in the next two chapters.

Chapter 3: Vegetation Management: Tree Removal

Owners of bluff properties have many questions about site development, erosion control, view clearing and beach access. Often, these questions are asked too late: after the damage is done and possible options are eliminated. Even when a property owner is aware that his or her decisions are critical to the long-term stability of a site, it can be difficult to judge the best course of action.

In preceding chapters the complexity of the shoreline environment and the role of vegetation has been discussed. By now you realize that it is important to consider all the factors involved before acting. This chapter and the next address some of the most common questions asked by shore property owners and offers generalized answers.

Should trees be removed?

This simple question generates a range of sometimes contradictory answers. There are many factors to consider before reaching a decision. These factors include: stability of the slope, species, age, health, current stability of the tree, position on the slope, surrounding vegetation, rooting habit/soil type, density of the stand, and the ability of the tree to sprout. Before we discuss these factors, it is necessary to mention some general considerations that apply to tree removals on steep slopes.

General Considerations Pertaining to Any Tree Removal

Tree Roots. The root systems of trees form an interlocking network, especially on many shoreline sites where rooting can be shallow. Often rooting is only two to three feet deep. The depth of root penetration is largely a function of soil depth and type, soil moisture, and the presence or absence of a dense layer of clay or till. These factors have a greater influence on rooting than any tendency of a tree to develop a characteristically deep or shallow root system.

Trees compensate for shallow rooting by increased spread of root systems. Recent research has indicated that a tree's root system will extend considerably beyond the dripline, often as much as two to three times as far. Extensive lateral root systems are common where soil moisture is excessive, soil is shallow, and impervious soil layers impede vertical growth. Where soils are porous, well-drained, deep, and no impervious layer exists, deeper rooting will occur.

Generally, the influence of a tree's roots on a given site will be related to the tree's age and size. Larger trees will have more extensive, often deeper and better developed root systems. Dominant trees, those larger and taller than the surrounding ones, have been more subject to wind and usually have developed stronger root systems as a result. Before clearing trees, consider the effects of removal on tree rootmass over time. Roots of dead trees decay, their stabilizing influence diminishing over a three to nine year period. As a result of the gradual loss of root strength after tree removal, barely stable slopes may fail several years after clearing or thinning.

Trimming debris can contribute to stability problems by smothering vegetation and by causing damage to the slope in sliding or rolling downhill. It is difficult to offer general recommendations for dealing with this material due to the wide range of site characteristics and debris volumes that might be generated.

Since regulations regarding the disposition of trimming debris vary it is advisable to

check with local planning or engineering departments for advice.

Disposing of bluff top clearing debris over the edge of a slope will be discussed later in the guide.

Do Not Remove Trees Without Cause. People tend to remove many more trees than are necessary during site preparation. The value of a healthy, strong tree on a slope or bluff far outweighs its value as lumber or firewood. A tree should be retained unless it is a hazard to life or property, is growing on the proposed house site or drainfield area or has some other major problem. Do not clear a reserve drainfield area before it is needed. Explore alternatives to removal thoroughly before deciding to cut. The location of trees and other factors involved should be considered carefully. Do not remove trees on slopes until home construction is complete. You may find that the trees do not need to be removed.

On Choosing a Tree Service

The tree care industry is currently undergoing something of a revolution. Many common practices, such as tree topping, are no longer recommended. There has been a great deal of recent research regarding how trees grow and react to environmental changes. New equipment and techniques are continually being developed.

Groups like the Seattle-based Plant Amnesty actively lobby to abolish topping and poor pruning practices. Professional associations such as the International Society of Arboriculture support research and provide certification programs for tree care practitioners. They are good sources of assistance in finding a tree service. See "For More Information."

Choosing a tree service can be a bewildering experience for a property owner. For an owner of shore property, making the wrong choice can have serious consequences. Beware of bids that seem "too good to be true." The money saved initially may pay dividends of disaster within a few years.

When hiring a tree service to work on a potentially unstable site, require proof of the following:

1. Experience (ask for references)

2. Proper equipment

3. Valid license and insurance

4. Understanding of your concerns

Most of the pruning practices described later in this guide are hazardous operations. They should only be performed by qualified and well-equipped personnel. Most property owners should not attempt to perform the work themselves.

Specific Factors to Consider in Tree Removal

Species. Different species have different characteristics. The growth habit, rooting habit, height, shape, longevity, strength, durability, resistance to salt and climatic stresses, and tolerance to pruning all differ among species. Refer to the plant lists in the Appendix for a relative comparison of characteristics for trees commonly encountered on Puget Sound shorelands.

Age. Tree age in relation to expected longevity of a particular species, can be an important consideration when deciding whether or not a tree should be removed. For example, should you cut down a 65 year-old, large Red alder that is obscuring your view? Because alder is a fairly short-lived species that seldom survives beyond 70 years of age, it is probably not going to survive much longer. In this case, expensive view pruning would not be warranted.

The advisability of the tree's removal would be dependent on its role in stabilizing the site. If the tree in question were a Pacific madrone, which can live for well beyond 200 years, then removal would not be advised. Alternatives such as pruning would be an excellent investment for the Pacific madrone. This simple example does not take into consideration other factors that may bear upon a decision to remove a tree in a particular location.

Health of the Tree. Tree health and vigor are important considerations when deciding on removal. Root rots and stem or trunk diseases are the most serious defects. In dense, single species stands infested by root rot, removal may be your only choice. It is advisable to confer with a knowledgeable professional, such as a forest pathologist or arborist if widespread forest health problems are observed.

Current Stability. An assessment of the stability of a tree in relationship to surrounding trees is important. Before landscape alterations begin, determine if the tree is part of an inter-dependent group or can be managed as an individual. Generally, if mature trees grow within 10 feet of each other and share crown canopy space, they are functionally a group. If rooting in the area is shallow due to high water table, impervious or impermeable layers, or shallow soils, then inter-dependence will be greater. If tree trunks lean away from each other (Illustration 8) it is probable they are "balanced" and the removal of one will predispose the other to windthrow.

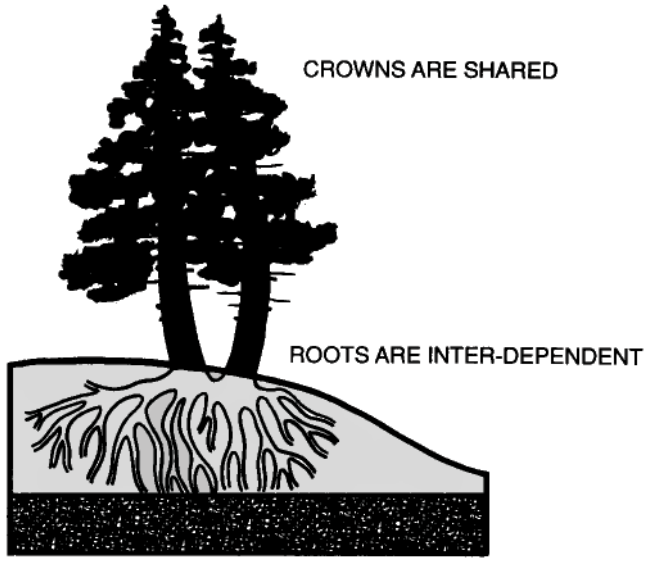


Illustration 8:
INTER-DEPENDENT GROUPING

It is often difficult to evaluate how inter-dependent a grouping is when considering a dense stand. Normally, the denser the stand and the younger the trees, the more can be removed safely. Again, consider all pertinent factors.

When a tree on a slope has become undermined or is otherwise in danger of falling over it should be cut. Determine if an individual tree is losing anchorage or if the lean is the result of soil movement as shown in Illustration 6. Exercise extreme caution when cutting trees on slopes.

Position on Slope. Consider a tree's location on the slope before removal. Illustration 9 depicts a situation where various conifers and deciduous broad-leaved trees are obscuring the

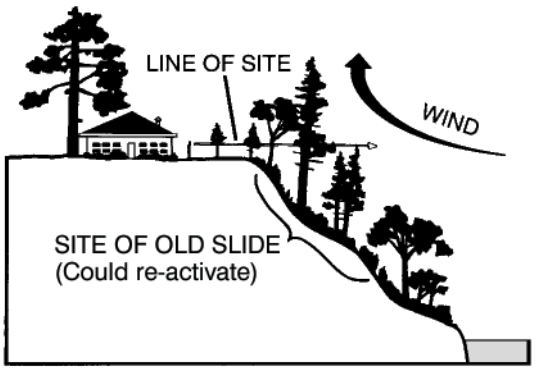


Illustration 9:
POSITION OF TREES ON A SLOPE

view. They are also protecting the residence from the full force of prevailing winds, as well as stabilizing the site of an old slide. Tree cover can often reduce the height of brush. If trees are removed, the brush grows higher thereby requiring constant trimming.

One solution would be to remove some or all of the trees to access a view. However, upon considering the benefits these trees provide and some of the possible adverse impacts that could result, a landowner might seek ways to enhance the view without removing the trees. This might include interlimbing, cutting windows, and skirting-up as discussed later in the question, "What are alternatives to tree removal and topping?" (See illustrations 12 and 13.)

Surrounding Vegetation. All factors should be considered together. This is especially important in regard to the vegetation surrounding trees being considered for removal.

As mentioned, some brush species thrive and flourish when a tree overstory is removed, creating a view management problem. This is particularly true for species such as elderberry, oceanspray, and salmonberry. Alder, wild cherry and some willow species may become maintenance problems when tree canopies are removed and additional light is able to reach the ground. Another species encouraged by increased light levels is Himalayan blackberry which is difficult to control. Invasive species such as Scot's broom prefer disturbed sites with abundant light, and can require constant control to maintain a view.

Native shrub species such as Oregon grape, salal, snowberry, and Evergreen huckleberry are excellent groundcovers that are often common under conifers. They are sometimes over-stressed when trees are removed and can be replaced by less desirable or weedy species.

Most brush problems occur in the area of the bluff between the uplands, the crest, and the upper margin of the slope face. Lower down on the slope, brush is not a consideration in view obstruction. When contemplating the removal of trees high on the bluff, consider the response of surrounding vegetation so as not to create subsequent problems.

Stability of the Slope. An analysis of slope condition by a geologist or geotechnical engineer is strongly advised and in many counties is required. Vegetative clues should be used in conjunction with the geotechnical data and an assessment of the role of the vegetation on the site should be made.

In situations where soil and hydrological conditions promote well-rooted, healthy, mature trees, the trees should be left insofar as is possible. As mentioned, the practice of removing a majority of trees on a slope can greatly increase the probability of a slope failure in the future as the trees roots decompose and their soil-binding capacity declines.

Some geologists or geotechnical engineers routinely recommend the removal of trees because of concerns that: 1) large trees exposed to wind can transmit that force to the slope, thereby causing slope failure; 2) soil moisture is reduced by evapotranspiration of trees, thereby creating cracks in impermeable layers and promoting water infiltration to lower soil layers; and 3) the weight of trees on the slope may cause landslides.

These concerns have been addressed in recent research and the overwhelming conclusion is that in the vast majority of cases, vegetation (especially well-rooted, mature trees) helps to stabilize a slope.

Density of the Stand. The implications of dense stands of short-lived species such as alder and willow have been discussed. In the case of dense stands of conifers such as Douglas-fir, Western hemlock, Red cedar, Grand fir, Sitka spruce or mixed stands of these species, the situation can be quite different. On stable sites with no serious ground water or surface runoff problems, the landowner has several options.

When trees are fairly young (between 5 and 30 years old) they are still capable of vigorous growth in response to thinning. It is possible to remove enough trees to attain a view and even improve the strength and growth of existing trees without creating a potentially hazardous situation. If the crowns of the trees are "crowding" each other and receiving light only from the top, then a thinning could be done. Caution should be exercised not to predispose the remaining trees to windthrow by altering the wind-deflecting properties of the windward trees or allowing wind to be channeled into the interior of a stand that was previously protected.

Removal of trees from a dense stand without damaging those remaining can be difficult and expensive, but the extra care required is a good investment in maintaining the health of the trees that protect your property. Broken tops and branches, as well as trunk scars left by falling trees can serve as entry ports for disease and insects. Consult with a qualified tree service when low-impact falling and removal of trees on a slope is necessary.

There are many other possible situations where stand density could be a consideration. Most of them require good judgement and compromise.

Ability of the Tree to Stump-sprout

The ability of a tree to sprout from a cut stump can be an important characteristic when a property owner is concerned about securing a view without jeopardizing the stability of a slope. The maintenance of a vigorous, live root system insures soil-binding benefits.

Though most tall brush species common to our area will readily sprout when cut, there are relatively few tree species that do so. All of these are broad-leaved deciduous trees. Careful cutting of the species listed offers a means of view clearing without jeopardizing slope stability. The following common trees are capable of sprouting when cut. (See the question "When is the best time to cut back vegetation?" in the next chapter.)

Willow: sprouts readily.

Red alder: often sprouts; leave four to five inches of trunk uncut for more vigorous growth. Older trees sprout less consistently. Repeated cutting increases mortality.

Bigleaf maple: sprouts profusely when cut. Older, larger stems, when cut, can be avenues of infection. Sprouts can grow as much as six feet per year.

Vine maple: sprouts similarly to Bigleaf maple. Vine maple can be trained and pruned into tree form.

Most conifers will not successfully stump-sprout when cut.

Remember that cutting back of brush and trees near the crest will be required periodically to maintain your view. If you find that brush must be cut more often than once every two to three years you may want to consider planting a lower-growing species to replace the existing brush. Kinnikinnick, an evergreen, forms a dense, low mat and has good erosion control properties. Allow at least three years for its establishment and provide protection from animal damage for the new plantings as required. The offending brush will eventually die if cut back repeatedly after two or three years. Under no circumstances should herbicides be applied to kill unwanted brush. The value of the root system far outweighs the inconvenience of maintenance when slope stability is a concern.

Chapter 4: Vegetation Management: Other Commonly Asked Questions

Should trees be topped?

As mentioned earlier, "topping" can be an emotion-charged term. In the context of view management it usually means the removal of a substantial portion of the upper tree trunk in conifers and the cutting of all branches at a particular height for deciduous trees. Illustrations 10 and 11 show typical topped trees.

Topping is not advised

Opinions vary on the usefulness and dangers of tree-topping. For years trees have been topped for a variety of reasons: to reduce height; to minimize wind resistance; to afford views; and to install television antennas. However, it has been clearly demonstrated that topping trees is a poor and damaging practice.

A topped tree requires periodic maintenance to maintain its reduced size. That can become expensive in the long-term. Also, conifers will often form a weakened top as the side branches all try to grow up as shown in Illustration 10. In addition, the cut top often becomes an entry site for decay organisms, that weaken the tree and increase the danger of a top breaking in high winds.

For broad-leaved trees such as maple, madrone or oaks severe topping is even more damaging. It can seriously harm the tree's health and cause various safety hazards. Illustration 11 shows a radically topped deciduous tree. There may be rare circumstances where the owner of bluff property may decide that the situation warrants topping a tree, but all alternative options should first be explored. Readers who seek more information can contact the International Society of Arboriculture or Plant Amnesty (see "For More Information").

Illustration 10:
TOPPED CONIFERS: One year later

What are alternatives to tree removal and topping?

Given the importance of tree cover on potentially unstable slopes and the advisability of retaining them for erosion control purposes, a landowner should explore alternative options to tree removal or topping.

Several trimming practices can be used successfully on conifers. They are listed below and can be used in combination to create views

without compromising tree health or slope stability.

View-enhancing Pruning Alternatives for Conifers

1. Windowing
2. Interlimbing
3. Skirting-up

Note: In any pruning practice or combination, a minimum of 60% of the original crown should be retained to maintain tree health and vigor. The removal of too much live foliage can reduce the tree's ability to supply food to the roots, thereby weakening them.

Windowing. This pruning practice allows a view "window" through the existing foliage of the tree's canopy (Illustration 12-A). In pruning major limbs and branch whorls, sections that obscure a view are removed. Many people find that this technique creates an aesthetically pleasing effect.

Interlimbing. The removal of entire branch whorls or individual branches throughout the canopy allows more light to pass through, as well as reducing wind resistance of the tree. As seen in Illustration 12-B, this practice can be used in conjunction with windowing to improve views.

Skirting-up. Limbing the tree up from the bottom allows a clear line of sight (Illustration 12-C). Instead of an obscuring mass of foliage, the tree trunk is the only object between you and the view. This technique is useful when the tree in question is located high on the bluff face or upon the tableland. Relatively more branches can be removed with this technique because the lower branches contribute less nutrients to the tree than higher branches.

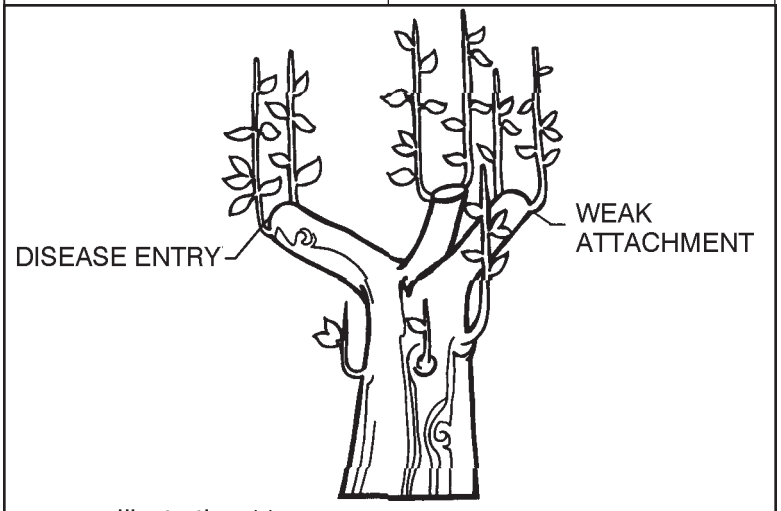


Illustration 11:
TOPPED DECIDUOUS TREE: One year later

Pruning Broad-leaved Trees

Pruning and trimming of broad-leaved trees is usually more complicated, especially for trees grown in the wild. The occurrence of these trees where they obscure views requires the landowner to weigh and consider the many factors discussed previously to decide if pruning or removal is a smart option. Generally, short-lived species such as alder, willow and Bitter cherry are not worth pruning, while trees like madrone, White oak, Bigleaf maple, and Vine maple will warrant the expense. Basically, proper pruning of broad-leaved trees entails removal of some limbs as shown in Illustration 13. Note the difference between "B" and "C". Refer to "Recommended Reading" and "For More Information" for information on proper pruning.

If a tree must be cut, should the stump and roots also be removed?

Stumps and root systems should be left undisturbed when a tree is cut on a slope. The beneficial nature of roots for erosion control has been discussed. Trees removed for foundation excavations, septic system construction, road building, or gardens should be removed during site development. Stumps remaining when trees are cut for view or hazard considerations should generally be left. They can be cut flush with the ground or be incorporated into a landscape design. In some cases stump grinders can be employed to remove the stump without causing the disturbance associated with pulling or digging the stump out.

Should groundcovers and brush be removed?

Extensive clearing of bluff properties is very common, especially on uplands. Since heavy equipment is on the property, people decide they may as well make the most of the machinery's presence. Rather than planning what requires site preparation (septic system, well site, house site, access road) they have the entire area scraped at one time. While it may appear simpler and less expensive to conduct site development this way, in the long run you may be setting the stage for chronic slope stability problems and greater expense. Keep in mind the processes at work on bluff properties and the benefits of vegetation, as well as the results of altering local hydrology, topography and vegetational cover. It makes sense to proceed carefully and thoughtfully in clearing your property.

Leave and maintain a buffer of groundcover and brush between the construction site and the crest of the bluff. If the vegetation is suitable it can be incorporated into a landscape scheme. Many native brush and groundcover species are effective as noise and site barriers between you and your neighbors. They are already established and require little care. If your property supports species such as Oregon grape, salal, snowberry, Wild rose, Sword fern, Evergreen huckleberry and Butterfly bush, then you have a wide range of valuable

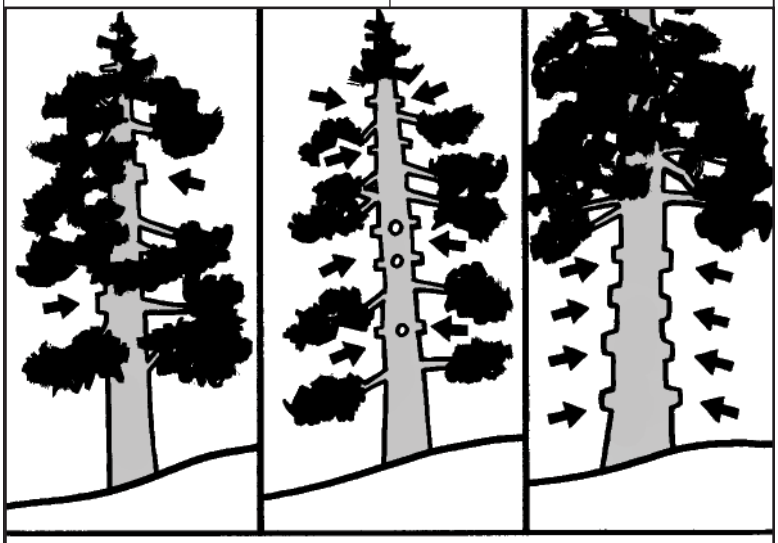


Illustration 12:
ALTERNATIVE PRUNING PRACTICES: Conifers

plant materials with which to work. On disturbed sites where plants such as blackberry, Scot's broom, thistle, dock, tansy and Bracken fern predominate, you may want to judiciously clear them out and establish native or ornamental plantings. This can require a lot of work and dedication on the part of the landowner. It should be done by hand to reduce damage to potentially unstable areas. In the case of horsetail, be fore-warned that trying to dig them out only makes them thrive, but sometimes establishing a dense growth of evergreen shrubs will discourage their growth. Refer to Slope Stabilization and Erosion Control Using Vegetation for some helpful suggestions.

Note: English ivy is common on many sites. It has a tendency to climb trees and can constrict tree growth and contribute to mortality. It should therefore be removed from the trunks of trees. Ivy also tends to cascade over sheer bluff faces. While it offers little rooting protection it does protect exposed bluff faces from wind and rain erosion. Ivy is emphatically not recommended for new plantings, but if it exists on a site it can be of some protective value. It is almost impossible to eradicate once it has become established.

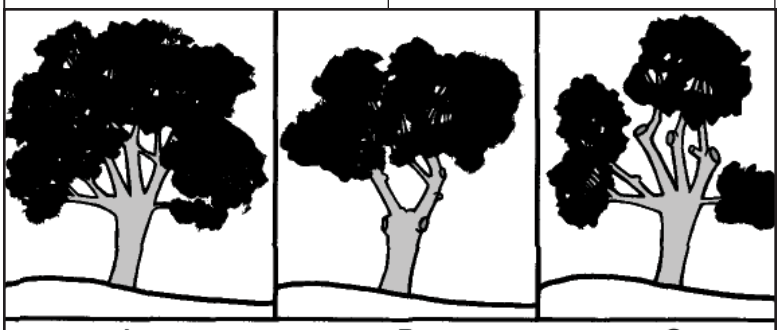


Illustration 13:
PRINING PRACTICES: Broad leaved trees

When is the best time to cut back vegetation?

Generally, the best time to trim woody vegetation is the period between late fall and early spring, when the plant is dormant. The frequency of trimming should not be so often that the food reserves needed for growth are depleted. Generally, a five-year maintenance schedule for most brush species will be adequate. Severity of pruning or trimming should be commensurate with the ability of the plant to tolerate the pruning damage.

Should I install a lawn?

Bluff-top property owners often install large expanses of lawn subsequent to land clearing. Lawns are relatively inexpensive to establish and maintain, and allow free access and open space around residences. They are especially good groundcovers for septic drainfields because of their shallow rooting. However, the shallow rooting of most grasses that makes them attractive cover for drainfields means their erosion control values are limited.

On sites where soil erosion and surface water runoff could be of concern it would be wise to limit the area of lawn. While low-growing or closely cropped vegetation (like lawns) helps filter and trap sediments to some extent, its capacity to do so is limited when compared to other groundcovers. During heavy rain periods, areas covered by

lawns soon become saturated since rooting is shallow, water retention capacity is minimal, and canopy interception is not available. Surface water can pool in depressions and runoff occurs.

Lawns on upland sites should be bordered on the downslope side by a buffer of deeper rooted, more effective groundcover like salal, Oregon grape, Wild rose, trailing blackberry, kinnikinnick or other low-growing plants. Lawns should not extend to the crest of a slope, nor should they be established on erosion-prone sloping areas that would tend to drain over the bluff.

Are some trees better than others?

Previous sections of the guide have discussed factors that contribute to a particular species' usefulness as an erosion control element. Generally, short-lived deciduous trees are of less value and require more management than longer-lived species. Conifers, maples, and the evergreen broad-leaf tree, Madrone, are the most valuable and every effort should be made to retain and safeguard them. The relative value of a tree is a function of the physical characteristics of the site, the natural processes influencing the property, and the property owner's needs and goals.

What about construction damage during site development?

Trees retained on a development site often die as a result of various construction-related influences. Understanding these damaging construction practices can help the property owner and contractor be more effective in preserving trees as well as increasing property values.

Construction Damage to Trees (see "Recommended Reading") is required reading. This informative publication discusses major construction-related impacts that should be avoided. These are:

1. Grade changes around trees

2. Soil compaction by heavy machinery

3. Mechanical injury caused by heavy machinery

4. Tree thinning

Give the trees you retain plenty of room. Keep machinery back at least to the edge of the dripline of the canopy. Do not bury roots when grading. Even a foot of fill over the existing grade can cause the death of a mature evergreen. Wounding of the tree by equipment can stress the tree directly as well as offer entry paths for decay organisms. Installations of temporary exclusion fencing during construction can be helpful.

Soil compaction is a common occurrence on construction sites. Hand clear brush surrounding trees rather than using heavy machinery. Compacted earth restricts root development and reduces water-holding capacity. Exclusion fencing will reduce soil compaction.

As mentioned, thinning of trees on the bluff top should be done only after consideration of factors such as species, rooting, hydrology, wind patterns, tree health, and age have been assessed. The economic value of the timber should be of secondary importance. The extra initial expense of careful site development will be a worthwhile investment.

Note: There are several general site development and construction-related practices that property owners should be aware of. Since they are beyond the scope of this guide, they are not discussed here. Refer to the Shorelands Technical Advisory Papers in "Recommended Reading."

What to do with clearing debris

The process of site development invariably creates a large volume of plant debris. The disposal of this material can become a major concern. The location of debris on your property will dictate the best disposal method to employ.

Upland areas, where development and home construction occurs, generate the largest volume of debris. The best way to deal with this material is by chipping. The resultant chips can be used on rustic walkways and as free mulching materials to discourage weeds. Other options include piling and burning or disposal off-site. In densely populated areas burning may be restricted and burning in rural areas may require a permit. Contact the Washington State Department of Natural Resources or your local Fire Department. Disposal off-site may be expensive but some counties have large-scale composting programs that accept clearing debris.

Never dump material over the bluff edge or allow your equipment operator to do so. Stumps and clearing debris can cause slope damage, add unwanted weight, disturb and smother vegetation, and make access difficult in the future. Yard waste and construction debris can also cause problems and a steep bluff is no place to dump toxic chemicals such as paint or solvents. It is up to you to make sure your contractor understands your concerns.

Are there any problems to consider in using the existing trees in my landscaping?

Often when trees are retained and integrated in a landscape design, they are damaged inadvertently by typical yard maintenance practices. Remember that native trees evolved over time to become suited to regional conditions such as rainfall, shade, and wind. Radical changes should be avoided or done gradually to allow the tree to adjust to new conditions over time.

One notable example is Pacific madrone. This tree is intolerant of root disturbance. Established madrones should never be watered in the summer. Because madrone is such a striking tree, it is often used as a major landscape element with flower beds surrounding it. As a result, the area is tilled and watered. Both of these practices can kill madrone within a few years. Madrone, while valued by many, can be a problem as a landscape element because it tends to shed leaves all year. Its value as wildlife habitat and its excellent erosion control qualities make it worthwhile nonetheless.

Bigleaf maple can often prove to be a maintenance concern because of heavy leaf-fall and a tendency to drop large limbs. Again, wildlife and erosion control benefits often outweigh these drawbacks. Maple branches should be removed where they present a hazard to residences but in general the tree should be retained. At present, there is little information available that deals with maintaining native vegetation in residential settings. The best practice is to alter local conditions as little as possible.

Why did my trees blow over?

After site development and construction is completed, and sometimes even after several years have passed, the retained trees on a property will blow over. This can cause property owners considerable expense. To safeguard against this occurrence it is necessary to understand the nature of the inter-dependence of trees in the original stand. This has been discussed in the question

"Should Trees Be Removed?" and in the question concerning construction damage. Briefly, trees blow over due to increased exposure to wind, root damage and decline, and changes in hydrology caused by vegetation removal and soil compaction. Careful consideration of factors discussed in this guide during site planning and careful construction practices during development will reduce subsequent tree loss. Blowdown often occurs as a result of tree removal or clearing on adjacent properties. Talk with your neighbors.

Why do the trees on my bluff look so scraggly?

As discussed in the section on "Factors Influencing Vegetation" in Chapter 2, trees exposed to severe environmental stresses such as exposure to wind and salt-laden air will develop differently than trees that have grown in protected environments. Trees growing on exposed bluff sites often are twisted, stunted, and smaller than their inland cousins. They often have many broken branches and tops. Their foliage can be sparse and of a different color than less-exposed trees of the same species.

Trees adjust in various ways to local conditions and show the wear and tear of time. These trees often protect the ones behind them from the full force of the elements. They are a valuable asset on a bluff site. Any pruning done on them should be carefully considered and properly executed. They should not be removed unless conditions absolutely warrant it.

Is this tree a hazard?

The question of hazard trees often comes up during site development. The conditions existing on a particular site and the specific tree characteristics dictate the hazard potential present. The erosion control values of a tree on bluff properties are an additional consideration in determining whether a tree should be removed or pruned.

Two major considerations contribute to the hazard present. First, a determination of the nature, probability, and severity of a failure must be made. Second, the worst-case damage resulting from a potential failure should be determined. For example, even if a tree is in poor shape with a broken top, an old unhealed trunk wound and perhaps other defects, if it will not cause property damage or personal injury when it falls, it is not a hazard. Conversely, if a tree is healthy and sound but has a large heavy branch overhanging a bedroom or nursery it could be a hazard and the limb should be removed. Remember Bigleaf maple's tendency to drop branches.

If a potentially hazardous situation exists and you cannot decide what to do, contact a qualified arborist or other competent person. Be sure to explain your concern regarding the stability of the site.

Note regarding snags: Snags are dead, standing trees. They have died for a variety of reasons: old age, insect attack, disease, past disturbances. In the case of conifers, they are seldom a blowdown hazard and may persist for many years. (Large conifer snags can remain standing for as long as 100 years.) They offer nesting and perching sites for many wildlife and bird species, including Bald eagles. If they are located so as not to constitute a hazard to structures, they should be retained. Smaller conifers and most hardwood trees will not last nearly as long (madrone and oak are exceptions). Generally snags will not be a threat to bank stability.

If I have existing slope erosion problems on my land how do I solve them? Can vegetation help?

Often, properties already have problems resulting from past practices like those described in the Introduction. There are many ways that low-cost solutions using vegetation can be implemented. A companion volume to this guide dealing specifically with the use of vegetation to control erosion is available from the Washington State Department of Ecology. Ask for *Slope Stabilization and Erosion Control Using Vegetation.*

Conclusion

This publication has stressed that shoreland areas in the Puget Sound region are complex and often fragile places. Influenced by many factors, they are in a constant state of change from the effects of wind, rain, and the waters of Puget Sound.

While not all landslides and erosion can be prevented, it is clear that the actions of shoreline property owners can have a great inpact on the stability of bluff areas. Land owners need to understand how their actions can affect their surroundings and learn to minimize or avoid development-related practices that can set the state for future problems and require costly, difficult solutions.

The clearing of trees and brush, installation of utilities, construction of access roads, and siting of homes should all be well-planned with landscape and stability concerns in mind. Compromise is often necessary between the needs of the property owner and the unforgiving realities imposed by land and water.

Wise planning and development will improve property values, reduce maintenance costs, and contribute to slope stability. Before you decide that doing things right is too expensive, talk to neighbors who have lived on the edge for a while. Their stories might sound similar to that of the hapless landowner in the Introduction. Make the effort to learn to live in harmony with your land.

Appendix A

Plants Commonly Found on Puget Sound Shoreland Sites

The following list illustrates the great diversity of plants found growing on Puget Sound bluff sites. There are many others that you may be familiar with that are not listed here. The influences of the Sound's intricate waterways and the surrounding mountains foster a multitude of species in the area. Some are found only in long-protected spots while others are seen almost everywhere.

Representative trees, shrubs, and herbaceous growth have been included to furnish readers with information on the plants that may be encountered on their property. The sprouting, rooting, and erosion control information is the result of observations by the author, verified through research and technical material where possible. The age and height listed for shrub and tree species are from varies sources. They are furnished to indicate general longevity and approximate size at maturity. Remember that many climatic and site factors can influence plant characteristics. Heights may vary considerably.

The plants listed here are not necessarily the most valuable species possible for erosion control, wildlife, or aesthetics. They are simply common throughout the area. Some of the most common shrubs are invasive, non-native plants that are becoming widespread problems. These are indicated by an asterisk (*). They should never be planted and should be discouraged where possible.

Readers who are interested in more detailed information on Northwest and Puget Sound flora can refer to "Recommended Reading" and "For More Information" in this appendix. There are several excellent field guides available as well.

