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July 19, 2019

Marty & Virginia Lauth

[redacted]

RE: GEOLOGIC HAZARD ASSESSMENT AND GEOTECHNICAL EVALUATION
4633 SOUTHWEST BEACH AVENUE
TAX LOT 7-11-27-CD 3600, ACCOUNT R420048
LINCOLN CITY, OREGON 97367
Branch Engineering Inc Project No. 19-225

On behalf of the property owners, Marty and Virgina Lauth, Branch Engineering Inc. (BEI) conducted a Geologic Hazard Assessment and Geotechnical Evaluation of the subject site at 4633 SW Beach Avenue in Lincoln City, Oregon performed by Gary C. Sandstrom, Certified Engineering Geologist, Gary C. Sandstrom Geologist LLC and Ron Derrick, Principal Geotechnical Engineer, BEI Inc. This study was requested for the planned construction of a single-family residence on the property. The purpose of the study is to identify the geologic hazards that may affect the proposed site development and provide engineering design recommendations for design and construction as specified in the Lincoln City Municipal Code, Chapter 17.47 Natural Hazards. A prior Engineering Geologic Hazards Investigation was performed for the subject site by H.G. Schlicker & Associates, Inc. in October 2001, and is used as a reference herein. Our report is a stand along document as Lincoln County regulations require updating or regeneration of reports older than 10 years.

1.0 Scope of Work

A site visit and geologic reconnaissance of surface features was conducted on May 31, 2019 by a Certified Engineering Geologist (Gary Sandstrom). Geotechnical Engineer Ron Derrick excavated a hand-augured exploratory boring during the same site visit. In addition, the following websites, literature and map sources were reviewed:

- Lincoln City Municipal Code Chapter 17.47 Natural Hazards, https://www..codepublishing.com/OR/LincolnCity/
- Google Maps, https://www..google.com.maps, Figure 1
- Google Earth, earth.google.com,
- Lincoln County Assessor, http://maps.co.lincoln.or.us, Figure 2
- ORMAP GIS, http://www.ormap.net Oregon Map website listing tax lot numbers
- USGS, https://viewer.nationalmap.gov, 2014 Lincoln City Quadrangle Map from US Dept. of Interior, Geological Survey
- Priest, G.R. and Allan, J.C., *Evaluation of Coastal Erosion Hazard Zones along Dune and Bluff-Backed Shorelines, Lincoln County, Oregon: Cascade Head to Seal Rock,* State of Oregon, DOGAMI, Open File Report O-04-09, 2004, Figure 3 7

- Snavely, P.D., MacLeod, N.S., Wagner, H.C. and Rau, W.W., *Geologic Map of the Cape Foulweather and Euchre Mountain Quadrangles, Lincoln County, Oregon,* US Dept. of the Interior, Geological Survey, Misc. Investigation I-868, 1976

- Schlicker, H.E., Olcott, G.W., Beaulieu, J.D. and Deacon, R.J., 1973, *Environmental Geology of Lincoln County, Oregon,* State of Oregon, DOGAMI, Bulletin B-81

- Snavely, P.D., MacLeod, N.S. and Wagner, H.C., *Preliminary Bedrock Geologic Map of the Cape Foulweather and Euchre Mountain Quadrangles, Lincoln County, Oregon,* US Dept. of the Interior, Geological Survey, Open File Report 72-350, 1972 Figure 4

- Priest, G.R., *Erosion and Flood Hazard map of the Taft-Siletz Spit Area, Coastal Lincoln County, Oregon,* State of Oregon, DOGAMI, Open File Report O-97-16, 1997, Figure 5

- United States Dept. of Agriculture, Natural Resources Conservation Service, Pacific Northwest Soils website, https://websoilsurvey.sc.egov.usda.gov

- State of Oregon, DOGAMI website, Statewide Geohazards Viewer (HazVu), http://www.oregongeology.org/hazvu/, Figures 6 thru 11

- State of Oregon, DOGAMI website, LIDAR, https://gis.dogami.oregon.gov/maps/lidarviewer, Figure 12

- Federal Emergency Management Agency (FEMA) Flood Map Service Center, https://msc.fema.gov/portal/home

- H.G. Schlicker & Associates, *Engineering Geologic Hazards Investigation Tax Lot 3600, Map 7-11-27CD, 4633 SW Beach Avenue, Lincoln City, Oregon,* October, 2001

- Komar, P.D., *The Pacific Northwest Coast, Living with the Shores of Oregon and Washington,* Duke University Press, 1998

2.0 Project Location and Description

The vacant, 0.22-acre ocean-front subject parcel is located in the Taft district of Lincoln City (see Figure 1 - Google Maps Location), approximately ¼-mile north of the mouth of the Siletz River and about 1/3-mile south of the Inn at Spanish Head. The vacant property is located on the west side of SW Beach Avenue about 400 feet north of SW 48th Street and is listed on the ORMAP website as Tax Lot 3600 in T7S, R11W, Section 27 CD. It is rectangular in shape, measuring 50-feet north to south and about 185-feet east to west, with cleared relatively gentle slopes in the eastern margin and heavily-vegetated, moderately-steep to steep slopes leading down to the Pacific Ocean beach about 170- to 180-feet west of the SW Beach Avenue pavement (see Figures 13 and 14, Cross Section). The elevation ranges from about 80-feet on the east side of SW Beach Avenue to about 70-feet at the slope break, and about 20-feet at the base of the steeper western slopes about 35-feet west of the west property line. A vegetated dune field with common driftwood logs extends westward more than 100-feet from a north/south-trending gravel road/path at the base of the slope. The head of the sand beach shown on the Lincoln County website photo is about 190-feet west of the western property line. The crest of the bluff underlying the site vicinity is coincides with the west shoulder of SW Coast Avenue, a little more than 200-feet east of the subject site at an approximate elevation of 120-feet. Neighboring properties to the north, east, and south are occupied by single-family residences, and the 5.75-acre tax parcel west of the subject property is owned by Lincoln County.

A single-family residence has been proposed for the site, but no plans were available at the time this report was drafted. Disposal of gutter discharge is not certain at this time, but sanitary sewer manholes and storm grates were observed in SW Beach Avenue.

3.0 Site Geology

The general geology and site-specific observations are presented below with a discussion of the potential hazards associated with the site.

3.1 Geologic Literature

The slopes underlying the project site are classified in the geologic literature (Figure 3 DOGAMI O-04-09 Geologic Map) as Quaternary (less than 2.6 million years old) Marine Terrace deposits overlying upper Eocene-age (approximately 34-40 million years old) Nestucca Formation at an unknown depth (see Figure 4 USGS OFR-72-350-1 Geologic Map). The Marine Terrace deposits are described in O-04-09 as unconsolidated to moderately consolidated gravel, beach and dune sand; locally contains minor consolidated clay-rich paleosol, colluvium, debris flows, and alluvial interbeds. DOGAMI B-81 describes the Marine Terrace Deposits as up to 75 feet of semi-consolidated uplifted beach sand overlain locally by fine-grained dune deposits, with occasional localized gravel lenses. The deposits are further described (B-81) as thick- to thin-bedded planar to cross-bedded, fine- to medium-grained marine and non-marine sand; locally contains cobble and pebble lenses; upper surfaces of terrace deposits covered locally by dune sands (older dune sands are iron stained and contain soil zones). Beach sands are mapped west of the base of the steep slopes west of the subject parcel and intrusive Columbia River Basalt deposits are mapped in the vicinity of the Inn at Spanish head about 1/3-mile to the north. The Nestucca Formation is described as thin-bedded tuffaceous marine siltstone and sandstone with tuff and glauconitic sandstone interbeds. The closest Nestucca Formation deposit mapped in B-81 is about 0.6-mile north of the subject site, but O-04-09 does not map Nestucca deposits at that location.

