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December 7, 2020

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

Sent via e-mail: ross@newhcontracting.com

Re: Geotechnical Assessment – Future Lot 1
Cowlitz County Parcel 508890100
SCOTT HILL ROAD, Woodland, WA 98674

Strata-Design Project No. 20-0212.1

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 1[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 alternative 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 1. An assessment for Future Lot 2 is being prepared and will be released under a separate cover.

We understand that your plan is to construct a wood frame stick-built residence at the upper elevation site. We understand that access will be from the existing 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 upper elevation Lot 1 location. Photo 1 shows the general condition of the flat upper elevation portion of the site. As shown in Figure 3, The potential building site is adjacent to a landslide scarp and consists of a flat area at

[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.

the top of the driveway adjacent to the city water facility boundary. Figure 3 shows the mapped landslide hazards indicating that the Future Lot 1 site is located within "Potentially Unstable Slopes" and is located adjacent to a mapped "Active Landslide" and "Deep Seated Landslide Scarp".

The approximate flat building area forms an approximate 100 by 75-foot triangular shaped site. Property line off sets would likely reduce the size of the "buildable" area using conventional building foundations. Our expectation is that special foundations (such as piles or piers) or a walk-out configuration will be required along with potential lowering of the site to create a buildable situation.

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 flood 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 (Photo 1) located adjacent to a mapped landslide zone. Our initial observation of the terrain indicates steep ground to the south typically associated with a landslide scarp formed over time by ancient landslides. Figure 6 shows that the roadway below the site was likely cut in between 2010 and 2019. Google Earth shows earthwork in 2013. These observations were confirmed in our previous studies[1].

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. In this case, our drilling indicates that

[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.

the failure surface at mid-slope is about 50 feet depth[1]. Recent monitoring of the inclinometer casing carried out on 7/31/20 and 10/27/20 indicates no movement, at least over the recent summer months since the inclinometer casing was installed. 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.

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 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 the top of the approximately 120-foot-high scarp. The scarp was likely formed by downslope movement of the soil wedge the top of which forms the flatter area below. Failure modes on you site would likely consist of breaking-back at the slope break. Stabilization at the subject location would thus require that the foundations penetrate below the expected base of the failure plus a factor of safety.

The attached stability analysis (Figure 7) shows that the upper slope is reasonably stable (FS = 1.4). The soil parameters 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 of the proposed construction the base of any foundation elements would need to penetrate a minimum of 20 feet below the base of the home to penetrate below the failure surface at the FS = 1.4 level.

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 small structures can generally be 25 to 50 years. As indicated, our observations of the site indicate the potential for breakback of the slope within the design life of the structure. However, if constructed at the indicated depth, the structure will likely be protected from catastrophic failure. However, we would assume that 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. In the case of your septic drain field, it can be shown that for a typical household, sewage water input into the drain field is negated by natural evapotranspiration processes. 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 a suitable diffusion area (likely the inside of the access road). 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.

Our site observations indicate no site distress or ground cracking associated with the proposed Lot 1 building envelope shown on Figure 3. If a walkout or multiple level residence is planned, retaining walls will be required as part of the overall construction. Further, installation of piles or piers are recommended to extend the founding zone to below the potential failure surface associated with a FS = 1.4. A Strata representative should be retained as appropriate to confirm that the above has been accomplished during the design and construction phase 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 20 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. 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 inside edge of the access road/drive. 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 – Figure 2 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. pile 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 adjacent to 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
- 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 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

