Strata-Design
1087 Lewis River Road #309
Woodland, WA 98674
D. 360-225-3945
C. 971-201-7359
Email: rickthrall@strata-design.com
www.strata-design.com

December 8, 2020

Mr. Ross North
227 NE Main Street
Battleground, WA 98604

Sent via e-mail: ross@newhcontracting.com

Re: Geotechnical Assessment – Future Lot 2
Cowlitz County Parcel 508890100
SCOTT HILL ROAD, Woodland, WA 98674

Strata-Design Project No. 20-0212.2

Dear Mr. North,

This report summarizes the results of Strata-Design's (STRATA) geotechnical assessment for the proposed residential project in Woodland, Washington, at the location shown on Figure 1. Our work was completed in accordance with our recent discussions regarding the conceptual short plat shown of Figure 2. We completed a previous comprehensive study of the overall parcel which includes Future Lot 2[1]. This present project plan has apparently replaced the previous apartment complex plan.

We understand that you have purchased the property with the intent of building on the Lot 2 site (Figure 3). Figure 3 shows a LIDAR view with topography of the site and active landslides superimposed on the LIDAR image. As shown on Figure 2, we identify two proposed building sites on the parcel (Future Lot 1 and Future Lot 2). This report consists of an assessment of Future Lot 2. An assessment for Future Lot 1 has been completed and released to you under a separate cover on December 7, 2020.

We understand that your plan is to construct a wood frame stick-built residence at the elevation site. We understand that access will be from an existing "roughed in" driveway and that associated utilities will consist of connections to City services.

**GEOLOGY AND SURFACE CONDITIONS**

As part of our previous study, we carried out detailed multiple site reconnaissance visits of the entire parcel, including the proposed Lot 2 location. Photos 1 and 2 shows the general condition of the lower site. As shown in Figure 3, The potential building site is located approximately mid-slope adjacent to the base of an approximate 75-foot-high

[1] Report entitled "Proposed Apartment Complex and Access Road, Meriwether Apartments, Parcel No. 508890100 and surrounding areas, Scott Hill Road, woodland, WA.". Report Prepared for: Mr. Ross North. Report Prepared by: Strata-Design, sealed by Dr. Rick Thrall, PE GE. September 2, 2020.

landslide scarp and consists of an approximate 50- to 100-foot-wide relatively flat area at approximate el. 90 to 100 feet. The slope continues to the base of the slope at approximate el. 40 feet. Figure 3 shows the mapped landslide hazards indicating that the Future Lot 2 site is located within "Potentially Unstable Slopes" and is located within the body of a mapped "Deep Seated Landslide Scarp". We have determined in our original report that lower elevation portions of the overall site to the east are actively moving[1]. As such, it is our expectation is that special foundations (such as piles or piers) or a walk-out configuration will be required to create a buildable situation as the subject site.

As detailed in our previous overall report[1], the site is in the Western Cascades geologic province of Washington where bedrock is primarily volcanic rocks associated with the older Cascades volcanic arc. The project site overlies a southeast facing terrace riser to a large gently sloped terrace surface located along the northern side of the Lewis River valley in Woodland. This terrace extends about 3,000 feet southwesterly from the bordering uplands and is up to about 2,000 feet wide.

Recent geologic mapping by the U.S. Geological Survey (Evarts, 2004[2]) shows the terrace is underlain by the silt and sand facies of the Late-Pleistocene age glacial outburst deposits, also known as the Missoula Floods (map unit Qfs). The Missoula Flood (MF) deposits originated from repeated ice dam failures in front of glacial Lake Missoula in Idaho and western Montana; the floods spanned a period between 17,000 and 13,000 years ago. Figure 4 shows the mapped geologic units. Figure 5 shows that the mapped erosion hazard is "Severe". Figure 6 shows a comparison between the 2010 and 2019 lidar maps.

**DISCUSSION**

As indicated, the proposed potential building site consists of a limited size flattened area (Photos 1 and 2) located at the base of a scarp face and within the body of a mapped landslide zone. Our initial observations of the terrain indicate steep ground to the north and south of the site typically associated with a landslide terrain formed over time by ancient landslides. Certain areas of the Pacific Northwest and regions of southwest Washington and northwest Oregon include roughly defined areas of ancient landslide terrain which, as with the subject parcel, are superimposed on various county and statewide maps (Figure 3 for our subject site). Typically, ancient (or deep-seated inactive) landslides are large land wedges with deep failure surfaces which have moved in the past and have reached a secondary limit of stability over time.

The inactive areas are typically considered to be marginally stable because a preferential failure surface has been formed in the subsurface over geologic time, which typically indicates a weak failure zone at depth (i.e. deep-seated). The

[2] Evarts, K., 2004, Geologic Map of the Woodland 7.5 minute quadrangle, Clark and Cowlitz Counties, Washington, U.S. Geological Survey Scientific Investigations Map 2827, 1:24,000 scale.

indicated soil wedges are thus delicately balanced on the hillside and even small changes in loadings or drainage may trigger massive movements.

