

This testing will be completed prior to any disturbance to adequately document the extent and potential of the cultural resources for nomination to the National Register of Historic Places.

Necessary mitigation measures would be determined after testing in consultation with the Washington OAHP and the Yakama Nation.

### 3.11 GEOLOGY, TOPOGRAPHY, AND SOILS

#### 1 What are the geologic, topographic, and soil conditions in the area?

The topography and geography of the project site reflect the general characteristics of the area.

The eastern portion of the site on Easton Ridge is on a steep sloping hillside composed largely of bedrock of Teanaway Formation basalt, basaltic tuff, and breccia. The western edge of the steep portions of the site includes talus slopes of rocks formed by rockfall from above. The topography is stepped. A hillside rises from an elevation of about 2,200 feet to an initial ridge about 3,000 feet in elevation. A second slope rises to the crest of Easton Ridge at an elevation of about 4,400 feet. Between the two ridges is a less steep sloping area with a valley containing a stream.

The western portion of the site consists of a gently sloping alluvial plain at an elevation of about 2,200 feet. There is an electrical transmission line at about the boundary of the alluvial plain and the sloping hillside.

The site topography and geology are typical of the Roslyn Basin of the Upper Yakima River Watershed, which is a classic U-shaped, glacially scoured valley. Figure 3-30 maps the geology in the vicinity. The valley was occupied by a large glacier complex that included coalescent glaciers from the Keechelus Lake, Kachess Lake, and Cle Elum Lake drainages. Deposits of at least three major glacial intervals have been mapped. These are the Lakedale Drift (15,000 years before present), the Thorp Drift (>700,000 years before present), and the Kittitas Drift (120,000 years before present). During Thorp and Kittitas times, the glaciers extended down the valley as far as the Teanaway River. The most recent glacial advance (the Fraser glaciation/Lakedale Drift) extended just east of the Easton area.

The bedrock of Easton Ridge is either Shuksan Greenschist or Silver Creek Pass Member andesite. The major structural feature in the area is the Straight Creek Fault (SCF). The SCF is a major right-lateral strike-slip fault extending north into Canada (Tabor et al. 2000). Portions of the SCF are thought to have been active within the last 10,000 years

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**What is a talus slope?**

**A talus slope, or scree, is mass of rock fragments that have collected at the base of a cliff or steep slope from which they have fallen.**

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**What is an alluvial plain?**

**An alluvial plain occurs when deposits (usually silt or silty clay) from running water, such as streams, rivers, or floods, form a plain.**

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**What is a glacial drift?**

**Glacial drift is rock material that was transported and deposited by glaciers when they melted.**

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(Slemmons et al. 1981; Vance and Miller 1983). The southern extent of the SCF is interpreted to loosely follow Kachess Lake, pass through Easton, and curve to the southeast, following the Yakima River Valley, or alternatively through Ambolis Mountain, crossing the Yakima River Valley about 2 miles east of Easton (Tabor et al. 2000; Cheney 1999). The fault is inactive, pre-Tertiary in age (more than 65 million years before present), with right-lateral displacements of between 90 and 180 kilometers (Cheney 1999; Tabor et al. 2000). At the Marian Meadows site, one minor fault mapped by Cheney (1999) as the Tucker Creek Fault extends from Easton Ridge through the western edge of the site and trends from Easton Ridge to the southwest towards Lake Easton.

Deposits on the valley floor are unconsolidated including:

- Glacially deposited glacial gravel and sand outwash.
- Alluvium (water-carried deposits) consisting of moderately sorted cobble gravel along the rivers and poorly sorted gravelly sand on small alluvial fans where streams discharge from the hillsides (Tabor et al. 2000).

The soils on the site and in the vicinity reflect the different environments in which they were formed. Soils are summarized in Table 3-36 and shown on Figure 3-31. The alluvial plain portion of the site corresponds to the Kladnick soil, a well-drained, ashy, sandy loam found on slopes of 0 to 3 percent, with low shrink-swell potential, and no ponding or water saturation within the upper 72 inches. Raedeke Associates, Inc. (2006) described this soil as homogenous 7.5YR 4/3, brown sandy loam to 18 inches, with no redoximorphic features.

The major portion of the steep-sloping southwest face of Easton Ridge at the site corresponds to Roxer soil, a shallow well-drained gravelly, ashy, sandy loam on slopes of 45 to 60 percent, with low shrink-swell potential, and no ponding or water saturation within the upper 72 inches. Raedeke Associates, Inc. (2006) described soils of the Easton Ridge as 7.5YR 4/2 to 4/4, very gravelly sandy loam to 18 inches, with no redoximorphic features.

