North Edmonds Earth Subsidence and Landslide Hazard Area Summary Report Edmonds, Washington

March 14, 2007

Prepared for

City of Edmonds
Community Services Department
Edmonds, Washington

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PURPOSE

The purpose of this document is to provide a summary of key reports and information that are pertinent to permit applicants and their design team for property development within or adjacent to the North Edmonds Earth Subsidence and Landslide Hazard Area, as defined by Edmonds Community Development Code (ECDC) Chapter 19.10. This document does not summarize individual plat or property consultant reports; these consultant reports are available for review in the City of Edmonds (City) Development Services office. This document provides applicants and their design team with technical information and identifies issues that should be considered and addressed related to landslide hazards and landslide processes in the North Edmonds Earth Subsidence and Landslide Hazard Area.

BACKGROUND

The North Edmonds area includes a large historic/prehistoric landslide often called the Meadowdale Landslide in previous documents. The landslide includes a massive downset block of land that extends from the steep bluffs along the east edge of the slide to Puget Sound. In this summary report, the downset block is referred to as the "landslide mass." The identification of the landslide mass will change over time. Some areas currently outside of the landslide mass may become part of the mass as slopes regress from natural or other erosional processes.

The landslide mass is defined as the area that has previously moved in historic or prehistoric times and is referred to as the North Edmonds Earth Subsidence and Landslide Hazard Area (North Edmonds ESLHA). This area is subject to the terms of the City's original "Meadowdale Ordinance" (Ordinance #2661) and subsequent revisions and updates enacted by the City of Edmonds. The requirements of the most recent ordinance revisions are contained in ECDC Chapter 19.10. Development in Landslide Hazard Areas, including areas both within and outside of the North Edmonds ESLHA, is also controlled by the provisions of ECDC 23.80, Geologically Hazardous Areas.

NORTH EDMONDS LANDSLIDE ORDINANCE

The North Edmonds (Meadowdale) landslide hazards and risks have been known for a number of years, and the landslide has been the subject of many previous geologic and geotechnical studies. Large scale landsliding of the area was described in newspapers in 1947 and damaging slides have been historically recorded in many years since that time. In the past, development in the area was limited because of landslide hazards. In 1984, Local Improvement District (LID) No. 210 was passed for the Meadowdale area (which included the landslide mass as well as properties east of the slide). In 1984, a public sanitary sewer, limited storm sewers, and other drainage components were installed under this

LID. The installation of these various LID improvements generally lowered groundwater levels within the slide and lowered the risk to new development.

Since 1988, residential development has been allowed in the landslide area under specific conditions and requirements prescribed under City Ordinance 2661. The ordinance included development guidelines and requirements to limit risks for a property owner and risk of impacts to adjacent properties. Development within the landslide area under Ordinance 2661 has occurred assuming that an acceptable risk of landsliding for a property is less than 30 percent in 25 years. Under those conditions, property development was only allowed if a property owner and their consultant provided an estimated landslide risk for the property, based on sound scientific and engineering principles, that was less than 30 percent in 25 years.

Substantial risks due to landslide hazards exist within the North Edmonds ESLHA. These risks are estimated to range from less than 10 percent probability of occurrence in 25 years to about 30 percent probability of occurrence in 25 years (GeoEngineers 1985). The actual landslide hazard risk depends on both regional and site-specific conditions, including topography, geology, surface water, groundwater, and vegetation conditions. In many cases, the landslide hazard risk can be reduced and impacts mitigated through appropriate siting, land development, and design features. It is the responsibility of the applicant and their design team to:

- Clearly identify landslide hazards that affect or are affected by property development, and
- Provide measures to reduce hazards and mitigate impacts.

KEY NORTH EDMONDS AREA GEOTECHNICAL STUDIES

The current understanding of the North Edmonds ESLHA has been developed from geologic and geotechnical studies that began in the 1960s and have continued through the present time. Most of these reports are available for viewing at the City's Development Services office. Key area-wide technical reports are summarized below. The following key reports have formed the historic basis of the North Edmonds ESLHA and the related ordinances enacted by the City.

- Dames & Moore. 1968. This report evaluated the overall stability of the Meadowdale area from a geologic standpoint and identified soil and groundwater conditions, described slide history of the area, and provided a map showing geologic contacts, the ancient slide scarp, and areas of 1947 and 1955-56 movement. This report concluded that it was feasible to install sanitary sewers and that installation would benefit the stability of the area. This report also suggested that new residential development in much of the Meadowdale area should be prohibited unless some measures are made to control groundwater and surface water.

