Chapter 3

Affected Environment, Significant Impacts, and Mitigation Measures

CHAPTER 3

AFFECTED ENVIRONMENT, SIGNIFICANT IMPACTS, MITIGATION MEASURES AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

INTRODUCTION

This chapter describes the affected environment, significant impacts of the Proposed Actions and alternatives, relevant mitigation measures, cumulative impacts and significant unavoidable adverse impacts. For each element of the environment, impacts are discussed for Alternatives 1 and 2 and the No Action Alternative (Alternative 3).

Note that "Johnson Ditch" is used in this document to refer to the watercourse in its existing condition as a ditched stream; "Johnson Creek" is used to refer to the watercourse in its proposed realigned condition; the drainage basin for the watercourse is referred to as the "Johnson Creek basin". For an explanation of the City of Tukwila's regulated watercourse definitions, see Section 3.2, Water Resources, and Section 3.2, Plants and Animals including Table 3.3-1.

3.1 EARTH

This section describes existing geologic conditions and the presence of hazardous areas on and adjacent to the site. Potential impacts to site topography, geology and hazards from infrastructure development and full buildout under the Proposed Actions (Alternatives 1 and 2) and the No Action Alternative are also evaluated. This section is based on the February 2005, Technical Report on Geology, Soils and Groundwater, prepared by Associated Earth Sciences, Inc (see Appendix A). Groundwater is discussed in Section 3.2, Water Resources.

3.1.1 Affected Environment

Topography

Regional topography was formed by glaciation, massive prehistoric mudflows, and stream incision, and generally consists of the flat valley floor of the Green/Duwamish River valley, and fairly steep valley walls at the western and eastern edges of the valley. Topography in the valley has very little relief. Exceptions include the Green River levee, roads constructed on fill material (including S 200th Street onsite, which rises 10 to 15 feet above the valley floor), and a flood protection barrier dike located onsite. The topography of the western valley wall is fairly steep, with portions in excess of 40 percent slope. The western valley wall has been modified by large-scale excavations into the steep slopes during the 1960s, and by construction of Orillia Road. In some areas, the western valley wall is dissected by a number of small drainage ravines.

The site is generally comprised of relatively flat areas located on the Green River valley floor adjacent to the Green River, and hillside areas with some slopes in excess of 40 percent located to the west of the valley floor, adjacent to I-5. The majority of the 40 percent or steeper slopes are located on the western valley wall, north of S 196th Street to the northern site boundary. The portion of the western valley wall south of S 196th Street generally has slopes of between 15 to 40 percent with small areas of 40 percent or steeper slopes. Ground surface elevations on the valley floor portion of the site range from approximately 15 feet mean sea level (fmsl) near the south end of the site to 28 fmsl near the north end of the site. Elevations at the top of the hillside portion of the site range from 290 to 350 fmsl. A former sand and gravel mine is located north and east of the intersection of 200th Street and Orillia Road intersection. The operation ceased in the early 1980s and the mine was backfilled with construction debris in the 1990s (see Section 3.5, Hazardous Materials, for details).

Fourteen watercourses (ditches, ditched streams and streams) were identified on the site (see Section 3.2, Water Resources, including Figure 3.2-1 for further description of onsite watercourses). The site contains 19 wetlands totaling 48.7 acres (see Section 3.4, Wetlands, including Figure 3.4-1, for further description of onsite wetlands).

Geologic Conditions

Information on geologic conditions is based on a review of available soil, groundwater, and geologic data, site-specific geotechnical reports by GeoEngineers (2004) and several types of field exploration activities conducted for this EIS, including: 1) reconnaissance and mapping of current site geologic and hydrologic conditions; 2) drilling and completion of 12 observation wells; 3) stream reconnaissance; and 4) groundwater level monitoring. Field investigation activities were performed between August 2003 and September 2004 (see Appendix A for details).

Regional Geology

The Puget Sound region is underlain by deposits associated with multiple glaciations and nonglacial intervals resulting in a complex stratigraphic framework. Bedrock is at ground surface approximately 1 ¼ miles north and 2 to 2 ½ miles northeast of the site; however, the depth to bedrock increases dramatically to the north and south of these locations, and depth to bedrock is between 600 and 1,200 feet below ground surface beneath the site.

The Green River valley floor consists of sediment deposited during massive prehistoric mudflows (lahars) from the slopes of Mount Rainier. Following the period of massive lahars and the retreat of Vashon-age glacial ice, the steep hillsides directly to the west of the valley floor were formed by stream incision, with the lower bluff slopes also formed by sediment deposition from landslides and other forces (see Appendix A for further information on regional geology).

Site Geology

Figure 10 in Appendix A shows the surficial geology of the site. Figures 11 and 12 in Appendix A illustrate surface and subsurface geology relative to site topography (the locations of the cross-sections are shown on Figure 13 in Appendix A).

Four geologic units on and in the vicinity of the site were identified: pre-Olympia-age deposits, Vashon Stade deposits, recent sediments, and fill soils. These units are further divided into 11 stratigraphic units: Fine-Grained Pre-Olympia-Age Deposits ($Qpon_f$), Coarse-Grained Pre-Olympia-Age Deposits ($Qpog_2$), Undifferentiated Coarse-Grained Pre-Olympia-Age Deposits ($Qpog_{1,2}$), Pre-Olympia-Age Diamict ($Qpog_t$), Coarse-Grained Pre-Olympia-Age Deposits ($Qpog_1$), Vashon Advance Outwash (Qva), Vashon Lodgement Till (Qvt), Vashon Ice-Contact

Deposits (Qvic), Green/Duwamish River Valley Alluvium (Qal), Landslide Deposits (Qls), and fill soils (see Appendix A for further description of the site geology).

$Qpon_f$ – Fine-Grained, Pre-Olympia-Age Deposits

Fine-grained pre-Olympia-age deposits were exposed surficially in the Stream E-2 and G ravines onsite. These sediments generally consisted of hard, laminated tan to gray silt. The fine-grained silts within $Qpon_f$ retard the flow of groundwater, and have caused the formation of springs within the E-2 stream ravine.

$Qpog_2$ – Coarse-Grained Pre-Olympia-Age Deposits

Coarse-grained pre-Olympia-age deposits were exposed surficially in the Stream E-1 and E-2 ravines onsite.

$Qpog_{1,2}$ – Undifferentiated Coarse-Grained Pre-Olympia-Age Deposits

In some areas, $Qpog_2$ is not differentiated from overlying $Qpog_1$, and coarse-grained pre-Olympia-age deposits are mapped as $Qpog_{1,2}$ (see Figure 10 in Appendix A).

$Qpog_t$ – Pre-Olympia-Age Diamict

A diamict ($Qpog_t$) consisting of very dense, gray, greenish-gray, and grayish-brown, silty gravel with sand, was exposed surficially in the Stream E-1 and E-2 ravines. The diamict retards the flow of groundwater, and has caused the formation of several springs in the E-1 and E-2 stream ravines. These include spring flow to Wetland 15, approximately 1,400 feet north of Stream E-2, and spring flow to Stream G ravine, approximately 1,300 feet south of Stream E-1. Thus, $Qpog_t$ deposits are interpreted to extend northward and southward to Wetland 15 and the Stream G ravine. However, south of the Stream G ravine immediately upslope from the Wetland 1 area, $Qpog_t$ deposits are interpreted to be truncated by large-scale mass wasting. (Spring flow in the Wetland 1 area is interpreted to correlate with undifferentiated $Qpog_2$ deposits.)

$Qpog_1$ – Coarse-Grained Pre-Olympia-Age Deposits

Coarse-grained pre-Olympia-age deposits were exposed surficially in the Stream E-2 ravine above the diamict deposit. These sediments generally consisted of well sorted, dense, brown fine to medium sand. $Qpog_1$ deposits were present from near the top of the Stream E-2 ravine to near the top of the exposure of $Qpog_t$. Underneath the plateau, groundwater in wells completed within the $Qpog_1$ sediments was confined (see Section 3.2, Water Resources, Groundwater Quantity for details).

Qva –Vashon Advance Outwash

Vashon advance outwash is interpreted to underlie the Angle Lake Plateau. Water well reports indicated that dense sand with varying amounts of gravel is present at ground surface or underneath a lodgement till cap. Underneath the plateau, the lower portion of the sandy unit generally contained groundwater ranging from approximately elevation 290 to 330 fmsl; however several water well reports did not encounter water in the Qva (see Section 3.2, Water

Resources, Groundwater Quantity for details). This unit is interpreted to be absent below approximately elevation 270 fmsl in the vicinity of the site.

Qvt – Vashon Lodgement Till

Thin lodgement till was exposed at the top of the Stream E-2 ravine. The lodgement till consisted of dense, brownish-gray to gray silty sand with varying amounts of gravel. Vashon lodgement till is interpreted to mantle higher elevation portions of the western slope of the Green/Duwamish River Valley.