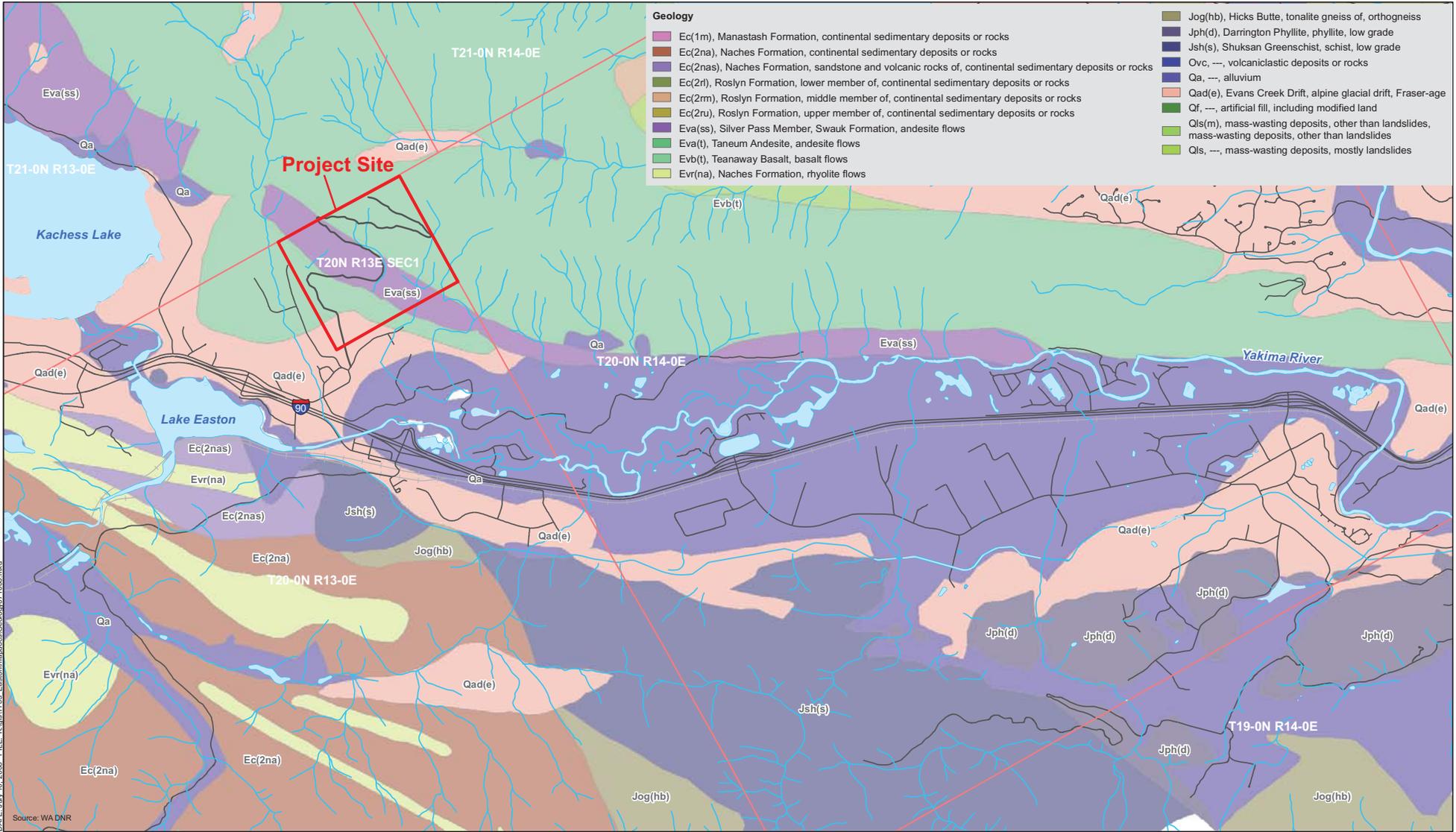
A small portion of Easton Ridge is classified as Roxer Complex, divided into the Roxer soil composing about 40 percent of the Complex, and Roxer soil with basalt stratum as 55 percent of the Complex. The Roxer soil with basalt stratum is well drained on slopes of 45 to 65 percent, with low shrink-swell potential, no ponding or water saturation within the upper 72 inches, and bedrock at a depth of 40 to 50 inches.

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**What is a Fault?**

**A fault is a crack in the earth surface where the rock on either side of the fault has moved in different directions. When the surfaces slide against each other suddenly, the energy released can create an earthquake.**

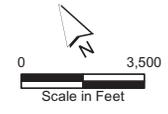
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Source: WA DNR

Parametrix



- Geology**
- Ec(1m), Manastash Formation, continental sedimentary deposits or rocks
  - Ec(2na), Naches Formation, continental sedimentary deposits or rocks
  - Ec(2nas), Naches Formation, sandstone and volcanic rocks of, continental sedimentary deposits or rocks
  - Ec(2r1), Roslyn Formation, lower member of, continental sedimentary deposits or rocks
  - Ec(2rm), Roslyn Formation, middle member of, continental sedimentary deposits or rocks
  - Ec(2ru), Roslyn Formation, upper member of, continental sedimentary deposits or rocks
  - Eva(ss), Silver Pass Member, Swauk Formation, andesite flows
  - Eva(t), Taneum Andesite, andesite flows
  - Evb(t), Teanaway Basalt, basalt flows
  - Evr(na), Naches Formation, rhyolite flows
  - Jog(hb), Hicks Butte, tonalite gneiss of, orthogneiss
  - Jph(d), Darrington Phyllite, phyllite, low grade
  - Jsh(s), Shuksan Greenschist, schist, low grade
  - Ovc, ---, volcanioclastic deposits or rocks
  - Qa, ---, alluvium
  - Qad(e), Evans Creek Drift, alpine glacial drift, Fraser-age
  - Qf, ---, artificial fill, including modified land
  - Qls(m), mass-wasting deposits, other than landslides, mass-wasting deposits, other than landslides
  - Qls, ---, mass-wasting deposits, mostly landslides