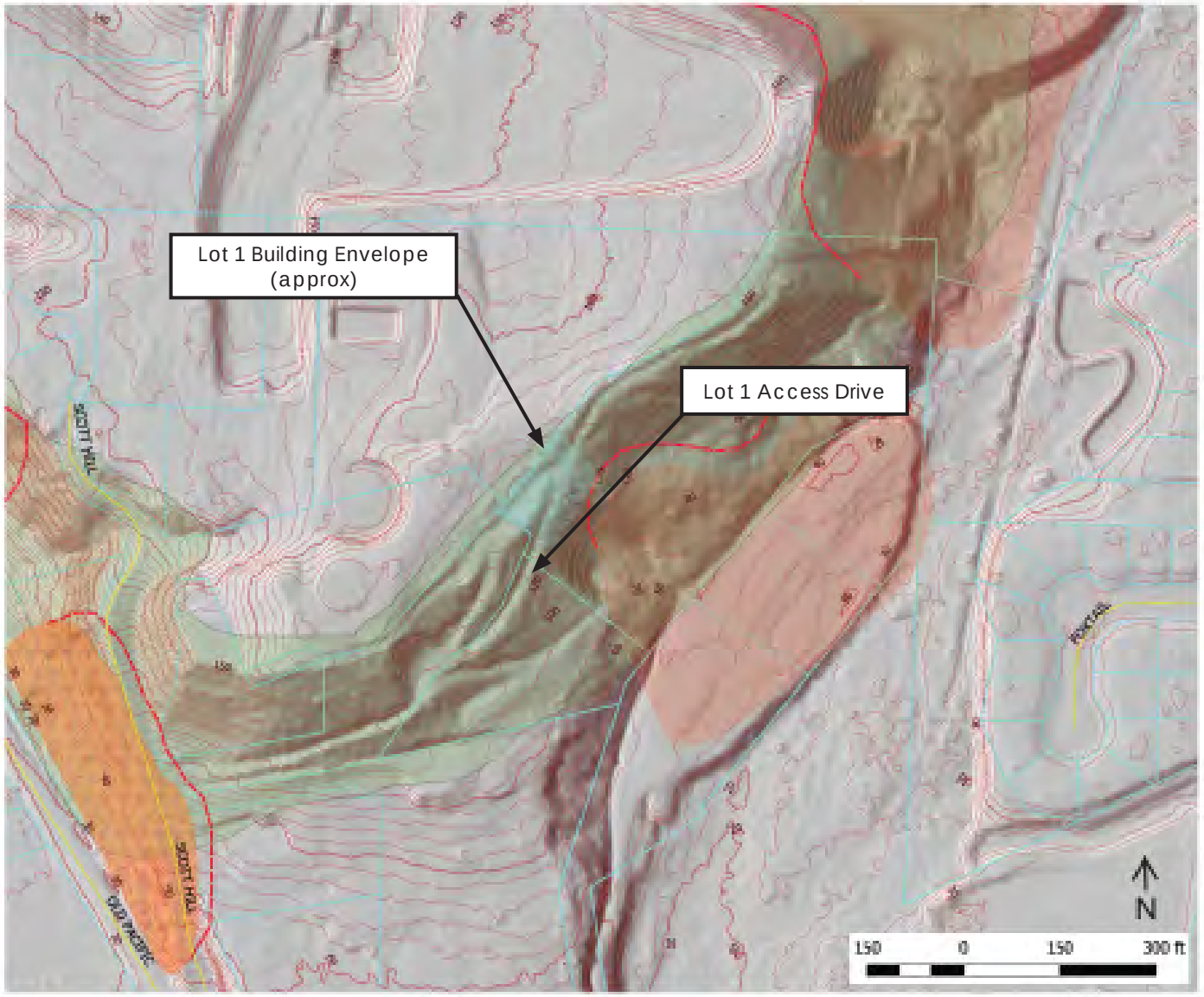
Attachments:
Figures 1 to 7,
Photo 1,
Attachment 1 - Checklist

STRATA DESIGN	Project: 20-0212.1	**SITE LOCATION MAP** Woodland Residential Development, Future Lot 1	**Figure 1**
	December 2020		

Conceptual Short Plat

WOODLAND, WASHINGTON

STRATA DESIGN	Project: 20-0212.1 December 2020	**CONCEPTUAL SHORT PLAT-DEVELOPER PROVIDED MAP** Woodland Residential Development, Future Lot 1	**Figure 2**