Qvic – Vashon Ice-Contact Deposits

Vashon ice-contact deposits are sporadically present along the western slope of the Green/Duwamish River valley. Medium dense to dense, brown fine to medium sand to silty sand interbedded with silt is exposed along the valley wall in discrete locations. Immediately south of the Southcenter Golf driving range, medium dense brown fine to medium sand interbedded with layers of silt grades laterally toward the south into dense silty sandy gravel, with till-like pods of unsorted gravel in a silty fine sand matrix. Some interstices were filled with silt/clay. The hummocky terrain of portions of the western slope between S 200th Street and the Wetland 1 ravine area is interpreted to be Vashon ice contact deposits.

Qal – Green/Duwamish River Valley Alluvium

Green/Duwamish River Valley alluvium was encountered in all of the shallow wells completed for this EIS (OBW-1 through OBW-12). The alluvium was also found in the majority of the exploration borings previously completed for the S 200th Street corridor and in the areas proposed for infrastructure elements with the Tukwila South project, including the Southcenter Parkway extension, southern stormwater pond, relocated flood protection barrier dike, and Green River off-channel habitat restoration area. The alluvium generally consisted of very loose to medium dense, occasionally dense, gray sand with varying amounts of silt and interbeds of non-organic, very soft to very stiff, gray and brown silt.

Qls - Landslide Deposits

Landslide deposits generally consist of unsorted to internally coherent surficial deposits transported downslope by gravity. Onsite landslide deposits are present in the area of Wetland 1 and Wetland 15, Streams E-1 and E-2, and along the western slope south of the Wetland 1 area (see discussion under Landslide Hazard Areas later in this section and Appendix A, including Figure 10, for a further description of landslide deposits onsite).

Fill Soils

Fill soils (those not naturally placed) are present across the site in developed areas in the northern half of the site and along existing road and levee corridors. Undocumented fill has also been placed at various locations across the site. Fill soil composition ranges from sand, gravelly sand, silty sand, silt, organic debris and other materials. Fill soils range from low to high strength, depending on the amount of compaction, permeability and compressibility.

The thickest area of fill occurs on the southern portion of the site, associated with the former sand and gravel mine. The borrow pit, which was mined out in the early 1980s, was subsequently backfilled in the 1980s and 1990s with construction debris from numerous facilities in the Puget Sound Region. The fill consists of predominantly silty sand, and, to a lesser extent, debris that includes concrete, metal, wood, asphalt, bricks, plastic, possible kiln dust, and other materials. The fill horizon ranges in thickness from 3 feet to 71 feet and is underlain by native sand. The lateral extent of the fill is bounded to the north, west, and east by native material (refer to the Hazardous Materials section of this EIS and Appendix G for further information on the former borrow pit).

At the southeastern corner of the S 200th Street and Orillia Road intersection, undocumented fills of up to 20 feet were encountered at a former construction equipment storage, maintenance and fueling area. The fill consisted predominantly of a mixture of silty sand with lenses of sandy silt, silt, some gravel, and to a lesser extent, debris.

Surface Soils

Physical and chemical weathering of surficial glacial deposits and recent stream deposits has resulted in the formation of various types of surface soils on the site. Figure 3.1-1 shows surface soils on the site, based on U.S. Department of Agriculture, Soil Conservation Service (SCS) mapping and modified from site-specific subsurface investigations, geologic interpretation and slope mapping. The five factors typically used to define the type, characteristics and formation of specific soils are: 1) parent material; 2) climate; 3) topography; 4) organisms (biota); and 5) time. Table 3.1-1 summarizes soil characteristics, including slope, permeability, runoff rate and erosion hazard, of soil types found on the site. Further description of the soil types onsite is contained in Appendix A.

Geologic Hazards

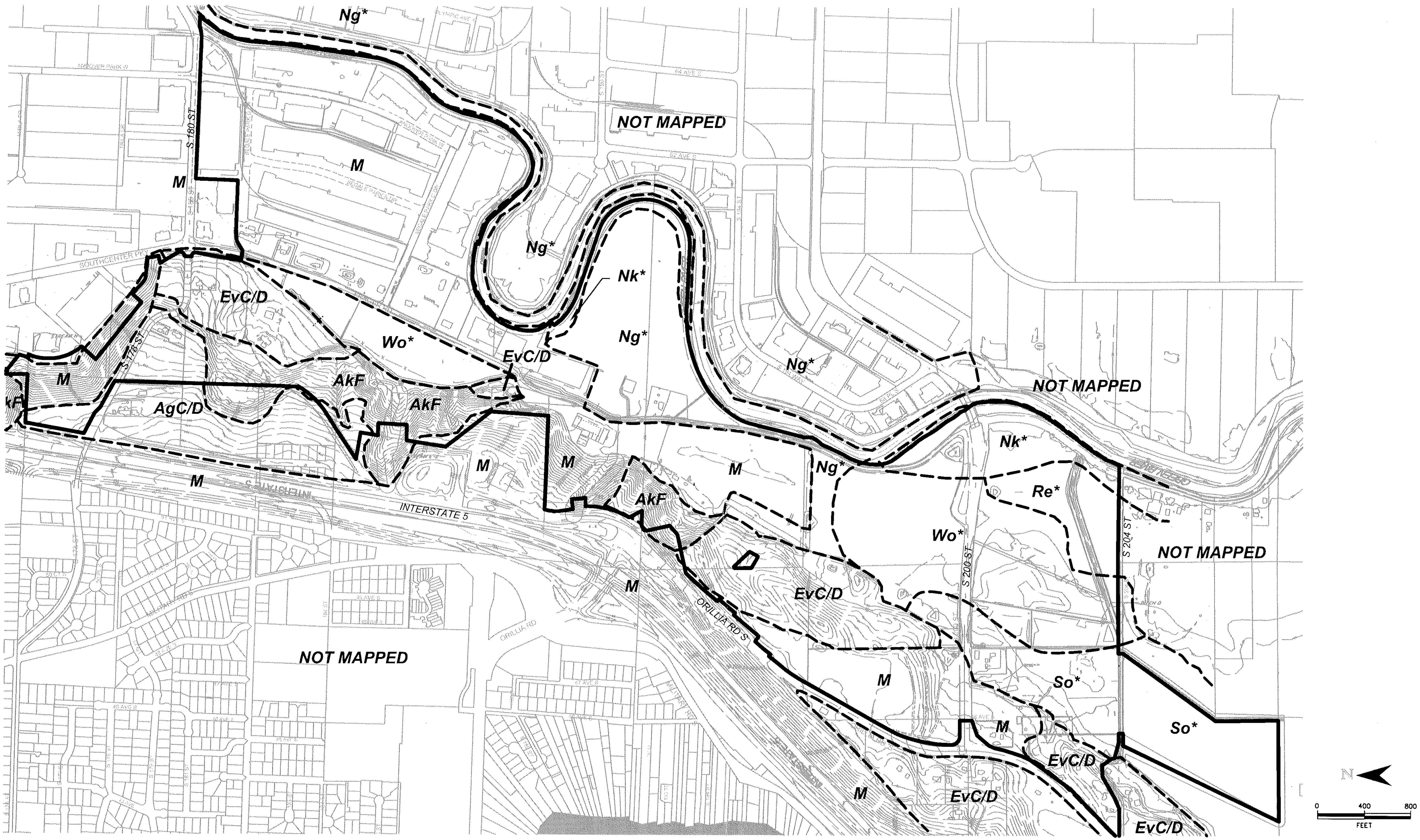
Geologic hazards are described in Chapter 18.45 of the City of Tukwila Municipal Code (TMC). Geologic hazards relevant to the site, as defined by TMC 18.45, include areas of potential geologic instability. Per TMC 18.45, erosion hazards areas are included within landslide hazard area designations.

TMC 18.45.120A defines and classifies areas of potential geologic instability as follows:

1. *Class 1 areas, where landslide potential is low, and which slope is less than 15%;*
2. *Class 2 areas, where landslide potential is moderate, which slope is between 15% and 40%, and which are underlain by relatively permeable soils;*
3. *Class 3 area, where landslide potential is high, which include areas sloping between 15% and 40%, and which are underlain by relatively impermeable soils or by bedrock, and which also include all areas sloping more steeply than 40%;*
4. *Class 4 areas, where landslide potential is very high, which include sloping areas with mappable zones of groundwater seepage, and which also include existing mappable landslide deposits regardless of slope;*

Erosion Hazard Areas

Erosion hazard area categories are related to landslide hazard area categories, as defined by TMC 18.45. Potential erosion hazard is generally low in Class 1 landslide hazard areas and high in Class 2, Class 3 and Class 4 landslide hazard areas when vegetation is removed in these areas. Figure 3.1-2 shows landslide/erosion hazard classifications on the site.



LEGEND

AkF	Alderwood and Kitsap	**Ng**	Newberg silt loam	**M**	Modified land; includes former quarries and developed land; soils may be disturbed or absent
AgC/D	Alderwood gravelly loam	**Nk**	Nooksack silt loam		
EvC/D	Everett gravelly sandy loam	**So**	Snohomish silt loaom	– – – – - - - -	Soils mapping unit contact
Wo	Woodinville silt loam	**Re**	Renton silt loam	———	Project boundary

* May contain areas of Modified land developed since the soil survey of 1973

REFERENCE: Associated Earth Sciences, Inc.