Plants Commonly Found on Puget Sound Shoreland Sites (Herbaceous)

Common Name	Botanical Name	Native/Non-native	Dediduous/ Evergreen	Rooting habitat**	Erosion control Quality	Ground Cover Quality
Sword fern	Polystichum munitum	Native	Evergreen	Shallow	Fair	Good
*English ivy	Hedra helix	Non-native	Evergreen	Shallow-moderate	Poor	Good
Honeysuckle	Lonicera spp.	Native	Deciduous	Shallow-moderate	Fair	Fair
Nettle	Urtica spp.	Native	Deciduous	Wide, very shallow	Poor	Poor
Foxglove	Digitalis purpurea	Non-native	Deciduous	Very shallow	Poor	Poor
Perennial pea	Lathyrus spp.	Non-native	Deciduous	Shallow-moderate	Fair	Fair
Bracken fern	Pteridium aquilimum	Native	Deciduous	Shallow	Fair	Poor
*Horsetail	Equisetum spp.	Mostly non-native	Deciduous	Wide, shallow	Poor	Fair
*Grasses	Various	Mostly non-native	Evergreen	Shallow-moderate	Fair	Excellent (low)

* Invasive, do not plant
**Please note that the dept and character of the roots are determined more by sil conditions than species characteristics.
Greenbelt Consulting, Vegetation Management: A Guide for Puget Sound Bluff Property Owners

Plants Commonly Found on Puget Sound Shoreland Sites (Shrubs, small trees)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat**	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height (ft)
Trailing Blackberry	Rubus ursinus	Native	Semi-deciduous	Shallow	Fair	Good	Yes	Vine
*Himalaya blackberry	Rubus discolor	Non-native	Semi-Evergreen	Moderate	Poor	Good	Yes	Vine-cane
Vine maple	Acer circinatum	Native	Deciduous	Deep, wide	Excellent	Fair	Yes	10+
Oceanspray	Holodiscus discolor	Native	Deciduous	Deep, wide	Excellent	Good	Yes	10+
*Scot's broom	Cytisus scoparius	Non-native	Deciduous	Deep, wide	Excellent	Good	Yes	To 8
Willow	Salix spp.	Native	Deciduous	Deep, wide	Excellent	Fair/Good	Yes	10+
Snowberry	Symphori carpos albus	Native	Deciduous	Deep, wide	Excellent	Excellent	Yes	3+
Rose	Rosa spp.	Native	Deciduous	Shallow-moderate	Good	Good	Yes	2-10
Elderberry	Sambucus spp.	Native	Deciduous	Moderate	Fair	Poor	Yes	To 15
Salmonberry	Rubus spectabilis	Native	Deciduous	Moderate	Good	Fair	Yes	To 12
Salal	Gaultheria shallon	Native	Evergreen	Shallow-moderate, dense	Good	Excellent	Minor	To 4

* Invasive, do not plant
**Please note that the dept and character of the roots are determined more by sil conditions than species characteristics.
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Plants Commonly Found on Puget Sound Shoreland Sites (Shrubs, small trees)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat**	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height (ft)
Oregon grape	Mahonia spp.	Native	Evergreen	Shallow-moderate	Good	Good	Minor	To 6
Butterfly bush	Buddleia spp.	Non-native	Deciduous	Moderate	Fair	Fair	Yes	6
Red huckleberry	Vaccinium parvifolium	Native	Deciduous	Moderate, wide	Good	Fair	Yes	To 12
Evergreen huckleberry	Vaccinium ovatum	Native	Evergreen	Moderate, wide	Excellent	Good	Minor	To 8
Devil's club	Oplopanax horridum	Native	Deciduous	Wide, shallow	Fair	Good	Yes	To 12
Serviceberry	Amelanchier alnifolia	Native	Deciduous	Deep, wide	Excellent	Fair	Yes	12+
Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat**	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height (ft)

* Invasive, do not plant
**Please note that the dept and character of the roots are determined more by sil conditions than species characteristics.

Greenbelt Consulting, Vegetation Management: A Guide for Puget Sound Bluff Property Owners

Plants Commonly Found on Puget Sound Shoreland Sites (Trees)

Oregon white oak	Quercus garryana	Native	Deciduous	Deep, sparse	Good	Minor	60	200+
Grand fir	Abies grandis	Native	Evergreen/ Conifer	Moderate	Good	No	200+	300+
Douglas-fir	Pseudotsuga menziesii	Native	Evergreen/ Conifer	Deep	Good	No	200+	300+
Bigleaf maple	Acer macrophyllum	Native	Deciduous	Deep, wide	Excellent	Yes	60	200+
Red alder	Alnus rubra	Native	Deciduous	Shallow-moderate Tolerates wet sites	Fair	Yes	50-100	65
Bitter cherry	Prunus emarginata	Native	Deciduous	Shallow-moderate	Fair	No	50	50
Western hemlock	Tsuga heterophylla	Native	Evergreen/ Conifer	Shallow-Moderate	Good	No	150	300+
Sitka spruce	Picea sitchensis	Native	Evergreen/	Shallow-moderate	Good	No	100+	300+
Western red cedar	Thuja plicata	Native	Evergreen/ Conifer	Moderate, wide Tolerates wet sites	Good	Yes	100+	350+
Pacific madrone	Arbutus menziesii	Native	Evergreen/ Broad-leaved	Deep, wide, tenacious	Excellent	Minor	70+	200+

* Invasive, do not plant
**Please note that the dept and character of the roots are determined more by sil conditions than species characteristics.

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Plants Commonly Found on Puget Sound Shoreland Sites (Trees, cont.)

Common Name	Botanical Name	Native/ Non-native	Dediduous/ Evergreen	Rooting habitat**	Erosion control quality	Ground cover quality	Capacity to Sprout	Mature height (ft)
Pacific yew	Taxus brevifolia	Native	Evergreen/ Conifer	Deep, wide	Excellent	Minor	30+	250+
Willow	Salix spp.	Native	Deciduous	Moderate, wide Tolerates wet sites	Excellent	Yes	50+	60
Black cottonwood	Populus trichocarpa	Native	Deciduous	Wide Wet sites	Fair	Yes	140	200
Shore pine	Pinus contorta	Native	Evergreen/ Conifer	Deep, wide	Good	No	30+	200
Western white pine	Pinus monticola	Native	Evergreen/ Conifer	Deep, wide	Good	No	150+	250+
English holly	Ilex aquifolium	Non-native	Evergreen/ Broad-leaved	Moderate	Good	Minor	40	150

* Invasive, do not plant
**Please note that the dept and character of the roots are determined more by sil conditions than species characteristics.

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Appendix B — Glossary

ASPECT: ..... The direction a particular slope is facing.

BLUFF FACE: ..... The sloping portion of a high bank (see Illustration 1).

BLUFF RETREAT: ..... The rate at which a bluff or shoreline is eroding as a result of surface erosion and/or mass soil movements. Used by some regulatory agencies to guide setback requirements.

BLUFF TOE: ..... The base of a bluff where it meets the beach (see Illustration 1).

BRANCH WHORLS: ..... The circular growth of branches around the same point on the trunk of a conifer.

BROAD-LEAVED: ..... Having flat leaves rather than needles as conifers do.

BUFFER: ..... A protective strip of vegetated land.

CLEAR-CUT: ..... A timber harvest method that removes all the trees on an area in one operation.

CONIFER: ..... A cone-bearing tree with needles rather than leaves (i.e., pines, firs, hemlocks).

CREST: ..... Upper edge or margin of a shoreline bluff (see Illustration 1).

CROWN CANOPY: ..... The branches and foliage of a tree.

DEBRIS AVALANCHE: ..... A form of landslide where a water-saturated upper soil layer and the vegetation growing on it slides over an underlying less permeable subsoil creating a relatively shallow, narrow slide scar, usually two to three feet deep and 15 to 30 feet wide.

DECIDUOUS: ..... Losing leaves or needles in the fall.

EARTHFLOW: ..... A rapid mass movement of a flowing assemblage of saturated soil, vegetation, and associated debris.

EROSION: ..... The wearing away of land by action of wind or water.

EVAPORATION: ..... The process whereby moisture is turned to water vapor and removed from a surface. Rate increases as humidity decreases.

EVAPOTRANSPIRATION: ..... The loss of water through a plant's leaves or needles from the body of the plant due to evaporation and transpiration.

EVERGREEN: ..... A plant that retains its needles or leaves for more than one growing season.

EXOTIC PLANT: ..... A plant that has been introduced into a region where it is not normally found.

FLORA: ..... The plants of a region.

GLACIAL TILL: ..... Term commonly used to emphasize glacial origin. See Till.

GROUNDWATER: ..... Water within the pores between soil particles. Usually a permanent groundwater table is evident. This is a source of water for wells and springs. If water percolating through the soil encounters barriers such as clay or hardpan before reaching the permanent groundwater table, a perched water table may form.

HARDPAN: ..... A hard, impervious layer of soil (often clay-rich), or iron-oxide cemented material. In Puget Sound the term is commonly used by drillers and contractors to describe glacial till.

HERBACEOUS: ..... Non-woody plants such as ferns, nettles, and foxglove.

HORIZON: ..... One of a particular layer of soil (e.g., the organic-rich "a" horizon) as used in soil science.

HYDROLOGY: ..... (In the context of this guide) Refers to the properties, distribution, discharge, re-charge, and movement of surface and sub-surface water.

IMPERMEABLE: ..... Unable to permit water or roots to move through freely (see Impervious Surface).

IMPERVIOUS SURFACE: ..... A soil or surface through which water, air, or roots penetrate slowly or very little (that is, concrete, compacted soil).

INTERDEPENDENT: ..... A group of plants that by growing together protect each other from disturbance by wind, erosion, or other natural processes. Shallow rooted trees will often remain windfirm because they form a wide, spreading root mat. (See Illustration 7.)

JACKSTRAWED: ..... A group of trees that has lost firm rooting through wind, land movement, or excessively wet soils and appears chaotic or no longer oriented toward the light.

LANDSLIDE: ..... The downhill movement of a mass of soil or rock, usually wet or saturated, that results in episodic erosion. (Sometimes simply referred to as "slide," but also including falling or flowing masses as well.)

MASS SOIL MOVEMENT: ..... See Landslide.

NATURAL LANDSCAPE ELEMENTS: Natural watercourses, topography, hydrology, and vegetation that comprise a particular site.

NON-NATIVE PLANT: ..... See Exotic Plant.

OVERSTORY: ..... The portion of a plant community that forms the upper-most crown cover or canopy.

PERCHED WATER: ..... Groundwater that accumulates over an impervious soil layer from

rainfall or other sources that finds release on bluff faces. Perched water is released on bluff faces as seeps or springs.

PIONEER SPECIES: ..... Plants that colonize disturbed sites after land clearing, logging, fire, or landslides. They are normally replaced over time by other species. Alder, willow, and fireweed are common examples.

PLANT COMMUNITY: ..... An inter-related and inter-dependent assemblage of vegetation having structural and species diversity (i.e., Western red cedar, Western hemlock, salal, Oregon grape, Evergreen huckleberry, Sword fern, mosses, and lichens).

REGENERATION: ..... 1) The process by which an area is restocked with plants. 2) Young trees, either naturally seeded or planted.

SEEPS: ..... See Perched Water.

SHEAR STRENGTH: ..... A measure of the ability of a soil to resist forces that tend to separate it from its position on a slope and cause it to move.

SILVICS: ..... The study of life history and general characteristics of forest trees and stands in relation to environmental factors.

SLOPE: ..... The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by the horizontal distance, multiplied by 100. Slope is also measured in degrees (90 degrees being vertical) or as a ratio. A 100% slope would be 45 degrees or 1:1.

SOIL COMPACTION: ..... Reduction of the total pore space in a soil. Results in a soil that retains less water and resists root penetration. Soils with high clay content are more easily compacted than sandy soils.

SOIL CREEP: ..... A process of slow, downslope movement over a long period of time.

SOIL HORIZON: ..... See Horizon.

SOIL SLUMP: ..... A deep-seated mass movement of soil. The mass moves down and rotates, leaving a concave depression above.

STRATA: ..... A layer of soil or rock.

STRATIGRAPHY: ..... The sequence or order of rock or soil layers in a geologic formation.

SUCCESSION: ..... The process of replacing one plant community with another over time (that is, alder to Douglas-fir to Western hemlock).

SUCCESSIONAL SPECIES: ..... The plant species that comprise a plant community in a given successional stage (for example, early successional species are alder, willow and Bitter cherry).

SURFACE WATER: ..... Rain, snowmelt, lawn sprinkling, or other additions to the soil surface. Also refers to lakes and streams (in contrast to groundwater).

THINNING: ..... Tree removal in a forest stand that reduces tree density and numbers in a given area. Most discussions of thinning stress increased growth and yield of timber.

TILL: ..... Unstratified glacial drift consisting of unsorted, intermixed clay, sand, gravel, rock, and boulders. Generally well-cemented and impermeable.

TOE OF SLOPE: ..... See Bluff Toe.

TOPOGRAPHY: ..... The physical features of a surface area including relative elevations and the position of natural and human-made features.

TRANSPIRATION: ..... The process by which water vapor is lost to the atmosphere from living plants.

TREE FAILURE: ..... A tree or portion of a tree that collapses as the result of some structural weakness such as root rot, dead branches, mechanical wounds, or other causes.

UNCONSOLIDATED MATERIALS: Geologic materials such as sand, gravels, and mixed sediments whose particles are loose and uncemented.

UNDERCUTTING: ..... The removal of material at the base of a steep slope or cliff by the erosive action of waves, running or seeping water, or windblown sand.

UNDERMINED ROOTS: ..... Roots that are not firmly anchored due to soil removal or loss, beneath and/or around them. Can affect both live and dead trees or stumps.

UNDERSTORY: ..... Trees or other plants that tolerate reduced-light conditions and normally grow beneath the overstory.

UPLANDS: ..... The tops of bluff areas usually developed for home sites.

WATER TABLE: ..... The level at which soil and/or rock is saturated with water. Can be seasonal. Water table can be altered by changes in hydrology.

WINDTHROW: ..... Trees blown over by the wind. Often caused by thinning or adjacent clearing.

Appendix C — For More Information

Elisabeth C. Miller Library, Center for Urban Horticulture
University of Washington, GF-15
Seattle, WA 98195
206/543-8616 (Continuing Education 206/685-8033)

International Society of Arboriculture
Pacific Northwest Chapter
P.O. Box 15729
Seattle, WA 98115
206/365-3901

Plant Amnesty
906 NW 87th Street
Seattle, WA 98117
206/783-9813

Puget Sound Water Quality Authority
P.O. Box 40900
Olympia, WA 98504
800/547-6863

Washington Native Plant Society
P.O. Box 576
Woodinville, WA 98072

County Planning and Engineering Departments — Usually located at your county courthouse.

Public Utilities — Your utility may have information in published form.

Soil Conservation District Offices — Usually located at your county courthouse.

Washington State University Cooperative Extension Offices — Usually located at your county courthouse.

U.S. Army Corps of Engineers
Seattle District
P.O. Box C-3755
Seattle, WA 98124
206/764-3742

U.S. Environmental Protection Agency
1200 - 6th Ave.
Seattle, WA 98101-3188
206/533-1200

U.S.D.A. Soil Conservation Service — Check the Yellow Pages for an office near you.

Washington Sea Grant
University of Washington, HF-05
Seattle, WA 98195
206/543-6600

Washington State Department of Ecology
Shorelands & Coastal Zone Program
P.O. Box 47600
Olympia, WA 98504-7600
206/459-6836

Washington State Department of Natural Resources — Contact the nearest regional office.
P.O. Box 47000
Olympia, WA 98504-7000
800/527-3305

Washington State Department of Wildlife
P.O. Box 43200
Olympia, WA 98504-3200
206/753-5700

Appendix D — Recommended Reading

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Washington State University Cooperative Extension Bulletins

EB440 *Trees of Washington*

EB1157 *Construction Damage to Trees*

EB1619 *Pruning Trees: A Guide for Homeowners*

PNW184 *Thinning: An Important Timber Management Tool*

PNW195 *Impacts of Forest Practices on Surface Erosion*

PNW209 *Slope Stability on Forest Soils*

PNW217 *Compaction of Forest Soils*

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Tree Removal on Steep Slopes of Puget Sound Shorelines

The mechanical and hydrogeological benefits which trees and other vegetation provide to maintain slope stability and reduce erosion are well documented. Most of the wooded bluffs rimming Puget Sound are in a delicate equilibrium. For example, natural events such as an unusually intense winter rainstorm or human activities such as a concentration of upland runoff or careless logging on the bluff can reduce stability, even trigger landslides. As a planner or permitting agency official, what are your responsibilities regarding tree cutting? Given that there may be downslope impacts, possibly serious hazards to homes or public facilities, do you make decisions regarding tree cutting and/or removal? If so, remember the admonition to physicians: "First, do no harm."

Let's assume that trees have already been cut and downslope residents voice concerns about effects on bank stability. Some questions that may arise:

- Was the cutting authorized by your agency or another agency (e.g., DNR) that has jurisdiction?
- Who owns the land? Property side lines on waterfront/view lots are commonly skewed (Fig. 1). Property boundaries on the face of a bluff are commonly unmarked or inaccessible.
- Who cut the trees or hired the cutter? Timber trespass is not uncommon in such settings. Has a timber trespass occurred?

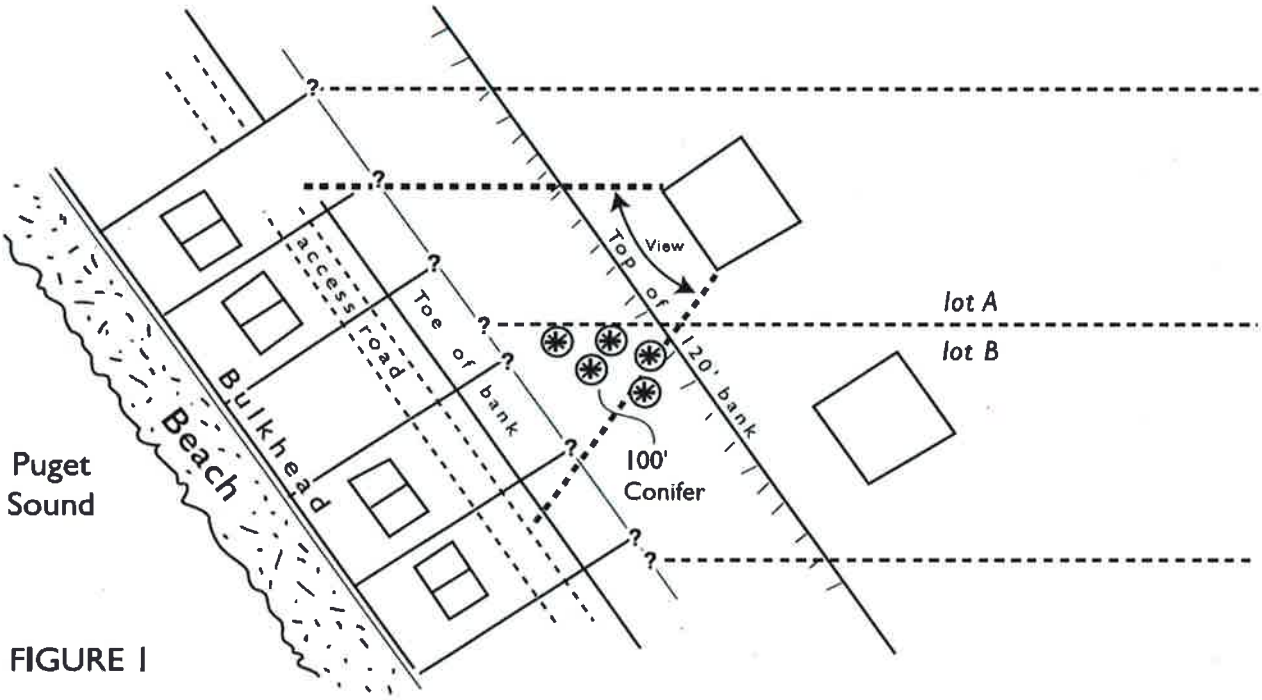


FIGURE 1

Figure 1. Sketch shows a typical scenario for development along shoreline bluffs. Note angle between lot side lines and edge of bank. Trees on lot B partially obscure the view from lot A, a setting ripe for timber trespass and/or legal squabbles. (Skewed property lines where there are no beach homes below can also complicate matters. In cases where wave erosion is at the toe of the bluff, a bulkhead fronting property B would mostly protect the home on lot A.)

Property ownership and cutting responsibility questions are basic to questions of log removal/leave and slope rehabilitation/replanting. As our main focal point here is on removal, an obvious question arises: Who pays for it? A property owner who cuts his or her own trees (after obtaining necessary permits, if any) is obviously responsible for such decisions. What about the rather common situation in such settings of 'timber trespass'? In at least some situations the owner is entitled to triple damages from the illegal cutter. Will the property owner allow access to the site for removal of the downed trees? If so, will that increase his or her liability for accidents or some future slide from their property? Such legal aspects of the problem are not trivial. Economics, including potential liability, may decide what (if anything) is done regarding tree removal, slope rehabilitation, and revegetation.

Upon what can 'damages" for trespass be based? The value of a tree for lumber can be calculated rather precisely on the basis of market factors such as species, size, cost to reach market, and current price. What about aesthetic value? (Some arborists and/or real estate professionals may be able to offer an estimate of the impact of the loss of the trees on property value.) The value of an individual tree or group of trees in relation to their role in maintaining slope stability is even more difficult to quantify, but it is often a significant consideration.

Let's assume that the trees were cut with city or county permission. Assume that the loss of trees will have some detrimental effect on slope stability, both immediately (precipitation interception, transpiration) and long term (loss of root/soil reinforcement, anchoring over time). Assume that the potential for any damage resulting from the instability (e.g., landslides) will be increased by the presence of large woody debris left on the slope. As the planner in the Permit Center who signed off on the cutting, should you insist on removal of the cut trees? (Hint: This slope may slide anyway, whether the logs are removed or not.)

As mentioned, the loss of mature or at least well-established trees has a significant effect on the stability of already marginal slopes. Soil disturbance and the further loss of young trees and brush, as well as the forest floor duff and litter, can further degrade stability. Log removal efforts can seriously disrupt shallow soils and such ground cover. Thus we are faced with two major options: leave the trees where they fell or remove them. Either choice can impact slope stability and legal liability. Logs can be removed with little or no further disturbance of soil and ground cover by what loggers and commercial foresters call "full suspension" techniques.

Logs are lifted, not dragged. This requires specialized heavy equipment both at the top and bottom of a slope (or at least a strong "block" or pulley with a massive anchor at one end). Full suspension can also be achieved by balloons or large helicopters. All such techniques are very expensive and/or impractical or impossible to use in most populated shoreline bluff settings. The 'reach' of a crane from the top or from the base of a bluff is limited, even where such sites are accessible; they are almost useless on bluffs in the 150- to 300-ft range.

Horse logging can minimize soil and underbrush disturbance, but cannot be done on slopes as steep as most of our shoreline bluffs. Tractors and excavators need roads on such slopes, and the logs still must be dragged to the road. Also, the roads themselves leave unstable slopes as well as concentrate storm runoff long after the logging is complete. Thus by process of elimination, we are left with hand labor for removing large woody debris from most steep coastal bluffs.

Assuming that hand labor is the only practical option for removal of downed timber from steep (35+ degree) slopes, let's consider its limitations.

- It is dangerous, hard work, even for the experienced.
- Thus, experienced help can be expensive.
- Amateur do-it-yourself help can be more expensive (i.e., medical, liability)
- There is a limit to the size of material that can be handled (excluding help from gravity, which we are trying to avoid)

Some ways we can minimize these limitations are:

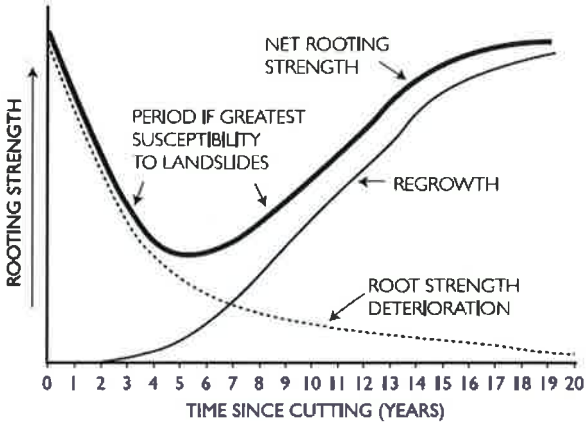
- If there is no hazard (people, structures) below, reconsider. Maybe the logs should be left in place; let nature take its course (i.e., rot and gravity)
- Leave wood in contact with the ground, if possible, to facilitate rotting.
- Work when spring slide hazard is past; remove wood in early fall.
- If a log is oriented within 20 degrees or so of perpendicular to the slope and is supported by a sprouting stump at both ends, leave it.
- Cut (and split?) a log into sizes that can be manhandled.
- Leave tops and limbs smaller than 3- to 4-in. diameter scattered on the slope as ground cover.
- Do not pile tops/limbs, as piles can prevent regrowth (natural or planted) and smother native brush.

In precarious areas directly above a residence, hazards can be minimized by common-sense techniques such as tying a downed tree to a stump before cutting it into logs. Temporary 'cyclone fences' can be strung between standing trees above the downslope home. Experienced woodsmen (for example, cedar cutters) can move wood in ingenious ways with little equipment. Don't try to "fine tune" their plan; every situation of trees, topography, and potential hazard is unique. Perhaps the best conditional constraint would be that no additional disturbance to the slope should occur.

Before ordering removal of large downed trees on a steep slope, the planner/permit official might want to check with their legal counsel. What is at hazard downslope? Do homeowners at the base of the bluff understand the options and potential hazards? For example, a "cartwheel" of firewood from a 3- to 4-ft fir can become lethal if it starts rolling on a steep slope. Who is liable? The wood cutter? The property owner? The agency that ordered or approved the removal? All of the above? (An industrial or commercial downslope property owner might want to make their own plans regarding timber cutting/log removal.)

What about stumps? A stump and its rootball, *if mobilized* into a shallow fast-moving slide (debris avalanche), can add to the future damage potential of the mud and smaller debris. However, removing stumps *will increase* the likelihood of such events. As the roots of many stumps rot, their ability to provide reinforcement and anchoring of the soil/vegetation mat decreases. However, they may still provide that critical role, albeit to a decreasing extent over time, while new trees are getting established. (See figure 2) Generally, stumps of cut trees should not be removed.

FIGURE 2. CONCEPTUAL GRAPH INDICATING ROOT STRENGTH DETERIORATION AFTER CUTTING (R. SIDLE, 1984)



Special mention is warranted for stumps that sprout, thus keeping the stump alive and its roots functioning. Species such as maple, willow, and madrone usually sprout and, after several years, may provide the same slope stabilizing benefits as the standing tree. It is not unusual to see cut-over slopes slide except for the area at and below a single sprouted maple stump. Also, removing a stump on a bluff via hand labor is slow and expensive and creates a bare patch subject to erosion and increased infiltration. Except in isolated instances where a stump is an obvious hazard, they should be left.

If you need to remove large (1-ft+) trees from an area of steep ground (35+ degrees) where property and lives below could be at stake, get a pro. The passing 'blow-hard' who can shrug and walk away from his self-created "accident" won't do. Get a responsible expert (one who is licensed, bonded). That person should be able to tell if a particular site is a 'piece of cake' or will require much finesse. If

the hazard potential is great, you might want a second opinion. As a public official, with your signature on the application, carefully exploring all options may save you and your agency later grief and expense.

Mitigation of damage to the slope from tree cutting and removal of debris should be a routine condition of permitting tree removals. Mitigation specifications should reduce both short- and long-term stability and erosion impacts which are likely to occur as a result of tree removal. Measures such as revegetation with suitable native species are often effective if an agency requires adequate monitoring and project maintenance during the establishment period (3-5 years). Vegetative buffers at the crest of the slope, as well as drainage controls of upland and slope surface-water run-off are also valuable mitigation tools.

Cutting of trees and removal of large woody debris from steep slopes can impact slope stability and have long-term legal ramifications for landowners and permitting agencies. Caution and common sense should be exercised in managing steep, often unstable, marine slopes.

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TREES, SOILS, GEOLOGY, AND SLOPE STABILITY

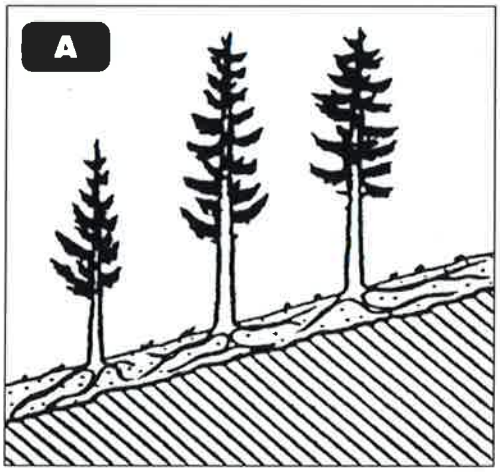
The following drawings and narratives are provided as a very simplified representation of how trees may influence slope stability on Puget Sound marine shorelines. They illustrate several generalized combinations of soil depth, stratigraphy, and tree rooting. The degree to which trees may influence stability on a given slope is a complex function of various specific, interacting physical, biotic, and human-related factors.

Physical factors include slope geometry and gradient, geologic materials, stratigraphy, hydrology, and the local effects of shore processes. Climatic variability can alter the dynamic equilibrium of a slope in significant ways.

The species mix of trees as well as their spacing, age, vigor and health, influence how effectively trees can stabilize slopes. The successional stage and complexity of the associated plant community can be a significant factor. The role of associated vegetation, though significant, in effecting hydrologic conditions, soil formation, and other factors which may influence erosion rates and slope stability is not addressed here.

Forested marine slopes are often barely stable, have adjusted to the various forces acting on them and have developed a delicate equilibrium. They are sensitive to alterations such as view clearing and tree removal, as well as upland site development such as lot clearing and grading. They may also be highly sensitive to cumulative upslope disturbance and local watershed modifications which effect slope hydrology. Disturbances such as logging, roadbuilding, and urbanization in developing watersheds can significantly alter conditions and upset the dynamic equilibrium of slopes, thereby indirectly causing increased landslide activity on previously stable slopes.

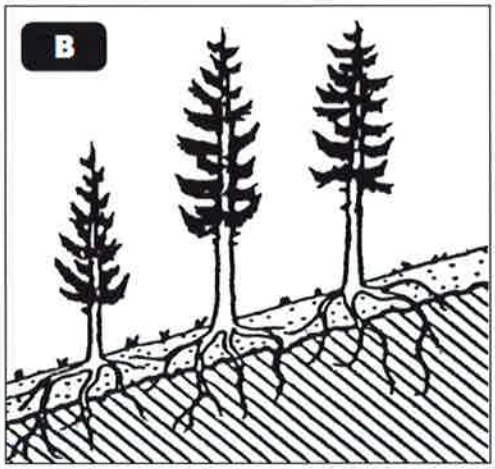
It should be emphasized that the following examples are greatly simplified when compared to actual conditions found on Puget Sound shorelines. For example; our shorelines are often steeper and the subsoils (geologic parent materials) are complex, resulting in erratic concentrations of groundwater, which complicate slope stability assessments.



Type A

Characterized by shallow (less than 3 feet) soils overlaying parent material (competent rock, glacial till, dense silt or clay) which resists root penetration. Surface soils are fully reinforced with tree roots. Lateral rooting, though shallow, often resists slope failures if tree density and distribution is adequate to provide an interconnected root-web matrix. Rooting is plate-like. Roots are at failure plane. Subject to rapid, shallow slides during extreme rain-on-snow events.

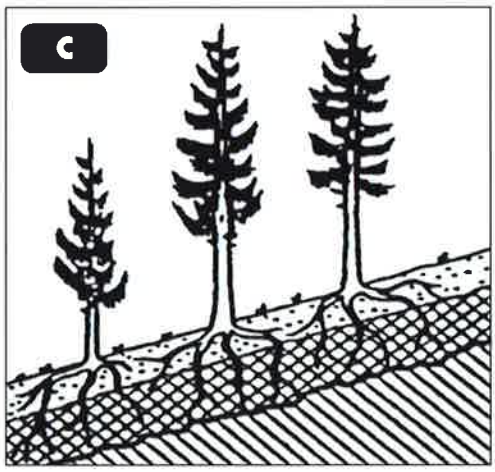
Stabilizing effect of roots: Moderate if not compromised. Tends to become rapidly unstable when disturbed, or subjected to increased hydrological influences. Anchoring - minor. Soil cohesion - high.



Type B

Characterized by shallow (less than 3 feet) soils overlaying parent material (dense sand, glacial till, etc.) which allows significant root penetration. Degree of anchoring into parent material by roots is dependent on the nature of the fractures in the parent material and the predominant tree species. Roots intersect potential failure plane, providing shear resistance.

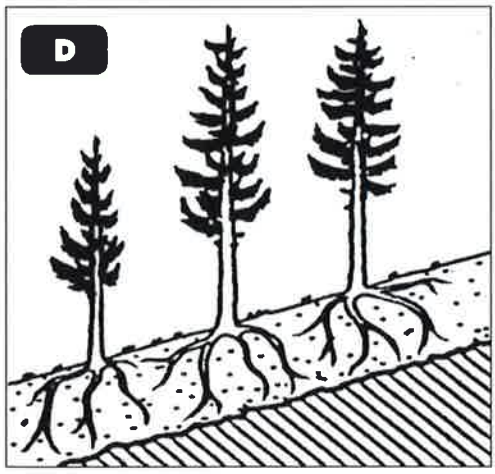
Stabilizing effect of roots: High. Individual trees are stable without a significant dependence on adjacent trees. Both anchoring and soil cohesion benefits are high.



Type C

Characterized by deeper soils (3-12 feet) with a non-distinct transition zone in which soil shear strength increases with depth. Assumptions include: (1) transition zone functions as a drainage moderator, allowing a concentration of groundwater and increased pore-water pressure; (2) failure plane passes through the transition zone; (3) soil zone is more easily penetrated and permeated by roots than in B, above. (Example: sandy loam over loose till over compacted till.)

Stabilizing effect of roots: Anchoring - high.
Soil Cohesion - high.



Type D

Characterized by deep soils where both the failure plane and the soils are deeper than the root zone. The actual depth of the soil for this condition to occur depends on root morphology (depth, spread, etc.) of the particular tree species on the slope. For example, on a slope where Red alder predominates, a relatively shallower soil depth would exhibit Type D conditions, while on a slope forested by Douglas-fir the stabilizing effects would be significantly greater for the same depth.

Stabilizing effect of roots: Anchoring - minor.
Soil Cohesion - moderate.

Illustrations adapted from: Vegetation Influences on Debris Slide Occurrences on Steep Slopes in Japan, Y. Tsukamota and O. Kasakobe. 1984

Prepared for Coastal Training Program by Elliott Menashe (www.greenbeltconsulting.com) 2004

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Value, Benefits and Limitations of Vegetation in Reducing Erosion

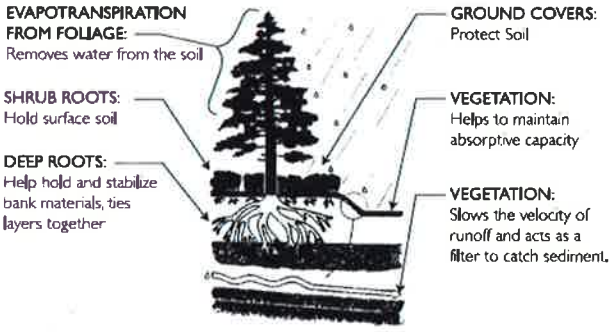
Trees, shrubs, and groundcovers can maintain slopes and reduce erosion from surface water, shallow groundwater and, to some extent, coastal processes. Evergreen trees and other vegetation are most valuable and able to protect soil and remove water during the winter months when deciduous plants are dormant. A diverse mix of both evergreen and deciduous plants provides the greatest protection.

Plants can also have value as sight and sound barriers, discourage access to hazardous areas, and define space in a yard. Native plants enhance wildlife habitat by providing nesting and hiding cover, food, and safe travel corridors. Once established, native plants require little maintenance or care. Species should be chosen for their ease of establishment, adaptability, usefulness, and availability.

Extensive lawns, especially in the vicinity of the bank crest, should be avoided because grass tends to increase surface-water sheetflow during wet conditions when soils are saturated. Low-growing evergreen or perennial plants should be established on the upper crest of the bank.

