Attachment 15

MOTT MACDONALD

Technical Note

Project:	507407672		
Prepared by:	Christopher Day and Michelle Gostic	**Date:**	May 13, 2019
Approved by:	Shane Phillips	**Checked by:**	Dave Simpson
Subject:	Recommended First-Floor Elevation at Former Hardel Mutual Plywood Corp. Site, 1210 West Bay Drive, Olympia, WA.		

1 Introduction

The Milestone Companies, LLC is assisting with the redevelopment of the former Hardel Mutual Plywood Corp. site on West Bay Drive Olympia, WA (Thurston County parcel 72600200100). The site is located along Budd Inlet and is subject to tides and wave runup (see Figure 1). One of the critical path items is establishing the minimum elevation of the finished first floor. To address this item, Milestone has asked Mott MacDonald (MM) to determine the most appropriate first floor elevation. The recommended first floor elevations in this memo are based on local building code requirements, National Flood Insurance Program (NFIP) regulations, the effective Flood Insurance Study by the Federal Emergency Management Agency (FEMA, 2018), and the City of Olympia's (2019) Sea Level Rise Response Plan.

2 Water Levels and Waves

2.1 Tides

Tides at the site are based on the established datums at NOAA Station 9446969, Olympia, Budd Inlet, Puget Sound, WA (47° 3.6' N, 122° 54.2' W), located 0.7 miles east-northeast of the site location. The tidal datums in Table 1 are based on water levels measured between March 30, 1977 and April 6, 1978. The spring tide range is 14.6 feet, while the average tide range is 10.5 feet.

Attachment 15 2

Figure 1. Site location

Table 1. Tidal Datums at NOAA Station 9446969, Olympia, Budd Inlet, Puget Sound, WA

		feet MLLW	feet MSL	feet NAVD88
Highest Observed Water Level (12/15/1977)		17.94	9.59	13.95
Mean Higher High Water	MHHW	14.56	6.21	10.57
Mean High Water	MHW	13.55	5.20	9.56
Mean Sea Level	MSL	8.35	0.00	4.36
Mean Tide Level	MTL	8.31	-0.04	4.32
National Geodetic Vertical Datum of 1929	NGVD29	7.40	-0.95	3.41
North American Vertical Datum of 1988	NAVD88	3.99	-4.36	0.00
Mean Low Water	MLW	3.07	-5.28	-0.92
Mean Lower Low Water	MLLW	0.00	-8.35	-3.99
Lowest Observed Water level (1/2/1977)		-4.33	-12.68	-8.32

2.2 Storm Tide / Stillwater Elevation

The stillwater elevation is the flood level due to the astronomical tide and storm surge but excluding the effects of waves (FEMA, 2005). Strong winds and low atmospheric pressure during storms can raise water levels above the predicted tidal elevation. Storm surge effects coinciding with a high tide can result in extreme water levels and flooding. On December 15th, 1977, storm-driven flooding inundated several buildings along Budd Inlet and Capitol Lake (FEMA, 2018). This event was an approximately 1-percent-annual-chance event (FEMA, 2018, p.11) and produced the highest observed water levels while the Olympia tide gage was in operation (see Table 1).

Table 2 summarizes the stillwater elevation as a function of return period. The return period is related to the average annual chance. For example, a water level with a return period of 100 years has a 1 in 100 or 1 percent chance of occurring any given year. The stillwater elevations in Table 2 were determined based on a statistical analysis of the estimated water levels in Budd Inlet from 1983 to 2010 (CHE, 2011). Further details regarding the methods used to estimate stillwater elevations appear in CHE (2011).

Table 2. Extreme Stillwater Elevations at Olympia (CHE, 2011)

Return Period (years)	Annual Chance	feet MLLW	feet NAVD88
2	50%	17.1	13.1
5	20%	17.5	13.5
10	10%	17.7	13.7
25	4%	18.0	14.0
50	2%	18.2	14.2
100	1%	18.4	14.4
500	0.2%	18.7	14.7

2.3 Waves

To assess the contribution of wave effects (run-up, overtopping, set-up) to flooding potential, wave conditions in Budd Inlet were estimated by CHE (2011) using the Simulating Waves Nearshore (SWAN 40.51) model (Delft University of Technology, 2006). Although the strongest winds are from the southwest, Budd Inlet shorelines are most impacted by winds from the north that have the longest fetch. Wave information was extracted at the project site for various return periods and is summarized in Table 3. Average wave setup values were on the order 0.4 feet for all storm scenarios (CHE, 2011).