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Figure 3.1-1
SOILS MAP

Tukwilla South Project EIS

BLUMEN CONSULTING GROUP, INC

Table 3.1-1
SUMMARY OF SCS SOILS TYPES ON SITE

Soil Name and Symbol	Parent Geologic Unit	USDA Textural Classification	Percent Slope	Permeability	Runoff Rate	Erosion Hazard
Alderwood and Kitsap (Akf)	Qvt/ Qpog/ $Qpog_t$	Gravelly sandy loam and silt loam	25-70	Varies	Rapid to very rapid	Severe to very severe
Arent, Alderwood (Amc)	Qvt/ Qpog/ $Qpog_t$	Gravelly sandy loam	6-15	Varies	Medium	Moderate to severe
Alderwood Gravelly Loam (AgC)	Qvt/ Qpog/ $Qpog_t$	Gravelly sandy loam	6-15	Moderately Rapid	Slow to medium	Low to moderate
Alderwood Gravelly Sandy Loam (AgD)	Qvt/ Qpog/ $Qpog_t$	Gravelly sandy loam	15-30	Moderately Rapid	Medium	Severe
Everett Gravelly Sandy Loam (Evc)	Qvic	Gravelly sandy loam	5-15	Rapid	Slow to medium	Slight to moderate
Everett Gravelly Sandy Loam (EvD)	Qvic	Gravelly sandy loam	15-30	Rapid	Medium to rapid	Moderate to Severe
Woodinville Silt Loam (Wo)	Qal	Silt loam to silty clay loam	0-2	Moderately Slow	Slow	Slight
Newberg Silt Loam (Ng)	Qal	Silt loam and very fine sandy loam	0-2	Moderate	Slow	Slight
Nooksack Silt Loam (No)	Qal	Silt loam and very fine sandy loam	0-2	Moderate	Slow	Slight
Snohomish Silt Loam (So)	Qal	Silt loam to silty clay loam and loamy sand	0-2	Moderate to Moderately Rapid	Slow	Slight
Renton Silt Loam (Re)	Qal	Silt loam and very fine to fine sandy loam	0-1	Moderately Rapid to Very Rapid	Slow	Slight
Modified Land (M)	Fill	Varies	Varies	Varies	Varies	Slight to moderate

Source: AESI, 2005.
SCS = Soil Conservation Service
USDA = U.S. Department of Agriculture

Landslide Hazard Areas

An analysis of the existing landslide hazard potential on the site was conducted to identify landslide hazard areas. Hazard risks were subdivided into four categories per TMC 18.45, as described in Table 3.1-2 and shown in Figure 3.1-2.

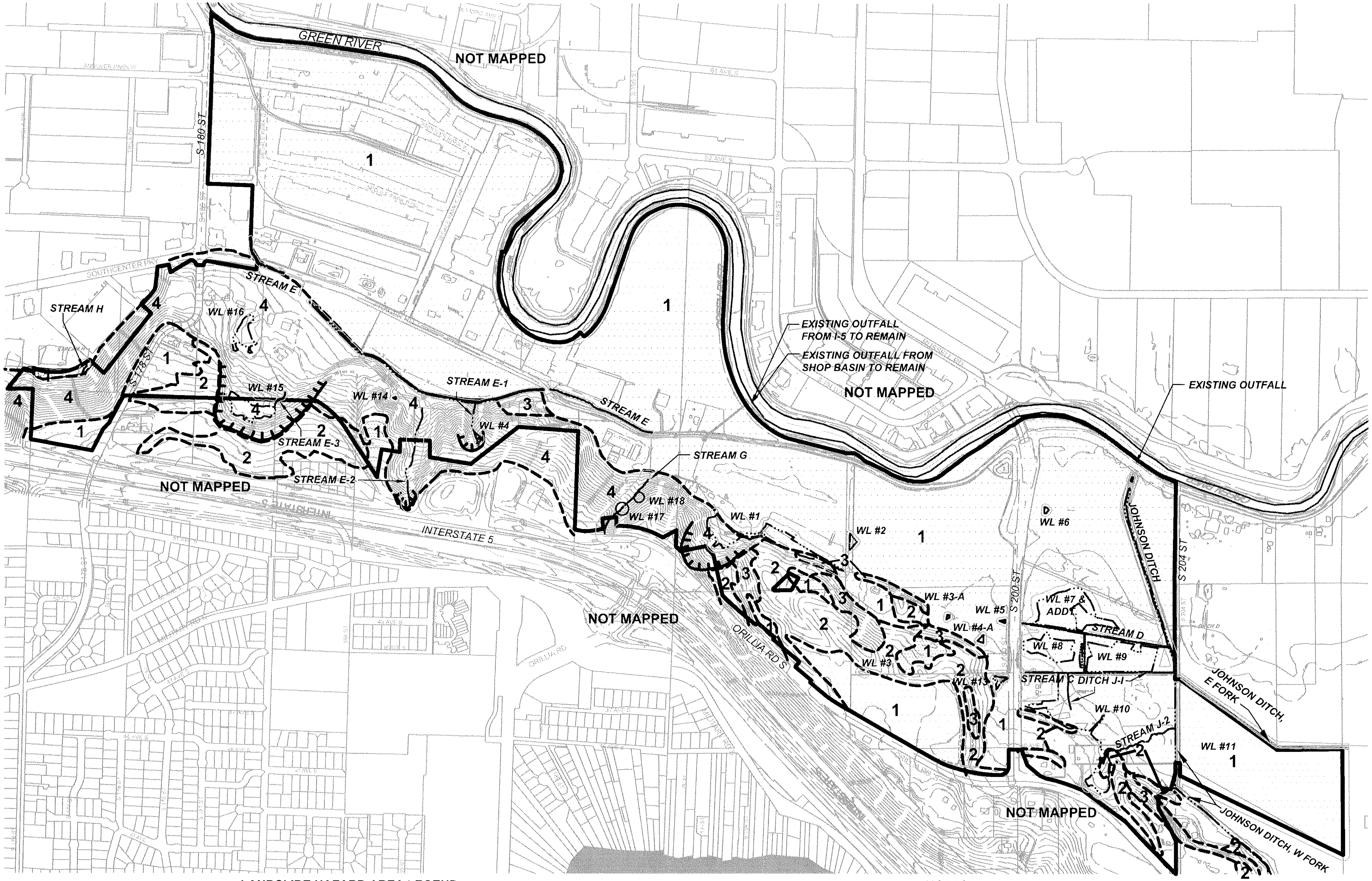

Figure 3.1-2

LANDSLIDE/EROSION HAZARD AREAS

Tukwilla South Project EIS

BLUMEN CONSULTING GROUP, INC

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LANDSLIDE HAZARD AREA LEGEND

(1)	Class 1: Low risk		Existing slide scarp		Project boundary
(2)	Class 2: Moderate risk				Stream/ditch/wetland
(3)	Class 3: High risk		Hazard contact line	WL #2	Wetland No. 2
(4)	Class 4: Very high risk				

REFERENCE: Associated Earth Sciences, Inc.

NOTES:

1. Erosion hazard areas are related to the catagories developed for landslide hazard areas per TMC 18.45.120A. Potential erosion hazard is generally low in Zone 1 areas and high in Zones 2, 3, and 4 areas.
2. The banks of the Green River are classified as Landslide Hazard Area Class 3: High Risk, but are too small to be shown at this map scale.
3. Offsite hazard area 1 is not delineated.
4. Roadway embankments associated with I-5, Orillia Road, South 200th Street, and South 178th Street may be in excess of 15%, but are not considered hazardous areas because they are engineered slopes.

Table 3.1-2
LANDSLIDE HAZARD ZONE DESCRIPTIONS

Class	Landslide Potential	Description
Class 1	Low	Includes slopes of less than 15%.
Class 2	Moderate	Includes slopes between 15 and 40%. Underlain by permeable soils.
Class 3	High	Includes slope between 15 and 40% underlain by relatively impermeable soils or bedrock. Includes all areas sloping more steeply than 40%.
Class 4	Very High	Includes sloping areas with mappable zones of groundwater seepage, and which also include existing mappable landslide deposits regardless of slope.

Source: AESI, 2005; Tukwila Municipal Code 18.45.120A.

Generally, the two types of landslides that commonly occur in the Puget Sound region include rotational slides/slumps (deep seated earth movement, usually involving the regolith [topsoil and weathered zone] and the underlying sedimentary units) and flows (usually involving the upper few feet of the regolith). Slumps can be very large and may require extensive stabilization measures. Flows are very dependent on the moisture content and weathering characteristics of the sediment. Slides of this type are typically triggered by groundwater seepages, oversteepening of the banks by stream erosion, or movement of saturated sediments on steep slopes.

Based on available information, the relatively flat valley bottom portion of the site is a low potential landslide hazard area (Class 1), with the exception of a narrow band along the Green River encompassing the steep slope river banks. This narrow band is Class 3 – high potential. The western slope is divided into three hazard areas: Class 2 - moderate potential; Class 3 - high potential; and Class 4 - very high potential (see Figure 3.1-2).

