FINAL Report

SEA LEVEL RISE RISK ASSESSMENT

PACIFIC COUNTY

June 2023

Prepared for:
Pacific County
Department of Community Development
P.O. Box 68
South Bend, WA 98586

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DCG WATERSHED

Title-page image: Willapa Bay, Washington. Photo credit: Department of Ecology

Authors, DCG/Watershed, Inc.
Dawn Spilsbury Pucci, Ecologist/GIS Analyst
Alexandra Plumb, Environmental Planner

<u>Report Limitations</u>

Use Limitations: This report was prepared to evaluate the anticipated sea level rise and extreme flood extents for Pacific County based on the parameters requested by the Department of Community Development. No one other than Pacific County staff and their agents should use this report for any purposes other than general information. The report does not incorporate existing groundwater conditions and is not considered to be inclusive of all facilities or infrastructure that may not have been included in the references databases. This report is intended to provide high-level information and general adaptation strategies. The conclusions and identified strategies were based on the best available science and mapping resources. It is noted that the projections referenced in this report may change over time due to anthropogenic changes or existing conditions.

Data Limitations: The information contained in this report is based on the application of technical guidelines currently accepted as the best available science and in conjunction with the manuals and criteria outlined in the methods section. All discussions, conclusions and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state, and federal regulatory authorities. No other warranty, expressed or implied, is made.

The data acquired from the National Oceanic and Atmospheric Administration (NOAA) is utilized with the accompanying disclaimer: The data and maps in this tool illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are relative to Mean Higher High Water (MHHW) (excludes wind driven tides). The data, maps, and information provided should be used only as a screening-level tool for management decisions. As with all remotely sensed data, all features should be verified with a site visit. The data and maps in this tool are provided "as is," without warranty to their performance, merchantable state, or fitness for any particular purpose. The entire risk associated with the results and performance of these data is assumed by the user. This tool should be used strictly as a planning reference tool and not for navigation, permitting, or other legal purpose (NOAA Office for Coastal Management, 2021).

Executive Summary

Pacific County Department of Community Development received a pilot grant from the Washington State Department of Ecology to complete a sea level rise vulnerability and risk assessment under contract with DCG/Watershed. This assessment was conducted to identify areas that are at risk of loss or damage, assess the extent of loss and characterize the extent of vulnerability. For the purposes of this assessment, two scenarios were mapped that included the projected increase in the daily average high tide as well as what an extreme flood event might look like by 2050 and 2100. Following the mapping exercises, several critical infrastructure or facilities that preserve public health and safety were evaluated to characterize the risks that may be associated with sea level rise or extreme flood events within the given timeframe. These areas were quantified and given a vulnerability score of low, medium, or high depending on the extent and timing of the inundation. Adaptation strategies were then identified to assist the County and community in their planning efforts to protect and preserve critical facilities by mitigating the anticipated climate change impacts. It is the intent of the Pacific County Department of Community Development to use this report as a guide and apply for additional Washington State Department of Ecology grant funding to continue this assessment and further investigate areas identified as requiring more in depth investigation, potentially including hydrologic modeling, to further develop policies and regulations for mitigating sea level rise and climate change impacts.

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1 Introduction

Coastal communities are facing rising seas and increasing storm impacts to various degrees, largely dependent on location. Several factors affect how much seas will rise, how far inland the water will reach and at what frequency. Sea level rise mapping attempts to assess the potential impact for theoretical scenarios into the future based on best available science. As coastal communities are likely to be most impacted by sea level rise, efforts are being made to develop localized mapping projections to better understand where the vulnerabilities are anticipated to determine adaptation strategies to mitigate risk.

To initiate this effort, DCG/Watershed, under contract with Pacific County Department of Community Development (DCD) and the Washington State Department of Ecology, has completed a sea level rise (SLR) Vulnerability and Risk Assessment for Pacific County (County). The goals for this assessment include identifying assets with potential for loss or damage from sea level rise; characterizing the risk of loss; and identifying areas of the Pacific County community, resources, sectors, or assets considered most vulnerable based on mapping projections of two different scenarios. Past efforts by the County to assess risk include the development of a Hazard Mitigation Plan (2021), as well as mitigation efforts to reduce identified hazards such as the incorporation of dune protection standards in shoreline management, and use of the highest astronomical tide (HAT) line to establish shoreline buffers along the eastern side of the Long Beach peninsula under the Pacific County Shoreline Master Program (SMP). These efforts underscore the importance of identifying risk factors in the County and of the current wide community support for addressing sea level rise and climate change impacts. This Sea Level Rise Vulnerability and Risk Assessment will inform future adaptation strategies and planning efforts to reduce the anticipated impacts of climate change.

DCG/Watershed has developed a GIS-based model of localized sea level rise projections and coastal flooding hazards resulting from extreme events, based on existing data. DCG/Watershed also developed a sea level rise ArcGIS story map to visually communicate the Sea Level Rise Vulnerability and Risk Assessment results in a user-friendly and informative interface. The data presented in this report is, in part, the result of coordination with the County's Shoreline Master Program (SMP) periodic review process and has capitalized on public engagement opportunities. Other efforts that address the changing shoreline environment are underway at the time of this report and include the development of a master plan for erosion mitigation measures for North Cove (Nouri & Phillips, in draft 2023) and an assessment of changing conditions and plan development to strengthen ecological and community resilience to climate change and coastal hazards along the Columbia River from Baker Bay to Grays Bay (UW Sea Grant and Lower Columbia Estuary Partnership, in draft 2023).

Following this report, it is the intent of Pacific County DCD to apply for additional Washington State Department of Ecology grant funding to create additional policy and regulatory language that incorporates sea level rise projections into development standards, particularly within the Shoreline Master Program (SMP).

2 Public Engagement

To encourage engagement and provide continuous communication about the project, Pacific County DCD hosted a dedicated sea level rise webpage on their County website to inform the public about the process, events, and draft maps and reports. As a part of this assessment, the community was encouraged to attend virtual public meetings to review maps of possible flooding under different mapping scenarios and share where flooding is currently seen during extreme tide events. DCG/Watershed conducted this assessment and outreach events in partnership with the Washington Sea Grant and the Lower Columbia Estuary Partnership. This study is complementary to their ongoing Baker Bay to Grays Bay Sea Level Rise Resilience project and King Tides Program (UW Sea Grant and Lower Columbia Estuary Partnership, in draft 2023). The County's Master Plan for North Willapa Erosion Mitigation effcountorts is being developed concurrently with this project (Nouri & Phillips, in draft 2023).

Two (2) virtual public meetings were held to review the north County and south County maps, respectively. DCG/Watershed shared the draft scenario maps in 11 different sections of the County to review the anticipated extent of sea level rise and extreme flood extents for 2050 and 2100. The public was able to review the maps during the meeting to provide feedback and then, also using an online whiteboard tool (Miro), to provide written comments on the individual maps. Some of the questions that were asked of the community at the public meetings include:

- Do the maps accurately portray what you are seeing?
- What should we (DCG/Watershed) be considering that we aren't already for the risk assessment?
- What other information do you need to help you plan for sea level rise and extreme flood events?
- What is the best way to share this information with you in the future?

The public provided a local perspective of existing conditions to help identify gaps in the mapping projections. Some of the public comments received included questions around required highway elevations to mitigate loss, predicted flooding conditions following an earthquake event, and whether extreme flood events would cause permanent impacts to on-site septic systems, wells, and related infrastructure. It was noted that if infrastructure is anticipated to be permanently impacted, development regulations should be reviewed to ensure that new construction is protected from a public health and safety perspective. Potential limitations to the study were discussed including that predicted sea level rise and extreme flood event extents are imperfect for identifying anticipated inundated areas and that this review process does not incorporate wave run-up extent or compounded riverine and tidal flooding. In areas where wave run-up or compounded riverine and tidal flooding may occur, the extent of inundation is likely to be increased from mapped saltwater heights and

the currently projected values would be considered conservative in nature. The public comments also included specific areas where the mapped inundation did not reflect current conditions including Stringtown Road/Vandalia, standing groundwater in the City of Ilwaco near the Fire Station, and Naselle in areas surrounding the river and associated floodplain.

Photo Credit: Naselle River, Pacific County DCD

3 Sea Level Rise Mapping

The purpose of mapping sea level rise is to show residents, County planning staff and Planning Commissioners the possible extent of flooding due to sea level rise. Mapping requires evaluation of the current tidal height, the amount of projected sea level rise to be added to that surface, a map of the earth's surface to display the inland tidal extents, and a map of the various critical elements that have been identified as key areas of concern for the community (buildings, roads, habitat, etc.) to assess the exposure to the projected extent of sea water. With this information, the community can make informed decisions for development planning, prepare for emergencies and a sustainable, resilient future.

As levels of daily average tides are expected to increase, so are the tidal heights reached during storm-driven flood events when atmospheric pressure is low and wave energy is high. A second element that drives higher-than-average tides are "King tides." King tides are experienced when the moon is at its closest point to the Earth and simultaneously, the sun aligns with the moon. This instance results in a gravitational pull from both sources in the same direction, which exacerbates the tidal cycle. King tides can result in extreme flood events, especially when they are compounded with storm events or similar weather conditions. Climate change impacts are predicted to increase the frequency of storm events. Additionally, the increase in sea level rise is anticipated to expand the extent of extreme flood events from existing conditions. Together, it is predicted to assume with reasonable certainty that coastal communities will experience extreme flood events at increased frequencies and at greater extents than current conditions due to climate change.

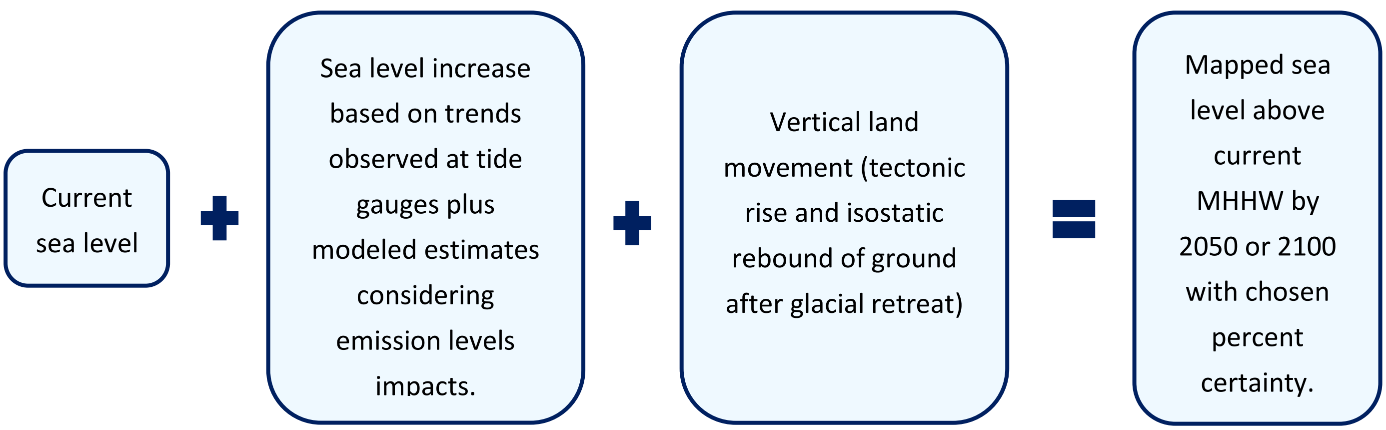
The County requested an assessment of the impacts of future relative sea level rise by 2050 and 2100. These two mapping scenarios each include mapped levels of current mean higher high water (MHHW) levels, the projected increase of the average daily high tide that has an 83% probability of occurring (under current

conditions) and the extent of an extreme flood event. The specific details of the process used to determine these amounts of sea level rise are summarized at a very high level in this report. For more details, readers are encouraged to consult the associated technical reports cited below in the reference section and available at the Coastal Hazards Resilience Network's website: https://wacoastalnetwork.com.

3.1 Relative Sea Level Rise

Recently, projections for relative sea level rise (RSLR) above MHHW levels, by a given year, were developed with associated probabilities (Miller I. M., 2018). For example, planners can select specific scenarios to assess the impacts of sea level rise by 2050 for a given probability (1% to 99%). These probabilities are intended to communicate the likelihood that sea level rise will reach or exceed a particular amount by a certain time; therefore, the higher the probability (i.e. 99%), the more conservative (lower) the amount of sea level rise expected. Pacific County chose to assess sea level rise for 2050 and 2100 at the 17%, 50% and 83% probability levels, and mapped scenarios specifically focused on the sea level rise assessed at the 83% probability level. In other words, maps were created for sea level rise scenarios that are very likely (83% chance) to be reached or exceeded by 2050 and 2100.

Relative Sea Level Rise is calculated by utilizing rates of averaged sea level rise recorded on tide gauges over a historic period of time, the projected increase of sea levels moving forward in time based on a warming climate and the rate of vertical land movement.



Vertical land movement is estimated to be approximately 10 inches +/- 5 inches /century of uplift along the outer coast of Washington and along the Columbia River to 1 inch +/- 1 inch/century of uplift in the Willapa River area (University of Washington Climate Impacts Group, 2018).

The RSLR projections also do not take into consideration subsidence as result of a subduction zone earthquake. Coastal subsidence would result in a drop in elevation relative to sea levels, of –4.0 feet to -5 feet, 2 inches along the outer coast to -2.0 feet to -5 feet, 11 inches in the Willapa River area. This would have an effect of raising sea levels very abruptly (University of Washington Climate Impacts Group, 2018).

The RSLR projections do not consider wave run up and storm surge impacts, at this time (Miller I. M., 2018).The approach used to map the projections in this assessment is considered a "bathtub" approach. Hydrodynamics that may impact water level depth and extent of inundation, such as waves, bathymetry, currents, or vegetation, are not taken into consideration (Norheim, 2018).

The RSLR projection mapping approach used for this assessment differs from the approach used by FEMA to produce Base Flood Elevation (BFE) maps in that BFE maps are based on historical observations of flood events and do not account for any future change to rate or level increases due to climate driven changes. FEMA BFE maps do take into consideration hydrodynamic effects, such as wave run-up and currents but apply a coarse elevation estimate of an historic 100-year coastal flood event.

3.2 Future Extreme Flood Extent

Extreme flood events occur when factors such as tides, surge and wave run-up combine resulting in a higher-than-normal sea level. It is expected that these events will become more severe and occur more frequently than in the past (Miller I. M., 2019).

To assess the extent of an extreme flood, flood level projections from a follow-up report titled *Extreme Coastal Water Level in WA State: Guidelines to Support Sea Level Rise Planning* (Miller I. M., 2019) were added on top of the RSLR projections from I. M. Miller 2018. This report refers to a "still water level" (SWL) and a "total water level" (TWL) (Figure 1). SWL is measured by tide guages and accounts for tides, storm surge, seasonal and annual water level cycles and long term average sea level trends. TWL also attempts to account for wave run-up. However, TWL is rarely measured directly (as it occurs between open water tide guages where the level is measured and upland areas where sea water inundates) and is more difficult to assess acurately. Ongoing development of a wave modeling system for Washington State, called "Coastal Storm Modeling System" (CoSMoS), is likely to improve these projectionss and will be available for Pacific County in the future (USGS, n.d.).

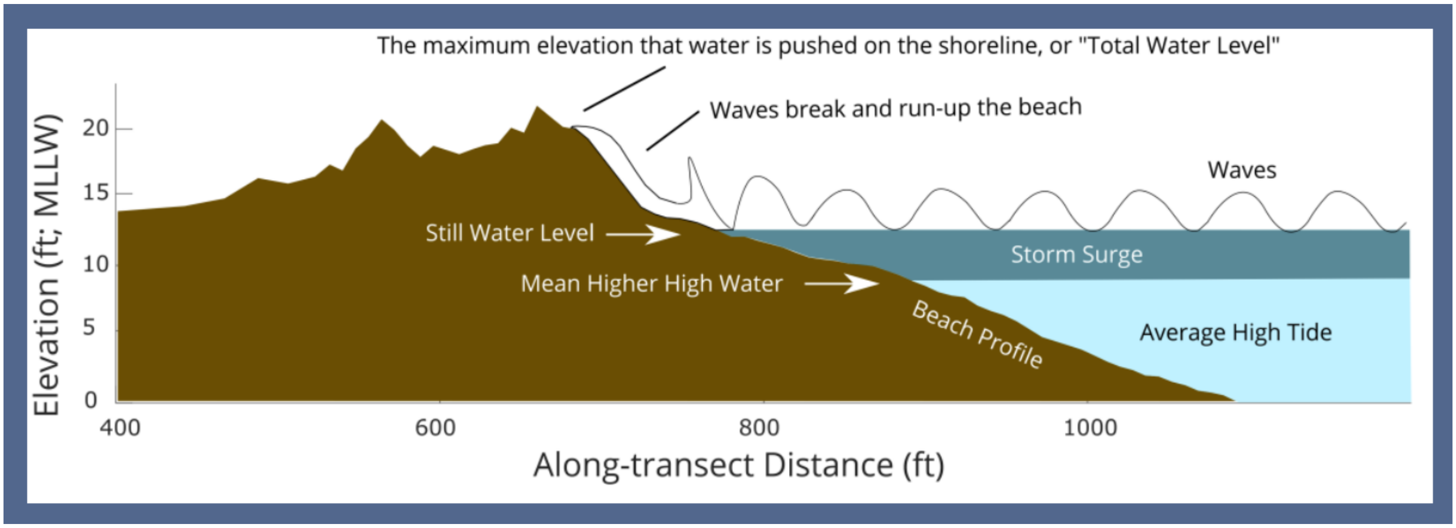
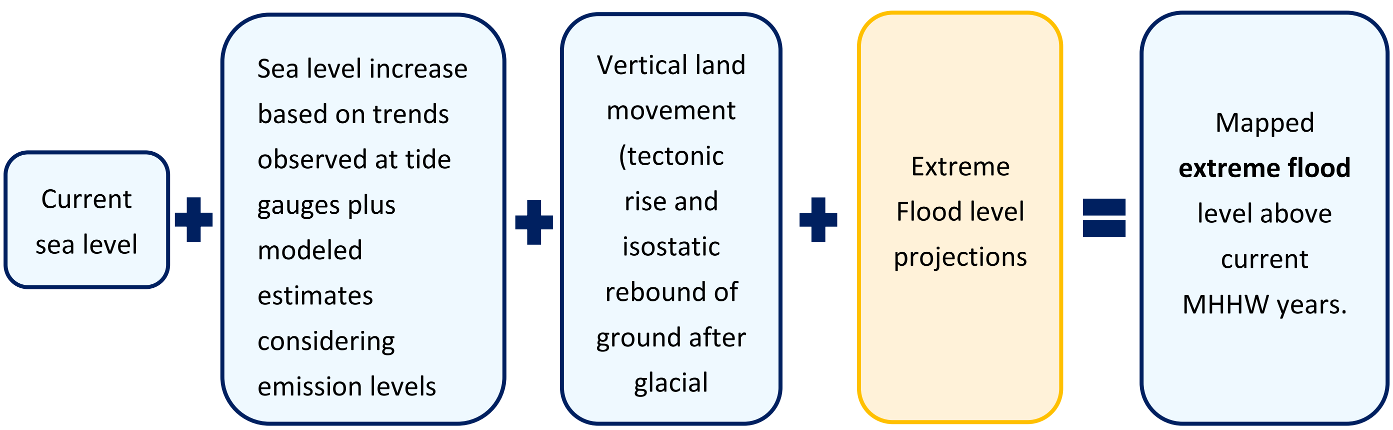


Figure 1. Illustration of the difference between tides, storm surge and wave runup. *(Source: I.M. Miller et al 2019)*

Wave run-up is expected to impact the outer coast more than inside Willapa Bay and along the Columbia because of the open water fetch length the waves and wind have to build energy and momentum. To address this higher risk for the coastline facing directly west, a TWL value was used to assess extreme flood events for that coastline only. The increased risk for that coastline outweighed the reduced certainty of the projectionss, so the higher potential flood levels were considered here. For all other coastlines in the County, the SWL values were used.



For this assessment, Pacific County chose to assess the levels seen now during what would be considered an event with a 2% and a 5% chance of occurring in any given year. These storms are commonly referred to as a “20-year” and a “50-year” storm event, respectively (Table 1). However, this terminology is misleading due to the fact that an area can see mulitple “20- or 50-year events” in a single year should there be a paritcularly active storm season. It is predicted that high-intensity storms will occur more frequently and for more prolonged durations in the future. So while the extent of current flooding during extreme events or mapped as the “100-year” floodplain on FEMA BFE maps may not differ drastically from the scenarios mapped in this assessment, it is important to note that the increased frequency and duration of these events should be considered in development, maintenance and emergency planning efforts.

Photo credit: Pacific County Tourism Bureau (Cape Disappointment, Long Beach)

3.3 Sea Level Rise for Pacific County

Table 1. Sea Level Rise Projections for 2050 and 2100 in Pacific County.