- Roger Lowe Associates, Inc. 1979. This report provided a summary of the Meadowdale area landslide history, geology, and hydrology. This report provided a landslide hazard map that enumerated the probability of landslide hazards in the Meadowdale slide area at the time the

report was prepared (prior to LID sewer and drainage improvements). The probabilities of landslide movement ranged from 2 to 90 percent over a 25-year period and much of the landslide mass area had probabilities greater than 30 percent. The probabilities presented in the report were based on a 30- to 40-year historical record and site observations of landslide feature ages and activity. The report identified that the stability of the Meadowdale Landslide is very sensitive to groundwater levels. The report also identified land use and risk reduction measures, including the installation of sanitary sewers, storm drainage, and interceptor drains. The report provided a summary of the results of stability analyses with respect to possible improvements in factors of safety and potential lowered groundwater levels.

- GeoEngineers, Inc. 1985. This report provided a summary of predicted improvements in stability due to the LID measures implemented in 1984. GeoEngineers' evaluation was based on comparing 4 years of groundwater data prior to the LID construction with 3 months of data following LID construction. The report concluded that an average 3-ft decline in groundwater levels was observed in the Meadowdale Landslide mass. The decline in groundwater levels was tied to an increase in factor of safety and a decrease in landslide hazard risk. A map showing this decreased landslide risk, modified from the original 1979 mapping, was provided in this report. The probabilities shown on the revised map range from 2 to 30 percent over a 25-year period. The reduction in probabilities presented in the report was based on subjective evaluations that related change in factor of safety from lower groundwater levels to reduction in risk. The intent of the report was to help identify and approximately quantify the relative degree of risk for various broad areas within the overall landslide mass so that this information could be used for planning and communication of the relative landslide hazards to the public. The information was not intended to provide a detailed assessment of lot-specific landslide hazards or a precise estimate of landslide probabilities at a particular location.

- Landau Associates. 2007. Previous mapping of the landslide hazard area boundary was based on hand-drawn lines on older USGS base maps. Various inaccuracies became evident in the base map over time. In addition, the landslide boundary included areas that had previously failed as a result of landslide movement, as well as some adjacent areas that could be hazardous, but had not yet failed. The definition of what was inside or outside the boundary line was not always consistent and subject to interpretation. To address these issues, the City had LiDAR (light detection and ranging) mapping flown of the entire city in 2005. The topographic and imaging data from the LiDAR survey provided current, high quality base mapping that formed the basis for the development of landslide hazard mapping for the entire city. Particular emphasis was placed on the North Edmonds ESLHA. Topographic data, LiDAR imaging, previous geologic studies, geotechnical reports prepared for individual properties, and geologic mapping was reviewed to develop the boundary of the North Edmonds ESLHA. It was decided that the boundary of the North Edmonds ESLHA should be set at the interpreted boundary of the landslide mass (i.e., the interpreted top of the landslide scarp surrounding the North Edmonds landslide). The results of the mapping and evaluation process are summarized in a Landau Associates report and the North Edmonds ESLHA boundary line is incorporated in the City's Landslide Hazard Area maps. It should be noted that setting the boundary line at the interpreted top of the landslide scarp defines the intended extent of the requirements of ECDC 19.10 for the North Edmonds ESLHA and is not meant to imply that landslide hazards are not present beyond that line. However, requirements for considering and addressing landslide hazard areas defined on the basis of slope steepness and requirements for addressing areas adjacent to landslide hazard areas are already addressed in ECDC 23.80, Geologically Hazardous Areas.

NORTH EDMONDS AREA LANDSLIDE SETTING AND HISTORY

An understanding of the landslide setting, conditions, and history will help the applicant and their design team to better address issues in site development.