Regional geologic mapping identifies a large landslide block along the western slope of the Green/Duwamish River Valley area trending south from near the Orillia Road/I-5 interchange to approximately 1 mile south of the Orillia Road/S 212th Street junction, offsite. A portion of the regionally mapped slide area was studied in detail in 1967 when cracks began appearing along Military Road approximately 2,300 feet west (upslope) from Wetland 11 (see Figure 3.1-2) on the southern portion of the site, and was determined to be a post-glacial ancient landslide complex. The cracking was determined to be likely a result of sand and gravel mine activity on the site located near the base of the slope removing lateral support and allowing for expansion. The mining activity was immediately greatly reduced and then halted altogether.

The onsite portion of the western slope south of Wetland 1 is part of the large landslide complex (more than 10,000 years old) described above and mapped as Qvic/Qls in Figure 10 of Appendix A. As part of the fill activities at the former sand and gravel pit, a drainage collection system was installed beneath the fill. Orillia Road improvements constructed in the late 1990s improved drainage on the upslope portion of the site. The Qvic/Qls sediments are generally permeable, consisting of sand and gravelly sand. Groundwater is present within these sediments; however, no seepage line along the slope was observed in the field (see Section

3.2, Water Resources and Appendix A for details). Because of the permeability of the Qvic sediments and the drainage collection system installed as part of mining/fill activities, the landslide hazard of the Qvic/Qls material is predominantly Class 2 with areas of Class 1 and 3 (see Figure 3.1-2).

From the Wetland 1 area northward, the western slope is generally steeper, consistently of greater than 40 percent slopes, and contains spring lines. Several bowed tree trunks and scarp features are present along this portion of the slope, indicative of past landslide activity. Due to the presence of groundwater seepage, evidence of past landslide activity, and steepness of slope, much of the slope from the Wetland 1 area northward is mapped as Class 4. Smaller areas of Class 2 and Class 3 are present where either Qvic sediments are mapped or no evidence of seepage or other landslide indicators were observed (see Figure 3.1-2).

A shallow debris flow occurred onsite in the Stream E-1 ravine (see Figure 3.1-2) following a record rainfall event in October 2003. Several small landslides are present near the head of the Stream E-2 ravine, and are interpreted to be caused by rapid stream/ravine incision related to runoff from the Bow Lake landfill prior to construction of I-5.

A landslide in the Wetland 15 area occurred prior to 1936, and appears to be a slump failure. The feature is fairly large, about 850 feet in width from wall to wall, with an approximate 80-foot tall head scarp. Investigations conducted for this EIS concluded that the slide debris from the failure likely spread out into an alluvial fan, and was likely relatively thin (see Appendix A for details).

Seismic Hazards

The site is located in an area of low to moderate historical seismicity, based on the relatively short period of monitoring (125 years); although the site is within a moderate to high seismic risk zone (see below Appendix A for further information). Recorded earthquakes of magnitude 5.0 (M 5.0) or over occurred in the site vicinity in 2001 (M 6.8, about 28 miles southwest of the site); 1995 (M 5.0, approximately 5 miles southwest of the site); 1965 (M 6.5, approximately 6 miles west of the site); and in 1954 (M 5.0), 1949 (M 7.1), 1932 (M 5.0) and 1880 (M 6.0). See Appendix A for a complete description of historical seismicity and types of earthquakes in the site vicinity.

An analysis of the existing seismic hazard potential on the site was conducted to identify seismic hazard areas. Four types of potential geologic hazards are usually associated with large seismic events: ground rupture along a surficial fault zone; ground motion response; liquefaction; and seismically induced landslides. The site contains areas that are considered highly susceptible to liquefaction. Those areas are generally within the low-lying Green River valley sediments (see Liquefaction below). The four potential seismic hazard types are described in detail below.

Surficial Fault Zones. Ground rupture occurs as offsets of the ground surface and is limited to the immediate areas of the fault. No evidence of surface faults or associated ground ruptures were observed at the site.

There are several active crustal faults in western Washington that may pose infrequent seismic hazards in the vicinity of the site. Regional crustal faults that are mapped in the vicinity of the site include the Seattle Fault and the Tacoma Fault. The site is located approximately 7 miles south of the Seattle Fault Zone and 12 to 15 miles north of the Tacoma Fault Zone. Since 1970 the largest two earthquakes associated with the Seattle Fault were a M 5.0 event beneath Point Robinson and a M 4.9 event beneath southwestern Bainbridge Island (see Appendix A for further discussion of the Seattle and Tacoma fault zones).

Ground Motion Response. Ground motion from an earthquake results from shear, pressure, and surface waves propagating through the earth's crust from the earthquake's hypocenter. The ground motion caused by these waves is the seismic shaking felt during an earthquake. The intensity of the shaking felt at a given location during and immediately after an earthquake is a result of several variables including: 1) the magnitude of the earthquake; 2) distance from the earthquake; 3) depth of the earthquake; 4) the type of rocks and unconsolidated sediments underlying a given site; and 5) attenuation of the seismic energy between the earthquake and a given site.

The University of Washington's Pacific Northwest Seismograph Network (PNSN) created a "shake map" of peak acceleration and velocity from wave forms collected from the 2001 Nisqually earthquake. Peak acceleration is the maximum acceleration experienced by a particle at the earth's surface during the course of the earthquake motion. The shake map shows very strong perceived shaking within Green River valley sediments at the site (peak acceleration of 18-34 percent of the acceleration of gravity [g, 9.8 meters per second]). The Nisqually earthquake was a large and deep event, occurring within the Juan de Fuca plate. A crustal earthquake of comparable size (e.g. Seattle or Tacoma fault zone rupture) may generate significantly greater ground motion response.

The United States Geological Survey (USGS) has created seismic hazard maps to predict the expected peak ground acceleration from earthquakes based on known faults and seismicity. According to the USGS, in the next 50 years there is a 10 percent chance that ground motions will exceed 30-35 percent g in the vicinity of the site. The USGS work contributed to the 1997 *Uniform Building Code* (UBC) determinations of seismic zones in the Pacific Northwest. The seismic zones used by the UBC range from Seismic Zone 0 (area of low seismic risk) to Seismic Zone 4 (area of high seismic risk). The site is located within Seismic Zone 3 of the 1997 UBC. The 1997 UBC is superseded by the 2003 International Building Code (IBC). Design guidelines are presented in the 2003 IBC for minimizing earthquake damage to structures based on anticipated ground motions for a specific region.

Liquefaction. Liquefaction is the process in which soil loses strength or stiffness during vibratory shaking, such as that caused by earthquakes, and temporarily behaves as a liquid. The seismically induced loss of soil strength can result in failure of the ground surface and can be expressed as landslides or lateral spreads, surface cracks and settlement, and/or sand boils.

Liquefaction-induced lateral spreading can be localized or large-scale. Large-scale lateral spreading can form adjacent to waterways on gently sloping or flat ground surfaces that liquefy during an earthquake. Seismically induced liquefaction typically occurs in loose, saturated, non-cohesive sandy and silty soils commonly associated with recent river, lake, and beach sedimentation. In addition, seismically induced liquefaction can be associated with areas of loose, saturated fill.

Field exploration for this EIS, previous explorations, area well logs, soil surveys conducted by King County and mapping by the USGS indicate that the much of the site is underlain by young alluvial deposits that are relatively loose and fine-grained (see Figure 18 in Appendix A). This material may be subject to liquefaction under strong seismic shaking.

Mapping done by the Washington Department of Geology and Earth Resources (WDGER) assigned liquefaction susceptibility ratings to four categories of geologic deposits found in the site vicinity. These categories include:

- Category I (high liquefaction susceptibility): artificial fill and modified land (excepting most fills along transportation routes), post-Vashon alluvium, and beach deposits;
- Category II (low to high liquefaction susceptibility): post-Vashon lacustrine deposits, landslides, and colluvium;
- Category III (low liquefaction susceptibility): all Pleistocene glacial and nonglacial deposits; and,
- Category IV (low to nil liquefaction susceptibility): all Tertiary bedrock.

According to this mapping, all of the young alluvial deposits in the Green River valley on the site are considered highly susceptible to liquefaction (Category I). The sediments on the slope are considered Category III (low liquefaction susceptibility) with some areas of Category II; however, the undocumented fill on the lower portion of the slope to the north and south of S 200th Street is considered Category I (see Figure 18 in Appendix A).

Based on a history of liquefaction on and surrounding the site and the existing onsite soils, the potential for liquefaction to occur on the site during a large seismic event is high (see Appendix A for additional information).

Seismically Induced Landsliding.

Landslides include rotational slides (slumps); translational slides; rock falls; soils falls; lateral spreads; mud, earth and debris flows; and rock, soils, and debris avalanches (USGS, 1998). Three principle effects of earthquake vibration and wave propagations trigger landslides of soil or rock: 1) the mechanical effect of intense horizontal shaking that may exceed the force of gravity, 2) repeated compressional stresses caused by shaking in clays, sands, and silts with weak interparticle bonding, and, 3) reduction of intergranular bonding by sudden shock.

Several seismically induced landslides occurred during the 1949, 1965 and 2001 earthquakes in the Puget Lowland. Seismically induced landslides that are documented in the vicinity of the site are discussed in Appendix A.

The material that makes up the slope along the southwestern portion of the site is mapped as a landslide deposit by the USGS; however, the age of the event is uncertain and researchers suggest that it occurred near the time of the last glacial ice-sheet retreat. It is unknown whether or not this landslide was induced by associated seismic events. A portion of this landslide complex is discussed under Landslide Hazards above.

