R. Warren Krager, R.G., C.E.G.
Consulting Engineering Geologist
Oregon CEG #E957

May 3, 2021

Judy and Karl Nusch, in care of:
Jason R. Morgan, P.E.
Morgan Civil Engineering, Inc.
PO Box 358, Manzanita, OR 97130

Subject: Preliminary Site Investigation Report, Proposed New Home
03N 10W 29BA, Tax Lot 13100, Glenesslin Partition Plat 2004-04
Cherry Avenue, Manzanita, Oregon

Dear Ms. Allen, Mr. Nusch, and Mr. Morgan,

As you requested, I have completed my preliminary engineering geologic site investigation report for the proposed new home on Tax Lot 13100. This site evaluation and geologic hazard review report has been prepared in general accordance with the City of Manzanita Zoning Ordinance #95-4 Section 3.085 for beach and dune areas. The property is mapped in a stable dune and marine terrace area. However, a disturbed, eroded dune area is mapped as an active mass-movement area on the adjacent property to the south.

R. Warren Krager, R.G., C.E.G. (Oregon Licensed Engineering Geologist E-957) conducted the site reconnaissance visit to the property with Jason Morgan, of Morgan Civil Engineering, Inc. on Friday, January 29, 2021. Approximately ½-hour was spent on site observing and discussing site, drainage, general building set back and design requirements, and geologic hazard conditions. We also observed exposed surface soils, natural drainage conditions of the lot and the general age and condition of streets, existing adjacent homes and graded and natural slopes in the general project area.

In preparing this report, available geologic hazard maps and reports, tax lot maps, architectural design concept sketches and available topographic data and aerial photographic images were reviewed for detailed information pertinent to the subject property and vicinity. The following geologic reports, maps, aerial photos and other information were reviewed and used in preparation this report:

- Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon, Oregon Department of Geology and Mineral Industries (DOGAMI), Bulletin 74, 1972.
- Evaluation of Coastal Erosion Hazard Zones Along Dune and Bluff Backed Shorelines in Tillamook County, Oregon: Cascade Head to Cape Falcon, Oregon Department of Geology and Mineral Industries (DOGAMI), Open File Report O-01-03, 2001.
- Geologic Map of the Tillamook Highlands, Northwest Oregon Coast Range (Nehalem, 15-minute Quadrangle), United States Geological Survey (USGS), Open File Report 94-21, 1994.
- City of Manzanita Zoning Ordinance #95-4 Section 3.085.

10655 S.W. Park Street ● Tigard, Oregon 97223 ● Phone 360-903-4861● Email warrenkrager@gmail.com

- Google Earth aerial photographs of the Manzanita, Oregon area, photo dates: September 3, 1994, July 29, 2000, June 15, 2003, June 29, 2005, December 12, 2005, August 1, 2011, July 6, 2012, July 30, 2014, August 23, 2016, and June 22, 2017.
- Local Source (Cascadia Subduction Zone) Tsunami Inundation Map, Manzanita-Nehalem, Oregon, Tsunami Inundation Map Series Till-02, Oregon Department of Geology and Mineral Industries (DOGAMI), map date 7-12-2012.
- Geologic Investigation of Coastal Property, Neahkahnie Beach, Oregon, prepared by Robert O. VanAtta, Ph.D., prepared for Glenesslin Subdivision, Tax Lots 13100-15300, July 18, 1977.
- Oregon Department of Geology and Mineral Industries, DOGAMI LIDAR Viewer http://www.oregongeology.org/lidar/dataviewer/.
- DOGAMI Statewide Landslide Information Database for Oregon (SLIDO).
- City of Manzanita Zoning Ordinance #95-4 Section 3.085.