Example of how to read the table below using the three planning scenarios:
By 2050, there is an 83% probability that Tokeland will experience MHHW levels that are 4 inches higher than today's MHHW. There is also an 83% probability that Tokeland will experience at least one extreme flood event that exceeds 4 to 4 feet, 11 inches feet above current MHHW if experiencing what is commonly referred to as a "20 to 50-year" storm. *See below for referenced numbers in highlighted boxes.*

	2050						2100					
Area ID*	**Sea Level Rise**			**Extreme Flood levels on top of SLR**			**Sea Level Rise**			**Extreme Flood levels on top of SLR**		
	17%	50%	**83%**	17%	50%	**83%**	17%	50%	**83%**	17%	50%	**83%**
1	0' 10"	0' 6"	**0' 4"**	4' 2"	3' 11"	**3' 9"**	2' 6"	1' 9"	**1' 1"**	5' 11"	4' 1"	**4' 5"**
2	0' 6"	0' 4"	**0' 0"**	3' 11"	3' 9"	**3' 5"**	2' 0"	1' 2"	**0' 6"**	5' 5"	4' 7"	**4' 0"**
3	0' 7"	0' 4"	**0' 0"**	13' 6"	13' 2"	**12' 11"**	2' 1"	1' 4"	**0' 6"**	15' 9"	14' 11"	**14' 1"**
4	0' 9"	0' 6"	**0' 2"**	4' 5"	4' 2"	**3' 11"**	2' 5"	1' 7"	**0' 11"**	6' 4"	5' 6"	**4' 10"**
5	0' 9"	0' 5"	**0' 1"**	4' 5"	4' 1"	**3' 10"**	2' 4"	1' 6"	**0' 9"**	6' 3"	5' 5"	**4' 7"**
6	0' 7"	0' 4"	**0' 0"**	4' 4"	4'0"	**3' 9"**	2' 1"	1' 4"	**0' 7"**	6' 0"	5' 2"	**4' 6"**
7	0' 9"	0' 6"	**0' 4"**	4' 5"	3' 2"	**4'0"**	2' 5"	1' 9"	**1' 0"**	6' 4"	5' 7"	**4' 11"**
8	0' 10"	0' 7"	**0' 4"**	4' 6"	4' 4"	**4'0"**	2' 7"	1' 10"	**1' 2"**	6' 6"	5' 9"	**5' 1"**
9	0' 11"	0' 7"	**0' 5"**	4' 7"	4' 4"	**4'1"**	2' 9"	2' 0"	**1' 4"**	6' 7"	5' 11"	**5' 2.5"**
10	0' 9"	0' 6"	**0' 4"**	4' 5"	4'2"	**4'0"**	2' 5"	1' 9"	**1' 0"**	6' 4"	5' 7"	**4'11"**
11	0' 7"	0' 5"	**0' 2"**	13' 6"	13' 4"	**13' 1"**	2' 4"	1' 6"	**0' 11"**	15' 11"	15' 1"	**14' 6"**

*See map below for Area ID locations.
Bold numbers considered for mapping analyses. See Section 2.
Source: (University of Washington Climate Impacts Group, 2018)

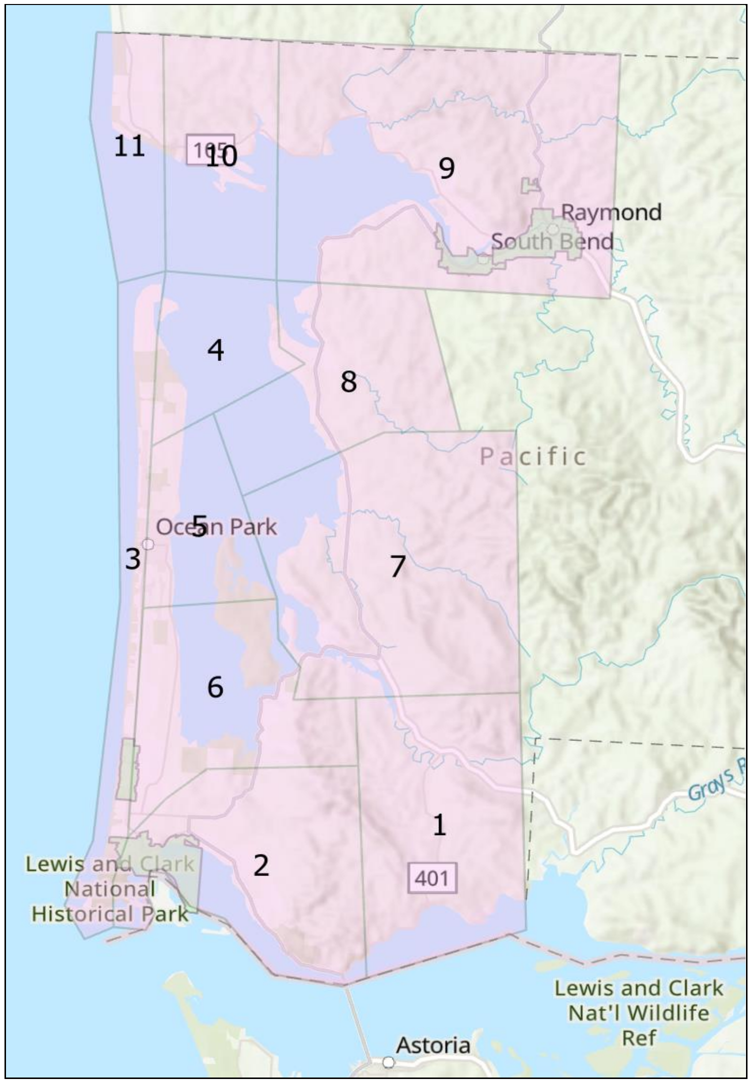


Figure 2. Map of Areas of Pacific County corresponding to Area IDs in Table 1.

4 Vulnerability and Risk Assessment

4.1 Mapping Values

To map the potential impact on Pacific County from the sea level rise, the County chose to use levels predicted with an 83% probability for 2050 and 2100 and look at the potential extreme flooding. For this County-wide scale assessment, it was determined that it would be prudent to map sea surface increases in one-foot increments rather than the inches-differences documented in the previous section (Table 2). The rationale for this approach, in consultation with the primary author of the projections modeling cited in the previous section, was driven primarily by the fact that when mapping at a County-wide scale (e.g., 1:50,000 or greater), the differences between inches of tidal elevation would not be visible. NOAA's Office for Coastal Management has made one foot increment sea level rise mapping layers available for these types of large-scale analyses (NOAA Office for Coastal Management, 2021). A result of using these NOAA layers with the 1-foot increments is that, by using the +1 foot increase mapping layer, the assessment will consider a more extreme rise in the daily average high tide than is projected to occur with 83% probability by 2050, which is projected to be between zero and five (5) inches. This 'overestimate' of daily average high tides is beneficial when planning expensive capital projects that will be on the landscape for decades and for emergency response planning. These higher levels will ensure that if sea levels rise faster than predicted, or as predictive modeling improves, the results of this assessment will still apply. However, by 2100, the +1 foot mapping layer is the average of the projected increases of six (6) inches to one (1) foot, four (4) inches increase in daily average high tides.

The exception to the above approach is for extreme flood events along the outer coast of Pacific County. NOAA's mapping layers cover a +1 foot to a +10 feet sea level increase. The extreme flood events for the outer coast in Pacific County are projected to have the potential to exceed twelve (12) feet above MHHW at least once in the next 20 years. However, due to the uncertainty in the TWL extreme flood projections, mapping a +10-foot sea level rise will predict impacts to an adequate degree until new wave modeling is completed and applied to Pacific County in the future, at which point, this modeling effort should be addressed. During the public outreach efforts to vet draft mapping efforts using the +10 foot layer, the community stated that flooding to the mapped extent has been seen in many of the identified areas under current conditions. As noted in the Extreme Coastal Flooding Report, the risk with these storms is very likely their increased frequency and duration (Miller I. M., 2019).

Table 2. Mapped levels of sea level rise compared to the modeled projections.

	Type of Event	Projections	Mapped
Willapa Bay 2050	Sea Level Rise	0’ 0” – 0’ 5”	1 ft
	Extreme Flood Extent	3’ 9” – 4’ 1”	4 ft
Coast 2050	Sea Level Rise	0’ 0” – 0’ 2”	1 ft
	Extreme Flood Extent	12’ 11”– 13’ 1”	10 ft
Willapa Bay 2100	Sea Level Rise	0’ 7” – 1’ 4”	1 ft
	Extreme Flood Extent	4’ 6” – 5’2”	5 ft
Coast 2100	Sea Level Rise	0’ 6” – 0’ 11”	1 ft
	Extreme Flood Extent	14’ 1” – 14’ 7”	10 ft

The **2050 Mapping Scenario** shows the current MHHW, what the average daily high tide would look like with a +1-foot increase above the current MHHW and what an extreme flood event would look like with a +4 foot increase above the current MHHW in Willapa Bay and a +10 foot increase above the current MHHW along the West-facing outer coast.

The **2100 Mapping Scenario** shows the current MHHW, what the average daily high tide would look like with a +1-foot increase above the current MHHW and what an extreme flood event would look like with a +5 foot increase above the current MHHW in Willapa Bay and a +10 foot increase above the current MHHW along the West-facing outer coast.

With a one-foot tidal increase above the current MHHW, an additional 4,060 acres would be inundated (Figure 3). An extreme flood in the 2050 scenario would temporarily inundate 16,790 more acres than current day MHHW tidal events (Figure 4). The 2100 scenario would temporarily inundate 127,870 more acres than current day MHHW tidal events (Figure 5).

The impact of the one-foot increase is quantified separately, and in addition, to the 2050 and 2100 mapping scenarios because the impacts of an increase in the daily average high tide has different implications, potentially, then the impacts from an extreme flooding event that occurs occasionally.

Alterations to the topography of an area, for example the backfilling of the South Bend Lagoon, may not be reflected in the tidal layers (+1 ft, +4 ft, +5 ft, +10 ft map layers) if the alteration has happened since 2010 as that is the land cover layer used by NOAA for most of Washington State, including Pacific County.

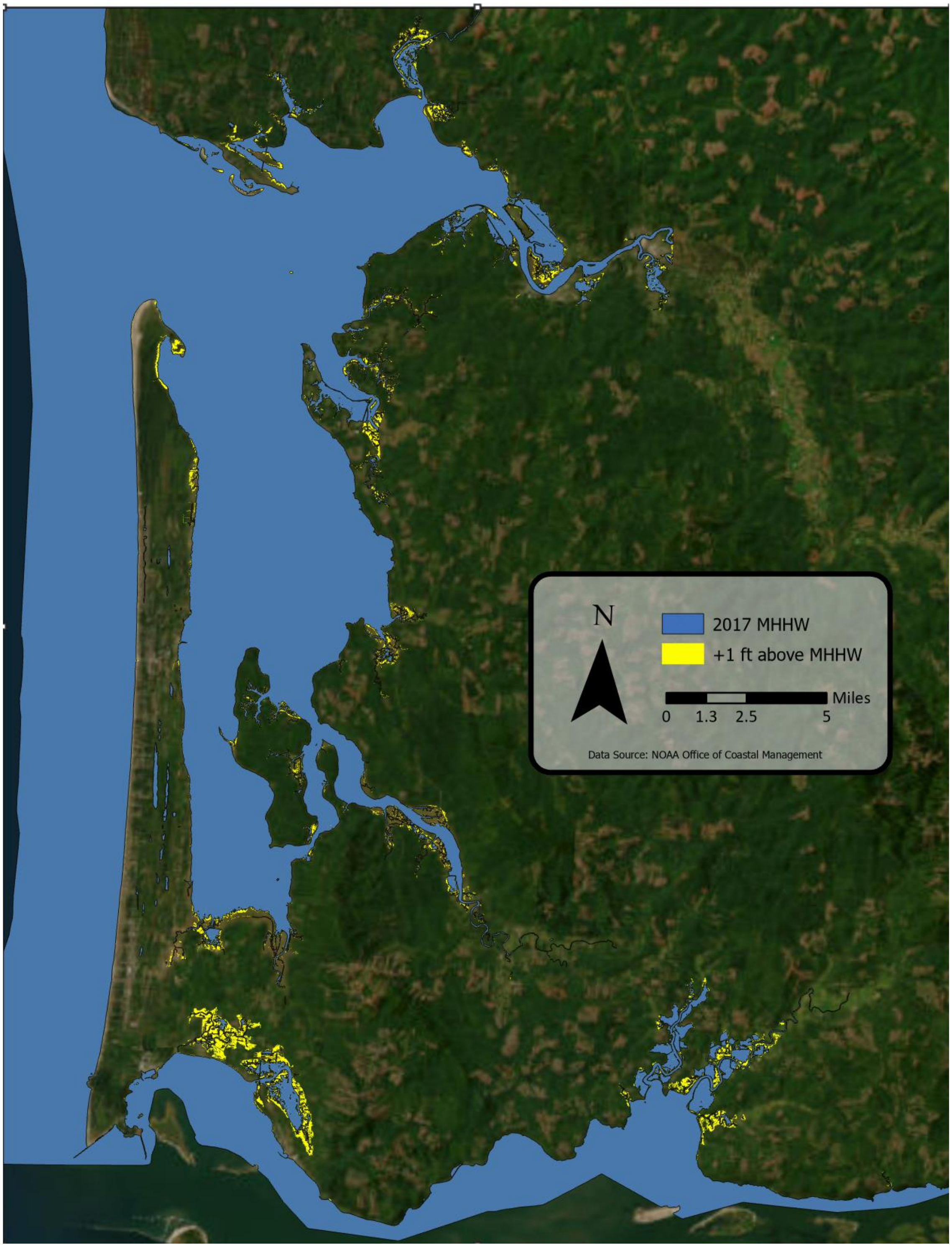


Figure 3. Extent of tidal inundation for +1-foot rise in sea level above current MHHW.

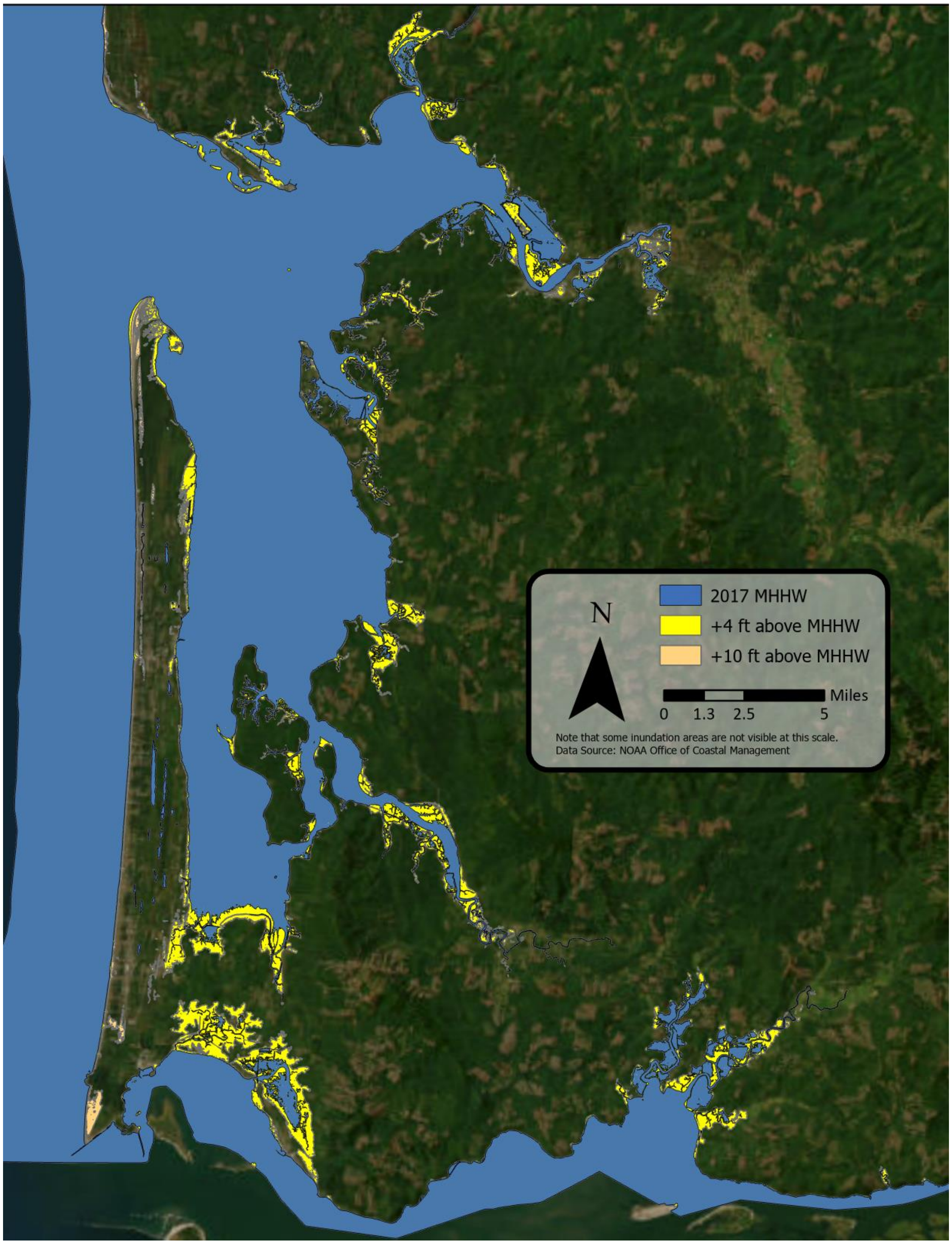


Figure 4. 2050 Mapping Scenario: illustrating the extent of extreme flooding projected for 2050. (Due to the scale of the map displayed, there are some areas of potential inundation that are not visible but are included in the analysis and are visible on smaller scale maps.)

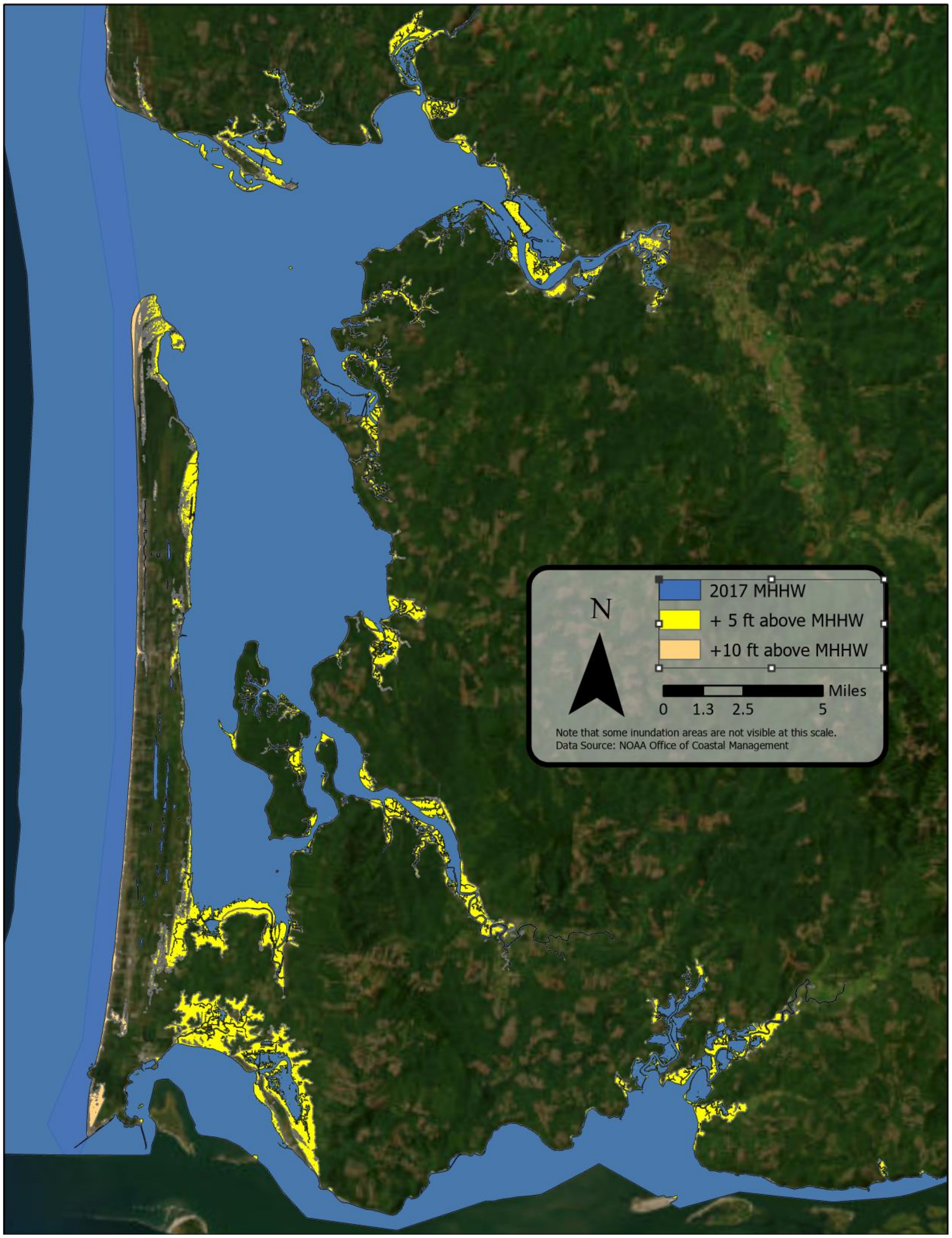


Figure 5. 2100 Mapping Scenario: illustrating the extent of extreme flooding projected for 2100. (Due to the scale of the map displayed, there are some areas of potential inundation that are not visible but are included in the analysis and are visible on smaller scale maps.)

4.2 Scale of Risk Determination

Vulnerability ratings were categorized by a moderate or high risk if one or more of the facilities are anticipated to be impacted by the corresponding ranking criteria scenario (Table 3). This rating is intended to be broad in nature to consider prioritizing facilities that will have the greatest likelihood of impacts from sea level rise and/or extreme flooding. The anticipated areas of inundation are quantified below in their respective subsections (Table 4). Where risk is noted with "potentially", these ratings are based on general proximity of these types of facilities to locations with an increased flooding risk but that are not mapped with the specificity to have a high certainty of rating accuracy.

It is important to note that these vulnerability ratings do not include the additional consideration of erosion that is potentially exacerbated by sea level rise and extreme coastal flooding. This rating system only considers the exposure of facilities to the interaction of sea water on ground surface as it inundates inland areas with increased frequencies and to greater extents.

This assessment does not quantify the amount of subsidence that may be occurring. Any infrastructure that is located in an area that is subsiding will have an increased exposure to inundation.

This assessment does not include an examination of any impacts subsurface. Buried infrastructure was not included in the review of critical infrastructure. Recommendations summarized later in this document include a review of sea level rise impacts on subsurface geology and this could include the impacts to buried infrastructure.

Sources of data used in the mapping exercise are listed in Appendix A.

Table 3. Description of each risk vulnerability rating.

Vulnerability Rank	Description
Low	Unlikely to be inundated by sea level rise or extreme flood events between present and 2100.
Medium	Likely to be inundated by one or more extreme flood events between present and 2100.
High	Likely to be inundated by sea level rise or one or more extreme flood events between present and 2050.

Table 4. Vulnerability rankings for each critical facility

Type of Critical Facility	Vulnerability Rank
Airports	High
Coastal On-Site Septic Systems	High (Potentially)
Coastal Residences	High
County Buildings	Moderate
Cranberry Bogs (if tide gate fails)	Moderate
Fire Stations	Low (except in Raymond)
Group A Water Systems	High (Potentially)
Hospitals	Low
Libraries	Low
Police Stations	Low (except in Raymond)
Ports	High
PUD Stations and Structures	High (Potentially)
Roads	High
Sewer Districts/Water Treatment Plants	Moderate
Schools	Moderate
Shellfish/Seafood Industrial Facilities	High

4.3 Transportation

4.3.1 Roads

The length of roads that are likely to be impacted by each of the scenarios was calculated (Table 5) and mapped below. This exercise assumes that existing bridges have clearance to pass these water levels provided that the road present on the land immediately before and after the bridge does not appear to be inundated. The tidal surface represents where water flows under bridges. When the comparison between the current roads mapping layer was intersected with NOAA's tidal surface layers, the software program included that the roads

crossing those tidal surface areas would be flooded. This error was corrected by removing the stretches of roads that are actually bridges from the analyses.