In the case of your site, Figure 3 shows that the mapped scarp areas are relatively steep. As shown, the wedge of landslide soils (red zone) is massive covering multiple acres including several adjacent parcels. The proposed building site is perched at mid-slope within the landslide mass. The scarp was likely formed by downslope movement of the soil wedge over geologic time. Failure modes at the subject site would likely consist of continued movement of the soils mass from extreme precipitation. We would assume that no excavation would be permitted at the toe of the slope below the Lot 2 site. Excavation at the toe without appropriate stabilization would likely trigger additional sliding.

Our previous drilling indicates that the failure surface at mid-slope is interpreted to be about 50 feet deep[1]. Figure 6 – Vertical Elevation Heat Map, shows that the flattened portion of the building site has not moved significantly between 2010 and 2019. Recent monitoring of the inclinometer casing carried out on 7/31/20 and 10/27/20 indicates no movement and extends the no movement finding (since the 2010 map) to October of 2020. Groundwater monitoring indicates levels hovering around 61 feet depth in the lower aquifer. A possible upper aquifer was identified at about 33 feet depth although no monitoring casing was installed at that depth.

As described, downslope creep movements are expected. Further, larger destructive movements could occur intermittently over geologic time in response to unusually large storm events or design level seismic events. We thus recommend that the stabilization at the Lot 2 location consists of pile supported foundations penetrating below the expected base of the failure plus tie-backs back into the extended scarp area. Due to the depth of the potential failure surface, the residence should be pushed back toward the scarp as much as possible.

The attached stability analysis (Figure 7) shows that the upper slope of the scarp is reasonably stable (FS = 1.4). The overall calculated static FS of the entire slope is 1.16. Under seismic loadings equal to ½ the PGA[1,3], the FS is less than 1.0, thus any residence should be built to remain standing in an earthquake or significant landslide movement (for life safety) but the structure would likely not be useable after the design seismic event or larger movement. The soil parameters for the FS calculation were developed in our previous report[1]. Overall, as shown, landslides such as that existing on your parcel are typically difficult and prohibitively expensive to stabilize for residential use. As such, if building in these areas is contemplated, selective siting, minimal ground disturbance, avoiding drainage changes and building appropriate structures is critical to avoiding large differential movements and potential catastrophic structural failures. In the case

[3] https://asce7hazardtool.online/

of the proposed construction at Lot 2, the base of any foundation elements would need to penetrate a minimum of about 40 feet below the base of the home to develop the minimum FS = 1.16 level. Further, appropriate depth and capacity tie-backs socketed back into the scarp materials to the north would be required. The pile and tie-back design are not part of this report but can be developed once you select a house footprint and location.

Standard Practice in geotechnical engineering is that we roughly determine the probability of a foundation failure within the lifetime of the proposed structure. In the case of residential construction, a reasonable design lifetime of your proposed residential structures can generally be 50 to 75 years. As indicated, our observations of the site indicate the potential for further downslope movement within the design life of the structure. However, if constructed with piles and tiebacks as indicated, the structure will likely protect life safety in the event of catastrophic failure. Further, we would assume that, due to slow creep, yearly periodic inspection and potential maintenance, replacement or additions to the foundation elements are strongly recommended to be carried out on 5-year intervals.

The site should be developed such that there are no ponded water areas or increased water flows over the surface or infiltrating into the subsurface. All trenches should be covered with low permeability soil and sealed so that surface water does not collect and flow into the trenches. Also, gravel backfill sections in trenches should be broken up by low permeability water stops placed on minimum 50-foot centers. All roof drains should be collected and run by tight line pipe to the base of the slope. Paved surfaces should consist of permeable bricks or porous concrete such that storm water is diffused and not concentrated. Under no circumstance should ponds or impounded flows of any kind be constructed within the property. Landscaping that requires watering beyond natural rainfall amounts is discouraged.

If your plans are for a walkout or multiple level residence is planned, retaining walls will be required as part of the overall construction. Retaining wall design is not part of this scope, however, once a site plan is developed, we could provide a proposal for retaining wall design. A Strata representative should be retained as appropriate to confirm that the above recommended items have been accomplished during the design and construction phases of the work.

## GEOTECHNICAL ASSESSMENT CHECKLIST

This letter and attached checklist (Attachment 1) are intended to meet the requirements of the slope hazard provisions of Cowlitz County Ordinance 19.15.150 Sections G and I. The following address the required checklist items, as follows:

**Site Plan** – Figures 1 to 7 shows all required information. No specific site layout has been finalized. However, we understand that the house will consist of a multilevel wood frame residence placed approximately within the building envelope shown on Figure 3.

**Accuracy Statement –** The accuracy and all assumptions of this report are made and relied upon within the standards of the engineering profession.