A northeast- to southwest-trending normal fault downthrown to the southeast is mapped (OFR-72-350-1) intersecting the beach just north of the concrete, public-access stairway situated about 700-feet (0.14-mile) north of the subject site. A similar, parallel normal fault downthrown to the southeast, is mapped about 0.85-mile southeast of the subject site underlying Cutler City. The closest active fault mapped on the DOGAMI HazVu Website (Figure 6, Expected EQ Shaking and Nearest Fault Map) is situated at the mouth of the Siletz River about 0.3 mile south of the subject site and trends WNW to ESE.

The website for the U.S. Dept. of Agriculture Natural Resource Conservation Service, Soil Survey Data, maps surface soils as Bandon fine sandy loam on 12-50% slopes described as colluvium from sedimentary rocks that is very limited to development for buildings with basements due to slopes and moderately limited by a possible shallow, thin, cemented pan. Soils are rated well-drained, AASHTO A-8, in Hydrologic Group C with slow infiltration rates when thoroughly saturated

3.2 Geologic Hazard Mapping

The DOGAMI HazVu website does not map any landslides (Figure 8) in the site vicinity but does rate the eastern and western margins of the parcel at moderate risk from landsliding – landsliding is possible. The steep slopes west of the parcel are rated at high risk – landsliding is likely due to future bank erosion from wave action, and the central area of the subject site, the likely location of the proposed residence, has no mapped landslide risk.

The steeper slopes and beach west of the subject parcel are mapped in the active Coastal Erosion Hazard Zone in DOGAMI O-04-09 and on the HazVu website (DOGAMI HazVu Coastal Erosion Hazard Map, Figure 7). DOGAMI LIDAR Bare Earth Slope imaging shows the steep western slopes begin about 190 feet west of the SW Beach Avenue pavement. A schematic of the anticipated erosion rate is shown on Figure 15 (Bluff Erosion Hazard Zone Diagram) where the

high hazard zone suggests active erosion within 60 years; this zone extends west of the treeline on the site about 140 feet from the pavement. The moderate hazard zone extends eastward to about 110-feet west of the pavement, the approximate location of HA-1, and the low hazard zone ends about 80 feet west of the pavement; no hazard is mapped in the easternmost margin of the site. Previous hazard mapping (Figure 5 DOGAMI O-97-16) mapped erosion rates in the site vicinity at 0 to 0.1-foot per year, averaging 0.05 foot per year, or a little more than a half inch per year. Google Earth historical imagery dating from 1994, in our opinion shows no significant change in the location of the edge of the bluff, and vegetative cover has become increasingly dense on the dune area west of the road/path at the base of the slope while the height of the dune remained fairly constant. OFR-O-04-09 quotes research than indicates the Lincoln City vicinity is submerging at a rate of approximately 1.5 millimeters a year due to crustal warping and sea level increase due to global warming.

The site is expected to experience severe shaking in the event of a large Cascadia Subduction Zone (CSZ) earthquake and very strong shaking during a more distant or smaller earthquake as shown on Figures 9 and 10 (DOGAMI HazVu Cascadia EQ Expected Shaking Map and DOGAMI HazVu EQ Expected Shaking Map). The site is situated in the low soil liquefaction hazard zone (Figure 11) and is mapped outside the tsunami and flooding hazard zone. The proposed homesite vicinity is above the statutory tsunami inundation line mapped at about 70-feet elevation shown on both the HazVu website and on DOGAMI Tsunami Inundation Map Linc02 Lincoln City South; however, this author believes that a tsunami generated from a large CSZ earthquake would impact the site to some extent due to accelerated bank erosion or debris deposits. The nearest active fault shown on the HazVu website is situated at the mouth of the Siletz River about 0.3 mile south of the subject site and trends WNW to ESE.

3.3 Prior Site Investigations

Oceanographer Paul Komar (*The Pacific Northwest Coast)* notes the Taft vicinity has very slow rates of erosion: recent photos show little change in the edge of the bluff compared to photos taken in the 1920s.

H.G. Schlicker and Associates performed an engineering geologic hazards investigation of the subject site summarized in their October, 2001 report (see Appendix). A cross section was generated and two hand-augered exploratory borings were excavated on the subject site (see Figure 3 in the Schlicker report). B-1 was located approximately 15-20 feet west of this investigation's HA-1 to a depth of 7 feet and encountered generally medium stiff, brown silt with organics interpreted as fill to about 1.5-feet, grading below about 4 feet to gray-brown, soft to medium stiff clay with minor sand and organics. Dense gray to tan silty fine- to medium-grained sand was encountered below 6 feet, and no static groundwater was reported. Boring B-2 was located about 70-75 feet west of the west edge of the SW Beach Avenue pavement and encountered interpreted sandy fill to a depth of about 2.5-feet overlying soft to medium stiff, dark brown silt with organics grading to brown to dark gray clay with organics below about 3 feet, with dense yellow-brown to tan fine- to medium-grained sand below about 5.5 feet. Materials observed were interpreted as slack-water deposits possibly associated with a bay or shallow stream environment. The report interprets an old landslide block on the middle and lower portions of the steeper western slopes with no observed indications of recent movement, but somewhat undercut by wave erosion at the base of the slope. The steep (70^{o}), approximately 10-foot high headscarp was observed near the top of the slope on the subject property. These features were obscured by erosion and vegetation growth since that report was written (2001) but appear to be consistent with recent observations. The report also interprets a fairly recent active landslide at the edge of the bluff spanning the two south neighboring properties about 100-feet wide and 25-feet thick with the lateral scarp just south of the south property line of the subject parcel. This slide resulted in eastward migration of the edge of the bluff of about 25-feet and the report warns of possible northward migration of the slide into the subject site. The report suggests the slide block interpreted on the lower slopes of the subject site will likely act as somewhat of a buffer against larger slides, but small block failures or sloughing of one to three feet could occur at any time.

The report also reports the existence of the dune with scattered grasses west of the slopes, noting it is a relatively ephemeral feature that could rapidly vanish and undercutting at the toe of the slope could occur. The report mentions the grassy dune has been in place since 1962 and generally agrees with the erosion rates predicted in DOGAMI O-97-16. Due to the possibility of future landsliding the report recommends of minimum setback from the edge of the bluff of 40 horizontal feet (about 145 feet from the SW Beach Avenue pavement). Foundation options recommended are spread footings bearing on the dense sands or structural fill, or support by piers or piles embedded a minimum of 5 feet into the dense sands. Discharge from drains "should not be disposed of along the bluff unless tight-lined to the base of the bluff".

3.4 Soils observed

One exploratory hand-augered boring was excavated during the site visit (see Figure 2 Lincoln County Photo Tax Map for location and HA-1 Boring Log Summary in Appendix B). The boring was excavated approximately 20 feet north of the southern property line and 114 feet west of the west edge of pavement of SW Beach Avenue and materials observed were generally soft to medium stiff organic silt/clay overlying dense sand and are consistent with the findings by Schlicker in 2001.

A near vertical exposure of Marine Terrace deposit, medium brown silt to sandy silt about 6 to 8-feet high was observed below the edge of the bluff on the south neighboring parcel. Similar materials overlain by a thin layer of dark gray/brown organic silt/clay topped by tan sand/sandstone were observed a couple lots to the north in a near-vertical exposure totaling about 20-feet in height. The tan sand/sandstone materials observed on the northern scarp were not observed on the subject site during our recent reconnaissance nor mentioned in the 2001 Schlicker report; the materials apparently eroded away in the area of the subject site prior to 2001.

