

3. Affected Environment, Potential Impacts, and Mitigation Measures

3.1 Earth

This section describes the geographic and geologic setting of the Thurston Highlands site, and significant processes related to Earth elements that are to be considered. Studies that have been performed include a review of available reports and data from federal and state agencies, and the investigation of subsurface conditions by test pits and borings. It is concluded that there will be impacts to existing topography from the grading proposal. Normal design and construction standards will minimize potential impacts associated with erosion. The risk of impact from earthquakes or volcanic activity is considered low.

3.1.1 Topography

AFFECTED ENVIRONMENT

The Thurston Highlands project site is located within the Puget-Willamette Lowland of the Pacific Northwest. This physiographic region extends from south of the San Juan Islands to Eugene, Oregon. Elevations range from sea level to several hundred feet above sea level. In the area of the Thurston Highlands site, lowlands are drained by westward-flowing rivers with headwaters in the Cascades and estuaries in Puget Sound. The Nisqually River, sourced by the Nisqually Glacier on Mount Rainier, is located about one mile northeast of the site, and flows into Puget Sound at the Nisqually Delta, about 10 miles northwest of Yelm. The Deschutes River, located about 6 miles southwest of the site, has headwaters in the Cascade foothills, and flows into Budd Inlet of Puget Sound at Olympia.

The Nisqually River flows in a valley incised to a depth of 50 to 200 feet within a broad alluvial plain (Yelm Prairie) formed by the Nisqually River in geologically recent times. The alluvial plain has only minor local relief, with an elevation ranging from about 250 feet mean sea level (msl) in the north Yelm area to about 350 feet near the City center and to the southwest.

The Thurston Highlands site is approximately 1,240 acres in size, comprising all of Section 27, the eastern portion of Section 26, and the southern portion of Section 23, Township 17 North, Range 1 East of the Willamette Baseline and Meridian, in Thurston County. Most of the site occupies an upland area at elevations between 400 feet and 550 feet msl. The southeastern portion of the site is located in the alluvial plain with an elevation of about 350 feet msl. Between the alluvial plain and the upland area there is a sharp rise in topography, with slopes of up to 30 percent. This marks the side of the valley formed by the Nisqually River following the most recent glaciation. The upland area has local relief of up to 50-foot slopes with numerous closed depressions representing a “kame and kettle” depositional environment (described further in Subsection 3.1.2).

POTENTIAL IMPACTS DURING CONSTRUCTION

Full Build-Out Conceptual Land Use Alternatives

Recontouring the site would be required in order to develop grades suitable for buildings, utilities (stormwater and wastewater), and road construction. Grading activities would be largely restricted to the upland portion of the site, including possible filling of some isolated low-value wetlands (Coot Company 2008B). Additional construction fill could also be obtained from borrow areas on the Tahoma Terra and Thurston Highlands sites. The bluffs between the upland and

valley alluvial plain will be preserved in an erosion hazard protection area. Grading impacts would be similar for any of the conceptual land use alternatives (KPFF Consulting Engineers 2008).

Indirect impacts during construction may arise if it is necessary to import specialized fill; for example, drain gravel, if it cannot be obtained by processing onsite resources. Removal of material from the source borrow pits will result in changes to the topography at these locations.

Phase 1 Development Concept

Phase 1 development is proposed in the northern section of the site. Grading impacts would be similar to those described for full build-out. Three isolated wetlands within Phase 1 would be impacted by construction. Wetlands D14, G1 and G2 may be filled as a result of grading to create uniformly level building areas for single-family homes (Coot Company 2008B). Some regrading may be required in the vicinity of Wetland H associated with an access road to adjoining property across the wetland.

No Action Alternative

No clearing or grading would be performed on the site under the No Action Alternative; therefore, there would be no alteration of existing site topography.

POTENTIAL DEVELOPED-CONDITION IMPACTS

Full Build-Out Conceptual Land Use Alternatives

Following construction, only minor additional regrading activities would occur; for example, associated with placement and/redistribution of topsoil for plantings.

If import of specialized material, for example landscape rock, is required, it would result in changes to the topography at the source quarry. Quarries are regulated by their own site-specific permits.

Phase 1 Development Concept

Grades developed during Phase 1 construction would be maintained in the developed condition, with possible minor changes for landscaping.

No Action Alternative

There would be no developed-condition impacts to the topography of the site with the No Action Alternative.

MITIGATION MEASURES

Incorporated Plan Features. The most significant topographic features of the site are the forested bluffs that separate the alluvial plain of Yelm Prairie from the upland area. These bluffs will be largely preserved as erosion hazard protection areas.