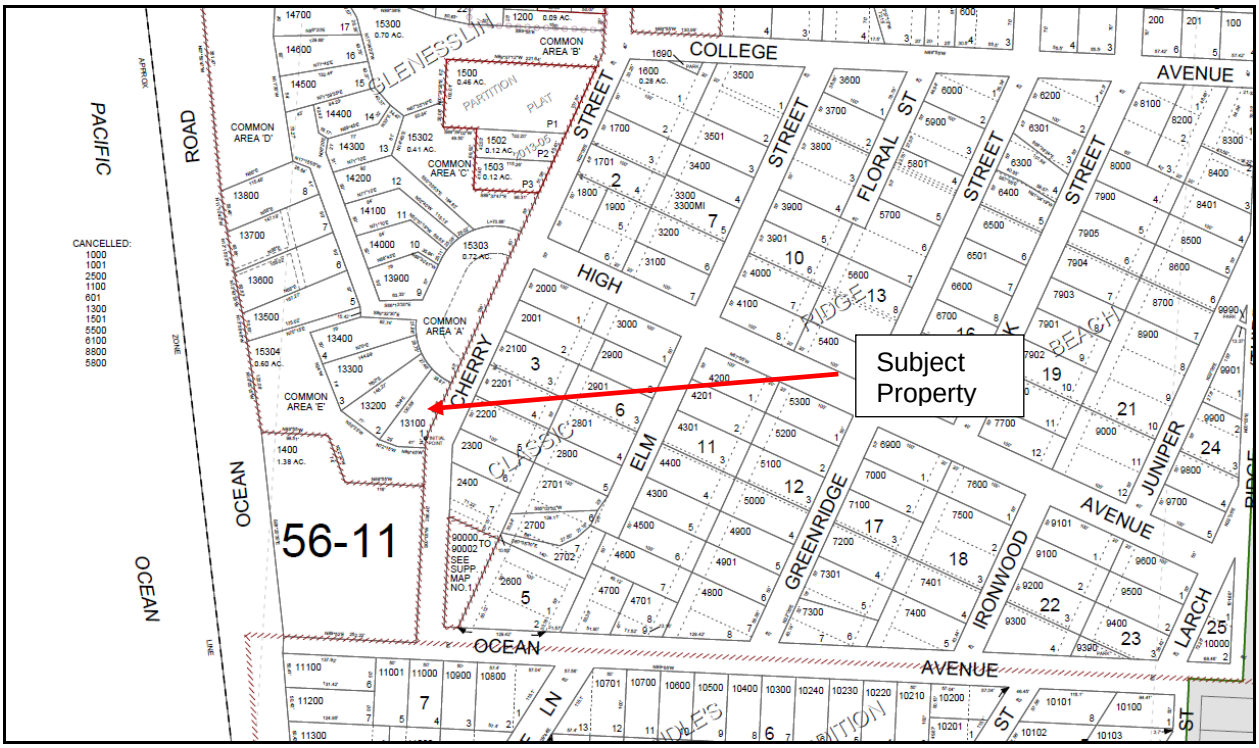

Figure 1- Portion of Tillamook County Tax Map 3N10W29BA

Site Location and Project Description

The subject property is on Cherry Street between High Avenue and Ocean Avenue in the Glenesslin Partition Plat 2004-14. Tax Lot 13100 lies on the west side of Cherry Street, south of the intersection with Cherry Lane as shown in Figure 1, and Photo 1. The subject lot varies in width from about 35 feet to about 70 feet (east-west) and about 90 feet to 130 feet in length, (north-south). The lot is vacant, and the building area is well vegetated with a dense cover of native shrub and small pine trees, Photo 1.

Photo 1- Vertical aerial view of Glenesslin Partition Plat 2004-14, Manzanita, Google Earth Photo date June 22, 2017.

The subject property lies in an upland, vegetation-stabilized sand dune area with steep descending slopes and irregular topography on the south and western margins of the parcel. The southern margin of the lot lies near a disturbed dune slope caused by human foot traffic between Cherry Street and Ocean Road. This vegetation and sand disturbance was noted in the Robert O. VanAtta, Ph.D., report prepared for the subdivision in 1977, and is now included as a mapped landslide in Oregon Department of Geology and Mineral Industries State Landslide Information Database.

Review of Google Earth air photos dated over the past two decades suggest no significant erosion abatement or mitigation has occurred. The foot traffic erosion has caused the loose sand to ravel back to a slope gradient less than 40 percent along the denuded sand pathways between streets. The fully vegetated dune slopes on the subject lot and those adjacent to north have natural slopes steeper than 50 percent that remain conditionally stable with intact organic duff and thin, developing organic surface soil.