LOT 1 SITE PLAN

3- 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

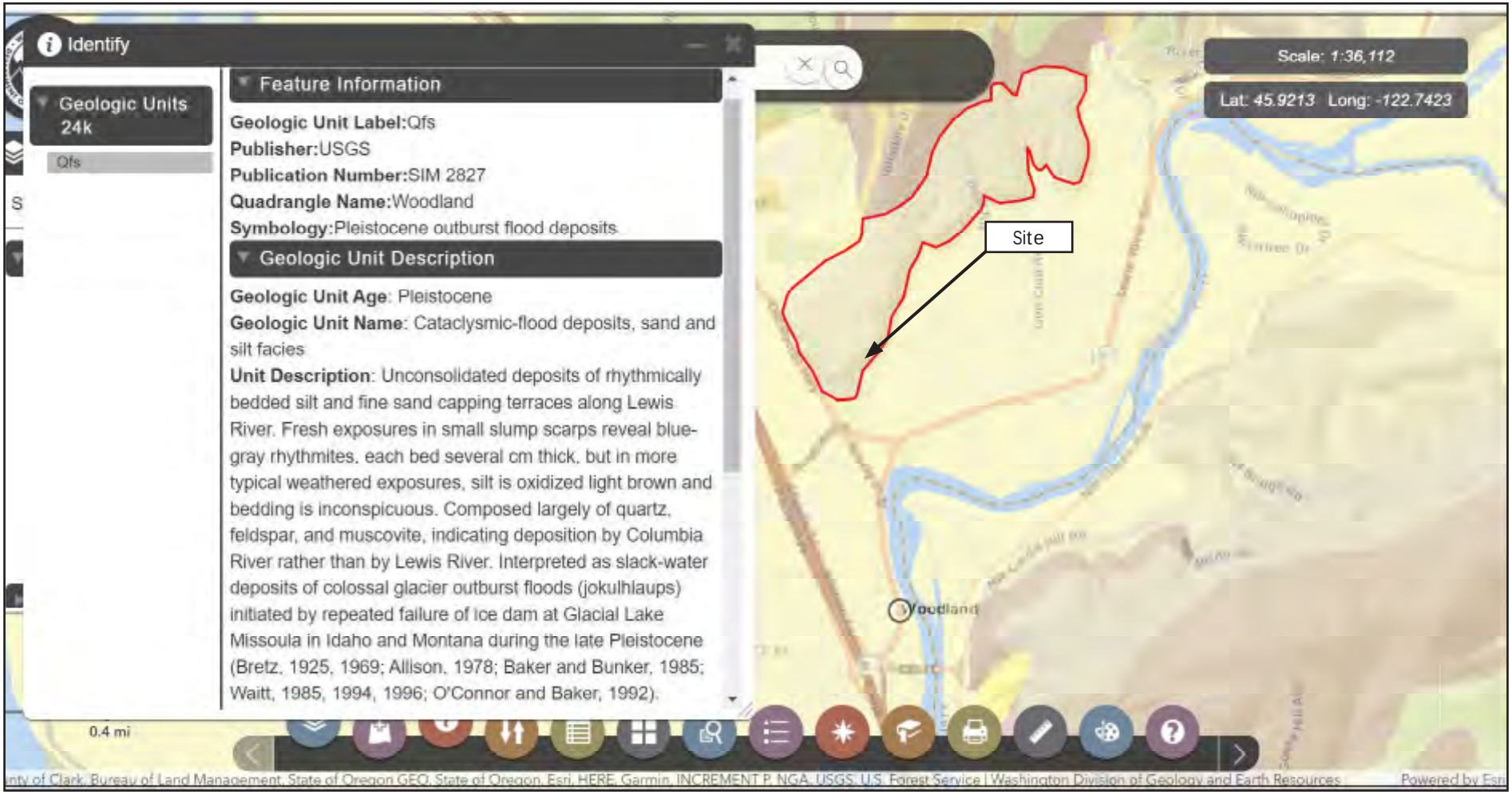
- Active Landslide
- Deep Seated Landslide Scarps
- Spring Locations
- Shallow Landslides
- Sag Ponds
- Potentially Unstable Slopes
- Deep Seated Landslides