Landslides and other ground failures typically occur in locations of past ground failures. Based on the documentation of landsliding onsite and in the site vicinity, the potential for landsliding to occur on the site during a large seismic event is moderate to high (see Appendix A for additional information).

3.1.2 Impacts

Following is an analysis of probable significant impacts associated with geologic conditions and hazards including: erosion hazards, landslide hazards and seismic hazards. Impacts are discussed separately for the infrastructure development and buildout phases. Alternatives 1 and 2 would include major infrastructure construction to facilitate site development as described briefly below and in more detail in Chapter 2 of this Draft EIS. Under Alternatives 1 and 2, the proposed amount of site grading, the potential for impacts related to erosion and landslide hazards, and the proposed practices to manage stormwater to avoid and minimize impacts would be similar.

Alternatives 1 and 2

The exploration and analysis completed for the site indicates that, from a geotechnical standpoint, the site is suitable for the proposed development, provided the proposed mitigation measures are implemented. See Appendix A, including Table 6-1 in that document, for specific geotechnical conclusions and recommendations for the various project components.

Infrastructure Development Phase

The infrastructure development phase of Alternatives 1 and 2 would include the extension of Southcenter Parkway and installation of major infrastructure utilities; the relocation of the flood protection barrier dike; overall site mass grading; implementation of the Green River Off-Channel Habitat Restoration and wetland rehabilitation plans; and, construction of temporary and permanent stormwater quality treatment and runoff control facilities (ponds). See Chapter 2 for additional information on these activities and their phasing. Site-specific geotechnical reports have been prepared by GeoEngineers to address the initial infrastructure development elements, and are included as Appendix 4 to Appendix A.

Alternative 1 and 2 would require grading for construction of infrastructure components (stormwater facilities and sanitary sewer system), to achieve desired roadway elevations and to balance the movement of earthwork onsite as much as possible. Site grading would excavate portions of the western hillside and would fill lowland portions of the site. An overall goal of the mass grading plan would be to limit the degree of import (or export) from the site.

Preliminary grading plans indicate that approximately 1.4 million cubic yards of cut would be required during infrastructure development (the first three construction seasons). Of this total, it is estimated that 56,000 cubic yards would be for the extension and expansion of Southcenter Parkway, and 60,000 cubic yards would be for the realignment of S 178th Street, with the remaining cut to establish site grades for future development areas. Major areas of cut/excavation would include Planning Area B in the northwest corner of the site and the Green River Off-Channel Habitat Restoration Area (see Chapter 2, including Figures 2-7 for a depiction of conceptual grading activities onsite in year 3 and Figure 2-9, for a depiction of the S 178th Street realignment plan).

Of the 1.4 million cubic yards of cut, it is estimated that approximately 1.16 million cubic yards would be used onsite as fill. This would include 71,000 cubic yards of fill for the Southcenter

Parkway extension, 10,000 cubic yards of fill for the S 178th Street realignment, with the remaining fill used to establish site grades for future development areas. Another area of fill would include the relocated flood protection barrier dike. An additional approximately 400,000 cubic yards of material would be imported to the site for acceptable roadway and development area fill. Further, it is assumed that approximately 500,000 cubic yards of fill for preloading to establish finished grades would be imported to the site from locations that are permitted and approved for such export; a portion of the 500,000 cubic yards could be imported during the infrastructure development phase (the remainder would be imported during full buildout of the site as development occurs).

Potential geotechnical impacts of grading activities could occur from activities such as site preparation, structural fill placement, and foundation installation. Examples of potential adverse impacts could include sloughing of oversteepened temporary or permanent cut slopes, failure of fill soils due to improper placement and compaction, seepage from stormwater facilities which could promote landslides or erosion, or excessive foundation settlement if natural bearing sediments are disturbed. However, numerous mitigation measures are proposed to preclude such impacts, and since geotechnical oversight would be an integral part of the proposed infrastructure and building design and construction process, adverse impacts would not be expected (see Section 3.1.3 Mitigation Measures and Appendix A for further discussion of geotechnical mitigation measures).

Construction dewatering could temporarily impact the alluvial aquifer. Where dewatering lowers the water table below its historic level, it would likely cause consolidation and settlement in proximity to the dewatering well. Since the drawdown is greatest at the dewatering well and decreases to zero at the radius of influence (300 to 500 feet from the well), the settlement would vary in the influence area, and differential settlement would gradually change with distance from the dewatering well. Within approximately 100 feet of any dewatering well, settlement could occur on the order of one inch or more. Beyond 100 feet, the drawdown would not be sufficient to cause settlement. Dewatering for utilities along Southcenter Parkway would induce settlement before piping is installed; therefore, proposed piping would not be subject to settlement.. Dewatering in the area of S 204th Street would not likely be below historic groundwater levels. As a result, no settlement of this roadway would be expected. Any existing utilities in the immediate area could also experience some settlement. However, differential settlement from dewatering would likely be gradual. This settlement could affect flow in gravity lines, but would not affect pressure lines. There are no existing gravity lines in the area to be dewatered; therefore, no settlement impacts to existing pipes would occur (see Section 3.2, Water, and Appendix 4 to Appendix A of this Draft EIS for further discussion of dewatering).

Erosion Hazard Impacts

Erosion is considered to be both a long- and short-term hazard for the proposed Tukwila South project; however, the risks would be greatest during the infrastructure development phase.

In order to evaluate the impacts that Alternatives 1 and 2 would have on the existing erosion hazard areas (see Figure 3.1-1), an analysis was first conducted to determine the potential for probable significant impacts, if proposed mitigation measures (as described below and in Appendix A) were not implemented. Based on this analysis, erosion impacts from Alternatives 1 and 2 were considered to be possible under three primary activities: 1) clearing and grading activities; 2) potential for an increase in spring flows associated with construction and development on the site; and 3) potential for changes in stream flow associated with construction and development on the site.

Clearing and grading activities during infrastructure development would increase the erosion potential through the removal of vegetation and the exposure of soil directly to precipitation and runoff. The most significant increase in erosion hazard potential would occur when earthwork activity commences. Where development is proposed to occur on slopes, uncontrolled gully and sheet erosion along slopes or in stream channels could lead to oversteepening of the slopes and subsequent slope instability hazards. For both slope and valley floor development, any unmitigated erosion would produce sediment that could then be transported to onsite wetlands and streams, and to offsite receiving waters. Uncontrolled raindrop erosion would suspend fine-grained particles into the runoff flow. Silt and clay particles, once mobilized during the earthwork activities, could be difficult to trap and could be discharged into streams through the stormwater control facilities, unless mitigation measures are implemented.

The construction of temporary stormwater retention areas or unlined temporary collection systems could cause groundwater mounding. Where this occurs above steep slopes (such as during mass grading of Planning Areas B, G and I (see Figure 2-3 for a depiction of planning areas onsite), new springs could form, or flow at existing springs could be increased resulting in erosion along the slope. Erosion from these areas could enter stream channels or cause the oversteepening of the slope and trigger landslides.

Any uncontrolled stormwater runoff or wetland discharge from infrastructure development could cause erosion in the onsite stream channels (see Watercourse Erosion Hazard Impacts below and Appendix A for discussion).

Erosion hazards impacts are most likely to occur where mass grading occurs in or near Erosion Hazard Zones 2, 3 or 4. This would include grading in Planning Areas B, G and I, and along portions of the Southcenter Parkway extension where cuts would occur at the base of the western slope and where construction activities affect the banks of the Green River, in Erosion Hazard Zone 3 (see Figure 3.1-1 for a depiction of erosion hazard areas).

Planning Area B is largely within Erosion Hazard Zone 4. Mass grading in Planning Area B would include construction of the re-alignment of South 178th Street and excavation of the northern stormwater pond (see Figure 2-9 for a plan of the S 178th Street alignment). Portions of Planning Area G that would be mass graded are largely mapped Erosion Hazard Zone 1 or 2, with smaller areas of Erosion Hazard Zone 3. The area between the graded benches is not proposed to be graded. Portions of the mass grading on Planning Area I would include small areas mapped Erosion Hazard Zone 2 and 3 (see Figure 24 in Appendix A for a depiction of the Area G mass grading and Figure 3.1-2 for a depiction of the erosion/landslide hazard areas onsite).

Excavation for the Green River Off-Channel Habitat Restoration Area, for the new stormwater outfall to the Green River, abandonment of the existing Johnson Ditch floodgate and outfall, and for the mouth of the new Johnson Creek could affect the banks of the Green River, in Erosion Hazard Zone 3.

Proper control of surface water runoff would be important to alleviate potential erosion hazards, and subsequently any potential slope stability hazards on the steeper portions of the site. To mitigate and reduce the sheet and channel erosion hazard potential on the site, infrastructure construction under Alternatives 1 and 2 would include the installation of temporary and permanent stormwater control system. This would include construction of temporary erosion and sediment control facilities and ponds, as well as permanent ponds in the first year of the infrastructure development program.