I estimate from the Google Earth aerial photo, Photo 1, that the open sand pathway in the disturbed dune slope extends northeast at about 33 percent incline, to elevations of about 113 to 116 feet above sea level. The head scarp of the disturbed, eroded sand slope lies within about 40 feet horizontally and 10 feet vertically, from the southern margin of Tax Lot 13100. The eroded sand area is limited to a narrow foot path at the west shoulder of Cherry Street. Under existing conditions and use, the barren sand slope ravel/ erosion path, lies on trend to continue retrogressively up-slope to the northeast into the steeper vegetated dune slopes on Tax Lot 13100. The 33 percent slope incline of the disturbed sand trough projects to daylight on Lot 13100 at about elevation 125-foot contour, more than 30 feet north into the lot.

The subject lot lies at elevations of approximately 134 feet to 115 feet above mean sea level (msl), based on elevations shown on Figure 2. The elevations above approximately 125 feet above sea level on the southern 30 some feet of Tax Lot 13100 are at risk of eventual erosion or slope raveling if foot traffic and erosion continue, or under seismic or tsunami scenarios. Tax Lot 13220, adjacent to the west, at elevation up to 135 feet above sea level, is currently undeveloped with some dune erosion extending to higher elevations its southern edge. Potentially unstable slopes are present along the western boundary of Tax Lot 13100, particularly along the southern end of the lot at the 130-foot elevation or higher dune slope crest.