Figures 6 – 8 display the locations of the roads that may be flooded for each scenario. The table below summarizes the total length of roads that may become inundated. The inundation under the extreme flood scenarios is likely to be temporary. The sea level rise scenario represents an event on normal weather days when a MHHW tide would be expected.

Table 5. Miles of road inundation by scenario

Scenario	Miles of Roads Potentially Inundated
+1-foot above current MHHW	3.1
Extreme flood from the 2050 mapping scenario (+4-feet in the Bay, +10-feet along outer coast)	35.0
Extreme flood from the 2100 mapping scenario (+5-feet in the Bay, +10-feet along outer coast)	52.4

It should be noted that these analyses don't consider the ability of water crossing structures to pass increasing water volumes and velocities, which are expected to be observed with more intense rain events. Surveying the capacity of culverts and tide gates, height of bridges, and structural integrity of bridge footings are recommended to be considered in future capital improvement plans. This information is critical to ensuring that the existing infrastructure is adequate to convey the increased water volumes expected with sea level rise and extreme flood events.

Photo credit: Longview Daily News (State Route 4, Naselle)

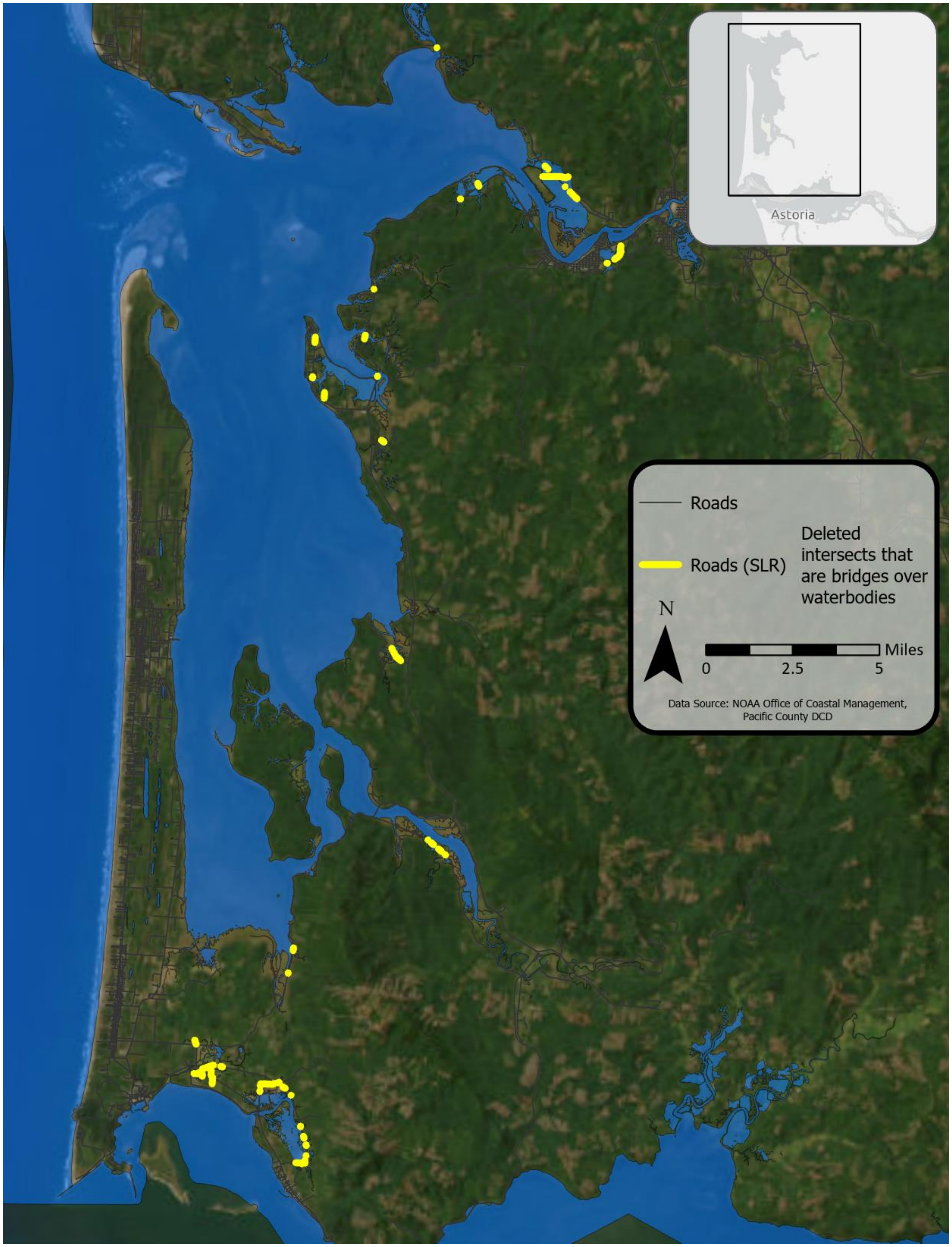


Figure 6. Locations and lengths of roads at risk of inundation to be inundated by a +1-foot increase in sea level.

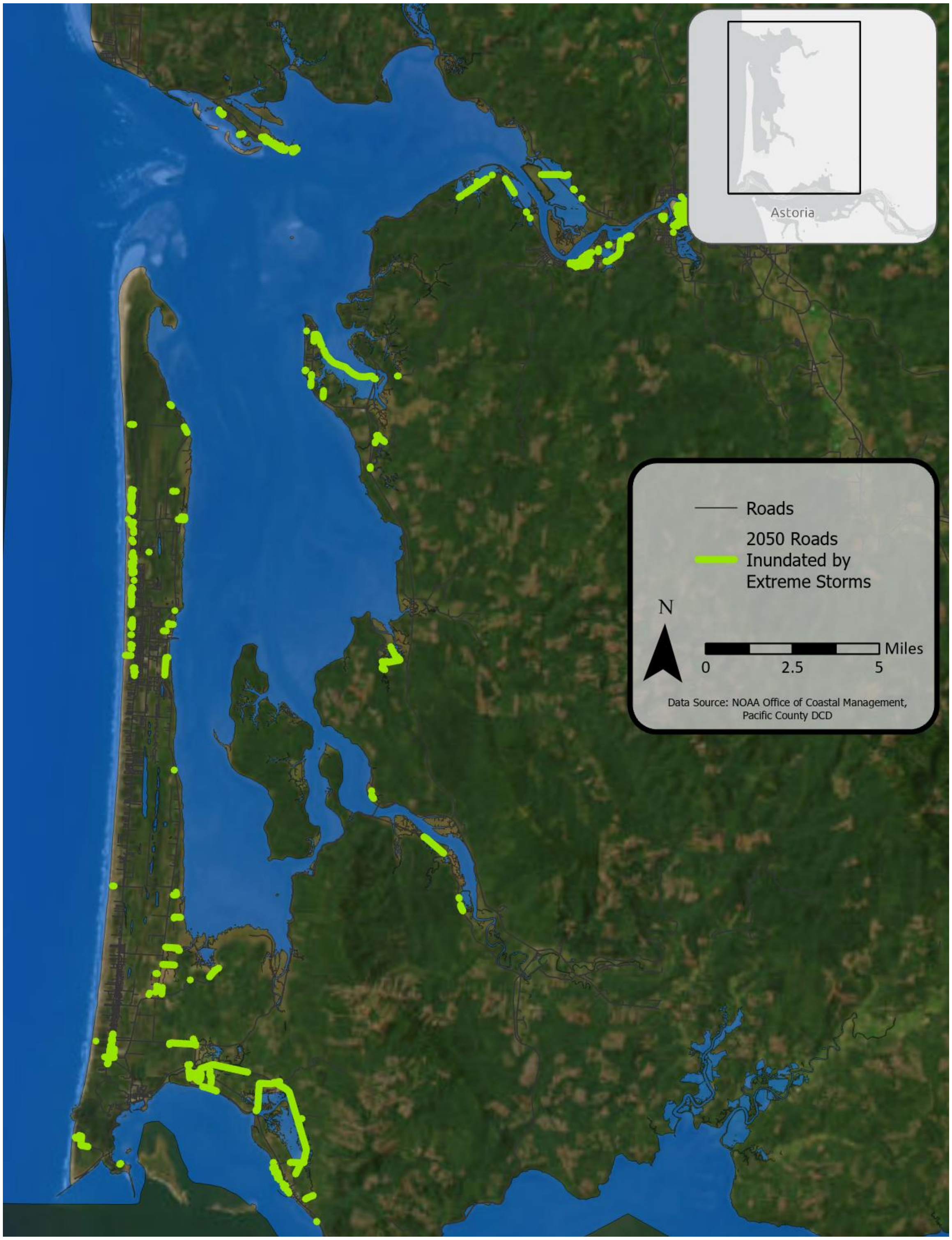


Figure 7. 2050 Mapping Scenario: Location of roads likely to be inundated by extreme floods.

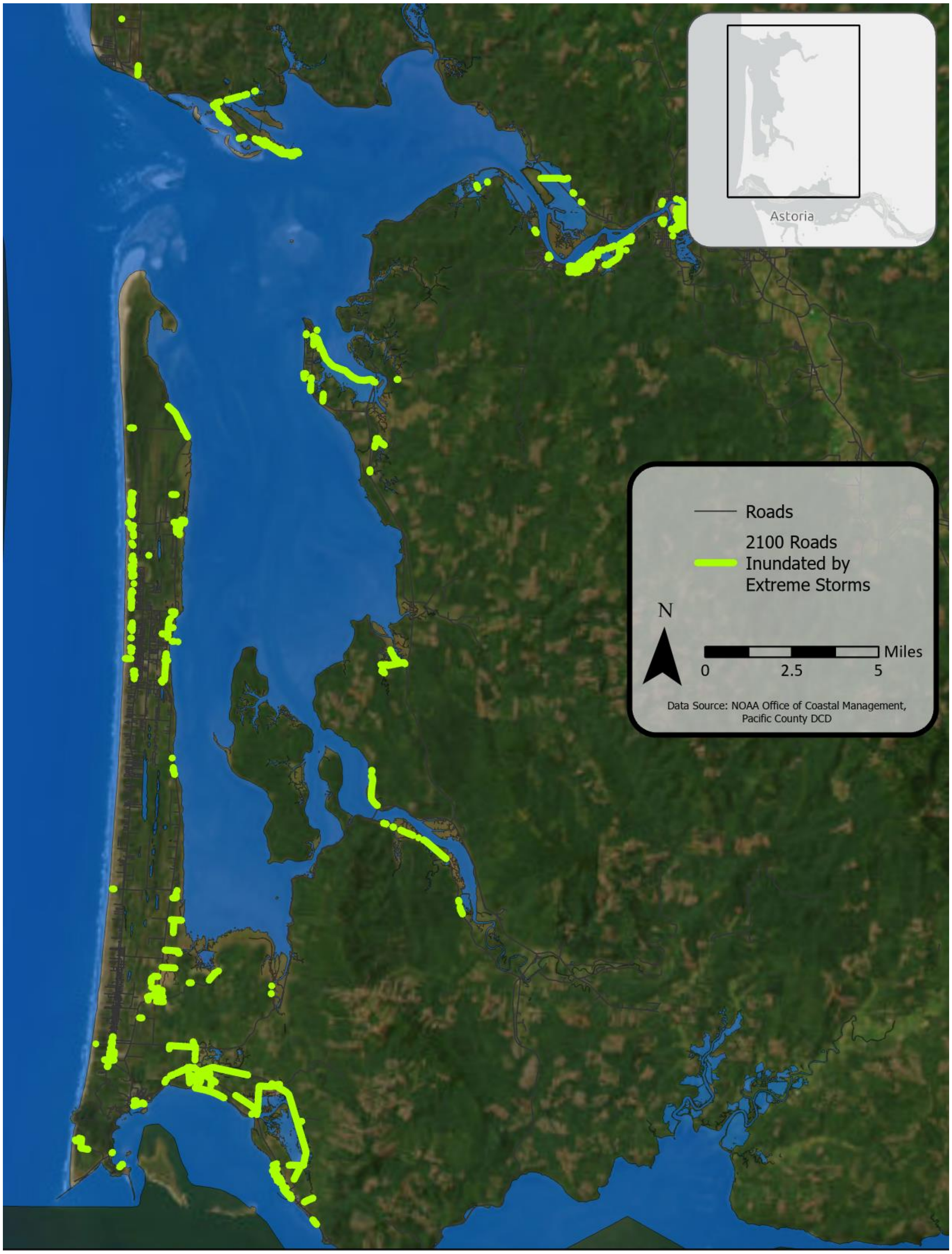


Figure 8. 2100 Mapping Scenario: Location of roads likely to be inundated by extreme floods.

4.3.2 Airports

Figure 9. Ilwaco Airport - Port of Ilwaco (Photo Credit: Port of Ilwaco)

Pacific County has a public airport that is owned by the Port of Ilwaco located off Stringtown Road. The airport is located approximately two miles east of Ilwaco and is estimated to be 13 feet above sea level. Based on the sea level rise projections outlined below, the existing airport is at a high risk of inundation by an extreme flood event in the 2050 mapping scenario (Figure 9). Though modeling does not demonstrate that the airport would be flooded by a +1-foot rise in sea level, much of the area in the vicinity is likely to be flooded and may hinder access.

The Willapa Harbor Airport, two miles west of Raymond, is likely to be inundated by an extreme flood event in the 2050 mapping scenario with the surrounding area often impacted by high tides (Figures 10 and 11).

These facilities, beginning with the Ilwaco Airport, are recommended to be evaluated to determine what measures can be implemented to reduce impacts to the function of the runways under future conditions. In the event of an emergency, such as an extreme flood event, a serviceable and accessible airport may be critical. It is recommended that the County or Port of Ilwaco designate or create an upland landing area for evacuation or supply deliveries during emergencies.

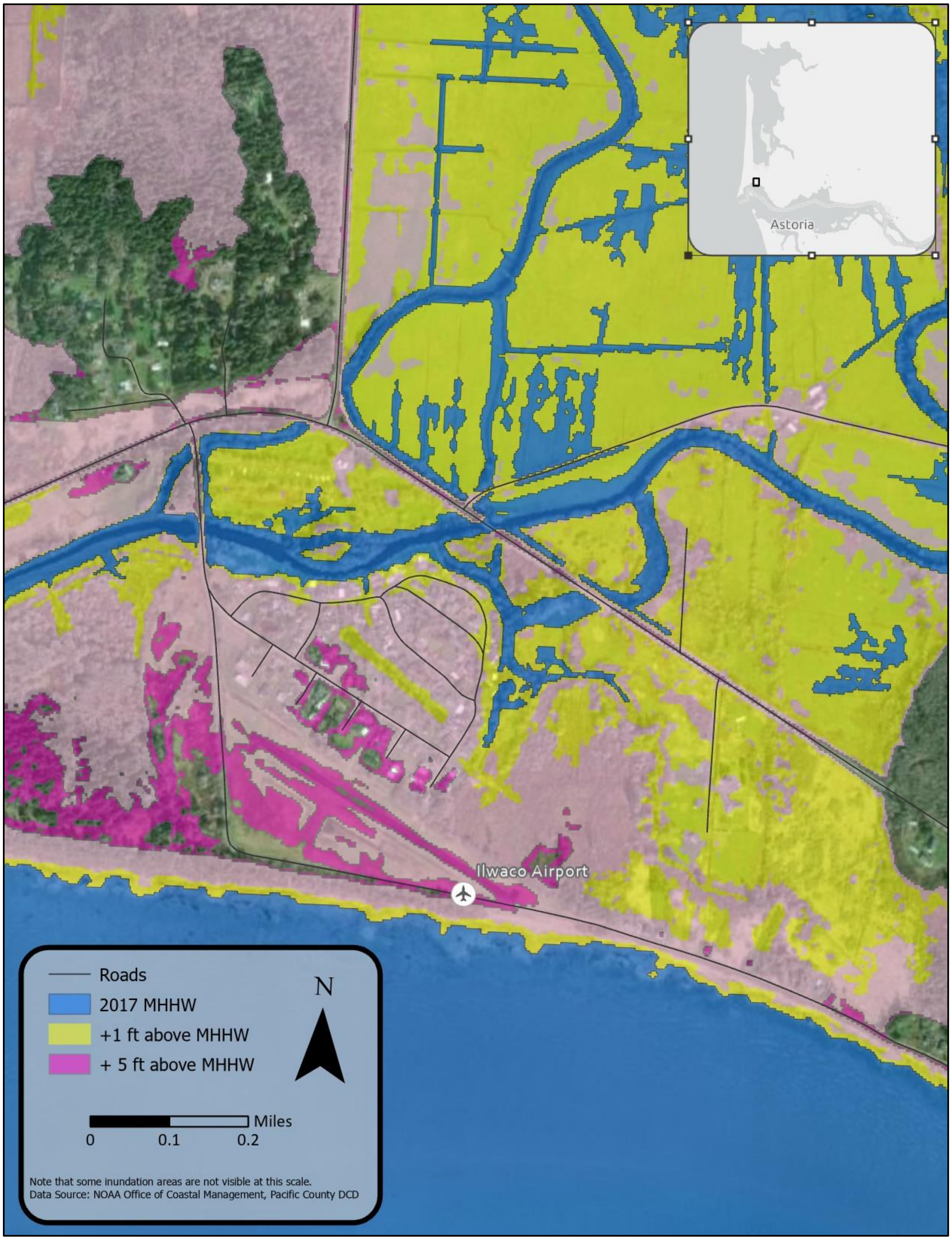


Figure 10. Extent of potential flooding at the Ilwaco airport in the 2050 and 2100 mapping scenarios.

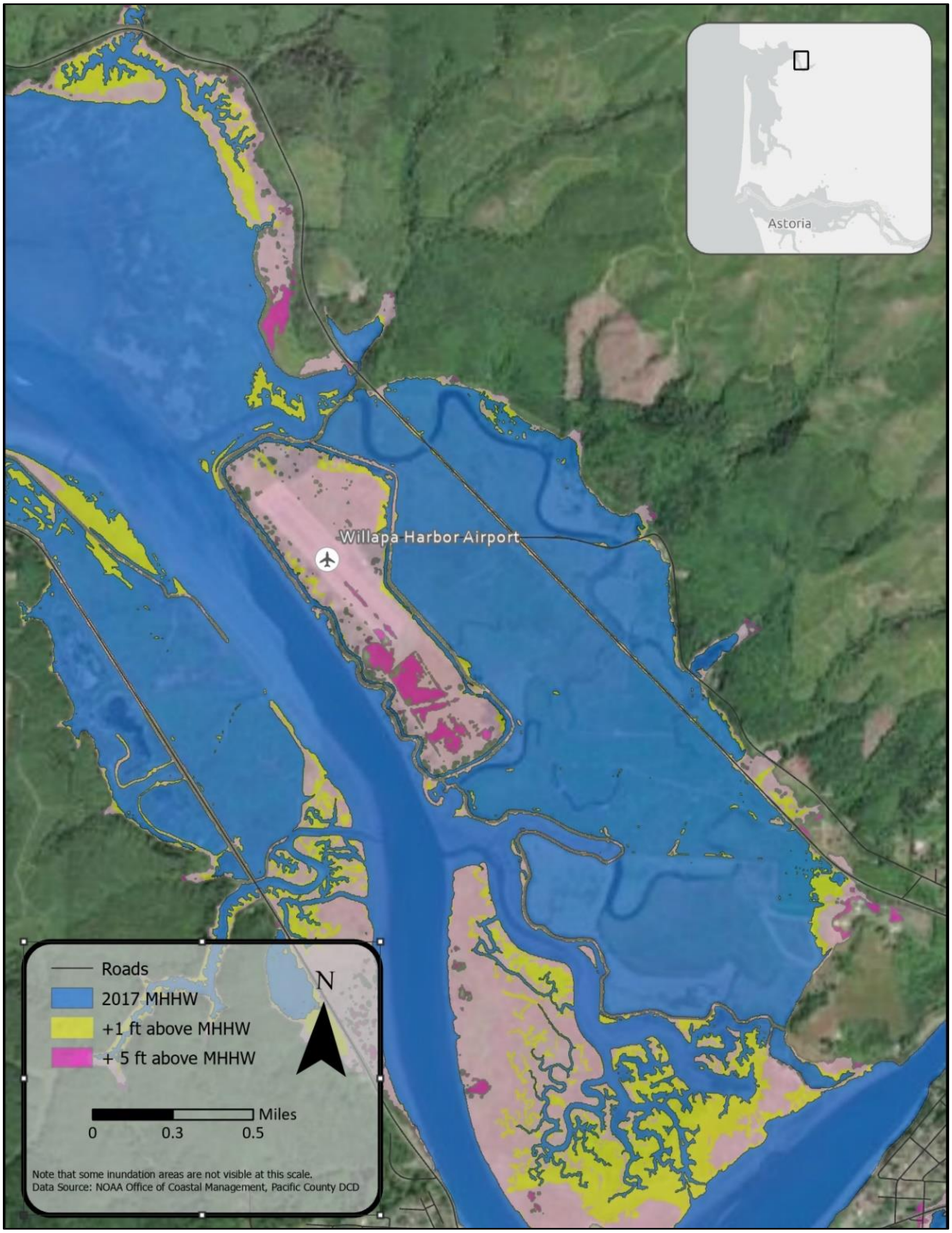


Figure 11. Extent of potential flooding at the Willapa Harbor airport in the 2050 and 2100 mapping scenarios.

4.4 Critical Infrastructure

There are several types of facilities that were categorized as critical to public health and safety in alignment with the Pacific County Comprehensive Plan. For the purposes of this report, hospitals, police and fire stations, public libraries, schools, on-site septic systems, public water systems, electrical substations and wastewater treatment centers (WWTC) were considered critical facilities. Airports and roads are also critical infrastructure and are covered separately in Section 4.3 Transportation, above. Any impacts to these identified facilities could compromise the health and safety of the community by reducing public services or critical functions. Several areas have been identified as moderate or high risk of inundation by sea level rise or extreme flood events (Table 6). These areas are recommended to be prioritized when considering the next steps to protect and preserve infrastructure. Public Utilities District (PUD) stations and related structures, Group A water systems and other drinking water sources, and sewer districts are also considered critical facilities. However, mapping for these facilities was not available to the degree necessary for a detailed analysis at the time this assessment was conducted. For example, septic locations are only available for Naselle and Tokeland. Drinking water source locations were not accurate and likely incomplete. It is recommended that a complete and spatially accurate mapping inventory be conducted to assess the extent of inundation risk.

