3.1 EARTH

This section describes existing soil and geologic conditions on the site, and evaluates potential impacts from development under the Proposed Action and alternatives. This section is based on the Geotechnical Engineering Report, prepared by Kleinfelder (see **Appendix C**).

3.1.1 Affected Environment

Information on site conditions is based on a field exploration and laboratory analysis of samples from borings and test pits on the site, and previous geotechnical investigations in the site vicinity. Field investigations of the site were conducted in November 2004.

Site Topography and Geologic Conditions

Most of the site slopes gently to the south, with approximately 3 to 6 feet of relief between the north and south ends of the site. A depression, extending from the southwestern portion of the site to the current Kingswood Drive, ranges in depth from between 3 and 6 feet lower than the adjacent grade.

Surface and Subsurface Soils

Topsoil

Topsoil at the ground surface consists of loose to medium dense brown sand with roots and other organics. The organic content varies with depth and location. This layer generally extends to depths of 2 to 3 feet below ground surface (bgs) and up to 4 feet in isolated areas.

Fill

Uncontrolled fill was encountered from 1 to 15 feet bgs in some locations. The fill consists of loose to dense sand with silt and gravel.

Recessional Outwash

Recessional Outwash was encountered beneath the topsoil, and extends to a depth of about 4 to 21 feet bgs. This layer consists of loose to medium dense, yellow-brown to gray-brown sand.

Over-Consolidated Lacustrine Deposits

Over-Consolidated Lacustrine Deposits were encountered beneath the Recessional Outwash in a number of locations. This layer consists of dense to very dense, gray-brown to gray sand, sand with gravel, and silty sand with gravel.

Groundwater

In February 2005, five shallow groundwater monitoring wells were installed onsite to assess background groundwater quality and to periodically assess shallow groundwater depths and gradient flow. These wells were installed to a depth of 25 feet in the shallow water table aquifer beneath the site. Groundwater elevation measurements obtained during March, April, and June

2005, indicate that shallow groundwater at the site generally flows in a northeasterly direction. The groundwater gradient is relatively flat and varies from approximately 0.0035 to 0.0055 vertical feet per one horizontal foot of slope. Based on the groundwater depth measurements, depth to groundwater ranges between a high of 13.5 feet to a low of 22.9 feet below the ground surface. The corresponding groundwater elevations at the site range between 160.74 feet to 164.76 feet above mean sea level (MSL). The water table is expected to fluctuate based on weather conditions (see **Appendix E** for details). See **Section 3.2**, Water Resources, for further discussion of groundwater.

Geologic Hazards

Seismic Hazards

Seismicity. Seismic mapping by the United States Geological Survey (USGS) 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 in UBC Seismic Zone 3.[1] There are no known active faults crossing the site.

Historically, the Puget Sound region has been subjected to frequent earthquakes of moderate intensity. Three earthquakes that resulted in significant damage occurred in 1949 near Olympia (magnitude 7.1 on the Richter scale), in 1965 near Seattle (magnitude 6.5), and in February 2001 near Olympia (magnitude 6.8). The February 2001 earthquake resulted in damage throughout the Olympia area.

Based on seismic risk analyses for similar sites in the Puget Sound region, ground accelerations at the proposed site could be on the order of 0.35g to 0.15g for upper and lower level events, respectively (g is the force of gravity, an acceleration of 9.8 meters/second^2; when there is an earthquake the forces caused by the shaking can be measured as a percentage of the force of gravity, or percentage of g). The lower level represents an event with a 50 percent probability of exceedance during a 50-year design life, and the upper level represents an event with a 10 percent probability of exceedance. The lower level represents an event similar to the 2001 earthquake.

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. The uniformly graded sand, low silt content and loose to medium dense consistency of subsurface soils at the site, together with the relatively high groundwater table at the site, make portions of these geologic units potentially susceptible to liquefaction during an upper-end seismic event. However, based on an analysis conducted for this EIS, liquefaction within the Recessional Outwash or Over-Consolidated Lacustrine Deposits underlying the site would not likely occur during a lower level earthquake such as the February 2001 earthquake, or during an upper level earthquake. In addition, a prior investigation of the site by AMEC Earth and

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[1] While the 2003 International Building Code (IBC) was adopted by the State of Washington in 2004, seismic zones are described in the Uniform Building Code (UBC), which was previously in effect in Washington; the Geotechnical Engineering Report for the proposed project (**Appendix C** to this EIS) discusses seismic zones consistent with the UBC, and design considerations consistent with the IBC.

Environmental, Inc., (2002) did not reveal liquefaction-prone soils below the site, and interpreted the risk of liquefaction to be low.

3.1.2 Impacts

Proposed Action

From a geotechnical standpoint, the site is suitable for the proposed development. The building would be constructed with a conventional shallow foundation system, which would provide satisfactory support.

Under the Proposed Action, approximately 1 to 3 feet of topsoil would be stripped from the site in the location of the proposed building and paved areas. Topsoil not suitable for use as onsite fill material would be removed from the site and disposed of at an approved location.