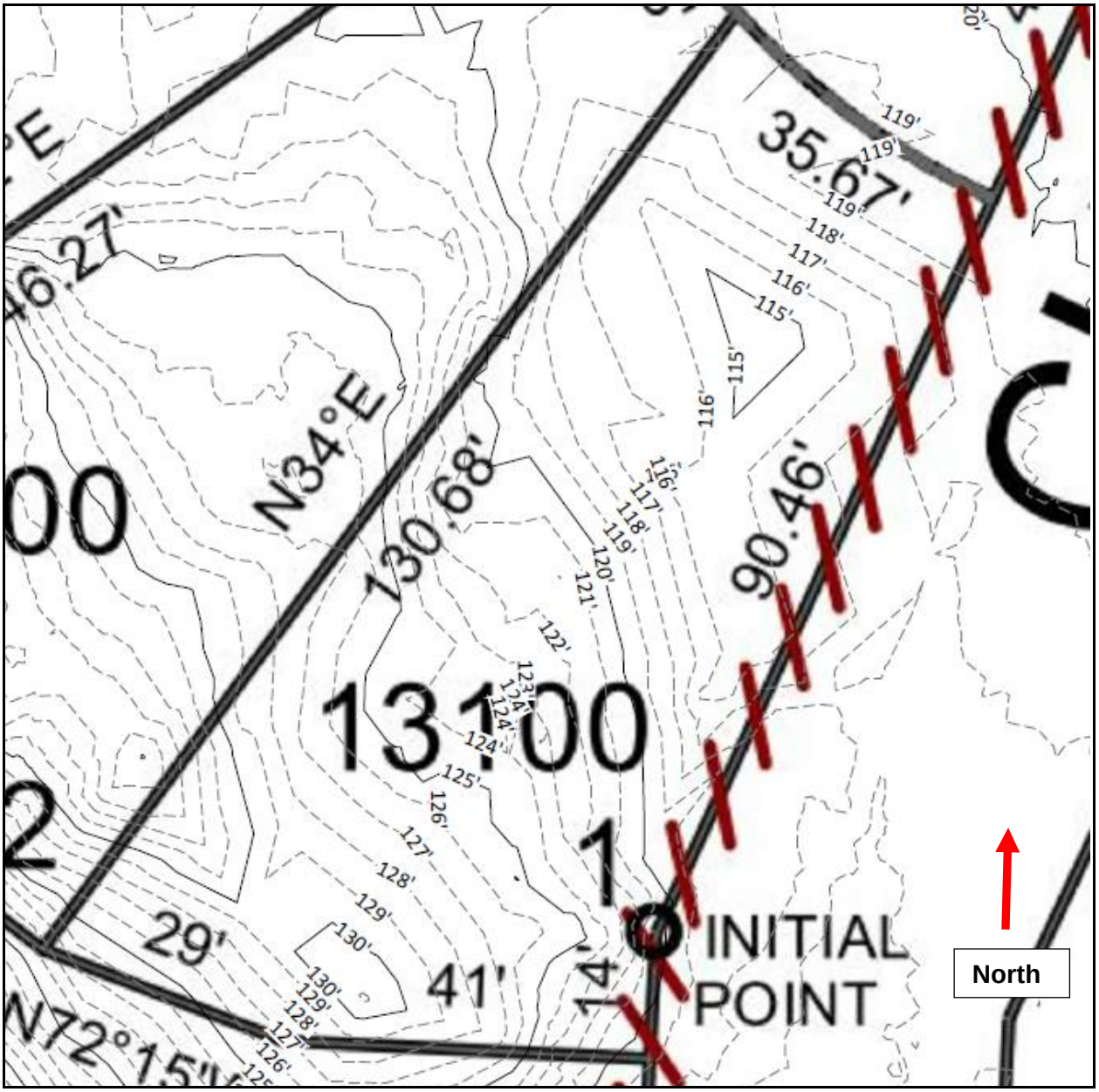

Figure 2- Lidar based topographic plan of Tax Lot 13100 prepared by Morgan Civil Engineering.

I have not seen a site plan or design concept sketch for a proposed home on Tax Lot 13100. I understand you intend to seek a variance to allow a 4-foot reduction in side-yard setback along the border with Cherry Street to allow more options to design a home for the relatively narrow sloping lot. I expect a home on this lot would require engineered retaining walls, possible shored excavations, and deep foundations, particularly on the steeply sloping south end and along the southwestern lot boundary. Some grading would be expected to structurally fill the closed depression on the northern end of the lot.

Soils and Geology

Surface soils in the project area are mapped by the USDA NRCS Web Soil Survey of Tillamook County, Oregon as Waldport fine sand, thin-surface, 15 to 60 percent slopes. The fine-grained sand soil forms from dunes on marine terraces, foredunes and blowouts. The near surface sand soil on the property does not appear to have been recently disturbed, but as noted, the sand on steep slopes of the south end of the lot may be susceptible to future erosion or instability. The typical Waldport soil profile described by the USDA includes up to about one inch of decomposed plant material underlain by up to about 60 inches of fine sand. The USDA does not describe the contact with underlaying marine terrace sediments or bedrock.

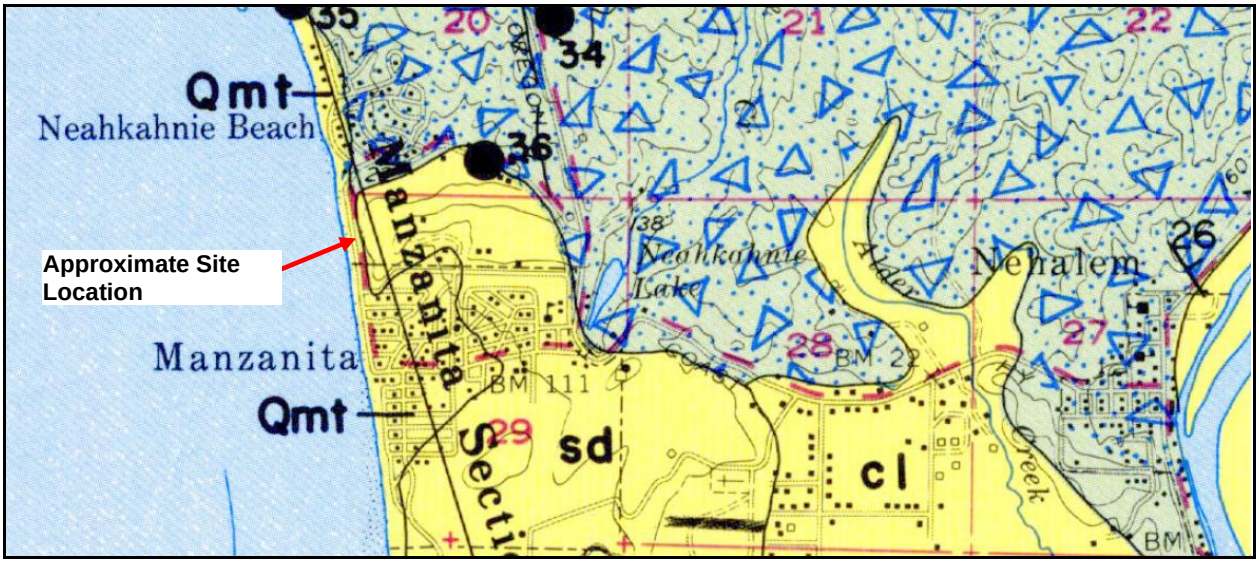

Figure 3- Portion of Geologic Map of Nehalem Quadrangle, DOGAMI Bulletin 74 (1972).