LANDSLIDE GEOLOGY AND SETTING

The soils in the North Edmonds area include soils from glacial and interglacial periods and disturbed soils from post-glacial landslide processes. Outside of the landslide area (east of the landslide), the uppermost soil in many areas is glacial till—an unsorted and consolidated mixture of sand, silt, and gravel that has been glacially consolidated and is very dense. Directly beneath this unit (or at the surface if till is not present), is a glacial outwash deposit of sand and sandy gravel. The bottom of the outwash deposit often includes transitional interbeds of silty sand and silt. The glacial outwash unit is present along the steep slopes that form the eastern edge of the landslide. Both the glacial till and the outwash are considered to be from the most recent glacial period, termed the Vashon age. An older-age sequence of silt and clay, often termed the Whidbey Formation, underlies the outwash deposit. Within the landslide mass, the outwash sands and underlying silt and clay have been disturbed from sliding and form landslide deposits. In some cases, the landslide movement has completely mixed up these soils so no soil structure can be seen. In other cases, landslide failure occurred as large blocks of soil that stayed intact, so bedding may be visible.

Landsliding in the area is caused by a combination of topography, geology, and groundwater. The slopes throughout the area are steeper than the strength of soils will support. Within the landslide complex, soils strengths in disturbed soils are very low, so slopes may be unstable at 3H:1V (horizontal:vertical) or 4H:1V and flatter. On the outer edge of the landslide complex, undisturbed soils have higher strengths, but existing slopes are also steeper; many areas are steeper than 1H:1V, and slopes are potentially unstable. In both conditions, groundwater or seepage is typically a triggering factor acting to reduce soil strength and cause erosion. The subsurface conditions present on the east edge of the landslide complex are similar to other landslide areas in the Puget Sound region; permeable sands are eroded by groundwater that lies above relatively impermeable silts and clays causing a zone of frequent and active ground movement.

LANDSLIDE HISTORY

Landsliding in the area, and throughout the Puget Sound region, probably began thousands of years ago as glaciers retreated. The landsliding activity reflects a process of steep slopes attempting to reach geologic equilibrium. The North Edmonds landslide is not yet in equilibrium, so continued ground

movements should be expected to occur for an extended period of at least hundreds and possibly thousands of years into the future.

Several very large landslide events have been documented in the area in the 1940s and 1950s (information prior to the 1940s has not been identified). In 1947 an area south of the wharf was involved in a large landslide event that had been identified variously as between about 800 ft long (Dames & Moore 1968) to greater than 2,400 ft long (Seattle Post-Intelligencer February 23, 1947), with impacts that extended up to about 1,000 ft eastward from the shoreline. As part of this landslide event, which apparently continued over some period of time, four homes were reportedly wrecked and 20 to 40 homes threatened or endangered. In 1955-56, another large slide is documented (Dames & Moore 1968) that destroyed at least 2 homes and damaged many other homes. It is appropriate to note that the density of development in this area in the 1940s and 1950s was significantly less than present day conditions. A large-scale landslide similar to these earlier landslides could be expected to involve many more structures if it were to occur today.

Since the 1950s, large-scale movements of the landslide mass have not been documented. Generalized movement does occur in the landslide area as evidenced by roadway cracking and localized, small-scale slope failures. The risk of large-scale landsliding has been substantially reduced by the LID improvements that were installed in 1984. However, extreme climatic conditions have the potential to affect groundwater sufficiently to reactivate the overall landslide mass. For instance, the 'rain-on-snow' event of late 1996 and early 1997 caused several slides in the North Edmonds area and throughout the Puget Sound region. In particular, large-scale landslides that caused significant damage occurred along the bluffs in the town of Woodway and in the Perkins Lane area of Magnolia Hill in Seattle. Smaller scale landsliding, such as sloughs or debris flow on the east edge (scarp) of the landslide complex and movements of benches within the landslide mass continue to occur indicating that the North Edmonds landslide area is still active.

LANDSLIDING – LOCATIONS, HAZARDS, AND PROCESSES

Previous geologic reports for the area considered landslide locations, hazards, and processes known at the time the reports were completed. Although the specific boundaries of areas with certain hazards may have changed over time, the concept of identifying landslide hazards and processes is still directly applicable to development within the North Edmonds ESLHA. The previous reports did not provide detail about the expected severity of landsliding with respect to property damage or potential loss of life. It should be noted that most previous reports were completed before substantial development of the area within and directly adjacent to the landslide area. Some small landslides (such as from bluffs along the east side of the landslide complex), may be happening more frequently over time (or they may

now be reported more often as development has increased on properties near the bluff). The type and frequency of landsliding should be expected to change over time—factors that need to be considered for development.