**Alternatives Analysis** –Alternatives are described in the text of this report.

**Mitigation Plan** – All footings should be pile supported with piles extending at least 40 feet below floor level.

The upper and lower slopes within the construction zone should remain undisturbed as much as possible except where excavations will be supported by retaining walls. It is important to minimize disturbance to the soils and vegetation as much as practical and that the removal of trees or disturbance of vegetation on the slopes is discouraged.

We understand that multiple retaining walls may be constructed into the hillslope to accommodate a tiered or walkout configuration. We understand the retaining walls will be designed by others based on appropriate lateral pressures. Although retaining wall design is not part of this scope, we can provide geotechnical design parameters for the wall once the wall location and layout is determined, if desired.

Drainage surfaces and slopes should be carefully graded and planted. Roof, retaining wall and foundation drains should be collected and transmitted by tight line to the base of the slope below the house. Surface flows should not be concentrated or allowed to flow unimpeded along non-vegetated or stabilized ground. Surface water should not be ponded. In no case should surface flows be allowed to move downslope into the active landslide areas depicted on Figure 3.

**Site Plan (details)**

- Geologic hazards are shown on Figure 3. Figure 4 shows that the site is located within a mapped “Severe” erosion hazard zone.
- Details of the development activity (residential construction) are laid out in the previous text and figures.
- No development should take place outside of the area immediately adjacent to the proposed residential development, retaining wall(s), drainage areas and access road.
- Drainage surfaces and slopes should be carefully graded and planted. Roof drains should be collected and transmitted by tight line into the inside ditch along the access road. Any pipes should extend to the base of the drainage to the north of the site. In no case should stormwater flows be released onto the slope below the house.

**Project Description** – Figures 2 and 3 shows a conceptual layout of the parcel and the proposed residential improvements. The general description of the residence and surrounding construction is included in the above text.

**Feasibility** – The residential construction, as currently planned is feasible assuming our recommendations are followed. We assume standard construction practice per IBC will be carried out in addition to our above

indicated recommendations (i.e., piles with tie-back supported footings, drainage mitigation, multi-level retaining walls, etc.).

**Surface and Subsurface Geology** – The geology information is shown on Figure 4 and is described in the above text.

**Project Relationship to Geologic Hazards.** – The proposed residence location will be constructed within landslide terrain as depicted on Figure 3 and within the above described "severe erosion" hazard area as shown on Figure 5.

**Field Investigation/Reference Information.** – References include the following:

- Cowlitz County EPIC planning clearance website
- Cowlitz County GIS Point Cloud Data from 2010 and 2019
- Multiple site visits beginning spring, 2020.
- Google Earth images
- Washington DNR Website Geology Mapping and adjacent Lidar Maps of the area.
- USDA Website Soils Maps
- General experience with multiple projects in the area

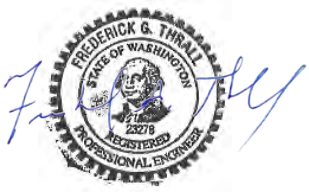
Areas of Avoidance – Construction activities should be confined to the immediate proposed residential site, retaining wall site, access road, and storm drain disposal areas. Construction disturbance of sloping areas outside of those immediate areas is discouraged.

**SUMMARY**

As indicated, we have determined that due, the nature of the potential active landslide, any permanent residential structure would need to be pile supported. We have determined that "The development will not increase the threat of the geological hazard to adjacent properties beyond predevelopment conditions", assuming our above recommendations are followed in specificity.

We trust this document meets your present needs.

Sincerely,
Strata-Design, Inc.