Earthwork required for construction of the Proposed Action would require approximately 49,500 cubic yards of cut. Of this, approximately 25,000 cubic yards of cut material would be used onsite as fill material, and approximately 24,500 cubic yards of cut material (previously placed undocumented fill) would be exported from the site. Exported fill would be hauled to an approved location. In addition, approximately 32,500 cubic yards of fill material would be imported to the site. Excavation and fill is not expected to exceed 10 vertical feet, with the majority of fill material used to fill the existing depression on the site. **Figure 3.1-1** depicts the grading plan under the Proposed Action.

The proposed utility systems, including stormwater control facilities, would be designed and constructed to be above the groundwater elevation measured onsite (see **Section 3.2, Water Resources** and **Appendix E** for more information on groundwater). As such, dewatering during construction would not be expected to be necessary.

Geologic Hazard Impacts

Some ground settlement could occur as a result of construction of the proposed building and parking areas. However, with appropriate placement and compaction of fills, total settlement is estimated at less than ¾ inch, and differential settlement is estimated at less than ½ inch over 50 feet.

Potential seismic hazard impacts in the event of a large seismic event would be addressed through building design to comply with the 2003 International Building Code (IBC). Structures on the site would be designed to survive an event such as the February 2001 earthquake (magnitude 6.8) with little damage.

As portions of the site could be susceptible to liquefaction during a seismic event, a shallow foundation system deriving its support from soil above susceptible layers could experience post-construction settlement as a result of ground failures due to liquefaction. However, based on recent analysis of the site and past investigations, the risk if liquefaction during a seismic event would likely be low. As stated above, the proposed building would be constructed with a conventional shallow foundation system. However, prior to construction of the foundation the existing uncontrolled fill on the site would be overexcavated; the exposed subgrade would be compacted; and structural fill consisting of recessional outwash, lacustrine deposits, and/or imported select fill placed.

Figure 3.1-1
Grading and Stormwater Control Plan, Proposed Action

Alternative 1

Impacts to earth-related conditions under Alternative 1 would be similar to those described for the Proposed Action (see **Figure 3.1-2** for the grading plan under Alternative 1). The cut and fill amounts, and amounts of imported and exported materials, would be similar. Dewatering would not likely be necessary during construction, because utility systems would be designed and constructed to be above the groundwater elevation measured onsite. Potential geologic hazard impacts would also be similar and would include minor settlement. As with the Proposed Action, Alternative 1 would be designed per the IBC for the earthquake seismic zone in which the site is located (Seismic Zone 3[2]) and the potential for liquefaction impacts would be low.

No Action Alternative

The No Action Alternative would require no earthwork and would not result in any potential for geologic hazard impacts. However, any future building on the site would likely result in similar potential for settlement as the Proposed Action. The potential for seismic events to affect the site would exist on the site with or without construction of a new structure.

3.1.3 Mitigation Measures

- Onsite topsoil would not be used as fill material, except for landscaping purposes.
- Prior to placing structural fill, the exposed subgrade would be compacted per the recommendations from the geotechnical report (see **Appendix C** for details).
- Structural fill would consist of onsite native soils (recessional outwash and over-consolidated lacustrine deposits) and/or imported select fill material.
- Where uncontrolled fill is encountered, it would be overexcavated to a minimum depth of 3 feet below the pavement section of the proposed parking lot.
- Temporary erosion and sediment control (TESC) measures appropriate for the season in which construction is being performed would be implemented, based on a TESC plan. These would include stabilized construction entrance, filter fabric fences, cover measures (such as vegetative cover), and avoiding vehicle tracking of mud offsite, per the City of Tumwater's Drainage Design and Erosion Control Manual for the Thurston Region (1994), as amended.
- During construction, stormwater would be infiltrated onsite via temporary infiltration ditches and trenches.
- During earthwork activities, temporary slopes would be protected from the elements by covering with a protective membrane of plastic sheeting or similar impermeable material.

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[2] While the 2003 International Building Code (IBC) was adopted by the State of Washington in 2004, the Geotechnical Engineering Report for the proposed project (**Appendix C** to this EIS) discusses seismic zones consistent with the UBC, and design considerations consistent with both the UBC and IBC. The UBC was in effect in the City of Tumwater prior to adoption of the IBC.

Figure 3.1-2
Grading and Stormwater Control Plan, Alternative 1

- Permanent slopes would be planted with a deep-rooted, rapid-growth vegetative cover as soon as possible after completion of slope construction. Grass or groundcover would be planted on all exposed areas with side slopes of 3H:1V or greater. Exposed slopes would be covered with plastic, straw, etc. until they can be landscaped.

- Structures constructed on the site, including the proposed retail store and gas station, would meet IBC design standards for seismic design.[3]

3.1.4 Significant Unavoidable Adverse Impacts

With implementation of proposed mitigation measures, no significant earth-related impacts would be expected.

[3] The International Building Code (IBC) was adopted by the State of Washington in 2004.