Table 3. Estimated Wave Conditions at Project Site for Various Return Periods (CHE, 2011)

Return Period (years)	Annual Chance	Wind Speed from North (mph)	Significant Wave Height (feet)	Peak Wave Period (seconds)	Wave Direction (degrees)
10	10%	27.7	1.5	2.6	5.0
50	2%	35.5	2.1	3.0	5.0
100	1%	39.2	2.3	3.5	5.0
500	0.2%	45.8	2.8	3.5	5.0

2.4 Special Flood Hazard Areas and Base Flood Elevations

Except for a narrow section of the property along the street, the effective Flood Insurance Study by FEMA (2018) maps most of the site within a Special Flood Hazard Area, specifically an AE zone (see Figure 2). A and AE zones are areas subject to flooding during a 1 percent annual chance (100-year) flooding event. AE zones have a designated base flood elevation (BFE), while A zones do not. The BFE within the AE zone is +15 feet NAVD88 (see Table 4). The riprap area along the shoreline is located within a VE zone. V and VE zones are subject to flooding with “velocity” hazards due to wave action. VE zones have a designated BFE, while V zones do not. The BFE within the shorefront VE zone is +17 feet NAVD88 (see Table 4).

BFEs in coastal areas are equal to the Total Water Level during the 1 percent annual chance (100-year) event rounded to the nearest foot. In VE zones, the Total Water Level is the sum of the astronomical tide, storm surge, wave setup, and wave runup. In coastal AE zones, the Total Water Level includes primarily astronomical tide, and storm surge. Depending on location, the Total Water Level within a coastal AE zone may also include either wave setup or the decay of overtopping landward of the revetment, bulkhead, bank, or dune crest. Because BFEs are rounded to the nearest foot, the corresponding Total Water Level during the 1 percent annual chance event may be up to 0.5 feet higher or lower.

Table 4. Summary of 1% Annual Chance (100-Year) Water Levels

	Processes	Location	Elevation (feet NAVD88)
Stillwater Elevation	Astronomical Tide + Storm Surge	Offshore	14.4
VE Zone BFE / Total Water Level	Astronomical Tide + Storm Surge + Wave Setup + Runup	Beachfront & Existing Riprap Revetment	17
AE Zone BFE / Total Water Level	Astronomical Tide + Storm Surge + Decay of Overtopping	Remainder of Site Landward of Revetment	15