THE VALUE OF VEGETATION IN STABILIZING SLOPES

FIGURE 1. ROLE OF VEGETATION IN REDUCING EROSION AND STABILIZING SLOPES. (MENASHE, 1993)

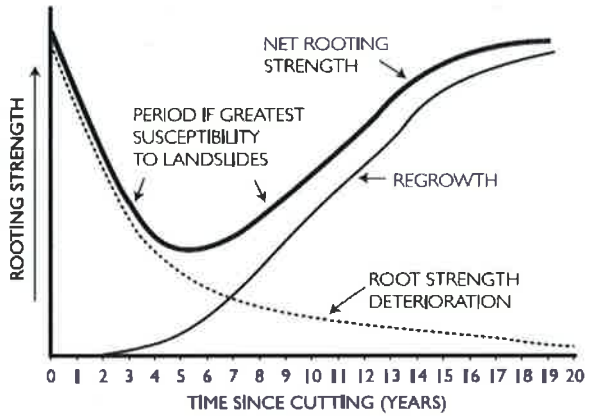


1. Foliage intercepts rainfall, causing absorptive and evaporative losses that reduce surface water runoff and erosion.
2. Evergreen trees and shrubs continue the metabolic activity known as evapo-transpiration, which extracts moisture from the soil, throughout the year. As logging or clearing occurs, water table levels rise, and soils remain saturated for longer periods, reducing soil cohesion and increasing the rate of land slides.
3. Roots reinforce the soil, increasing lateral soil sheer strength and cohesion during saturated conditions. Many slopes can persist beyond their angle of repose and remain stable as a result of the complex root networks within soil blocks.
4. Tree roots anchor soil strata vertically and laterally by means of large-diameter structural roots. These roots may extend well beyond the tree's canopy or crown.
5. Roots, especially the fine feeder roots of trees, shrubs and groundcovers, bind soil particles at the ground surface, reducing their susceptibility to surface erosion and slumpage during saturated soil conditions.
6. Large trees can arrest, retard, or reduce the severity and extent of failures by buttressing a slope. This works in much the same way as retaining walls. In the case of trees, though, the system is to some extent self-repairing, and it becomes progressively stronger over time, whereas engineering structures are strongest when installed and become progressively weaker over time. Obviously, planted trees need adequate time to develop root systems and become effective in stabilizing slopes.

LIMITATIONS OF VEGETATION

The limitations of vegetation in preventing, reducing or arresting slope failures and erosion is often due to previous land management practices such as logging, topographic alterations, increased or channelized surface water flow, and wholesale clearing. Once initiated, slope failures require an expenditure of time, effort, critical planning and money to stabilize them successfully. The use of vegetation in particular requires foresight and several years of monitoring and maintenance until plants are established and effective. Establishment can take up to three years. It can take up to 15 years for shrubby vegetation to develop the values discussed above, even longer for trees to reach sufficient stature to be effective. The impacts of tree cutting on steep slopes can take several years to become apparent, as illustrated in figure 2.

FIGURE 2. CONCEPTUAL GRAPH INDICATING ROOT STRENGTH DETERIORATION AFTER CUTTING (R. SIDLE, 1984)



Landowners need to be aware that not all vegetation provides effective erosion control. Just because it is green does not necessarily mean it works. Such common species as Himalayan blackberry, horsetails, English ivy, and red alder are often present on disturbed slopes and have limited erosion control value. Blackberry and ivy, in particular, tend to discourage more desirable vegetation from becoming established.

In some situations a combination of geotechnical engineering and vegetative techniques are required to assure a practical solution to slope problems. The best time to employ inexpensive relatively vegetative means is before severe failures occur. Note: It should be clearly understood that unusually harsh climatic conditions prior to full development of a vegetative root matrix could result in failure or partial failure of such a slope stabilization system. Landscape contractors should have an understanding of the processes affecting slopes, techniques to be employed to ensure success, and the potential hazards of working on steep slopes in vulnerable areas.

There are several situations where vegetation is relatively or completely ineffective in protecting a slope from failure. These include: (1) lower banks subject to wave attack; (2) areas of deep-seated geologic instability; (3) bluffs near vertical; and (4) unstable areas too wet or dry for vegetation to become established.

RECOMMENDATIONS

Plantings in areas that have not recently been subjected to slope failures are a wise investment. Preventive measures, employed before serious problems occur, are relatively inexpensive. Bear in mind that plantings of more desirable species to replace existing species such as red alder should be well established (2-3 years) before alders are removed, in order to maintain adequate soil-binding benefits within the effective root zone (ERZ) of the cut trees. The ERZ can be approximated as a one-foot radius of lateral root extent for every inch of diameter of the tree's trunk. Preparatory to planting, alders (as well as cherry) can be thinned to a spacing that will not compromise slope integrity during the establishment period. Tree cutting on slopes without replanting can have serious future consequences as illustrated in figure 2.

Proper selection of shrub and tree species for position on the slope will minimize view maintenance requirements while greatly improving slope stability. Care should be taken in selecting species that thrive under site-specific conditions found locally on the slope. These include soil moisture, light/shade, and rooting type.

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Landslide susceptibility revealed by LIDAR imagery and historical records, Seattle, Washington ☆

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Received 28 April 2006; received in revised form 31 August 2006; accepted 19 September 2006
Available online 15 November 2006

Abstract

Light detection and ranging (LIDAR) data were used to visually map landslides, headscarps, and denuded slopes in Seattle, Washington. Four times more landslides were mapped than by previous efforts that used aerial photographs. The mapped landforms (landslides, headscarps, and denuded slopes) were created by many individual landslides. The spatial distribution of mapped landforms and 1308 historical landslides show that historical landslide activity has been concentrated on the mapped landforms, and that most of the landslide activity that created the landforms was prehistoric. Thus, the spatial densities of historical landslides on the landforms provide approximations of the landforms' relative susceptibilities to future landsliding. Historical landslide characteristics appear to be closely related to landform type so relative susceptibilities were determined for landslides with various characteristics. No strong relations were identified between stratigraphy and landslide occurrence; however, landslide characteristics and slope morphology appear to be related to stratigraphic conditions.

Human activity is responsible for causing about 80% of historical Seattle landslides. The distribution of mapped landforms and human-caused landslides suggests the probable characteristics of future human-caused landslides on each of the landforms. The distribution of mapped landforms and historical landslides suggests that erosion of slope-toes by surface water has been a necessary condition for causing Seattle landslides. Human activity has largely arrested this erosion, which implies that landslide activity will decrease with time as hillsides naturally stabilize. However, evaluation of glacial-age analogs of areas of recent slope-toe erosion suggests that landslide activity in Seattle will continue for the foreseeable future.

Keywords: Landslide; LIDAR; Geomorphology; Seattle; Washington; Coastal bluff; Historical records

1. Introduction

Landslides commonly cause property damage and occasionally human casualties in the Seattle, Washington area (Fig. 1). The hazard posed by landslides in Seattle has been so significant that city agencies began maintaining landslide records in 1890 (Laprade et al., 2000) when the city's population was only about 5000 people (www.historylink.org). These records have been cataloged in a historical landslide dat abase containing 1433 entries of landslides reported between 1890 and 2003 (Laprade et al., 2000; Shannon and Wilson, Inc., 2003). Although measures have been taken in Seattle to promote land use, development, and construction practices that do not exacerbate the landslide problem, the relative proportion of human-

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doi:10.1016/j.enggeo.2006.09.019

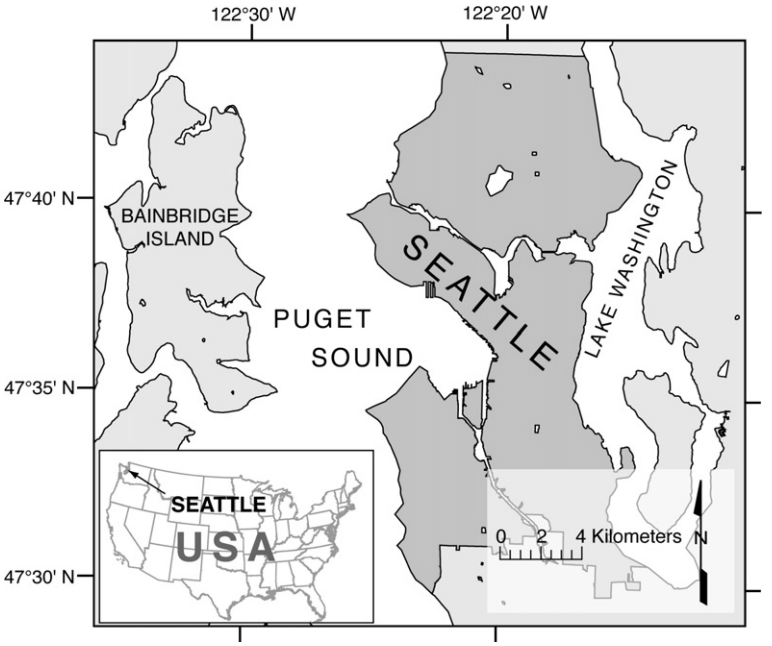

Fig. 1. Map showing the location of Seattle in relation to Puget Sound, Lake Washington, and Bainbridge Island.

caused landslides has increased significantly since the 1980s (Schulz, 2005).

The continuing occurrence of destructive landslides in Seattle may be partly due to a lack of recognition of landslide-prone terrain and incomplete understanding of the necessary conditions that result in Seattle landslides. Geologic, coastal, and landslide-specific maps of Seattle (Waldron et al., 1962; Waldron, 1967; Youngmann, 1979; Yount et al., 1993; Wait, 2001) identify only a very small part of the total area in which historical landslides have been reported (Schulz, 2004, 2005). These maps were constructed using aerial photographs, ground-based study, and historical records. Several studies have postulated that coastal erosion contributes to landsliding in the Seattle area (e.g., Thorsen, 1989; Hampton et al., 2004), although most of these conclude that since the majority of the Seattle shoreline has been protected from wave attack by human activities, coastal erosion is no longer a factor in landslide occurrence (e.g., Galster and Laprade, 1991; Shipman, 2004). Following significant landslide events of the early 1970s, Tubbs (1974, 1975) concluded that landslide activity in Seattle is typically caused by high pore-water pressures that occur near the basal contact of the Vashon advance outwash (also referred to as Esperance Sand, Mullineaux et al., 1965). Tubbs (1974, 1975) mapped a 61-m-wide strip centered along this contact as a zone of particular landslide hazard. Tubbs' conclusion has been advanced by many scientists and engineers (e.g., Galster and Laprade, 1991; Gerstel et al., 1997; Laprade et al., 2000; Savage et al., 2000; Coe et al., 2000; Wait, 2001; Montgomery et al., 2001; Coe et al., 2004; Shipman, 2004) and adopted by the City of Seattle for regulating development of landslide-prone terrain. However, only 29% of historical landslides (Shannon and Wilson, Inc., 2003) occur within the contact strip (using the contact as mapped by Troost et al., 2005), an equal percentage occurred on Seattle-zoned steep slopes (>40% inclination and 3.3 m height) located outside of the contact strip, and 30% occurred within zoned areas of concentrated historical landsliding (Laprade et al., 2000). The performance of Seattle zoning in assisting identification of the causes of landslides demonstrates that landslide occurrence in Seattle is not fully understood.

The dense vegetation typical of the Seattle area (Fig. 2) obscures the morphology of landslides both in the field and in aerial photography. Light detection and ranging (LIDAR) data can be processed to reveal the topography beneath vegetation and has proven useful in the Puget Sound region for identifying tectonic fault scarps (Haugerud et al., 2003; Johnson et al., 2003; Sherrod et al., 2004), previously unmapped landslides, and other geomorphic landforms (Haugerud et al., 2003). The present study sought to: 1) create a landslide inventory map for Seattle using LIDAR-derived imagery and to evaluate the relative quality of the LIDAR-derived map against previous Seattle landslide inventory maps created using aerial photographs, 2) create a landslide susceptibility map using LIDAR imagery and records of historical landslides,

Fig. 2. Photograph showing typical vegetation in Seattle covering a landslide complex. View is toward the southeast from south of West Point (Fig. 3) on June 14, 2005. The vertical escarpment is approximately 12 m high. Photo by Jeffery Coe (US Geological Survey).

and 3) evaluate results in the context of landslide causation in Seattle. A secondary goal of the present study was to perform an evaluation of the locations and characteristics of historical Seattle landslides and their relations to stratigraphic conditions and landslide-related landforms mapped using LIDAR imagery.

2. Setting of landslides in Seattle

Seattle occupies an isthmus between Puget Sound and Lake Washington and has an area of 215.6 km^2 (Fig. 3). The recent geologic history of the area includes cycles of Pleistocene glaciation followed by Holocene coastal erosion, stream incision, and grading by humans. Dominant landforms in Seattle are mostly glacial in origin and include elongate, north–south trending ridges and valleys sculpted by glacial ice, and former glacial outwash valleys and lake beds. These glacial landforms create a rolling upland surface, generally 50 or more meters above current sea level, that reflects the landscape present upon retreat of glacial ice and recession of meltwater (Figs. 3 and 4). The upland surface is locally truncated by bluffs along coastlines and drainages.

2.1. Post-glacial landscape evolution

Glaciers retreated from the Seattle area about 16,400 years ago (Booth, 1987; Booth et al., 2005). Glacial meltwaters were locally impounded, resulting in formation of lakes. Melt-off of the glaciers and other factors caused the relative levels of Puget Sound and Lake Washington to rise; about 6 to 10 m of rise occurred during the past 5000 years (Booth, 1987, Fig. 8; Sherrod et al., 2000). As is generally the case when surface-water bodies meet elevated land (e.g., Hampton et al., 2004), the rising levels of Puget Sound and Lake Washington resulted in erosion of the uplands by wave action and formation of coastal bluffs (Booth, 1987; Shipman, 2004) that truncate the glacially sculpted upland surface along most of the Seattle shoreline. Sea level rise since glacial melt-off has resulted in an estimated 150 to 900 m of retreat of Seattle's coastal bluffs, primarily by landsliding (Galster and Laprade, 1991; Shipman, 2004). Most of Seattle's coastal bluffs are no longer subjected to wave attack due to fill (human-constructed soil) placement along coasts, human lowering of the level of Lake Washington, and construction of shoreline protection structures.

The upland surface is incised throughout Seattle by drainages, many of which were produced during glacial melt-off (Booth et al., 2000; Troost et al., 2005) but now carry little or no water. Many drainages present during the late 1800s (Fig. 5) have since been filled or controlled by humans, thus the erosive power of Seattle streams has been greatly reduced.

Human activity has made Seattle perhaps the most graded city in North America (Galster and Laprade, 1991). Major grading activities in the latter part of the 19th and early part of the 20th centuries included

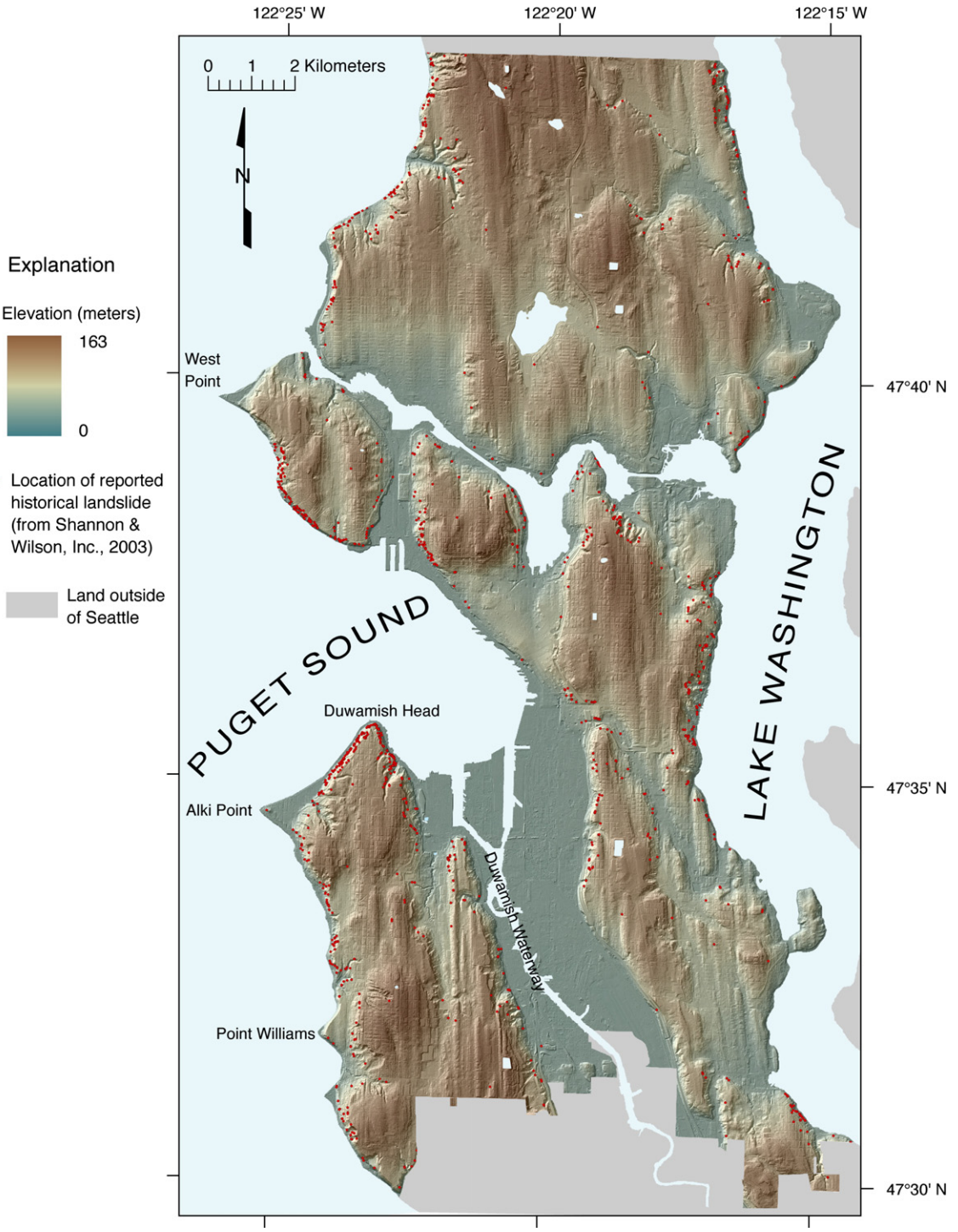

Fig. 3. Shaded relief map created from the LIDAR-derived, bare-earth digital elevation model (DEM) of Seattle showing land-surface elevations and locations of historical landslides (locations modified from Shannon and Wilson, Inc., 2003).

filling tidal flats, wetlands, and coastal areas to create more land area, and excavation of hills and filling of lowlands to flatten parts of the city. Grading has been so extensive that about 13 km of former coastal bluffs now appear as inland hills due to fill placement into Puget Sound (Fig. 5).

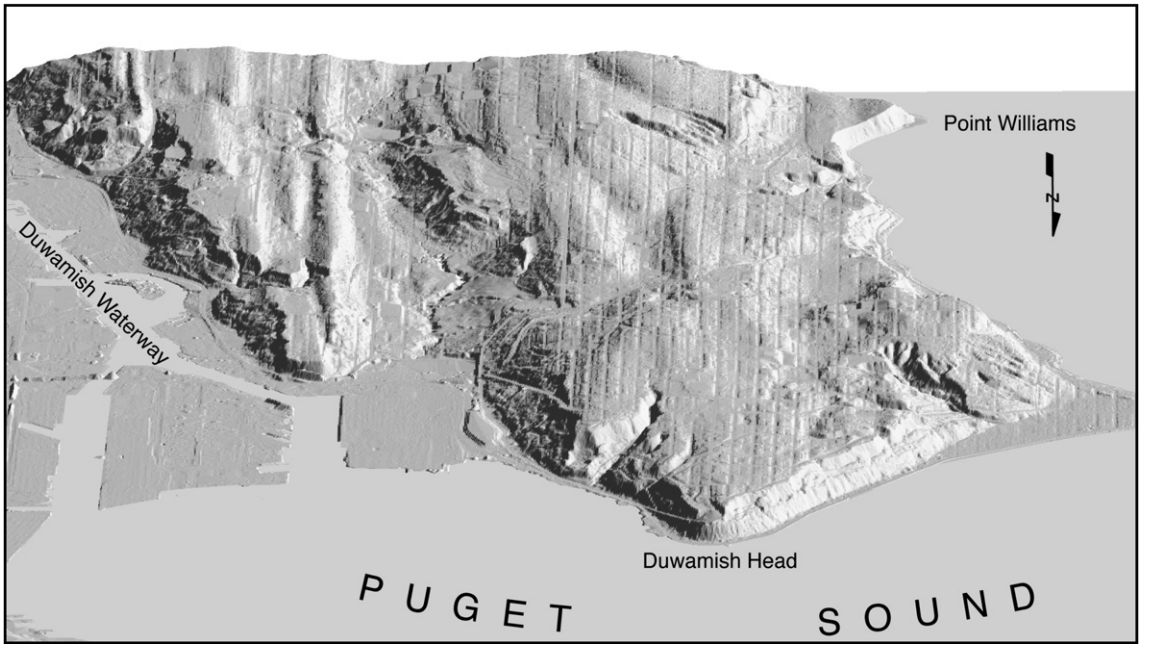

Fig. 4. Oblique aerial view created from the LIDAR-derived, bare-earth DEM with two times vertical exaggeration. View is toward the south of part of southwestern Seattle. The land area is approximately 4.6 km across at the top of the figure. The glaciated nature of the upland surface is highlighted by the north–south-oriented drumlins in the left part of the figure. The upland surface is truncated by bluffs along the Duwamish Waterway and Puget Sound, and by incised drainages, such as those near Duwamish Head and east (left) of Point Williams.

2.2. Topographic and geologic conditions

Seattle's coastal bluffs and slopes along drainages are up to 125 m high and are generally steepest at their crests along escarpments that usually range from 60° to vertical (Figs. 2–4). Slopes below the escarpments usually exceed about 30°. A sub-horizontal bench occurs about midslope along perhaps one-half of the bluffs and drainage slopes, below which the slopes are generally very steep (greater than 45°).

Stratigraphic units that underlie Seattle (Fig. 5) are primarily Pleistocene glacial outwash and till, and interglacial lacustrine and marine deposits, with Tertiary bedrock exposed in parts of southeastern Seattle (Troost et al., 2005). Beach and tidal deposits, alluvium, colluvium, landslide deposits, and fill (human-placed soil) locally overlie older stratigraphic units. Seattle's Pleistocene sediments are generally flat lying and laterally continuous, such that the stratigraphy beneath most of the city is similar. The youngest Pleistocene sediments result from the Vashon stade of the Fraser Glaciation (Armstrong et al., 1965), which occurred between about 16,400 and 17,400 years ago (Booth et al., 2005). According to Troost et al. (2005), Vashon recessional outwash deposits (Qvr) formed during glacial retreat, generally occupy low-lying parts of the upland surface (Fig. 5), and consist of stratified sand and gravel deposited by streams, and laminated silt and clay deposited in lakes. Vashon till (Qvt) caps most of the uplands and is typically a very dense, poorly sorted mixture of sand, silt, and gravel. Till is generally underlain by the Vashon advance outwash (Qva), which is comprised of well-sorted silty sand and gravel that was deposited in front of the advancing Vashon glacier. The basal contact of the advance outwash illustrates the flat-lying, laterally continuous characteristics of Seattle's Pleistocene deposits; this contact occurs on most hillsides that extend from near sea level to the uplands, and it can be continuously traced as far as 13 km (Fig. 5). The advance outwash is generally underlain by and grades into very dense, laminated clayey silt lacustrine deposits that comprise the Lawton Clay (Qvlc). Pre-Fraser age sedimentary deposits (Qpf) underlie the Lawton Clay and are comprised of a highly variable sequence of poorly to well-sorted gravel, sand, silt, and clay.

Two major aquifers underlie Seattle, one of which primarily occurs in the advance outwash (Qva) (Newcomb, 1952; Vaccaro et al., 1998). This aquifer is perched on the Lawton Clay (Qvlc) or on pre-Fraser deposits (Qpf) where the Lawton Clay is absent.

Because of its perched nature, groundwater flow within the advance outwash has a lateral component toward the margins of the isthmus and results in groundwater discharge onto slope faces and into overlying colluvium (Newcomb, 1952; Galster and Laprade, 1991; Vaccaro

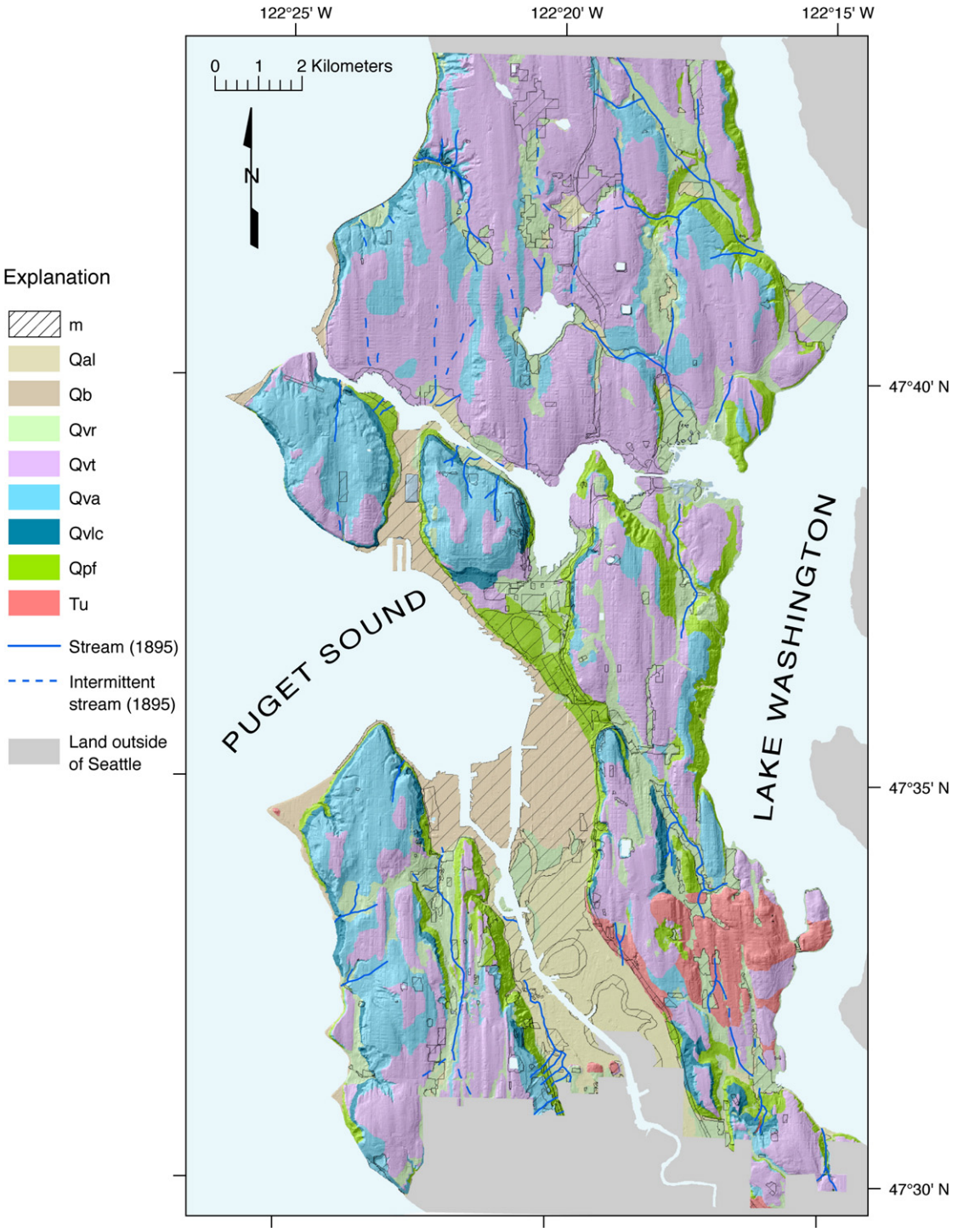

Fig. 5. Simplified geologic map of Seattle (simplified version of 1:12,000-scale maps, Troost et al., 2005) also modified to include late 19th century stream locations. Map units include: m = modified land (Holocene); Qal = alluvium and wetland deposits (Quaternary); Qb = beach and tide flat deposits (Quaternary). Deposits of the Vashon stade of the Fraser Glaciation (Pleistocene) include: Qvr = recessional outwash, lacustrine, ice-contact, and peat deposits; Qvt = till; Qva = advance outwash deposits; Qvlc = lacustrine deposits. Units older than the Vashon deposits include: Qpf = sedimentary deposits of pre-Fraser-glaciation age (Pleistocene); and Tu = sedimentary and volcanic bedrock units of Tertiary age. Streams were digitized from the U.S. Geological Survey Snohomish topographic quadrangle, 1:125,000 scale, 1895. Geology and streams are draped on a shaded relief map generated from the LIDAR-derived, bare-earth DEM.

et al., 1998). Based on the author's observations from boreholes and groundwater modeling, this discharge zone is generally from 3–26 m thick and its top is from 30–70 m below the upland surface. Groundwater also flows from the advance outwash downward through the Lawton Clay (Qvlc), where present, and recharges the aquifer that occurs in pre-Fraser deposits (Qpf) (Newcomb, 1952; Vaccaro et al., 1998).

Direct recharge from the advance outwash (Qva) to the pre-Fraser deposits (Qpf) occurs beneath perhaps one-third of Seattle where Lawton Clay (Qvlc) appears to be absent (Fig. 5).

3. Data and methods

3.1. Seattle LIDAR elevation data

LIDAR data for Seattle were acquired under the direction o f the Puget Sound LIDAR Consortium (PSLC). The LIDAR data were acquired November 1, 2000–April 1, 2001, which corresponds to the leaf-off period in Seattle. The data and description of their acquisition and processing are available at the PSLC website (http://pugetsoundlidar.org).

LIDAR ground-surface measurements for Seattle were acquired from aircraft at an average spacing of about 2 m (Haugerud and Harding, 2001). The data were processed to remove vegetation, buildings, and other aboveground features, thus creating a bare-earth digital elevation model (DEM) (the DEM used for the present study). The Seattle bare-earth DEM has vertical accuracy that is typically about 30 cm, but it is considerably less accurate in some areas, particularly those with dense vegetation because of reduced ground-surface measurements in these areas (Haugerud and Harding, 2001; PSLC, http://rocky2.ess.washington.edu/data/raster/lidar/lidar-data/index.html). The vertical error in these areas is as great as nearly 5 m, or about half the maximum vertical error identified in the USGS 10-m DEM (W.C. Haneberg, Haneberg Geoscience, pers. commun., 2005). Additionally, the corners between low-inclination and high-inclination surfaces were rounded during data processing, resulting in steep slopes whose crest and toe locations and overall inclination are not properly represented in the bare-earth DEM (Haugerud and Harding, 2001). The LIDAR bare-earth DEM data are in the Washington State Plane coordinate system and have a grid cell size of 1.8 m (6 ft).

3.2. Historical landslide data

Landslides in Seattle are concentrated along the coastal bluffs, but have also been reported on hillsides along drainages and on steep, glacially sculpted landforms (Waldron et al., 1962; Waldron, 1967; Tubbs, 1974; Youngmann, 1979; Yount et al., 1993; Harp et al., 1996; Gerstel et al., 1997; Baum et al., 1998; Laprade et al., 2000; Wait, 2001). Nearly all Seattle landslides are triggered by heavy winter precipitation (e.g., Tubbs, 1974, 1975; Galster and Laprade, 1991; Miller, 1991; Gerstel et al., 1997; Baum et al., 1998; Chleborad, 2000; Laprade et al., 2000; Montgomery et al., 2001; Coe et al., 2004). Historical records (Shannon and Wilson, Inc., 2003) show that 93% of reported landslides occurred between November 1 and April 30 (generally considered Seattle's winter rainy season). Earthquake-related ground shaking caused both small and very large landslides around A.D. 900 (Ludwin et al., 2005) and during 1949, 1965, and 2001 (Highland, 2003). Historical records also indicate that 80% of reported landslides have been at least partly caused by human activity.

Seattle landslides generally may be characterized as shallow slides, flows, and falls and topples (grouped and referred to as falls during this study), as well as deeper slides of earth and debris (terminology from Cruden and Varnes, 1996). The database of historical Seattle landslides (Shannon and Wilson, Inc., 2003) indicates that 72% were shallow (less than about 3 m thick). Shallow landslides in Seattle often have long, rapid runout and pose significant hazards to structures and humans located in their paths (Fig. 6). Deep landslides (greater than about 3 m thick) are the second most abundant type in Seattle (19%) and are usually slow moving and larger than shallow landslides so can adversely affect more structures. Flows are relatively uncommon in Seattle (6%), as are falls (3%). Eighty-five percent of historical Seattle landslides were small (less than 930 m^2 in area); 15% were large (greater than 930 m^2 in area). About 15% of historical landslides traveled rapidly at least 15 m from their initiation points; these landslides are referred to herein as long-runout landslides.

The historical landslide database was produced from records of various government agencies and those of Shannon and Wilson, Inc. (Laprade et al., 2000; Shannon and Wilson, Inc., 2003); only records for 1308 of the landslides were used during the present study (Fig. 3) because these landslides were located with certainty during creation of the database. Each landslide in the database is spatially represented by a point located at the approximate center of the headscarp (Laprade et al., 2000). The points are considered accurate to within 15 m (W.D. Nashem, Shannon and Wilson, Inc., pers. commun., 2004). The database provides attributes for each landslide (if they could be determined), such as date of

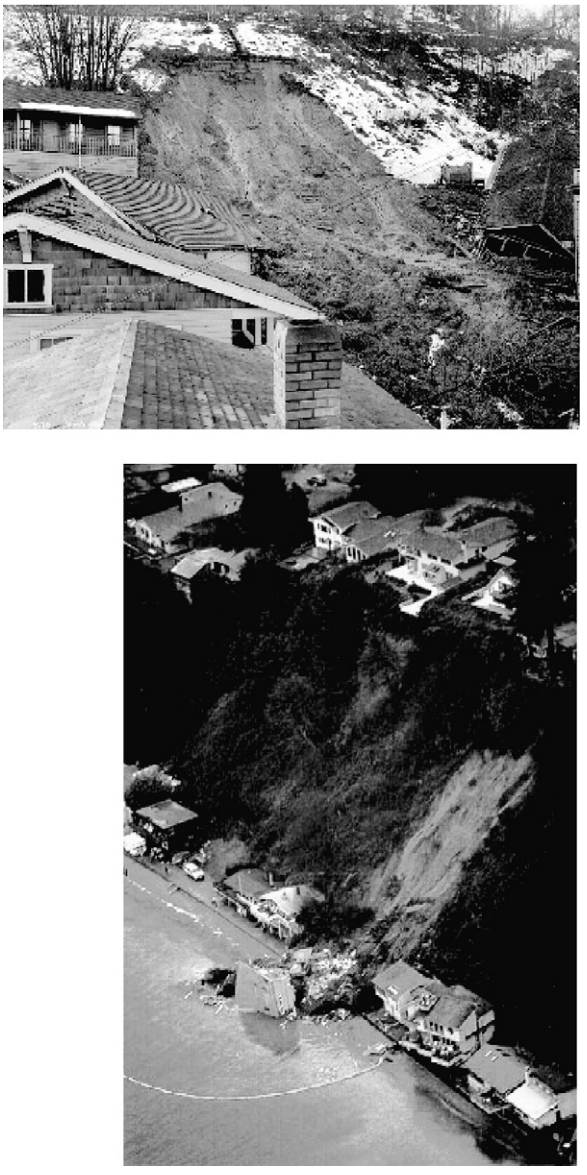

Fig. 6. Photographs of typical Seattle-area landslides. Top photograph is of a landslide that occurred in the area between Alki Point and Duwamish Head (Fig. 3) in 1916 (courtesy of Seattle municipal archives photograph collection, http://clerk.ci.seattle.wa.us/~public/phot1.htm). Bottom photograph is of a landslide that occurred on nearby Bainbridge Island (Fig. 1) in 1997 and killed a family of four (photograph by T. Tamura, The Seattle Times, used by permission).

occurrence, landslide type, size, and potential causes. During the present study, historical landslides were considered to have been human caused if records indicated that human activity had concentrated surface water or groundwater on or in the landslides, or if the landslides involved slopes excavated or loaded with soil by human activity.