Table 6. Number of critical facilities potentially impacted by each flood scenario.

Scenario	Number of Hospitals, Police/Fire, Schools, Libraries, Potentially Inundated
+1-foot above current MHHW	0
Extreme flood from the 2050 mapping scenario (+4-feet in the Bay, +10-feet along outer coast)	6
Extreme flood from the 2100 mapping scenario (+5-feet in the Bay, +10-feet along outer coast)	9

The analysis for the +1-foot sea level rise did not indicate any of the hospitals, police or fire stations, schools, libraries, substations or WWTCs would be impacted. However, the police and fire station in Raymond, as well as the WWTC near Raymond and the substations north of Ilwaco and west of South Bend (Figures 12-15), are likely to be inundated during an extreme flood in the 2050 mapping scenario. The Raymond Library and High School and the substation west of Long Beach, are also likely to be inundated in the 2100 mapping scenario. The ground under the Tokeland tsunami tower will likely be inundated in the 2100 mapping scenario, as well.

Most critical facilities throughout the County appear to be located higher than predicted flooding, except for those mentioned above (Figures 16-19).

While the coastal residences may be able to withstand periodic inundation (see Section 4.5 Coastal Residences), wells and septic systems are particularly vulnerable to sea-water intrusion and can be quickly compromised with prolonged periods of inundation. Failed on-site septic systems pose a community health and safety risk by potentially releasing raw sewage contaminants in the environment. Similarly, sea-water intrusion for wells can impact the availability of potable water. Adaptation strategies are encouraged to be considered to improve resiliency for new or existing coastal residence appurtenances and reduce public health and safety risks. It is important to note that the current analyses do not include the interaction of existing groundwater conditions. It would be beneficial to conduct a supplemental study to this report to evaluate the existing conditions and incorporate with hydrodynamic modeling what these conditions may be for coastal conditions, particularly on the Long Beach Peninsula as it is considered a critical aquifer recharge area with a shallow water table. These conditions in conjunction with the anticipated climate change impacts may result in increased extents of both sea level rise and extreme flooding, which will further impact coastal residences and their related appurtenances.

**Maps that are less than a full page are repeated in Appendix B as a full- page size.*

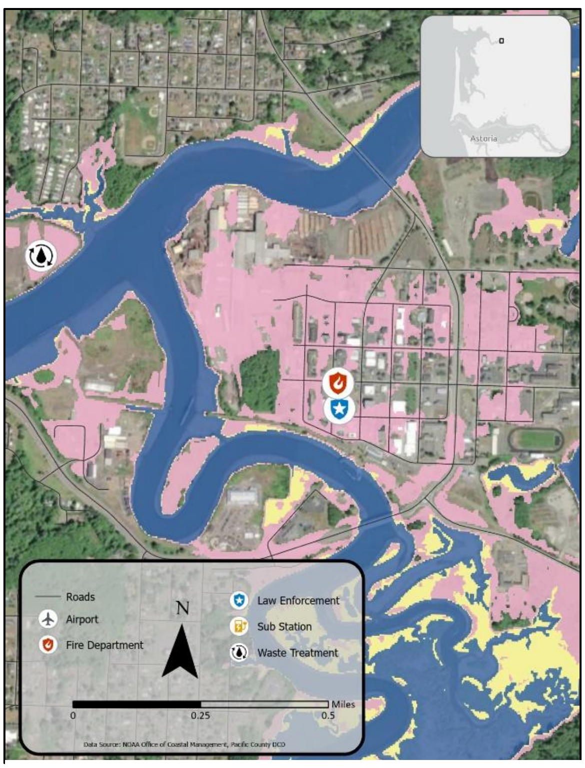


Figure 12. Critical facilities in the City of Raymond at risk during extreme flooding in the 2050 mapping scenario.

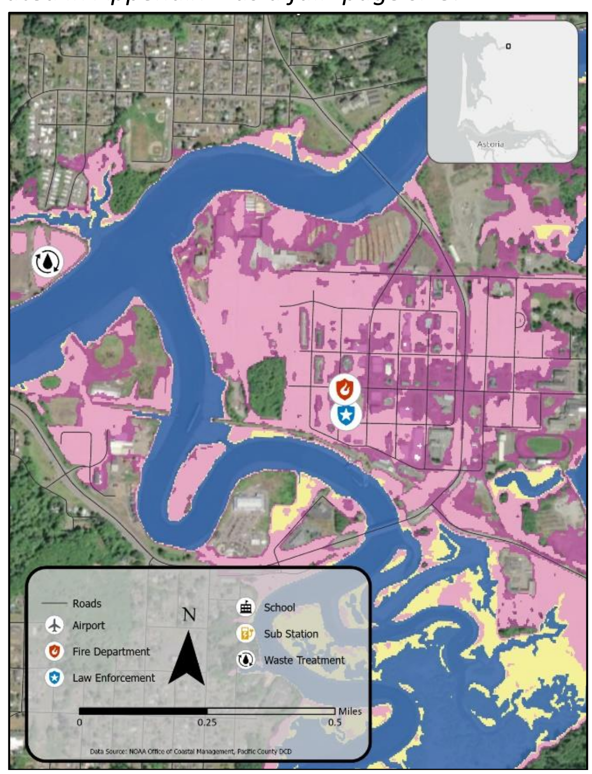


Figure 13. Critical facilities in the City of Raymond at risk during extreme flooding in the 2100 mapping scenario.

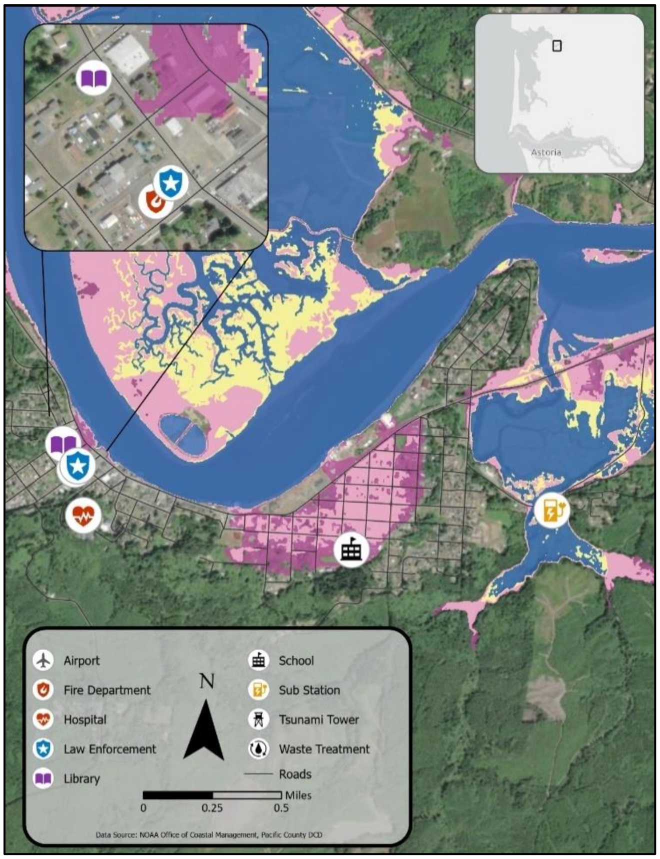


Figure 14. Critical facilities in South Bend compared to extreme flooding in the 2050 and 2100 mapping scenarios.

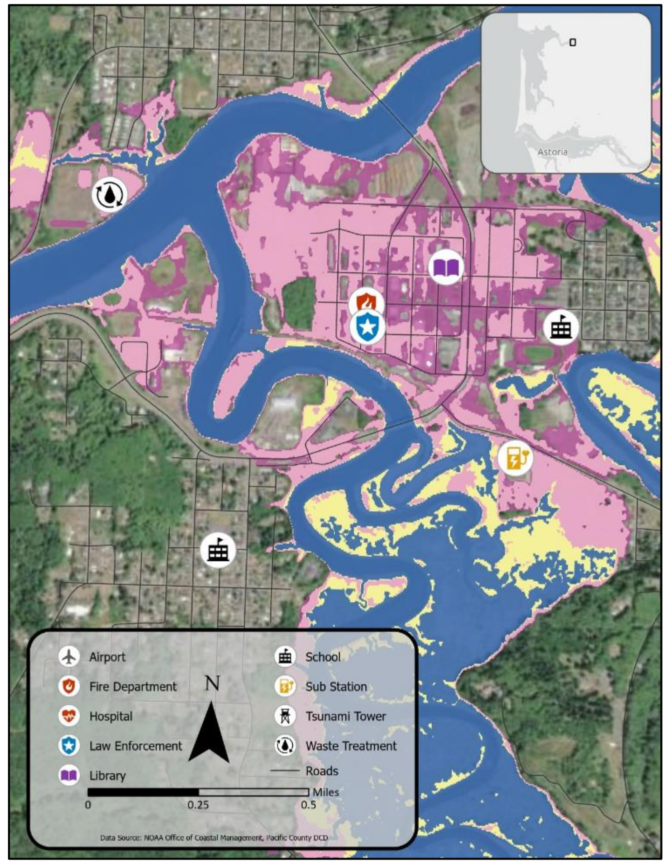


Figure 15. Critical facilities near Raymond compared to extreme flooding in the 2050 and 2100 mapping scenarios.

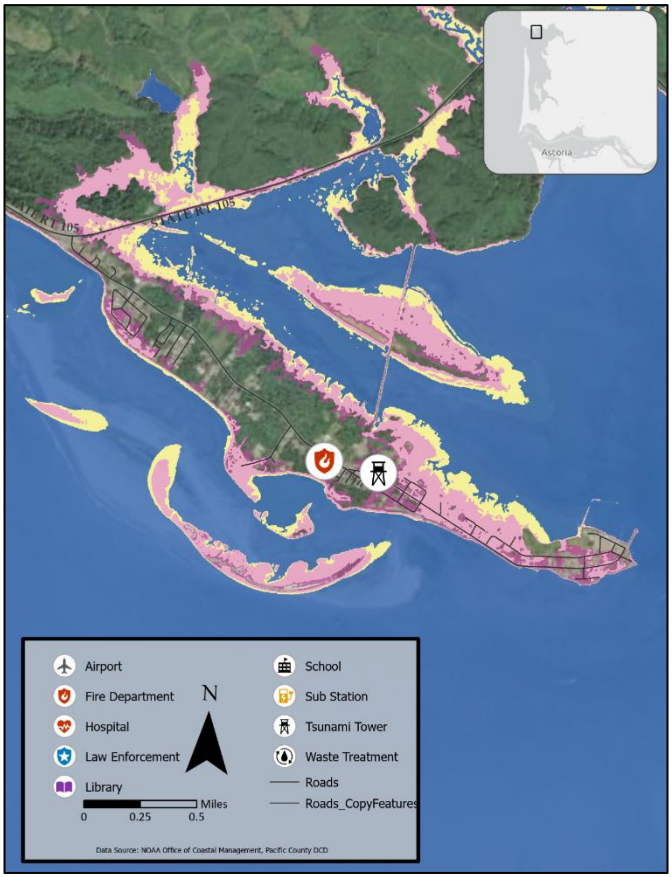


Figure 1612. Critical facilities near Tokeland compared to extreme flooding in the 2050 and 2100 mapping scenarios.

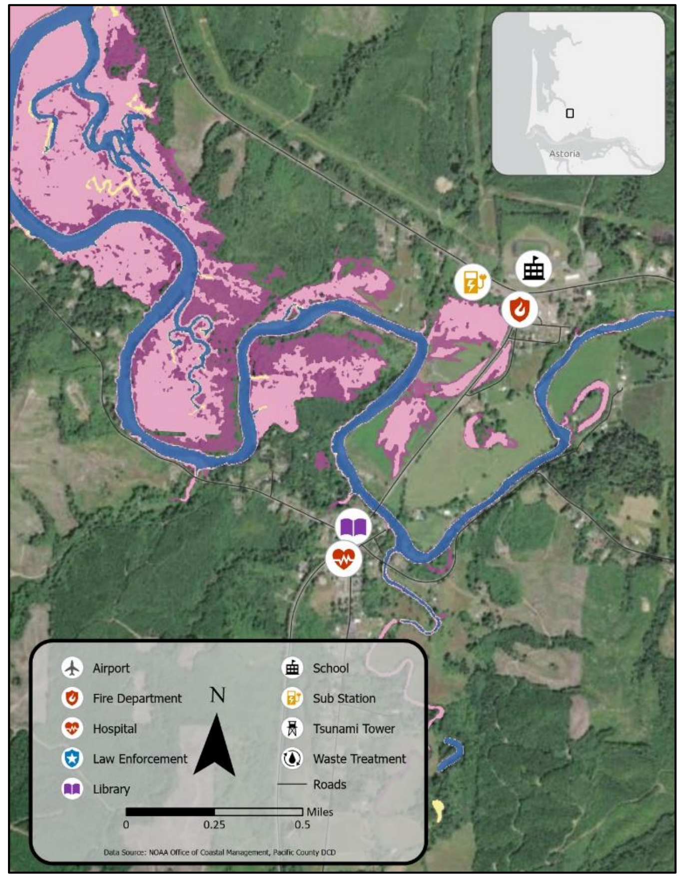


Figure 17. Critical facilities near Naselle compared to extreme flooding in the 2050 and 2100 mapping scenarios.

Figure 18. Critical facilities near Ocean Park compared to extreme flooding in the 2050 and 2100 mapping scenarios.

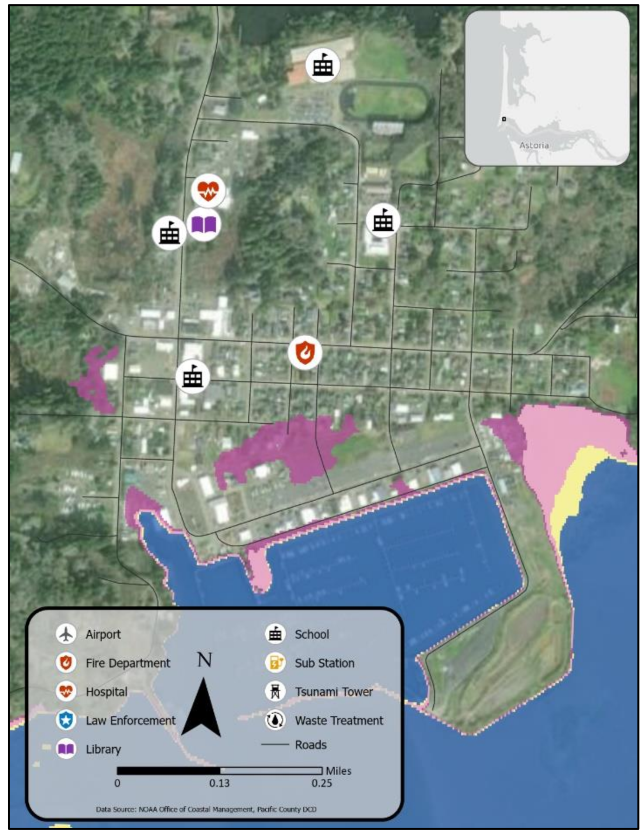


Figure 19. Critical facilities near Ilwaco compared to extreme flooding in the 2050 and 2100 mapping scenarios.

4.5 Coastal Residences

Coastal residences have varying degrees of vulnerability based on the proximity to the shoreline and the existing elevation. Overall, greater distances from the shoreline are considered to have lower risk of inundation as climate change impacts are increased. The number, and location, of buildings that can be considered vulnerable to tidal inundation was assessed (Table 7). Several historic structures, as identified by the Department of Archaeology and Historic Preservation (DAHP)'s online mapping tool, WISAARD, are rated/identified as having high vulnerability due to their location. These registered structures have been identified as a focus for preemptive flood protection given that they will be difficult to relocate or replace and are of cultural significance. Adaptation strategies can be implemented for existing and future coastal residences to prevent or reduce damage to structures as a result of sea level rise or extreme flooding over time.

For this analysis, a layer of building footprints that was generated by Microsoft using machine learning to identify structures from aerial imagery. It documents the location of 18,672 building footprints. This layer has

some inaccuracies and occasionally misses structures. At the time of this assessment, it is the most accurate mapping data for a county-scale assessment. To account for this error, the number of potentially inundated buildings is rounded to the nearest five.

Table 7. Buildings potentially inundated by the different flooding scenarios.

Scenario	Number of Buildings Potentially Inundated (rounded to nearest 5)	Historic Structures Potentially Inundated
+1-foot above current MHHW	190	0
Extreme flood from the 2050 mapping scenario (+4-feet in the Bay, +10-feet along outer coast)	1,465	Tokeland Hotel Oysterville Historic District
Extreme flood from the 2100 mapping scenario (+5-feet in the Bay, +10-feet along outer coast)	1,980	Tokeland Hotel Raymond Post Office Tokeland Coast Guard Station Oysterville Historic District

Under the 2050 mapping scenario, the City of Raymond and South Bend are likely to experience an extreme flood event that will temporarily impact many buildings within their urban centers (Figures 20 and 21).

Most buildings on the east side of the Tokeland Peninsula are at risk of inundation in the 2050 mapping scenario. In addition to the inundation of the only ingress and egress for this area, plans for emergency access that are not road-dependent will be important.

Many of the buildings on the Tokeland Peninsula are not under threat by a 1-foot rise in sea levels, but several may experience temporary flooding during an extreme storm event in the 2050 mapping scenario, especially along the east coast of the peninsula and along the interior lagoons (Figures 22 and 23).

Figures 24 through 31 show different rural areas throughout the County and the buildings that are at risk from flooding by average daily high tides (red house symbols), as well as at risk from temporary inundation by extreme coastal flooding in the 2050 and 2100 mapping scenarios (orange and yellow house symbols, respectively).

What this analysis could not consider with available information was the impact of delayed drainage of flood waters due to an increased amount of time the marine water is expected to be preventing drainage out of coastal culverts and tide gates. Flooding due to extreme rain events is already occurring in many places

throughout the County, such as south of Naselle, and drainage is a known concern. It is recommended that the County focus hydrological studies and updated drainage and infrastructure maintenance and repairs be focused in areas that are also facing risk from potential extreme coastal flooding. It should also be noted that there are ongoing efforts to better understand how flooding rivers intersect with SLR and how to quantify potential impacts. It is recommended that the County review BAS and apply updated river-marine interaction information once published.

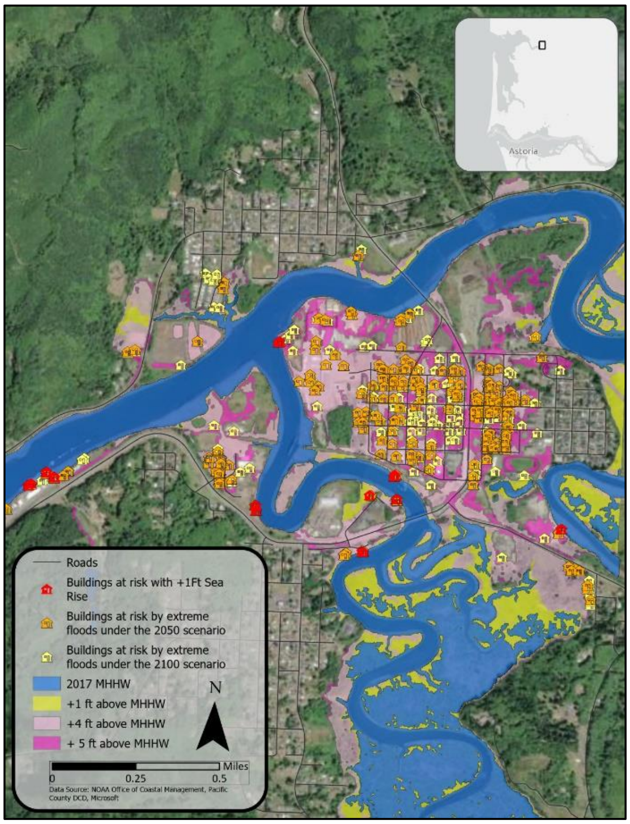


Figure 130. Buildings in Raymond at risk of inundation under the 2050 and 2100 mapping scenarios.

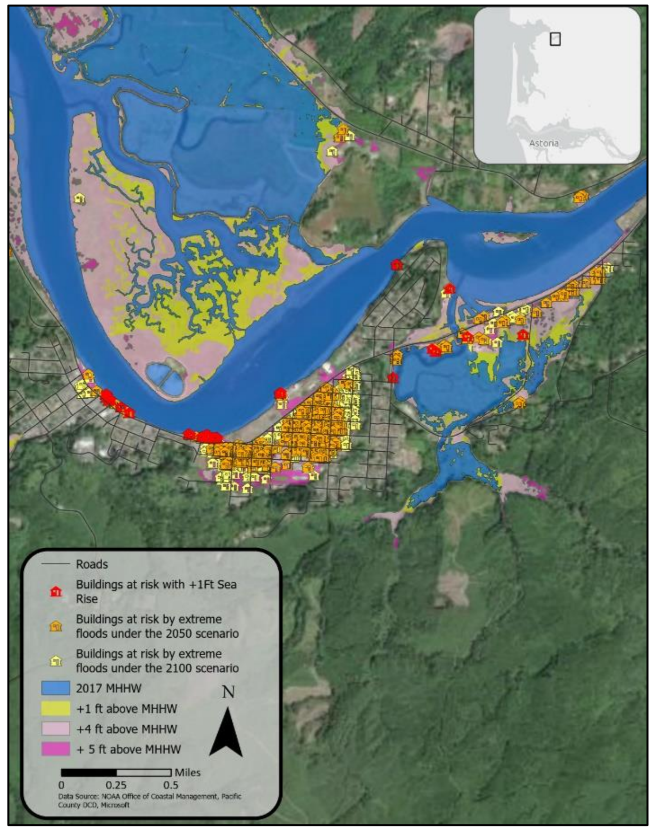


Figure 21. Buildings in South Bend at risk of inundation under the 2050 and 2100 mapping scenarios.