Applicable Regulations. The City of Yelm would require a site excavation plan, as well as grading permits for individual phases of development within the Master Planned Community.

Other Possible Mitigation Measures. To the extent practicable, cut and fill volumes would be balanced during each phase of the development, and excavated topsoil would be stockpiled for reuse. This would minimize the need for sand and gravel resources from offsite areas, therefore reducing impacts from traffic and mineral extraction industries. As sections of a borrow area are excavated to final grade, they would be reclaimed and vegetated with native plant and tree species.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

Grading the site for roads, building lots and utilities would result in changes to existing topography. Although these changes are unavoidable, they would not result in significant adverse impacts to predominant topographic features such as slopes, or adversely affect drainage, due to the proposed stormwater management plan (see Draft EIS Section 3.19.4).

3.1.2 Geology and Soils

Subsurface conditions of the Thurston Highlands site have been explored by 19 borings that were subsequently used for the installation of piezometers and wells to observe groundwater conditions, and 140 test pits to evaluate geologic conditions and infiltration properties. Details are presented in reports prepared by Insight Geologic (2008), Parnell (2006), and Pacific Groundwater Group (2008). The locations of these investigations are shown on Figure 3.1-1. Logs for the borings and wells are presented in Pacific Groundwater Group (2008) Appendix A; and logs for the test pits are presented in Insight Geologic (2008) Appendix B. The borings and monitoring wells were completed to depths up to 127 feet below ground surface. The test pits were excavated with a track-mounted hydraulic excavator to depths ranging between 10 and 15 feet below ground surface, and were backfilled with the excavated material after logging.

The geologic materials encountered in the exploratory test pits were highly variable but generally consistent with a moraine/outwash depositional environment. The materials encountered ranged from poorly-graded gravel (GP) to clay (CL) to the full depths explored. Most soils encountered in the upper 20 feet of the explorations contained moderate to significant quantities of fines (passing #200 sieve). Silty to clayey soils were encountered in several areas of the site, particularly the low-lying area in the southern portion of the property that is not designated for development.

The upland area designated for development of the Regional Sports Complex in the northeastern portion of the site (southwest quarter of Section 23) appears to be underlain by finely-laminated silts. Throughout the upland portion of the property, moderately-thick zones of sand and gravel with relatively little fine material were encountered in monitoring well borings installed by Pacific Groundwater Group. Generalized geologic cross-sections were developed using these deeper explorations, as shown on Figures 3.1-2 and 3.1-3.

Insert Figure 3.1-1 Site Map

Insert Figure 3.1-2 Geologic Profiles A-A and B-B

Insert Figure 3.1-3 Geologic Profile C-C

AFFECTED ENVIRONMENT

Regional Geology. On a global scale, the Pacific Northwest is located along the margin of the North American plate, above the subduction zone of the Juan de Fuca plate. This geologically active zone has resulted in regionally high relief, and ongoing seismic and volcanic activity. Within this area, the Puget Lowland occupies a north-south trough filled with glacial and interglacial deposits, bedrock along the east and west margins. During the Pleistocene period, glacial ice advanced into the Puget-Willamette Lowland at least seven times (Troost, Booth and Laprade 2003). The most recent advance was named the Vashon Stade of the Fraser Glaciation, and extended to the Chehalis area, south of the Thurston Highlands site. Glacial deposits vary widely, from gravels, sands and silts deposited as moraines at the sides of an ice sheet or in close proximity to the terminus. Ahead of the ice sheet, meltwater rivers and streams deposit a mixed assemblage of material, primarily gravels and sands. Locally, lakes form in depressions or where outlets have been blocked. These areas are characterized by deposits of silts and clays, often showing rhythmic layering. This is in response to annual thawing leading to erosion and transport of sediments, with settling and deposition of the finer fractions taking place in the quiescent period when inflow is reduced by freezing temperatures. Beneath the ice sheet, till is deposited. The characteristics of the till depend upon the eroded source rock and the thickness of the ice sheet under which the till is laid down. In the Puget Lowland, the till is typically a dense silty sand with occasional cobbles and boulders. However, near the terminus of the ice sheet, the till is less densely consolidated and more variable in composition.