Some damage was generally caused by each landslide in the database; landslides were typically not reported if they did not affect a built structure (Laprade et al., 2000; Coe et al., 2004). Therefore, the spatial distribution of landslides in the database is dependent on the history and density of land development in Seattle. Areas of Seattle where landslides have been reported were developed as early as the 1840s to as late as the 1960s. Hence, a bias toward greater spatial density of historical landslides likely exists in the database for areas that have been occupied longer. In addition, landslides on coastal bluffs and steep slopes along drainages may be reported less frequently than those that occur in the uplands because development of coastal bluffs and slopes along drainages is generally of lower density than that of the uplands.

The reporting bias present in the historical landslide database has greater adverse effects as the spatial distributions of historical landslides in smaller parts of Seattle are compared because of temporal settlement patterns that could suggest, for example, greater landslide density in a given area only because the area was inhabited longer. For the present study, the spatial distributions of historical landslides on landforms that are present throughout Seattle (not locally within Seattle) are compared so adverse effects of temporal settlement patterns should below. The landslide database bias due to development density probably has greater effect on the results of the present study. The effect should be a false indication of greater relative landslide susceptibility in areas that are presumably less susceptible (i.e., the more densely developed, relatively flat uplands).

A second limitation of the historical landslide database that could affect results of the present study is the representation of historical landslides as discrete points located at the centers of their headscarps. These points do not represent the entire areas covered by the respective landslides so the conditions present at each landslide (e.g., topography, geology) cannot be directly determined. This limitation should have little effect on the results of the present study because 85% of Seattle landslides are less than about 30 m across (based on small landslides being defined as less than 930 m^2 in area) and geologic conditions are assumed to generally be consistent within this small an area.

3.3. Mapping landslides and landforms using LIDAR imagery

Landslides (i.e., landslide deposits), headscarps, and denuded slopes were mapped from LIDAR-derived

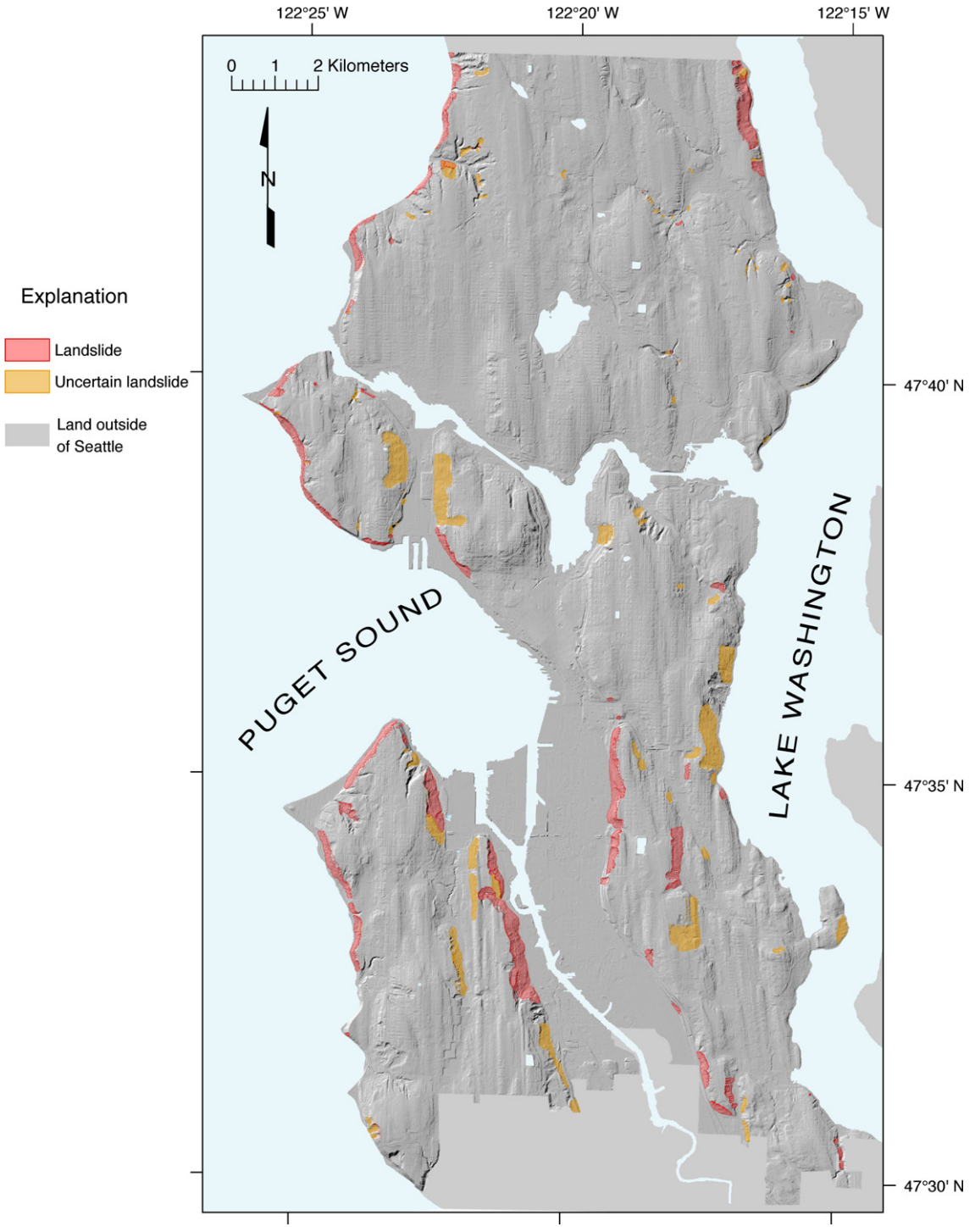

Fig. 7. Landslides mapped using LIDAR imagery (Schulz, 2004) draped on a shaded relief map generated from the LIDAR-derived, bare-earth DEM.

imagery because they are the primary landforms in Seattle created mainly by landslide activity. These landforms in all cases truncate the glacially sculpted upland surface (e.g., Fig. 4). Landslides and headscarps were only mapped when both could be identified for a given landslide; isolated headscarps or landslide deposits

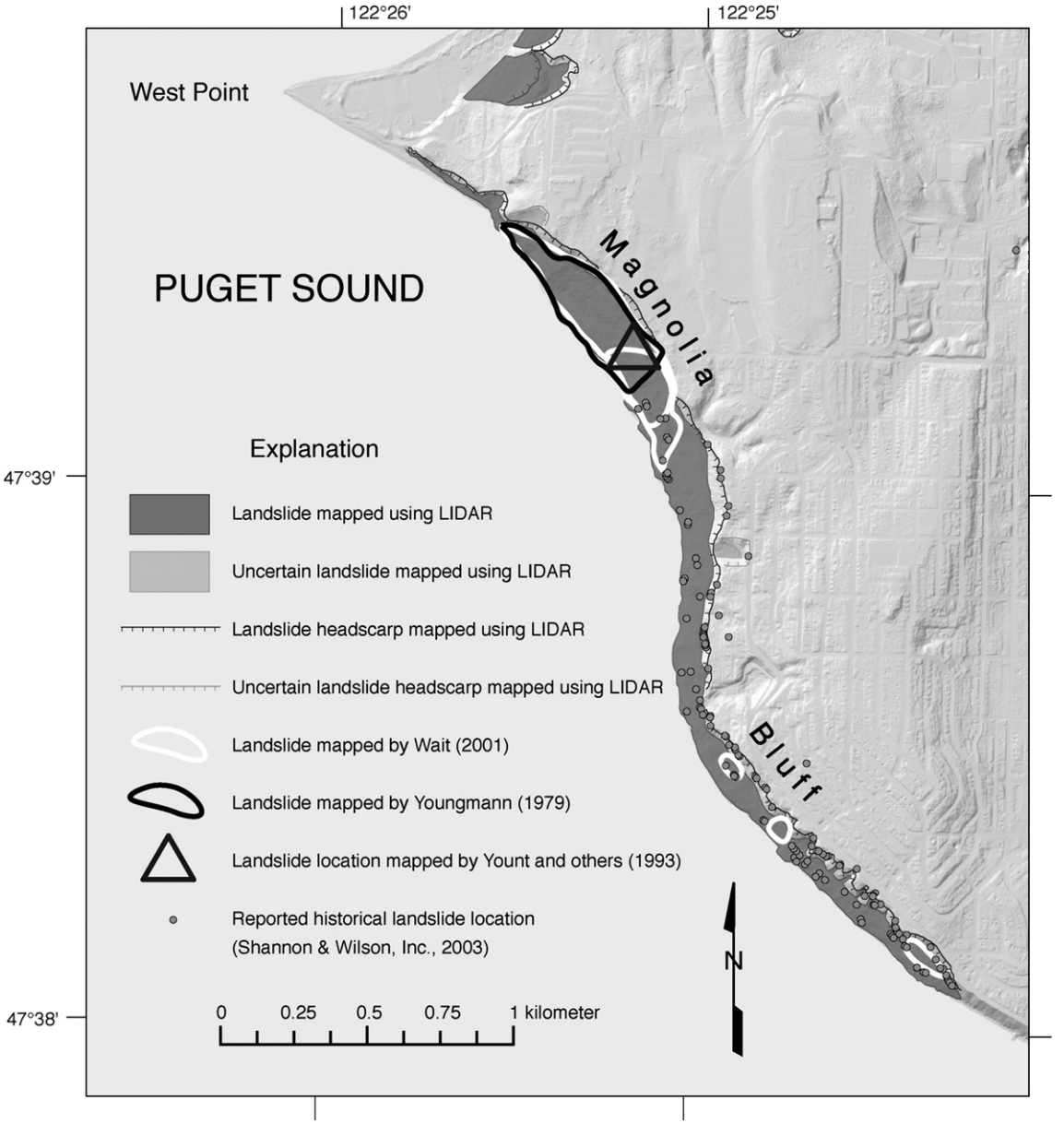

Fig. 8. Landslides along part of Magnolia Bluff near West Point (Fig. 3) that were mapped by Wait (2001), Youngmann (1979), Yount and others (1993), Shannon and Wilson, Inc. (2003), and by Schulz (2004) using LIDAR-derived imagery.

were not mapped. Denuded slopes are herein defined as slopes that formed by erosion and mass wasting (Bates and Jackson, 1987) following deglaciation, but which lack discernible deposits of individual landslides in the LIDAR imagery and usually also during ground-based study. Denuded slopes, therefore, were mapped where the glacial upland surface is truncated, but where landslides could not be identified. Field observations indicate that denuded slope areas probably lack discernible landslides because many Seattle landslides are too small and thin to be resolved by LIDAR and their deposits have often been removed or modified by erosion, mass wasting, and human activity.

Landform mapping was performed using an ESRI ArcInfo v. 8.3 –9.0 geographic information system (GIS). LIDAR-derived imagery that was used for mapping included shaded relief, slope, and topographic contour maps, as well as almost four-hundred topographic profiles.

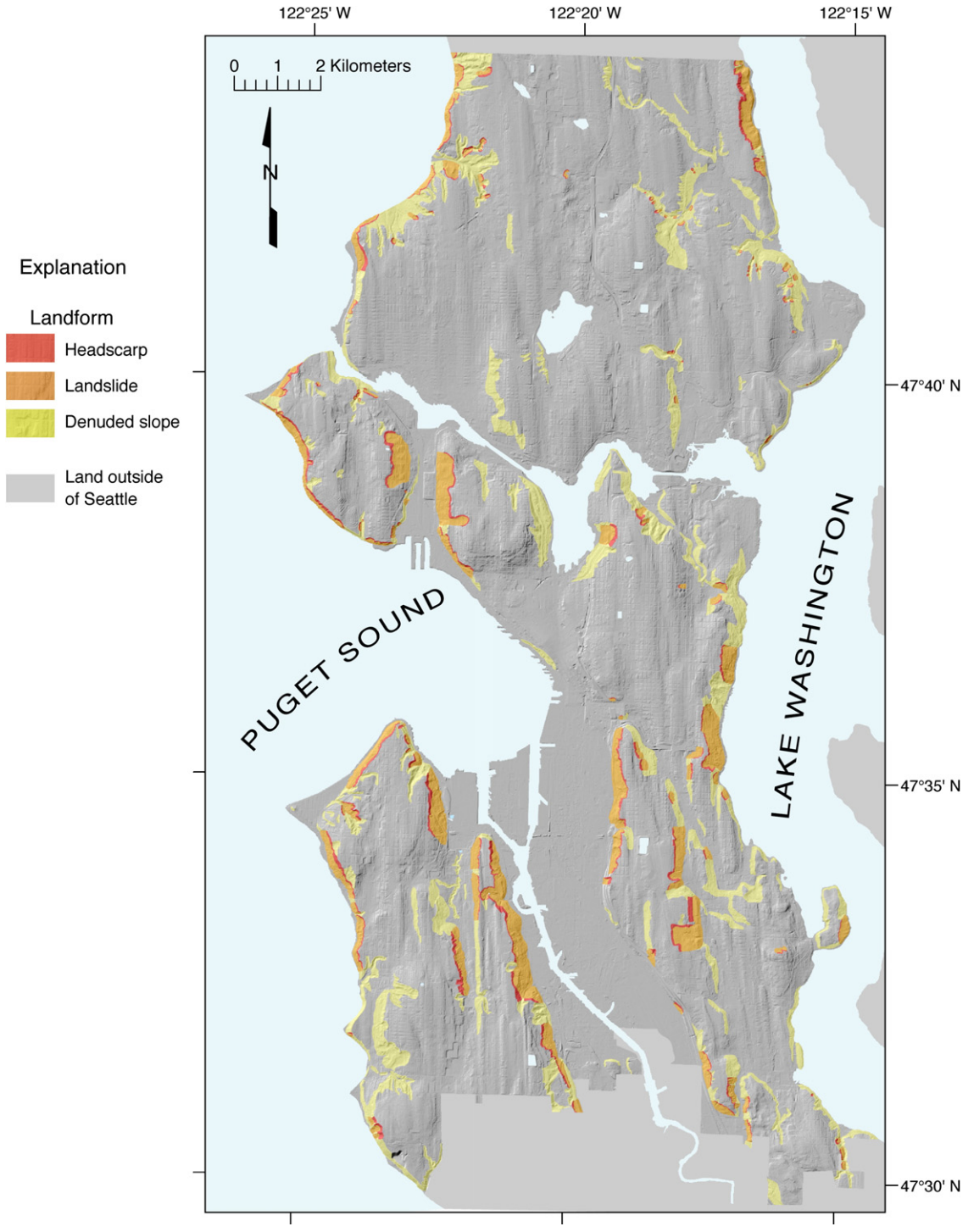

Fig. 9. Landslide-related landforms mapped using LIDAR imagery (Schulz, 2005) draped on a shaded relief map generated from the LIDAR-derived, bare-earth DEM.

These maps and profiles were visually evaluated for topographic characteristics indicative of landslides, such as scarps, hummocky topography, convex and concave slope areas, midslope terraces, and offset drainages. Maps were evaluated at scales ranging from 1:30,000 to 1:2000; mapping was generally performed at 1:5000. Mapped

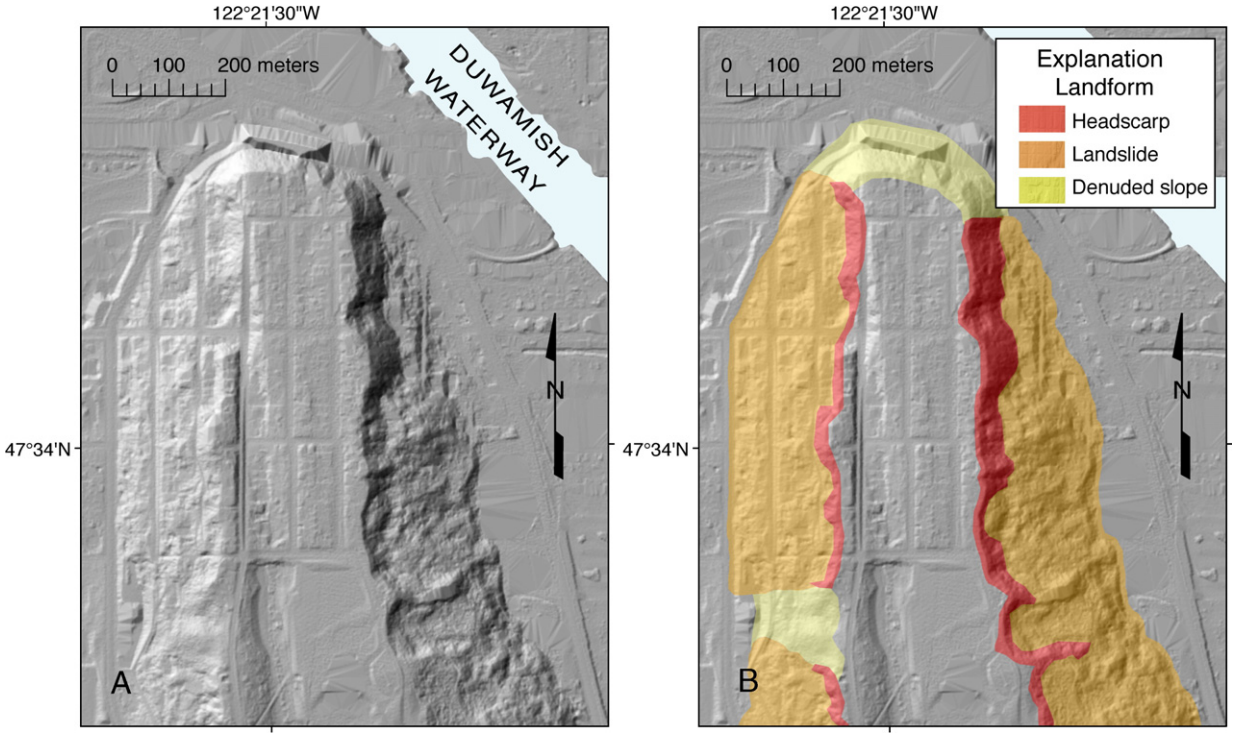

Fig. 10. (A) Shaded relief map of part of Seattle generated from the LIDAR-derived, bare-earth DEM. (B) Landslide-related landforms mapped using LIDAR imagery (Schulz, 2005) draped on the shaded relief map shown on Fig. 10A.

landforms were evaluated in the field during August 2003 and the maps were revised based on field observations, although very little revision was necessary.

3.4. Spatial relations between LIDAR-mapped landforms, stratigraphy, and historical landslides

The spatial densities (in landslides/km^2) of historical landslides by landform were determined using the GIS. Prior to the analysis, mapped landslide landforms were expanded 10 m in all directions, and mapped headscarp and denuded slope landforms were likewise expanded, although not into adjacent landform areas (no overlap exists between the mapped landform areas). This expansion was performed to account for errors in the LIDAR data and in locations of both the mapped landforms and historical landslides. Historical landslides that presumably occurred mostly on the landslide landform were identified as such due to this expansion; historical landslides whose headscarp centers are within 10 m of the initially mapped landslide landform boundaries were identified as occurring on the landslide landform.

The numbers of historical landslides that occurred within stratigraphic units were determined by identifying landslides within the mapped unit boundaries (mapped at 1:12,000 scale) using the GIS. The areas of stratigraphic units corresponding to mapped landforms were also determined using the GIS.

4. Results

LIDAR-derived imagery was used to map 173 landslides and associated headscarps (Fig. 7 and Schulz, 2004). Field evaluation and historical records indicate that nearly all (165 of 173) LIDAR-mapped landslides are actually complexes of multiple landslides.

Landslides and headscarps were classified as uncertain if there was uncertainty regarding the origin of the features. Feature certainty appeared to approximately correlate with activity level with uncertain features being relatively inactive and certain features being relatively active. The total number of landslides mapped using LIDAR is about four times that of previously published maps produced using aerial photographs, and the LIDAR-mapped landslides include all landslides depicted on those maps (Waldron et al., 1962; Waldron, 1967; Youngmann, 1979; Yount et al., 1993; Wait, 2001). Fig. 8 shows results of LIDAR mapping and previous efforts for part of Seattle. The smallest landslide

mapped using LIDAR was just over 20 m across; however, a few larger landslides were identified during ground reconnaissance that had not initially been mapped using the LIDAR imagery. These landslides were in heavily wooded areas and the largest of these landslides was about 30 m across. Landslides were consistently identified using the LIDAR imagery if they had landslide-related topographic features that were at least 30 m long and a few meters high.

Fig. 9 shows the landforms mapped using LIDAR. Fig. 10 shows a large-scale view of map results for part of Seattle illustrating topographic features mapped as landslide-related landforms. Similar to the finding that nearly all LIDAR-mapped landslides and associated headscarps were created by many, much smaller individual landslides, mapped denuded slopes also appear to have been formed by many individual landslides as indicated by intersecting landslide scars observed in the field and evaluation of historical records. The landslide, headscarp, and denuded slope landforms cover 4.6%, 1.2%, and 9.5% of Seattle's land area, respectively. Most (93%) historical landslides occurred on the mapped landforms, and nearly all (99.7%) naturally occurring historical landslides occurred on the landforms.

4.1. LIDAR-mapped landforms, historical landslides, and geologic conditions

All of the stratigraphic units shown on Fig. 5 are represented within the mapped landforms and at the locations of historical landslides (Fig. 11). Forty-nine percent of the landslides mapped using LIDAR intersect the basal contact of the advance outwash (Qva). At least 93% of the LIDAR-mapped landforms are located along coastlines and drainages (including former coastlines and drainages altered by human activity). Fig. 12 shows an example of the distribution of historical landslides, mapped landforms, and stratigraphic conditions in an area that includes the greatest density of historical landslides in Seattle (Coe et al., 2004). Fig. 13 shows an additional example of this distribution. Fig. 14 shows the percentages by stratigraphic unit of historical landslides with various characteristics that occurred on the mapped landforms.

4.2. Landslide features within mapped landforms

The landslides that created the mapped landforms are of variable age and type (e.g., Figs. 12 and 13). Descriptions of the historical landslides shown in Figs. 12 and 13 indicate that they only account for a small part of the total area of the mapped landforms; hence, most of the landslide activity responsible for creation of the landforms was probably prehistoric. Figs. 12A and 13A show that historical landslides are concentrated within the mapped landforms, and appear to generally be located on the steepest parts of slopes. Figs. 12B and 13B illustrate the flat-lying nature of Seattle stratigraphy, the distribution of historical landslides within all slope-comprising stratigraphic units, and, by comparison with Figs. 12A and 13A, indicate that all stratigraphic units are represented in the mapped landforms (except for beach deposits).

Table 1 shows the spatial densities (in landslides/km^2) of historical landslides within each landform area and within the remainder of Seattle (the area in which landslide-related landforms were not identified during mapping and which covers 84.7% of Seattle).

Historical landslide densities increase from the denuded slope landform to the landslide landform, and are greatest for the headscarp landform (Table 1).

The densities of human-caused historical landslides are generally much greater than those of natural historical landslides (Tables 2,3). Table 4 provides ratios of the densities of human-caused historical landslides to the densities of natural historical landslides and shows that human activities are at least partly responsible for causing 7.4 times the number of natural historical landslides. The ratios also indicate the potential for human activity to result in specific types of historical landslides on each of the landforms. Comparison of Tables 3 and 4 shows that, in general, the lower the density of naturally occurring historical landslides on a landform (Table 3), the greater the relative abundance of human-caused historical landslides (as indicated by higher ratios on Table 4). For

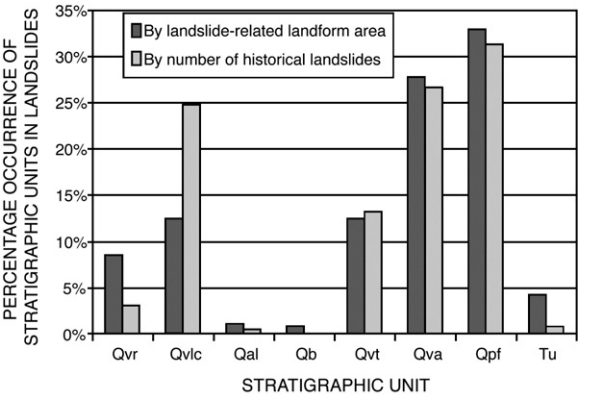

Fig. 11. Landslide occurrence by stratigraphic unit in terms of the percentage of each unit within the landslide-related landforms and in terms of the percentage of the number of historical landslides within each unit.

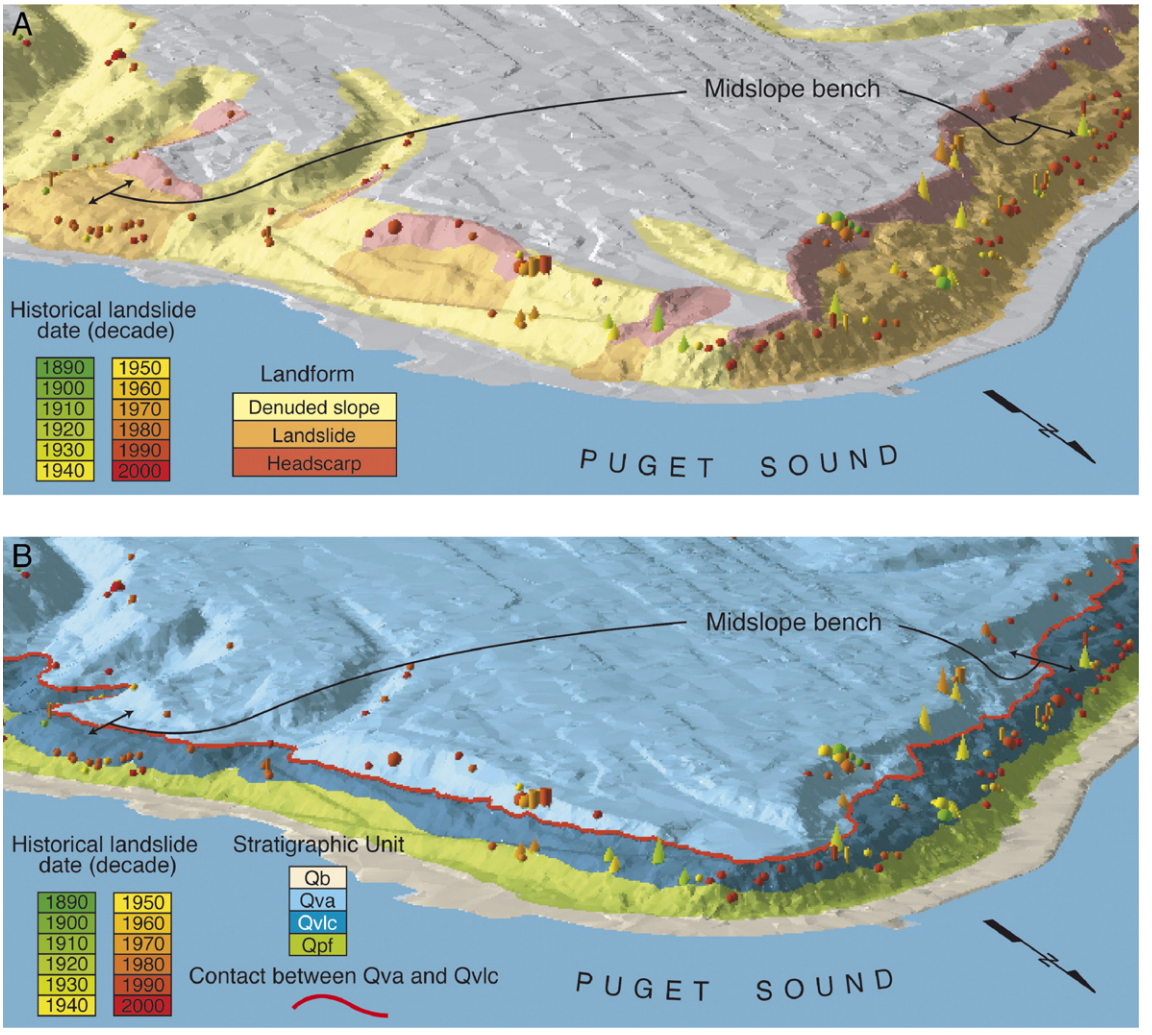

Fig. 12. Oblique aerial view created from the LIDAR-derived, bare-earth DEM. View is toward the south of the Duwamish Head area of Seattle (Fig. 3) and is approximately 1300 m across at the top of the figure. Landslide-related landforms (A), stratigraphic units (B) (simplified version of Troost et al., 2005), and locations of historical landslides (modified from Shannon and Wilson, Inc., 2003) are shown. These locations are represented by colored symbols of variable size; colors indicate the decade during which each landslide occurred. Deep landslides (greater than about 3 m thick) are represented by cones, shallow landslides (less than about 3 m thick) by spheres, and flows by cylinders. Large symbols indicate large landslides (greater than about 930 m^2 in area) while small symbols indicate small landslides (less than about 930 m^2 in area). The midslope bench that occurs along many Seattle slopes is apparent along the bluff in the right third of the figure.

example, the density of all natural historical landslides is least outside of the mapped landform areas (remainder of Seattle) at 0.02 landslides/km^2 and is greatest within the headscarp landform area at 17.58 landslides/km^2 (Table 3), while the ratio of human-caused to natural historical landslides is greatest outside of the mapped landform areas (remainder of Seattle) at 19.0 and is least within the headscarp landform area at 5.6 (Table 4). The greater density of human activities in areas that are less naturally susceptible to landslides (i.e., the relatively flat uplands) may explain this trend in historical landslide density.

The densities of historical landslides within the mapped landforms (Table 1) are essentially equivalent to the relative susceptibilities of the landforms to historical landsliding. The densities should approximate the relative susceptibilities of the landforms to future landsliding, since future landslide activity in Seattle will likely be similar to that of the past (e.g., Thorsen, 1989; Baum et al., 1998; Laprade et al., 2000). The susceptibilities are relative in that they are only meaningful when compared between landforms or landslides with different characteristics in Seattle. For example, Table 1 shows densities

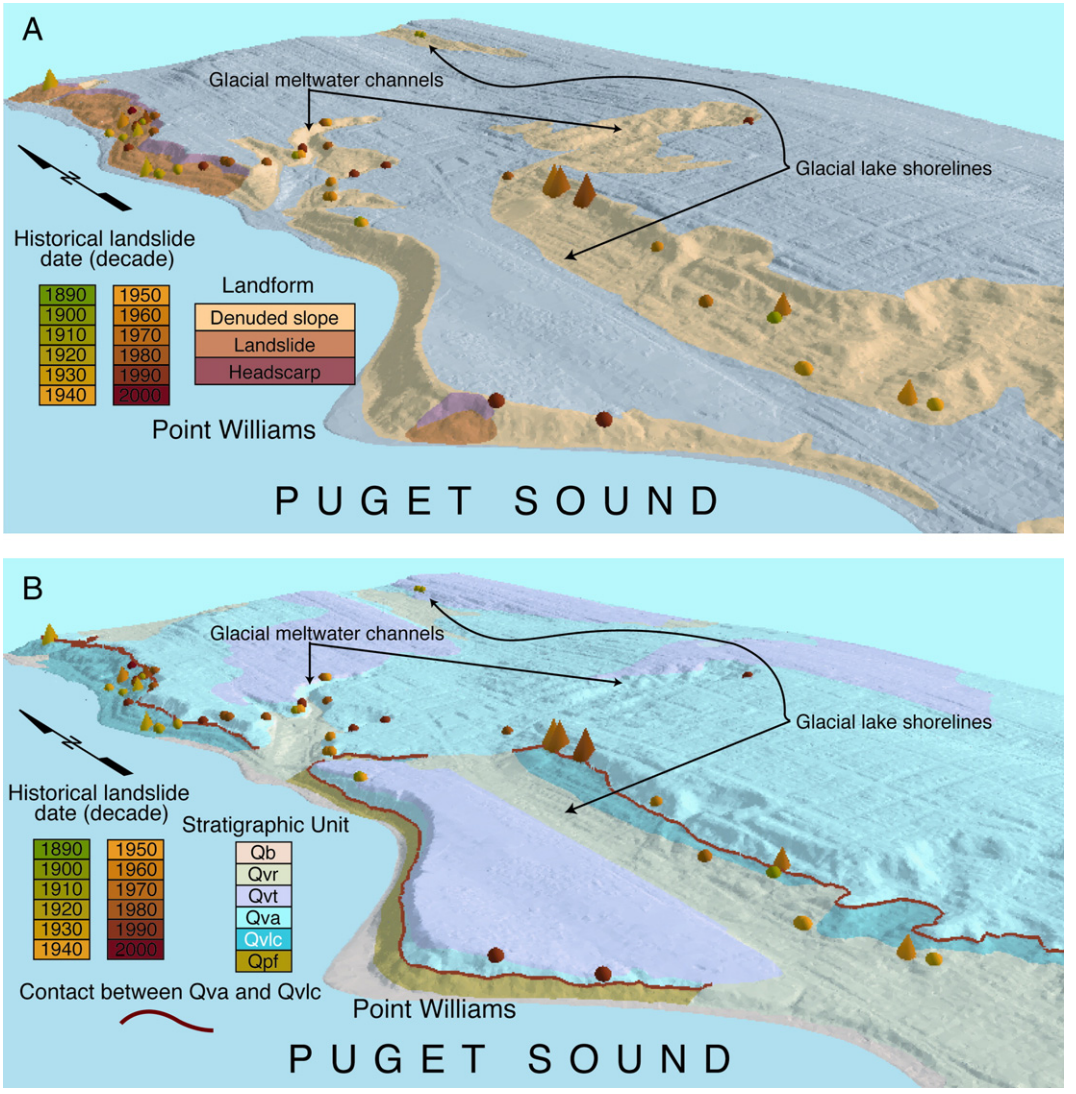

Fig. 13. Oblique aerial view created from the LIDAR-derived, bare-earth DEM. View is toward the northeast and is of the Point Williams area of Seattle (Fig. 3). The land area shown is between 1700–2000 m wide from east to west. Landslide-related landforms (A), stratigraphic units (B) (simplified from Troost et al., 2005), and locations of historical landslides (modified from Shannon and Wilson, Inc., 2003) are shown. These locations are represented by colored symbols of variable size; colors indicate the decade during which each landslide occurred. Deep landslides (greater than about 3 m thick) are represented by cones and shallow landslides (less than about 3 m thick) are represented by spheres. Large symbols indicate large landslides (greater than about 930 m^2 in area) while small symbols indicate small landslides (less than about 930 m^2 in area). Former glacial meltwater channels and glacial lake shorelines are indicated. Point Williams is a park, hence landslides therein are probably rarely reported.