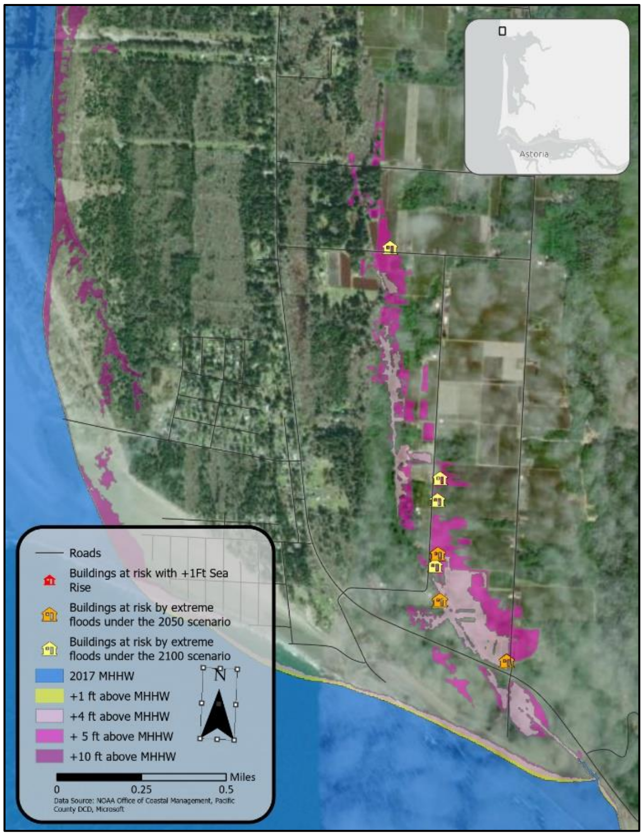


Figure 22. Buildings in North Cove at risk of inundation under the 2050 and 2100 mapping scenarios.

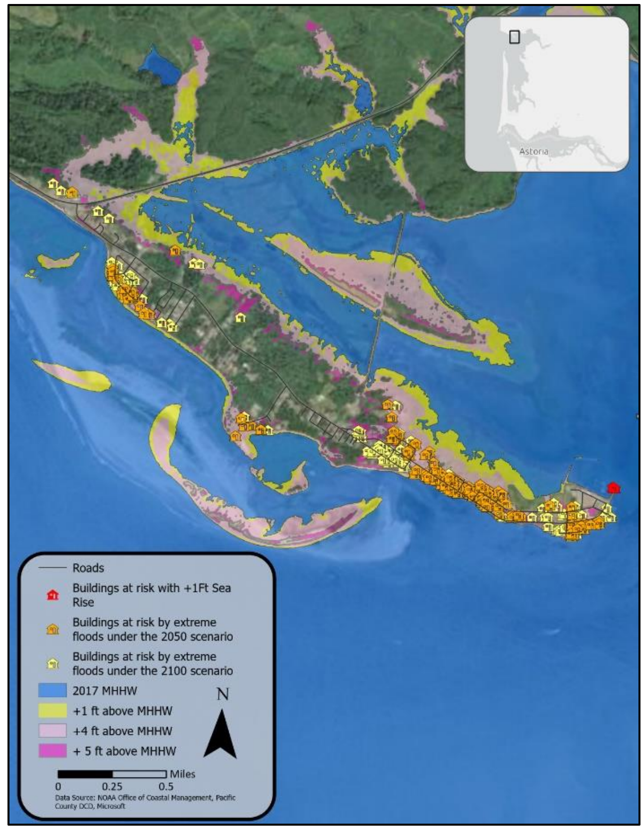


Figure 23. Buildings in Tokeland at risk of inundation under the 2050 and 2100 mapping scenarios.

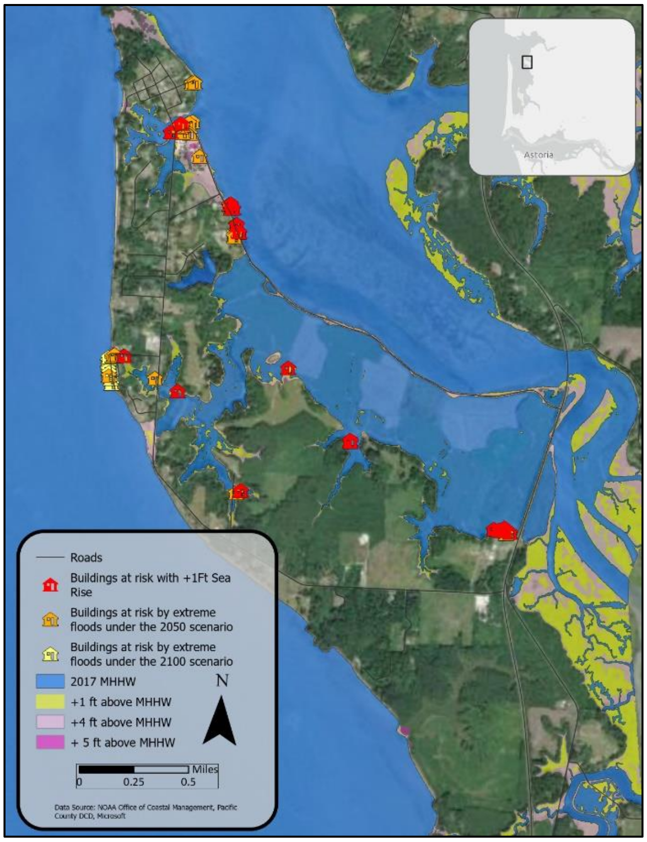


Figure 24. Buildings in Bay Center at risk of inundation under the 2050 and 2100 mapping scenarios.

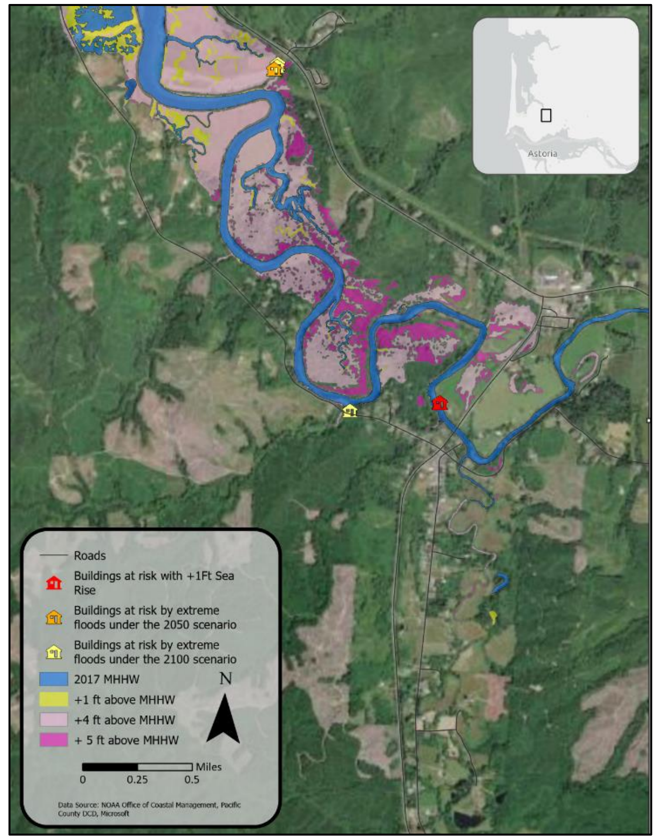


Figure 25. Buildings in Naselle at risk of inundation under the 2050 and 2100 mapping scenarios.

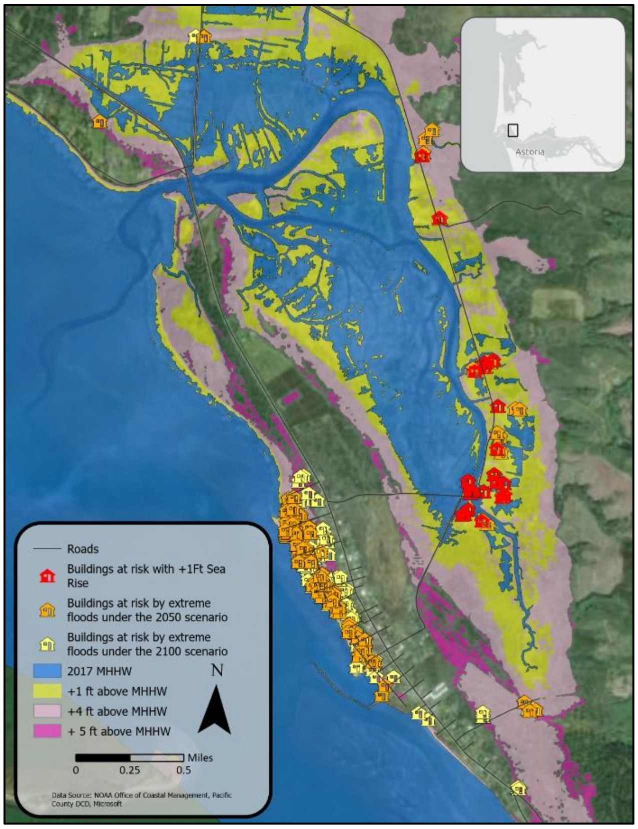


Figure 26. Buildings in the City of Chinook at risk of inundation under the 2050 and 2100 mapping scenarios.

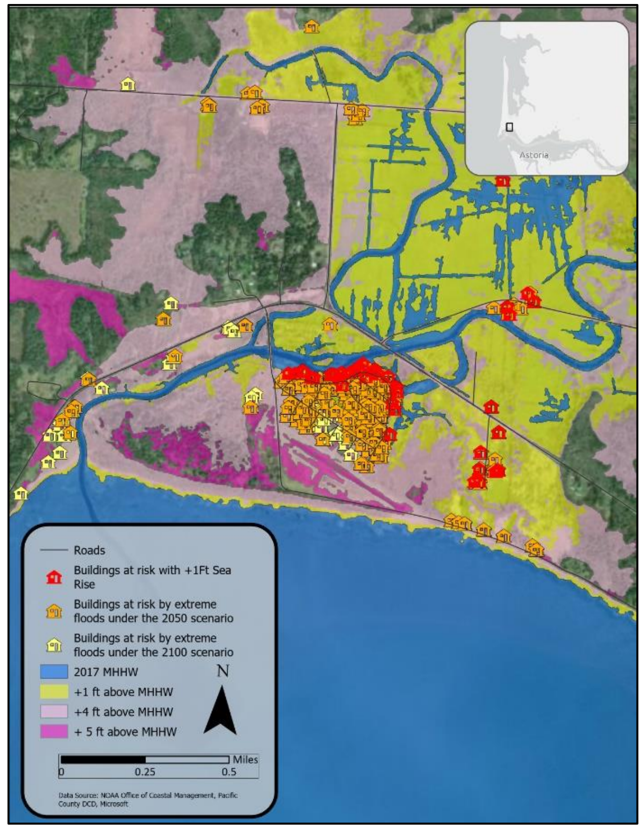


Figure 27. Buildings near the Port of Ilwaco at risk of inundation under the 2050 and 2100 mapping scenarios.

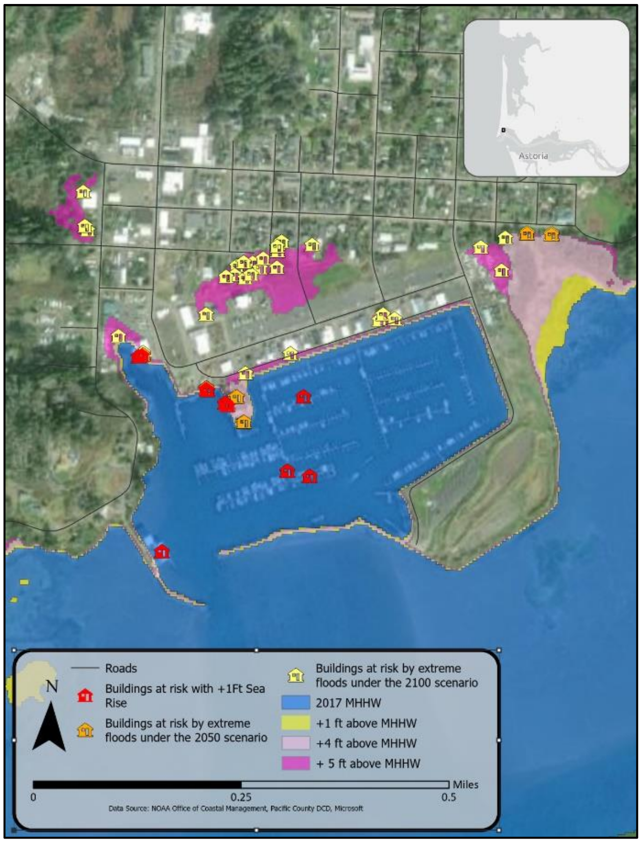


Figure 28. Buildings in the City of Ilwaco at risk of inundation under the 2050 and 2100 mapping scenarios.

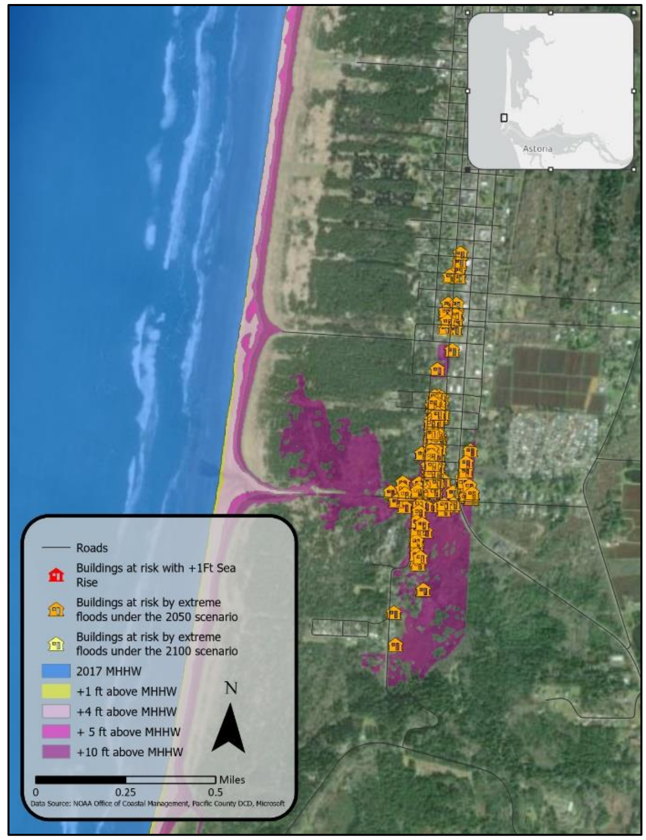


Figure 29. Buildings in Long Beach at risk of inundation under the 2050 and 2100 mapping scenarios.

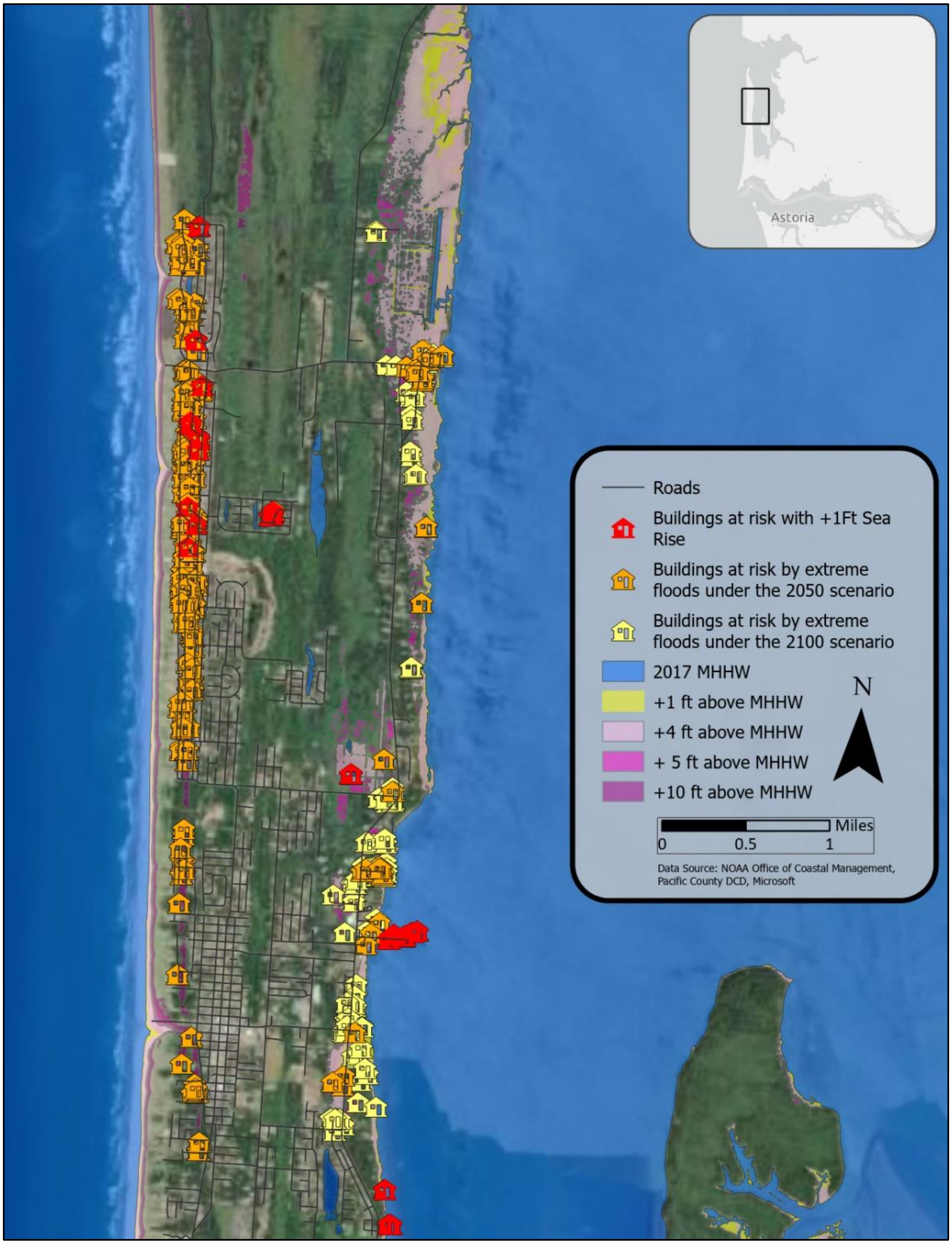


Figure 30. Buildings near Ocean Park and Surfside at risk of inundation under the 2050 and 2100 mapping scenarios.

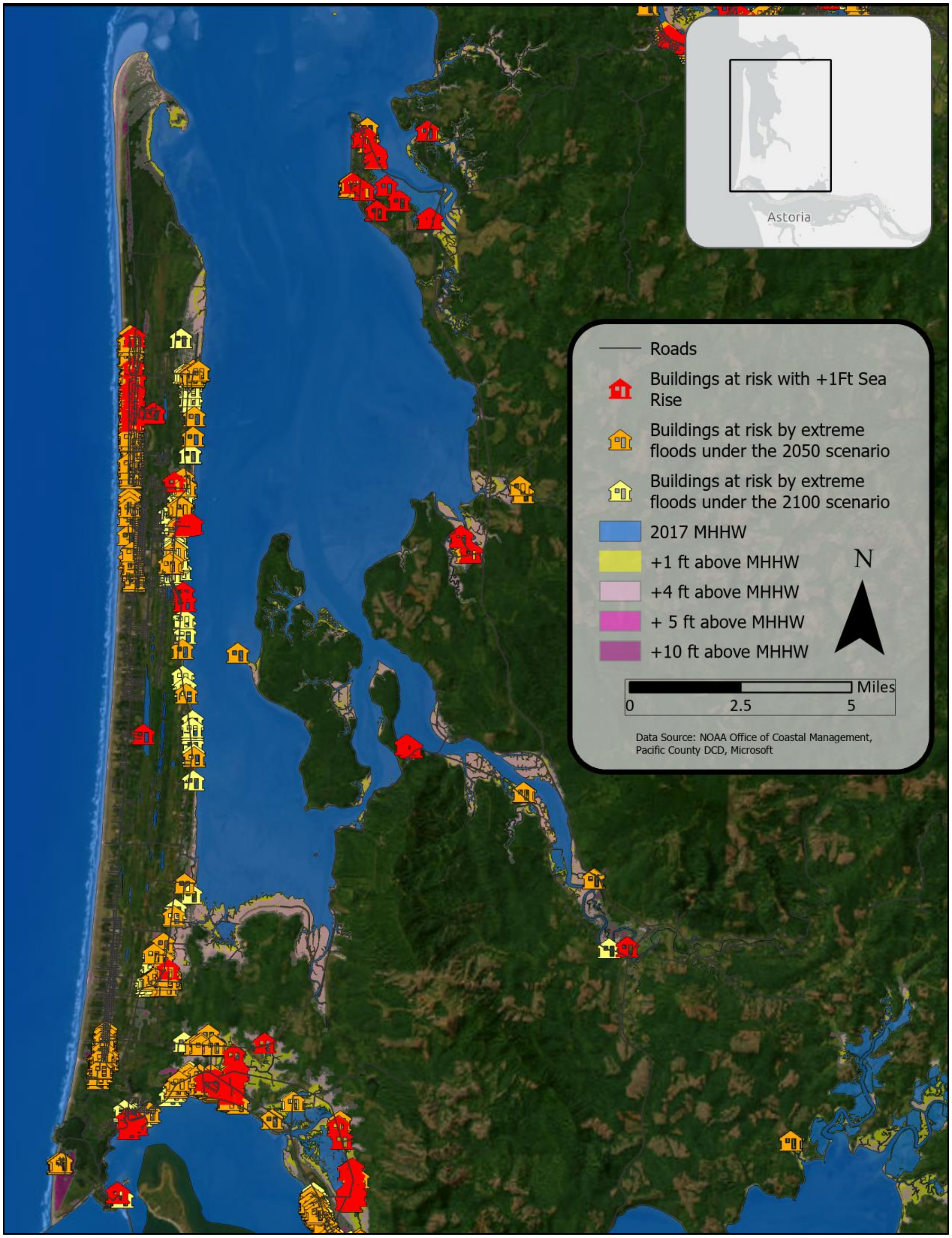


Figure 31. Buildings on the Long Beach Peninsula at risk of inundation under the 2050 and 2100 mapping scenarios.