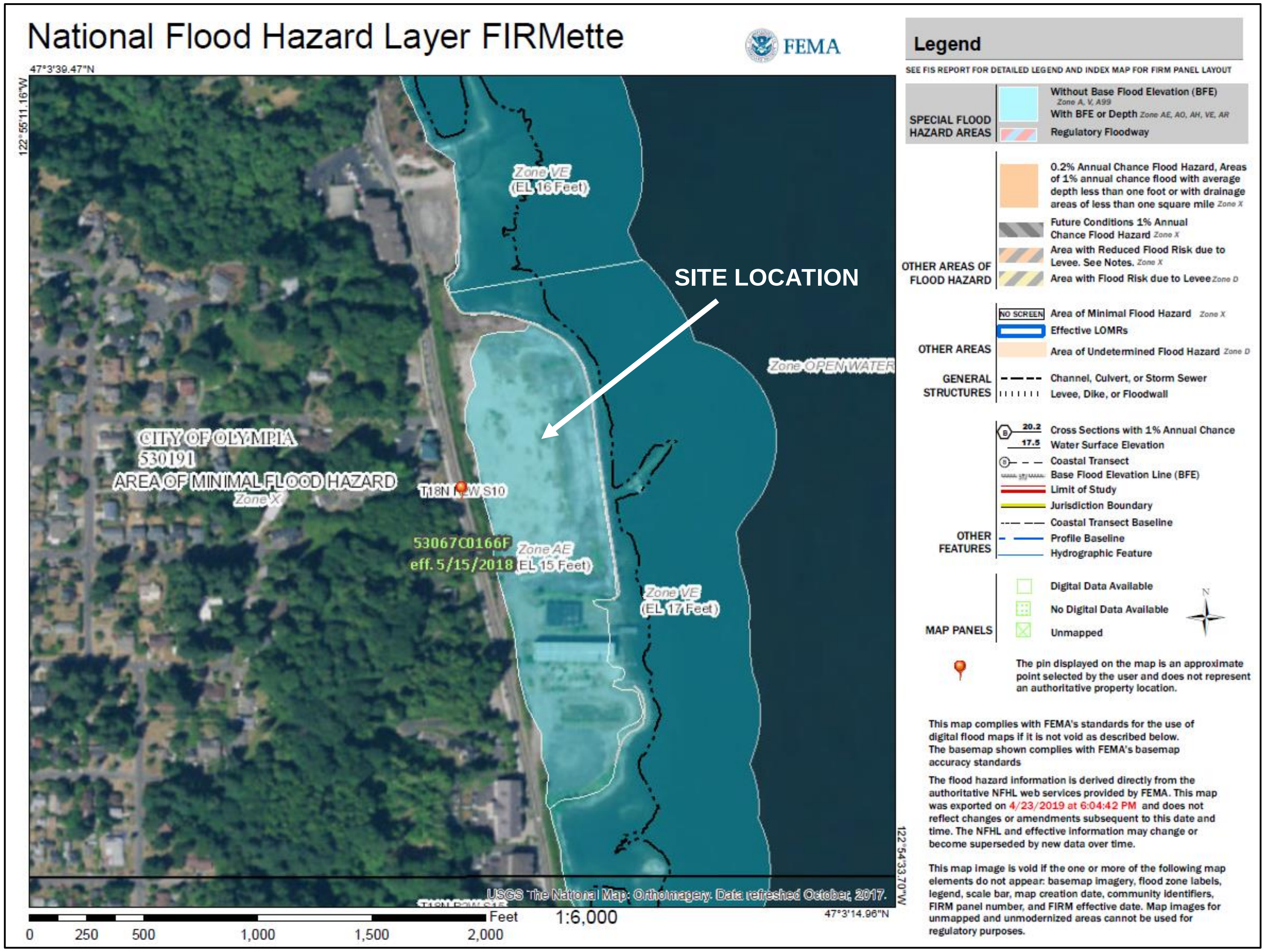

Figure 2. Special Flood Hazard Areas at site location

3 Sea Level Rise

To determine an appropriate first floor elevation for the proposed building, future changes in water level elevation due to sea level rise must be considered. Sea level rise was identified as one of three primary climate hazards likely to impact the City of Olympia (AECOM, 2017). In addition, the March 2019 Olympia Sea Level Rise Response Plan (AECOM, 2019, p. 117) recommends that the City "Require [the] minimum finish floor elevation to be set considering project's projected lifespan." Table 5 presents relative sea level rise projections from 2020 to 2070 for Budd Inlet. This study recommends the more conservative sea level rise estimate of 1.7 feet by 2070.

Table 5. Summary of Sea Level Rise Estimates for City of Olympia

Source	Sea Level Rise Estimate 2020-2070 (feet)
AECOM & City of Olympia Max. Scenario (AECOM, 2017)	1.7
WA Coastal Resiliency Project (2018) Median Value, High Greenhouse Gas Scenario (Miller et. al., 2018)	1.3

4 City of Olympia Municipal Code Requirements

4.1 Lowest Floor Definition

The City of Olympia Municipal Code (OMC) 16.70.020(O) defines the "lowest floor" as the "lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, is not considered a building's lowest floor."

4.2 Requirements for Lowest Floor

For residential construction, OMC 16.70.050(B)1.a requires that "New construction and substantial improvement of any residential structure shall have the lowest floor, including basement, elevated one foot or more* above the base flood elevation (BFE)."