With proper implementation of the proposed mitigation measures, significant erosion hazard impacts for Alternatives 1 and 2 would not be expected, even in areas where a high erosion hazard risk is present. Mitigation measures, specific to alleviating potential erosion hazards from the infrastructure development phase, are described in detail in Section 3.1.3, Mitigation Measures, and in Appendix A.

Watercourse Erosion Hazard Impacts

Onsite watercourses could be impacted by infrastructure development occurring in the areas draining to the watercourses, or if stormwater is proposed to be discharged to the streams.

Potential watercourse erosion hazard impacts, as a result of the increase in impervious surfaces (roadway construction) and compaction of the ground surface by construction equipment associated with the infrastructure development phase, could include uncontrolled stormwater runoff from the impervious surface areas and stormwater facilities to the onsite watercourses and wetlands. Uncontrolled stormwater runoff could increase the duration and peak flow discharges of the watercourses resulting in an increase in watercourse incision, particularly where watercourse channels are poorly developed. Stormwater discharge, or natural occurring high flows from storm events, can cause erosion of the side banks and trigger landslides. Both sidebank erosion and landslide activity could result in an increase in the bed load transport rate. An increase in sediment transport could result in the plugging of the downstream culverts and related localized flooding. In addition, subsequent high flows could result in the erosion of previously deposited sediments and creek meandering.

Streams on the western slope likely have the capacity to transport coarse sediment and large woody debris due to the steep stream gradient. However, once the streams reach the low gradient valley floor, any coarse sediment or large woody debris would drop out of the sediment load and would be deposited near the base of the slope. Coarse sediment and large woody debris could also be recruited due to landslides and would similarly be deposited at the base of the slope. However, the existing agricultural ditches and ditched streams on the valley floor have little capacity to transport coarse sediment.

Conversely, revisions to the natural drainage patterns during the infrastructure construction phase could result in a reduction of discharge to watercourses under unmitigated conditions. A reduction of flow could also result in a buildup of sediment within the channels and lead to plugging of culverts and localized flooding. Fine-grained sediment could also accumulate in the channels from stormwater pond discharge, if proper water quality treatment is not maintained, particularly during the earthwork phase of development. See Section 3.2, Water Resources, for a discussion of impacts to watercourse water quality.

No development is planned for areas draining to Streams H, E-3, E-2, E-1, G and J-2, and no stormwater discharge is proposed to these streams (see Figure 3.1-2). Therefore, no stream erosion impacts to these streams are anticipated.

The entire length of Streams C, D and Ditch J-1 would be eliminated during the infrastructure development phase of Alternatives 1 and 2. Therefore, no stream erosion impacts to these watercourses would occur.

Mass grading during the initial infrastructure development phase would require relocation of 2,807 feet of Stream E to culverts as needed for the Southcenter Parkway extension and other construction activities. (Mitigation for fills to ditches and ditched streams is discussed in Section 3.3, Plants and Animals, including Fisheries, and in Appendix E). No stormwater runoff from portions of the site under construction during infrastructure development, nor following this phase, would be directed to Stream E. The remaining portion of Stream E would continue to receive runoff and groundwater discharge from the undeveloped western hillside, and no stream erosion impacts from Alternatives 1 and 2 would be anticipated.

Under Alternatives 1 and 2, existing Johnson Ditch would be filled, and a new stream course and corridor for new Johnson Creek would be created. Similar to the existing valley floor ditches and ditched streams, the new Johnson Creek would be a very low gradient, silt-bedded channel with little capacity to transport coarse sediment. Based on hydrographic modeling the new Johnson Creek would be designed to erode under flood flows. No stream erosion impacts to new Johnson Creek would be anticipated with infrastructure development (see Section 3.2, Water Resources, and Appendix C for details).

Landslide Hazard Impacts

Sloping ground has an inherent risk of instability. In some cases, due to the low-slope gradients and geologic and hydrologic conditions, the landslide risks may be considered low. The risk is greater on steeper slopes, in weak and/or saturated soils where ongoing or historic landslide activity has occurred. Most large-scale landslides are natural occurring phenomena; however, the risk of a landslide could be increased as a result of development.

In order to evaluate the potential for impacts on the existing landslide hazard zones under Alternatives 1 and 2, an analysis of potential landslide impacts was conducted. This analysis reviewed the potential for probable significant impacts, if mitigation measures were not implemented, in an attempt to determine the effectiveness of the proposed infrastructure development plans and to provide additional measures, if necessary. From this analysis, landslide impacts from and to Alternatives 1 and 2 were considered under three primary activities: 1) stormwater management, 2) clearing, and 3) grading (earthwork).

Uncontrolled stormwater discharge onto sloping areas or streams could cause erosion, undermine steep slopes, and cause landslides. Concentrating stormwater on uplands above steep slopes could increase infiltration and cause spring discharge to increase, potentially triggering landslides. Stormwater on the site under Alternatives 1 and 2 would be directed into temporary and permanent stormwater facilities. During the infrastructure development phase, stormwater would be directed into a series of construction treatment ponds, adjacent to the permanent southern stormwater control pond, and would be treated for turbidity, prior to discharge to the Green River. Stormwater from planning areas containing Landslide Hazard Areas 2, 3 or 4 (including portions of Planning Areas B, G and I and construction activities occurring on the banks of the Green River) would be directed to this tightlined system, conveyed to the valley floor, and directed to stormwater facilities, prior to discharge to the Green River (see Figures 2-3 and 3.1-2).

Uncontrolled clearing could increase the existing landslide hazard potential of Landslide Hazard Zones 2, 3 or 4 by removing the vegetation that would normally reduce the runoff volume and rates. Concentrated stormwater runoff on cleared slopes could precipitate erosion and oversteepening of the hillside and result in slope instability.

Uncontrolled grading (earthwork) activities could also increase the existing landslide hazard risks. Fill soils placed on or adjacent to steep slopes could increase the driving forces of the soil column and result in slope failures. Grading typically alters surface drainage patterns. In addition, improperly placed fill soils could fail due to inadequate compactive effort, use of organic material or soft, fine-grained soils, placement of material at oversteepened gradients, or other factors. Cut slopes could also fail due to removing the toe support for a slope, or from improper drainage control. If the new drainage pattern resulted in an increase in either surface or subsurface water flow on or near a slope, landslides could develop.

Landslide hazard zones relative to site planning areas are shown on Figures 2-3 and 3.1-2. The site is primarily underlain by Landslide Hazard Zone 1, which is considered to possess a low risk of landslide hazards under existing conditions. Landslide Hazard Zone 2 is considered to have a moderate slope instability risk and occurs in portions of Planning Areas A, G, and I. Landslide Hazard Zone 3 is considered to have a high slope instability risk, and occurs in Planning Areas G and I, and encompasses the banks of the Green River. Landslide Hazard Zone 4 is considered to have a very high slope instability risk. The vast majority of Landslide Hazard Zone 4 is located in Planning Area E, and is not proposed for development. Three other portions of the site are identified as Landslide Hazard Zone 4. These include: (1) the northernmost portion of Planning Area G, which is not proposed to be graded; (2) the majority of Planning Area A, which is not proposed to be graded; and (3) the majority of Planning Area B, which would be crossed by the realignment of S 178th Street, used as a source of on-site fill material, and mass graded to allow for construction of the northern stormwater pond. A large landslide zone is mapped immediately upslope of Planning Area B and landslide deposits mantle the majority of Planning Area B (see Figure 3.1-2 for a depiction of landslide hazard zones and Appendix A for further information). Geotechnical engineering and the implementation of Best Management Practices (BMPs) would be necessary in Planning Area B to reduce the potential for impacts in landslide hazard areas.

BMPs would be implemented during infrastructure development to reduce potential impacts to landslide hazard areas on the site or to adjacent properties immediately upslope or downslope of hazard zones, such as Orillia Road, Interstate 5, the Bow Lake Transfer Station, and the Levitz Furniture store. Site-specific mitigation measures would also be implemented. See the Mitigation Measures in Section 3.1.3 and Appendix A for a list of landslide-related mitigation measures. With implementation of the proposed mitigation measures, infrastructure construction would not increase the existing landslide hazard risks on or immediately adjacent to the Tukwila South site.

Seismic Hazard Impacts

The effects of an earthquake can result in more damage in areas which are converted from an undeveloped condition to a more developed condition, thereby increasing the risk of seismic hazards. As described under Affected Environment above, the site is located in an area of relatively low historical seismicity. The hazards associated with seismic events at the site could include surface ground rupture, ground motion, liquefaction, and seismically induced landslides.

Surface Ground Rupture

No evidence of surface ground rupture was observed on the site at the time of fieldwork for this EIS. Consequently, the potential of a ground surface rupture impacting the site as a result of seismic activity would be low and no mitigation would be required.

Ground Motion

Large earthquakes with magnitudes of up to 7.1 have occurred in the Puget Sound in the past. Significant ground motion caused by an earthquake of sufficient intensity could result in damage to buildings, roadways, and other structures including utilities. Buildings built under the International Building Code (IBC) would be designed to be able to sustain some damage from ground motion during the design seismic event without causing life safety concerns.