Rick Thrall, PE GE,
Expires 10/09/2022

**Attachments:**
Figures 1 to 7,
Photos 1, 2
Attachment 1 - Checklist

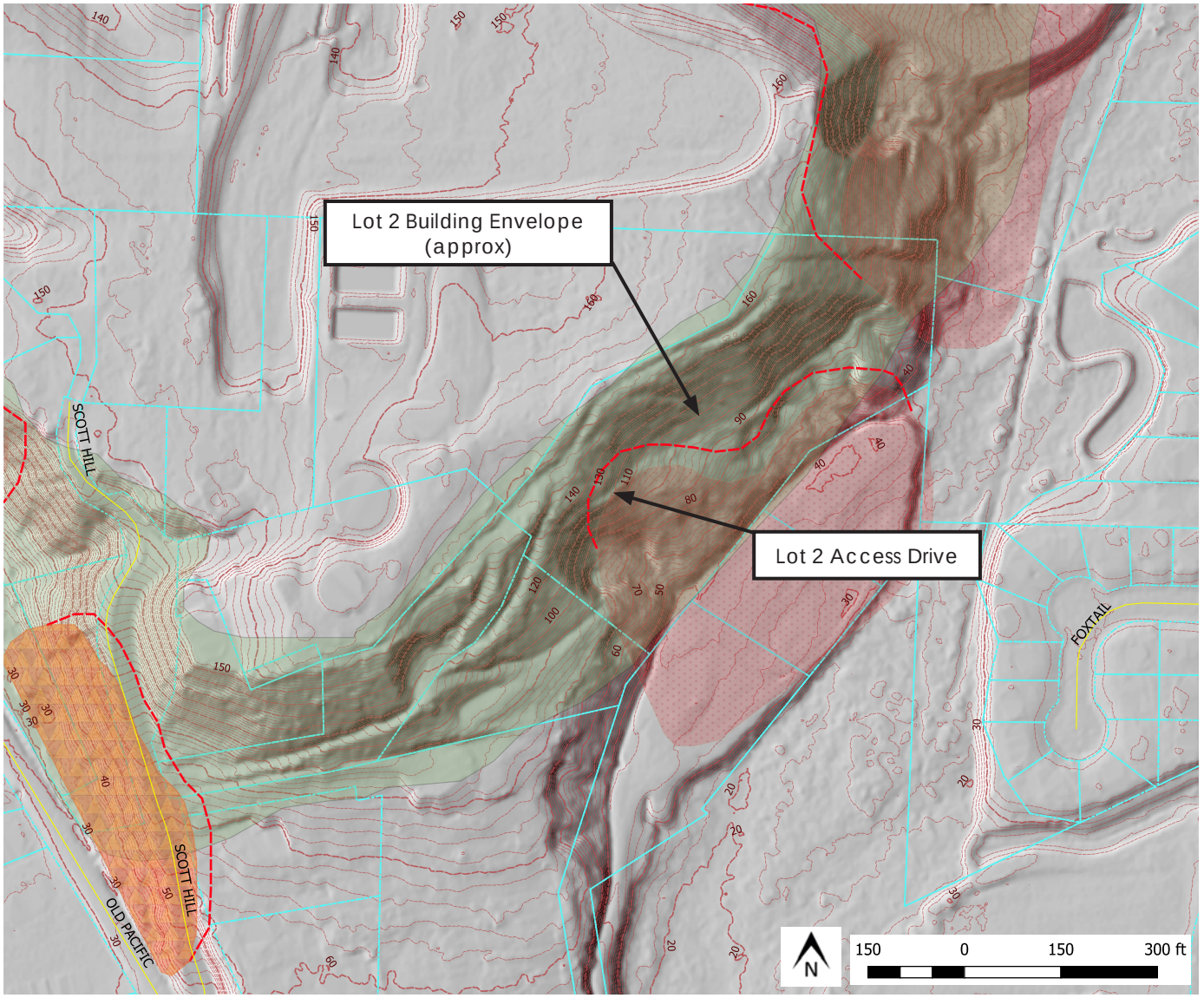

| | | | |
|---|---|---|---|
| STRATA DESIGN | Project: 20-0212.2 | **SITE LOCATION MAP**<br>Woodland Residential Development, Future Lot 2 | **Figure 1** |
| | December 2020 | | |

# Conceptual Short Plat

WOODLAND, WASHINGTON


| | | |
|---|---|---|
| STRATA DESIGN | Project: 20-0212.2<br>December 2020 | **CONCEPTUAL SHORT PLAT-DEVELOPER PROVIDED MAP**<br>Woodland Residential Development, Future Lot 2 |