The location of landslides, the types of hazards, and the landslide process affect the development of properties in the North Edmonds ESLHA. Table 1 summarizes relationships between location, type of landslide hazard, landslide processes, and recommended geotechnical report requirements and issues to be considered in the design of property improvements within or adjacent to the North Edmonds ESLHA. Specific requirements for development are provided in the City of Edmonds North Edmonds ESLHA Checklist for Permit Submittal and the Geotechnical Report Guidelines.

POTENTIAL LANDSLIDING LOCATIONS

In and adjacent to the North Edmonds ESLHA, various types of landslide hazards and processes may occur at different locations. For a common understanding of landslide issues, the North Edmonds landslide area has been divided into five zones, A through E. These zones are schematically shown on Figure 1.

- Zone A. This zone includes the lowermost (west) parts of the landslide. Slide movement from the large-scale slide complex and smaller slides within the complex can both affect this zone. Impacts from sliding in this zone have the potential to affect the nearby Burlington Northern Santa Fe (BNSF) railroad.

- Zone B. This zone includes the majority of the landslide mass or complex. Soils in this area are typically disturbed, although blocks of intact soil may be found within this zone. Localized small-scale failures occur in this zone from weak soils and localized groundwater conditions. Large-scale sliding of the slide complex has the potential to affect this zone.

- Zone C. This zone lies near the edge of the landslide complex. This zone is most affected by landslide hazards due to slides that initiate on the steep slopes on the east side of this zone. Small-scale failures within this zone are also possible. This zone has the highest risk to public safety.

- Zone D. This zone encompasses the active scarp of the landslide and incorporates ground that is outside the currently active landslide area. The west part of this zone includes parts of the slope that are actively failing as shallow debris slides. This zone also includes areas that can potentially fail as large block failures. The eastern part of this zone includes currently stable ground that has not yet failed behind the present top of the landslide scarp. This area could be subject to failure from a large block-type landslide failure or a series of shallower debris slides occurring on the face of the bluff and the resultant bluff retreat over a period of years. Any development near a designated landslide hazard zone will require consideration of the landslide hazard, potential bluff retreat, and buffers (designated as a distance of 50 ft or the height of the steep slope back from the top of the slope, whichever is greater, per the requirements of ECDC 23.80).

- Zone E. This zone lies outside of the active landslide area and the area that may be involved in long-term slope retreat. However, development in this zone has the potential to contribute to surface water or groundwater conditions that affect hazards within Zones A though D. Locally steep slopes may also be present in this area that are unrelated to the North Edmonds ESLHA, but that could be considered a landslide hazard area as defined by ECDC 23.80.

It is important to understand that it is possible to have features, hazards, and processes common to one zone present in another zone. As part of development permitting, the applicant and their design team will need to identify specific hazards and processes that apply to the property.

LANDSLIDE HAZARDS

Four different types of landslide hazards were identified by Roger Lowe Associates (1979) and GeoEngineers (1985) on their maps. These hazards consist of:

- No hazard identified
- Encroaching landslide debris originating upslope
- Hazards from landslides in ground that has not previously failed
- Hazards from reactivating landslide debris causing ground failure and movement.

More than one type of hazard can occur at any given location. Due to impacts from landsliding adjacent to an area, hazards can occur in areas that have previously been stable and have not previously failed. The landslide hazards identifiers also recognize that landsliding and related hazards can occur in areas that are now stable, but that have the potential to become unstable at some time in the future. The applicant and their design team must identify all landslide hazards that currently exist on the property, as well as those likely to exist in the future, and determine if those hazards have the potential to affect human safety or cause property damage.

LANDSLIDE PROCESSES

The Landslide Hazard Map, initially developed by Roger Lowe Associates (1979) and also used by GeoEngineers (1985) identified four landslide processes that commonly occur in the area:

- Slumps
- Debris Slides
- Debris Avalanches
- Debris Flows.

Multiple hazards and multiple processes can be present at any location. For each hazard identified on a property, the applicant and their design team shall identify the types of processes associated with the hazard. The site design should include features to reduce hazards, mitigate impacts from site hazards, and cause no additional impacts to other property owners in the area.

SEVERITY OF LANDSLIDING

Previous maps of the North Edmonds landslide area did not distinguish between size or severity of landslide hazards. As part of the development permit process, applicants and their design team should assess the size of possible landslide impacts and present design features to mitigate impacts. All impacts that could affect public safety must be mitigated. It may not be possible to fully mitigate property damage impacts from very large-scale landsliding. In this case, the applicant's geotechnical report should clearly identify the steps taken to reduce the impacts and the possible impacts that are not fully mitigated by design. For instance, the designer's report should note that significant structural damage should be expected if large-scale reactivation of the North Edmonds landslide should occur.