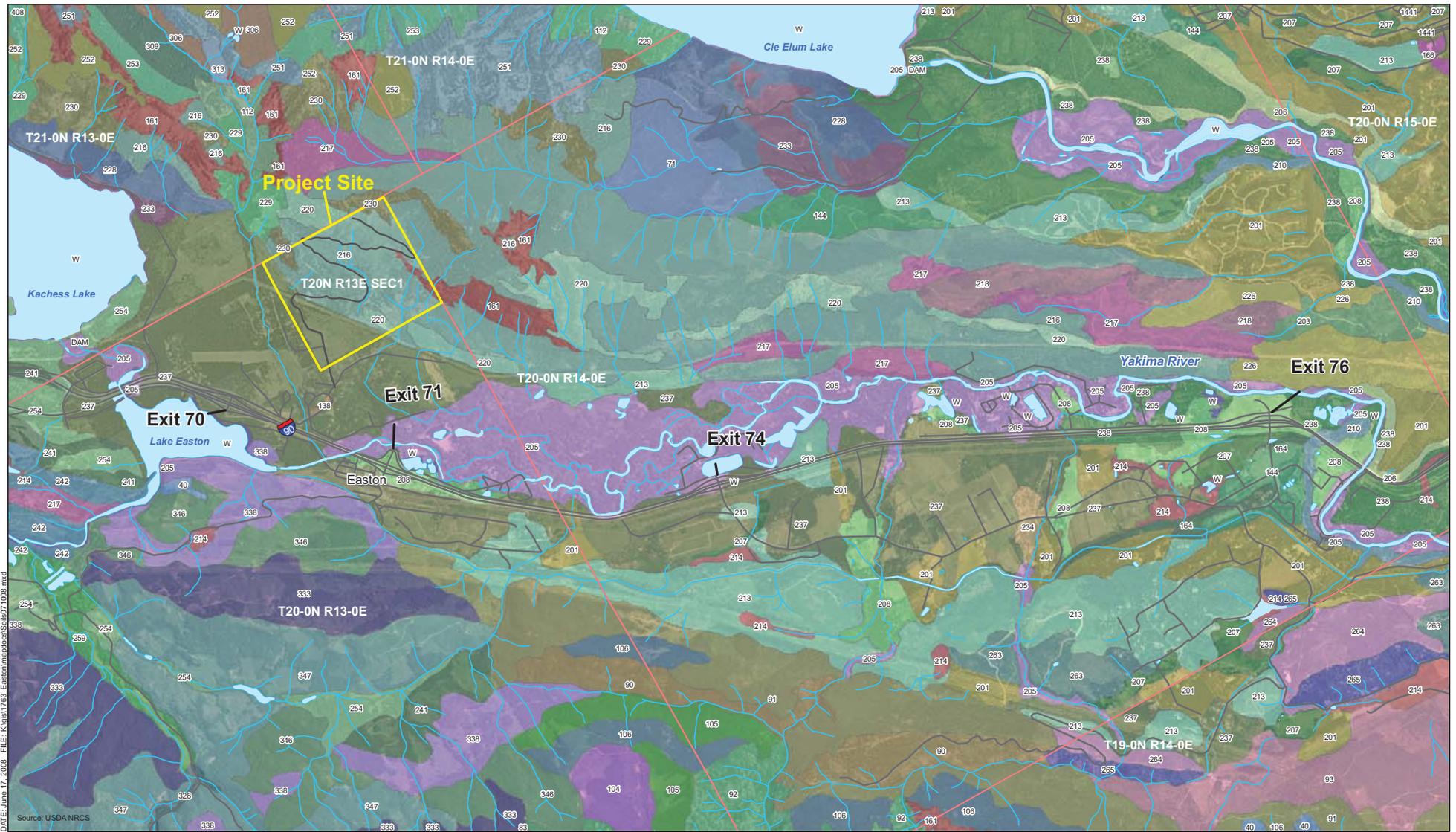
- Legend**
- Township Boundaries
  - Road
  - Stream
  - Lake

**Figure 3-30**  
Marian Meadows  
Vicinity Geology

**Table 3-36. Soil Properties at the Marian Meadows Site**

Soil name	Approximate percent of site	Soil type	Parent material	Infiltration rate	Natural drainage class	Erosion Factor, T	Wind erodability group	Shrink-swell potential	Ponded	Water saturation in upper 72 inches
Kladnick	24	ashy sandy loam	glacial outwash with a mantle of volcanic ash	high	Well-drained	3	2	Low	N	N
Roxer	68	gravelly ashy sandy loam	from basalt and glacial till with a mantle of volcanic ash	moderate	Well-drained	5	3	Low	N	N
Roxer Complex (Roxer 45% and Roxer-basalt substratum 55%)	2	gravelly ashy sandy loam/ basalt substratum	basalt colluvium and glacial till with a mantle of volcanic ash	moderate	Well-drained	3/5	3	Low	N	N
Rock Outcrop/Roxer Complex	4	--/as above	--/as above	very slow/moderate	--/Well-drained	--/3and5	--/3	--/Low	N	N
Rock Outcrop	2	--	--	very slow	--	--	--	--	N	N

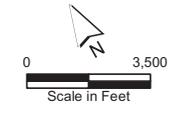
Source; USDA (2008)



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Source: USDA NRCS

Parametrix



- Legend**
- Project Site
  - Township Boundaries
  - Lake
  - Road

**Figure 3-31**  
Marian Meadows  
Vicinity Soils Map

Rock outcrop occurs in a small portion of the Marian Meadows development site as unweathered rock or a mixture of Roxer Complex soils and rock outcrop (NRCS 2008).

## 2 What risks or hazards are associated with geology, topography, and soils?

Geologic and natural hazards that could potentially affect the Marian Meadows development site include seismic activity and erosion hazards such as landslides or other types of mass movements.

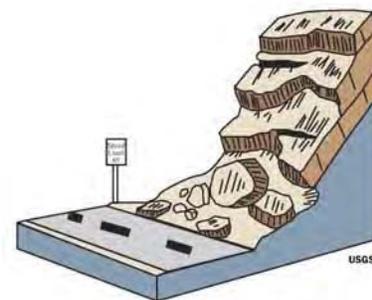
### *Landslide Hazards*

Landslide hazard areas are those portions of the landscape that have existing landslides or are at risk of future landslides. Mass movement (also called mass wasting) is the more general classification that includes landslides. Mass wasting involves the downward and outward movement of slope-forming materials such as rock, soils, artificial fills, and combinations of these materials (Gray and Sotir 1996). A type of mass wasting is surface erosion, consisting of detachment and transport of individual material particles.

Several mass wasting classification systems are available for detailed studies, but these can be simplified into 1) those that are deeper and typically occur over extended time periods but can occur rapidly during earthquakes, and 2) shallow slides that occur fairly rapidly (Washington Forest Practices Board 1997). The main geological hazards with potential for occurring on the site and in the vicinity are rockfall, translational slides, soil creep, and erosion.

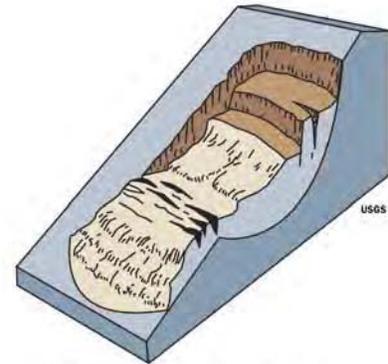
**Rockfall** includes freefall, tumbling, and rolling of fragments of rock or highly compact soils. Rockfalls typically originate from steep cliffs or features created by human activities such as road cuts. Material strength, surface gradient, joint pattern and spacing, geologic contacts, groundwater, and faulting are some of the primary factors related to rockfall occurrence. Run-out from the source area can extend quite far on steep slopes (Norman et al. 1996; Chatwin et al. 1991).

Typically, debris form a wedge or debris fan at the toe of the source area. An example of this feature is the talus slopes on the site. Other rockfall is related to road construction or other human-induced disturbance.