**Figure 2**




## LOT 2 SITE PLAN

**2- and 10-foot Contour Intervals**

**SCOTT HILL RD**
**WOODLAND, WA**

Job #20-0212.1

STRATA DESIGN

**Legend**

- 10-ft Contours
- 2-ft Contours
- Cowlitz Parcel and Property Lines

DNR Landslides

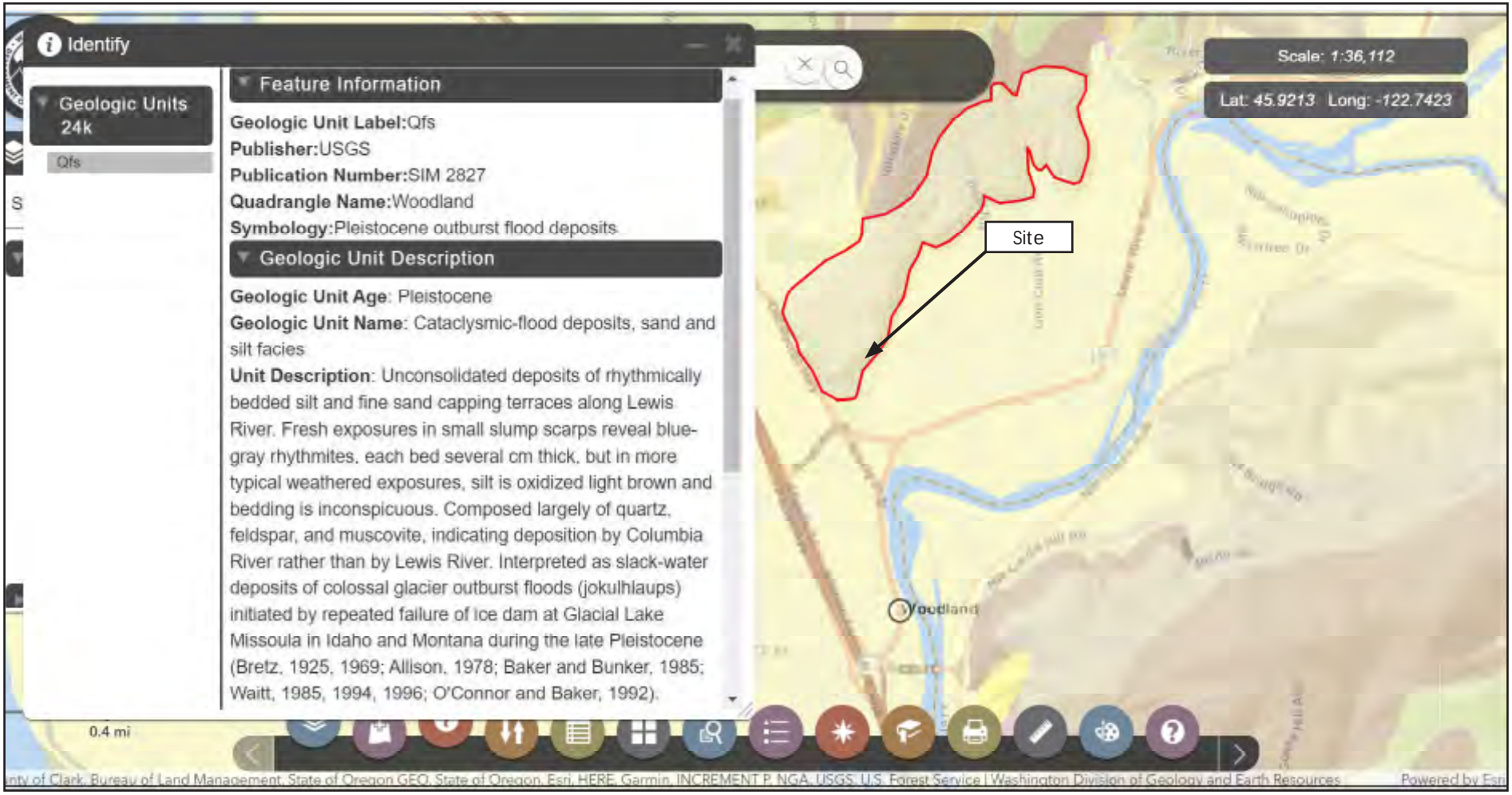
- Active Landslide