CHANGES OVER TIME

The risk of landslide hazards in the area will remain substantial for hundreds to thousands of years. Landslide processes and susceptible locations will change over time. Some changes may be due to human influences; other changes are part of natural geologic processes. The assessment of landslide hazards and processes on a parcel should consider changes that may occur over time. For all zones, development shall not increase the likelihood, extent, or severity of hazard for the applicant's property or other properties. For lots in Zones C and D, slope retreat processes must be explicitly considered in the applicant's technical documentation. For these zones, applicants should evaluate the effect of slope retreat processes over a minimum 120-year period. The 120-year period has been chosen as the normal useful life of residential structures under normal upkeep and maintenance conditions. For some site improvements, an alternate 'normal useful life' may be appropriate and can be proposed by the applicant.

Groundwater levels in and near the North Edmonds area will affect the stability in all zones. Groundwater levels are affected by a wide range of factors, both natural and human caused. Changing climatic conditions could lead to increased groundwater levels in the future. Municipal sewers and storm sewers and drains remove some surface water before it can re-infiltrate back into the landslide mass. However, watering associated with gardens and lawns introduces water back into the landslide area and into the groundwater and removal of trees and vegetation also increases the amount of precipitation that is available to infiltrate to the groundwater. Thus, the net effect from human factors is not known.

RISK REDUCTION AND MITIGATION MEASURES

The applicant and their design team need to evaluate the landslide hazards in relationship to the proposed development and incorporate means to reduce the risk related to potential landsliding and to develop measures to mitigate the potential remaining hazards.

Mitigation measures may take a variety of forms, depending on the specific site conditions and details of the design. For example, some structures within the North Edmonds ESLHA have been supported on pile foundations extending down through the landslide debris and founded on underlying undisturbed materials. Other projects have been designed with a shallow foundation consisting of a relatively rigid structural foundation mat or grid that is designed to span over areas of underlying vertical or horizontal soil movement. In essence, the structure is designed to stay intact even if soil support under a portion of the structure is lost due to landsliding.

Structures located near the base of the steep bluff have been designed considering the potential for landslide debris flow originating from upslope areas. Mitigation measures for structures near the base of the steep slope that could be impacted by debris flows have included debris deflection or catchment walls above the structure, reinforced shear walls within the structure, minimal door or window openings on the uphill side of the structure, and placement of the main living and sleeping areas away from the upslope side of the house.

CONCLUSIONS

The 1984 LID activities, a combination of sanitary sewers (with associated removal of septic systems) and limited storm drainage improvements, have, on the average, lowered groundwater levels and improved the stability of areas within the landslide mass. The storm drainage portions of the LID were installed primarily to protect City-owned property such as the new sanitary sewer line. The LID improvements were not intended to address groundwater levels outside the landslide mass, and thus have not changed stability in these areas. The improvement in stability from lower groundwater levels could change in the future, and activities associated with the development of the North Edmonds ESLHA and surrounding areas can affect stability in both positive and negative ways. The North Edmonds ESLHA Ordinance and associated requirements contained in ECDC 19.10 allows development if landslide risks can be reduced and impacts can be shown to be mitigated by appropriate design. Nonetheless, it is imperative that applicants and homeowners understand that living in a known landslide area presents a real and substantial risk to both public safety and private/public property. Residents in and immediately adjacent to the North Edmonds ESLHA should be prepared to accept that risk.

USE OF THIS REPORT

This report was prepared for the use of the City to summarize geotechnical and geologic information related to the North Edmonds ESLHA. The information in this summary report is general in nature and could be used as background information, but should not be used as a basis for design and development of individual lots. Within the limitations of scope, schedule, and budget, our services have been conducted in accordance with generally accepted geotechnical engineering and geologic practices. No other warranty, express or implied, is made as to the professional advice included in this report.

We appreciate the opportunity to provide geotechnical services to the City. If you have any questions regarding the information contained in this report, or if we may be of further service, please call.