3.5 Hazard Reconnaissance Observations

A geologic hazard reconnaissance of the subject site was performed during the site visit on June 31, 2019 by Certified Engineering Geologist Gary C. Sandstrom. The recon consisted of traversing the subject property and neighboring slopes where accessible for indications of slope instability. A cross section of the site was generated using a hand-held digital level and measuring wheel between SW Beach Avenue and the top of the steeper slopes at the western margin of the site. Google Earth imaging and the DOGAMI LIDAR website were also referenced for elevations and distances during drafting of the cross section.

LIDAR imaging (Figure 12) suggests SW Beach Avenue was constructed on a bench excavated into the relatively gentle west-facing slopes of the north-south trending bluff with some spoils pushed onto the western shoulder forming the short, moderate slope leading down 15-feet from the edge of the pavement to the east property line of the subject site. Grading of the north-neighboring parcel likely generated the short, moderate slope about a foot high observed near the common boundary. The eastern half of the site is underlain by gentle, west-facing slope ranging from 1- to 5-degree. The area is vegetated with long grass, scattered blackberries and occasional ferns, with common blackberry vines the on the short moderate slope adjacent to SW Beach Avenue. A stand of lodgepole pine trees with salal, wax myrtle, English ivy and fern understory, cleared in places, extends westward from about 120-feet west of the SW Beach Avenue pavement, beginning a few feet west of the exploratory boring. Slopes begin to steepen slightly about 150-feet west of the pavement, increasing to more than 12 degrees at about 170-feet, increasing to about 27 degrees past 190-feet and generally exceeding 45 degrees past about 200-feet. Abundant, dense vegetation combined with steep slopes made the slopes beyond 200-feet relatively inaccessible. A narrow pathway was found down to a platform on the south neighbor's wooden stairway to the beach and the base of the slopes were accessed from that stairway.

Near vertical bare soil scarps were observed (see below Photo DSC03506) on the south-neighboring parcel and a couple of parcels to the north as mentioned above.

The south-neighboring scarp is likely the headscarp of the recent landslide mentioned in the Schlicker report. The northern scarp may be a continuation of the headscarp observed on the subject site in 2001 but now obscured by vegetation, or the headscarp of a separate but similar landslide.

A graveled roadway/path at an elevation of about 18-feet at the base of the slope below the subject site extends along the base of the bluff, and a parallel low dune estimated 5-6 feet high rises gently to the west with relatively dense salal and low lodgepole pines and scattered grassy areas for about 50-60 feet, with just dune grass extending westward down gentle slopes for another 80-90 feet to the current vegetation line at about elevation 21-22 feet. Driftwood logs are scattered across the surface of the dune, becoming generally less abundant to the south. Historical Google Earth imaging dating since 1994 show a fluctuating vegetation line generally at least 120-feet from the road, and the extent brushy vegetation appears to have increased somewhat in extent during that time. The Schlicker report mentions the dune has been present since 1962.

No indications of instability such as bare soil scarps, tension cracks, sunken grades, incised erosion channels, unusual drainage or water-loving vegetation were observed east of the edge of the bluff (about 190-200 feet west of the pavement) during the recon. Soils probed relatively soft/loose with a ½-inch diameter steel T-bar, but no flowing or ponded water was observed and no static groundwater was encountered in the exploratory boring. The steeper slopes observed beyond 200-feet west of the pavement exhibited steep upper slopes, leaning trees and some erosional washing, but no signs of ongoing significant movement such as springs, toppled vegetation or bare soil debris piles.

4.0 Conclusions

The proposed home-site is underlain by approximately 4- to 5-feet of soft to medium stiff organic clay/silt overlying relatively dense Marine Terrace Deposits of weakly indurated sandstone. Gentle, relatively un-disturbed slopes with no landslide hazard mapped by DOGAMI underlie most of the parcel including the proposed homesite location, but landsliding has occurred along the western edge of the bluff resulting in steep slopes near the western margin. The headscarp of the landslide is situated at an estimated distance of 200-feet west of the

pavement, about 185-feet from the east property line, but is not catalogued as such on the DOGAMI HazVu or SLIDO websites. The LIDAR website shows an estimated distance of about 177-feet from the steep slopes to the east property line, a distance interpreted from field measurements of about 178- to 185-feet.

An erosion rate of 0 to 3/10-inch per year was estimated for the site vicinity in a 1997 DOGAMI report and the Schlicker report concurred, and that rate is consistent with Paul Komar's mention of very slow bluff recession rates in the Taft vicinity. A dense stand of lodgepole pine and salal has been established on the edge of the bluff and on the talus slopes, becoming denser since the 2001 Schlicker report, and there have been no indications of ongoing or recent deep movement. Comparison of Google Earth images from 2001 and 2018 in our opinion suggest a possible eastward migration of the edge of about 5 to 7 feet due more to erosional rounding of the break than eastward migration of the vertical headscarp. Comparison of the cross sections from the Schlicker and current report was inconclusive, showing a greater distance (about 4-feet) in 2019, suggesting the earlier cross section was measured near the south boundary line of the subject parcel rather than the centerline on the parcel as in the current report (no site plan with the location of the cross section was included in the report copy available).

The DOGAMI HazVu website maps no coastal erosion hazard west of the SW Beach Avenue pavement for about 80-feet, low hazard from about 80- to 110-feet, medium hazard from about 110- to 140-feet, high 140- to 195-feet and very high hazard beyond 195-feet. OFR-04-09, upon which the website is based, has an erosion zone diagram that suggests a residence built 140-feet or less from the pavement would be relatively safe from bank erosion concern for about 60 years, and construction east of a line 110-feet would be relatively safe for about 100 years. These values suggest a bluff retreat rate of about 80-feet in 100-years, or 9-inches a year, or about 16-feet since the 2001 Schlicker report. In our opinion the HazVu ratings are highly conservative based on our observations; however, faster erosion rates may occur with increased sea level rise due to global warming (DOGAMI OFR-04-09 also estimates a net sea level rise of about 1.5 millimeters per year subsidence relative to the current sea level in the Lincoln City vicinity). Comparison of 2001 and 2018 Google Earth images in our opinion shows possible bluff retreat of up 5-7 feet in that time period by incremental erosion rather than landsliding and in our opinion a value of about 4-inches per year is a good estimate for a current erosion rate at the edge of the bluff. It should be noted that the slope break vicinity observed in the 2001 Google Earth images appeared grassy with a lack of brush and dense vegetation that would tend to slow erosion. The increased density of vegetation now present may slow the erosion rate to a couple inches a year or less. If the dune west of the base of the slopes disappears due to erosion, waves could undercut the slope and increase the erosion rate more in line with the HazVu prediction of about 9-inches per year.

Research by geologist Chris Goldfinger at Oregon State University suggests the chance of a massive subduction zone earthquake in the next 50 years in the Newport/Lincoln City vicinity has a one in three to one in four probability, and an earthquake timeline graph is included showing size and frequency of coastal earthquakes

Occurrence and Relative Size of Cascadia Subduction Zone Megathrust Earthquakes

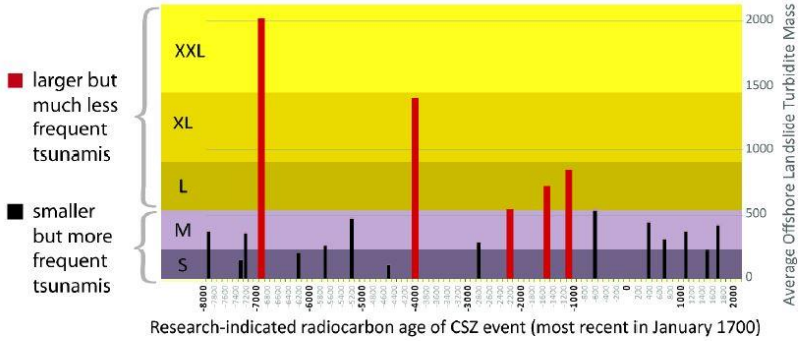


Figure 3: This chart depicts the timing, frequency, and magnitude of the last 19 great Cascadia Subduction Zone events over the past 10,000 years. The most recent event occurred on January 26, 1700. The 1700 event is considered to be a "medium sized" event. The data used to create this chart came from research that examined the many submarine landslides, known as "turbidites," that are triggered only by these great earthquakes (Witter and others, 2011). The loose correlation is "the bigger the turbidite, the bigger the earthquake."