Contours derived from 2010 Lidar, from Washington DNR

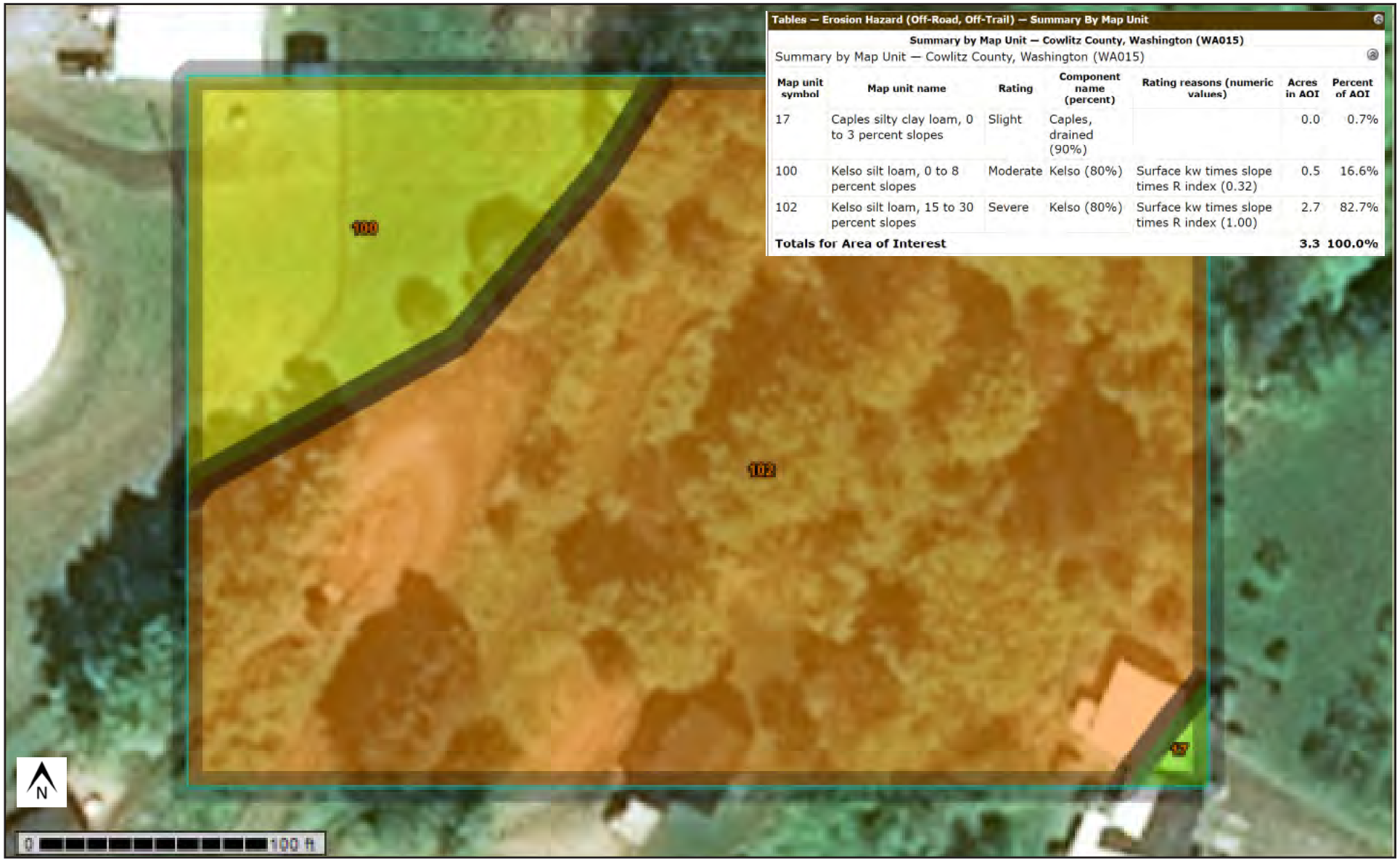
Lot lines and DNR data provided by Cowlitz County GIS Server