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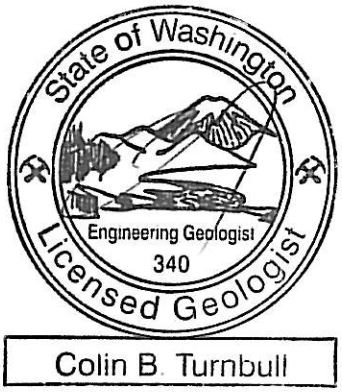

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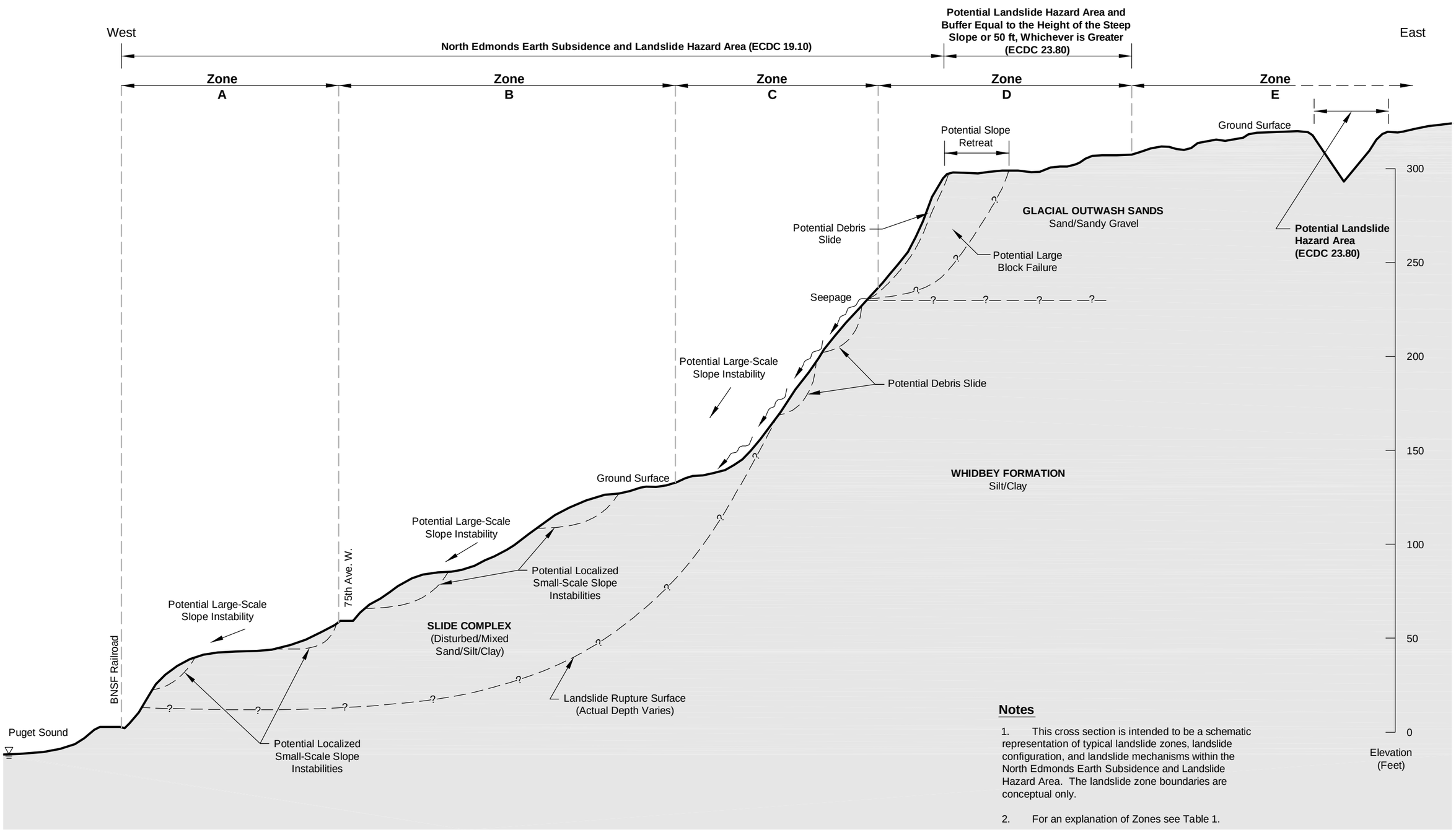

Notes

1. This cross section is intended to be a schematic representation of typical landslide zones, landslide configuration, and landslide mechanisms within the North Edmonds Earth Subsidence and Landslide Hazard Area. The landslide zone boundaries are conceptual only.