Most geologist believe large subduction zone earthquakes will remobilize old slides and generate new landslides in areas prone to instability. In our opinion this site is at a relatively high risk for damage to structures in the event of an earthquake. HazVu rates the soil liquefaction hazard for the site vicinity as low, with severe shaking in the event of a CSZ earthquake and very strong shaking for more distant or lesser earthquakes. The statutory tsunami inundation line is mapped by both HazVu and DOGAMI TIM Linc02 at the approximate slope break, below the proposed homesite vicinity. It should be noted that one of the effects of a large CSZ earthquake could be instantaneous subsidence along the coast of up to 5-feet as the stress causing the upward bowing of the continental plate is released.

5.0 Recommendations

A conservative estimated erosion rate of 9 inches a year as suggested by the HazVu Coastal Erosion Hazard website would result in about 40-feet of bluff regression over the design life of 50 years, essentially the same as the set-back from the slope-break recommended in the Schlicker report. Presently the slopes steepen significantly about 195-feet from the pavement, or 180-feet from the east property boundary and in 50 years the distance could decline to about 140-feet from the property line. Adding another 20-feet as a safety buffer, we recommend 120-feet as the maximum setback from the eastern property line for standard rebar-reinforced spread footings. Deep foundations along the western wall and the southwestern corner of the residence (closest point to anticipated future instability) would add an additional factor of safety if desired, or reinforcing the footings to facilitate future underpinning may also be considered in design, if that should become necessary. Siting the structure further west would likely require additional geotechnical investigation including deeper geotechnical borings, slope stability analysis and piles into the dense subgrade materials.

We suggest that a foundation subgrade evaluation be performed by a qualified geotechnical engineer or engineering geologist at the time of building foundation excavation to ensure the presence of suitable undisturbed native subgrade. We anticipate that competent sand will be encountered after excavation of fill and/or unsuitable surface soils to a depth of approximately 4 to 5-feet. Suitable subgrade is expected to have an allowable bearing capacity of at least 1,500 psf. Footing drains should be installed and daylighted to drain as water may pond on the underlying dense sands. A seismic site classification of C (Table 20.3 of 2014 ASCE 7-10) can be used for foundations bearing on dense sand.

Perimeter landscape grades shall slope away from foundations so that water does not pond adjacent to footings and landscaping and irrigation should be designed to reduce excessive soil moisture. Adequate gutter and foundation drains are also recommended to route water away

from the residence and tops of slope to a suitable point of disposal to lessen the chances of settlement and slope erosion, preferably offsite to a municipal disposal system (a storm sewer grating was observed adjacent to the north-neighboring parcel) or by tightline down to beach level. Deep-root vegetation should be maintained, as much as possible, on the site to lessen erosion, particularly west of about 145-150 feet from the eastern property line.

There is no anticipated need for earth retaining structures. The site vicinity is likely to experience subsidence within the design life of the planned residence; therefore, we recommend the footings be reinforced with at least three No. 4 steel reinforcing bars placed parallel in the footings to mitigate foundation cracks. Seismic strapping the frame of the residence to the foundation footings will reduce the risk of the residence shifting off its foundation in the event of an earthquake. BEI concludes that the subject site is suitable for the proposed development as conditions currently exist; however, coastal properties are subject to severe ground shaking, and tsunami erosion in the event of a CSZ earthquake event that is predicted on a 300- to 500-year reoccurrence interval with the last event occurring over 300 years ago. Owners and residents assume the risk of such an event occurring and the potential damage to property which cannot be completely mitigated by engineering techniques.

6.0 Report Limitations

This report presents BEI's site observations, site research, site explorations, and recommendations for the proposed site development. The conclusions in this report are based on the conditions described in this report and are intended for the exclusive use of Marty and Virginia Lauth and their representatives for use in the site development design and construction. The analysis and general recommendations provided herein may not be suitable for structures or purposes other than those described herein. Services performed by the geologist and geotechnical engineer for this project have been conducted with the level of care and skill exercised by other current geotechnical professionals in this area under similar budget and time constraints. No warranty is herein expressed or implied. The conclusions in this report are based on the site conditions as they currently exist and it is assumed that the limited site locations that were physically investigated generally represent the subsurface conditions at the site. Should site development or site conditions change, or if a substantial amount of time goes by between our site investigation and site development, we reserve the right to review this report for its applicability. If you have any questions regarding the contents of this report, or if we can be of further assistance, please contact our office.

Sincerely,
Branch Engineering Inc,

Ronald J. Derrick
Digitally signed by Ronald J. Derrick
Date: 2019.07.24 08:39:53 -07'00'