**Rockfall**

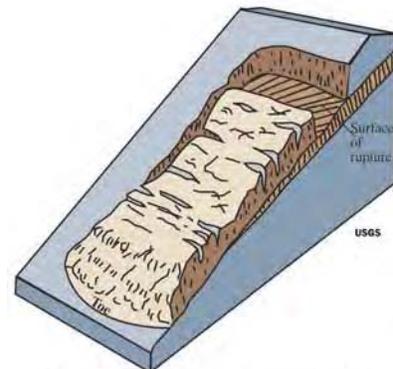
**Deep-seated rotational slides** are relatively deep movements that often occur slowly over time. These slides typically involve deep deposits and have a bowl-shaped or broad curving failure surface with a steep headwall scarp and additional scarps in the slide mass. Rotational slumps can be small, covering only a few yards (as is common along overly steep road cut and fill slopes), or they can be very large, covering many square miles. Source areas are associated with over-steepened valley walls with thick glacial and weathered bedrock deposits, geologic contacts and faults, and areas with concentrated groundwater conditions.



**Rotational landslide**

**Translational slides** occur along relatively shallow, fairly planar failure surfaces. A planar surface is a relatively even sloping surface. Shallow rapid translational slides often occur on shallow deposits over bedrock. Some of the causes of slides include:

- Alteration of the moisture content of the overlying material that forms a lubricated layer between the upper deposits and relatively impermeable deposits below.
- Additional weight on the overlying material that overcomes the friction between the upper and lower surfaces.
- Removal of materials at the toe of a slope that previously held the deposit in place.



**Translational landslide**

Human activities that can contribute to translational slides include:

- Alteration of slopes by development or roads that intercept surface and shallow groundwater.
- Removal of vegetation that increases surface runoff and shallow groundwater.
- Diversion and concentration of increased water runoff down steep slopes that reduces stability of the surface soils. (Montgomery et al. 2000; Bunn and Montgomery 2004; Church 2002; Gomi et al. 2002; Dunne and Leopold 1978; and others).

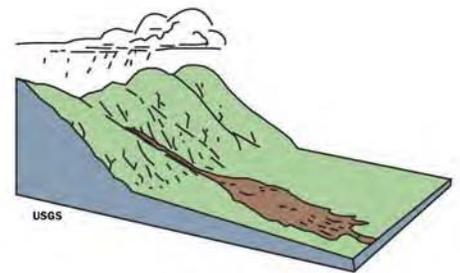
**Soil creep and raveling** are ongoing gradual movements of slope materials. Over many years, soil creep and raveling result in the accumulation of thicker soils at the lower portions of slopes and concave hollows. Motion is too slow to present a safety hazard but developments that require cutting into steep slopes need to plan for maintenance related to raveling and soil creep.

**Debris flows and alluvial fans** refer to the mechanism and the typical deposit of these types of geological hazards. They are generally associated with an episode of high water runoff that can be associated with storms, or they may be associated with other landslide types that suddenly release a large amount of mixed earth and water that move rapidly downhill. The characteristic deposit is the alluvial fan that is found at the point where a steep valley reaches a valley bottom and drops its load of heavy materials, spreading out in a fan shape. There is an

alluvial fan at the foot of the ravine that drains the central portion of the project site as indicated on Figure 3-32, an additional smaller fan near the northern property line, and an additional off-site fan at the foot of the drainage that traverses the southern portion of the site.

Erosion is the wearing away of the land surface by running water, wind, processes of mass wasting and corrosion (solution and other chemical processes), as well as waves or moving ice. The term "geologic erosion" refers to natural erosion processes occurring over long (geologic) time spans. "Accelerated erosion" generically refers to erosion that exceeds what is presumed or estimated to be naturally occurring levels, and which is a direct result of human activities.

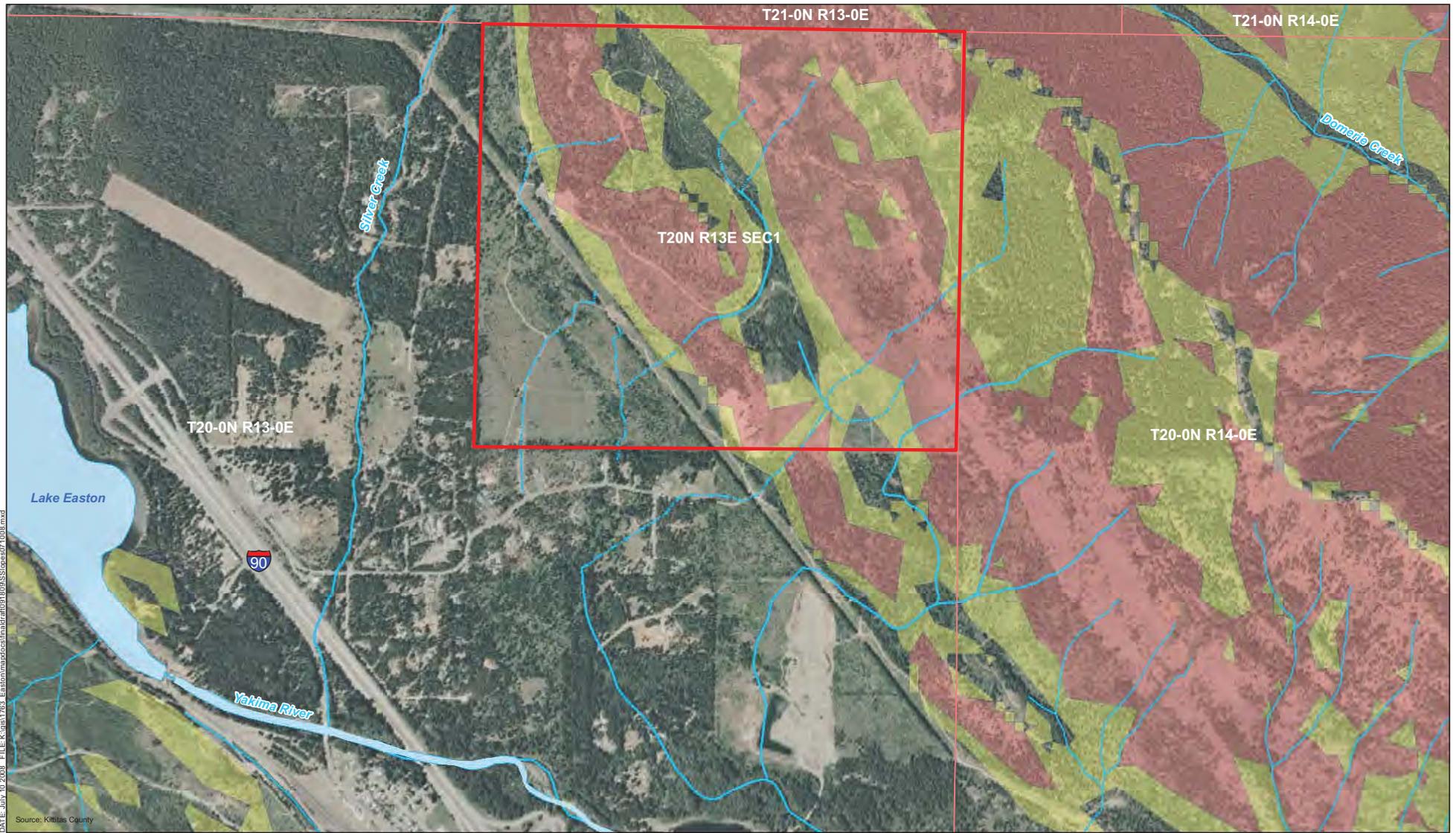
Undisturbed areas of the Pacific Northwest typically have dense vegetation, decomposed organic material, and loose surface soils. These features reduce surface water runoff and associated erosion and rilling. Water runoff and erosion can occur when vegetation or surface soil layers are removed. If left unchecked, erosion areas can grow into problem areas, delivering significant amounts of sediment to lakes, streams, downslope properties, and wetlands, and possibly leading to landslides. Erosion is also related to channel migration, volcanic activity, lakeshore processes, agriculture, and clearing and grading.



