Landslide Hazard Areas

What are landslide hazard areas?

In unincorporated King County, the landscape is sculpted from soils deposited by ice and water during previous glacial cycles of the ice age, or Pleistocene period, more than 10,000 years ago. The advance and retreat of ice sheets across the Puget Sound region deposited alternating layers of silt, sand, and mixed sediment called till or “hardpan.” Where exposed along slopes and bluffs, these conditions are susceptible to landslides and debris flows, especially following periods of intense rainfall or snowmelt.

King County Code (KCC) defines landslide hazard areas as areas subject to severe risk of landsliding, such as zones of instability-prone soil conditions, areas of past landsliding, areas potentially unstable due to stream or wave erosion, areas at risk of snow avalanches, and areas located on alluvial fans (see KCC 21A.06.680). Development standards within landslide hazard areas depend on the nature of the hazard including whether the slope inclination is over 40 percent or not.

The Department of Local Services, Permitting Division (Permitting) is responsible for determining the existence, location, and classification of critical areas including landslide hazard areas during review of a permit application or Critical Area Designation. Permitting is also responsible for determining whether a permit application complies with the standards and regulations in KCC 21A.24.

What development standards apply to landslide hazard areas?

Development proposals and alterations on sites containing landslide hazard areas are subject to development standards given in KCC 21A.24.280.B. Those standards can be summarized as follows:

1. **A buffer is required from all edges of a landslide hazard area**. The buffer is the preferred regulatory tool to eliminate or minimize the risk of property damage or injury resulting from landslides. Permitting is responsible for determining the width of the buffer, based on the data and recommendations given in a geological critical area report. Several factors influence the buffer width required for a landslide hazard, including but not limited to the history of landsliding, slope failure mechanism, slope height, steepness, soil or rock types, groundwater, drainage, vegetation, erosion, building loads, earthquake forces, and debris runout zones.

   In most cases, the minimum buffer allowed without a geological critical area report is 50 feet. Consequently, if development is located outside the buffer and critical area setback more than 65 feet from a landslide hazard area, a geological critical areas report is not required.

For landslide hazard areas over 200 feet in height, Permitting may increase the minimum critical area setback outside the buffer to 100 feet. This would result in a total setback from the landslide hazard of 150 feet, without a geological critical area report.

2. **Removal of any vegetation from a landslide hazard area or associated buffer is generally prohibited**. Specific exceptions for allowed alterations to landslide hazard areas are given in KCC 21A.24.045.
3. **Disturbance to the ground surface and vegetation of the landslide hazard area must be minimized**. Minimization follows the avoidance and mitigation sequence in KCC 21A.24.125.
4. **Alterations shall not decrease slope stability on contiguous properties**.
5. **The risk of property damage or injury resulting from landsliding shall be eliminated or minimized**. For most developments, the risks on- and off-site are minimized by avoiding the hazard area by means of a landslide hazard buffer. The buffer must be wide enough to locate development outside the area which could decrease stability or otherwise be threatened by landsliding. How to evaluate slope instability is discussed in more detail, below.

   For development allowed within the landslide hazard area and buffer (see KCC 21A.24.045), a permit application still must demonstrate that the proposal—including construction methods—will minimize risks and not destabilize the landslide. Geotechnical engineering such as retaining walls or deep foundation elements may be necessary as mitigation to minimize impacts in these circumstances.
6. **Development is required to comply with the recommendations given in a geological critical area report.** A geological professional may give specific conditions necessary to minimize risks. If Permitting geological review agrees that the recommendations meet critical area standards and regulations, those requirements and recommendations must be implemented in a development proposal.

How to assess slope instability and landsliding?

A landslide hazard area is a balancing act of competing forces. Slopes are subject to many destabilizing forces—scour from wind and water, hydrostatic pressure from groundwater, intermittent seismic shaking, and most importantly, gravity. Conversely, slopes must internally resist these forces—the resisting forces are commonly expressed as friction and cohesion (stickiness). Where the disturbing forces are greater than the resisting forces, the slope is considered unstable and at risk of failure.

Slope failure, or landsliding, comes in a variety of forms including shallow instability where the weathered ground surface slides off of more competent unweathered soils as well as deep-seated instability where large blocks of earth can move downhill. Both forms are hazardous; on average,

local soils weigh about 130 pounds per cubic foot, so it does not take a large volume of moving soil to threaten people or property.