(relative susceptibilities) of 122.23 and 0.47 for the headscarp landform and the remainder of Seattle, respectively. These values suggest that the likelihood of future landslide occurrence on mapped headscarp landforms is 244 times greater than within the remainder of Seattle area. As another example, shallow and deep landslides have densities (relative susceptibilities) of 27.38 and 10.99, respectively, on the landslide landform. Therefore, the likelihood of shallow landsliding is 2.5 times that of deep landsliding on the landslide landform. For comparison, on the headscarp landform, shallow and deep landslides have susceptibilities of 83.08 and 14.78, respectively; therefore, the likelihood of shallow landsliding is 5.6 times that of deep landsliding on the headscarp landform. Hence, the landslide landform is about two times (5.6/2.5) more susceptible than the headscarp landform to deep landsliding relative to shallow landsliding. Comparisons that cannot meaningfully be made

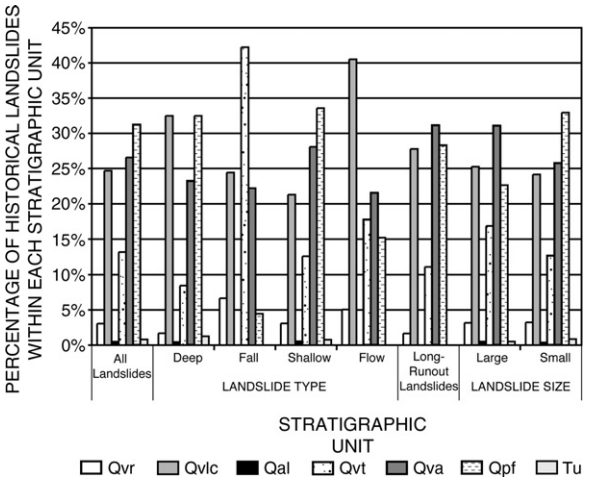

Fig. 14. Percentage of historical landslides that occurred within each stratigraphic unit. Deep landslides are greater than about 3 m thick, shallow landslides are less than about 3 m thick, long-runout landslides have greater than 15 m of rapid displacement, large landslides have area greater than about 930 m^2, and small landslides have area less than about 930 m^2.

include comparing susceptibility values between different landslide feature classes (i.e., type, long-runout, and size).

5. Discussion

5.1. LIDAR-based map utility

Previous landslide mapping efforts in Seattle included geologic mapping for part of Seattle (Waldron, 1967), geologic mapping for all of Seattle (Waldron et al., 1962; Yount et al., 1993), geologic mapping along the Puget Sound coastline of Seattle (Youngmann, 1979), and solely landslide mapping for all of Seattle (Wait, 2001). These efforts included identification of some recent landslides that were not identified using LIDAR, although these recent landslides fall within landslide complexes mapped using LIDAR (Fig. 8). Wait's map (2001) is most applicable for comparison to results of the present study and used 1:2,000–1:2,500-scale black-and-white, color, and color-infrared aerial photographs taken during March 1974, June 1986 and 1991, and September 1995 and 1997. Evaluation of Wait's map (2001), which identified the most landslides of the previous efforts, indicates that aerial photographs were instrumental for identifying recent individual landslides; therefore, aerial photographs appear to be more effective than LIDAR in the Seattle area for discerning boundaries of recently active landslides within landslide complexes. The resolution of the LIDAR data appears to be inadequate to resolve many landslide boundaries within landslide complexes. However, LIDAR was much more effective for identifying presumably older landslides and the boundaries of complexes in which recently active landslides occurred (Fig. 8). For example, of the 128 historical landslides shown in Fig. 8, 124 are located within LIDAR-mapped landslide complexes (including headscarps), while only 19 fall within the boundaries of landslides mapped by Wait (2001). Note that the northern end of the LIDAR-mapped landslide complex in Fig. 8 is absent historical landslides because it is a city park. Landslides in parks typically go unreported because they rarely damage built structures, which partly illustrate the reporting bias of the historical landslide database.

Common to many landslide inventories, the Seattle landslide inventories constructed using LIDAR, aerial photography, and other means (Waldron et al., 1962; Waldron, 1967; Youngmann, 1979; Yount et al., 1993; Wait, 2001; Schulz, 2004) omit many areas prone to landsliding because they omit excavated landslide scars. Denuded slopes appear to primarily consist of coalescing landslide scars and disrupted, thin landslide deposits. Over 37% of historical landslides in Seattle occur on LIDAR-mapped denuded slopes, thus denuded slopes should be considered in regional evaluations of landslide susceptibility.

5.2. Occurrence of landslides in Seattle

The occurrence of Seattle landslides does not appear to be spatially related to stratigraphic conditions (Figs. 11–13). Most Seattle landslides occur in pre-Fraser deposits (Qpf), advance outwash (Qva), Lawton Clay (Qvlc), and till (Qvt), and do not preferentially occur to a significant extent in any of these units (Fig. 11). These stratigraphic units typically comprise Seattle's high, steep hillsides that extend from near sea level to the upland surface (Fig. 5). It appears that the relative number of landslides within each stratigraphic unit is directly proportional to the relative amount of land area underlain by each unit along Seattle's high, steep hillsides (Figs. 5 and 11). This contradicts the conclusion that the basal contact of the advance outwash (Qva) defines a zone where most landslides occur in Seattle (Tubbs, 1974, 1975). Although 29% of historical landslides occur within the 61-m-wide strip centered along this basal contact (as mapped by Troost et al., 2005), they only do so where the contact coincides with a mapped landform; 64% of historical landslides occur within mapped landforms that are absent the contact strip. Historical landslides do not occur within the part of the contact strip that occurs outside of the mapped landforms (24% of the contact strip area). The presence of landslides near the contact appears to be coincidental; advance

Table 1
Densities of historical Seattle landslides (landslides/km^2)

Location	All Landslides	Shallow [a] landslides	Deep [b] landslides	Flows	Falls	Long-runout [c] landslides	Large [d] landslides	Small [e] landslides
Headscarp landform	122.23	83.08	14.78	10.39	9.19	22.77	23.17	93.47
Landslide landform	42.77	27.38	10.99	3.40	0.60	5.80	7.00	34.08
Denuded slope landform	23.74	17.75	3.50	0.88	0.78	2.87	2.68	19.80
Remainder of Seattle	0.47	0.35	0.10	0.01	0.00	0.03	0.04	0.41
All of Seattle	6.07	4.23	1.10	0.37	0.21	0.83	0.88	4.90

Note: Some density values in this table are greater than the sums of densities of human-caused and natural landslides (Tables 2 and 3) because this table includes landslides for which the cause is unknown.
[a] Shallow landslides are less than about 3-m thick.
[b] Deep landslides are greater than about 3-m thick.
[c] Long-runout landslides have greater than 15 m of rapid displacement.
[d] Large landslides are greater than 930 m^2 in area.
[e] Small landslides are less than 930 m^2 in area.

outwash (Qva) is present nearly everywhere beneath Seattle (Fig. 5) and its stratigraphic position dictates that its basal contact occurs along most high, steep slopes (e.g., Figs. 12,13). Tubbs' (1974, 1975) conclusion that landslides preferentially occur near the base of an aquifer (i.e., the base of the advance outwash) is based on sound reasoning. Elevated groundwater pore pressures do trigger Seattle landslides; however, they cannot cause landslides in the absence of a slope (excluding liquefaction-type failures).

Natural historical landslides essentially all (99.7%) occurred within the mapped landform boundaries. One condition was identified at the locations of nearly all of the mapped landforms; surface water eroded slope toes at some time since retreat of glacial ice. This erosion is of highly variable age and occurred along glacial lakeshores, glacial meltwater streams, recent streams, and the coasts of Lake Washington and Puget Sound. Figs. 12 and 13 illustrate the apparent relationship between surface-water erosion of slope toes and the locations of landslides. Landslides have been concentrated along former and present surface-water bodies and have not occurred elsewhere.

Landsliding due to surface-water erosion of slope toes has well known characteristics (e.g., Quigley et al., 1977; Edil and Vallejo, 1980; Buckler and Winters, 1983; Vallejo and Degroot, 1988; Hampton et al., 2004). Erosion of slope toes removes supporting materials and thereby reduces the shear strength available to resist landsliding (e.g., Terzaghi, 1950; Hutchinson, 1968; Quigley et al., 1977; Vallejo and Degroot, 1988; Hampton et al., 2004; Shipman, 2004). Landslides that form due to slope-toe erosion remove support for upslope areas, which similarly fail. Landslides progressively occur upslope until the slope crest fails. Concurrent with the progressive failures, landslide debris that reaches the slope toe is eroded by surface water, which undermines upslope landslide debris and underlying native deposits, making them fail. This cycle continues while slope-toe erosion is active, and the result is essentially parallel retreat of the failing slopes. If erosion ceases, landslide deposits accumulate along the lower parts of slopes and

Table 2
Densities of human-caused historical Seattle landslides (landslides/km^2)

Location	All landslides	Shallow [a] landslides	Deep [b] landslides	Flows	Falls	Long-runout [c] landslides	Large [d] landslides	Small [e] landslides
Headscarp landform	98.26	69.90	11.58	10.39	6.39	20.37	20.77	77.49
Landslide landform	35.18	21.89	9.69	3.30	0.30	5.40	6.40	28.58
Denuded slope landform	20.18	15.47	3.31	0.68	0.58	2.58	2.43	17.66
Remainder of Seattle	0.42	0.31	0.10	0.01	0.00	0.03	0.04	0.37
All of Seattle	5.05	3.56	0.99	0.34	0.14	0.76	0.80	4.22

[a] Shallow landslides are less than about 3-m thick.
[b] Deep landslides are greater than about 3-m thick.
[c] Long-runout landslides have greater than 15 m of rapid displacement.
[d] Large landslides are greater than 930 m^2 in area.
[e] Small landslides are less than 930 m^2 in area.

Table 3
Densities of natural historical Seattle landslides (landslides/km^2)

Location	All landslides	Shallow [a] landslides	Deep [b] landslides	Flows	Falls	Long-runout [c] landslides	Large [d] landslides	Small [e] landslides
Headscarp landform	17.58	8.39	2.00	0.00	2.80	2.00	2.40	9.59
Landslide landform	5.30	3.80	0.70	0.10	0.30	0.30	0.30	4.00
Denuded slope Landform	2.24	1.22	0.19	0.10	0.15	0.10	0.24	1.12
Remainder of Seattle	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01
All of Seattle	0.68	0.40	0.07	0.01	0.06	0.05	0.06	0.41

[a] Shallow landslides are less than about 3-m thick.
[b] Deep landslides are greater than about 3-m thick.
[c] Long-runout landslides have greater than 15 m of rapid displacement.
[d] Large landslides are greater than 930 m^2 in area.
[e] Small landslides are less than 930 m^2 in area.

reduce the slope inclinations, which increases slope stability. As slope inclinations decrease along the lower parts of slopes, landslides progressively concentrate near the slope crests until crest inclinations also decrease to a point of stability due to evacuation of landslide debris. Natural landsliding essentially ceases at that time.

In a setting as is present in Seattle where slope-toe erosion results in landslides, stratigraphic conditions can affect landslide characteristics (Fig. 14) and slope morphology. Perhaps the strongest evidence of these effects in Seattle are the midslope topographic benches often located near the top of the Lawton Clay (Qvlc) (e.g., Figs. 12,13), which can be explained as follows. Surface-water erosion of slope toes has generally occurred within pre-Fraser deposits (Qpf) and Lawton Clay (Qvlc) because of their stratigraphic position. Landslides in pre-Fraser deposits (Qpf) and Lawton Clay (Qvlc) that result from this erosion are generally small (Fig. 14) and undermine upslope areas. This undermining causes landslides in advance outwash (Qva) and overlying till (Qvt), which are generally large (Fig. 14). Because landslides are generally large in the advance outwash (Qva) and till (Qvt) and those in underlying units are generally small, landslides in the advance outwash (Qva) and till (Qvt) may result in more rapid, though episodic retreat of the upper part of slopes, thus forming the topographic benches. Deposits of landslides from the advance outwash (Qva) and till (Qvt) accumulate on the benches and downslope, and were generally mapped as landslide landforms during the present study. The escarpments formed by these landslides were generally mapped as headscarp landforms. Landslide deposits that accumulate on benches may partly buttress escarpments located upslope, resulting in a period of increased slope stability along headscarps. Landsliding continues downslope of the bench during this period as slope-toe erosion by surface water continues, resulting in additional retreat of pre-Fraser deposits (Qpf) and Lawton Clay (Qvlc). Fig. 12 illustrates this greater concentration of landslides downslope from benches than on headscarps, even though slope-toe erosion has been arrested in this area for about one hundred years by human activity. Retreat of the slope below the bench progressively undermines deposits on the bench and upslope and may result in complete removal of the bench, possibly forming a denuded slope. Future landslide activity results in

Table 4
Ratios of human-caused landslide densities to natural landslide densities in Seattle

Location	All landslides	Shallow [a] landslides	Deep [b] landslides	Flows	Falls	Long-runout [c] landslides	Large [d] landslides	Small [e] landslides
Headscarp landform	5.6	8.3	5.8	All HC	2.3	10.2	8.7	8.1
Landslide landform	6.6	5.8	13.9	33.0	1.0	18.0	21.3	7.2
Denuded slope landform	9.0	12.7	17.0	7.0	4.0	26.5	10.0	15.8
Remainder of Seattle	19.0	28.0	All HC	None	None	None	None	33.5
All of Seattle	7.4	8.9	13.3	24.7	2.4	16.4	12.4	10.2

Note: "All HC" indicates that all landslides were human caused; "None" indicates no landslides were reported.
[a] Shallow landslides are less than about 3-m thick.
[b] Deep landslides are greater than about 3-m thick.
[c] Long-runout landslides have greater than 15 m of rapid displacement.
[d] Large landslides are greater than 930 m^2 in area.
[e] Small landslides are less than 930 m^2 in area.

additional slope retreat and possible repeated cycles of bench creation and destruction.

Landslide activity will not cease concurrent with cessation of slope-toe erosion because slopes whose toes were eroded will require time to naturally stabilize through landsliding, as described above. Landslides have occurred in Seattle for more than one hundred years after human activities arrested slope-toe erosion (Fig. 12), thus more time than this is required to achieve stability. This is not surprising because most landslide-susceptible slopes in Seattle are of much greater extent than typical Seattle landslides (e.g., Fig. 6) so individual landslides do little to stabilize slopes. Seattle landslide complexes and denuded slopes whose formation initiated during glacial melt-off (e.g., Fig. 13) provide analogs to areas where slope-toe erosion has recently ceased. Overall slope inclinations appear to be more gentle and historical landslide activity appears to be reduced in areas that have been free of slope-toe erosion since soon after deglaciation compared to areas of recent slope-toe erosion (Fig. 13; note that Point Williams is a park, hence landslides therein may generally be unreported, similar to the park in the northern part of Fig. 8). However, historical landslides have occurred in the areas free of slope-toe erosion since deglaciation. Therefore, more than about 16,400 years is required to naturally achieve slope stability in Seattle, given past climatic conditions. It does not appear that human-constructed, slope-toe erosion protection has made significant impact on landslide activity to date, as suggested by the temporal and spatial distributions of landslides shown on Fig. 12. This figure shows the Seattle bluff area that has been protected from slope-toe erosion by human activity for the greatest length of time, yet landslides still occur low on the bluff.

6. Conclusions

Imagery derived from LIDAR data was used to identify and map about four times more landslides in Seattle than had been mapped previously using aerial photographs. Landslides mapped using LIDAR mainly consist of many smaller landslides that occurred during both prehistoric and historic times, and as such are landslide complexes. LIDAR imagery was also effective for mapping denuded slopes, which are mainly produced by landslides and are susceptible to future landsliding. Nearly all mapped landslide complexes, headscarps, and denuded slopes are located along slopes that have been subjected to toe erosion by wave action or stream flow.

Locations of historical landslides are heavily concentrated on mapped landslide, headscarp, and denuded slope landforms; 99.7% of natural historical landslides occur on these landforms. Historical landslide spatial densities are related to landform type. These densities are greatest along the headscarp landform and decrease to the landslide landform and then to the denuded slope landform. The landforms were primarily created by prehistoric landslide activity, so the concentration of historical landslide activity on mainly prehistoric landforms indicates that landslide locations have been consistent in recent times. It follows that future activity will be similar, so the spatial densities of historical landslides on the landforms were used to generate a landslide susceptibility map. This map indicates the relative susceptibility to landslides with different characteristics occurring on each of the landforms and in the area outside of them. Areas outside of the mapped landforms are virtually unsusceptible to landslides; landslide susceptibility on the landforms is about 47 to 244 times greater than that outside the landforms.

The concentration of historical landslides on LIDAR-mapped landforms, the distribution of these landforms along current and former surface-water bodies, and observed bluff retreat in Seattle indicate that slope-toe erosion was a necessary condition for forming Seattle landslides, and its effects continue to result in landslides. There appears to be little stratigraphic control on the occurrence of landslides in Seattle; the number of historical landslides that occurred on three of the four primary stratigraphic units present along most Seattle hillsides differs by just 6% and appears to be directly proportional to the distribution of the units on susceptible hillsides. This apparent lack of stratigraphic control on landslide occurrence conflicts with the generally accepted theory that landslides in Seattle typically occur due to conditions present near the basal contact of the advance outwash. Evaluation of the distribution of the contact, mapped landforms, and historical landslides indicates that historical landslides only occur near the contact where its location coincides with a mapped landform. The presence of the contact near historical landslides appears to be coincidental. Stratigraphic control on landslide characteristics and slope morphology is evident, however.

Future landslide activity in Seattle is expected to be similar in style and location to recent activity. Erosion of most slope toes in Seattle has been arrested by human activity. This will result in a reduction in landslide activity starting from the lower parts of slopes and progressing upslope as hillside inclinations are reduced by landsliding. However, evaluation of the distributions of historical landslides in areas where glacial meltwater eroded slope toes indicates that 16,400 years without

slope-toe erosion has been insufficient for hillsides to naturally self-stabilize. In addition, man's removal of landslide debris on the lower parts of slopes serves the same purpose as erosion; stabilization of hillsides by accumulation of landslide deposits near their bases is not allowed to occur. However, humans have accelerated the process of slope evolution by partly causing about 80% of Seattle's landslides (Shannon and Wilson, Inc., 2003), so the ultimate stabilization of Seattle's hillsides through landsliding may require less time than if landsliding was purely natural. Clearly, landslides in Seattle will continue to pose hazards for the foreseeable future. The areas in which landslide susceptibility is greatest and the kinds of landslides that will likely occur in specific areas have been identified by mapping landslide-related landforms using LIDAR.

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Example of Geohazard Map using Digital Elevation Model (DEM) data

A 10-m digital elevation model (DEM) data layer was used to calculate hillshade depictions at three different illumination angles to allow interpretation of landforms associated with landslides and debris flows. Illumination from northwest (315 azimuth), northeast (045 azimuth), and south (180 azimuth) at inclination of 35° above the local horizon are depicted in Figure 1. Slope and aspect results are displayed, along with roughness calculated for the center of a moving 9x9 array.

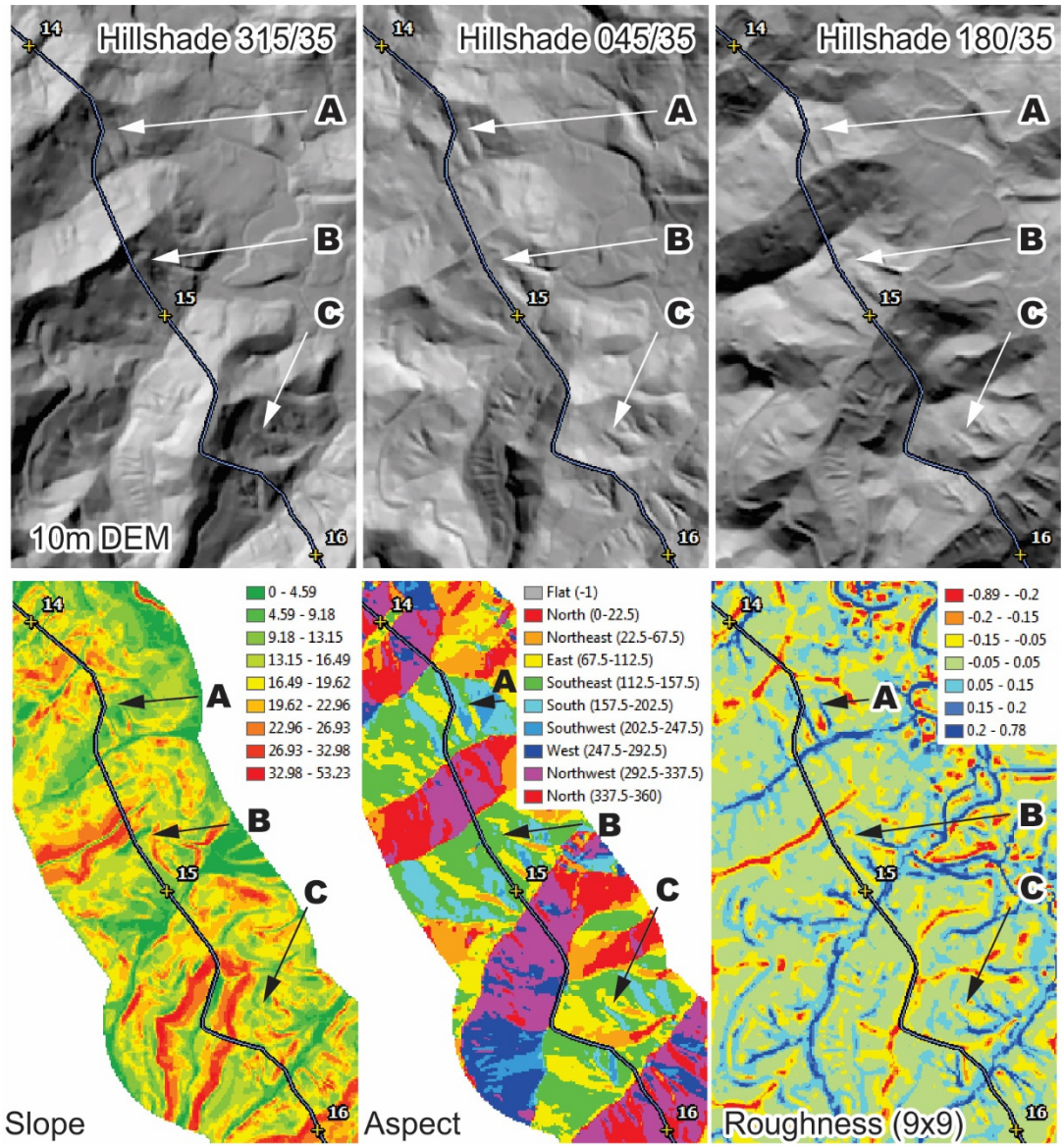

Figure 1. Calculated GIS layers for a two-mile stretch of pipeline alignment in West Virginia. Hillshade, slope, and aspect are GIS utilities; roughness was calculated for the center of a moving array of 81 pixels (9x9) using rgh=(array_mean – DEM)/array_range

Three points (A, B, and C) are identified in Figure 1 to illustrate geohazard interpretation. Point A is a right-hand bend at about MP 14.4, Point B is a topographic bench at about MP 14.8, and Point C is irregular terrain at about MP 15.6. Point A was identified because the right-hand bend (PI) is located in a first-order stream channel, the head of which ends at a steep spot. Such topographic features are called 'hillslope hollows' or swales and are known to be debris flow source areas (Keaton et al., 1985). The hollow and the channel below it tend to have higher soil moisture than adjacent slopes and ridges. Construction activities on this slope would need to be done to minimize the potential for destabilizing the channel and slope. The roughness panel in Figure 1 make the channel stand out with blue color that represents concave slope elements; by contrast, the red color in the roughness panel represents convex slope elements that are ridges.

Point B in Figure 1 represents a bench that is visible in the hillshade, slope, and roughness panels. The contour-like feature in the hillshade panels suggests that this is a road; in this geology such a feature may be a coal seam that has been exposed for small-scale mining. The bench would represent the deposits of excavated earth materials. The pipeline trench across the bench would be in 'fill' deposits and might be less stable than slopes without benches.

Point C refers to irregular terrain that appears to be a landslide deposit. The pipeline alignment at this location appears to be on a narrow secondary ridge with landslide deposits on both sides. The roughness panel in Figure 1 shows some concave elements in light blue color on both sides of the pipeline alignment, and a first-order channel ending in a hillslope hollow on the right side of the alignment adjacent to a small-angle right-hand bend.

Landslide inventory maps, by their nature, tend to overlook apparently stable, non-landslide terrain, and, as can be seen in the hillshade panels in Figure 1, different illumination angles allow landslide features to standout or be subdued. Landslide inventory mapping could be improved if regional comprehensive landslide hazard evaluations produced probability distributions (Keaton and Haneberg, 2013); however, a comprehensive landslide hazard evaluation has not been compiled for the Appalachian Mountains.

Landslides are secondary events triggered by a primary event or process, such as precipitation or earthquakes. Hurricane-induced torrential storms have occurred in the Appalachian Mountains and produced landslides and debris flows (Wieczorek and Morgan, 2008). Therefore, the annual frequency of landslides or debris flows depends on the annual frequency of triggering events, and landslides and debris flows do not always happen at every susceptible location when triggering events occur (Keaton and Roth, 2008). For a risk analysis, probability distributions developed for one of the few localities where they are available could be used with the understanding that no specific evaluation has been prepared for the Appalachian Mountains. An approach that is available now is to map apparently stable slopes and landslides with comparable level of detail (Keaton and Rinne, 2002; Keaton and Roth, 2015). This approach differentiates five classes of slope and landslides: 1) unstable slopes, 2) slopes with inactive landslides, 3) potentially unstable slopes, 4) apparently stable landslides, and 5) apparently stable slopes. Such an approach would be helpful for a quantitative risk analysis of geohazards.

Ground subsidence and settlement can be related to sinkhole activity (karst) in areas underlain by soluble bedrock or soil formations, or caused by groundwater pumping in unconsolidated formation.

Amec Foster Wheeler has the capability to acquire synthetic aperture radar (SAR) satellite data and process it for interpretation of regional ground subsidence, as we did recently at a site in south-central Mississippi (Panda et al., 2015).

The distribution of soluble bedrock and soil formations has been compiled by the U.S. Geological Survey; the pipeline alignment crosses sinkhole-prone terrain in West Virginia and Virginia and comes close to it in North Carolina. Calculated GIS products in Figure 2 reveal several sinkholes in an area underlain by two dolostone formations. The GIS panels in Figure 2 are similar to those in Figure 1, except the base DEM in Figure 2 has a pixel dimension of 3 m instead of 10-m.

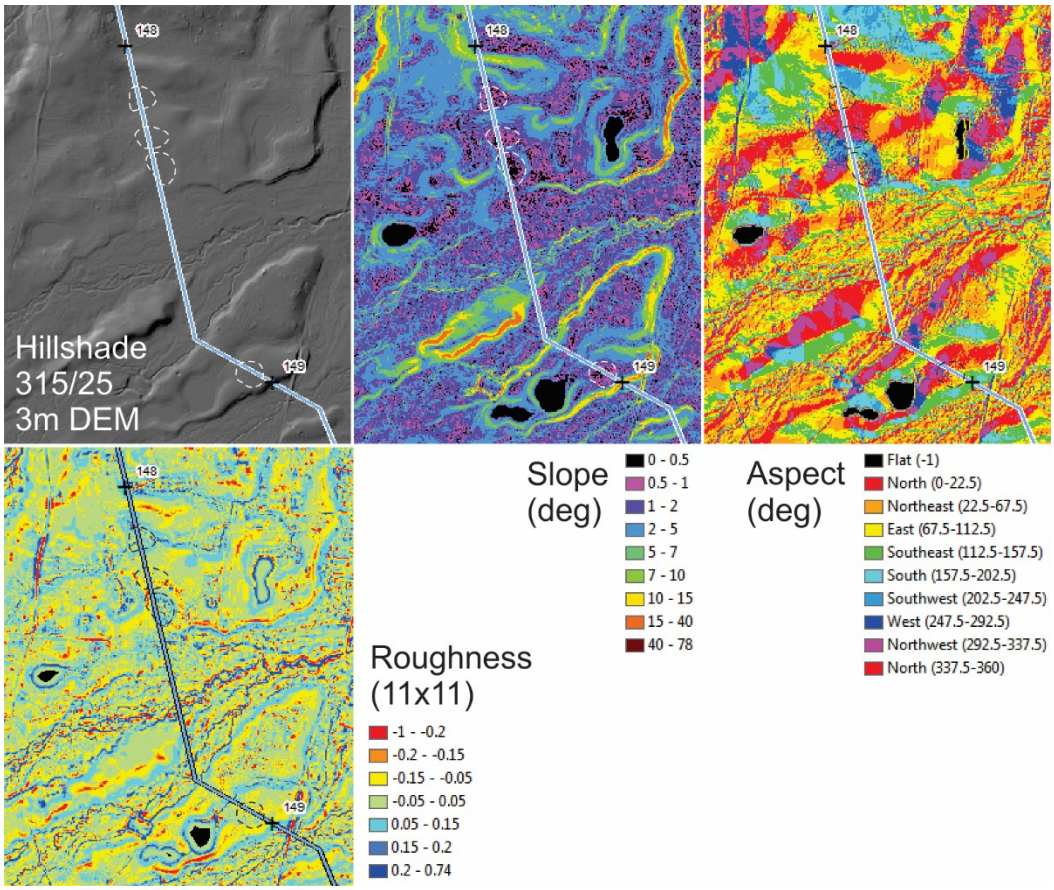

Figure 2. Calculated GIS layers for a one-mile stretch of the ACP alignment in Virginia. Hillshade, slope, and aspect are GIS utilities; roughness was calculated for the center of a moving array of 121 pixels (11x11) using rgh=(array_mean – DEM)/array_range.

Oval depressions are apparent in the hillshade panel in Figure 2, and can be identified in the slope, aspect, and roughness panels, also. Fine dashed white lines were used to trace areas in the slope panel along the pipeline alignment that has characteristics similar to the features that are most likely sinkholes. The dashed lines from the slope panel were copied onto the aspect and roughness panels as black lines, and the hillshade panel as dashed white lines. Thus, it appears that four potential

sinkhole areas are located along the pipeline alignment between MP 148 and MP 149. The river channel between about MP 148.5 and MP 148.8 could be concealing other potential sinkholes that do not have surface expression. This portion of the alignment could be evaluated with geophysical methods, such as electrical resistivity or micro gravity. Ground penetrating radar has been successful in detecting subsurface voids in some locations; however, it does not work well in clay-rich or saturated soils.

Sinkhole occurrence has not been documented systematically in the United States. Florida established a database of reported sinkholes that is maintained by the Florida Geological Survey. The events included in this database have not been verified and the date associated with the entry is the date of reporting, not necessarily the date of occurrence. Nonetheless, the Florida sinkhole incident report database is the best available and was used by Keaton and Boudra (2014) for characterizing sinkhole hazard for pipeline risk assessment in Florida and could be modified for use elsewhere.

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Wetlands in Washington State

Volume 2: Guidance for Protecting and Managing Wetlands

FINAL
April 2005
Ecology Publication #05-06-008

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Suggested code language for mitigation ratios is provided in Appendix 8-B. Guidance on compensatory mitigation ratios for use with the western and eastern Washington wetland rating systems is provided in Appendices 8-C and 8-D, respectively. Appendix 8-F provides the rationale behind these mitigation ratios.

Timing of Mitigation

Generally, mitigation actions are conducted concurrently with or soon after the wetland impact occurs. Standard ratios are typically established based on this assumption. If mitigation is conducted in advance of the impacts, then the risk and temporal loss are reduced and the ratio should be reduced commensurately. If the mitigation is conducted well after the impact, the ratio should be increased.

8.3.7.2 Special Types of Compensatory Mitigation

In addition to addressing the more common mitigation actions (e.g., creation, restoration, and enhancement), local jurisdictions should consider including language in their regulations specifying the circumstances under which special types of compensatory mitigation may be used, such as preservation, mitigation banks, in-lieu fee programs, and programmatic mitigation areas. These types of programs are discussed below.

Preservation

The preservation of existing wetlands as a means of compensating for wetland impacts is highly controversial because it always results in a net loss of wetland area and is perceived as trading one wetland for another one that is already protected. The reality is that some wetland types are not adequately protected under existing laws and can benefit from being placed in public ownership or protected by a conservation easement.

For example, many forested wetlands can be logged under current state laws, and wetlands with significant habitat value are very difficult to protect without large buffers and corridors to connect them to other habitats. Preservation of large tracts of wetlands and uplands can provide benefits that are impossible to achieve using typical regulatory approaches. One way to think about the issue of "net loss" with respect to preservation is that some wetlands are going to experience unmitigated impacts unless they are preserved. In that sense, preservation provides a "net gain" over what would otherwise occur.

Preservation has the following basic advantages as a compensatory mitigation tool:

- Larger mitigation areas can be set aside due to the higher mitigation ratios required for preservation
- Preservation can ensure protection for high-quality, highly functioning aquatic systems that are critical for the health of the watershed and aquatic resources that may otherwise be adversely affected

- Preservation of an existing system removes the uncertainty of success that is inherent in a restoration, creation, or enhancement project

Generally, the use of preservation to compensate for impacts is appropriate only in very limited circumstances. The preservation of a *high-quality* wetland in the same watershed or basin where a wetland loss has occurred, however, is often an acceptable form of compensation when done in combination with other forms of compensation such as re-establishment or creation. See Appendix 8-B for features indicative of high-quality sites.

Note that the use of preservation of wetlands as compensatory mitigation should not allow applicants to circumvent the standard mitigation sequence of avoiding and minimizing impacts first, followed by compensating for unavoidable losses. Additionally, preservation projects should be subject to the same requirements as other types of wetland mitigation (e.g., monitoring and long-term protection). Preservation of wetlands generally requires significantly higher ratios to offset impacts than wetland restoration or creation (see Appendix 8-C and D).

Generally, the preservation of at-risk, high-quality wetlands and habitat may be considered an acceptable part of a mitigation plan when the following criteria are met:

1. Preservation is used as a form of compensation only after the standard sequencing of mitigation (avoid, minimize, and then compensate)

2. Restoration (re-establishment and rehabilitation), creation, and enhancement opportunities have also been considered, and preservation is proposed by the applicant and approved by the permitting agencies as the best option for compensation

3. The preservation site is determined to be under imminent threat; that is, the site has the potential to experience a high rate of undesirable ecological change due to on-site or off-site activities that are not regulated (e.g., logging of forested wetlands). This potential includes permitted, planned, or likely actions

4. The area proposed for preservation is of high quality or critical for the health of the watershed or sub-basin due to its location

In addition, please refer to Appendices 8-B, 8-C, and 8-D for additional criteria and further guidance on the use of wetland preservation in compensatory mitigation.