- Deep Seated Landslide Scarps
- Spring Locations
- Shallow Landslides
- Sag Ponds
- Potentially Unstable Slopes
- Deep Seated Landslides

Contours derived from 2010 Lidar, from Washington DNR

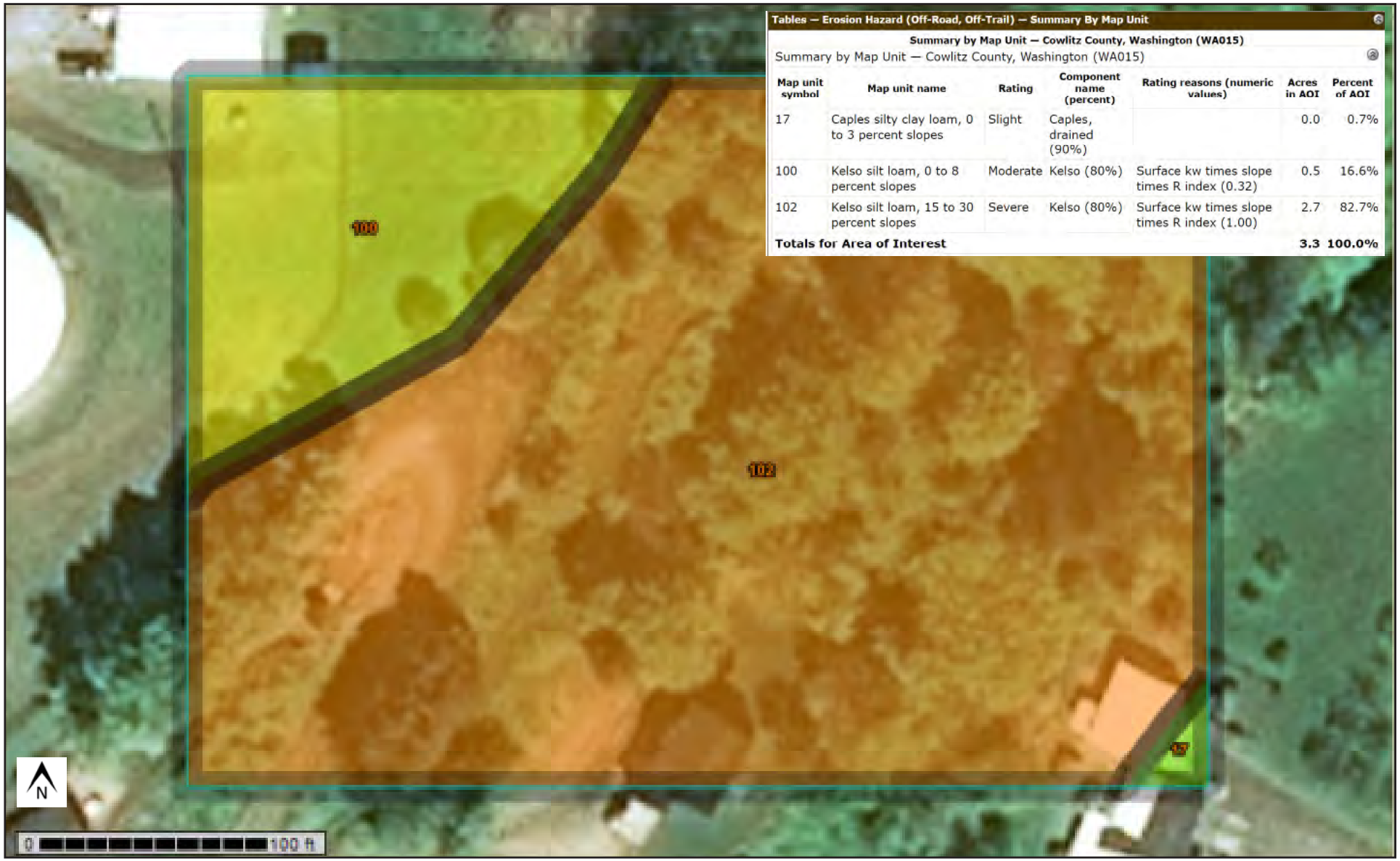
Lot lines and DNR data provided by Cowlitz County GIS Server