Permitting geological review regularly requests that quantitative slope stability analyses be provided in the geological critical area report to evaluate slope stability. The standard method of quantitative slope stability analysis is a “limit equilibrium analysis” and multiple software programs have been developed to run these analyses. The output of a limit equilibrium analysis is the ratio of resisting forces to disturbing forces, which is called the factor of safety (FS). The boundary condition between stability and instability is where the resisting forces are equal to the disturbing forces; this condition is known as the limit equilibrium state and is expressed as FS=1.0.

For purposes of design, KCC 21A.24.310.B.3 follows the regional industry standard and specifies that:

> *The risk of slope instability shall be considered to be minimized where a slope stability analysis demonstrates the factor of safety to exceed 1.5 for static conditions and 1.1 for seismic conditions. […]*
>
> *seismicity shall be modeled as a horizontal force equal to one half the peak ground acceleration adjusted for site class effects, or PGA_m, as given for the site in the International Building Code and American Society of Civil Engineers 7 standard*

The design FS is higher than the limit equilibrium state of FS=1.0 to account for and mitigate potential uncertainties between the model (both input parameters and shortcomings of the methodology) and the reality the built-out condition will have to withstand. Applying factors of safety for design that are more conservative than our best estimate of reality is a fundamental engineering practice.

King County Code does provide an exception to the standard criteria for a slope stability analysis for when a more detailed deformation analysis is conducted. Geological professionals that are considering a more detailed analysis are recommended to contact Permitting geological staff prior to permit submittal.

Permitting geological staff do not require quantitative slope stability analysis for all landslide hazard areas. In some cases, a buffer reduction can be justified based on qualitative reasoning such slope geometry, slope gradient, or landslide classification. For instance, landslide hazards under 40 percent inclination are often characterized as alluvial fans or debris flows. Review for development proposed near the toe of a debris fan would be more concerned with the runout distance of a future debris flow event rather than instability within the landslide in general (slope stability analysis of upslope landslides may still be necessary to estimate debris volumes).

What alterations are allowed in landslide hazard areas and buffers?

Allowances for development activities, or alterations, depend on the ground surface inclination of the landslide hazard area.

For areas within landslide hazard areas with a ground surface inclination **under 40 percent**, all alterations are allowed if they comply with the development standards in KCC 21A.24.280.B (discussed above) and avoidance and mitigation sequencing in KCC 21A.24.125, as well as any other applicable requirements in code.

For areas within landslide hazard areas and buffers with an inclination of **over 40 percent** (which is also a steep slope hazard), development is generally restricted within buffers to minimize impacts to stability and conserve native vegetation. However, exceptions for some specific types of development, or alterations, are given in KCC 21A.24.280.A.

For landslide hazard areas over 40 percent inclination and buffers, allowed alterations are listed by category in a table found in KCC 21A.24.045.C. These categories include allowances for certain projects involving structures, grading, utilities, roads, recreation, and agriculture. If an alteration is allowed, specific conditions are given in KCC 21A.24.045.D. Each of the applicable conditions must be met in addition to the steep slope development standards for the proposed alteration to be allowed within a steep slope hazard area or buffer.

Any alteration allowed must still meet the development standards for steep slopes, specifically demonstrating that the risk of property damage or injury resulting from slope instability shall be eliminated or minimized for the proposal. The allowed alteration must also apply the avoidance and mitigation sequencing in KCC 21A.24.125 as well as any other applicable standards and regulations of KCC 21A.24 to be allowable.

Where can I find more information?

More information regarding critical areas is available on our website.

- Geological Critical Area Report Requirements
- Steep Slope Hazard Area guidance
- Alluvial Fan Hazard Area guidance

For most areas in unincorporated King County, the iMap GIS webpage contains a mapping layer of areas likely to qualify as steep slope hazard areas.

For more information? Visit our customer service page.

For complex projects or projects potentially constrained by steep slope hazard areas or buffers, we strongly recommend you apply for a **voluntary pre-application meeting** and submit a geological critical area report for feedback from Permitting geological review staff. It's often valuable to present your conceptual development proposal and receive comments during the preliminary design phase to gain a better understanding of regulations that will impact project design and feasibility. This information early in a project can avoid the time and expense of redesigns or infeasibility later on in the permitting process. An applicant may also choose to receive comments from additional review staff if related to their proposal.

- Pre-application Meeting Information