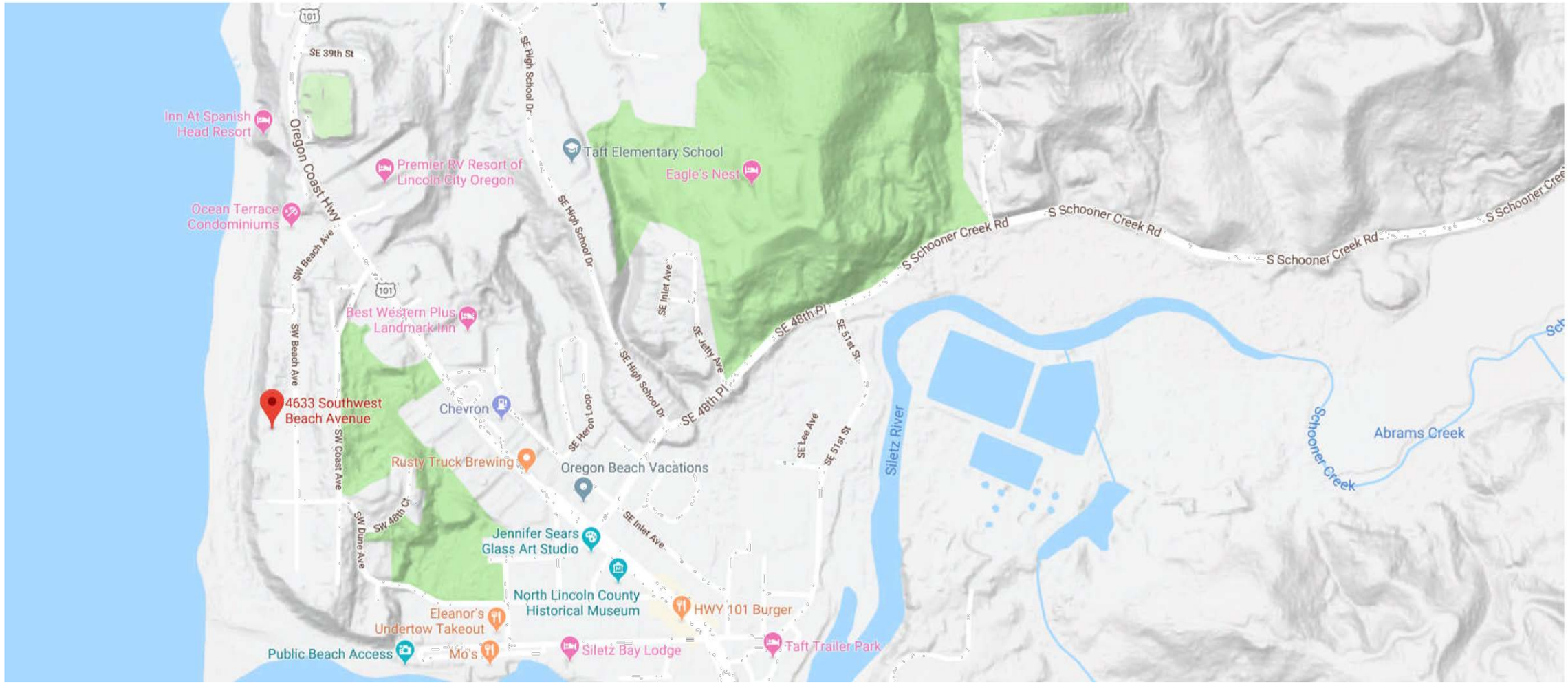
EXPIRES: 12/31/2019

Ronald J. Derrick, P.E., G.E.
Principal Geotechnical Engineer

Gary Sandstrom, R.G., C.E.G.
Certified Engineering Geologist

4633 SW Beach Ave

T7S R11W 27CD Lot 3600 Lincoln City, OR 97367



Branch ENGINEERING Inc
Since 1977
310 5th STREET, SPRINGFIELD, OREGON 97477

SCALE: (11"x17")

SITE LOCATION MAP

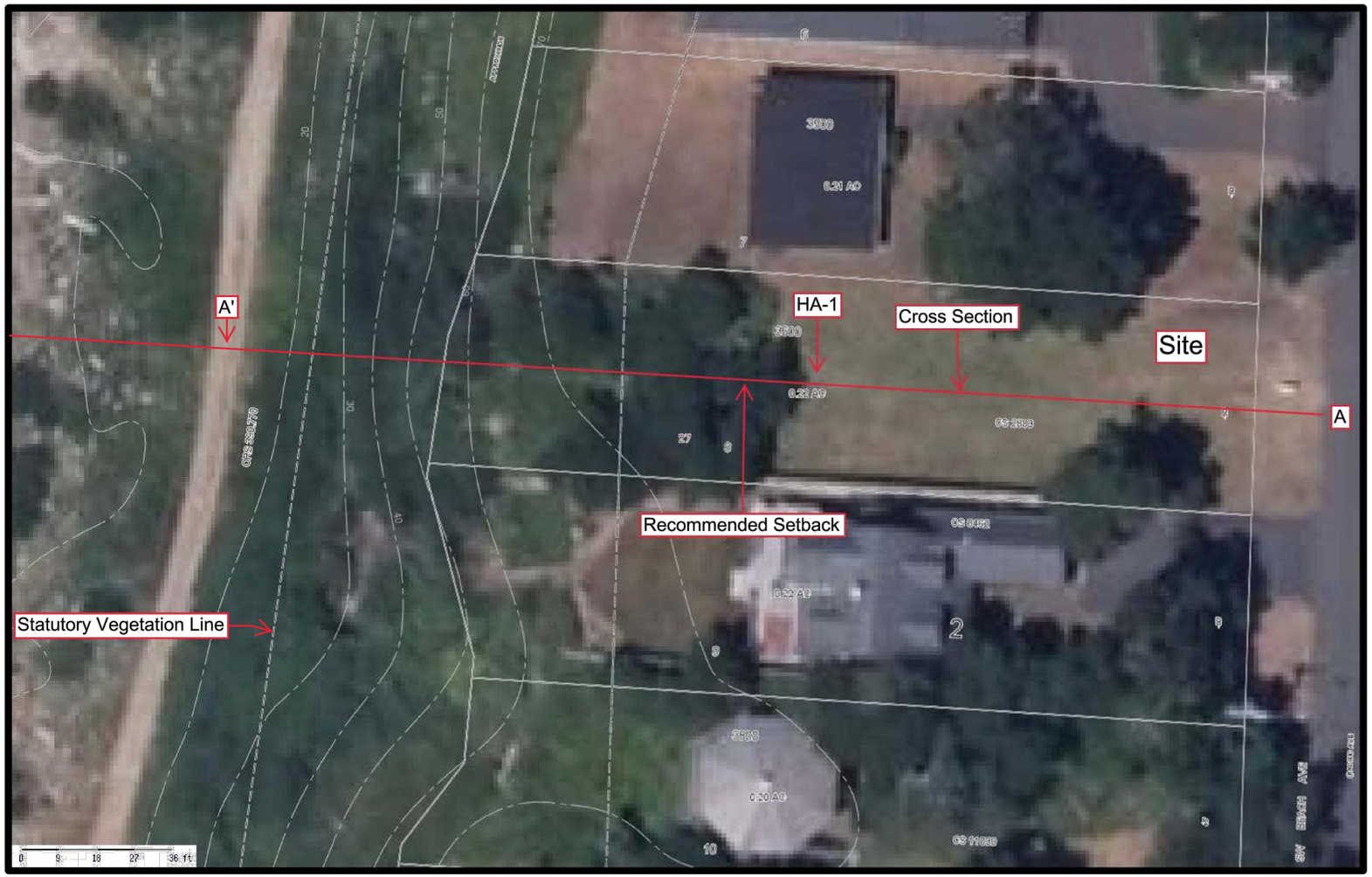
4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-1
07-16-2019

PROJECT NO. 19-225

4633 SW Beach Avenue

T7S R11W 27CD Lot 3600 Lincoln City



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310 5th STREET, SPRINGFIELD, OREGON 97477

SCALE: (11"x17")

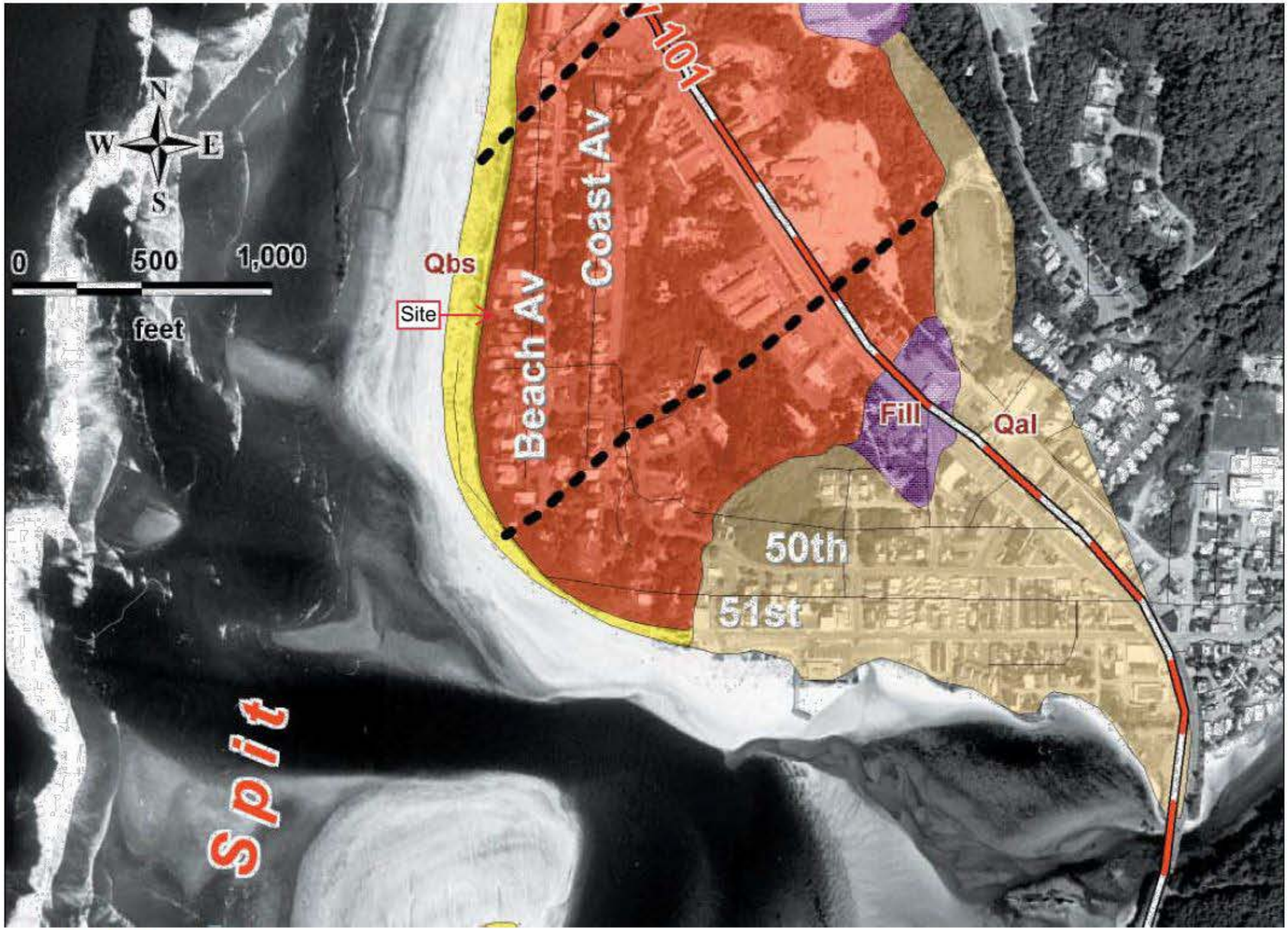
SITE EXPLORATION MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-2