Available geologic mapping in Figure 3 and Figure 4, show geologic deposits of the project area include a narrow strip of Quaternary marine terrace deposits (map unit **Qmt**) to the west of younger Quaternary to Holocene sand dunes, **sd** or **Qb**. The Quaternary marine terrace deposits include sediments that were deposited by the ocean at lower elevation, and their surfaces have been subsequently left in their present position above sea level. The terraces are variable in composition but generally are composed of level beds of fine-grained sand, silt and clay. This dune area formed upon the emergent terrace during a time of rapidly fluctuating sea levels, toward the end of the last ice age. Dunes of similar age reach heights over 200 feet above sea level in parts of Manzanita.

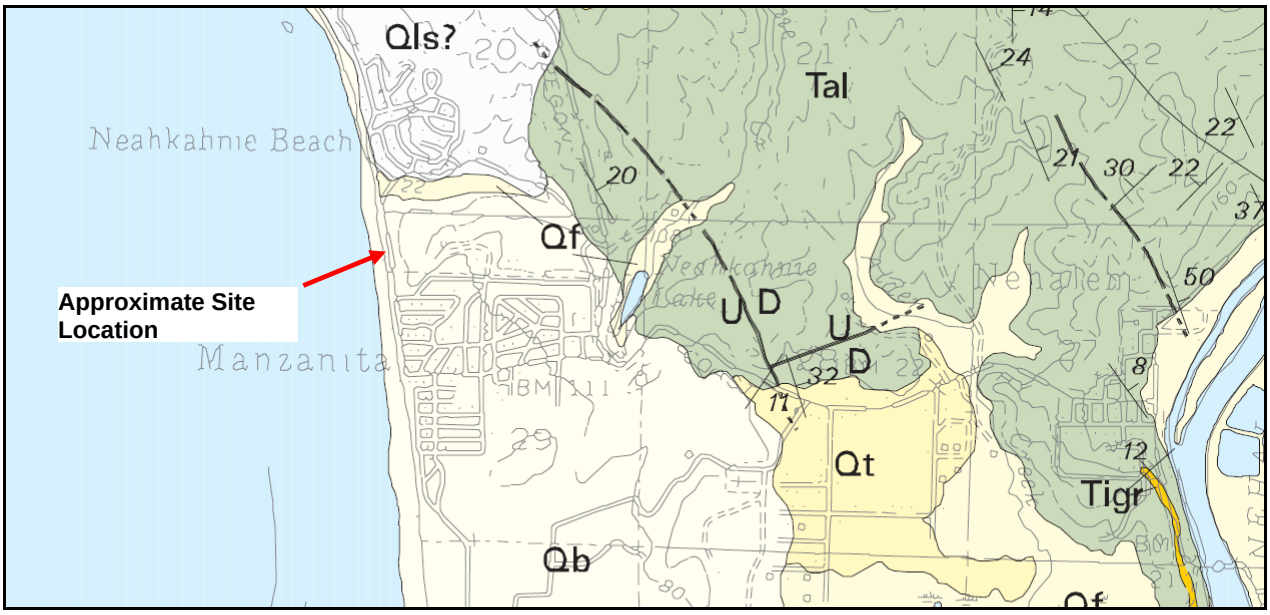

Figure 4- Portion of Geologic Map of the Tillamook Highlands, Northwest Oregon Coast Range Nehalem, 15-minute Quadrangle, USGS, Open File Report 94-21, 1994.