4.6 Commercial Areas (Cranberries, Shellfish, Ports)

Pacific County is heavily reliant on the marine and agricultural industries as the primary sources of economic viability. With rising sea levels and increased extreme flood events, these industries are vulnerable to the expected climate change impacts. Pacific County is known for their cranberry and shellfish production, as well as crabbing and fishing industries. Shellfish and fin fish commercial facilities are primarily based in the Port of Ilwaco, Port of Chinook, Bay Center, Nemah, South Bend, Raymond and Tokeland. Whereas cranberry bogs and production facilities are predominately present on the Long Beach Peninsula and in North Cove. Shellfish and fin fish facilities are water dependent and are particularly vulnerable to sea level rise due to the risk of compromising ancillary structures along the shoreline or port and potential impacts to juvenile habitat of shellfish and fin fish. Changes in salinity and/or temperature may affect the spawning and habitat conditions for shellfish or fin fish. The Port of Ilwaco is currently experiencing inundation during extreme flood events and is intending to reconstruct their existing bulkhead to preserve function as climate change impacts are experienced.

Photo credit: Scenic Washington (Scenic Washington | Cranberry Museum)

Cranberry bogs rely on freshwater for production. Cranberry growers have stated that the freshwater level in the bogs rises and falls in synchrony with the tides demonstrating the hyporheic connection between the salt water and inland water (Allen, 2023). Any saltwater intrusion would compromise the ideal growing conditions and would ultimately result in conversion of agricultural activities. This would impact the livelihood for cranberry growers and large commercial operations that rely on Pacific County for products. Ensuring the drainage and flow control systems remain functioning will include monitoring and maintenance of outlet channels and tide gates as sea level rise results in less time for water to flow out of the system and into the marine environment.

4.7 Habitats

Sea level rise is anticipated to have significant impacts on freshwater ecosystems in low-lying coastal areas as a result of saltwater inundation. Many plant and animal species found near coastlines have adapted to a certain level of salinity and have varying ranges of tolerances. However, some species that are not salt-tolerant will die

off and be replaced by those that are salt-tolerant. Particular animal species may not be affected by a change in salinity, their food source could be impacted and cause disruptions in the ecosystem and food web functions.

Based on the mapped wetland available from the National Wetland Inventory (United States Fish and Wildlife Service, 2023), approximately 3,291 acres of wetlands are predicted to be impacted by 1-foot of sea level rise (Table 8). The impact to the 1,170 acres of estuarine and marine wetlands is likely to be minimal since these systems are already saline. The 2,070 acres of freshwater wetland – both emergent and forested/shrub – are likely to experience the most impact of the wetlands mapped. With the introduction of salt water more frequently, these vegetative communities are likely to die off and salt-tolerant estuarine species will become established. Figure 32 shows the area of wetlands that has the potential to experience the most impact from a one-foot increase in daily average high tides.

The amount and location of wetlands impacted by saltwater inundation during the extreme flood scenarios was not modeled as these events result in only temporary and infrequently. Ecosystems need to be exposed to more prolonged periods of salt inundation before converting from fresh to saltwater species dominant. The elevated water velocities and wave energies associated with extreme flood events are expected to be the ecosystem change drivers in these situations.

Photo credit: Chinook Observer (Willapa Bay during King Tide Event)

Increases in sea level rise and extreme coastal storms may result in a loss of tidal flats and area beaches. A reduction in estuarine beaches and increases in shoreline armoring may result in a loss of spawning grounds for forage fish and negatively impact other intertidal species (Glick, 2007). Inundation of tidal flats would impact the commercial shellfish industry by reducing the number of suitable sites for aquaculture activities. As Dungeness crabs and juvenile salmon rely on estuaries as nurseries, changes in habitat composition in estuaries may lead to a population reduction. Additionally, changes in composition of tidal wetlands may reduce the capacity to support salmonids.

Table 8. Acres of Wetlands potentially inundated by the different scenarios.

Wetland Type	Acres Potentially Impacted by +1 ft SLR (nearest 5 acres)
Estuarine and Marine Wetland	1,170
Freshwater Emergent Wetland	1,435
Freshwater Forested/Shrub Wetland	635
Freshwater Pond	15
Lake	5
Riverine	35
Grand Total	**3,291**

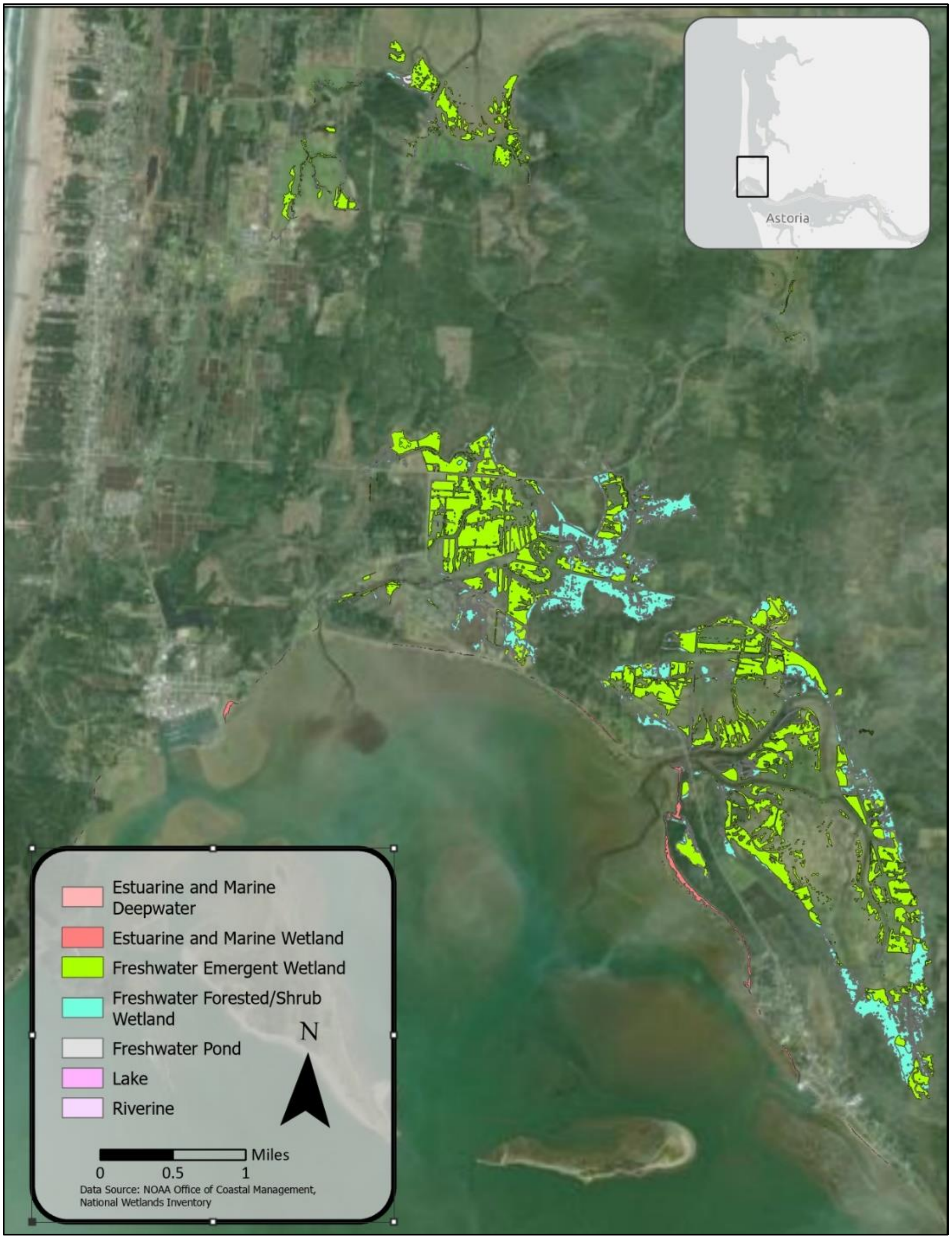


Figure 14. Some of the Pacific County wetlands likely to be impacted by 1-foot of sea level rise.

5 Adaptation Strategies

To mitigate the anticipated sea level rise impacts, it is recommended to consider incorporating adaptation strategies to protect vulnerable areas and reduce loss of property and infrastructure. Following this report, the County would benefit from a study prepared by a licensed hydrogeologist to evaluate the risk of seawater intrusion for public and private wells and on-site septic system drainfields. To provide an advanced projection of the potential vulnerabilities, it is recommended to evaluate the interaction between current groundwater conditions and predicted extreme flood events and sea level rise. An evaluation of drainage concerns and adaptive measures to address increasing flooding related to atmospheric rivers is also recommended.

Photo Credit: Pacific County Economic Development Council, Port of Chinook

The evaluation of the interactions can also be used to determine where current freshwater habitats may be converted to saltwater or estuarine conditions through hydrodynamic modeling. The current analysis does not include this interaction and likely underrepresents future conditions. These additional studies could be used to inform revisions of development regulations and protection standards to mitigate impacts. An evaluation of the additional studies would be intended to create specific recommendations for regulatory standards versus broad adaptation strategies.

The following adaptation strategies may be considered based on a review of successful practices from other jurisdictions and informed by this vulnerability and risk assessment include, but are not limited to:

Require sea-level rise projections for potentially impacted properties. When a reduced shoreline setback is requested, the County may consider requiring a report prepared by a qualified consultant that includes sea level rise projections to a minimum of 2050 to ensure adequate protection. In the event of a subsequent study, the site-specific recommendations could create an additional setback based on the predicted inundation to prevent loss of structures or related residential appurtenances, including wells and on-site septic systems.

<u>Revise development setbacks</u>. It is recommended to review existing building setback requirements for areas adjacent to coastal bluffs (Ex: Lynn Point, Rhodesia Beach). Geotechnical reports could include accelerated rates of erosion caused by increasing sea levels and hours of wave attack, as well as a factor of safety distance that is related to the cause of the erosion. The setback is recommended to factor in the life expectancy of the proposed development or redevelopment (approximately 75-100 years).

<u>Support the consideration of anticipated climate change impacts in habitat restoration efforts</u>. Many restoration project sponsors are proficient at prioritizing projects based on ecological importance and vulnerability to sea level rise. During the planning of habitat restoration projects, it would be beneficial to consider consulting experienced organizations with experience in the County implementing restoration projects. Examples of efforts that incorporate planning for climate change impacts could include expanding the area of planned restoration to accommodate for habitat migration, restoring a diverse array of habitat types to allow for adaptation during changes in compositions, and addressing upstream stressors that may impact the ability of estuarine habitats to respond to sea-level rise.

<u>Consider evaluating anticipated impacts to commercial water-dependent industries.</u> As Pacific County relies heavily on the commercial shellfish industry, it is recommended to further evaluate the anticipated impacts to tidal mudflats and estuaries to inform resiliency and adaptation efforts. This effort could include educating invested parties and investigating funding opportunities to reduce impacts to industries to the extent practicable. In future studies, it is recommended to evaluate the interaction between current groundwater conditions and predicted extreme flood events and sea level rise to predict potential impacts more accurately. The evaluation of this interaction through hydrodynamic modeling can also be used to determine loss of tidal mudflats or impacts to estuarine areas.

Photo Credit: Guy Glenn Jr., Port of Ilwaco

<u>Consider regulations for new or replaced on-site septic systems</u>. Short- and long-term considerations could be made for construction of new or replaced on-site septic systems in proximity to shorelines and floodplains that may become vulnerable. Examples of adaptation strategies include for new subdivisions adjacent to shorelines, community drainfields could be required and may consider locating the facilities as far from the shoreline as practicable. Other strategies include advanced or anchored septic systems for properties that cannot meet development standards, off-site relocation for development of structures damaged by storm

events related to sea level rise or reoccurring flood events, and utility consolidation or relocation, where applicable.

Consider regulations for new or replaced public water supplies. Short- and long-term considerations could be made for construction of new or replaced public water supplies in proximity to shorelines and floodplains that may become vulnerable. Examples of adaptation strategies include for new subdivisions adjacent to shorelines, a shared public water supply could be required and may consider locating the well and related infrastructure as far from the shoreline as practicable. Other strategies include off-site relocation for development of structures damaged by sea level rise or reoccurring flood events, and utility consolidation or relocation, where applicable.

Limit redevelopment or expansion of existing legal non-conforming structures in vulnerable locations. Pacific County could consider developing improved policies and regulations for non-conforming development near coastal areas that are vulnerable to sea level rise or extreme flood events. These regulations could consider limiting proposals for expansion or redevelopment to legal non-conforming structures. Regulations may require proposals to comply with the standards for new development, including regulations that minimize risk of anticipated sea level rise impacts and/or recorded deed restrictions to notify existing and future property owners of the subject limitations.

Require special considerations when permitting critical infrastructure and facilities. It is recommended to incorporate sea level rise projections into the design and permitting of critical infrastructure to improve resiliency. Critical facilities and infrastructure, such as roadways with no alternative routes, bridges, public water and sewer facilities, and hospitals, are encouraged to be designed with measures to ensure their continued function over time. When considering repair or replacement of these facilities, it is recommended to plan for more extreme projections to prevent impacts to function as climate changes impacts are observed.

Photo Credit: Pacific County Department of Community Development, North Cove

Consider incentivizing Passive Management Strategies. There are several techniques that could be considered to mitigate impacts from erosion, flood events and sea level rise that involve minimal impacts to coastal habitats. Some of these techniques could include surface and groundwater management improvements and vegetation management or retention. The improved management of stormwater and groundwater can reduce additional inputs that could exacerbate flood events or natural shoreline conditions. Management or retention of vegetation can help stabilize shorelines, particularly coastal bluffs, which are experiencing erosion. These techniques can often be implemented without a qualified consultant and limited permits. More involved management strategies include structure relocation or elevation to reduce impacts from flooding.

Photo Credit: Connie Allen, MyCoast: Washington, SR 105 Seamobile

Photo Credit: Connie Allen, MyCoast: Washington, SR 105 Seamobile

Encourage alternatives to hard shoreline stabilization measures. As extreme flood events become more frequent and sea level rises, requests for shoreline stabilization measures will become more common. Techniques that can help mitigate impacts but preserve marine habitat could include beach nourishment, soft shore armoring or hybrid measures. Soft shore techniques could include placement of large wood root wads, re-sloping and/or revegetating existing slopes, or a combination of several measures. However, it is noted that alternatives to hard armoring are not feasible in all instances. Prior to approving new hard armoring or replacement, it is recommended to encourage or require alternatives to be evaluated and implemented, where practicable.

Prioritize transportation connectivity and resiliency. As outlined in this report, there are several instances where roadways or transportation facilities are likely to be inundated during flood events or with sea level rise projections. To protect public safety, alternative modes of transportation are encouraged to be evaluated or considered for low-laying coastal areas to ensure access to residences for emergency services. Vulnerable roadways that will restrict access to residences or portions of the County are recommended to be prioritized on the Pacific County Capital Improvement Plan and be constructed at a height that will be resilient to extreme flood events and sea level rise. It is noted that the Port of Ilwaco Airport is likely to be inundated as well. This area is recommended to be evaluated to determine what measures can be implemented to reduce impacts to the function of the runway. In the event of an emergency, it is recommended to designate or create an upland landing area, if needed.

Photo Credit: Jackson Blaylock, Chinook

Evaluate existing stormwater infrastructure and conduct maintenance, where needed. Increased stormwater runoff is anticipated as result of climate change from increased rainfall. Increased stormwater can exacerbate flood events and normal sea level conditions. It is recommended to evaluate the existing stormwater infrastructure to ensure the system has the capacity to convey additional stormwater runoff. Routine maintenance will ensure the system is functioning and is likely to prevent future complications. The County is encouraged to review the existing stormwater management requirements for residential and commercial development and consider incentivizing low impact development techniques, where possible.

Photo Credit: Mike Nordin, Conservation District, South Bend

Develop a repetitive loss program. A potential method for improving climate resiliency would be to develop regulations pertaining to prohibiting repairs of a structure continuously impacted by coastal hazards, particularly sea level rise related storm damage. An example of this program could include that for structures that are subject to repetitive loss, steps could be taken to require reduction or elimination of the flood hazard. Initial permits to repair a structure following storm damage could be permitted. If the property is damaged a second time within a designated timeframe, conditions or additional development standards could be required to prevent future damage. The County could consider requiring a deed restriction. If the property is damaged a third time, repairs may not be permitted unless adequate documentation is provided that the proposed repairs would eliminate or significantly reduce future hazards.

Photo Credit: Department of Community Development, Long Beach Peninsula

6 Conclusions

Assessing the impacts of sea level rise is an evolving science. The further out projections are cast, the lower the confidence in those results. When communities are planning on how to build structures with a 70-to-100-year lifespan, these uncertainties can be considered but it is advised that the community consider the current projections as a 'best case scenario.' Since coastal scientists began providing sea level rise and storm frequency projections, the amounts of predicted rise and increased storm magnitude have always increased, not decreased. Therefore, it is prudent that a community consider these projections as conservative with the disclaimer that actual conditions may extend beyond these mapping scenarios within the given timeframes.

There are many confounding variables for modeling sea level rise that include predicting human behavior and predicting subduction zone earthquakes, which are impossible to predict with a high degree of certainty. The estimates produced by Miller et al. (Miller I. M., 2018 & 2019), apart from being a huge undertaking to incorporate many variables into a cohesive model, are also averages and do not capture year to year variability in extreme weather events. The sea level projections modeled identify a trend of sea level rise eventually exceeding vertical land elevation change for most of the Pacific County.

By modeling the intersection of three different potential future flooding scenarios — with community areas of interest, the following conclusions were developed:

- Areas most at risk to sea level rise and extreme flood impacts include:
  - The Port of Ilwaco (roads, buildings, airport and wetland conversion),
  - City of Raymond (roads, critical infrastructure, residences),
  - South Bend (residences), and
  - Tokeland (roads, residences, historic buildings).
- Most critical infrastructure is unlikely to be threatened by sea level rise projections. Temporary inundation during extreme flooding is limited to a few locations.
- Most residences are not at risk by a +1 feet of sea level rise above MHHW. This does not include potential erosion that may result from increased storm activity. Additional analyses may be needed to determine if existing wells and on-site septic systems will be impacted by saltwater intrusion.
- All airports are potentially impacted by extreme flooding and are at risk of inundation under the 2050 mapping scenario.

Additional future assessments should include a more in-depth analysis of flooding interactions. Particularly, future assessments are encouraged to review existing drainage problems that will be exacerbated by climate change impacts. These drainage impacts, as well as saltwater intrusion, could have drastic impacts on coastal

on-site septic systems and wells. It is recommended to consult with a hydrogeologist to evaluate groundwater interactions with saltwater for these facilities. As referenced in this report, mapping data for private infrastructure is lacking and therefore, impacts were difficult to quantify in this report and are likely underrepresented in this report. It is recommended to develop improved maps for public and private drinking water sources, on-site septic systems, and other wastewater treatment plants.

In future evaluations, it is recommended to review and evaluate the Flood Control District No.1 for potential updates and alterations to ordinances pertaining to land alterations and drainage as the current draft is from 1997. Specifically, the County could consider evaluating the existing Ordinances for consistency with the 2019 Stormwater Management Manual for Western Washington (SWMMWW) prepared by the Washington State Department of Ecology. For areas that are limited in access with no alternative routes, such as East Tokeland, it is recommended to develop emergency plans to ensure public safety and accessibility of public services. The County could also consider examining water-crossing structures, including bridges and culverts, to ensure that conveyance of higher volumes of water at higher velocities can be maintained.

It is also recommended to periodically review updated and new coastal resiliency modeling and adaptation strategies. In particular, review of the CoSMOS model as it is developed for Washington's outer coast should further inform the County's and communities resiliency planning efforts. As more research is completed pertaining to how rivers respond to climate changes and interact with the marine environment, the findings should be applied in areas such as Raymond, Naselle and along the Columbia.

Following this report, it is the intent of Pacific County Department of Community Development to apply for additional Washington State Department of Ecology grant funding to continue this assessment at a more detailed scale and develop policies and regulations to mitigate sea level rise and climate change impacts. Additional studies around hydrodynamic modeling could be conducted to inform a more site-specific evaluation of the interactions of existing conditions with future sea level rise projections. These interactions could be used to inform regulatory language that incorporates sea level rise projections into development standards, particularly within the Shoreline Master Program (SMP). The mutually agreed upon sea level rise mapping projections could also be used in environmental assessments prepared by qualified consultants that would be required for development applications to ensure public health and safety is protected to the extent practicable.

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8 Appendix A – Data Sources

Data Type	Source
Flow Control Structures (tide gates, dikes)	• County GIS • Community feedback
Drinking Water Sources (group systems)	County
Septic and Wastewater (individual septic systems for Tokeland and Naselle, only)	County
Critical Infrastructure • Airports • Fire Stations • Law Enforcement • Hospitals • Libraries • Schools • Bridges • Tsunami Tower • Roads	• County • Web Mapping Services
Building Footprints	Microsoft 2021
Zoning	County GIS
Historic Buildings and Districts	Department of Archaeology and Historic Preservation (DAHP)
Sea Level Rise Tidal Surfaces	National Oceanic and Atmospheric Administration (NOAA)
Wetlands	United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI)

9 Appendix B – Map Enlargements

Note: All maps in Appendix B are duplicates of half-page sized maps in the document. The Figure numbers reflect the numbers from the report for cross referencing purposes.