For commercial construction, OMC 16.70.050(B)2.a requires that "New construction and substantial improvement of any commercial, industrial or other nonresidential structure shall either have the lowest floor, including basement, elevated one foot or more* above the base flood elevation" [asterisk* from OMC]. However, this section also states that "*Applicants who are floodproofing nonresidential buildings should be notified that flood insurance premiums will be based on rates that are one foot below the floodproofed level (e.g., a building floodproofed to the base flood level will be rated as one foot below). Floodproofing the building an additional foot will reduce insurance premiums significantly." Thus, the municipal building code implies that for commercial or mixed-use structures, a lowest floor elevation two feet above BFE should be considered to reduce flood insurance costs.

4.3 Requirements for Crawlspaces in Residential Buildings

OMC 16.70.050(B)1.c (and others) requires that in residential buildings:

- The height of the below-grade crawlspace, measured from the interior grade of the crawlspace to the top of the crawlspace foundation wall must not exceed four-feet at any point,
- There must be adequate drainage system that removes floodwaters from the interior area of the crawlspace, and;
- Any building utility systems within the crawlspace must be elevated above the BFE or designed so that floodwaters cannot enter or accumulate within the system components during flood conditions. Ductwork, in particular, must either be placed above the BFE or sealed from floodwaters.

4.4 Requirements for Development in FEMA Special Flood Hazard Areas (SFHAs)

OMC 16.70.050(C) states that “No new construction, substantial improvements, or other development (including fill) shall be permitted within Zone AE on the community’s FIRM [Flood Insurance Rate Map], unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.”

OMC 16.70.050(D) establishes further restrictions for FEMA-designed VE zones and coastal A and AE zones:

- All buildings or structures shall be located landward of the reach of the mean high tide.
- All new construction and substantial improvements shall be elevated on piling or columns.
- The bottom of the lowest horizontal structural member of the lowest floor (excluding the piling or columns) must be elevated to or above the base flood elevation plus one (1) foot or as required by ASCE/SEI 24-14, Table 4-1, whichever is more restrictive.
- All spaces below the lowest floor’s supporting member must be open so as not to impede the flow of water, except for breakaway walls.
- The use of fill for structural support is prohibited.

For most types of residential and commercial buildings, ASCE/SEI 24-14, Table 4-1 requires the lowest horizontal structural member to be elevated at least one foot above the BFE. However, in buildings used for large assemblies (theaters, churches, concert halls, schools, etc.) the required elevation is two feet above the BFE, and for more critical facilities (hospitals, fire stations, police stations, etc.), the required elevation is three feet above the BFE.

4.5 Additional Code Requirements to Address Sea Level Rise in Downtown Olympia

Chapter 16.80 of the Olympia Municipal Code addresses “sea level rise flood damage in the downtown areas of Olympia”. These provisions are applicable to the area defined in “the downtown sea level rise map published by the City” (OMC 16.80.020(A)), which is shown in Figure 3. Because the site location lies west of this area, OMC Chapter 16.80 is not legally binding at the site. However, because the subject property is located along the same body of water, the tides, wave climate, and sea level rise trends are the same as those affecting the downtown area. For this reason, guidance from OMC Chapter 16.80 should still be considered for design purposes. In general, OMC 16.80.050 requires the following in the downtown area (Figure 3, red area):

- All new construction and buildings defined as substantial improvements shall have the lowest floor elevated, dry floodproofed or shall be provided with other acceptable methods of floodproofing as approved by the City of Olympia, Building and Safety Division to an elevation of 16 feet above NAVD88 or greater.