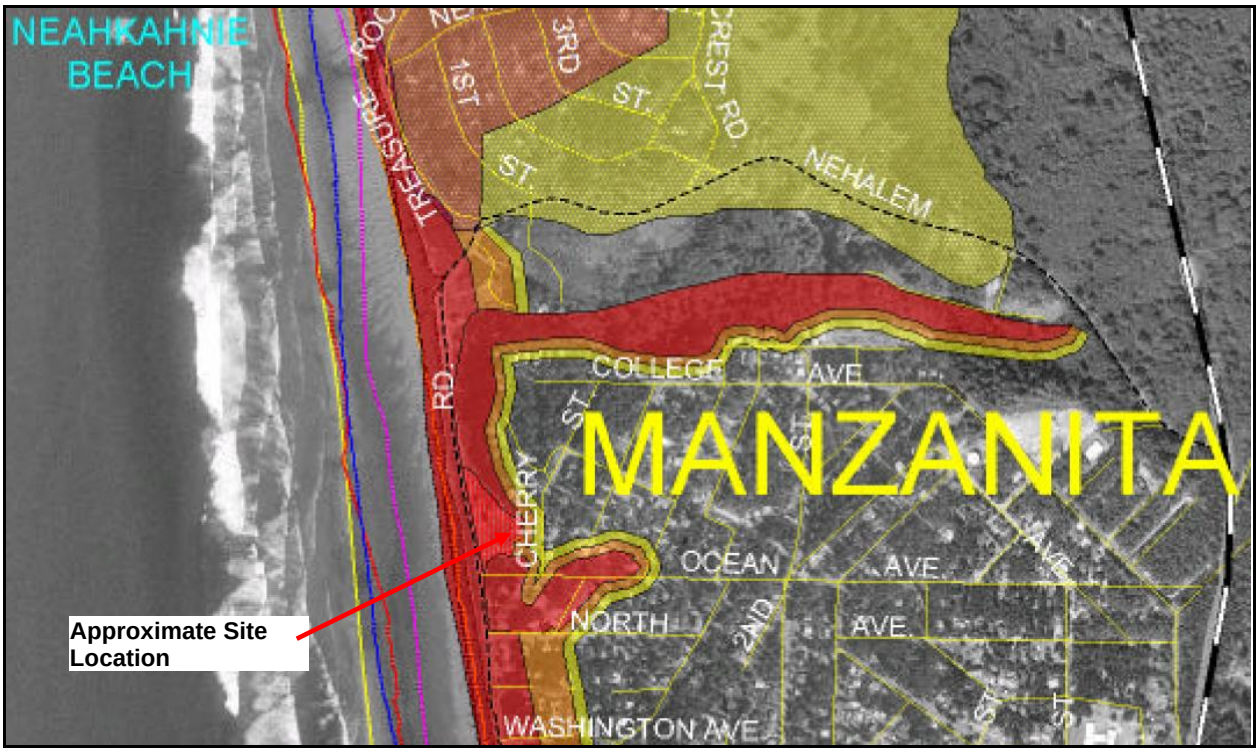

Figure 5- Evaluation of Coastal Erosion Hazard Zones Along Dune and Bluff Backed Shorelines in Tillamook County, Oregon: Cascade Head to Cape Falcon, Oregon Department of Geology and Mineral Industries (DOGAMI), Open File Report O-01-03, 2001. Project site is mapped in or near active mass movement area.

Coastal Erosion and Dune hazards

Based on mapping in DOGAMI Open File Report O-01-03, the subject property is within a high-risk coastal erosion hazard zone, Figure 5. The hazard zones are defined by DOGAMI as high (Red zone in Figure 5), moderate (orange), and low (yellow) risk hazard zones, which respectively indicate decreasing probability levels of occurrence, with the high-risk scenario having the greatest chance of occurrence during the next 60 to 100 years. As measured from Google earth air photos, the subject lot is located about 450 feet east from the easternmost edge of active ocean beach and foredune west of Ocean Road. The subject property is located inland of one public street and existing homes. Because of distance and elevation above sea level, the subject lot and home site are not considered subject to coastal erosion or active dune migration. Rising sea level and potential for increased storm erosion due to climate change could increase shoreline and dune erosion to low lying infrastructure and homes.

Geologic and Seismic Hazard Summary

The principal geologic hazard concern throughout western Oregon is an earthquake on the Cascadia Subduction Zone, CSZ. This is a thrust fault zone of tectonic plate convergence located in the sea floor about 50- to 60-miles off the northern Oregon coast. This active fault zone is now becoming the public's focus for design safety and emergency preparedness planning for much of the western Pacific Northwest region. This fault interface between the tectonic plates is considered locked-up and building increasing pressure and strain. When this locked fault moves or shifts, a strong earthquake can result.

The CSZ can produce a massive, global-scale earthquake that will cause strong ground shaking and structural damage region wide. Geologic and geophysical research has established that the CSZ has produced 19 large, magnitude 8-9 earthquakes in the past 10,000 years. Recurrence intervals between past earthquakes range from 110 years to 1,150 years, with an average recurrence interval of about 490 years. Historic Japanese tsunami records and modern tree ring dating techniques have been used to determine that the most recent CSZ earthquake occurred in January of 1,700 A.D.