Mitigation Banks

Mitigation banks offer an opportunity to implement compensatory mitigation at a regional scale and provide larger, better-connected habitat in advance of impacts. Mitigation banking involves the generation of "credits" through restoring, creating, enhancing and, in exceptional circumstances, preserving wetlands and other natural resources. These credits can then be sold to permit applicants who need to offset the adverse environmental impacts of projects that would occur within the *service area* of the bank. A bank's service area is akin to its "market area" or the geographic area in which

credits may be sold or used. Projects that use bank credits as compensation are called *debit projects*.

Wetland mitigation banks have two basic components as follows:

- **Bank site**. The bank is located at the physical site where credits for mitigation are generated by restoring, creating, enhancing, and/or preserving wetlands and associated natural resources.

- **Bank sponsor**. An organization operating under the provisions of a mitigation banking instrument that markets and sells credits, maintains a bank ledger, monitors and reports on the development of the bank site, and provides perpetual protection, management, and other services for the bank site.

Bank sites are normally protected in perpetuity by a legally binding protective covenant such as a conservation easement held by a long-term manager. Bank sponsors must also provide one or more temporary financial assurances to ensure the successful ecological development of the bank and an endowment to fund long-term management of the bank site(s).

Once released for sale, wetland bank credits are sold to permit applicants to compensate for wetland impacts that occur within the service area of the bank. As credits are sold, bankers debit them from the bank's ledger so they cannot be resold. Once all credits in a bank have been sold, the bank is closed.

Mitigation banks benefit the aquatic environment by consolidating numerous small wetland mitigation projects into larger, potentially more ecologically valuable projects. This results in economies of scale that benefit the regulated public, regulatory agencies, and the environment.

Another important feature of mitigation banks is that they are developed in advance of the adverse impacts for which they compensate, which ensures that the bank is ecologically successful before it is used to offset adverse impacts at other sites. Mitigation banks that are properly implemented offer improved ecological performance, lower mitigation costs to permit applicants, and a more streamlined permit process.

To date, few mitigation banks have been approved in Washington. However, as the regulatory agencies develop and implement the process to review and approve banks and gain experience in evaluating proposals, mitigation banks are likely to become more common in Washington.

As with any form of compensatory mitigation, the use of mitigation bank credits to offset impacts to the natural resources should not be considered prior to completing the two mitigation sequencing steps of avoidance and minimization. Then, the regulatory agency must determine whether purchasing credits from a particular bank would provide appropriate and practicable compensation for a proposed impact. In making its determination, the regulatory agency should consider whether any opportunity for mitigation that is environmentally preferable (e.g., on-site mitigation) is available, how

closely a bank's credits correlate with the particular wetland functions that would be altered by a proposed action, and whether using a bank to compensate for a proposed action would be in the best interest of the natural resource, particularly the affected watershed.

Current information on the Ecology's Wetland Mitigation Banking Program is available at http://www.ecy.wa.gov/programs/sea/wetmitig/index.html.

In-Lieu Fee Programs

Mitigation using in-lieu fees (ILF) occurs when a permittee pays a fee to a third party in lieu of conducting project-specific compensatory mitigation, purchasing credits from a mitigation bank, or conducting some other form of compensatory mitigation. This fee represents the expected costs to a third party to replace the wetland functions that would be lost or impaired as a result of the permittee's project. ILFs are typically held in trust by a non-profit conservation organization until they can be combined with other ILFs to finance a project that replaces the lost and impaired functions represented by those ILFs. The entity operating the trust is typically an organization with demonstrated competence in natural resource management, such as a local land trust, private conservation group, or government agency that manages natural resources.

ILF mitigation is used primarily to compensate for minor adverse impacts to the aquatic resources when more preferable forms of compensation are not available, practicable, or in the best interest of the environment. Compensation for projects that result in more substantial adverse impacts is usually provided by project-specific mitigation or a mitigation bank. ILF mitigation may be appropriate when:

- The amount of compensatory mitigation required for a project is too small to justify the cost of designing and implementing project-specific mitigation
- Practicable opportunities to conduct appropriate project-specific mitigation or purchase credits from an approved mitigation bank are not available
- Project-specific mitigation that could be implemented would likely result in a low-performing aquatic system, have a high risk of failure, be incompatible with adjacent land uses, or fail to address the needs of the watershed
- A minor amount of additional mitigation is needed to supplement project-specific mitigation that would not, by itself, fully compensate for a project's adverse environmental impact
- The permit process does not adequately compensate for cumulative effects from a project

ILF mitigation and mitigation banking share many similarities. For example, both types of mitigation allow permittees to fulfill their compensatory mitigation responsibilities by paying a fee to a third party who will accept responsibility for the required mitigation.

Also, mitigation banks and ILF-funded projects must both fully comply with existing federal mitigation guidance and policy, including a requirement for a written implementing agreement that normally includes construction plans, performance standards, monitoring and reporting provisions, a long-term management plan, financial assurances, a protective real estate agreement (e.g., conservation easement), and other measures, as appropriate, to ensure the ecological success of each project.

The fundamental difference between mitigation banking and ILF mitigation is the relative timing of the activities that offset the adverse environmental impacts for which they compensate. With mitigation banks, the environment-enhancing activities are conducted in advance of the adverse impacts, whereas with ILF mitigation, those activities normally are not conducted in advance of the adverse impacts. While specific ILF-funded mitigation projects may not always be identified in advance of project-related impacts, quickly expending collected ILFs to fund mitigation projects should be a high priority for any ILF program. However, regulatory agencies may adjust the size of ILFs to compensate for anticipated delays in expending them.

Local governments interested in developing an ILF program should evaluate the potential for cumulative and unmitigated impacts to hydrologic and water quality functions that may result from the program. Local governments should consider the use of stormwater controls (such as over-sizing ponds and swales) as a way to replace wetland hydrologic and water quality functions on-site and reduce cumulative effects from an ILF program.

Programmatic Mitigation Areas at the Local Level

Another approach for consolidating compensatory wetland mitigation involves directing compensation projects to a *programmatic mitigation area*. Simply defined, a programmatic mitigation area is a site (or series of sites) that have been identified by the local jurisdiction or a state or federal agency as a preferable site(s) for wetland compensation. Wetland compensation projects are constructed separately on the site but are all part of a common design. The programmatic mitigation sites are subject to the same minimum requirements as other compensation sites such as permanent protection, monitoring, restrictions on other activities on the site, etc.

The goal of a program for programmatic mitigation areas to allow the restoration of larger wetland areas that are important to the functioning of a stream basin or watershed because of their position in the landscape. Since many projects require relatively small areas of compensatory wetland mitigation, the programmatic mitigation area program allows the consolidation of these small compensation sites into a larger project.

The following is a summary of how a programmatic mitigation areas work?:

1. The lead regulatory entity (county or city jurisdiction, state or federal agency) identifies an area or areas as priority restoration areas

2. The regulatory entity develops a site development plan for the entire site and may either purchase the site or purchase an easement on the site

3. As projects needing compensation arise, the applicants are directed to perform either certain activities on the site (to aid in the completion of the plan) or directed to implement the site design on specific areas within the overall site

This approach has not been used much in Washington. The closest example available is Kitsap County's work along Clear Creek where several mitigation projects have been completed adjacent and complementary to each other. The county has actively directed compensation projects to the Clear Creek area. Another example is along Mill Creek in Auburn where the Emerald Green Race Track and Washington State Department of Transportation located their compensation sites in an area identified in the draft Mill Creek Special Area Management Plan or SAMP (U.S. Army Corps of Engineers 1997).

8.3.7.3 Impacts to buffers

Impacts to buffers should be handled similarly as impacts to wetlands. Applicants should be required to use all available means of modifying their development proposal, as well as using existing provisions for buffer averaging, before they are allowed to build in buffers. Where buffer impacts are unavoidable, compensation should be required in the form of wetland and/or upland restoration or enhancement.

8.3.8 Buffers

Buffers are defined in many ways (see Chapter 5 in Volume 1) but generally include relatively undisturbed, vegetated areas adjacent to critical areas such as wetlands and streams. The review of the scientific literature in Chapter 5 of Volume 1 indicates that the protection of buffers around wetlands is necessary to protect wetland functions. The scientific literature also provides considerable guidance on buffer characteristics, including widths, which are necessary to protect specific wetland functions. The literature does not provide clear direction on how to structure buffer protection and management programs. However, in addition to providing technical information on buffer effectiveness, the literature provides information that should help guide the development of buffer protection policies and regulations. This information can be summarized as follows:

- Four primary factors should be considered in determining the appropriate width and character of buffers, no matter what the physical setting is:
  - The quality, sensitivity, and functions of the aquatic resource
  - The nature of adjacent land use activity and its potential for impacts on the aquatic resource
  - The character of the existing buffer area (including soils, slope, vegetation, etc.)
  - The intended functions of the buffer

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Richmond Beach Preservation Association
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Nathan J. Beard, President
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July 16, 2015

VIA EMAIL TRANSMISSION AND U.S. MAIL

City of Shoreline Planning Commission
Shoreline City Hall
17500 Midvale Avenue North
Shoreline, WA 98133

Re: Richmond Beach Preservation Association
Critical Areas Ordinance comments and request to extend public comment date

To the Planning Commission:

I hope this letter finds you well. I write on behalf of the Richmond Beach Preservation Association, an organization representing the property owners on 27th Avenue Northwest.

At the recent June 18 Planning Commission meeting, Ms. Ginny Scantlebury offered public comment on behalf of our organization. As you will recall from Ms. Scantlebury's comments, the various intricacies associated with updating the Critical Areas Ordinance have been fairly difficult to follow. Understanding how the Critical Areas Ordinance update interplays with the Shoreline Master Program is a particularly challenging task. Since that last meeting, we retained a land use attorney. We retained this attorney to help our Association navigate the update, for advice on how to work with the Planning Commission towards our common best interests, and for her initial thoughts on what has been done to date.

Based on our attorney's review of the Planning Commission's process and the documents prepared to date, we have the following comments:

1. The piecemeal release of the proposed ordinance provides limited time for public review of the complete proposed ordinance;

2. The State has a 60-day window to review the proposed ordinance. This is a substantially longer period of review than is offered to the citizens directly affected by the proposed ordinance;

3. The State provides a mechanism for requesting additional time to submit the updated Critical Areas Ordinance. Additional time would create flexibility for detailed analysis and discussion; and

4. The State does not require a single "one size fits all" ordinance. In fact, the State recognizes ordinances can be flexible to address the unique characteristics of a specific area.

Accordingly, and as requested by the Richmond Beach Preservation Association at the June 18th Planning Commission meeting, we request the Planning Commission public hearing date be extended until October 2015. This extension will provide the public adequate time to review and understand the proposed Critical Areas Ordinance changes.

It has come to our attention the City sent an email on July 7th with an invitation to speak at a community meeting regarding Critical Areas Ordinance. As you can understand, this invitation comes to the public during the height of summer vacation season when the majority of neighborhood associations are adjourned. Given the time of year and short notice, it is impossible to (1) schedule a neighborhood meeting; and (2) draw a representative number of community residents for meaningful discussion. This should provide reason enough to extend the Public Hearing date.

We look forward to working with the City to draft a proposed Critical Areas Ordinance that is effective and reflects the diversity of the affected areas. An extension of the Planning Commission public hearing date to October 2015 will allow the public to provide informed comments to the Commission.

Please let us know your response to the foregoing comments and request to extend the Planning Commission public hearing date. My email address is njbeard@gmail.com, and my mailing address is 19419 27th Ave NW, Shoreline. If you have any questions, please do not hesitate to give me a call. My phone number is 206-818-9991. I look forward to hearing from you.

Very truly yours,

Richmond Beach Preservation Association

Nathan J. Beard
President

EKW LAW
EGLICK KIKER WHITED PLLC

Jane S. Kiker
kiker@ekwlaw.com

July 16, 2015

Via Email Plancom@shorelinewa.gov
And Hand Delivery

Planning Commission
City of Shoreline
17500 Midvale Avenue N
Shoreline, WA 98133

RE: 2015 Critical Areas Ordinance Update; Preliminary Comments Submitted By The Innis Arden Club

Dear Planning Commission:

The following comments concerning the City's proposed geologic hazard area amendments are submitted on behalf of the Innis Arden Club. Attached to this letter are comments prepared by the Club's geotechnical consultant, Garry Horvitz, P.E. LED, Senior Principal Geotechnical Engineer at Hart Crowser, regarding the same. Mr. Horvitz's resume is attached to his letter and details his extensive expertise in slope stability issues, particularly in this area. The Club anticipates submitting comments on other subchapters of the Critical Areas Ordinance (CAO), as draft language is proposed by Staff and considered by the Commission, throughout the Update process.

As a preliminary matter, it appears that the City is in a big hurry to adopt its critical area amendments on an expedited basis. However, Staff has already observed that such haste is unwarranted, at least based on State-adopted schedules for such periodic updates: "Shoreline would be considered to be in compliance if we are not more than twelve months past the deadline and can demonstrate substantial progress towards compliance." 6/18 Critical Areas Staff Report, at 12. The fact that the proposed amendments and supporting materials are voluminous further signals that careful consideration of them by the Planning Commission, the Council, and the public should not be hurried. To afford adequate time for meaningfully consideration of the substantial new language proposed in the CAO Update, the Innis Arden

Club joins with other groups in respectfully asking that the Planning Commission delay the public hearing until at least mid-September.

The proposed geologic hazard areas language contains a few noticeable improvements, such as increased clarity respecting the critical role played by site-specific geologic hazard critical area reports prepared by a qualified professional (e.g., a licensed geotechnical engineer or engineering geologist). However, the Club notes several significant inconsistencies, discussed below.

A. <u>The Proposed Prohibition On All Development Activities In Very High Risk Landslide Hazard Areas Is Inconsistent With Best Available Science (BAS) Determined Through Professional, Site Specific Evaluations</u>

In light of the amendments' increased reliance on site-specific evaluations of geologic hazard areas to determine appropriate activities, buffers, and mitigation, the draft regulations would improperly and unnecessarily distinguish between "very high risk" and "moderate to high risk" landslide hazard areas, flatly prohibiting any development in the former, <u>regardless</u> of what a professionally prepared, site specific evaluation might conclude or recommend. See, SMC 20.80.224.C ("Alteration of Very High Risk Landslide Hazard Areas").[1]

The BAS memo by City consultant Todd Wentworth of Amec Foster Wheeler does not support this blanket prohibition on all activities within a "Very High Risk Landslide Hazard Area." The City's consultant instead recommends that site-specific studies, which, he points out, constitute Best Available Science ("BAS"), be relied on to assess site conditions, identify a proposal's potential impacts in geologic hazard areas, evaluate the risks, and recommend mitigation. AMEC BAS Memo at 2. Further, as Staff acknowledged at the Planning Commission's June 18th meeting, the State does not specifically prohibit development in any geologic hazard area, including steep slopes. Planning Commission 6/18 Draft Minutes, at 4. In addition, the City's consultant acknowledged that the City of Seattle does not prohibit all development activity in the highest risk landslide hazard areas. Id. at 12. And, other municipalities' Codes we checked similarly do not impose blanket prohibitions on development activities in any particular classification of geologic hazard area.[2] Instead, they uniformly rely on reports and analyses prepared by qualified professionals to determine the site specific feasibility of any proposed activities, the appropriate buffers and mitigation required to address any potential impacts.

Hart Crowser's Garry Horvitz recommends that this arbitrary prohibition be replaced by the more "reasonable" (and BAS-supported) approach the City would apply to development

[1] This section of the draft ordinance contains typos in that there are two section C's and two section D's. The referenced section is on page 11 of the June 18th Agenda Attachment A.
[2] See, e.g., City of Edmonds (EMC 23.80-000 through -070); City of Bothell (BMC 14.04.800 through .880) and City of Kirkland (KMC 85.05 through .25).

proposed in the "moderate to high risk" landslide hazard areas: a requirement that a site specific geotechnical report support any proposed development with site specific mitigation designed to avoid any landslide hazards. Without such a provision, the Club is concerned that the arbitrary prohibition could prevent it from conducting necessary vegetation management on slopes that are barely 20 feet in height and barely 40% in grade, even where the soils are stable, there is no emergent water and the activity is otherwise supported by a geologic hazard report prepared by a qualified professional.

Staff's response to concerns voiced at the last meeting regarding this inconsistent approach has been that the Critical Area Reasonable Use and Special Use Permit processes set forth elsewhere in the Code will avoid unfairly burdening such property owners. However, these processes are not designed for situations where a private resident has been denied the right to remove and replant vegetation on a previously developed property, or property – such as the Innis Arden Reserve tracts – that is development-restricted. For starters, the Critical Area Special Use Permit applies only to public agency/utility proposals (e.g., a pipeline through a critical hazard area). SMC 20.30.333. In addition, the City's Critical Area Reasonable Use Permit process is primarily directed at permitting minimal site development ("reasonable economic use") where regulations would not otherwise allow it. Even if this process could be utilized for seeking approval of tree removal/ replanting activities in a "very high risk" landslide hazard area, requiring yet another permit process would unfairly burden an applicant whose proposed work includes no site development in the first place.

The June 18th meeting minutes reflect that Planning Commission Chair Scully returned to this issue three separate times during that meeting, and requested Staff to prepare alternative language to consider, that would allow activities in the "very high risk landslide hazard areas" where supported by a site-specific geotech report. However, the Staff Report prepared for the Commission's July 16th meeting indicates that staff is not yet prepared to provide or discuss this alternative language:

> These items are not yet ready for discussion so will be presented either at the scheduled August 6th or the August 20th meetings.

The August 20th meeting is to be the public hearing, and thus the last opportunity for the public to be heard by the Planning Commission. The Club is concerned that any delays in provision of the requested language are apt to frustrate, rather than facilitate, meaningful comment and deliberation on this critical issue.

B. <u>Best Available Science – and Common Sense – Do Not Support Removal of The Director's Discretion to Waive Requirement For Geologic Hazard Report For Activities In *Moderate* Risk Landslide Hazard Areas</u>

Proposed SMC 20.80.224.D ("Alteration to Moderate to High Risk Landslide Hazards") would eliminate the discretion currently afforded the Director to waive the requirement for a

geotechnical report for "proposals that include no development, construction or impervious surfaces" in "moderate to high risk" landslide hazard areas. This existing provision is entirely reasonable and avoids unnecessarily burdening property owners who seek permission to conduct minor site maintenance activities in a borderline moderate risk area (e.g., on a stable 15% slope). The only explanation offered for eliminating this discretion is to avoid the potential for claims of abuse. However, the background materials provide no support for this kind of speculation. Geotech Garry Horvitz addresses the elimination of the waiver in "moderate risk" areas, noting that, "the fact that these areas include modest (15%) slopes on relatively stable soils, where there is no emergent water or history of landslide activity, indicates that there may be instances where a determination could be made that no geologic investigation would be necessary."

Ironically, upon eliminating the Director's discretion to waive the report requirement as being subject to abuse claims, both consultant and Staff suggest that the required level of detail in geologic hazard reports can and should be varied at the Director's discretion, to reflect the relative complexity of a proposal, or sensitivity of the hazard area. No explanation is articulated for why this discretion would not subject the Director to similar claims of abuse or preferential treatment on a case by case basis. More importantly, Staff does not explain how this discretion would be exercised where the required elements of a full blown geotechnical evaluation have been codified to the very last detail, as is proposed in SMC 20.80.226. Will there be a variance process subsequently adopted to allow applicants to opt out of or "depart" from certain Code-required report details (e.g., identification of "all known faults within 200 feet" of a project to remove/replace a few trees, SMC 20.80.226.D (1)(g))? While the Club generally supports reliance on site specific evaluations for activities proposed in most geologic hazard areas, it appears that front-loading too much detail into the Code regarding mandatory report contents would interfere with the discretion urged by the Staff and consultant, and wind up unnecessarily burdening applicants – and the City.

C. Buffers And Setbacks; Slope Definitions

For the most part, the proposed geologic hazard buffer requirements appear consistent with the City's consultant's recommendation to allow the standard buffers to be reduced based on findings in site-specific studies, because "site specific conditions are unique and site-specific studies represent BAS." AMEC Memo at 4. However, nothing in the BAS memo directly supports the proposed minimum buffer of 15-feet found in SMC 20.80.230.C. In fact, the sample code provisions from the Department of Commerce suggest a narrower 10-foot minimum buffer where reductions are allowed pursuant to a site-specific study. Likewise, the City of Edmonds allows buffer reductions to 10-feet, on the same basis. The City's BAS supports buffer reductions to less than 15-feet based on a site specific evaluation, and SMC 20.80.230.C should be revised, accordingly.

The materials further provide no support, BAS or otherwise, for including a 15-foot horizontal distance at the top and toe of any slope greater than 15% as part of the regulated "landslide hazard area." The Code – like many other jurisdictions' codes – has long-defined the

top and bottom edge of the hazard area as "a distinct topographic break" in the slope. There is no scientific support for redefining this "distinct break" between hazardous and non-hazardous slopes to include a minimum 15-foot distance, horizontally. Although the proposed methodology is included in the AMEC memo, there is no scientific basis provided in support.

Geotech Garry Horvitz calls this "15-foot rule" an arbitrary measurement and explains that the extent of a geologic hazard area depends entirely on site specific geologic conditions and any proposed site specific activities. Thus, he concludes, the definition of the top and toe of a hazardous slope should be determined through the site specific geotechnical report. As Horvitz points out, the City of Bellevue determines hazardous slope "toe" and "top" in this manner, expressly deferring to the geotechnical report.

Horvitz' approach is consistent with the City Hearing Examiner's findings in the 2011 Bear Reserves appeal, where, in reliance on expert testimony from the Innis Arden Club's engineering geologist, she found that, depending on site conditions, such a break can occur even where narrow 5-10-foot trails have been constructed through these areas, parallel to the slope.[3] As the Club's expert engineering geologist testified in the Bear Reserve appeal hearing, proper determination of a distinct topographic break is based on direct observation of slope characteristics and load factors and the extent to which a "break" reduces the weight bearing on a given slope. If a topographic break on the slope removes significant weight from the lower portion of the slope, that break is considered a distinct topographic break, regardless of its horizontal width. A minimum width of five feet (at the most) might conceivably be defensible, but only if coupled with a provision granting exceptions based on a professional evaluation of load factors.

Staff's proposed definition of the "top and toe of slope" based on Amec's 15-foot rule would effectively result in an additional 15 horizontal foot "buffer" for every geologic hazard area. BAS simply does not support this overreaching regulation, and it is not supported by other jurisdictions' Codes, such as Bellevue's (above), or even the Sample Code provided by Department of Commerce. There is no support for adopting an arbitrary requirement in preference to site specific interpretation and scientific analysis provided by qualified experts.

D. The Proposed Draft Regulations Fail To Reasonably Distinguish Between Project Types

Innis Arden has 50 acres of dedicated private Reserve Tracts containing almost 8,000 trees and countless other vegetation. Per the Innis Arden Mutual Restrictive Easements, these open space Reserves must be used for parks, bridle trails, playgrounds, or other community

[3] October 21, 2011 Findings, Conclusions and Decision, *In re Innis Arden Club, Inc. v. Dept. of Planning and Development Services, Project No. 115423* ("Bear Reserves Appeal"). In the Bear Reserves appeal, the Department tried to insist on a similar 15-foot rule. However, it soon became clear that the City's consulting engineer could not offer a scientific basis for a flat 15-foot standard and the Hearing Examiner declined to adopt it.

purposes (many residents currently use the Reserves for jogging, hiking, dog-walking, birding and the like). For over half a century, long before incorporation of the City of Shoreline, the Innis Arden Reserves and their trees have been managed for environmental stewardship, hazard reduction, recreational use, and view preservation. In managing the Reserves over just the past three and a half years, the Club has spent over $100,000 in planting over 1400 trees and approximately 2000 smaller plants and shrubs, and performing invasive plant removal, trail maintenance and hazardous tree management.

The City Code should facilitate such management rather than hamper it. The Club has always accepted reasonable municipal regulation as part of its Reserves management. However, like other private property owners, under the current and proposed CAO it must undergo an expensive and burdensome permit process in order to even remove one or two unhealthy trees or invasive vegetation from the Reserves. Garry Horvitz' attached comments emphasize the important distinction between new site development (or redevelopment) and site "maintenance", such as vegetation management, particularly where the latter is on an already developed site where further development is substantially – or in some cases completely -- restricted.[4] The latter is typically limited to tree/vegetation pruning, invasive plant removal and remedial re-planting activity and does not include any grading, excavation, construction, demolition or other activities that actually modify the slope itself. Further, the "alteration" is typically temporary in nature with full restoration of the slope surface (including vegetation) the common result, at least where Best Management Practices are employed. In fact, such management activities often incorporate critical area enhancement or restoration measures.

In contrast, Horvitz explains that site development activities often result in permanent modification to the site's structural stability and physically alter its fundamental stability. Based on this, Horvitz recommends that the critical areas regulations should differentiate between such project types. The Club urges the Planning Commission to consider establishing two separate tracks/processes under the geologic hazard (and other critical area) regulations that would recognize these important distinctions and provide for expedited review and approval of vegetation management proposals in such critical areas, based on a site specific study that includes appropriate BMPs and mitigation.

Means of establishing this distinction in the Code could be to include "vegetation management on previously developed or development-restricted lots" as a separate category of activities under "Allowed Activities." SMC 20.80.224.B.[5] Alternatively, the City could include such vegetation management activity as one of the "partial exemptions" listed under SMC 20.80.040. The record does not support that the demolition of structures in geologic hazard areas

[4] The City's consultant acknowledges that it is property owners' increased attempts to "maximize the developable portions of their land within the constraints of the CAO code" that has led to landslide hazard areas becoming "a more contentious issue." Amec BAS Memo, at 2.

[5] Although the Club raises this critical issue in the context of its comments on geologic hazard areas, it applies equally to other critical areas such as streams/fish and wildlife habitat areas and wetlands.

– proposed as a "partial exemption" -- would have less of an impact on the surrounding area than a typical vegetation management project.

The Innis Arden Club thanks you for your consideration of the above comments.

Sincerely,

EGLICK KIKER WHITED PLLC

Jane S. Kiker
Attorney for The Innis Arden Club

cc: Client
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July 15, 2015

Mr. Rick Leary, President
Innis Arden Club, Inc.
17252 13th Avenue NW
Shoreline, WA 98177

Re: Geotechnical Engineering Review – Preliminary Comments On Proposed Revisions to City of Shoreline Critical Areas Ordinance
15-I-1140-043

Dear Rick:

This letter summarizes our initial review of the proposed changes to the City of Shoreline's Critical Areas Ordinance. Our preliminary review of these proposed changes relates specifically to the geotechnical/geological portion of the proposed changes. We have coordinated our efforts with Ms. Jane Kiker of Eglick Kiker Whited, counsel for the Innis Arden Club.

Summary of Findings

As discussed in greater detail below there are three main points that we would like to make with regard to the proposed Critical Areas Ordinance.

- A blanket prohibition on activities in "Very high risk landslide areas" is inconsistent and inappropriate;
- The determination of "top" and "toe" of hazard areas should be based on site specific analyses by a qualified professional rather than an arbitrary number;
- Geologic hazard area regulations should distinguish between site development activities and site maintenance activities.

Specifically, we have reviewed the following documents that are most pertinent to the discussion.

- Planning Commission Agenda Item from June 18, 2015, 6.a Critical Areas Ordinance Staff Report.
- Attachment A to that Report which presents proposed changes to Subchapter 2.
- Attachment B to that Report, Memorandum from Todd Wentworth of Amec Foster Wheeler, dated May 29, 2015.

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- Attachment C to that Report, Attachment C, Appendix A, Example Code Provisions for Designating and Protecting Critical Areas.

The primary focus of our review was the Best Available Science discussion offered by Todd Wentworth of Amec. Within that discussion we have primarily addressed potential landslide hazards, reviewing how the draft proposed regulatory language incorporates Amec's discussion/recommendations. We offer the following comments and opinions regarding the proposed changes:

With a few notable exceptions, addressed below, we generally concur with the discussion and many of the recommendations presented by Amec. Development issues in landslide hazard areas are now most typically and appropriately addressed through the use of site specific geotechnical/geologic investigations and studies to identify the extent of the hazard, how the proposed development might impact the hazard, how the hazard might impact the development and the methods that will be used to mitigate those adverse impacts. Some jurisdictions have the ability and expertise in house to be able to review studies put forth by project proponents. In those jurisdictions that do not have the in house capability of performing these reviews, third parties are retained by the governing authority.

Requirement For Site Specific Evaluation By Qualified Professional

Significantly, Amec recommends that all projects within landslide hazard areas undergo site specific evaluation as opposed to the current situation whereby the City can waive that requirement at its sole discretion in "moderate" and "high" risk areas. We concur that these site specific evaluations should be made for all applications in "high" or "very high" risk landslide hazard areas; however, it would be reasonable to retain the Director's discretion to waive the requirement for a site specific evaluation for minor projects in "moderate" risk areas. The fact that these areas include modest (15%) slopes on relatively stable soils, where there is no emergent water or history of landslide activity, indicates that there may be instances where a determination could be made that no geologic investigation would be necessary.

Amec goes on to provide a list of specific items that should be contained within a geotechnical investigation for a landslide hazard area. We generally concur with Amec that the scope of the investigation should be varied depending on the nature and extent of the proposed development activity and the sensitivity of the hazard area. However, we do question the process by which the City plans to vary the scope of the investigation, if – as is proposed in draft SMC 20.80.226.A through G – every possible detail of a geotechnical investigation has been codified as a mandatory element of the same. In other words, it is not clear from the proposed language how the City would go about waiving certain listed elements of the required investigation for a reduced-scope project, as it has suggested will be done.

Amec also comments about buffer areas and presents alternatives to the current definition and also recommends that exceptions to the stated buffers be allowed as these buffers should really be established on the basis of site specific conditions. We generally concur with Amec's recommendation that buffers should be determined through the site-specific geologic evaluation, and the proposed Code language's incorporation of that approach.

Blanket Prohibition of All "Uses and Activities" in "Very High Landslide Hazard Areas"

With respect to the "Very High Landslide Hazard Areas", the city's proposed regulations appear to take the Amec recommendations a step further than is appropriate, in our opinion. We read Amec's recommendation as requiring detailed geotechnical investigations of proposed development in all Landslide Hazard Areas, including those classified as "Very High Risk" areas. However, the City has included draft language that expressly **prohibits** development in these areas. SMC 20.80.224.C ("Alteration of Very High Risk Landslide Hazard Areas").[1] In our opinion the fact that an area has been designated to be a Very High Risk Area should not necessarily preclude development or maintenance activities in these areas. We recommend that this restriction be eliminated and that the language used in Section 20.80.224, GEOLOGIC HAZARDS – Development Standards, part C ("Alteration") be used for all classifications of landslide hazard area. In effect this section states that any development will need to be designed to mitigate any landslide hazard based on a qualified professional's evaluation and if that hazard cannot be mitigated then the proposal should be denied. This is by far a more reasonable approach.

Definition of Extent of Hazard Area

We take exception to Amec's proposed blanket use of a somewhat arbitrary definition of "distinct topographic break" as that phrase is used to define the extent of a particular hazard area. As noted above, in our opinion – and Amec's, otherwise -- the physical extent of a specific hazard area should be determined through a site-specific evaluation, not through arbitrary measurements adopted in the Code. The proposed change to the Code shown in Section 20.80.220, GEOLOGIC HAZARDS – Classification, Part A. Landslide Hazard Areas, presents a new methodology for defining the extent of the landslide hazard area that includes measuring an additional 15-feet horizontally from a slope to determine the "distinct topographic break" that defines its "toe" and "top" These dimensions — proposed to be applied to all situations, large or small -- are arbitrary and overly generalized. The extent of a landslide hazard area (when one is trying to define the extent of an area that is susceptible to landsliding) is a function of many geologic factors including the geologic nature of the soil deposits (i.e., till versus advance outwash sand versus lacustrine silts and clays), the stratigraphy of the various slope materials, the presence and abundance of groundwater, the erodibility of the site soils, the angle of the slope (greater than 40 percent? or 50 percent? or higher) and perhaps most importantly, the overall

[1] See p. 11 of 6/18 Agenda Attachment A. We note the 6/18 draft ordinance mistakenly includes in SMC 20.80.224 two "C" subsections and two "D" subsections. (Pp. 10-11). This should be corrected in the next draft.

height of the slope. Depending on the range of these factors and conditions, the area impacted by the potential instability of a potential landslide and the influence of activity on the stability of a high risk slope can extend much further away from the slope or much closer to the edge of the slope.

In other words, the 15-foot rule might be extremely NON-conservative in areas of very high slopes with abundant high groundwater. The opposite is also true where very light development or ground modification (e.g., tree removal and replacement) is done adjacent to very low slopes without any groundwater or other signs of instability. Our conclusion is that this definition should be based on an evaluation by a qualified geotechnical engineer or engineering geologist focused on the proposed site specific activities and site specific geologic conditions. The City of Bellevue has reasonably adopted such a provision:

> 20.50.048 T definitions.
>
> Toe of Slope. The lower boundary of the 40 percent slope as delineated on the slope category analysis; or in the case of landslide hazards, as delineated by the geotechnical report.
>
> Top of Slope. The upper boundary of the 40 percent slope as delineated on the slope category analysis; or in the case of landslide hazards, as delineated by the geotechnical report.

Differentiation Between Proposed Development of a Site and Maintenance of a Site

The City's Code defines "Use" as "An activity or function carried out in an area of land, or in a building or structure located thereon". Currently, the Code and proposed amendments do not differentiate between the potentially more intrusive activity of developing a site, (e.g., building a new residential or commercial building, side hill cuts and fills, retaining walls and roadways) as opposed to maintaining landscaping and vegetation on a slope (including tree removal). The former activity can result in permanent modification to the structural stability of the site and can physically alter the fundamental stability of the site whereas the latter activity is more likely to be temporary in nature and have no impact on the overall stability of a site provided it is done using Best Management Practices. The former is essentially "new construction" while the latter is "maintenance". In our opinion the Code should recognize the distinction between the two.

We appreciate the opportunity to provide you with these engineering services. Should you have any questions or wish to discuss any of these items in greater detail please don't hesitate to call.

Sincerely,

HART CROWSER, INC.