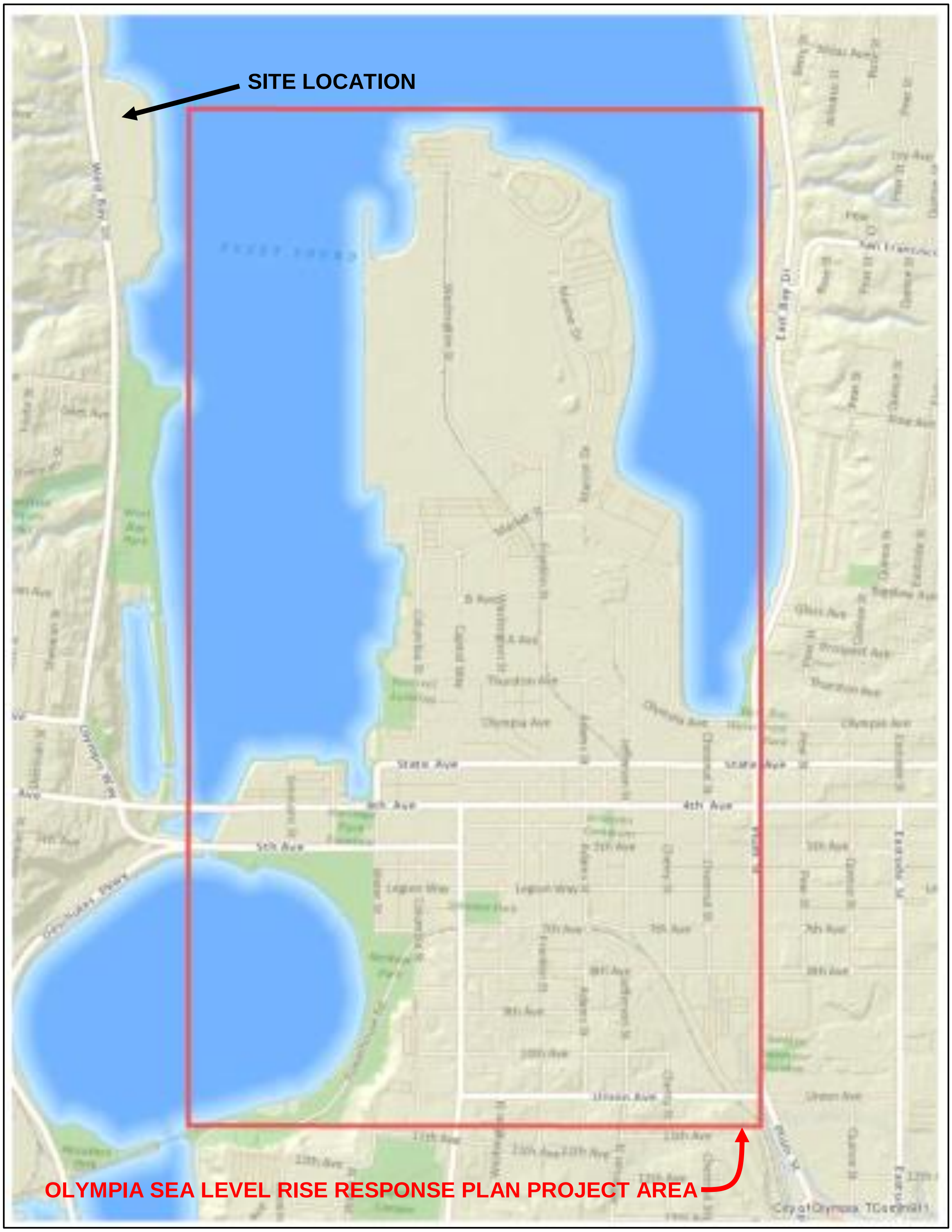

Figure 3. Olympia Sea Level Rise Response Plan Project Area (City of Olympia, 2019)

- Electrical, heating, ventilation, plumbing, and air-conditioning equipment and other service facilities shall be designed and/or otherwise elevated or located so as to prevent water from entering or accumulating within the components during conditions of flooding below 16 feet elevation. Locating such equipment below the 16 feet elevation is not allowed unless it can be demonstrated that the equipment is protected from flooding by an approved method.

5 National Flood Insurance Program Requirements

First-floor requirement under the NFIP's governing regulations are outlined below:

5.1 AE Zones

44 CFR 60.3 (C)(3) All new construction and substantial improvements of non-residential structures within Zones A1-30, AE and AH zones on the community's FIRM:

(i) [Shall] have the lowest floor (including basement) elevated to or above the base flood level or,

(ii) Together with attendant utility and sanitary facilities, [shall] be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy

44 CFR 60.3 provides for additional requirements regarding construction below the base flood elevation. However, as noted above, the Olympia Municipal Code requires the bottom of the lowest horizontal structural member of the lowest floor must be elevated at least one foot above the BFE, with open spaces or breakaway walls below.