Site Geology. The Thurston Highlands site is located near the southern limits of glaciation by the Puget Lobe of the Cordilleran ice sheet that occupied the Puget Sound Lowland during the Vashon Stade of the Fraser glaciation (approximately 30,000 to 15,000 years ago). Maximum ice thicknesses in the area at that time are estimated to have been several hundred feet (Noble and Wallace 1966). The material at the Thurston Highlands site is mapped as Vashon end moraine of the glacial lobe by Noble and Wallace (1966). It is likely that the glacial ice advanced and withdrew several times over the project area during the glacial period, depending on climatic conditions, resulting in several, thin zones of glacial till. Geologic material beneath the site generally consists of unconsolidated to poorly consolidated sand and gravel outwash with some glacial till exposed in the northern portion of the site. Much of the material appears to have been deposited episodically during the waning stages of the Vashon glaciation as meltwater stream deposits, as debris flow deposits from the snout of the glacier, as ablation till as stagnant blocks of ice melted and deposited the entrained sand and gravel, and as finely laminated lake deposits in episodic meltwater lakes.

Soils. Surficial soil conditions were evaluated by reviewing the U.S. Department of Agriculture Soil Survey of Thurston County, Washington dated 1979. According to the soil survey report, the following soils are located within the site boundaries:

- ◆ Alderwood gravelly sandy loam (15 to 30 percent slopes)
- ◆ Everett gravelly sandy loam (15 to 30 percent and 30 to 50 percent slopes)
- ◆ Indianola loamy sand (15 to 30 percent slopes)
- ◆ Mukilteo Muck
- ◆ Tenino gravelly loam (3 to 15 percent slopes and 15 to 30 percent slopes)
- ◆ Yelm fine sandy loam (3 to 15 percent slopes).

With the exception of the Mukilteo Muck, site soils generally consist of gravelly and sandy loam formed in areas of glacial till and outwash. These soils are generally well- to excessively-

drained. The Mukilteo Muck occurs in wetland areas and consists of peat and decayed vegetation.

Borrow Material. Several areas on both the Thurston Highlands and the adjacent Tahoma Terra site have been exploited in the past for sand and gravel borrow material.

Infiltration Properties. Geologic material at the site is moderately suited for infiltration of surface water. Estimated infiltration rates for the site range from less than 2 inches per hour to about 10 inches per hour based on textural classifications. From observations of geologic material encountered in deeper explorations conducted by Pacific Groundwater Group (2008), higher infiltration rates may be achievable at depths greater than 20 feet below existing grade. Figure 3.1-4 shows infiltration rates across the site based on existing surficial soil types.

Unique Physical Features. The upland portion of the Thurston Highlands site has a well developed “kettle and kame” topography typical of moraines at the terminus of ice sheets. Kettles are depressions that formed as blocks of ice became stranded during the glacial retreat. While the ice block persisted, deposition was limited compared with the adjacent area. Kames are irregularly shaped hills or ridges of stratified sands and gravels, formed by meltwaters in contact with ice margins.

The steep slope between the upland area and the alluvial plain marks the left bank of the river valley of the Nisqually River during geologically recent times. Because of changes in sea level relative to the adjacent land area caused by glacial loading and post-glacial rebound, and changes in global volumes of water held in ice, the base level of the Nisqually River was once at about 350 feet msl in the area of the Thurston Highlands site. Channel features from this time are clearly visible on aerial photographs of the area, and some of these are now occupied by streams and wetlands. Particularly well-developed features include the Ridgeline Trough, southeast of Hwy 507, and Thompson Creek in the area of the site.

Steep slopes occur in several areas of the site at inclinations greater than 30 percent (see Figure 3.1-5). There is no evidence of shallow slides or features indicative of deep-seated landslides associated with these slopes. The generally coarse-grained, granular nature of the soils provides strength and limits groundwater build-up in the slopes that could be conducive to soil failures.

Seismicity. As noted above in the discussion of the regional geology, the site is in a seismically-active area. Hundreds of earthquakes have been recorded in the Puget Sound area. In recent history, four of these earthquakes were large events: 1) in 1946, a Richter magnitude 7.2 earthquake occurred in the Vancouver Island, British Columbia area; 2) in 1949, a Richter magnitude 7.1 earthquake occurred in the Olympia area, 3) in 1965, a Richter magnitude 6.5 earthquake occurred between Seattle and Tacoma; and 4) on February 28, 2001, a magnitude 6.8 occurred at Nisqually near Olympia.

Research is currently underway regarding historical large-magnitude, subduction-related earthquake activity along the Washington and Oregon coasts. Geologists are reporting evidence that suggests several large-magnitude earthquakes (Richter magnitude 8 to 9) have occurred in the last 1,500 years, the most recent of which occurred about 300 years ago. No earthquakes of this magnitude have been documented during the recorded history of the Pacific Northwest.