**Figure 3**

| | | | |
|---|---|---|---|
| STRATA DESIGN | Project: 20-0212.2 | **LOT 2 SITE PLAN MAP**<br>Woodland Residential Development, Future Lot 2 | **Figure 3** |
| | December 2020 | | |




| | | | |
|---|---|---|---|
| STRATA DESIGN | Project: 20-0212.2 | **GEOLOGY MAP**<br>Woodland Residential Development, Future Lot 2 | **Figure 4** |
| | December 2020 | | |



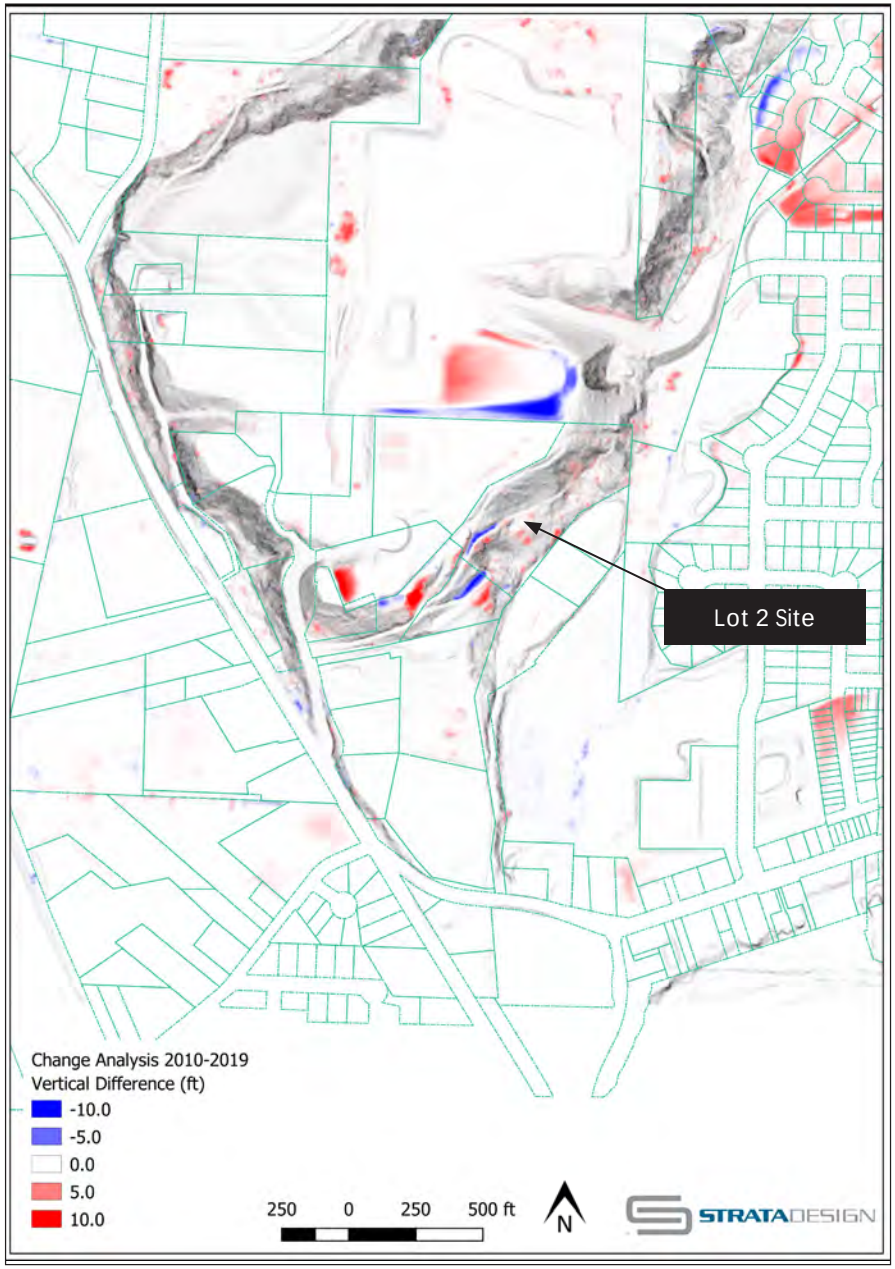

Tables — Erosion Hazard (Off-Road, Off-Trail) — Summary By Map Unit

**Summary by Map Unit — Cowlitz County, Washington (WA015)**

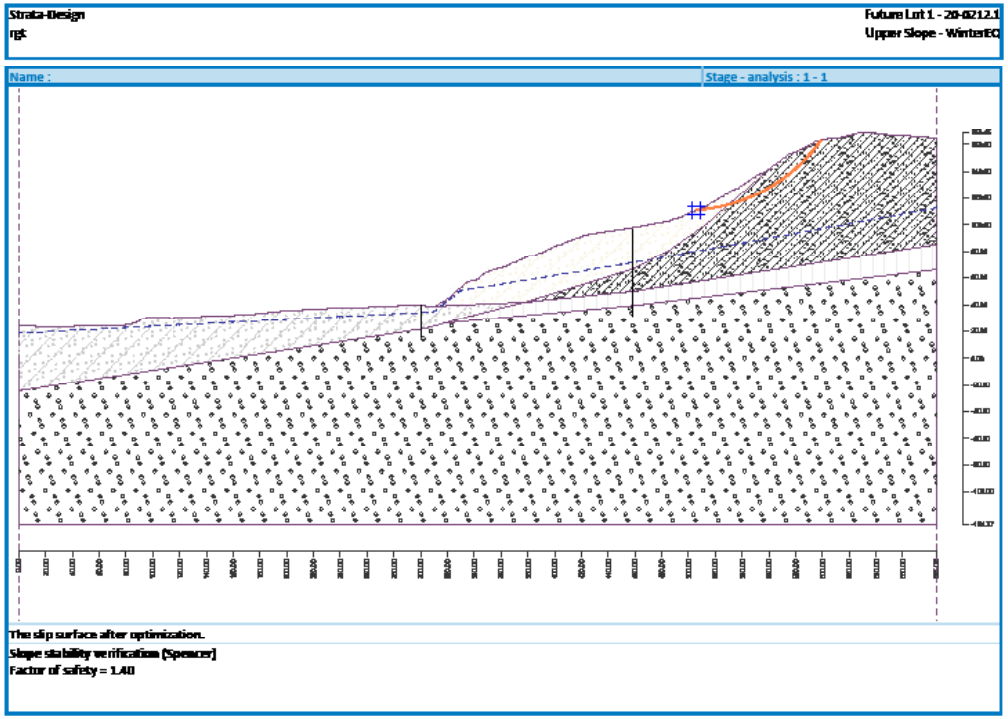
Summary by Map Unit — Cowlitz County, Washington (WA015)

| Map unit symbol | Map unit name | Rating | Component name (percent) | Rating reasons (numeric values) | Acres in AOI | Percent of AOI |
|---|---|---|---|---|---|---|
| 17 | Caples silty clay loam, 0 to 3 percent slopes | Slight | Caples, drained (90%) | | 0.0 | 0.7% |
| 100 | Kelso silt loam, 0 to 8 percent slopes | Moderate | Kelso (80%) | Surface kw times slope times R index (0.32) | 0.5 | 16.6% |
| 102 | Kelso silt loam, 15 to 30 percent slopes | Severe | Kelso (80%) | Surface kw times slope times R index (1.00) | 2.7 | 82.7% |
| **Totals for Area of Interest** | | | | | **3.3** | **100.0%** |

| | | | |
|---|---|---|---|
| STRATA DESIGN | Project: 20-0212.2 | **EROSION HAZARD MAP**<br>Woodland Residential Development, Future Lot 2 | **Figure 5** |
| | December 2020 | | |




| | | | |
|---|---|---|---|
| STRATA DESIGN | Project: 20-0212.2 | **VERTICAL ELEVATION HEAT MAP**<br>Woodland Residential Development, Future Lot 2 | **Figure 6** |
| | December 2020 | | |