07-16-2019

PROJECT NO. 19-225



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310 5th STREET, SPRINGFIELD, OREGON 97477

SCALE: (11"x17")

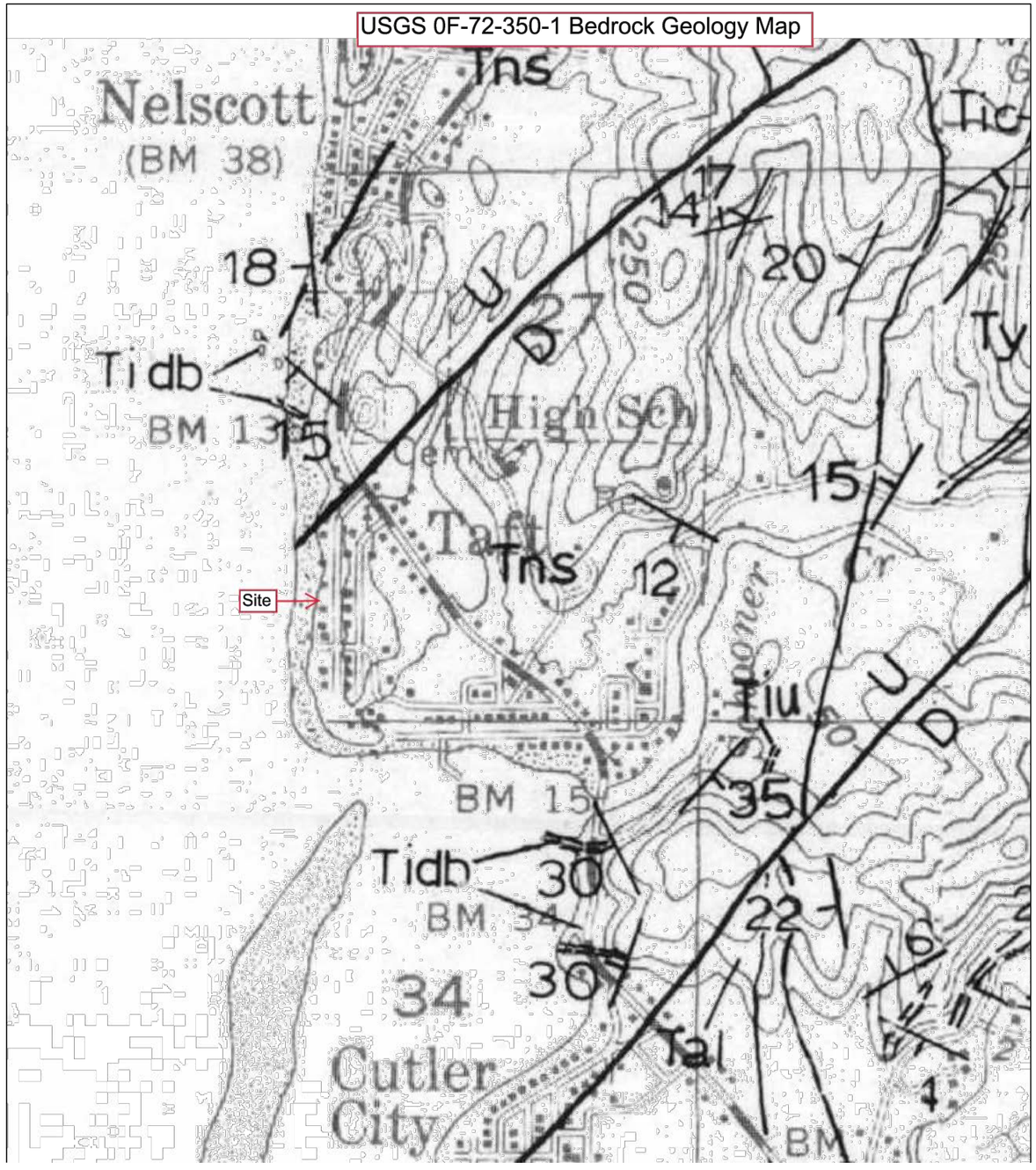
SITE GEOLOGY MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-3

07-16-2019

PROJECT NO. 19-225



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SCALE: (11"x17")

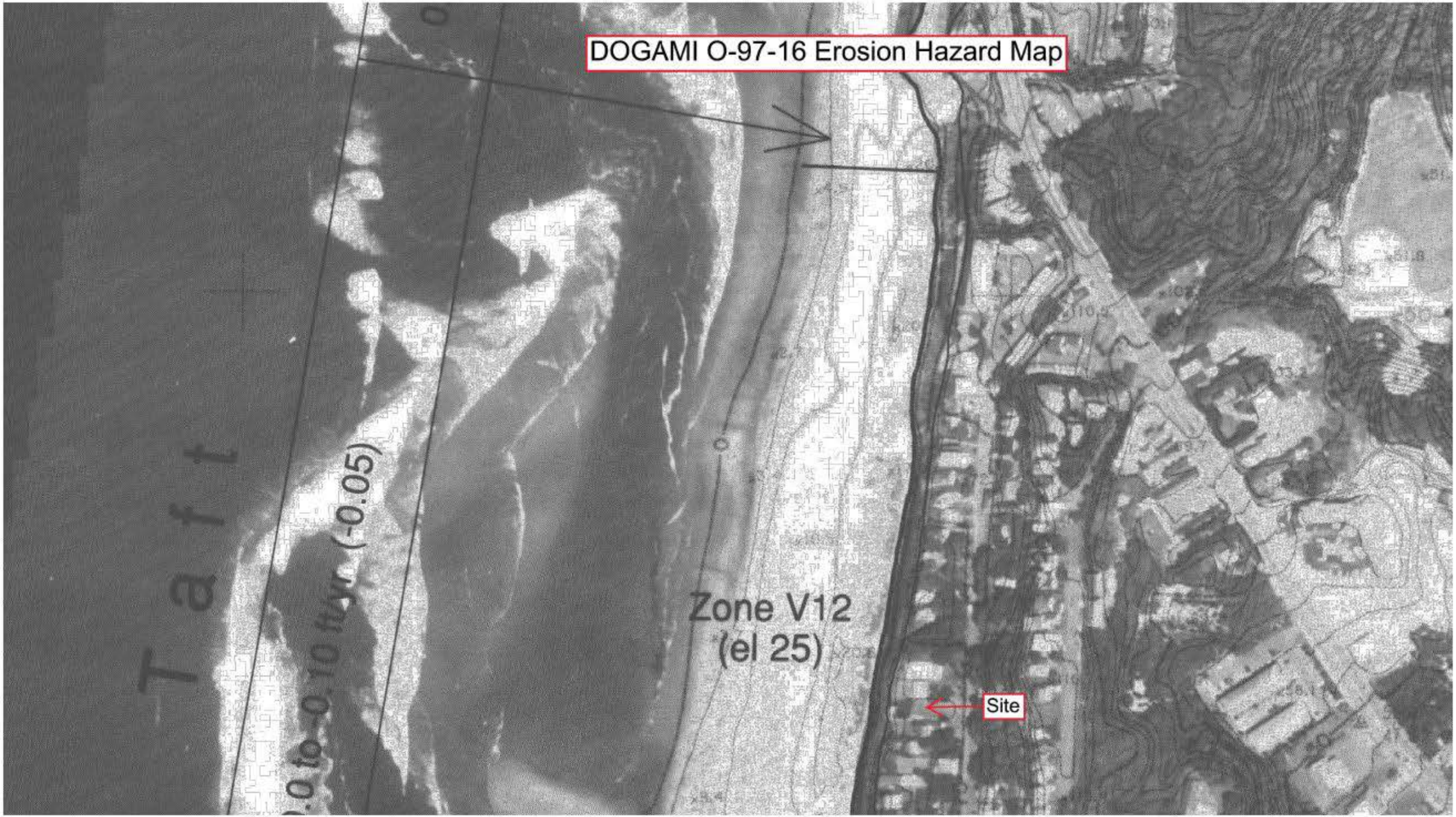
USGS BEDROCK GEOLOGY MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-4