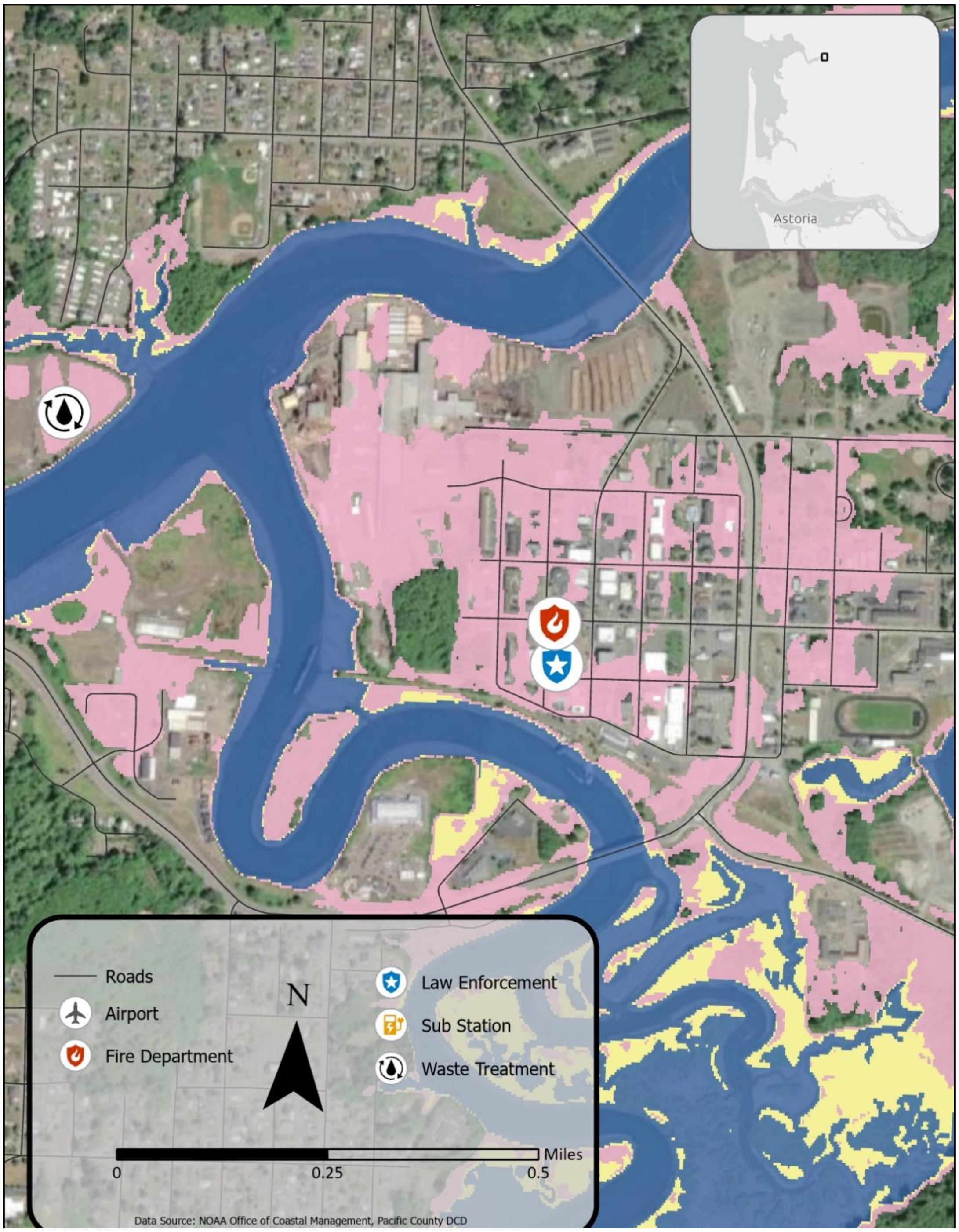

Figure 12. Critical facilities in the City of Raymond at risk during extreme flooding in the 2050 mapping scenario.

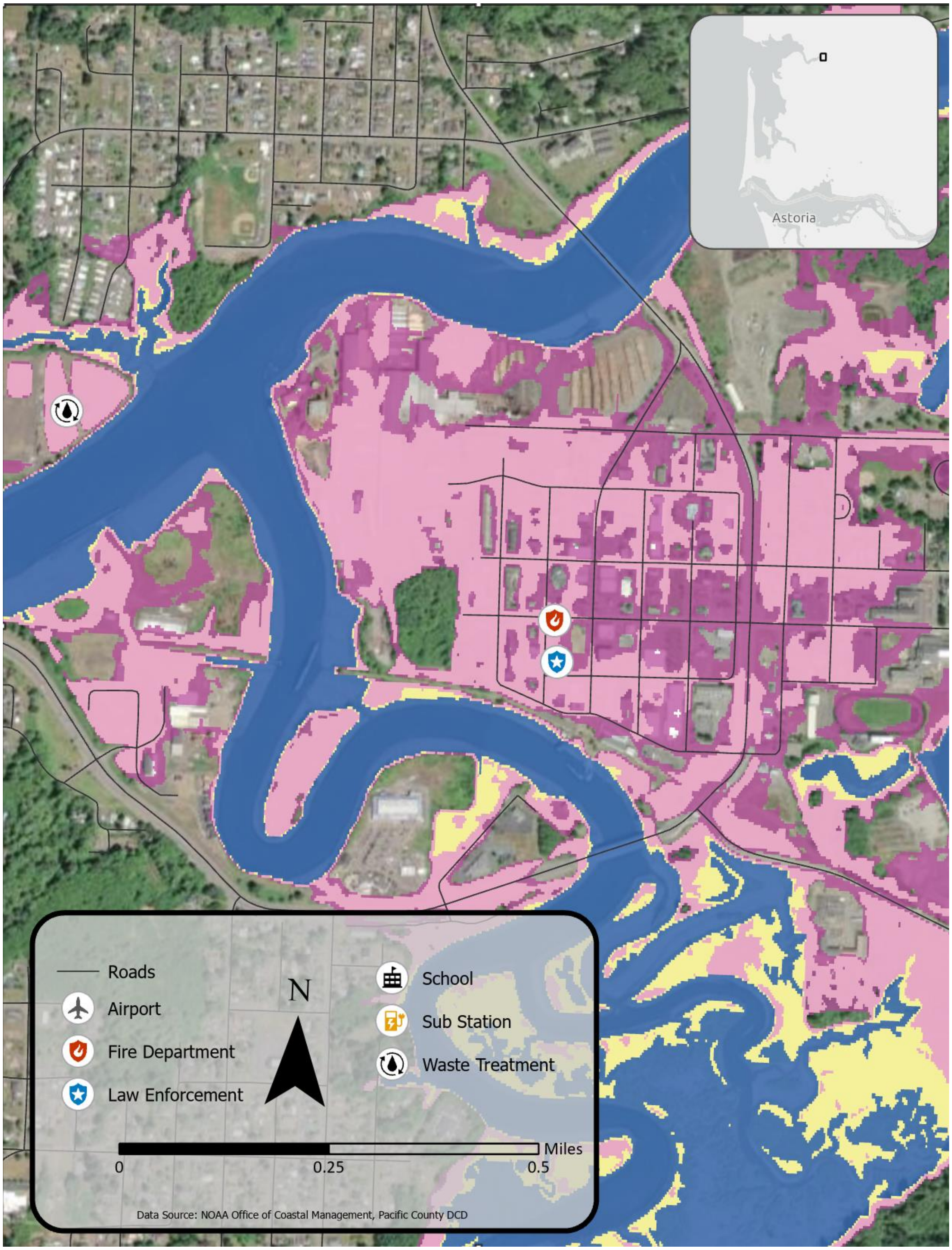

Figure 13. Critical facilities in the City of Raymond at risk during extreme flooding in the 2100 mapping scenario.

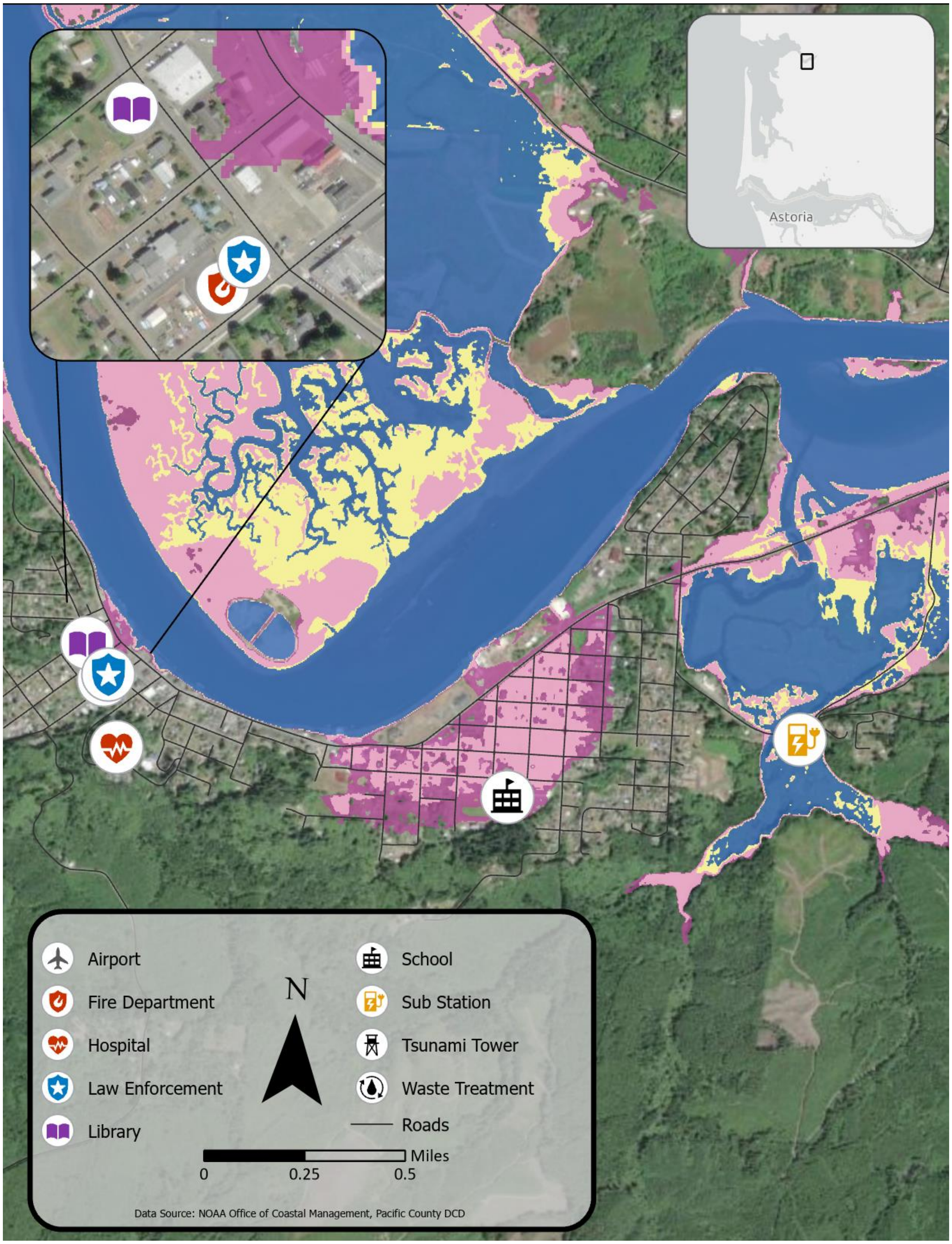

Figure 14. Critical facilities in South Bend compared to during extreme flooding in the 2050 and 2100 mapping scenarios.

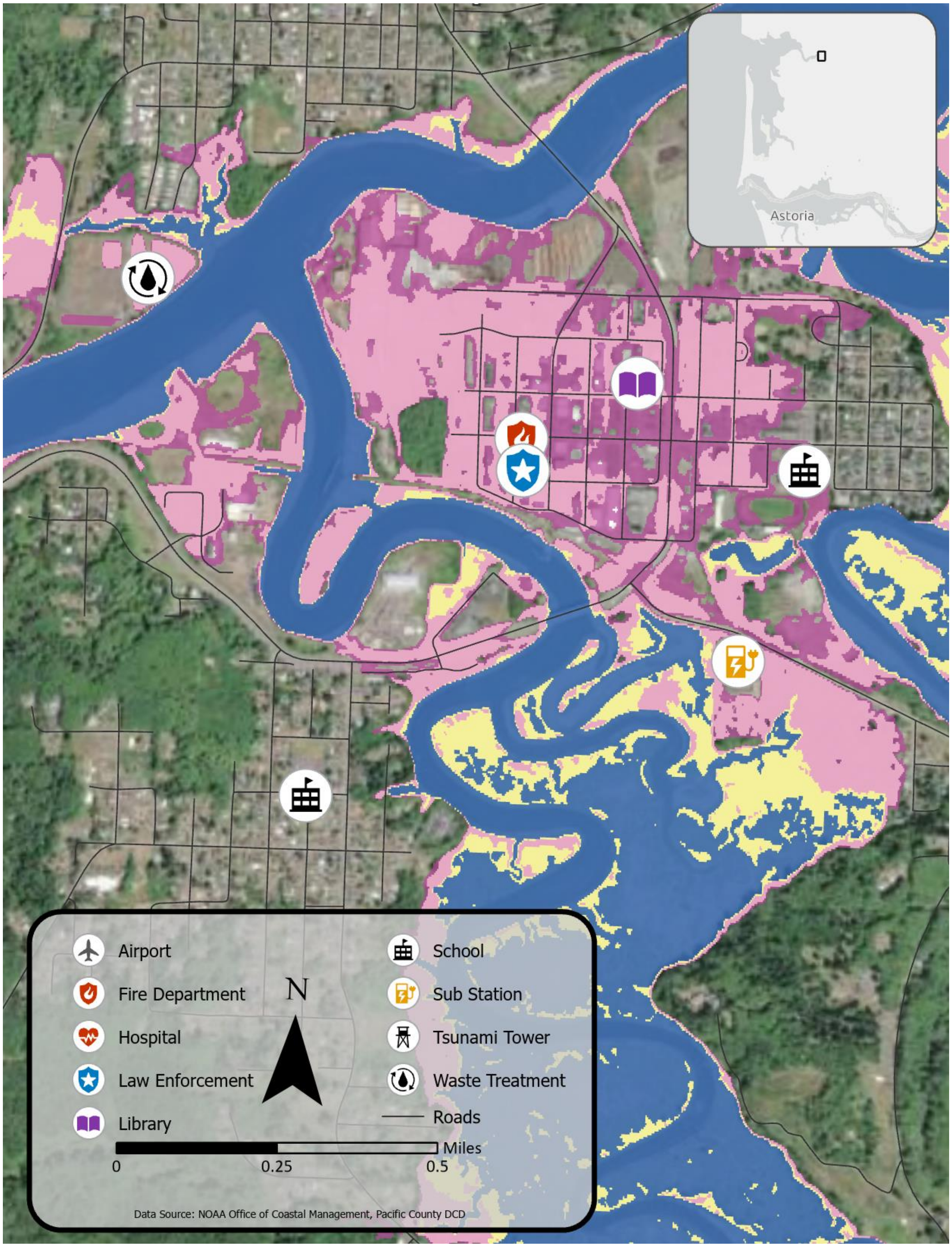

Figure 15. Critical facilities near Raymond compared to extreme flooding in the 2050 and 2100 mapping scenarios.

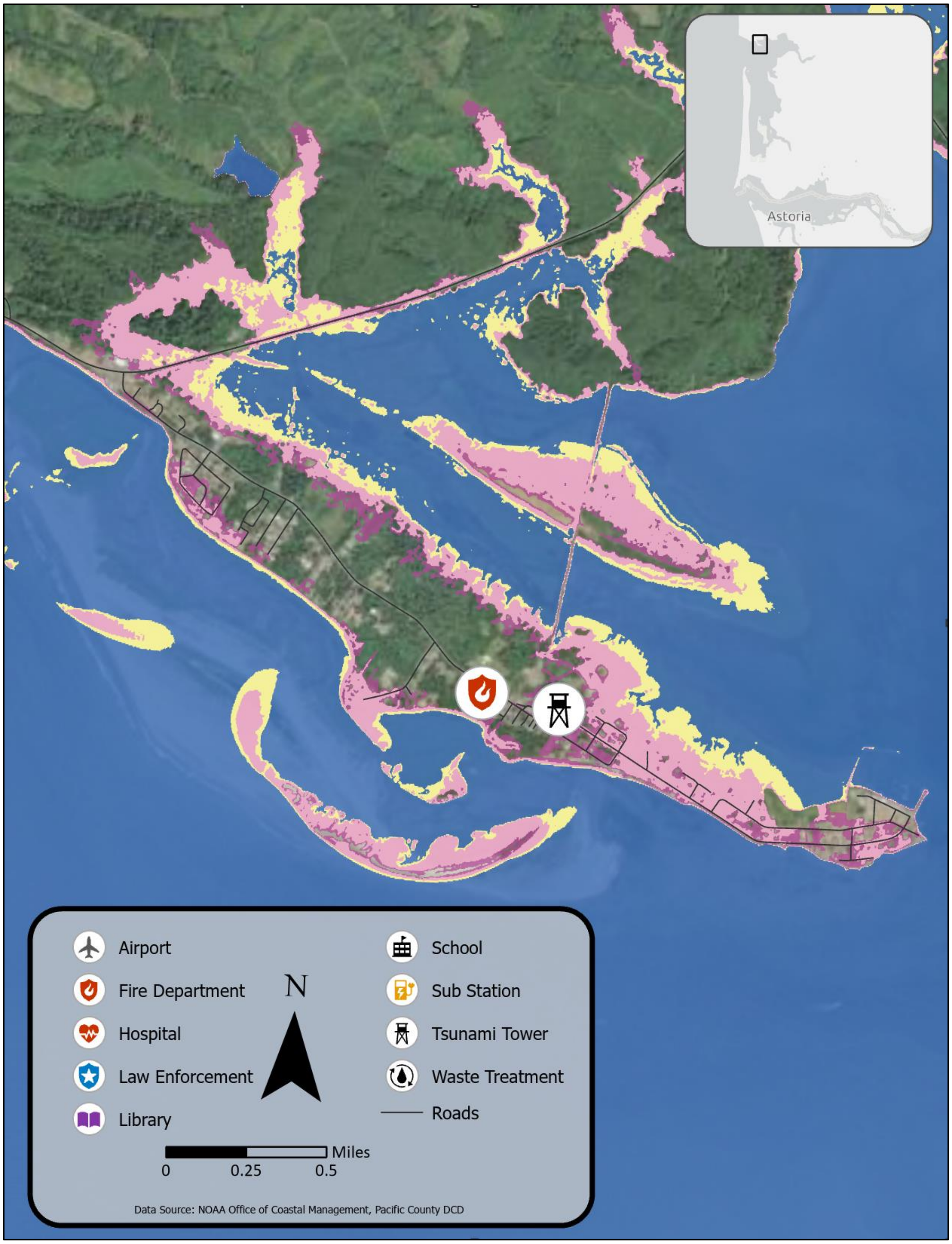

Figure 1615. Critical facilities near Tokeland compared to extreme flooding in the 2050 and 2100 mapping scenarios.

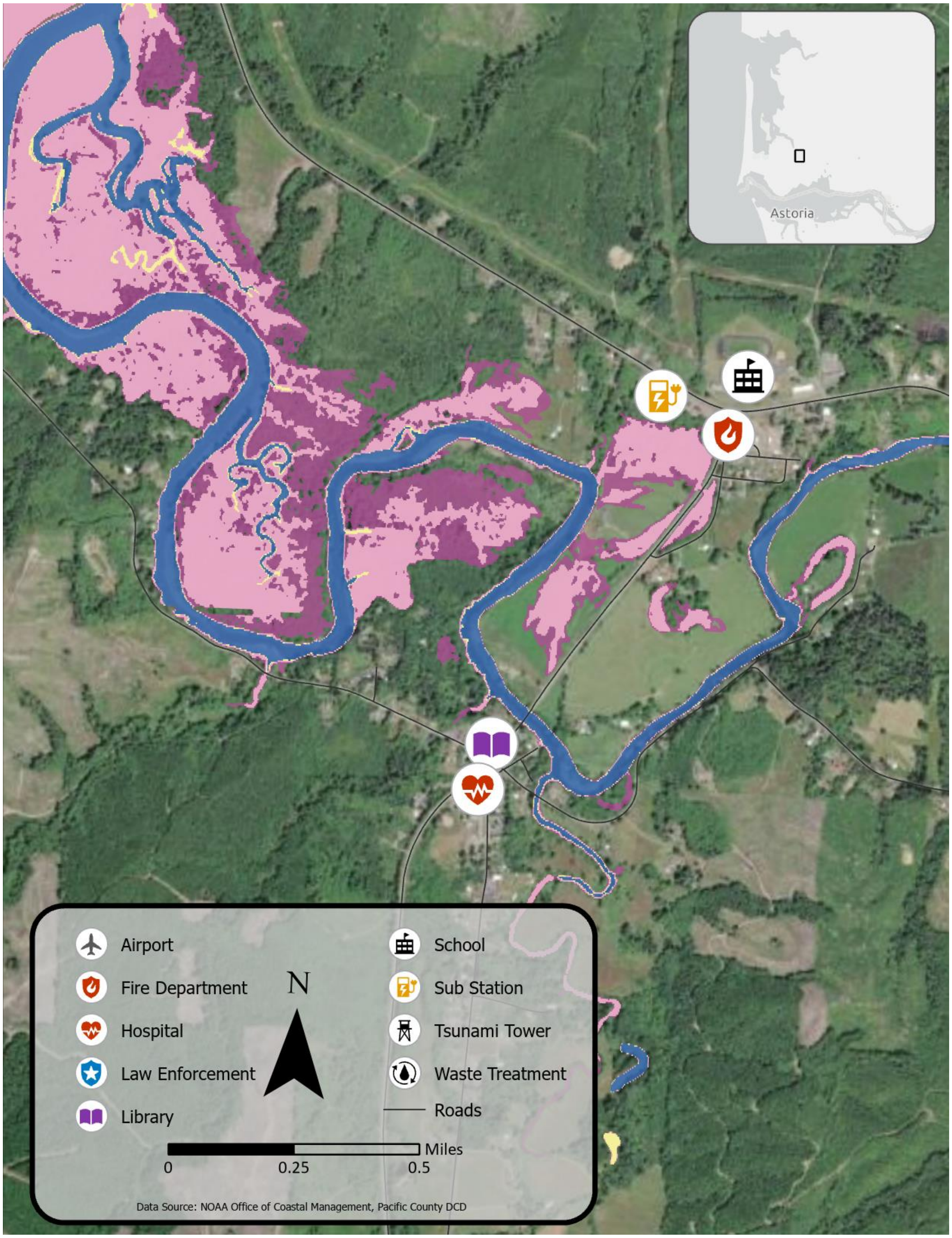

Figure 17. Critical facilities near Naselle compared to extreme flooding in the 2050 and 2100 mapping scenarios.

Figure 18. Critical facilities near Ocean Park compared to extreme flooding in the 2050 and 2100 mapping scenarios.