Liquefaction and Seismically Induced Landslides

Field exploration conducted for this EIS, explorations completed by others, area well logs, and published reports and maps indicate that much of the site is underlain by young alluvial deposits that are relatively loose and fine-grained, and accompanied by a shallow water table. This material is considered highly susceptible to liquefaction (Category I). The sediments on the slope are considered Category III (low liquefaction susceptibility) with some areas of Category II; however, the undocumented fill on the lower portion of the slope to the north and south of S 200th Street is considered Category I (see Figure 18 in Appendix A).

Based on the history of liquefaction on and surrounding the site and the existing onsite soils (described under Affected Environment above and in Appendix A), the potential for liquefaction to occur on the site during a large seismic event is high. Liquefaction can result in deformation of sediments, lateral spreading, ground oscillation, sand boils and loss of bearing capacity. Settlement of overlying structures is a probable impact of liquefaction. Liquefaction-induced spreading can be localized or large-scale. Large-scale spreading can form adjacent to waterways on gently sloping or flat ground surfaces that liquefy during an earthquake. Large-scale lateral spreads can damage all types of structures built on top of the lateral spreading soils.

Areas prone to seismically induced landslides would primarily correspond to Landslide Hazard Zone 2, 3 and 4, with or without further development on the site. A seismic event of significant local intensity might trigger landslides and debris flows in these areas, as well as the western slopes onsite, or could cause lateral spreading adjacent to the Green River.

Mitigation measures for liquefaction during the infrastructure development and full buildout phases of the project could include soil improvement techniques (to reduce liquefaction hazard) and structural improvement techniques (to accommodate liquefaction effects). Specific mitigation measures would be designed by a geotechnical engineer, and would be determined based on site-specific analysis for proposed structures. The Tukwila Municipal Code requires that structures be designed per IBC guidelines. See the Mitigation Measures below and Appendix A for a description of seismic-related mitigation measures.

With implementation of proposed mitigation measures, the infrastructure development phase of Alternatives 1 and 2 would not increase the existing seismic induced landslide hazard risks on or immediately adjacent to the Tukwila South site.

Full Buildout

Full buildout of Alternatives 1 and 2 would include final site grading as needed, including import of a portion of the approximately 500,000 cubic yards of fill for preloading and to establish finished grades for future building and onsite road development, and future foundation placement and building construction.

Erosion Hazard Impacts

As specific areas of the site are developed and stabilized, they would be connected to permanent stormwater management facilities, constructed during the infrastructure development phase. The potential for significant erosion impacts would be considerably less than that described for the infrastructure development phase, because mass grading would be completed and a comprehensive stormwater management system would be in place. Once buildings and roadways are completed, and landscaping and other vegetative cover have been re-established, the risk of erosion would be similar to existing conditions. However, any uncontrolled stormwater runoff from impervious surfaces (roads, roofs, driveways, parking lots) or from drainage conveyance systems (pipes, swales, outfalls) could still pose a risk after development, particularly on steep slopes. Proper control of surface water runoff would be important for alleviating potential erosion hazards, and subsequently any potential slope stability hazards on the steeper portions of the Tukwila South site.

Proposed erosion-related mitigation measures for full buildout include: the permanent stormwater management system that would be constructed during the infrastructure development phase; storm drainage infrastructure within the Southcenter Parkway extension sufficient to convey drainage from the site to the stormwater treatment and runoff control facilities; and, implementation of TESC BMPs during buildout of development parcels on the site (see the mitigation measures below and in Section 3.2, Water Resources for further description of these measures). With proper implementation of the proposed mitigation measures, significant erosion hazard impacts during full buildout would not be expected, including in areas where a high erosion hazard risk is present.

Stream Erosion Hazard Impacts

As described above for the infrastructure development phase, no development is planned for areas draining to onsite Streams H, E-3, E-2, E-1, G and J-2 (see Figure 3.1-2); therefore, no erosion impacts to these stream channels would be anticipated. The entire length of Streams C, D and Ditch J-1 would be eliminated by Alternatives 1 and 2 during the infrastructure development phase; therefore, no stream erosion impacts to these channels would occur during full buildout (see Section 3.3, Plants and Animals, including Fisheries, and Appendix E for a discussion of mitigation measures for ditch fill).

During full buildout, no stormwater runoff from developed portions of the site would be directed to Stream E, and no stream erosion impacts to Stream E would be anticipated.

During full buildout, the new Johnson Creek stream channel would have little capacity to transport coarse sediment, and would have the capacity to transmit flood condition flows. Therefore, no stream erosion impacts to new Johnson Creek would be anticipated (see Section 3.2, Water Resources, and Appendix C for details).

Landslide Hazard Impacts

As areas of the site are developed and stabilized, they would be connected to permanent stormwater management facilities constructed during the infrastructure development phase. The potential for significant landslide impacts would be considerably less during full buildout than during the infrastructure construction phase, because mass grading would be completed and a comprehensive stormwater management system would be in place.

Best Management Practices (BMPs) would be implemented during full buildout of Alternatives 1 and 2, as would site specific landslide hazard mitigation measures. Following construction, all stormwater runoff from developed portions at the site would be directed into tightlined systems that would discharge into approved stormwater facilities. Erosion control measures would be employed at all discharge points.

With implementation of the proposed mitigation measures, full buildout under Alternatives 1 and 2 would not increase the existing landslide hazard risks on or immediately adjacent to the site. See the Mitigation Measures below and Appendix A for a list of landslide-related mitigation measures.

Seismic Hazard Impacts

Seismic hazard impacts under Alternatives 1 and 2 during full buildout would be similar to those described for Alternatives 1 and 2 during the infrastructure development phase. Surface ground rupture impact potential would be low and no mitigation would be required. The International Building Code (IBC) would be followed to reduce the risk of impacts from ground motion during seismic events so that buildings could sustain some damage without causing life safety concerns.

The potential for impacts due to liquefaction during a large seismic event would be the same as described for the infrastructure development phase, and would be high in some areas of the site. Appropriate mitigation measures would be implemented to reduce the risk of liquefaction impacts.

With implementation of proposed mitigation measures, full buildout of Alternatives 1 and 2 would not increase the existing seismic induced landslide hazard risks on or immediately adjacent to the Tukwila South site.

Indirect/Cumulative

With implementation of proposed mitigation measures, Alternatives 1 and 2 would not result in increased risks of landslide, erosion or seismic hazards to offsite areas. There would be no increase in erosion hazard risks to the Green River as a result of these alternatives. Due to the proposed stormwater facilities and implementation of mitigation measures, no cumulative erosion/sedimentation impacts would be expected on the site or in the site area. No other earth-related cumulative impacts would be expected.

No Action Alternative

Erosion Hazard Impacts

The No Action Alternative would have less potential for erosion hazards than under Alternatives 1 and 2, as no initial major infrastructure phase would occur. Site development would occur on an incremental basis according to market demand. No development south of the existing flood protection barrier dike at S 196th Street would occur on the floor of the Green River Valley. The extension of Southcenter Parkway would occur, but would not involve cuts into the base of the western slope, as it would be improved in a different alignment. S 178th Street would not be re-aligned. Site grading in Planning Areas B and G would likely be less than under Alternatives 1 and 2; therefore, less area of high erosion risk would likely be developed. Since there would be no development south of the existing flood protection barrier dike at S 196th Street, there would be no increased potential for erosion hazard impacts in that portion of the site. No construction activities would affect the banks of the Green River.

Stream Erosion Hazard Impacts

Under the No Action Alternative, no development would occur in areas draining to Streams H, E-3, E-2, E-1, G and J-2 emanating from the western slopes and Streams C, D, Ditch J-1 and existing Johnson Ditch on the valley floor, and no stormwater discharge to these watercourses would result. Therefore, no stream erosion impacts would be anticipated under the No Action Alternative.

Construction of the Southcenter Parkway extension under the No Action alternative would require filling of 327 feet of Stream E. The channel would likely be realigned and enhanced to provide an equal amount of stream channel as that filled (see Appendix E for further information), and no stream erosion impacts would be anticipated.

Landslide Hazard Impacts

Under the No Action Alternative, it is assumed that no initial infrastructure development phase would occur, the re-alignment of S 178th Street would not occur, and the extension of Southcenter Parkway would be aligned in the center of the site and would not involve cuts into the base of the western slope. Mass grading would involve grading in Landslide Hazard Zone 2 and 3 areas in Planning Area G, and grading in Landslide Hazard Zone 4 in Planning Area B. No work would affect the banks of the Green River. The potential for probable significant adverse impacts related to landslide hazards would generally be less than under Alternatives 1 and 2. With implementation of appropriate mitigation measures, the No Action Alternative would not increase the existing landslide hazard risks on or immediately adjacent to the site.

Seismic Hazard Impacts

Seismic hazard impacts under the No Action Alternative would be similar to those described for Alternatives 1 and 2; however, with less development there would be less potential for seismic-induced damage to development. As under Alternatives 1 and 2, the potential for surface ground rupture impacts as a result of seismic activity would be low. As under Alternatives 1 and 2, the International Building Code (IBC) would be followed and buildings would be designed to be able to sustain some damage from ground motion without causing life safety concerns.

Liquefaction hazard risks would be similar to those described for Alternatives 1 and 2; however, there would be less potential for damage from liquefaction due to less overall development on the site. Appropriate mitigation measures would be required to reduce the risk of liquefaction impacts.