Insert Figure 3.1-4. Test Pit Locations and Infiltration Rates

Insert Figure 3.1-5. Existing Slope Conditions

In addition to the potential for damage due directly to shaking, damage may also occur from liquefaction of soils. Liquefaction refers to a condition where vibration or shaking of the ground results in development of excess pore pressures in saturated soils and subsequent loss of strength in the deposit of soil so affected. In general, soils that are susceptible to liquefaction include loose to medium dense "clean" to silty sands that are below the water table. Since the site area to be developed consists of coarse, granular material at elevations well above seasonal high ground water conditions, the potential for liquefaction at this site is very low.

Volcanic Activity. The Thurston Highlands site is located about 40 miles west of Mount Rainier; therefore, there could be geologic hazards associated with potential volcanic activity. The site is sufficiently distant to be well outside of the area designated as a potential blast zone (Hoblitt et al. 1998 Plate II). However, a volcanic eruption could result in ash fall. The thickness of ash that could be deposited in the Yelm area would depend upon the winds at the time of the eruption. Since the prevailing winds are generally westerly, this minimizes the potential for significant ash fall at the site. Mudflows, known as "lahars" are a potential hazard, and may occur without an associated volcanic eruption (Hoblitt et al. 1998 Plates I and II). The presence of Alder Dam on the Nisqually River would attenuate the downstream impacts. Any lahars reaching the Yelm area are expected to be limited to the confines of the current Nisqually River valley, and therefore would not affect the Thurston Highlands site.

POTENTIAL IMPACTS DURING CONSTRUCTION

Full Build-Out Conceptual Land Use Alternatives

As noted in Section 3.1.1, regrading the site is proposed for construction of any of the conceptual land use alternatives. Grading would be accomplished using conventional earthmoving equipment. It is anticipated that stripping of 3 to 6 inches will be required to remove organic material and topsoil prior to mass grading. The near-surface soils in some portions of the site contain a significant fraction of fines (silt or clay size particles), although it generally appears that the amount of fine material decreases with depth.

Soils with a significant fines fraction will likely be moisture-sensitive, and therefore may be difficult to operate on or adequately compact during wet weather.

Areas on site that have been used for borrow material could continue to be used as sand and gravel resources for fill and subgrade material as needed during Thurston Highlands grading and construction.

Phase 1 Development Concept

Construction impacts for Phase 1 would be similar to those described above for full build-out, though more limited in areal extent.

No Action Alternative

There would be no construction impacts to geology or soils associated with the No Action Alternative.

POTENTIAL DEVELOPED-CONDITION IMPACTS

Full Build-Out Conceptual Land Use Alternatives

Based on the anticipated grading that will be conducted on the site, it is likely that deeper, more permeable deposits may be utilized for local stormwater infiltration. There would be no additional impacts to geology or soils following construction.

Use of borrow material from an off-site source could produce impacts to geology and soils at the source locations. Permission to use these sources, and reclamation requirements, would be regulated by separate, site-specific permits.

Phase 1 Development Concept

As with developed-condition impacts for full build-out of the site, the deeper, more permeable deposits may be utilized for local stormwater infiltration after site grading, and there would be no additional impacts to geology or soils following construction within the Phase 1 development area.

No Action Alternative

There would be no developed-condition impacts to geology or soils associated with the No Action Alternative.

MITIGATION MEASURES

Incorporated Plan Features. Existing steep slopes on the site appear to be stable. However, to minimize potential instability associated with newly-constructed steep slopes as well as existing steep slopes, the proposal includes locating all roadways and building foundations outside a setback from the top of the slope equal to the height of the slope. Where additional geotechnical and engineering analyses show that safety requirements can be met, the width of this setback may be reduced. Drainage would be directed away from steep slopes to areas where infiltration would not impact stability.

Applicable Regulations. The City of Yelm will require submission of a site excavation plan as well as grading permits for individual developments.

Other Possible Mitigation Measures. To mitigate potential local instability, steep slopes may be recontoured by grading and terracing. During construction, drainage would be directed away from the slopes to minimize slope saturation that could lead to erosion and instability. The installation of utilities in excavations would require temporary cuts. Potential instability impacts would be mitigated by temporary support of excavations or by laying back cut slopes.

Impacts associated with moisture-susceptible soils during construction could be mitigated by undertaking earthwork in these areas during dry weather, whenever practicable. This would minimize operational difficulties and reduce the potential for erosion. Alternatively, sand and gravel could be incorporated into material containing excessive amounts of fines to improve soil properties during construction.

The use of on-site borrow material would minimize construction-related traffic and associated noise and emissions in offsite areas. The impacts of borrow material excavation

would be mitigated by installing appropriate erosion and sediment control measures. When the borrow areas are no longer required, they will be reclaimed in accordance with state regulations and governing permits by regrading and vegetating.