2. For an explanation of Zones see Table 1.

0 100 200

Approximate Scale in Feet
Vertical Exaggeration = 2x

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North Edmonds Earth Subsidence and Landslide Hazard Area
Edmonds, Washington

North Edmonds Landslide Area Geology and Slide Mechanisms

Figure 1

City of Edmonds/North Edmonds Landslide Hazard Areas | V:\074\137\200\Summary Report\Fig1.dwg (A) "Figure 1" 12/22/2006

TABLE 1
RECOMMENDED GEOTECHNICAL REPORT REQUIREMENTS
NORTH EDMONDS EARTH SUBSIDENCE AND LANDSLIDE HAZARD AREA

Locations	Technical Issues and Landslide Hazards	Recommended Report Requirements	Recommended Key Design Features
All Zones	Possible Technical Issues • Localized slope instability • Large-scale slope instability • Risk to public safety • Risk to private/public property • Potential impacts to North Edmonds Earth Subsidence and Landslide Hazard Area and other properties from surface water or groundwater conditions • Potential localized Landslide Hazard Area due to steep slopes (ECDC 23.80) Possible Potential Hazards • Encroaching landslide debris originating upslope • Reactivation of landslide debris causing ground failure and movement • Landslide in ground that has not previously failed	Possible Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Provide estimated vertical and horizontal differential movement for appropriate foundation design • Provide criteria for minimum span distance between foundation support due to potential loss of soil support • Provide information about the potential size and mass of landslide debris originating upslope • Provide required foundation and wall loading conditions based on impact forces from landslide debris originating upslope if determined to be a risk • Establish Steep Slope Buffer width based on rate of slope retreat or stable slope angle over 120-year period • Include a minimum 15 ft setback from Steep Slope Buffer for all site development • Provide recommendations for suitable vegetation; in most cases, buffer shall be maintained in undisturbed, natural condition • Determine if activities on property, particularly drainage features, are expected to impact the Landslide Hazard Area • Full Geotechnical Report may not be required if outside of the North Edmonds Earth Subsidence and Landslide Hazard Area and other designated Landslide Hazard Areas	Possible Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration typically prohibited in hazard area • Permanent irrigation systems prohibited in Zones A, B, C, D; minimize water that is used for irrigation in all zones • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Outdoor swimming pools prohibited in Zones A, B, C, D • If permitted, hot tubs should include special design features so that tub water is conveyed to a suitable and approved discharge point • Foundations should withstand high lateral forces from upslope and large-scale movement • Foundations should be designed to withstand loss of soil beneath parts of foundation • Structures should be designed to accommodate a certain level of vertical and horizontal movement from local and large-scale landsliding • Depending on location, may need to consider features for human safety from encroaching materials including deflection walls, reinforced shear walls; appropriate home layout features • Reinforced shear walls; appropriate door and window placement • Appropriate location of main living and sleeping areas • No yard waste, debris or fill may be placed within Steep Slope Buffer on either a temporary or permanent basis • No permanent irrigation in buffer or setback • No water discharged or infiltrated in landslide, buffer or setback
Zone A	Specific Technical Issues • Localized slope instability • Large-scale slope instability • Risk to public safety • Risk to private/public property Specific Potential Hazards • Reactivation of landslide debris causing ground failure and movement	Specific Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Provide estimated vertical and horizontal differential movement for appropriate foundation design • Provide criteria for minimum span distance between foundation elements	Specific Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration typically prohibited in hazard area • Permanent irrigation systems should not be allowed in Zones A, B, C, D; minimize water that is used for irrigation in all zones • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Outdoor swimming pools prohibited in Zones A, B, C, D • If permitted, hot tubs should include special design features so that tub water is conveyed to a suitable and approved discharge point • Foundations should withstand high lateral forces from upslope and large-scale movement • Foundations should be designed to withstand loss of soil beneath parts of foundation • Structures should be designed to accommodate a certain level of vertical and horizontal movement from local and large-scale landsliding
Zone B	Specific Technical Issues • Localized slope instability • Large-scale slope instability • Risk to public safety • Risk to private/public property Specific Potential Hazards • Reactivation of landslide debris causing ground failure and movement	Specific Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Provide information about the potential size and mass of landslide debris originating upslope • Provide estimated vertical and horizontal differential movement for appropriate foundation design • Provide criteria for minimum span distance between foundation elements • Provide required foundation and wall loading conditions based on impact forces from landslide debris originating upslope if determined to be a risk	Specific Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration prohibited in hazard area • Permanent irrigation systems prohibited in Zones A, B, C, D; minimize water that is used for irrigation in all zones • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Outdoor swimming pools prohibited in Zones A, B, C, D • If permitted, hot tubs should include special design features so that tub water is conveyed to a suitable and approved discharge point