**Debris flow**



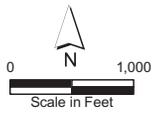
**Alluvial fans**



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Source: Kittitas County

**Parametrix**



**Legend**

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| <span style="border: 2px solid red; display: inline-block; width: 15px; height: 10px; vertical-align: middle;"></span> Project Site                        | <b>Streams</b>   | <span style="background-color: yellow; border: 1px solid black; display: inline-block; width: 15px; height: 10px; vertical-align: middle;"></span> Hazardous Slope   |
| <span style="border: 1px solid red; display: inline-block; width: 15px; height: 10px; vertical-align: middle;"></span> Township Boundaries                 | <span style="color: blue; font-size: 2px; text-decoration: underline wavy;">-----</span> Intermittent Stream | <span style="background-color: red; border: 1px solid black; display: inline-block; width: 15px; height: 10px; vertical-align: middle;"></span> Greater than 50% Slo |
| <span style="background-color: lightblue; border: 1px solid blue; display: inline-block; width: 15px; height: 10px; vertical-align: middle;"></span> Lakes | <span style="color: blue; font-size: 2px; text-decoration: underline wavy;">—————</span> Perennial Stream    |  |

**Figure 3-32**  
Marian Meadows  
Steep Slopes and Geologic Hazards

Vegetation, landform shape, slope gradient, slope length, soil type, rainfall intensity, drainage conditions, and other factors affect erosion rates. Undisturbed areas on the upper eastern slopes of the mountainous areas of the Cascade Mountains typically have dense vegetation, decomposed organic material, and loose surface soils. These features reduce surface water runoff and associated erosion and rilling. Slope gradient, slope length, and the shape of the slope affect the rate of erosion through the extent to which gravity acts on the movement of soil particles, the rate at which water moves across slopes, and the extent to which water flows are concentrated into rills and gullies. Soils that are impermeable or minimally permeable generate surface water runoff with lower intensity rainfalls and begin to erode sooner than very porous soils. Most soil types can erode when disturbed, but not all erosion is transported to adjacent properties or surface waters. Consequently, the proximity to surface waters is a component of the type or level of risk associated with erosion hazard areas.

A landslide hazard study of the Kachess Watershed, by the Washington DNR's Forest Practices Division, identified and mapped landslides and rated the hazard potential (Powell 2005). This assessment estimated that at least 69 percent of the mass-wasting features identified were in clear-cuts less than 5 years old. This correlation between mass wasting and clear-cuts may be due to the difficulty of identifying mass wasting features under forest canopy. The most common landslides were shallow landslide failures in clear-cut areas and on toes of deep-seated landslides located along stream drainages and in inner gorges. Generally, landslides were larger and deeper on the west side of Kachess Lake compared to the east side. Although the slopes are steeper on the east, they are generally more stable, possibly resulting from the dip-slope orientation of the strata.

**Seismic hazards** are another term for hazards related to earthquakes. Earthquake hazards are related to the presence of faults where sections of the earth surface move in different directions. The largest regional fault zone is the Cascade subduction zone that has the potential to produce earthquakes of a magnitude of 8 about every 500 years. The effect on sites in Eastern Washington may be attenuated somewhat by distance from the expected epicenters off the Washington coast (Frankel 2007). Most earthquakes in the Cascade Mountains have been relatively shallow. Reconstructions of the 1872 North Cascades earthquake, the largest historic earthquake in Washington, suggest an epicenter near Entiat with a magnitude of 6.8 (Bakun et al. 2002). In the Easton area, Modified Mercalli Intensities (an index of property damage on a scale of 1 to 12) are reported as between 6 and 7 (Coombs et al. 1976; WPPSS 1977). A Mercalli scale intensity 7 earthquake results in negligible damage in buildings of good design and construction, slight to moderate in well built ordinary structures, and considerable in poorly built or badly designed structures, with some chimneys broken.