Topsoil removed and stockpiled during construction would be redistributed on the site in areas to be landscaped. Where necessary to improve infiltration characteristics, native soil may be amended with organic material to improve infiltration rates.

Seismic design for the project area may be performed using the equivalent static force procedure and parameters presented in the 2006 International Building Code. Further details are provided in the Geotechnical Assessment Report prepared for the site (Insight Geologic 2008).

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

Site development would consume natural resources such as sand and gravel.

3.1.3 Erosion

AFFECTED ENVIRONMENT

There is no current evidence of runoff from the upland portion of the Thurston Highlands site due to the irregular topography with closed depressions, the reprod forest cover, and the permeable nature of the soils that underlie most of the property. As a result, erosion from surface water flow is negligible. Sliding and mass wasting from the bluffs above Thompson Creek does not appear to be significant. However, some local erosion is likely, for example where trees are blown down in windstorms, exposing the soil in the root area.

Flow velocities in Thompson Creek have been measured during hydrological studies of the creek. These data have been used to develop a computer model of the creek that allows prediction of flows under a range of precipitation conditions (Brown and Caldwell 2008). For typical wintertime conditions (flows ranging from 2 to 7 cfs) flow velocities vary along Thompson Creek from less than 1 foot per second to about 3 feet per second. During overbank flow conditions, the maximum velocity is about 3.5 to 4.0 feet per second. These velocities are not sufficiently high to cause significant erosion or transport of sediment. No substantial down-cutting has been observed along the Thompson Creek channel upstream of SR 510.

POTENTIAL IMPACTS DURING CONSTRUCTION

Full Build-Out Conceptual Land Use Alternatives

During construction there is the potential for site runoff to cause erosion and transport sediment. Areas that would be most susceptible include where construction grading would expose fine-grained soils, particularly on slopes. If uncontrolled, sediment could be washed into wetlands and/or Thompson Creek. The lower water velocities in these areas would result in suspended sediments settling out. This would potentially change the hydraulic and habitat characteristics of the wetlands and creek, if erosion and sedimentation were allowed to occur. Erosion potential would not differ substantially between the three conceptual land use alternatives.

Phase 1 Development Concept

Impacts during construction within the Phase 1 development area would be similar to those described above for full build-out, though more limited in areal extent.

No Action Alternative

Minor occurrences of erosion that may, at times, occur on the site would not be altered by the No Action Alternative.

POTENTIAL DEVELOPED-CONDITION IMPACTS

Full Build-Out Conceptual Land Use Alternatives

No erosion potential would be anticipated following full build-out of the Master Planned Community.

Phase 1 Development Concept

Similarly, no erosion would be anticipated in the completed condition of the Phase 1 development area.

No Action Alternative

If the No Action Alternative were selected, there would be no change from existing occurrence of erosion on the site..

MITIGATION MEASURES

Incorporated Plan Features. The Thurston Highlands stormwater management proposal includes complying with the Washington Department of Ecology 2005 Stormwater Management Manual for Western Washington or more recent guidance likely to be developed by regulatory agencies, including the City of Yelm, over the course of Thurston Highlands development (KPF Consulting Engineers 2008). Proper installation and maintenance of these facilities would minimize or avoid potential adverse impacts associated with erosion/sedimentation during construction and in the completed condition of the development.

Applicable Regulations. All construction sites greater than one acre in extent are required to obtain a National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permit from the Washington Department of Ecology. A requirement of a NPDES permit is to develop an Erosion and Sedimentation Control (ESC) Plan to be submitted to Ecology for approval prior to the start of construction. Best Management Practices (BMPs) identified in the ESC and detailed in the *Stormwater Management Manual for Western Washington* (Ecology, February 2005) would be implemented during construction to minimize erosion. Example BMPs that could be appropriate at the site include:

- ◆ Preserving natural vegetation in environmentally sensitive areas (e.g., high-value wetland buffers)
- ◆ Temporary and permanent seeding or sodding to re-establish vegetation
- ◆ Use of mulch, plastic covering, or erosion control netting on soil surfaces to limit erosion
- ◆ Silt fence, brush barrier, or straw wattles to reduce water velocities of rill and sheet flow

- ◆ Check dams, sediment traps or sediment ponds to reduce water velocities in ditches and allow settling of suspended particulates.

Other Possible Mitigation Measures. If necessary, approved additives could be used to enhance settlement of suspended sediments in temporary erosion/sedimentation control ponds during construction.

SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

No significant unavoidable adverse impacts in the form of erosion/sedimentation would be expected to occur during construction or in the completed condition of the development.