GARRY E. HORVITZ, PE, LEG
Senior Principal Geotechnical Engineer

GARRY E. HORVITZ, PE, LEG

Senior Principal Geotechnical Engineer

EDUCATION

MS, Civil (Geotechnical) Engineering, Massachusetts Institute of Technology, 1975

BS, Civil Engineering, State University of New York at Buffalo, 1973

REGISTRATIONS

Professional Engineer,
OR, 2004, #75506
WA, 1981, #19478
AK, 1983, #5255
HI, 1992, #7705

Licensed Engineering Geologist, WA
2002, #2201

Transportation Worker Identification Credential

AFFILIATIONS

American Society of Civil Engineers (ASCE); Coasts, Ocean, Ports, and Rivers Institute (COPRI)

Society of American Military Engineers (SAME)

With 39 years of experience, Garry is one of Hart Crowser's most senior engineers. Garry has provided project management and senior-level review for soil and foundation studies and engineering design on hundreds of developments and redevelopments—from preliminary siting through final design and construction. His expertise includes slope and embankment design; geotechnical engineering design of roadways, utilities, and elevated structures (bridges, piers, and wharves); engineering for pavement and roads, dredging, breakwaters and piers, seismic projects, and landslide stabilization; and foundation design for a wide range of industrial, commercial, and infrastructure projects. Representative examples of Garry's landslide/slope stability projects are listed below.

SLOPE STABILITY PROJECTS

Helsell Residence Landslide Repair, Greater Seattle (Shoreline), WA. Garry was geotechnical Project Manager for geologic/hydrogeologic assessments and design for repair of a major landslide in the Highlands area of Greater Seattle. The Helsell landslide involved a significant volume of slide debris which ultimately covered a 100-foot span of the BN railroad tracks at an elevation of about 200 feet below the residence. An estimated 10,000 to 15,000 cubic yards of material were involved in the event which involved three separate properties. The escarpment was up to 90 feet high and more than 200 feet long. Garry worked with the design team and owner to assess a wide variety of slope stabilization alternatives, considering not only the technical feasibility, but also constructability issues, relative cost, aesthetics, and logistics. An enhanced drainage/geosynthetic-reinforced soil slope was selected as the most cost-effective and constructible repair solution to provide stability long-term stability for the residence. Drainage design and surface erosion control were important elements of the repair.

Beach Drive Residence Landslide Repair, Shoreline, WA. Project Manager for multiple solutions at this residence based on the different site development needs. The work included designing stabilization methods for retention of a high bluff along Puget Sound. In areas where the top of steep slope was close to the new house, Garry designed a structural wall that could be retrofitted with permanent tieback anchors in the event of loss of ground in front of the wall. Based on a thorough review of past slide activity in the area, including aerial photos dating back to 1940, he assessed the rate of loss of the top of bank over time and then developed design parameters for the wall system that were not overly conservative in the assumptions of how much material might be lost in front of the wall over the life of the project.

In other areas that were not close to planned structures, he identified the geologic hazard so the owner could plan for future development. In these areas, installation of

enhanced subsurface drainage provided the greatest cost benefit to maintain the edge of bluff in its position. The use of structural alternatives was not considered appropriate due to the high cost and low potential for increasing the stability of the bluff.

Bonair Drive SW Slide Stabilization, West Seattle, WA. Garry provided senior-level technical review for fast-track work to stabilize portions of Bonair Drive SW which was experiencing accelerated movement, slipping approximately 1 to 3.5 feet downward, leaving an exposed scarp along 125 feet of Bonair Drive. At the same time, near-surface landsliding or mud flows occurred farther down the slope, causing damage to homes along Alki Avenue. The project included a site reconnaissance and deep borings in the slide area to assess soil and groundwater conditions. A key element was the identification of groundwater seepage zones about half-way down the slope face and saturated sands above hard silts. The project team worked with the contractor to design a trench drainage system to extend through the sand and into the underlying silt, thereby intercepting groundwater that was tending to flow along the top of the hard silt and daylighting about halfway down the slope face, causing the instability. In order to improve the stability for a longer segment of Bonair Drive, the trench drain was extended several hundred feet, toward the northeast. Even during construction, a significant amount of water was being picked up by the drainage system. To handle discharge of the water (another significant challenge), the design used an existing manhole, a new tightline on the face of a steep slope, and a new manhole installed at a critical location on the slope that was connected to the system using directional drilling.

Sunset Avenue SW/45th Avenue SW Emergency Slide Stabilization, West Seattle, WA. Garry provided senior technical review for geotechnical assessment and design services for emergency stabilization of a mass movement of soil and water that occurred on the northwest side of Sunset Avenue SW. Much of the slide material continued down a narrow drainage gully to the base of the slope and impacted a number of homes along Alki Avenue SW. The slide scarp was about 30 to 40 feet wide, about 20 feet horizontally from the northwest edge of Sunset Avenue, and about 75 feet wide at its base. Immediately below the crest of the scarp at Sunset Avenue was an oversteepened slope, about 30 to 40 feet high, with a more gradual slope below that. Total elevation difference between the street and the toe of this upper portion of the project was about 70 feet. After performing a site reconnaissance and subsurface explorations, the team designed and constructed a permanent tied-back soldier pile wall at the toe of the upper slope. A free-draining fill material and subsurface drainage system were then placed behind the wall at a relatively stable 2 horizontal to 1 vertical (2H:1V) angle up to Sunset Avenue. In the lower portion of the ravine, control of drainage from above was the main issue, more so than slope failure. The team identified sources of water that were feeding the ravine flows. This included unmapped drainage line discharges from private properties above, as well as natural flows. The team designed a series of catch basins and a drain line in the lower portion of the ravine to collect and tightline groundwater flows to a suitable discharge at Alki Avenue.

Hood Canal Bridge Information Review, WA. As Project Manager, Garry reviewed documents and reports pertaining to the cause of landslide at a residence near the Hood Canal Bridge. The owner alleged the movement was due to vibrations associated with pile driving for work completed for the Washington State Department of Transportation (WSDOT). Garry also visited the site. He provided an opinion paper specifying how damage from pile driving usually occurs, and the likelihood of the cause given the geological conditions at the site, the distance of the property from the construction, and the type of pile driving instruments used by WSDOT's contractor.

Slope Instability and Erosion, Seattle, WA. Garry provided geotechnical engineering consultation regarding slope instability and erosion at a residential property. The work included providing technical review of legal documents regarding the potential for construction on an adjoining property to have caused the landslide.

Diablo Lake Barge Facility, North Cascades National Park, WA. A rock slope failed, sending 16,000 cubic yards of rock and soil debris onto barge landing facilities and a road. As Project Manager for geotechnical services, Garry is helping Seattle City Light evaluate options for constructing a new barge landing facility and road. Tasks include seismic design, evaluation of slope stability, evaluation of constraints on earth moving operations, assessment of alternatives for foundation design and construction including shallow foundations, structural slabs use of micropiles and/or driven piles, gravity systems, and tieback anchors.

Interstate-90 Beacon Hill Section, Seattle, WA. Garry was geotechnical Project Manager working with the Washington State Department of Transportation on design of the Seattle section of I-90 to the Mt. Baker Ridge tunnel. A major portion of the project wraps around the steep side slopes of Beacon Hill. Hart Crowser's detailed design geotechnical studies included sophisticated laboratory and field testing, and innovative approaches to slope retention and stabilization that led to a total redesign of the project. The "value engineering" approach established by Hart Crowser resulted in extensive excavations by open cut methods with local and effective slope retention structures, as opposed to the costly multiple cylinder pile wall approach. Combined with the use of earth-reinforced structures, the majority of the roadway was designed to be an on-grade facility. Project cost savings of over $30 million were attributed to Hart Crowser's efforts on this section of I-90.

Belroy Apartments Steep Slope Development, Seattle, WA. Project Manager and Principal in Charge for a preliminary geotechnical engineering study for a proposed residential development on Bellevue Avenue. The City of Seattle Department of Planning and Development considers the Belroy site to contain an area of "steep slope" under the city's Environmentally Critical Areas regulations. Our work is supporting the Master Use permit process. Existing structures will be replace with a three- to four-story (with a portion as much as six to seven stories) residential building. Our services included geologic reconnaissance observations to identify obvious signs of potential instability. We provided recommendations regarding subsurface conditions, seismic considerations, shoring, groundwater control, slope stability, and the design phase study. We also provided conclusions regarding the impact of development on the existing slope, and whether the existing slope was created as a result of legal grading.

On-Call Permit Application Review Contract, City of Gresham, OR. Principal in Charge and QA Reviewer for an on-call contract for the City of Gresham Community Development related to third-party review of permit applications. Since August 2004, he has reviewed over 10 development applications for properties in hillside hazard areas designated by the City.

Upgrade of Miller Creek Wastewater Treatment Plant, Southwest Suburban Sewer District, King County, WA. Garry was the Geotechnical Project Manager for foundation engineering, slope stability issues, shoring for deep excavations, and construction dewatering. This project also called for design of buried utility lines within steeply sloping terrain.

Martin Luther King, Jr., Memorial Park, Seattle Parks Department, WA. Garry was Hart Crowser's Project Manager for site explorations, slope stability evaluation, cut and fill design, and foundation design for a memorial and reflecting pool located in a potentially hazardous slope area.

ASARCO Ore Dock and Copper Dock Demolition Slope Stability Evaluation, Ruston and Tacoma, WA. Project Manager and Principal in Charge for geotechnical engineering analysis and recommendations related to the slopes behind two docks, and the timber piles supporting the docks, as part of the proposed ASARCO Docks Demolition. The demolition work involves three docks supported by 2,300 creosote-treated timber piles, and the steep shoreline adjacent to the docks consists of slag fill that is not fully stabilized. Historical seismic slope failures have been reported in the general area. As a result, the long-term stability of the shoreline slope and the environmental cap adjacent to the docks is a matter of key concern when considering whether the piles should be removed as part of the dock demolition. The work included:

- Assessing the existing geotechnical information;
- Evaluating static and seismic stability with and without the timber piles using SLOPE/W computer modeling
- Based on the results of SLOPE/W modeling, using Newmark Sliding Block analysis to evaluate potential for displacement of the slope due to inertial loading under earthquake shaking
- Comparing predicted impacts to the proposed upland development plan and noting potential impacts to improvements such as buildings, a promenade, and other surface and subsurface construction.

Hart Crowser determined that keeping the piles in place would contribute to the stability of slopes and a potential reduction in settlement and lateral displacement, which would be directly beneficial to proposed upland development.

Geotechnical Engineering Conclusions Regarding Rock Fall, Ketchikan, AK. Garry reviewed records and information regarding a rock fall, which caused damage to a house and injured an individual. Conducted a site visit and took geometric measurements. Provided professional opinion regarding the cause of the slide and appropriate measures to take during construction to provide for a safe slope situation.

Retaining Wall Failure, Renton, WA. A retaining wall failed on an office property, which damaged a driveway, parking lot, and waterline. Garry reviewed project documents and provided an expert opinion on the cause of the failure.

Litigation Support for Building Development, Snohomish County, WA. Garry provided professional opinion for litigation regarding a residential development. Technical issues included site grading, site material quality, general area geology, and earthwork efficiency.

Slope Stability Evaluation, Naval Radio Station Jim Creek, WA. Principal in Charge of evaluations and recommendations for mitigation of slope stability issues at the Jim Creek Radio Station. The Station consists of wire mesh placed over an entire valley with a series of large support towers holding the radio array suspended over the valley.

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August 13, 2015

Via Email Plancom@shorelinewa.gov

Planning Commission
City of Shoreline
17500 Midvale Avenue N
Shoreline, WA 98133

RE: 2015 Critical Areas Ordinance Update: Innis Arden Club's Proposed Modifications to Staff Proposal Addressing Alteration and Classification of Geologic Hazard Areas

Dear Planning Commissioners:

To supplement its July 16, 2015 preliminary comments on the City's CAO Update, the Innis Arden Club submits for the Planning Commission's consideration the attached Exhibits A and B containing revisions to the proposed Code language respecting the alteration and classification of geologic hazard areas, SMC 20.80.224 and SMC 20.80.220, respectively.[1] In brief, the revisions would allow certain development activity in any landslide hazard area where it is supported by a site-specific evaluation by a qualified professional. In addition, delineation of such areas would be based on such a site-specific evaluation. The Club's proposed language is fully supported by the July 16, 2015 comments by Garry Horvitz, P.E. LED, Senior Principal Geotechnical Engineer at Hart Crowser.

Several commentators, including the Club in its preliminary comments, have noted that, based on Best Available Science ("BAS"), it would be overbroad to include a blanket prohibition on all activity in certain "steep slope" geologic hazard areas even where a qualified professional report analyzed the site and approved the activity with recommended mitigation. Such a blanket prohibition is not supported by Best Available Science ("BAS") per the May 29, 2015 BAS memo prepared by Amec Foster Wheeler, which advises that "site specific conditions are unique and site-specific studies represent BAS." (Emphasis added).

The proposed blanket prohibition is similarly inconsistent with State Department of Commerce Sample Code Provisions for Designating and Protecting Critical Areas recommendations, which do not differentiate between categories of landslide hazard areas for

[1] Attachment A to June 18, 2015 Agenda/Staff Report. In the attached Exhibits, the Club's proposed changes are in red, and are overlaid on Staff's proposed language.

purposes of regulating proposed alterations. Instead, they address such alterations proposals universally, as follows:

> 2. Alterations.
> Alterations of an erosion or landslide hazard area and/or buffer may only occur for activities for which a hazards analysis is submitted and certifies that:
> a. The development will not increase surface water discharge or sedimentation to adjacent properties beyond pre-development conditions;
> b. The development will not decrease slope stability on adjacent properties; and
> c. Such alterations will not adversely impact other critical areas. [2]

As noted previously, the Cities of Bothell (BMC 14.04.870), Edmonds (EMC 23.80.060 and .070), and Kirkland (KZC 85.15), are examples of other Washington cities that have adhered to this guidance requiring, as we have proposed here, alterations determinations to be based on site-specific evaluations, regardless of the landslide hazard area classification.[3] As in those cities, the modification we have proposed in Exhibit A does not rely on a patchwork of exemptions for certain alterations or certain slopes, but simply requires that all land use proposals in moderate/high or very high landslide areas be supported by a site-specific evaluation by a qualified professional. Per Section SMC 20.80.224.C, which would not be modified, a conclusion in the site-specific evaluation that a proposed alteration cannot be safely undertaken/mitigated would result in project denial.

As further addressed in its preliminary comments, the Club also supports modification of the proposed new "15-foot rule" for determining the geographic/topographic extent of certain landslide hazard areas, and urges the Planning Commission to instead adopt the language in the attached Exhibit B related to the same, requiring that such delineations also be determined pursuant to a site-specific scientific evaluation. The Code – like many other jurisdictions' codes – has long-defined the top and bottom edge of the hazard area as "a distinct topographic break" in the slope. However, there is no scientific support for redefining this "distinct break" between hazardous and non-hazardous slopes to include a minimum 15-foot distance, horizontally as Staff now proposes.

As previously noted, Geotech Garry Horvitz calls this "15-foot rule" an arbitrary measurement and explains that the extent of a geologic hazard area depends entirely on site specific geologic conditions and any proposed site specific activities. Thus, he concludes, the definition of the top and toe of a hazardous slope should be determined through the BAS site

[2] See, July 16, 2015 Agenda Packet and Staff Report Attachment C, Section "X.50.090".
[3] Cited Code excerpts are attached as Exhibit C for the Commissioners' convenience.

specific geotechnical report. As discussed (and quoted) in the Club's preliminary comments, the City of Bellevue is an example of a municipality that takes this approach.

Revising the proposed Code language as the Club proposes is straightforward and would re-ground the City's geologic hazard area standards in science, eliminating arbitrary, non-scientific distinctions between activities permitted in differently classified geologic hazard areas. Please feel free to contact me if you have any questions regarding these comments. We can also make Mr. Horvitz available to address any technical questions that may arise. Meanwhile, thank you for your consideration of these comments as well as those expressed in the July 16, 2015 letter on behalf of the Club.

Sincerely,

EGLICK KIKER WHITED PLLC

Jane S. Kiker
Attorney for The Innis Arden Club

Enclosures

cc: Client
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EXHIBIT A

20.80.224 GEOLOGIC HAZARDS- Development standards.

A. Activities and uses shall be prohibited in geologic hazard areas and their required buffers except as provided for in this Title.

B. **Activities allowed in all geologic hazard areas and buffers.** The activities listed below are allowed in the identified geologic hazard areas types pursuant to SMC 20.80.0XX Allowed Activities. Additional exemptions are listed in SMC 20.80.030 and 20.80.040, but do not apply within the shoreline jurisdiction. These activities do not require submission of a critical area report.

1. All exempt activities per SMC 20.80.040, unless critical area report is required for the exemption;

2. Installation of fences as allowed without a building permit in Chapter 20.50 Development standards; and

3. *Non-structural interior remodel.* ~~M~~maintenance, or repair of structures which do not meet the ~~development~~ standards of this chapter ~~for landslide or seismic areas,~~ if the maintenance or repair does not increase the footprint *or height* of the structure and there is no increased risk to life or property as a result of the proposed maintenance or repair.

4. **Landslide and Seismic Hazard Areas**. No additional activities allowed without submission of a critical area report in landslide and seismic hazard areas.

5. ***Erosion Hazard Areas.*** *If the site does not contain another type of critical area or critical area buffer and does not exceed any other threshold contained in SMC 20.50.320*, then up to 1,500 square feet may be cleared on any lot in an erosion hazard area without a permit, ~~unless the site also contains another type of critical area or any other threshold contained in SMC 20.50.320 would be exceeded.~~

C. **Alteration.** The City shall approve, condition, or deny proposals in a geologic hazard area as appropriate based upon the effective mitigation of risks posed to property, health, and safety. The objective of mitigation measures shall be to render a site containing a geologic hazard as safe as one not containing such hazard. Conditions may include limitations of proposed uses, modification of density, alteration of site layout, and other appropriate changes to the proposal. Where potential impacts cannot be effectively

mitigated to eliminate a significant risk to public health, safety, and property, or important natural resources, the proposal shall be denied.

~~**D. Alteration of Moderate and to High Risk Landslide Hazards.**~~

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1. *Development activities and uses that result in unavoidable* alterations *may be permitted* ~~proposed~~ in ~~moderate and to high *risk*~~ landslide hazard areas or their buffers *in accordance with an approved* ~~shall be evaluated by a qualified professional through the preparation of the geotechnical~~ *geologic hazard critical area* report *prepared by a qualified professional that certifies:*

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a. The development, as conditioned, will not increase surface water discharge or sedimentation to adjacent properties beyond pre-development conditions;
b. The development, as conditioned, will not decrease slope stability on adjacent properties; and
c. Such alterations will not adversely impact other critical areas.

~~However, for proposals that include no development, construction, or impervious surfaces, the City, in its sole discretion, may waive the requirement for a geotechnical report.~~ The recommendations contained within the ~~geotechnical~~ *critical area* report shall be incorporated into the *proposed* alteration of the landslide hazard area or their buffers.

2. The ~~geotechnical engineer and/or geologist~~, *qualified professional* preparing the report shall provide assurances that the risk of damage from the proposal, both on-site and off-site, are minimal subject to the conditions set forth in the report, that the proposal will not increase the risk of occurrence of the potential landslide hazard, and that measures to eliminate or reduce risks have been incorporated into the report's recommendations.

~~**C. Alteration of Very High Risk Landslide Hazard Areas.**~~

~~Development shall be prohibited in very high risk landslide hazard areas or their buffers except as granted by a critical areas special use permit, or a critical areas reasonable use permit *per SMC 20.30.333 and 20.30.336, unless otherwise allowed by the exemptions or allowed activities provisions of this Title, or subject to the provisions of the Shoreline Master Program where the proposed development activity is located within the shoreline jurisdiction.*~~

EXHIBIT B

20.80.220 GEOLOGIC HAZARDS- Classification.
Geologic hazard areas shall be classified according to the criteria in this section as follows:

A. Landslide Hazard Areas.

Landslide Hazard Areas are those areas potentially subject to landslide activity based on a combination of geologic, topographic and hydrogeologic factors as classified in SMC 20.80.220(B) with slopes 15 percent or steeper within a vertical elevation change of at least 10 feet. A slope is delineated by establishing its toe and top, and is measured by averaging the inclination over at least 10 feet of vertical relief. (see Figure 20.80.220(B)). The edges of the hazard are identified where the characteristics of the slope cross section change from one landslide hazard classification to another or no longer meet any classification.

1. The toe of a slope is a distinct topographic break which separates slopes inclined at less than 15 percent from slopes above that are 15 percent or steeper. A distinct topographic break should be determined in a geologic hazard critical area report prepared by a qualified professional ~~is an area that extends at least 15 feet horizontally away from the slope and that slopes less than 15 %.~~

2. The top of a slope is a distinct topographic break which separates slopes inclined at less than 15 percent from slopes that are 15 percent or steeper below. A distinct topographic break should be determined in a geologic hazard critical area report prepared by a qualified professional ~~is an area that is at least 15 feet horizontally away from the slope and that slopes less than 15%.~~

3. Hazard area classifications differentiated based on percent slope shall be delineated based on locating the top and toe of the slope characterized by a distinct topographic break between the 40% slope and adjacent slopes less than 40 percent, as determined in a geologic hazard critical area report prepared by a qualified professional. ~~change that extends at least 15 feet horizontally away from the slope and that slopes less than 40 percent, as determined by two (2) foot contour intervals, not averaging over the full landslide hazard area~~.

EXHIBIT C

Bothell Municipal Code

14.04.800 Designation of geologically hazardous areas.

Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible development is sited in areas of significant hazard. Such incompatible development may not only place itself at risk, but also may increase the hazard to surrounding development and use. Areas susceptible to one or more of the following types of hazards shall be designated as a geologically hazardous area:

A. Erosion hazard;

B. Landslide hazard;

C. Seismic hazard; and

D. Other geological events including mass wasting, debris flows, rock falls, and differential settlement. (Ord. 1946 § 3, 2005).

14.04.810 Designation of specific hazard areas.

A. Erosion Hazard Areas. Erosion hazard areas are those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "moderate to severe," "severe," or "very severe" rill and inter-rill erosion hazard[19] and/or those areas containing soils which, according to the USDA Soil Conservation Service Soil Classification System, may experience severe to very severe erosion hazard. Erosion hazard areas are also those areas impacted by shore land and/or stream bank erosion and those areas within a river's channel migration zone.

B. Landslide Hazard Areas. Landslide hazard areas are areas of historic failure or potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. Example of these may include, but are not limited to the following:

1. Areas of historic failures, such as:[20]

   a. Those areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" limitation for building site development;

   b. Those areas mapped by the Washington State Department of Ecology (Coastal Zone Atlas) or the Washington State Department of Natural Resources (slope stability mapping) as unstable (U or class 3), unstable old slides (UOS or class 4), or unstable recent slides (URS or class 5); or

c. Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Washington State Department of Natural Resources;

2. Areas with all three of the following characteristics:[21]

a. Slopes steeper than 15 percent;

b. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and

c. Springs or groundwater seepage.

3. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or that are underlain or covered by mass wastage debris of that epoch;[22]

4. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;[23]

5. Slopes having gradients steeper than 80 percent subject to rock fall during seismic shaking;[24]

6. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action;[25]

7. Areas that show evidence of, or are at risk from snow avalanches;[26]

8. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding;[27] and

9. Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of consolidated rock. A slope is delineated by establishing its toe and top and is measured by averaging the inclination over at least 10 feet of vertical relief.[28]

C. Seismic Hazard Areas. Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface faulting. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. Ground shaking is the primary cause of earthquake damage in Washington. The strength of ground shaking is primarily affected by:[29]

1. The magnitude of an earthquake;

2. The distance from the source of an earthquake;

3. The type of thickness of geologic materials at the surface; and

4. The type of subsurface geologic structure.

Settlement and soil liquefaction conditions occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow groundwater table.

D. Other Hazard Areas. Geologically hazardous areas shall also include areas determined by the director to be susceptible to other geological events including mass wasting, debris flows, rock falls, and differential settlement. (Ord. 1946 § 3, 2005).

14.04.820 Classification of geologically hazardous areas.

All geologic hazard areas should be classified according to the following categories for each geologic hazard type.

Classification	Documentation and Data Sources
Known or Suspected Risk	Documentation or projection of the hazard by a qualified professional exists.
Risk Unknown	Documentation or projection of the lack of hazard by a qualified professional exists, or data are not available to determine the presence or absence of a geologic hazard.

(Ord. 1946 § 3, 2005).

14.04.830 Mapping of geologically hazardous areas.

A. The approximate location and extent of geologically hazardous areas are shown on the adopted critical areas maps. The adopted critical areas maps include:

1. U.S. Geological Survey landslide and seismic hazard maps;

2. Washington State Department of Natural Resources seismic hazard maps for Western Washington;

3. Washington State Department of Natural Resources slope stability maps;

4. Federal Emergency Management Administration flood insurance maps; and

5. Locally adopted maps.

B. These maps are to be used as a guide for the city, project applicants and/or property owners and may be continuously updated as new critical areas are identified. They are a reference and do not provide a final critical areas designation. (Ord. 1946 § 3, 2005).

Allowed Activities

14.04.840 Activities allowed in geologically hazardous areas.

The following activities are allowed in geologically hazardous areas pursuant to BMC 14.04.150, Allowed activities, and do not require submission of a critical areas report:

A. Erosion and Landslide Hazard Areas. Except as otherwise provided for in this chapter, only those activities approved and permitted consistent with an approved critical areas report in accordance with this chapter shall be allowed in erosion or landslide hazard areas.

B. Seismic Hazard Areas. The following activities are allowed within seismic hazard areas:

1. Construction of new buildings with less than 2,500 square feet of floor area or roof area, whichever is greater, and which are not residential structures or used as places of employment or public assembly;

2. Additions to existing single-story residences that are 250 square feet or less; and

3. Installation of fences.

C. Other Hazard Areas. The director may allow the following activities within other geologically hazardous areas, if the activity will not increase the risk of the hazard:

1. Construction of new buildings with less than 2,500 square feet of floor area or roof area, whichever is greater, and which are not residential structures or used as places of employment or public assembly;

2. Additions to existing residences that are 250 square feet or less; and

3. Installation of fences. (Ord. 1946 § 3, 2005).

Critical Areas Report Requirements

14.04.850 Critical areas report – Additional requirements for geologically hazardous areas.

A. Preparation by a Qualified Professional. A critical areas report for a geologically hazardous area shall be prepared by an engineer or geologist, licensed in the state of Washington, with experience analyzing geologic, hydrologic, and groundwater flow systems, and who has experience preparing reports for the relevant type of hazard.

B. Area Addressed in Critical Areas Report. The following areas shall be addressed in a critical areas report for geologically hazardous areas:

1. The project area of the proposed activity; and

2. All geologically hazardous areas within 200 feet of the project area or that have potential to be affected by the proposal;

C. Geological Hazards Assessment. A critical areas report for a geologically hazardous area shall contain an assessment of geological hazards including the following site- and proposal-related information at a minimum:

1. Site and Construction Plans. The report shall include a copy of the site plans for the proposal showing:

a. The type and extent of geologic hazard areas, any other critical areas, and buffers on, adjacent to, within 200 feet of, or that are likely to impact the proposal;

b. Proposed development, including the location of existing and proposed structures, fill, storage of materials, and drainage facilities, with dimensions indicating distances to the floodplain, if available;

c. The topography, in two-foot contours, of the project area and all hazard areas addressed in the report; and

d. Clearing limits;

2. Assessment of Geological Characteristics. The report shall include an assessment of the geologic characteristics of the soils, sediments, and/or rock of the project area and potentially affected adjacent properties, and a review of the site history regarding landslides, erosion, and prior grading. Soils analysis shall be accomplished in accordance with accepted classification systems in use in the region. The assessment shall include, but not be limited to:

a. A description of the surface and subsurface geology, hydrology, soils, and vegetation found in the project area and in all hazard areas addressed in the report;

b. A detailed overview of the field investigations, published data, and references; data and conclusions from past assessments of the site; and site specific measurements, test, investigations, or studies that support the identification of geologically hazardous areas; and

c. A description of the vulnerability of the site to seismic and other geologic events;

3. Analysis of Proposal. The report shall contain a hazards analysis including a detailed description of the project, its relationship to the geologic hazard(s), and its potential impact upon the hazard area, the subject property, and affected adjacent properties; and

4. Minimum Buffer and Building Setback. The report shall make a recommendation for the minimum no-disturbance buffer and minimum building setback from any geologic hazard based upon the geotechnical analysis.

D. Incorporation of Previous Study. Where a valid critical areas report has been prepared within the last five years for a specific site, and where the proposed land use activity and surrounding site conditions are unchanged, said report may be incorporated into the required critical areas report. The applicant shall submit a hazards assessment detailing any changed environmental conditions associated with the site.

E. Mitigation of Long-Term Impacts. When hazard mitigation is required, the mitigation plan shall specifically address how the activity maintains or reduces the pre-existing level of risk to the site and adjacent properties on a long-term basis (equal to or exceeding the projected lifespan of the activity or occupation). Proposed mitigation techniques shall be considered to provide long-term hazard reduction only if they do not require regular maintenance or other actions to maintain their function. Mitigation may also be required to avoid any increase in risk above the pre-existing conditions following abandonment of the activity. (Ord. 1946 § 3, 2005).

14.04.860 Critical areas report – Additional technical information requirements for specific hazards.

In addition to the general critical areas report requirements of BMC 14.04.190 and 14.04.850, critical areas reports for geologically hazardous areas must meet the requirements of this section. Critical areas reports for two or more types of critical areas must meet the report requirements for each relevant type of critical area.

A. Erosion and Landslide Hazard Areas. In addition to the basic critical areas report requirements, the technical information for an erosion hazard or landslide hazard area shall include the following information at a minimum:

1. Site Plan. The critical areas report shall include a copy of the site plan for the proposal showing:

a. The height of slope, slope gradient, and cross-section of the project area;

b. The location of springs, seeps, or other surface expressions of groundwater on or within 200 feet of the project area or that have potential to be affected by the proposal;[30] and

c. The location and description of surface water runoff features;

2. Hazards Analysis. The hazards analysis component of the critical areas report shall specifically include:

a. A description of the extent and type of vegetative cover;

b. A description of subsurface conditions based on data from site-specific explorations;

c. Descriptions of surface and groundwater conditions, public and private sewage disposal systems, fills and excavations, and all structural improvements;

d. An estimate of slope stability and the effect construction and placement of structures will have on the slope over the estimated life of the structure;

e. An estimate of the bluff retreat rate that recognizes and reflects potential catastrophic events such as seismic activity or a 100-year storm event;

f. Consideration of the run-out hazard of landslide debris and/or the impacts of landslide run-out on down slope properties and critical areas;

g. Consideration of the effects of erosion on down slope properties and other critical areas;

h. A study of slope stability including an analysis of proposed cuts, fills, and other site grading;

i. Recommendations for building siting limitations; and

j. An analysis of proposed surface and subsurface drainage, and the vulnerability of the site to erosion;

3. Geotechnical Engineering Report. The technical information for a project within a landslide hazard area shall include a geotechnical engineering report prepared by a licensed engineer that presents engineering recommendations for the following:

a. Parameters for design of site improvements including appropriate foundations and retaining structures. These should include allowable load and resistance capacities for bearing and lateral loads, installation considerations, and estimates of settlement performance;

b. Recommendations for drainage and subdrainage improvements;

c. Earthwork recommendations including clearing and site preparation criteria, fill placement and compaction criteria, temporary and permanent slope inclinations and protection, and temporary excavation support, if necessary; and

d. Mitigation of adverse site conditions including slope stabilization measures and seismically unstable soils, if appropriate;

4. Erosion and Sediment Control Plan. For any development proposal on a site containing an erosion hazard area, an erosion and sediment control plan shall be required.

The erosion and sediment control plan shall be prepared in compliance with requirements set forth in the city of Bothell's adopted storm water and water quality standards;

5. Drainage Plan. The technical information shall include a drainage plan for the collection, transport, treatment, discharge, and/or recycle of water prepared in accordance with the city of Bothell adopted surface water standards. The drainage plan should consider on-site septic system disposal volumes where the additional volume will affect the erosion or landslide hazard area;

6. Mitigation Plans. Hazard and environmental mitigation plans for erosion and landslide hazard areas shall include the location and methods of drainage, surface water management, locations and methods of erosion control, a vegetation management and/or replanting plan, and/or other means for maintaining long-term soil stability; and

7. Monitoring Surface Waters. If the director determines that there is a significant risk of damage to downstream receiving waters due to potential erosion from the site, based on the size of the project, the proximity to the receiving waters, or the sensitivity of the receiving waters, the technical information shall include a plan to monitor the surface water discharge from the site. The monitoring plan shall include a recommended schedule for submitting monitoring reports to the city.

B. Seismic Hazard Areas. In addition to the basic report requirements, a critical areas report for a seismic hazard area shall also meet the following requirements:

1. The site map shall show all known and mapped faults within 200 feet of the project area or that have potential to be affected by the proposal.

2. The hazards analysis shall include a complete discussion of the potential impacts of seismic activity on the site (for example, forces generated and fault displacement).

3. A geotechnical engineering report shall evaluate the physical properties of the subsurface soils, especially the thickness of unconsolidated deposits and their liquefaction potential. If it is determined that the site is subject to liquefaction, mitigation measures appropriate to the scale of the development shall be recommended and implemented.

C. Other Geologically Hazardous Areas. In addition to the basic requirements, the director may require additional technical information to be submitted when determined to be necessary to the review the proposed activity and the subject hazard. Additional technical information that may be required, includes, but is not limited to:

1. Site Plan. The site plan shall show all hazard areas located within 200 feet of the project area or that have potential to be affected by the proposal; and

2. Hazards Analysis. The hazards analysis shall include a complete discussion of the potential impacts of the hazard on the project area and of the proposal on the hazard. (Ord. 1946 § 3, 2005).

Performance Standards

14.04.870 Performance standards – General requirements.

A. Alterations of geologically hazardous areas or associated buffers may only occur for activities that:

1. Will not increase the threat of the geological hazard to adjacent properties beyond pre-development conditions;

2. Will not adversely impact other critical areas;

3. Are designed so that the hazard to the project is eliminated or mitigated to a level equal to or less than pre-development conditions; and

4. Are certified as safe as designed and under anticipated conditions by a qualified engineer or geologist, licensed in the state of Washington.

B. Critical Facilities Prohibited. Critical facilities shall not be sited within geologically hazardous areas unless there is no other practical alternative. (Ord. 1946 § 3, 2005).