Risks associated with earthquakes include (Noson 1988):

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**What is the Mercalli Scale?**

**The modified Mercalli scale is used to describe the intensity of an earthquake on a scale of 1 to 12.**

**Lower numbers on the intensity scale generally describe how an earthquake is felt by people (1 is not felt by people). The higher numbers on the scale describe observed structural damage (12 is nearly total damage and destruction of**

- Structural damage to buildings may result from the forces of the earth movement.
- Landslides and rockfalls may be triggered during earthquakes. Many areas of unconsolidated soils that are normally stable may become unstable during earthquakes. Areas of rock that are stable under normal conditions may fail with ground shaking.
- Liquefaction occurs when sand or silt saturated with water is shaken violently enough to become “quicksand.” The liquefied material may then cause lateral-spread landslides or loss of bearing strength under foundations or roadways, depending on the depth and thickness of the liquefied zone and local topography. The groundwater table is generally low enough in the project area to avoid this occurrence; however, local areas of high groundwater may occur in relation to inflow of water in the alluvial fan.

The greatest potential for seismic hazards on the site is rockfall and shallow landslides.

### **3 What policies and standards address geological hazards?**

The GMA directs cities and counties to designate critical areas (RCW 36.70A.170) and adopt development regulations that protect critical areas (RCW 36.70A.060). Critical areas include geologically hazardous areas (RCW 36.70A.030[5][e]) that are defined as “areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns” (RCW 36.70A.030[9]).

WAC 365-190-080(4)(a) provides additional guidance and generally directs that some geological hazards can be reduced or mitigated by engineering, design, or modified construction or mining practices so that risks to health and safety are acceptable, and notes that when technology cannot reduce risks to acceptable levels, building in geologically hazardous areas is best avoided.

Kittitas County has adopted the following GPOs:

#### **Erosion/Landslide Hazards**

GPO 2.76 Design provisions should be adequately reflected in the Kittitas County Building Code.

GPO 2.77 Natural resource-based access and activities should not be unduly restricted or prohibited in areas of known geologic hazards.

GPO 2.78 Risk of erosion should be considered accordingly throughout Kittitas County, based on localized rainfall average.

GPO 2.79 Kittitas County recognizes the policies of the proposed Snoqualmie Pass Subarea Comprehensive Plan regarding Snow Avalanche Hazard Areas, including possible hazards outside of the Snoqualmie Pass subarea.

## Seismic Hazard Areas

GPO 2.80 Because of existing Kittitas County Building Code, the risk from tertiary effects does not indicate an unusual hazard at this time.

## Volcanic Hazards

GPO 2.84 The planning of volcanic hazards should be addressed through Kittitas County emergency management procedures, better planning of warning, and emergency communications.

GPO 2.85 Manual disposal of ash fallout into bodies of water shall not be allowed; alternatives for the handling and disposal of ash fallout should be considered by Kittitas County in emergency management procedures.

*Development standards* in the zoning code include the following:

**17A.06.010 Kittitas County Uniform Building Code.** The Kittitas County adopted version of the Uniform Building Code contains provisions for geologically hazardous areas and shall apply to all such areas (Ord. 94-22 [part], 1994).

**17A.06.015 Areas requiring specialized engineering.** Areas identified as high risk erosion/landslide geologic hazard areas, including cliff or talus slopes, may require specialized engineering to ascertain the property is suitable for development purposes. The director is authorized to require such engineering (Ord. 94-22 [part], 1994).

**17A.06.020 Natural resource based activities.** Natural resource based activities shall not be unduly restricted or prohibited in areas of known geologic hazards (Ord. 94-22 [part], 1994).

**17A.06.025 Areas of snow avalanche hazards - Snoqualmie Pass.** In conjunction with the Uniform Building Code, Kittitas County shall enforce the policies contained within the Snoqualmie Pass Subarea Comprehensive Plan for avalanche hazard areas (Ord. 94-22 [part], 1994).

**17A.06.035 Disposal of volcanic ash fallout.** Intentional disposal of volcanic ash fallout into any bodies of water shall not be allowed (Ord. 94-22 [part], 1994).

**Building Code.** The county has adopted the International Building Code, which includes standards for design and construction for seismic hazards. The Building Code has general standards for foundations that address the stability of underlying soils (1802) and footings on or adjacent to slopes (1805.3). The building code does not provide guidance to determine whether technology will reduce risks to acceptable levels, or whether building in a specific geologically hazardous area is best avoided.

## 4 How would geology, topography, and soils pose risks or hazards to facilities or persons living in the proposed project area?

The geology of the site has not been subject to detailed assessment. The assessment of risk from geologic hazards is analyzed in terms of the potential exposure to risk from the alternative PUD densities and pro-

forma layouts from the perspective of whether potential building areas are exposed to high risk areas. This comparative analysis does not take the place of detailed geotechnical analysis at the time of specific subdivision and other development proposals.

The project site was not explicitly mapped by DNR; however, hazard ratings for different types of landforms can be applied to the site. The western flat portion of the site has negligible geologic hazards (except for potential seismic hazards discussed below). The steep sloping eastern portion of the site has moderate to high potential rockfall and landslide and erosion hazard related to slope and soil type.

The on-site activity with the most extensive effects on existing topography and underlying geologic deposits is road construction on the eastern portion of the site. New roadways would be needed to meet current county grade standards. Existing logging roads on the site are generally too steep to meet subdivision standards. This would result in an entirely new roadway across very steep slopes from near the northern property line to the existing saddle or swale about a third of the way up the site. Other new roadways would be required in the steep sloping area in the eastern section of the site and on steep slopes in central portions of the site. Because of steep cross slopes, the area disturbed for side slopes for roadways would be extensive.

**Erosion.** Any disturbance of ground cover would increase the potential for erosion. Development of roads and housing on steep sites increases initial exposure because of the large area needed to “catch the slope” when creating a flat surface such as a road on a steep slope. On a 15 percent slope, the construction of a 26-foot-wide road surface with an uphill roadside ditch for drainage would result in a 2 to 1 side slope on either side that would extend about 5.50 feet to the point of intersection with existing grade. On a 30 percent slope, this lateral extent would be about 11 feet, on a 40 percent slope about 15 feet, and on a 70 percent slope about 25 feet. There is also the potential for erosion from existing logging roads on the site that have not been adequately stabilized prior to retirement. Many of these roads currently exhibit severe gullying. There is also the potential for erosion from continued ORV use on existing logging roads on private and public lands. Of particular concern to the City of Roslyn is the potential for water quality impacts from erosion related to ORV use on their watershed, which is within the National Forest. The extent of erosion risk on public lands is likely to be most effectively addressed by enforcement of the Forest Service Motorized Travel Management program currently under development. After adoption, ORVs or snowmobiles would be prohibited in certain areas, likely including the watershed. The effectiveness of this program will depend on enforcement.