5.2 VE Zones

In VE Zones, 44 CFR 60.3 (E) (4) requires buildings to be elevated on pilings and columns so that:

(i) The bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to or above the base flood level; and,

(ii) The pile or column foundation and structure attached thereto is anchored to resist flotation, collapse and lateral movement due to the effects of wind and water loads acting simultaneously on all building components

44 CFR 60.3 (E) (5) requires "the space below the lowest floor [to be] either free of obstruction or constructed with non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and water loads without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system." The safe loading of the breakaway walls must range from 10 to 20 pounds per square foot. Breakaway walls with a safe loading resistance above 20 pounds per square foot are, in most cases, not allowed.

44 CFR 60.3 (E) (6) prohibits the use of fill for structural support of buildings.

6 Recommended First Floor Elevation

6.1 Current Code (February 2017) Requirements and Recommendations

Based on our review of the City of Olympia Municipal Code, National Flood Insurance Program requirements, and the effective FIRM (May 2018) the following is required at the project site:

- The bottom of the lowest horizontal structural member of the lowest floor (excluding piling or columns) must be at least 16 feet NAVD88 per OMC 16.70.050(B)1.a and OMC 16.70.050(B)2.a.
- The proposed building should be elevated on piling or columns, and excluding breakaway walls, all spaces below the lowest floor should be open to avoid impeding the flow of water per OMC 16.70.050(D) within the AE and VE zones.
- The use of fill for structural support is prohibited within the AE and VE zones.

Because “flood insurance premiums will be based on rates that are one foot below the floodproofed level….Floodproofing the building an additional foot will reduce insurance premiums significantly” (see OMC 16.70.050(B)2). For this reason, we recommend 17 feet NAVD88 as the elevation of the lowest horizontal structural member of the lowest floor based on the City’s code (see Table 6).

6.2 Recommendations to Account for Sea Level Rise

The City of Olympia’s Sea Level Rise Response Plan (AECOM, 2019) recommends policies requiring the minimum floor elevations to consider the “project’s projected life span”. For this reason, the code may require consideration of sea level rise in the near future. We also note that due to sea level rise, the FIRMs will likely be updated at least once over the next 50 years, resulting in higher BFEs in the future. To address the risks associated with higher flood levels, future changes in the municipal code, and higher BFEs over the project’s life span, the following is recommended:

- The proposed building should not be sited within the VE zone.
- The bottom of the lowest horizontal structural member of the lowest floor (excluding piling or columns) should be above 19.2 feet NAVD88. Table 6 outlines the critical elevations referenced in determining the recommended first floor elevation. The recommended elevation accounts for the following elements in addition to the recommendations in Section 6.1 above, which are summarized in Figure 4:
  - BFE determination uncertainty = 0.5 feet.
  - Relative sea level rise projection (by 2070) = 1.7 feet.

Table 6. Summary of Critical Elevations

Description	Elevation (feet NAVD88)
Stillwater Elevation Offshore	14.1
VE Zone Base Flood Elevation	17
AE Zone Base Flood Elevation	15
OMC 16.70.050(B)1.a and OMC 16.70.050(B)2.a Required First Floor Elevation* AE Zone Base Flood Elevation + 1 foot	16
OMC 16.70.050(B) Recommended First Floor Elevation* **AE Zone Base Flood Elevation + 2 feet**	**17**
Mott MacDonald Recommended First Floor Elevation* **AE Zone Base Flood Elevation + 0.5 feet Total Water Level uncertainty + 2 feet per OMC 16.70.050(B) recommendation + 1.7 feet sea level rise**	**19.2**

*NOTE: Elevation of bottom of the lowest horizontal structural member of the lowest floor.