Figure 3

STRATA DESIGN	Project: 20-0212.1	**LOT 1 SITE PLAN MAP** Woodland Residential Development, Future Lot 1	**Figure 3**
	December 2020		



STRATA DESIGN	Project: 20-0212.1	**GEOLOGY MAP** Woodland Residential Development, Future Lot 1	**Figure 4**
	December 2020		



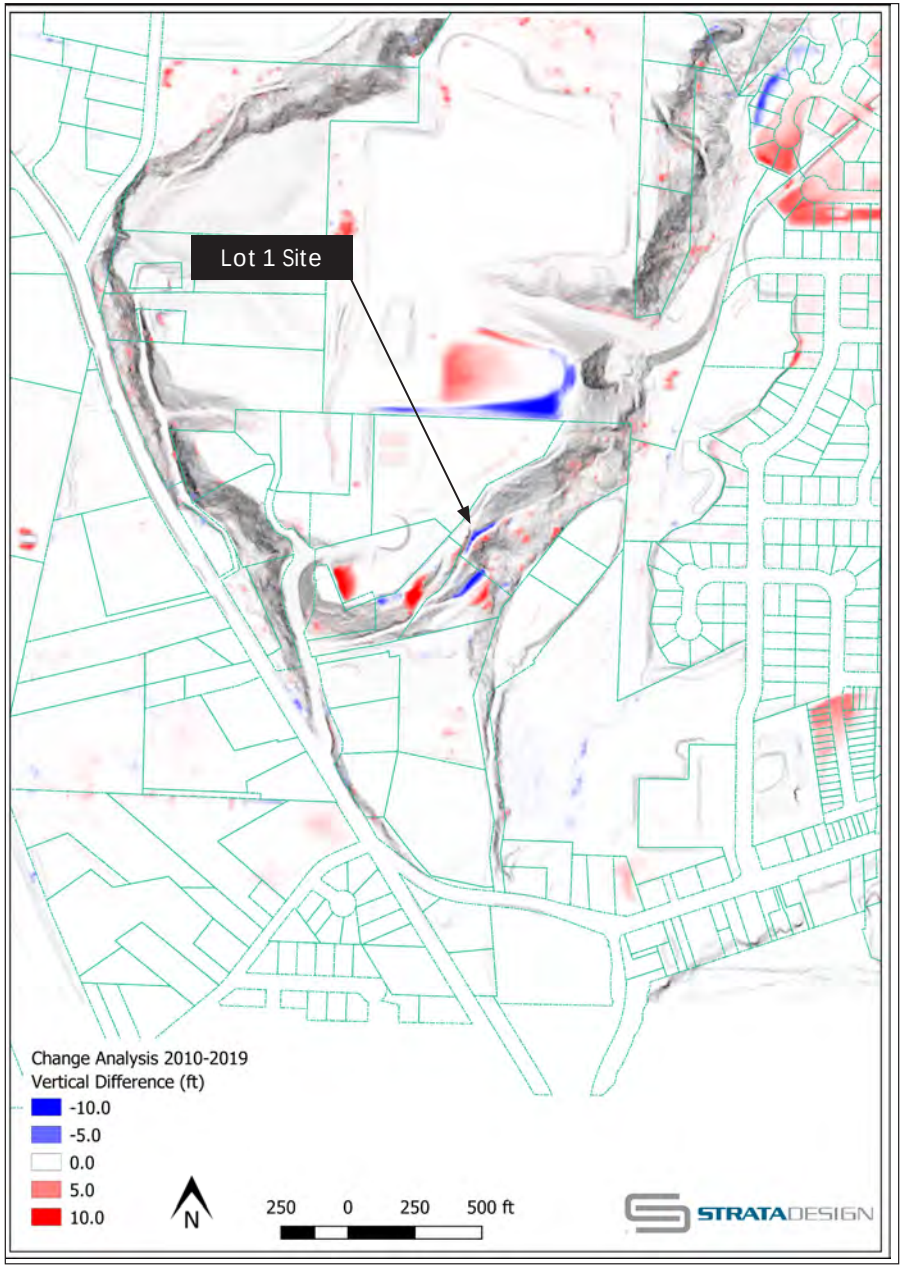
Tables — Erosion Hazard (Off-Road, Off-Trail) — Summary By Map Unit