**Landslide and Rockfall.** The potential for landslide is dependent on the character of underlying unconsolidated deposits and also on the dip slope of underlying bedrock. Deposits that are stable under natural conditions can be rendered subject to movement by a variety of human alterations including removal of materials from the toe of the slope, additional loading on the slope from the weight of fill for roads or homes, or through lubrication of the interface between permeable and impermeable deposits through changes in surface and groundwater flows from re-routing flows or from impervious surfaces. Information on the steeper eastern portion of the site is not well enough known to accurately assess risk

and would need to be assessed on a case-by-case basis with infrastructure and housing construction. It is possible that there are large areas subject to landslide, but more likely that smaller isolated shallow landslide failures would occur.

Rockfall hazards are present in any case where bedrock is disturbed on slopes and rock is not removed to a stable surface. There are, however, limitations on the accuracy of field work and assessment in reliably identifying the extent of removal needed to achieve a stable rock face. Rockfall is common in the area and is present on the site, as indicated in Figure 3-33, on existing logging roads on the eastern portion of the site. These roads, however, were constructed to lesser standards for temporary use than would be expected for permanent subdivision roads.

Seismic and rockfall hazards are increased during seismic events that may mobilize otherwise stable formations.

**Figure 3-33 Existing Rockfall on Marian Meadows Site**



**Avalanche.** Avalanche danger is present in any area with steep slopes and high snow accumulation. There are no landslide chutes identified on the property. However, areas of bedrock may mask the presence of snow movement because trees that otherwise would be displaced are not present. Large scale clearing of steep areas can lead to increased avalanche hazard through removal of trees and vegetation

that otherwise immobilize snowfall and prevent its movement under natural conditions. Current information indicates a relatively low risk of avalanche on the site, based on current information.

**Potential Risk.** The potential risk to persons and properties from geologic hazards, other than alluvial fans and debris flow, is limited to the steeper eastern portion of the site and the portion of the flat site close to steep slopes and rock faces where falling rocks could move a substantial distance prior to coming to a risk. The risk to individuals is likely to be episodic from individual unexpected events of limited extent, rather than to landslides or earth movement over a large area. Persons living in an area of landslide, rockfall, or alluvial fan hazard, however, are exposed to a low level of probability of occurrence over a long period of time, which can lead to a relatively higher risk to a given individual.

The greatest potential for seismic hazards on the site are rockfall, shallow landslides, and debris flow across alluvial fans and water flow downgradient of the fans where water is likely to flow after dropping sediments on the fan.

The geology of the site has not been subject to detailed assessment. Detailed geotechnical assessment is most appropriate at the time of preparation of detailed subdivision plans with road and lot layouts. The assessment of risk from geologic hazards is analyzed in terms of the potential exposure to risk from the alternative PUD densities and pro-forma layouts from the perspective of whether potential building areas are exposed to high risk areas. This comparative analysis does not take the place of detailed geotechnical analysis at the time of specific development proposals. **Alternative 1** would involve residential development on the entire site. This alternative has the greatest potential impacts from geologic hazards due to the extent of disturbance from road construction and future residential construction on the steep slopes in the eastern portion of the site. In addition, approximately 50 to 100 lots on the western portion of the site are exposed to extreme hazard from alluvial fans and debris flow.

**Alternatives 2, 3C, and 5** would have much less potential impact from geologic hazards due to avoidance of the steep eastern portion of the site where the majority of hazards exist. Alternative 5 also substantially reduces potential risk on the western portion of the site by eliminating development within alluvial fan and debris flow areas. Alternative 3C has lot sizes of sufficient size that provision could be made for avoidance of alluvial fan and debris flow areas while allowing building on portions of the lots outside the hazard areas.

**Alternative 3A, 3B, and 3D** would involve residential development on the entire site. These alternatives would have substantial potential impacts from geologic hazards due to the extent of disturbance from road construction and future residential construction on the steep slopes in the eastern portion of the site. The potential risk of Alternative 3D is only slightly less because of fewer larger lots because disturbance from the road system is likely to be similar. These alternatives would substantially reduce potential risk on the western portion of the site by eliminating development within alluvial fan and debris flow areas.

**Alternative 4** would have less impact on the steep eastern portions of the site than Alternatives 1, 3A, 3B, and 3D because development on the steep eastern portion of the site is clustered to avoid the most

sensitive portions of that area. This alternative substantially reduces potential risk on the western portion of the site by eliminating development within alluvial fan and debris flow areas.

The proposed mini-storage development is located to a large extent on alluvial hazard and flow hazard areas. The portion on the alluvial fan is subject to a high level of hazard with little potential for avoidance because of the unpredictability of such events. The development of residential use on the site to the west increases the potential for hazard from debris flow conveyance on the mini-storage to the extent that channeling flows to avoid residences concentrates flows in the area of the mini-storage.

## **5 What potential is there for utilizing mineral resources on the site?**

As indicated above, deposits on the valley floor are unconsolidated including glacially deposited glacial gravel and sand outwash and alluvium (water-carried deposits) consisting of moderately sorted cobble gravel along the rivers and poorly sorted gravelly sand on small alluvial fans where streams discharge from the hillsides (Tabor et al. 2000). Based on information from well logs, basin-fill sediments in the area are less than 200 feet thick consisting of coarse sands and gravels (Jones et al. 2006). The existing abandoned off-site gravel pit just south of the intersection of Pit Road and Sparks Road provides a readily accessible view of the characteristics of this deposit.

The Ellensburg Cement Products Company maintains a surface mine for concrete aggregate about a mile south of the site. The underlying deposits in this area are likely to be similar to the Marian Meadows site, although surficial deposits are characterized by more recent fluvial deposits from the Yakima River. If tests confirmed that gravel deposits on-site had suitable hardness and chemical constituents for aggregate, standard pit-excavation of gravels could be developed on the southern two-thirds of the Marian Meadows site.