Soil parameters - effective stress state

| No. | Name | Pattern | $\phi_{ef}$ [°] | $c_{ef}$ [psf] | $\gamma$ [pcf] |
|---|---|---|---|---|---|
| 1 | Landslide Mass - Mobilized St. Helens Deposits | | 25.00 | 100.0 | 120.0 |
| 2 | Alluvium | | 21.00 | 50.0 | 118.0 |
| 3 | Dense Alluvium | | 35.00 | 0.0 | 125.0 |
| 4 | Dense St. Helens Flood Deposits | | 32.00 | 150.0 | 125.0 |
| 5 | Wall Backfill | | 30.00 | 1000.0 | 120.0 |
| 6 | Silt | | 28.00 | 100.0 | 120.0 |

STRATA DESIGN

Project:
20-0212.2

December
2020

# STABILITY OF UPPER SLOPE

Woodland Residential Development, Future Lot 2

**Figure 7**

| Direction of Photograph: | Description of Photograph: | Photo |
|---|---|---|
| Closeup | General Drilling Operation at B-1 | 1 |

| Direction of Photograph: | Description of Photograph: | Photo |
|---|---|---|
| Closeup | Inclinometer Pipe Installation | 2 |

| | | |
|---|---|---|
| STRATA DESIGN | Project: 20-0212.2<br>July 2, 2020 | **PHOTOGRAPHIC LOG**<br>Woodland Residential Development, Future Lot 2 |

# Attachment 1 – Checklist

# Geotechnical Assessment – Engineer's checklist

PC#:_____none__ _____

_ Address:Scott Hill Road. ,

Woodland, WA 98674

Parcel #: 508890100

***This checklist must be filled out by the qualified expert and submitted with the geotechnical assessment/report. <u>No assessments/reports will be accepted over the counter without this sheet completed, signed, and stamped by the engineer of record.</u>***

Additional Notes: _____

_____

_____

_____

_____

Geotechnical Engineer(s) Signature: Frederick Thrall

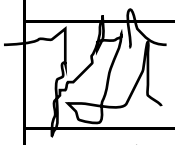
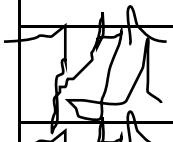
Geotechnical Engineer(s) Stamp:


Exp. 10/09/2022

**General Requirements for *<u>all</u>* Critical Area Assessments (CCC19.15.090(E)(2))**

| Engineer's Initials | Component | Notes, Other Information |
|---|---|---|
| | Site Plan | ☐ To scale, north arrow, and property line dimensions<br>☐ Locations and dimensions of all existing and proposed development or alterations |
| | Accuracy Statement | ☐ A statement specifying the accuracy of the report, and all assumptions made and relied upon |
| | Alternative Analysis | ☐ Analysis of site development alternatives, including a no development alternative |
| | Mitigation Plan | ☐ As needed to offset impacts<br>☐ Mitigation standards found in CCC 19.15.170 |

## General Requirements for Geotechnical Assessments (CCC19.15.150(I)(3) and 19.15.150(I)(4))

| Engineer's Initials | Component | Notes, Other Information |
|---|---|---|
|  | Site Plan | ☐ Type and extent of all geologic hazards and buffers within 200 feet that are likely to impact proposal<br>☐ Proposed development activity, including structures, drainfields, fill/grade areas;<br>☐ Dimensions of the proposed development activity to the property lines, critical areas, landslide scarp and slide mass<br>☐ Contour map of the site; including slopes delineated for ranges:<br>▪ 15-32%<br>▪ 33-79%<br>▪ 80% and greater<br>☐ Location and type of surface water runoff features within 200 feet of project area |
|  | Project Description | ☐ Detailed description of all elements of the project under review |
|  | Feasibility | ☐ Feasibility of the site for the proposed development activity |
|  | Surface and Subsurface Geology | ☐ A description of the surface and subsurface geology, hydrology, soils, and vegetation found in the project area |
|  | Project Relationship to Geologic Hazard(s) | ☐ Discussion of the project and its relationship to the geologic hazards found on site, which may include the type and extent of geologic hazard areas and buffers on, adjacent to, within 200 lateral feet of, or that are likely to impact the proposal or be impacted by the proposal |
|  | Field Investigation/Reference Information | ☐ An overview of any field investigations, published data, and references; data and conclusions from past assessments of the site; and site-specific measurements, tests, investigations, or studies that support the identification or lack of geologically hazardous areas |
|  | Areas of Avoidance | ☐ If applicable, an identification of any areas of the site recommended to be avoided by any aspect of the proposed development |
|  | Development Recommendations | ☐ If applicable, development recommendations for the proposed activities. These recommendations should include, but are not limited to, structure and septic system setbacks from geologic hazard areas, foundation design, filling and excavation, erosion control, drainage and site preparations |
|  | Mitigation | ☐ If necessary, identification of mitigation measures needed to address any anticipated geologic problems |
|  | Follow-up Studies | ☐ Discussion regarding the need for follow-up studies that should be conducted, such as geotechnical engineering reports, additional subsurface exploration or more extensive soil reports (if necessary) |
|  | Performance Standards Certification | ☐ Demonstration that all applicable performance standards are met |