Based on the geologic record of CSZ Earthquake recurrence intervals, the next CSZ earthquake is potentially overdue and may occur within many of our lifetimes. In 2008, the United States Geologic Survey (USGS) released results of research that estimated 10% probability that a magnitude 8-9 Cascadia Subduction Zone earthquake would occur within 30 years.

Other potential earthquake sources in this region include fault ruptures deep within the subducting oceanic plates and within the overlying continental crustal tectonic plate. However, the CSZ thrust fault earthquake mechanism is considered the greatest seismic hazard to the region and the seismic source which dictates building code design requirements for permitted habitable structures.

During a CSZ earthquake, the local area will probably experience a few minutes of very intense ground shaking. The subject lot may experience severe ground shaking, potential for seismically induced landslide, and risk of tsunami scour or erosion of dune slopes. Rapid undersea thrust

fault displacement expected during a CSZ earthquake will cause an ocean tsunami estimated to arrive at the Oregon coast about 15 to 30 minutes after the earthquake strikes.

Conclusions and Recommendations

The subject property is in a high-risk coastal erosion hazard zone and relatively high-hazard seismic risk area. The lot is not mapped in a CSZ earthquake tsunami inundation zone. However, seismic slope instability and tsunami scour at lower elevations could jeopardize slope stability of the building area on Lot 13100. The ongoing risk of sand slope raveling and erosion from human caused disturbance is considered relatively minor and could be mitigated with plantings, fencing, or avoidance of steep slope areas in selecting building sites. I concur that the desired building setback reduction request on the east side of the lot is reasonable considering the steep compound slopes to the south and west of lot. Moving the home footprint to the east or north will reduce long term slope instability risk to the home. Site grading, deep foundation options, or slope retaining structures may be available to further mitigate slope erosion and instability risk.

The subject lot has chronic seismic geologic hazard risk, but is generally feasible for new single-family home construction, subject to code required minimum design and construction criteria, and according to your recognition and acceptance of potential seismic and slope hazard risk as discussed above. There may be no complete engineering mitigation available for seismic slope stability and risk of tsunami scour at lower elevation. That said, it is the author's opinion that relative seismic stability and coastal erosion hazard risk are no greater for this lot than for many previously developed lots of the Manzanita area. Residential development of Tax Lot 13100 is not expected to increase geologic or seismic hazard or risk of coastal erosion on the subject lot or other private or public property.

For preliminary planning, I recommend base subgrade elevation of shallow spread foundations for structures to be set no higher than 125 feet above sea level. Pier or pile supported grade-beam foundations may be used at higher elevations to or to avoid deep excavation and potential temporary slope shoring requirements. Any structure within 25 feet of the south property boundary should be supported on an engineered deep foundation system. Helical piers advanced by hydraulic torque or small-diameter driven pipe piles or similar foundation system is recommended. Drilled and grouted piers or soldier pile may be options for retaining wall, shoring and foundation systems. According to individual structural design, temporary or permanent cut slope faces in loose sand may be covered with mesh and shotcrete to stabilize during earth work construction or as structural retaining wall facing.

Except for excavation or grading within 25 feet of the south lot boundary, it is my opinion that site preparation and grading for conventional residential construction may be planned and conducted in accordance with Oregon Structural Specialty Code (OSSC) Appendix J- Grading.

I should be contacted to review proposed grading and foundation plans for Tax Lot 13100.

Limitations

The engineering geologic reconnaissance and geologic hazard review performed for the proposed residential construction have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this discipline and area under similar budget and time constraints. No warranty, expressed or implied, is made regarding the interpretations and conclusions of this report.

This report may be used only by the client and their authorized agents for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both on- and off-site), or other factors may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its date of issue. If the project is delayed by more than 24 months from the date of this report, I would happy to review site and design conditions and revise this report if appropriate or provide further plan review or documentation of earthwork construction and foundation subgrade preparation at the time of construction.

If you have any questions regarding the information presented in this report, please do not hesitate to contact me at 360-903-4861 or warrenkrager@gmail.com.
Sincerely,

R. Warren Krager, R.G., C.E.G.
Oregon Licensed Engineering Geologist E-957