07-16-2019

PROJECT NO. 19-225



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DOGAMI EROSION HAZARD MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-5

07-16-2019

PROJECT NO. 19-225

HazVu Expected EQ Shaking and Nearest Active Fault Map

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SCALE: (11"x17")

HazVu EXPECTED EARQUAKE SHAKING AND NEAREST FAULT MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-6

07-16-2019

PROJECT NO. 19-225

HazVu Coastal Erosion Hazard Map

June 2, 2019

- Very High (Active) Hazard Zone
- High Hazard Zone
- Moderate Hazard Zone
- Low Hazard Zone
- NO DATA

1:960

0 0.01 0.01 0.02 mi

0 0.01 0.01 0.03 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus

N

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SCALE: (11"x17")

HazVu COASTAL EROSION HAZARD MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-7

07-16-2019

PROJECT NO. 19-225

6/2/2019

HazVu Landslide Hazard Map

N

https://gis.dogami.oregon.gov/maps/hazvu/ 1/1

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SCALE: (11"x17")

HasVu LANDSLIDE HAZARD MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-8
07-16-2019

PROJECT NO. 19-225

HazVu Expected EQ Shaking Map

June 2, 2019

Active Faults

Expected Earthquake Shaking

Violent

Severe

Very Strong

Strong

Moderate

Light

1:960

0 0.01 0.01 0.02 mi

0 0.01 0.01 0.03 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus

N

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SCALE: (11"x17")

HazVu EXPECTED EARTHQUAKE SHAKING MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-8

07-16-2019

PROJECT NO. 19-225

HazVu Cascadia EQ Expected Shaking Map

June 2, 2019

Statutory Tsunami Inundation Line

Cascadia Earthquake Expected Shaking

Violent

Severe

Very Strong

Strong

Moderate

Light

Scarp

Head Scarp

Deposits

Talus-Colluvium

1:960

0 0.01 0.01 0.02 mi

0 0.01 0.01 0.03 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus

N

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SCALE: (11"x17")

HazVu CASCADIA EARTHQUAKE EXPECTED SHAKING MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-10

07-16-2019

PROJECT NO. 19-225

HazVu Liquefaction Hazard Map

June 2, 2019

Active Faults

Moderate

High

Low

1:960

0 0.01 0.01 0.02 mi

0 0.01 0.01 0.03 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus

N

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SCALE: (11"x17")

HazVu LIQUEFACTION HAZARD MAP

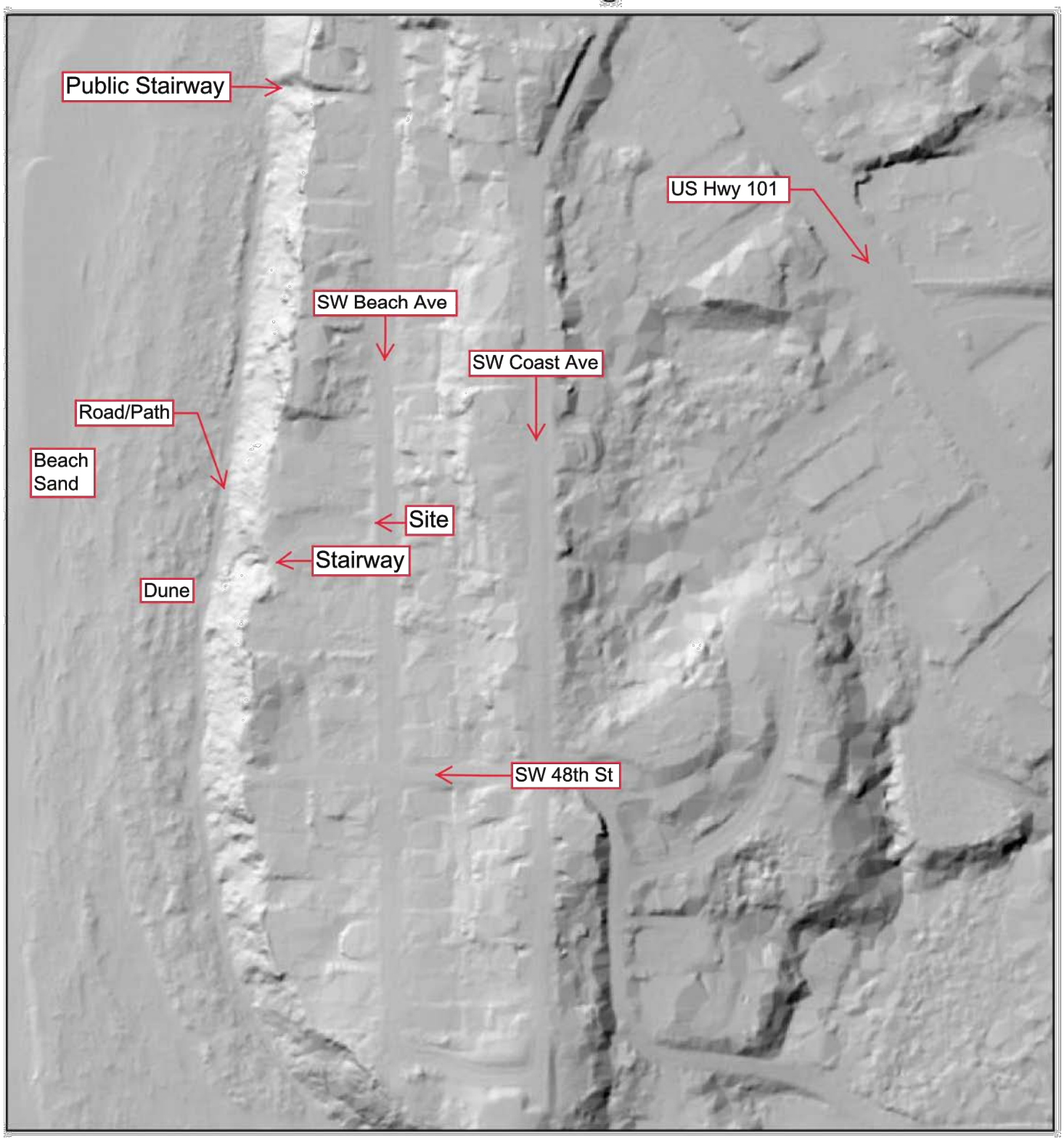
4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-11