The potential for seismically induced landslide impacts would be similar to those described for Alternatives 1 and 2, and would not be anticipated to result in significant impacts.

3.1.3 Mitigation Measures

- Major stormwater conveyance infrastructure would be installed within the Southcenter Parkway extension sufficient to convey stormwater runoff from the future buildout of the site to the permanent stormwater treatment and runoff control facilities.

- All construction activities that could affect the banks of the Green River would comply with applicable regulations from the Tukwila Shoreline Master Plan. Projects constructed in accordance with the Shoreline Master Plan would be required to obtain a substantial development permit, which can dictate specific temporary erosion and sedimentation control/stormwater pollution prevention plan (TESC/SWPPP) measures.

- A temporary and long-term construction stormwater management system would be installed during the initial infrastructure development phase, including the following:
  - Temporary erosion and sediment control (TESC) collection traps for stormwater, including pressure line interconnections to pump water between the traps, and from the traps south to the construction stormwater treatment ponds adjacent to the permanent pond south of S 200th Street (the south stormwater pond); and
  - A permanent stormwater pond north of the realigned S 178th Street (the north stormwater pond).

- During all construction at the Tukwila South site, Best Management Practices (BMPs) outlined in King County's Surface Water Design Manual (King County, 1998) would be implemented. Per King County's guidelines, the following erosion BMPs would be implemented during infrastructure and building development to address the potential for erosion. Specific BMPs to be implemented during future building and onsite road construction, would be outlined in geotechnical engineering reports and associated TESC plans for each specific project.
  - Source control measures would be employed to reduce erosion risks before they occur (potentially including hydroseeding, mulching and matting, plastic cover, etc.)
  - Temporary sediment traps or ponds would be installed to control sediment transport during construction;
  - Rock check dams would be established as warranted by open channel or swale conveyance during infrastructure development to reduce water flow velocity and trap sediment;
  - Filter fences would be used as a perimeter sediment interception measure, as warranted, adjacent to watercourses and retained wetlands on the low-slope areas of the site, the wetland rehabilitation area, and disturbed areas adjacent to the Green River to reduce the risk of sediment transport into these features;
  - Discharge points for stormwater release, including emergency overflow outfalls, would be provided with an energy dissipater to reduce the risk of erosion; dewatering and

construction stormwater discharge would include energy dissipation provisions prior to reaching the Green River;
- All turbid construction runoff would be collected and treated by sediment ponds, sand filters, temporary filtration, or other approved methods before release to any surface waters; temporary ponds for polymer treatment and a controlled batch release system after testing would be part of the stormwater management system;
- Clean water would not be allowed to enter construction areas or mix with construction water;
- TESC BMPs would be implemented and maintained in accordance with a Stormwater Pollution Prevention Plan (SWPPP) that would be prepared for the project as required by the NPDES permit (see Appendix B to this Draft EIS); and,
- TESC measures would commence at the same time as the clearing activities and be operating properly prior to beginning mass grading activities (refer to Appendix A for further details on the proposed BMPs and TESC plan).

- Isolated Erosion Hazard Class 2 and 3 areas in Planning Area I would be specifically delineated on the ground prior to mass grading (see Figure 2-3 for a depiction of the proposed planning areas and Figure 3.1-2 for a depiction of erosion hazard areas). Plans would be reviewed by the geotechnical engineer during the design process to evaluate the erosion risks, slope instability risks, and to provide specific mitigation recommendations designed to minimize the erosion hazard potential.

- The Erosion Hazard Class 2 and 3 areas in Planning Area G would be specifically delineated on the ground prior to infrastructure development (see Figures 2-3 and 3.1-2). Mass grading plans would be reviewed by the geotechnical engineer to evaluate the erosion and slope instability risks, and to provide specific recommendations designed to mitigate erosion hazards.

- During construction of the S 178th Street realignment, specific geotechnical recommendations would be implemented (see Appendix A for details).

- Construction activities for the Green River Off-Channel Habitat Restoration Area, the new stormwater outfall to the Green River, the abandonment of the existing Johnson Ditch floodgate and outfall, and for the mouth of the new Johnson Creek would comply with applicable shoreline regulations. Projects constructed in accordance with the Tukwila Shoreline Master Plan would be required to obtain a substantial development permit, which can dictate specific temporary erosion and sedimentation control/stormwater pollution prevention plan (TESC/SWPPP) measures. Mass grading plans would be reviewed by the geotechnical engineer to evaluate the erosion risks, slope stability risks and to provide specific recommendations to minimize erosion hazard potential (see Appendix A for details).

- During construction of the Southcenter Parkway extension, specific geotechnical recommendations would be implemented in relation to cuts into Erosion Hazard Class 3 and 4 areas along the base of the western slope (see Figures 2-3 and Figure 3.1); see Appendix A for further details on this mitigation measure).

- The geotechnical engineer would review the grading, erosion, and stormwater control plans prior to final plan design to further assist in recommending mitigation measures to address site-specific erosion hazards during infrastructure development.

- The following BMPs would be implemented to reduce potential impacts to landslide hazard areas on the site and adjacent properties immediately upslope or downslope of hazard zones, such as Orillia Road, Interstate 5, the Bow Lake transfer station and landfill, and the Levitz Furniture store.
  - A site-specific geotechnical evaluation of Planning Area G would be performed to confirm hazard risk and stability regarding the down-grading Qvic/Qls unit from Landslide Hazard Zone 4 to Landslide Hazard Zones 1 through 3 (based on slope gradient) prior to mass grading.
  - An additional site-specific geotechnical evaluation of the proposed S 178th Street realignment would be performed.
  - For specific development in areas containing Landslide Hazard Zones 3 and 4, site-specific geotechnical engineering studies would be performed as part of the design process, as required under the Tukwila Municipal Code (TMC 18.45.040 C, 18.45.060 and 18.45.130). This would be applicable to construction activities occurring along the banks of the Green River, in Planning Area A, and in portions of Planning Areas B, G and I (see Appendix A for specific requirements).
  - Site-specific geotechnical recommendations would be implemented for other infrastructure development phase elements, as shown in Appendix A.

- For Planning Areas A, and portions of Planning Areas B, G and I, no fill, topsoil, or other debris would be placed over the top of Landslide Hazard Zones 3 or 4. Any fill planned for slopes steeper than 5H:1V (Horizontal:Vertical) would be benched and compacted into the hillside. Depending on the proposed specific slope gradients, the use of retaining or erosion control structures could be required in these areas (see Figures 2-3 and 3.1-2).

- No cuts would be made on or at the toe of Landslide Hazard Zones 2, 3 or 4, unless approved by the geotechnical engineer. Any proposed cuts elsewhere on the site would also be reviewed by the geotechnical engineer prior to mass grading to evaluate the risk of slope instability and to provide specific mitigation recommendations designed to minimize landslide hazard potential (see Figures 2-3 and 3.1-2).

- The geotechnical engineer would be given the opportunity to review all grading, erosion, and drainage control plans prior to initiation of construction onsite to assist in reducing the landslide hazard risks.

- During site-specific engineering, horizontal ground displacement calculations would be performed, considering site and soil conditions, to account for the possibility of horizontal ground displacement resulting from liquefaction-induced lateral spreading during an earthquake.

- A settlement monitoring program would be developed and implemented to monitor settlement progress and determine when it would be appropriate to remove surcharge fill.

- Mitigation measures for liquefaction would include soil improvement techniques (to reduce liquefaction hazard) and structural improvement techniques (to accommodate liquefaction effects). These measures could include: soil densification methods; modifications leading to improving the cohesive properties of the soil (hardening or mixing), removal and replacement of liquefiable soils; permanent dewatering, which can reduce or eliminate liquefaction potential; soil reinforcement; and/or, use of shallow or deep foundations designed to accommodate the occurrence of liquefaction and associated vertical and horizontal deformations. Mitigation would be designed by a geotechnical engineer, and may consist of a combination of the above measures, or other equivalent measures.

- All structures would be designed per International Building Code (IBC), or adopted successor code, guidelines to be able to sustain some damage from ground motion during a seismic event without causing life safety concerns.

- Slopes to the west of the proposed realignment of S 178th Street would be further explored as part of the final roadway design to determine the specific presence, engineering properties and potential thickness of landslide material. Cuts would be evaluated to determine whether retaining walls and/or drainage improvements would be needed to maintain the stability of the cuts for the construction of the roadway.

- Other site-specific geotechnical recommendations would be provided by a geotechnical engineer in order to address potential earth-related impacts from infrastructure development and full buildout. A detailed list of geotechnical measures to address various infrastructure phase elements, including the relocated flood protection barrier dike, the new Green River levee (associated with the Off-Channel Habitat Restoration Area), Southcenter Parkway extension, the S 178th Street realignment, utility installation, stormwater ponds and outfalls, as well as geotechnical measures to address future building and onsite road development are described in detail in Appendix A.

3.1.4 Significant Unavoidable Adverse Impacts

The potential for impacts due to liquefaction during a large seismic event would be high on portions of the site; liquefaction could affect considerably more development under Alternatives 1 and 2 than under the No Action Alternative or under existing conditions. Implementation of mitigation measures would be intended to reduce the potential for significant impacts.