There also are extensive areas of exposed bedrock on the site that are largely Teanaway Formation basalt, basaltic tuff, and breccia. The western edge of the steep portions of the site includes talus slopes of rocks formed by rockfall from above. Bedrock can be mined by blasting and crushing to provide aggregate that may be used for base or surface courses on roads, and may be used as aggregate in asphaltic concrete. There is an existing area on site that was used by Plum Creek Timber Company as a quarry. The use on private logging roads, however, is not an indication that aggregate produced from that source meets accepted industry standards. Logging roads are generally used intensely for short periods of time and are not designed to the same standards as permanent facilities. If the bedrock on the site meets standards for aggregate, much of the steep eastern portion of the site could be utilized for extraction.

Use of crushed basalt or gravels for road and other purposes is dependent on its hardness and chemical composition. Typically, aggregate resources are subject to standards for resistance to abrasion and degradation. Abrasion standards are designed to set standards for the hardness of the rock and the resistance to withstand grinding actions during mixing, handling and transportation, as well as from traffic loads. Chemical tests are designed to measure the extent to which aggregate is subject to weathering from cyclic wetting and drying. Most public agencies in Washington State require aggregate

to meet specifications developed by WSDOT, which have specific standards for gradation and size, toughness and abrasion resistance, durability and soundness, particulate shape and surface texture, specific gravity, and chemical reactivity (WSDOT 2010).

Of particular interest for gravels from the alluvial deposits in the area as a potential source of aggregate for concrete or in crushed form for asphalt concrete, is chemical constituents on the matrix coating on the gravel clasts. In large portions of the Yakima River Valleys, the matrix coating on gravels have a high percentage of silica and a strong alkali-silica reactivity or iron-oxide precipitate which tends to result in low strength adherence of the cement mortar to the gravel aggregate (Barksdale 1991).

Extraction of aggregate on the site would have a variety of potential impacts on nearby land use and terrestrial habitat relating, largely due to noise and vibration impacts, as well as the change in topography and land cover and aesthetic concerns. Noise and vibration are typically produced by equipment used to extract and process aggregate, as well as heavy trucks used for transportation. Blasting required for utilization of bedrock also has very specific noise and vibration impacts that tend to affect a larger area than other operations. Kittitas County employs a CUP process to determine whether such a use is essential or desirable to the public convenience and not detrimental or injurious to the public health, peace, or safety or to the character of the surrounding neighborhood (KCC 17.60A.010).

All alternatives may be regarded as eliminating the potential for extraction of alluvial gravel resources on the site by covering the resource with infrastructure and residential land uses that would make extraction infeasible. The exception may be the open space areas in ASZ 4 included in Alternatives 4 and 5. Bedrock extraction on the steep eastern portions of the site not actively used by residences may be technically feasible; however, the development of residences in close proximity would result in substantial noise and vibration impacts on nearby residences, both on- and off-site. Bedrock extraction on the steeply sloping portions of the site farther to the east above elevation 2,500 feet may have reduced noise and vibration impacts on residences on the lower, western portion of the site, due to distance, and topographic screening that may be deemed acceptable. Transportation from the upper portions of the site would involve additional expense and risk to operators. Development of the site prior to aggregate extraction would reduce the probability that mining would be considered to meet standards for public health, peace, or safety or to the character of the surrounding neighborhood. Aggregate extraction may be a feasible interim use with residential development located on the site after reclamation; however, topographic modification and removal of vegetation may make such areas less desirable for residences.

The mini-storage development east of the BPA easement is generally located on underlying alluvial or talus deposits as well as an active alluvial fan. Its development may be considered to reduce or eliminate the potential for extraction of alluvial gravel resources for aggregate. The driveway and buildings, however are generally located far enough from bedrock that it would not preclude exploitation of the resource. The use also would not be as sensitive to noise, vibration, or other proximity impacts as residential use.

## **6 What measures may reduce the effects of geology and soils on facilities and persons in the proposed project area?**

Based on the limited assessment of on-site conditions and assessment of the potential exposure to risk, avoidance of development on the steep-sloping eastern portions of the site is the most effective means of reducing the risk to infrastructure, housing, and the people who use them. Alternatives 2 and 5 avoid the steepest portion of the site where rockfall and shallow landslides pose the greatest potential risk.

Alternatives 2, 4, and 5 also avoid areas of potential debris flow and alluvial fans.

In addition, the portion of the flatter eastern portion of the site where rockfall or landslides may be deposited is at risk and includes the area generally east of and including the BPA transmission line easement.

If development is approved on the steeper eastern portions of the site, appropriate geotechnical evaluation that may be implemented prior to consideration of a specific subdivision design and roadway layout and during construction is essential to identifying and implementing appropriate risk-reducing measures.

Evaluation during construction is essential because the nature of underlying geologic deposits cannot be accurately assessed from surface conditions without extensive subsurface investigation. The alternative of extensive subsurface drilling to characterize subsurface conditions is effective but very expensive.

Monitoring during construction with provisions to revise construction plans to meet specific performance standards is equally effective, if unforeseen conditions are adequately identified and mitigated. These measures can have unforeseen consequences on the amount of grading and vegetation removal.

Construction practices that over-excavate uphill areas of potential landslide or rockfall would reduce the risk of failure, but at a much greater cost of construction and with much greater displacement of vegetation. If not effectively stabilized, such cleared areas also would result in additional erosion.

## **3.12 SURFACE WATER RESOURCES**

### **1 What surface water resources are present in the project area?**

The Marian Meadows development site is located in the Easton sub-basin of the upper Yakima River watershed, EPA Hydrologic Unit Code (HUC) 17030001. The Yakima River watershed, upstream from Easton, covers approximately 188 square miles (USGS 1991), of which approximately 64 square miles are the Kachess River and Kachess Lake watershed.

The U.S. Geological Survey (USGS) has monitored stream flow for the Kachess River at Easton (Gaging station 12476000) from 1904 to 1978 and for the Yakima River at Easton (gaging station 12477000) from 1910 to 1915 and from 1941 to 1955.

Silver Creek, a tributary of the upper Yakima River, has headwaters on Kachess and Easton Ridges. A portion of Silver Creek lies located approximately 0.25 mile west of the Marian Meadows development site. The creek's discharge has not been gauged.