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

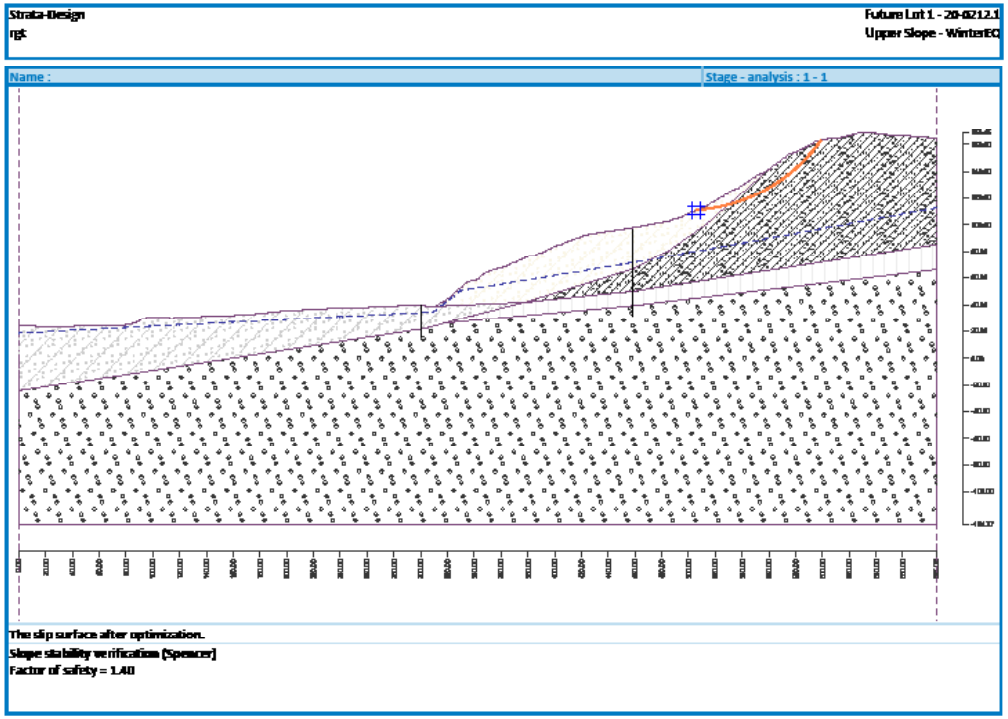
Summary by Map Unit — Cowlitz County, Washington (WA015)

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: 20-0212.1	**EROSION HAZARD MAP** Woodland Residential Development, Future Lot 2	**Figure 5**
	December 2020		



STRATA DESIGN	Project: 20-0212.1	**VERTICAL ELEVATION HEAT MAP** Woodland Residential Development, Future Lot 1	**Figure 6**
	December 2020		



Soil parameters - effective stress state

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [psf]	γ [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: 20-0212.1

December 2020

STABILITY OF UPPER SLOPE

Woodland Residential Development, Future Lot 2

Figure 6

Direction of Photograph:	Description of Photograph:
East	At Site

STRATA DESIGN	Project: 20-0212.1 Nov. 30, 2020	**PHOTOGRAPHIC LOG** Woodland Residential Development, Future Lot 1	**Photo 1**

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

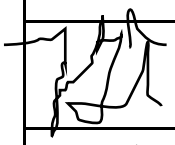
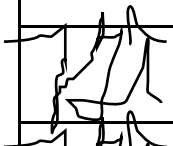
Geotechnical Engineer(s) Stamp:

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 ☐ 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 ☐ 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 ☐ Proposed development activity, including structures, drainfields, fill/grade areas; ☐ Dimensions of the proposed development activity to the property lines, critical areas, landslide scarp and slide mass ☐ Contour map of the site; including slopes delineated for ranges: ▪ 15-32% ▪ 33-79% ▪ 80% and greater ☐ 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