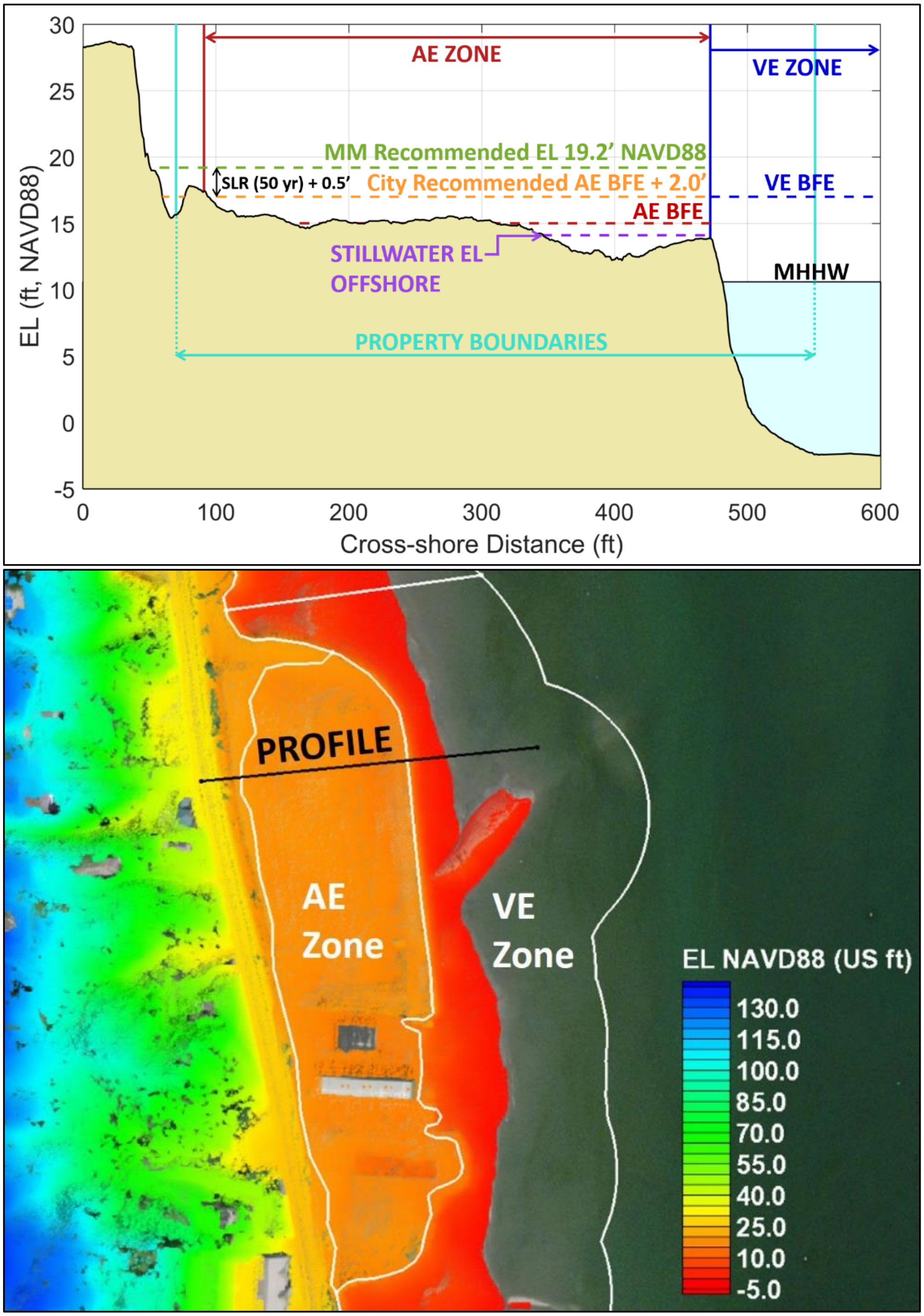

Figure 4. Cross-shore profile through project site showing Special Flood Hazard Areas and critical elevations. The profile is extracted from 2016 USGS LIDAR data.

7 References

AECOM. October 2017. “Sea Level Rise Response Planning Science Review.”

AECOM. March 2019. “Olympia Sea Level Rise Response Plan.”

Coast & Harbor Engineering. December 30, 2011. “City of Olympia Engineered Response to Sea Level Rise.”

Delft University of Technology. 2006. “SWAN User Manual, SWAN Cycle III version 40.51.”

Federal Emergency Management Agency (FEMA). February 2005. “Stillwater: FEMA Coastal Hazard Analysis and Mapping Guidelines Focused Study Report.”

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Miller, I.M., Morgan, H., Mauger, G., Newton, T., Weldon, R., Schmidt, D., Welch, M., Grossman, E. 2018. Projected Sea Level Rise for Washington State – A 2018 Assessment. A collaboration of Washington Sea Grant, University of Washington Climate Impacts Group, Oregon State University, University of Washington, and US Geological Survey. Prepared for the Washington Coastal Resilience Project.