TABLE 1
RECOMMENDED GEOTECHNICAL REPORT REQUIREMENTS
NORTH EDMONDS EARTH SUBSIDENCE AND LANDSLIDE HAZARD AREA

Locations	Technical Issues and Landslide Hazards	Recommended Report Requirements	Recommended Key Design Features
	• Landslide in ground that has not previously failed • Encroaching landslide debris originating upslope		• Structures should be designed to accommodate a certain level of vertical and horizontal movement from local and large-scale landsliding • Foundations should be designed to withstand loss of soil beneath parts of foundation • Depending on location, may need to consider features for human safety from encroaching materials including deflection walls, reinforced shear walls; appropriate home layout features
Zone C	Specific Technical Issues • Localized slope instability • Large-scale slope instability • Risk to public safety • Risk to private/public property Specific Potential Hazards • Encroaching landslide debris originating upslope • Reactivation of landslide debris causing ground failure and movement • Landslide in ground that has not previously failed	Specific Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Provide information about the potential size and mass of landslide debris originating upslope • Provide required foundation and wall loading conditions based on impact forces from landslide debris originating upslope if determined to be a risk • Provide estimated vertical and horizontal differential movement for appropriate foundation design	Specific Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration typically prohibited in hazard area • Permanent irrigation systems prohibited in Zones A, B, C, D; minimize water that is used for irrigation in all zones • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Outdoor swimming pools prohibited in Zones A, B, C, D • If permitted, hot tubs should include special design features so that tub water is conveyed to a suitable and approved discharge point • Depending on location, may need to consider features for human safety from encroaching materials including deflection walls, reinforced shear walls; appropriate home layout features • Reinforced shear walls; appropriate door and window placement • Appropriate location of main living and sleeping areas
Zone D	Specific Technical Issues • Risk to public safety • Risk to private/public property Specific Potential Hazards • Landslide in ground that has not previously failed	Specific Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Establish Steep Slope Buffer width based on rate of slope retreat or stable slope angle over 120-year period • Include a minimum 15 ft setback from Steep Slope Buffer for all site development • Provide recommendations for suitable vegetation; in most cases, buffer shall be maintained in an undisturbed, natural condition	Specific Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration typically prohibited in hazard area • Permanent irrigation systems prohibited in Zones A, B, C, D; minimize water that is used for irrigation in all zones • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Outdoor swimming pools prohibited in Zones A, B, C, D • If permitted, hot tubs should include special design features so that tub water is conveyed to a suitable and approved discharge point • Steep Slope Buffer is to be maintained in a natural, undisturbed condition; no gardens, patios, steps, pavers, garden retaining walls, sheds, patios or other garden our outdoor development features are allowed in buffer • No yard waste, debris or fill may be placed within Steep Slope Buffer on either a temporary or permanent basis • No permanent irrigation in buffer or setback • No water discharged or infiltrated in buffer or setback
Zone E	Specific Technical Issues • Potential impacts to North Edmonds Earth Subsidence and Landslide Hazard Area and other properties by affecting surface water or groundwater conditions Specific Potential Hazards • Potential localized Landslide Hazard Area due to steep slopes (ECDC 23.80)	Specific Report Requirements • Subsurface exploration must be at least 6 ft deeper than lowest elevation of the proposed foundation • Subsurface exploration required for retaining structures • Subsurface exploration must include measurement or estimate of high seasonal groundwater conditions • Determine if activities on property, particularly drainage features, are expected to impact the Landslide Hazard Area • Full Geotechnical Report may not be required	Specific Key Design Features • Temporary and permanent fills may be restricted • Roof drains and impervious surface runoff should be tightlined to stormwater system and separate from footing drain lines • Stormwater infiltration typically prohibited in hazard area • Select native, drought-tolerant vegetation (dense, low-lying, and deeply rooted species) • Hot tubs should include special design features so that tub water conveyed to a suitable and approved discharge point