07-16-2019

PROJECT NO. 19-225

LIDAR Image



June 6, 2019

Bare Earth Lidar Hillshade

255

0

1:3,840

0 0.02 0.04 0.09 mi

0 0.04 0.07 0.14 km

N

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SCALE: (11"x17")

LIDAR SITE MAP

FIGURE-12

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

07-16-2019

PROJECT NO. 19-225

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SCALE: (11"x17")

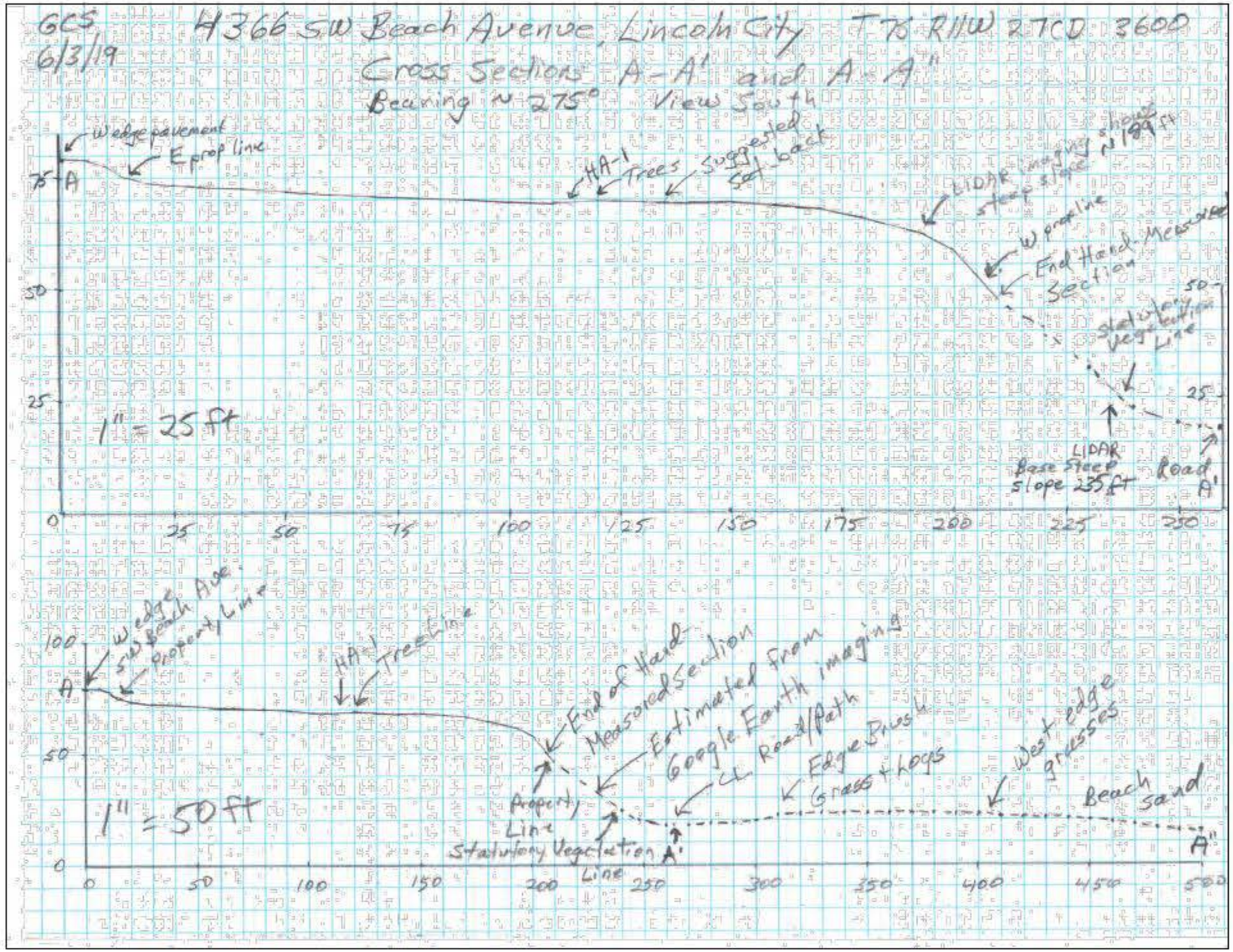
EXPECTED EARTHQUAKE MAP

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-13

07-16-2019

PROJECT NO. 19-225



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SCALE: (11"x17")

SITE CROSS SECTION

4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-14

07-16-2019

PROJECT NO. 19-225

DOGAMI OFR O-04-09 Bluff Erosion Hazard Zone Diagram

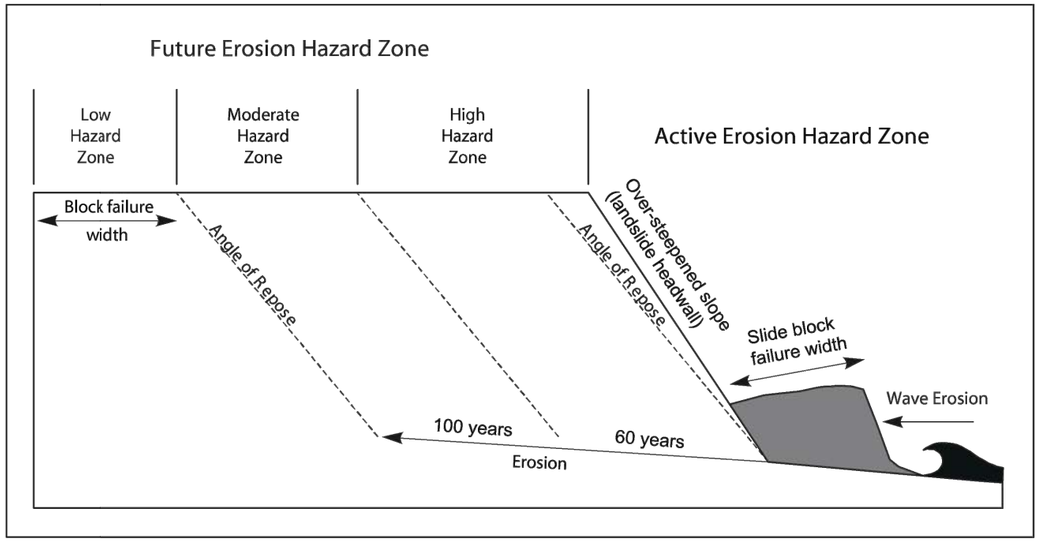

Figure 6. Schematic illustration of block failure on a bluff, angle of repose, and erosion rate in relation to possible hazard zones. These factors can be combined in a variety of different ways to produce hazard zones.

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SCALE: (11"x17")
BLUFF EROSION HAZARD ZONE DIAGRAM
4633 SOUTHWEST BEACH AVENUE LINCOLN CITY, OREGON

FIGURE-15
07-16-2019
PROJECT NO. 19-225

Soil Map—Lincoln County Area, Oregon
(4633 SW Beach Avenue)

Map Scale: 1:2,630 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 35 70 140 210

Feet
0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lincoln County Area, Oregon
Survey Area Data: Version 15, Sep 17, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Feb 12, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3E	Bandon fine sandy loam, 12 to 50 percent slopes	22.1	64.9%
4A	Beaches, 1 to 3 percent slopes	9.0	26.4%
Totals for Area of Interest		**34.0**	**100.0%**