14.04.880 Performance standards – Specific hazards.

A. Erosion and Landslide Hazard Areas. Activities on sites containing erosion or landslide hazards shall meet the standards of BMC 14.04.870, Performance standards – General requirements, and the specific following requirements:

1. Buffer Requirement. A buffer shall be established from all edges of landslide hazard areas. The size of the buffer shall be determined by the director to eliminate or minimize the risk of property damage, death, or injury resulting from landslides caused in whole or part by the development, based upon review of and concurrence with a critical areas report prepared by a qualified professional.

a. Minimum Buffer. The minimum buffer shall be equal to the height of the slope or 50 feet, whichever is greater.

b. Buffer Reduction. The buffer may be reduced to a minimum of 10 feet when a qualified professional demonstrates to the director's satisfaction that the reduction will adequately protect the proposed development, adjacent developments, and uses and the subject critical area.

c. Increased Buffer. The buffer may be increased where the director determines a larger buffer is necessary to prevent risk of damage to proposed and existing development;

2. Alterations. Alterations of an erosion or landslide hazard area and/or buffer may only occur for activities for which a hazards analysis is submitted and certifies that:

a. The development will not increase surface water discharge or sedimentation to adjacent properties beyond pre-development conditions;

b. The development will not decrease slope stability on adjacent properties; and

c. Such alterations will not adversely impact other critical areas;

3. Design Standards. Development within an erosion or landslide hazard area and/or buffer shall be designed to meet the following basic requirements unless it can be demonstrated that an alternative design that deviates from one or more of these standards provides greater long-term slope stability while meeting all other provisions of this chapter. The requirement for long-term slope stability shall exclude designs that require regular and periodic maintenance to maintain their level of function. The basic development design standards are:

a. The proposed development shall not decrease the factor of safety for landslide occurrences below the limits of 1.5 for static conditions and 1.2 for dynamic conditions. Analysis of dynamic conditions shall be based on a minimum horizontal acceleration as established by the current version of the International Building Code;

b. Structures and improvements shall minimize alterations to the natural contour of the slope, and foundations shall be tiered where possible to conform to existing topography;

c. Structures and improvements shall be located to preserve the most critical portion of the site and its natural landforms and vegetation;

d. The proposed development shall not result in greater risk or a need for increased buffers on neighboring properties;

e. The use of retaining walls that allow the maintenance of existing natural slope area is preferred over graded artificial slopes; and

f. Development shall be designed to minimize impervious lot coverage;

4. Vegetation Retention. Unless otherwise provided or as part of an approved alteration, removal of vegetation from an erosion or landslide hazard area or related buffer shall be prohibited;

5. Seasonal Restriction. Clearing shall be allowed only from May 1st to October 1st of each year; provided, that the city may extend or shorten the dry season on a case-by-case basis depending on actual weather conditions, except that timber harvest, not including brush clearing or stump removal, may be allowed pursuant to an approved forest practice permit issued by the city or the Washington State Department of Natural Resources;

6. Utility Lines and Pipes. Utility lines and pipes shall be permitted in erosion and landslide hazard areas only when the applicant demonstrates that no other practical alternative is available. The line or pipe shall be located above ground and properly anchored and/or designed so that it will continue to function in the event of an underlying slide. Storm water conveyance shall be allowed only through a high-density polyethylene pipe with fuse-welded joints, or similar product that is technically equal or superior;

7. Point Discharges. Point discharges from surface water facilities and roof drains onto or upstream from an erosion or landslide hazard area shall be prohibited except as follows:

a. Conveyed via continuous storm pipe downslope to a point where there are no erosion hazards areas downstream from the discharge;

b. Discharged at flow durations matching pre-developed conditions, with adequate energy dissipation, into existing channels that previously conveyed storm water runoff in the pre-developed state; or

c. Dispersed discharge upslope of the steep slope onto a low-gradient undisturbed buffer demonstrated to be adequate to infiltrate all surface and storm water runoff, and where it can be demonstrated that such discharge will not increase the saturation of the slope;

8. Subdivisions. The division of land in landslide hazard areas and associated buffers is subject to the following:

a. Land that is located wholly within a landslide hazard area or its buffer may not be subdivided. Land that is located partially within a landslide hazard area or its buffer may be divided; provided, that each resulting lot has sufficient buildable area outside of, and will not affect, the landslide hazard or its buffer;

b. Access roads and utilities may be permitted within the landslide hazard area and associated buffers if the city determines that no other feasible alternative exists; and

9. Prohibited Development. On-site sewage disposal systems, including drain fields, shall be prohibited within erosion and landslide hazard areas and related buffers.

B. Seismic Hazard Areas. Activities proposed to be located in seismic hazard areas shall meet the standards of BMC 14.04.870, Performance standards – General requirements.

C. Other Hazard Areas. Activities on sites containing or adjacent to other geologically hazardous areas, shall meet the standards of BMC 14.04.870, Performance standards – General requirements. (Ord. 1946 § 3, 2005).

Edmonds City Code

Chapter 23.80
GEOLOGICALLY HAZARDOUS AREAS

Sections:

Part I. Designation, Rating and Mapping

23.80.000 Geologically hazardous areas compliance requirements flowchart.

See Figure 23.80.000 at the end of this chapter. [Ord. 3527 § 2, 2004].

23.80.010 Designation, rating and mapping – Geologically hazardous areas.

Geologically hazardous areas include areas susceptible to erosion, land sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible development is sited in areas of significant hazard. Such incompatible development may not only place itself at risk, but also may increase the hazard to surrounding development and use. Areas susceptible to one or more of the following types of hazards shall be designated as a geologically hazardous area:

A. Erosion hazard;

B. Landslide hazard; and

C. Seismic hazard. [Ord. 3527 § 2, 2004].

23.80.020 Designation of specific hazard areas.

A. Erosion Hazard Areas. Erosion hazard areas are at least those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "moderate to severe," "severe," or "very severe" rill and inter-rill erosion hazard. Erosion hazard areas are also those areas impacted by shoreland and/or stream bank erosion. Within the city of Edmonds erosion hazard areas include:

1. Those areas of the city of Edmonds containing soils that may experience severe to very severe erosion hazard. This group of soils includes, but is not limited to, the following when they occur on slopes of 15 percent or greater:

a. Alderwood soils (15 to 25 percent slopes);

b. Alderwood/Everett series (25 to 70 percent slopes);

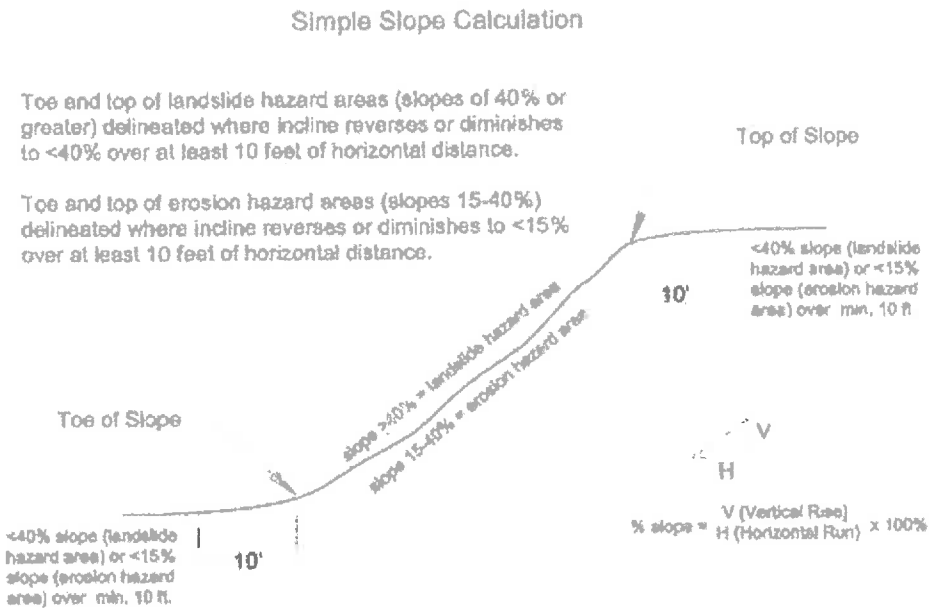
c. Everett series (15 to 25 percent slopes);

2. Any area with slopes of 15 percent or greater and impermeable soils interbedded with granular soils and springs or ground water seepage; and

3. Areas with significant visible evidence of ground water seepage, and which also include existing landslide deposits regardless of slope.

B. Landslide Hazard Areas. Landslide hazard areas are areas potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors. Within the city of Edmonds landslide hazard areas specifically include:

1. Areas of ancient or historic failures in Edmonds which include all areas within the earth subsidence and landslide hazard area as identified in the 1979 report of Robert Lowe Associates and amended by the 1985 report of GeoEngineers, Inc.;



Note: Slope, gradient changes and incline reversals or breaks below percent slopes defining landslide hazard areas (40%) and erosion hazard areas (15%) shall be included as part of a larger slope unless they are 10 horizontal feet or longer

Figure 1

2. Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of consolidated rock. A slope is delineated by establishing its toe and top (as defined in Figure 1 in subsection (B)(1) of this section) and is measured by averaging the inclination over at least 10 feet of vertical relief or 25 feet of horizontal distance. Benches, steps and variations in gradient shall be incorporated into a larger slope if they do not meet criteria defining toe and/or top depicted in Figure 1 in subsection (B)(1) of this section (see also Figure 2 at the end of this subsection). If the toe or top of a slope is located off of a subject property, then the location of the toe or top shall be delineated 200 horizontal feet from the property boundary or at its natural location, whichever is closer to the subject parcel (see Figure 2 at the end of this subsection);

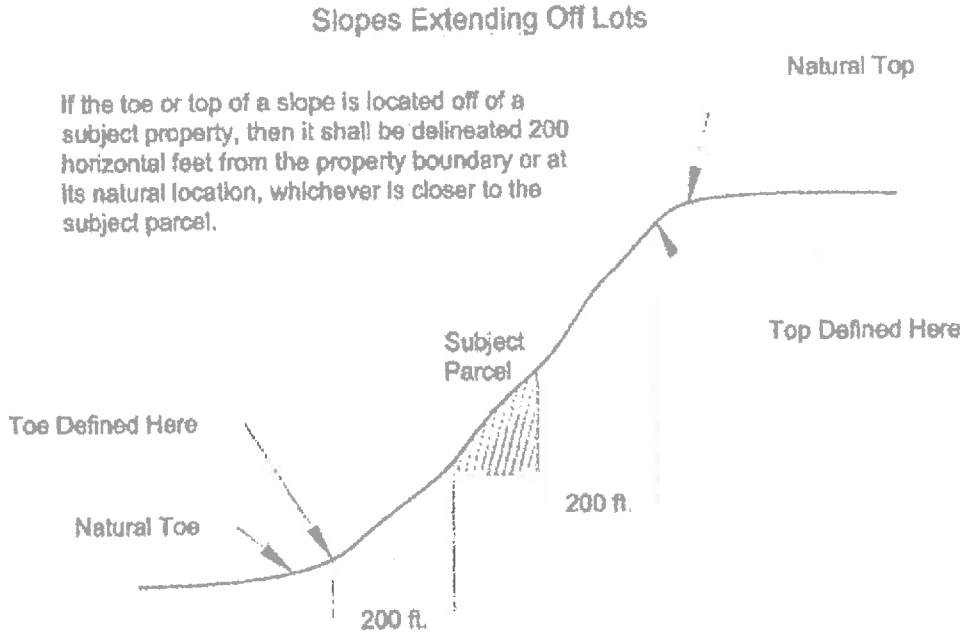


Figure 2

3. Any area potentially unstable as a result of rapid stream incision or stream bank erosion; and

4. Any area located on an alluvial fan, presently subject to, or potentially subject to, inundation by debris flow or deposition of stream-transported sediments.

C. Seismic Hazard Areas. Seismic hazard areas are areas subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, settlement, soil liquefaction, lateral spreading, or surface faulting. Settlement and soil liquefaction conditions occur in areas underlain by cohesionless, loose, or soft-saturated soils of low density, typically in association with a shallow ground water table. [Ord. 3527 § 2, 2004].

23.80.030 Mapping of geologically hazardous areas.

A. The approximate location and extent of geologically hazardous areas are shown on the city of Edmonds critical areas inventory. In addition, resources providing information on the location and extent of geologically hazardous areas in Edmonds include:

1. Washington Department of Ecology coastal zone atlas (for marine bluffs);

2. U.S. Geological Survey geologic maps, landslide hazard maps, and seismic hazard maps;

3. Washington State Department of Natural Resources seismic hazard maps for Western Washington;

4. Washington State Department of Natural Resources slope stability maps;

5. National Oceanic and Atmospheric Administration tsunami hazard maps; and

6. Federal Emergency Management Administration flood insurance maps.

B. The critical areas inventory and the resources cited above are to be used as a guide for the city of Edmonds development services department, project applicants and/or property owners and may be continuously updated as new critical areas are identified. They are a reference and do not provide a final critical area designation. [Ord. 3527 § 2, 2004].

Part II. Allowed Activities – Geologically Hazardous Areas

23.80.040 Allowed activities – Geologically hazardous areas.

The following activities are allowed in geologically hazardous areas as consistent with ECDC 23.40.220, Allowed activities, Chapter 19.10 ECDC, Building Permits – Earth Subsidence and Landslide Hazard Areas, and Chapter 18.30 ECDC, Storm Water Management, and do not require submission of a critical area report:

A. Erosion and Landslide Hazard Areas. Except as otherwise provided for in this title, only those activities approved and permitted consistent with an approved critical areas report in accordance with this title shall be allowed in erosion or landslide hazard areas.

B. Seismic Hazard Areas. The following activities are allowed within seismic hazard areas:

1. Construction of new buildings with less than 2,500 square feet of floor area or roof area, whichever is greater, and which are not residential structures or used as places of employment or public assembly;

2. Additions to existing single-story residences that are 250 square feet or less; and

3. Installation of fences. [Ord. 3527 § 2, 2004].

Part III. Additional Report Requirements – Geologically Hazardous Areas

23.80.050 Special study and report requirements – Geologically hazardous areas.

Critical area report requirements for geologically hazardous areas are generally met through submission to the director of one or more geotechnical engineering reports. In addition to the general critical areas report requirements of ECDC 23.40.090, critical areas reports for geologically hazardous areas must meet the requirements of this section and Chapters 18.30 and 19.10 ECDC as applicable. Critical areas reports for two or more types of critical areas must

meet the report requirements for each relevant type of critical area. Geotechnical report(s) submitted for the purpose of critical areas review are required as necessary in addition to reports, data and other information mandated per ECDC Titles 18 and 19.

A. Preparation by a Qualified Professional. A critical areas report for a geologically hazardous area shall be prepared by an engineer or geologist licensed in the state of Washington, with experience analyzing geologic, hydrologic, and ground water flow systems, and who has experience preparing reports for the relevant type of hazard. Critical areas studies and reports on geologically hazardous areas shall be subject to independent review pursuant to ECDC 23.40.090(B).

B. Area Addressed in Critical Areas Report. The following areas shall be addressed in a critical areas report for geologically hazardous areas:

1. The project area of the proposed activity; and

2. All geologically hazardous areas within 200 feet of the project area or that have the potential to be affected by the proposal.

C. Geological Hazards Assessment. A critical areas report for a geologically hazardous area shall contain an assessment of geological hazards including the following site- and proposal-related information at a minimum:

1. Site and Construction Plans. The report shall include a copy of the site plans for the proposal showing:

a. The type and extent of geologic hazard areas, any other critical areas, and buffers on, adjacent to, within 200 feet of, or that are likely to impact the proposal;

b. Proposed development, including the location of existing and proposed structures, fill, storage of materials, and drainage facilities, with dimensions indicating distances to the floodplain, if available;

c. The topography, in two-foot contours, of the project area and all hazard areas addressed in the report; and

d. Clearing limits;

2. Assessment of Geological Characteristics. The report shall include an assessment of the geologic characteristics of the soils, sediments, and/or rock of the project area and potentially affected adjacent properties, and a review of the site history regarding landslides, erosion, and prior grading. Soils analysis shall be accomplished in accordance with accepted classification systems in use in the region. The assessment shall include, but not be limited to:

a. A description of the surface and subsurface geology, hydrology, soils, and vegetation found in the project area and in all hazard areas addressed in the report;

b. A detailed overview of the field investigations, published data, and references; data and conclusions from past assessments of the site; and site-specific measurements, tests, investigations, or studies that support the identification of geologically hazardous areas; and

c. A description of the vulnerability of the site to seismic and other geologic events;

3. Analysis of Proposal. The report shall contain a hazards analysis including a detailed description of the project, its relationship to the geologic hazard(s), and its potential impact upon the hazard area, the subject property, and affected adjacent properties; and

4. Minimum Buffer and Building Setback. The report shall make a recommendation for the minimum no-disturbance buffer and minimum building setback from any geologic hazard based upon the geotechnical analysis.

D. Incorporation of Previous Study. Where a valid critical areas report has been prepared within the last five years for a specific site, and where the proposed land use activity and surrounding site conditions are unchanged, said report may be incorporated into the required critical areas report. The applicant shall submit a hazards assessment detailing any changed environmental conditions associated with the site.

E. Mitigation of Long-Term Impacts. When hazard mitigation is required, the mitigation plan shall specifically address how the activity maintains or reduces the preexisting level of risk to the site and adjacent properties on a long-term basis (equal to or exceeding the projected lifespan of the activity or occupation). Proposed mitigation techniques shall be considered to provide long-term hazard reduction only if they do not require regular maintenance or other actions to maintain their function. Mitigation may also be required to avoid any increase in risk above the preexisting conditions following abandonment of the activity.

F. Additional Technical Information Requirements for Erosion and Landslide Hazard Areas. In addition to the basic critical areas report requirements for geologically hazardous areas provided in subsections A through E of this section, technical information for erosion and landslide hazard areas shall meet the requirements of Chapter 19.10 ECDC and include the following information at a minimum:

1. Site Plan. The critical areas report shall include a copy of the site plan for the proposal showing:

a. The height of slope, slope gradient, and cross-section of the project area;

b. The location of springs, seeps, or other surface expressions of ground water on or within 200 feet of the project area or that have the potential to be affected by the proposal; and

c. The location and description of surface water runoff features;

2. Hazards Analysis. The hazards analysis component of the critical areas report shall specifically include:

a. A description of the extent and type of vegetative cover;

b. A description of subsurface conditions based on data from site-specific explorations;

c. Descriptions of surface and ground water conditions, public and private sewage disposal systems, fills and excavations, and all structural improvements;

d. An estimate of slope stability and the effect construction and placement of structures will have on the slope over the estimated life of the structure;

e. An estimate of the bluff retreat rate that recognizes and reflects potential catastrophic events such as seismic activity or a 100-year storm event;

f. Consideration of the run-out hazard of landslide debris and/or the impacts of landslide run-out on down-slope properties;

g. A study of slope stability including an analysis of proposed cuts, fills, and other site grading;

h. Recommendations for building siting limitations; and

i. An analysis of proposed surface and subsurface drainage, and the vulnerability of the site to erosion;

3. Geotechnical Engineering Report. The technical information for a project within a landslide hazard area shall include a geotechnical engineering report prepared by a licensed engineer that presents engineering recommendations for the following:

a. Parameters for design of site improvements including appropriate foundations and retaining structures. These should include allowable load and resistance capacities for bearing and lateral loads, installation considerations, and estimates of settlement performance;

b. Recommendations for drainage and subdrainage improvements;

c. Earthwork recommendations including clearing and site preparation criteria, fill placement and compaction criteria, temporary and permanent slope inclinations and protection, and temporary excavation support, if necessary; and

d. Mitigation of adverse site conditions including slope stabilization measures and seismically unstable soils, if appropriate;

4. Erosion and Sediment Control Plan. For any development proposal on a site containing an erosion hazard area, an erosion and sediment control plan shall be required. The erosion and sediment control plan shall be prepared in compliance with requirements set forth in Chapter 18.30 ECDC.

G. Limited Report Requirements for Stable Erosion Hazard Areas. At the director's discretion, detailed critical areas report requirements may be waived for erosion hazard areas with suitable slope stability. Report requirements for stable erosion hazard areas may be met through construction documents that shall include at a minimum an erosion and sediment control plan prepared in compliance with requirements set forth in Chapter 18.30 ECDC.

H. Seismic Hazard Areas. In addition to the basic critical areas report requirements for geologically hazardous areas provided in subsections A through E of this section, a critical areas report for a seismic hazard area shall also meet the following requirements:

1. The site map shall show all known and mapped active faults within 200 feet of the project area or that have the potential to be affected by the proposal.

2. The hazards analysis shall include a complete discussion of the potential impacts of seismic activity on the site (for example, forces generated and fault displacement).

3. A geotechnical engineering report shall evaluate the physical properties of the subsurface soils, especially the thickness of unconsolidated deposits and their liquefaction potential. If it is determined that the site is subject to liquefaction, mitigation measures appropriate to the scale of the development shall be recommended and implemented. [Ord. 3527 § 2, 2004].

Part IV. Development Standards – Geologically Hazardous Areas

23.80.060 Development standards – General requirements.

A. Alterations of geologically hazardous areas or associated buffers may only occur for activities that:

1. Will not increase the threat of the geological hazard to adjacent properties beyond predevelopment conditions;

2. Will not adversely impact other critical areas;

3. Are designed so that the hazard to the project is eliminated or mitigated to a level equal to or less than predevelopment conditions; and

4. Are certified as safe as designed and under anticipated conditions by a qualified engineer or geologist, licensed in the state of Washington.

B. Critical Facilities Prohibited. Critical facilities shall not be sited within geologically hazardous areas unless there is no other practical alternative. [Ord. 3527 § 2, 2004].

23.80.070 Development standards – Specific hazards.

A. Erosion and Landslide Hazard Areas. Activities on sites containing erosion or landslide hazards shall meet the requirements of ECDC 23.80.060, Development Standards – General Requirements, and the specific following requirements:

1. Buffer Requirement. A buffer shall be established from all edges of landslide hazard areas. The size of the buffer shall be determined by the director consistent with recommendations provided in the geotechnical report to eliminate or minimize the risk of property damage, death, or injury resulting from landslides caused in whole or part by the development, based upon review of and concurrence with a critical areas report prepared by a qualified professional.

a. Minimum Buffer. The minimum buffer shall be equal to the height of the slope existing within the project area or 50 feet, whichever is greater;

b. Buffer Reduction. The buffer may be reduced to a minimum of 10 feet when a qualified professional demonstrates to the satisfaction of the director that the reduction will adequately protect the proposed development, adjacent developments and uses and the subject critical area;

c. Increased Buffer. The buffer may be increased where the director determines that a larger buffer is necessary to prevent risk of damage to proposed and existing development;

2. Alterations. Alterations of an erosion or landslide hazard area and/or buffer may only occur for activities for which a hazards analysis is submitted and certifies that:

a. The development will not increase surface water discharge or sedimentation to adjacent properties beyond predevelopment conditions;

b. The development will not decrease slope stability on adjacent properties; and

c. Such alterations will not adversely impact other critical areas;

3. Design Standards. Development within an erosion or landslide hazard area and/or buffer shall be designed to meet the following basic requirements unless it can be

demonstrated that an alternative design that deviates from one or more of these standards provides greater long-term slope stability while meeting all other provisions of this title. The requirement for long-term slope stability shall exclude designs that require regular and periodic maintenance to maintain their level of function. The basic development design standards are:

a. The proposed development shall not decrease the factor of safety for landslide occurrences below the limits of 1.5 for static conditions and 1.2 for dynamic conditions. If stability at the proposed development site is below these limits, the proposed development shall provide practicable approaches to reduce risk to human safety and improve the factor of safety for landsliding. In no case shall the existing factor of safety be reduced for the subject property or adjacent properties;

b. Structures and improvements shall be clustered to avoid geologically hazardous areas and other critical areas;

c. Structures and improvements shall minimize alterations to the natural contour of the slope, and foundations shall be tiered where possible to conform to existing topography;

d. Structures and improvements shall be located to preserve the most critical portion of the site and its natural landforms and vegetation;

e. The proposed development shall not result in greater risk or a need for increased buffers on neighboring properties;

f. The use of retaining walls that allow the maintenance of existing natural slope area is preferred over graded artificial slopes; and

g. Development shall be designed to minimize impervious lot coverage;

4. Vegetation Retention. Unless otherwise provided or as part of an approved alteration, removal of vegetation from an erosion or landslide hazard area or related buffer shall be prohibited;

5. Seasonal Restriction. Clearing shall be allowed only from May 1st to October 1st of each year; provided, that the director may extend or shorten the dry season on a case-by-case basis depending on actual weather conditions, except that timber harvest, not including brush clearing or stump removal, may be allowed pursuant to an approved forest practice permit issued by the city of Edmonds or the Washington State Department of Natural Resources;

6. Point Discharges. Point discharges from surface water facilities and roof drains onto or upstream from an erosion or landslide hazard area shall be prohibited except as follows:

a. Conveyed via continuous storm pipe downslope to a point where there are no erosion hazard areas downstream from the discharge;

b. Discharged at flow durations matching predeveloped conditions, with adequate energy dissipation, into existing channels that previously conveyed storm water runoff in the predeveloped state; or

c. Dispersed discharge upslope of the steep slope onto a low-gradient, undisturbed buffer demonstrated to be adequate to infiltrate all surface and storm water runoff, and where it can be demonstrated that such discharge will not increase the saturation of the slope; and

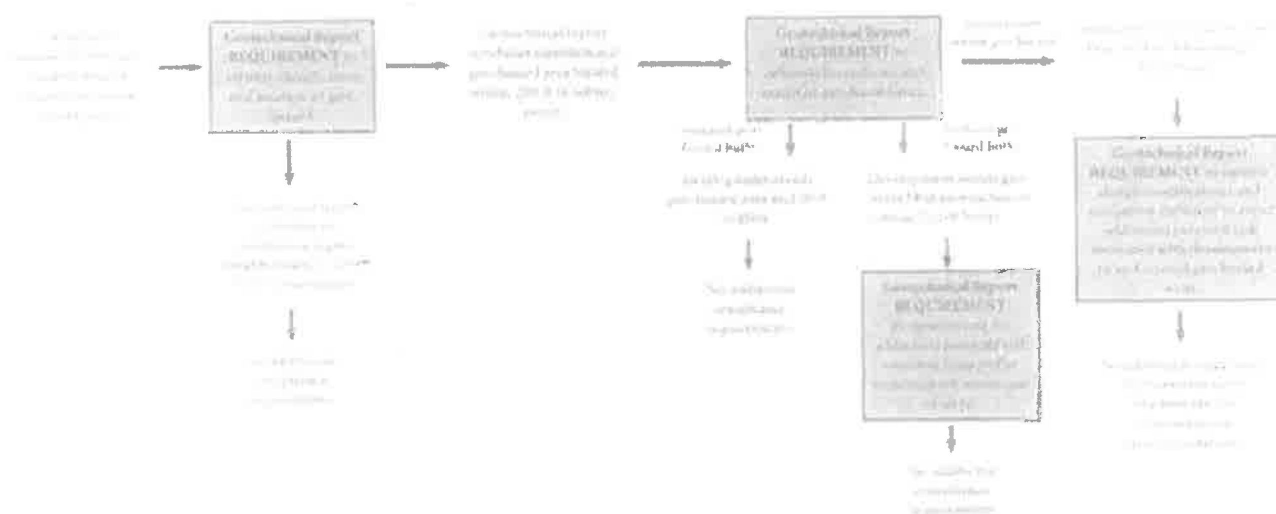
7. Prohibited Development. On-site sewage disposal systems, including drain fields, shall be prohibited within erosion and landslide hazard areas and related buffers.

B. Earth Subsidence and Landslide Hazard Area. In addition to the requirements of this chapter, development proposals for lands located within the earth subsidence and landslide hazard area as indicated on the critical areas inventory shall be subject to the provisions of Chapter 19.10 ECDC.

C. Seismic Hazard Areas. Activities proposed to be located in seismic hazard areas shall meet the standards of ECDC 23.80.060, Development Standards – General Requirements. [Ord. 3527 § 2, 2004].

CITY OF EDMONDS CRITICAL AREAS
Critical Areas Compliance Requirements*

Geologically Hazardous Areas



*Report requirements may be met through submission of a single critical area report or multiple reports in combination.

Figure 23.80.000

85.05 User Guide

1. This chapter establishes special regulations that apply to development on property containing geologically hazardous areas. These regulations add to and, in some cases, supersede other regulations of this code. See Chapter 95 KZC for additional regulations that address trees and other vegetation within and outside of geologically hazardous areas.

2. If you are interested in developing property that contains a geologically hazardous area, or if you wish to participate in the City's decision on a proposed development on any of these areas, you should read this chapter.

3. For properties within jurisdiction of the Shoreline Management Act, see Chapter 83 KZC.

(Ord. 4252 § 1, 2010; Ord. 4010 § 3, 2005)

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85.10 Applicability

1. General – This chapter applies to any property that contains any of the following:

   a. An erosion hazard area.

   b. A landslide hazard area.

   c. A seismic hazard area.

2. Conflict with Other Provisions of this Code – The provisions of this chapter supersede any conflicting provisions of this code. The other provisions of this code that do not conflict with the provisions of this chapter apply to property that contains a geologically hazardous area. If more than one (1) provision of this chapter applies to the subject property because of the presence on the subject property of more than one (1) type of geologically hazardous area, then the regulations that provide the greatest protection from the hazardous area shall apply to the area governed by multiple regulations.

3. SEPA Compliance – Nothing in this chapter or the decisions made pursuant to this chapter in any way affect the authority of the City to review, condition, and deny projects under SEPA.

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85.12 Environmentally Sensitive Areas (ESA) Maps

As part of the City's SEPA Ordinance, City Council adopts, and from time to time amends, a map folio entitled "Kirkland Sensitive Areas." This folio contains maps entitled "Seismic

Hazards" and "Landslide and Erosion Hazards." These maps will be used as a guide only to determine the presence of seismic hazards, erosion hazards, and landslide hazards, and the determination regarding whether these hazards exist on or near the subject property will be based on the actual characteristics of these areas and the definitions of this code.

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85.13 Definitions

The following definitions apply throughout this code, unless, from the context, another meaning is clearly intended:

1. Environmentally Sensitive Areas Maps – As defined in Chapter 90 KZC.

2. Erosion Hazard Areas – Those areas containing soils which, according to the USDA Soil Conservation Service King County Soil Survey dated 1973, may experience severe to very severe erosion hazard. This group of soils includes, but is not limited to, the following when they occur on slopes of 15 percent or greater: Alderwood gravelly sand loam (AgD), Kitsap silt loam (KpD), Ragnar Indianola Association (RdE) and portions of the Everett gravelly sand loams (EvD) and Indianola Loamy fine sands (InD).

3. Geologically Hazardous Areas – Landslide hazard areas, erosion hazard areas and seismic hazard areas.

4. Landslide Hazard Areas – Both of the following:

    a. High Landslide Hazard Areas – Areas sloping 40 percent or greater, areas subject to previous landslide activities and areas sloping between 15 percent and 40 percent with zones of emergent groundwater or underlain by or embedded with impermeable silts or clays.

    b. Moderate Landslide Hazard Areas – Areas sloping between 15 percent and 40 percent and underlain by relatively permeable soils consisting largely of sand and gravel or highly competent glacial till.

    5. Seismic Hazard Areas – Those areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction, which conditions occur in areas underlain by cohesionless soils of low density usually in association with a shallow groundwater table.

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85.14 Erosion Hazard Areas

Regulations to control erosion are contained within KMC Title 15 and in other codes and ordinances of the City. Development activity within erosion hazard areas is regulated using these

other provisions of this code and other City codes and ordinances and may be subject to increased scrutiny and conditioning because of the presence of an erosion hazard area.

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85.15 Required Information – Landslide Hazard Areas and Seismic Hazard Areas

The City may require the applicant to submit some or all of the following information, consistent with the nature and extent of the proposed development activity, for any proposed development activity in a landslide hazard area or seismic hazard area or on property which may contain one (1) of these areas based on the environmentally sensitive areas maps or preliminary field investigation by the Planning Official:

1. A topographic survey of the subject property, or the portion of the subject property specified by the Planning Official, with contour intervals specified by the Planning Official. This mapping shall contain the following information:

    a. Delineation of areas containing slopes 15 percent or greater.

    b. The proximity of the subject property to streams.

    c. The location of structured storm drainage systems on the subject property.

    d. Existing vegetation, including size and type of significant trees.

2. A geotechnical investigation, prepared by a qualified geotechnical engineer or engineering geologist, to determine if a landslide hazard area or seismic hazard area exists on the subject property.

3. A geotechnical report, prepared by a qualified geotechnical engineer or engineering geologist, showing and including the following information:

    a. A description of how the proposed development will or will not affect slope stability, surface and subsurface drainage, erosion, and seismic hazards on the subject and adjacent properties.

    b. Evidence, if any, of holocene or recent landsliding, sloughing, or soil creep.

    c. The location of springs, seeps, or any other surface expression of groundwater, and the location of surface water or evidence of seasonal runoff or groundwater.

    d. Identification of existing fill areas.

    e. Soil description in accordance with the United Soil Classification Systems.

f. Depth to groundwater and estimates of potential seasonal fluctuations.

4. Geotechnical recommendations, prepared by a qualified geotechnical engineer, for special engineering or other mitigation techniques appropriate to the hazard area along with an analysis of how these techniques will affect the subject and adjacent properties, including discussions and recommendations on the following:

a. The present stability of the subject property, the stability of the subject property during construction, the stability of the subject property after all development activities are completed and a discussion of the relative risks and slide potential relating to adjacent properties during each stage of development.

b. Location of buildings, roadways, and other improvements.

c. Grading and earthwork, including compaction and fill material requirements, use of site solids as fill or backfill, imported fill or backfill requirements, height and inclination of both cut and fill slopes and erosion control and wet weather construction considerations and/or limitations.

d. Foundation and retaining wall design criteria, including bearing layer(s), allowable capacities, minimum width, minimum depth, estimated settlements (total and differential), lateral loads, and other pertinent recommendations.

e. Surface and subsurface drainage requirements and drainage material requirements.

f. Assessment of seismic ground motion amplification and liquefaction potential.

g. Other measures recommended to reduce the risk of slope instability.

h. Any additional information believed to be relevant by the geotechnical engineer preparing the recommendations or requested by the Planning Official.

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85.20 Required Review – Landslide Hazard Areas and Seismic Hazard Areas

1. General – Except as specified in subsection (2) of this section, the City will administratively review and decide upon any proposed development activity within a landslide hazard area or seismic hazard area.

2. Other Approval Required – If the proposed development on the subject property requires approval through Process I, IIA, or IIB, described in Chapters 145, 150, and 152 KZC, respectively, the proposed development activity within the landslide hazard area or seismic hazard area will be reviewed and decided upon as part of that other process.

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85.25 Performance Standards – Landslide Hazard Areas and Seismic Hazard Areas

(See also Chapter 95 KZC)

As part of any approval of development in a landslide hazard area or seismic hazard area, the City may require the following to protect property and persons:

1. Implementation of the geotechnical recommendations to mitigate identified impacts, along with a written acknowledgment on the face of the plans signed by the architect, engineer, and/or designer that he/she has reviewed the geotechnical recommendations and incorporated these recommendations into the plans.

2. Funding of a qualified geotechnical engineer or engineering geologist, selected and retained by the City subject to a 3-party contract, to review the geotechnical report and recommendations.

3. That a qualified geotechnical professional be present on-site during land surface modification and foundation installation activities, and submittal by a geotechnical engineer of a final report prior to occupancy, certifying substantial compliance with the geotechnical recommendations and geotechnical-related permit requirements.

4. The retention of any and all trees, shrubs, and groundcover, and implementation of a revegetation plan including immediate planting of additional vegetation.

5. Specifically engineered foundation and retaining wall designs.

6. The review of all access and circulation plans by the Department of Public Works.

7. Limitation or restriction of any development activity that may:

   a. Significantly impact slope stability or drainage patterns on the subject property or adjacent properties;

   b. Cause serious erosion hazards, sedimentation problems or landslide hazards on the subject property or adjacent properties; or

   c. Cause property damage or injury to persons on or off the subject property.

8. Dedication of one (1) or more natural greenbelt protective easements or tracts.

(Ord. 4010 § 3, 2005)