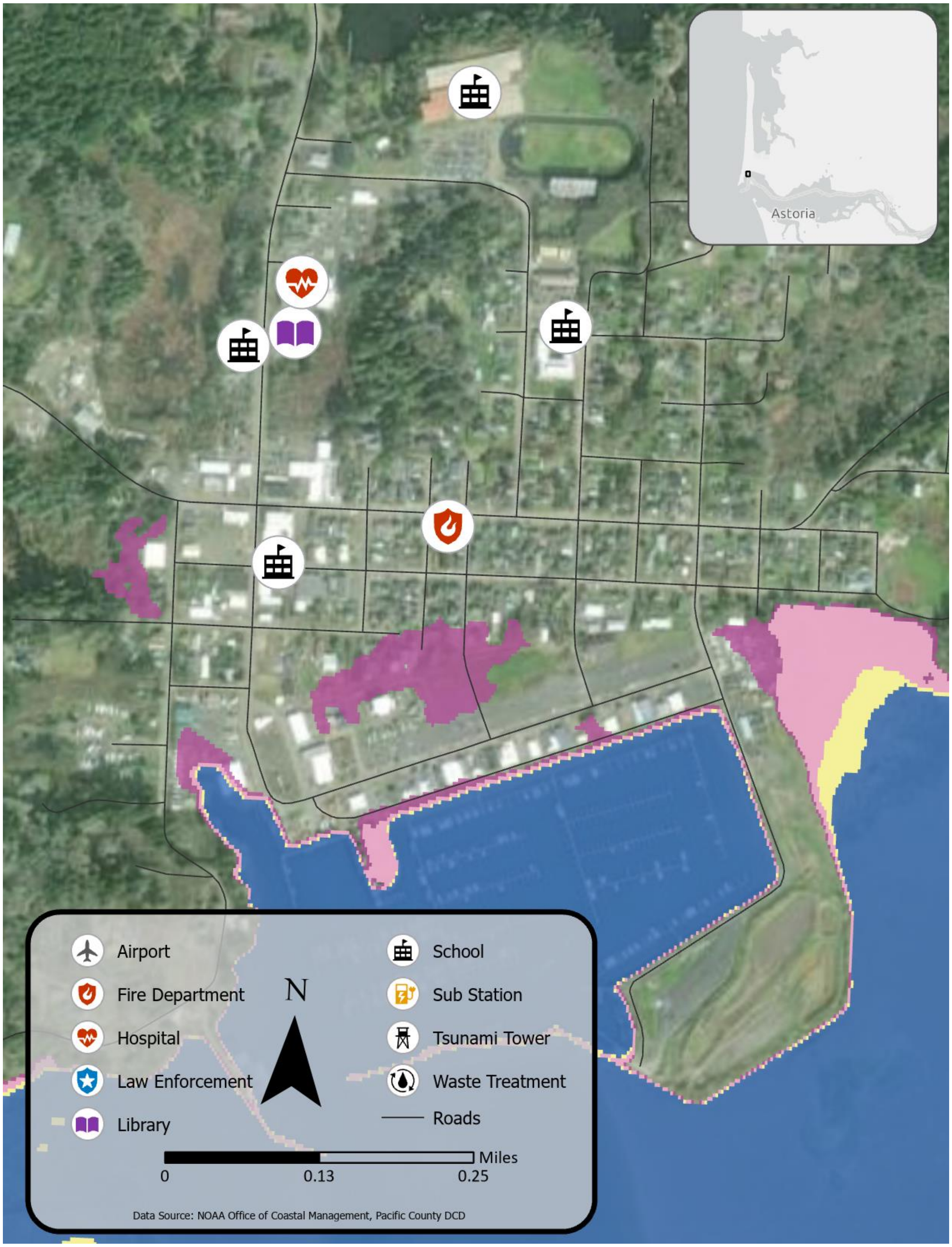

Figure 19. Critical facilities near Ilwaco compared to extreme flooding in the 2050 and 2100 mapping scenarios.

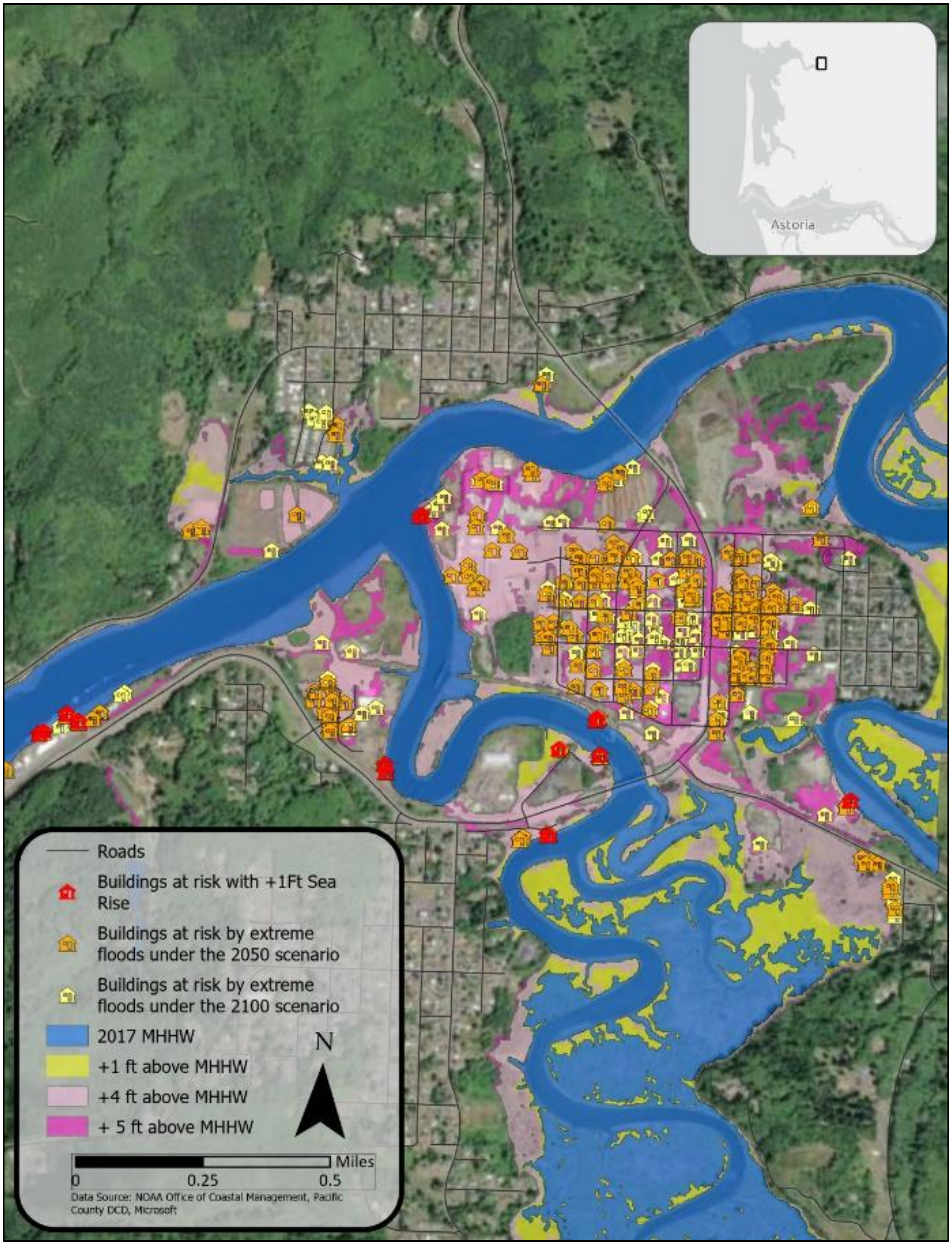

Figure 160. Buildings in Raymond at risk of inundation under the 2050 and 2100 mapping scenarios.

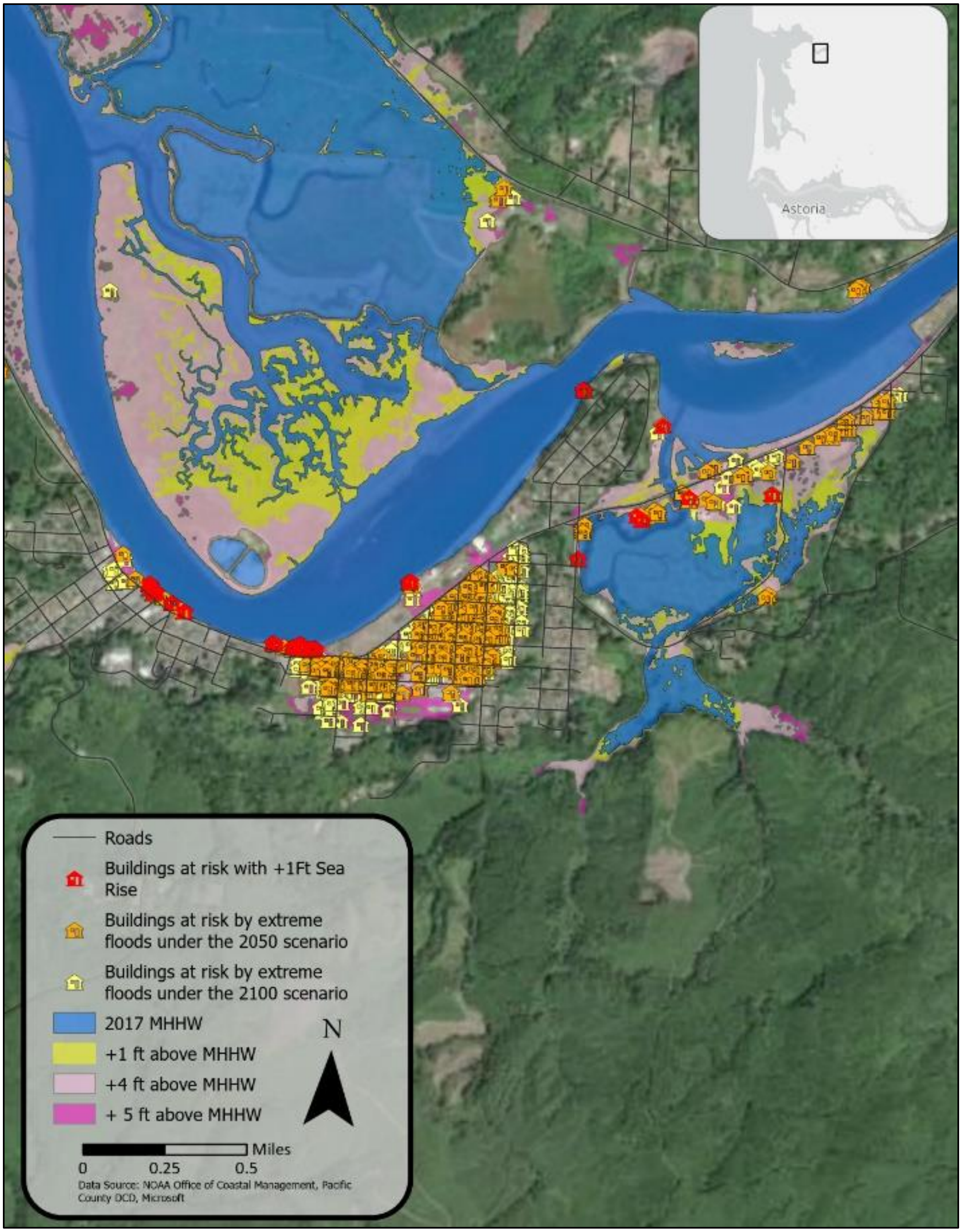

Figure 21. Buildings in South Bend at risk of inundation under the 2050 and 2100 mapping scenarios.

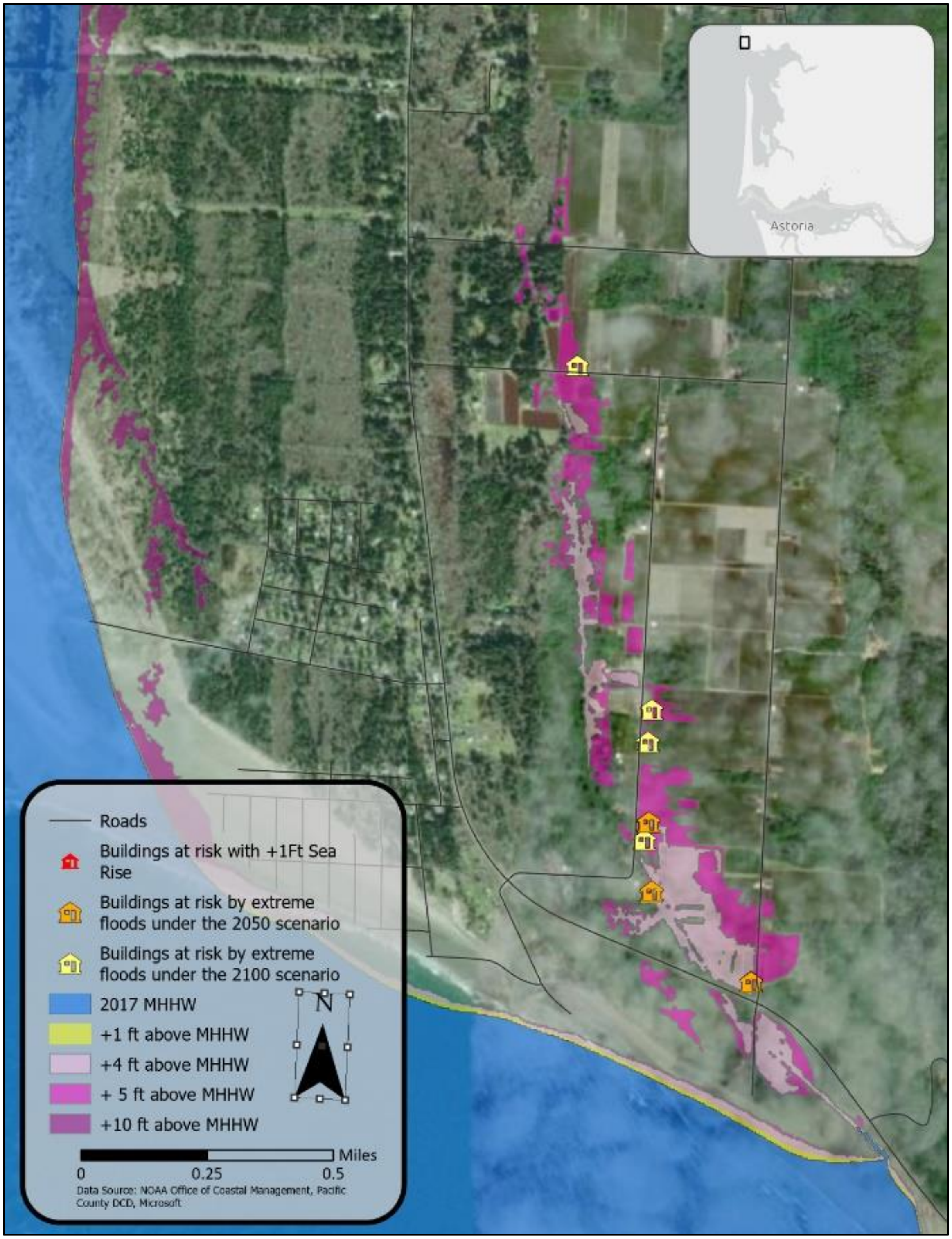

Figure 22. Buildings in North Cove at risk of inundation under the 2050 and 2100 mapping scenarios.

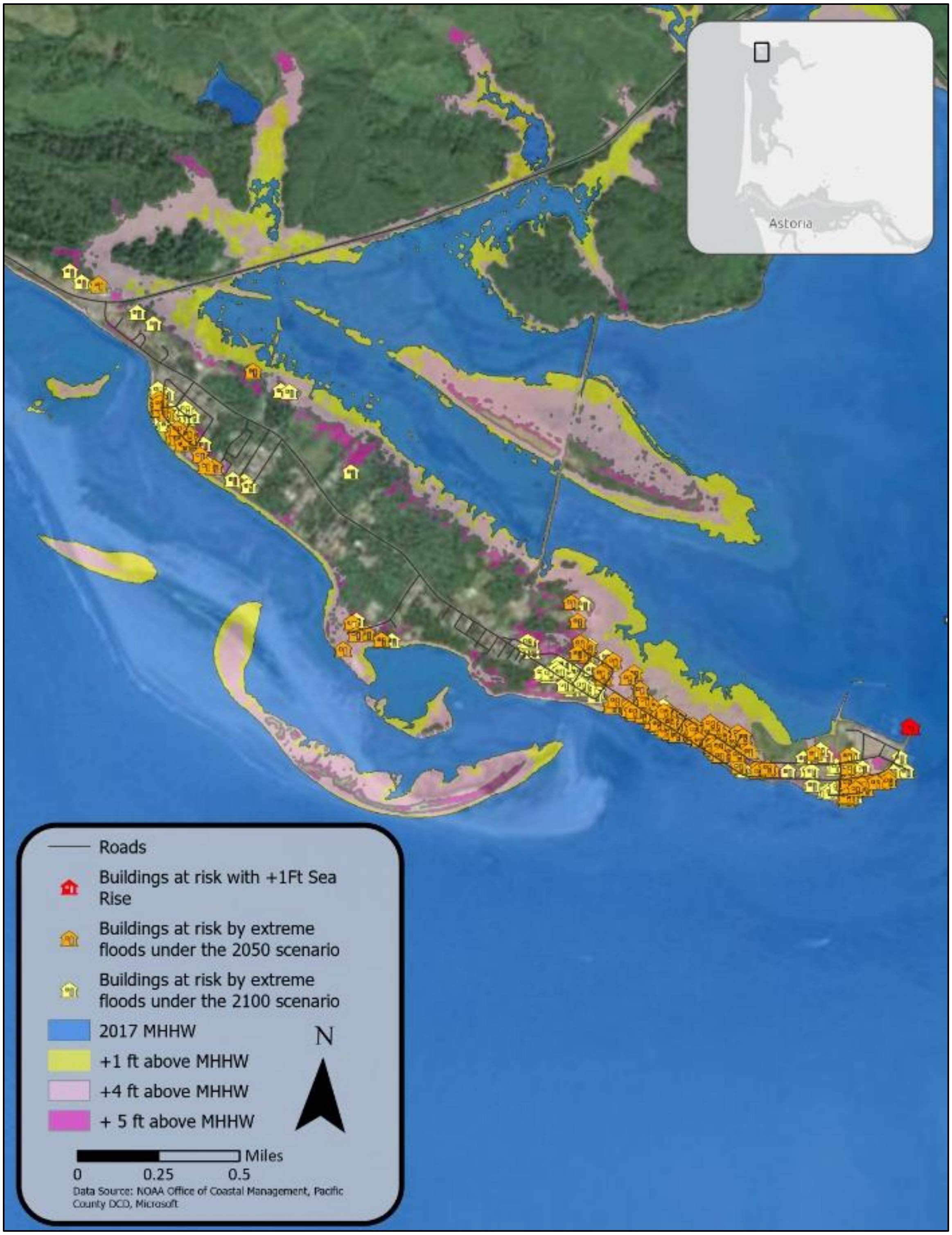

Figure 23. Buildings in Tokeland at risk of inundation under the 2050 and 2100 mapping scenarios.

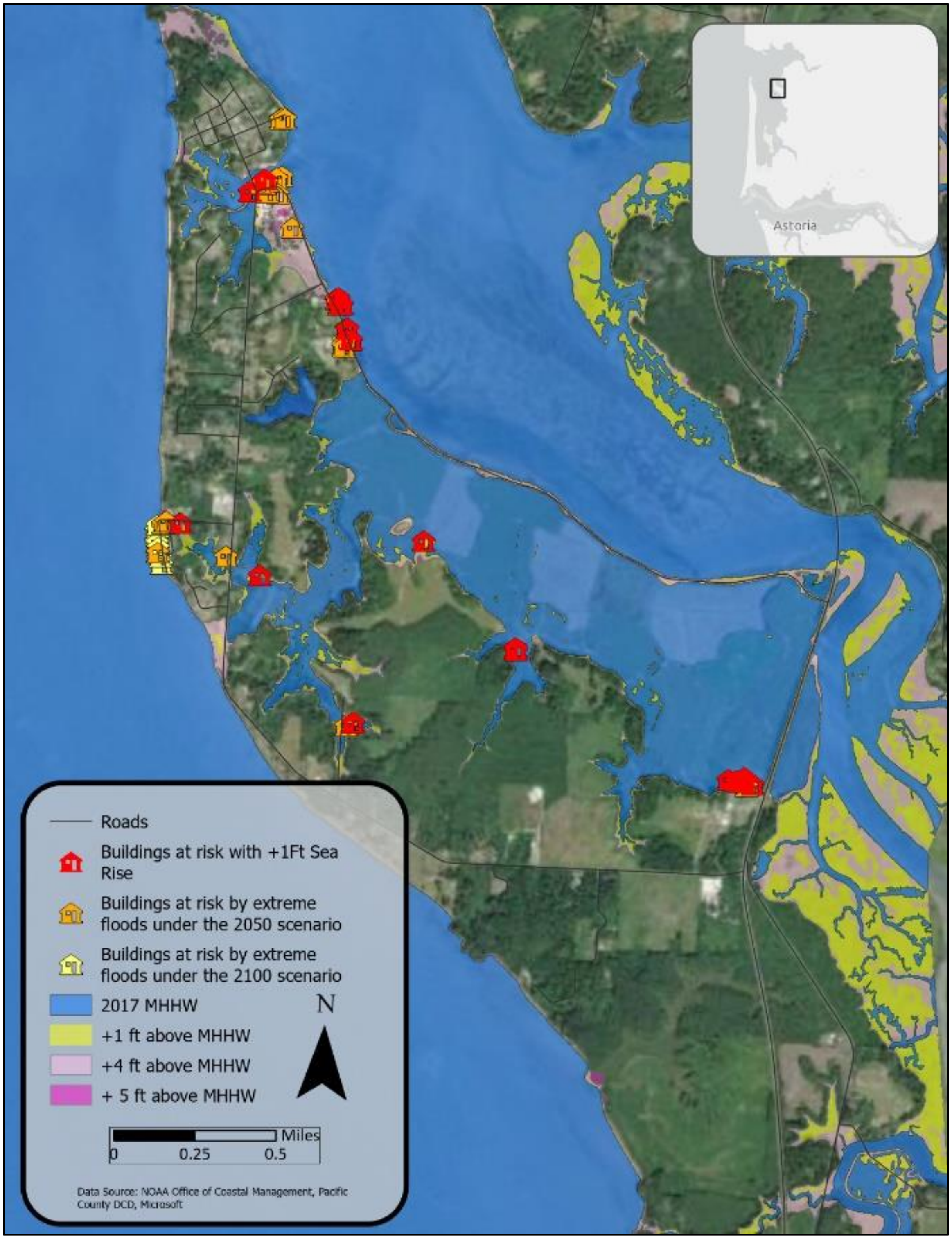

Figure 24. Buildings in Bay Center at risk of inundation under the 2050 and 2100 mapping scenarios.

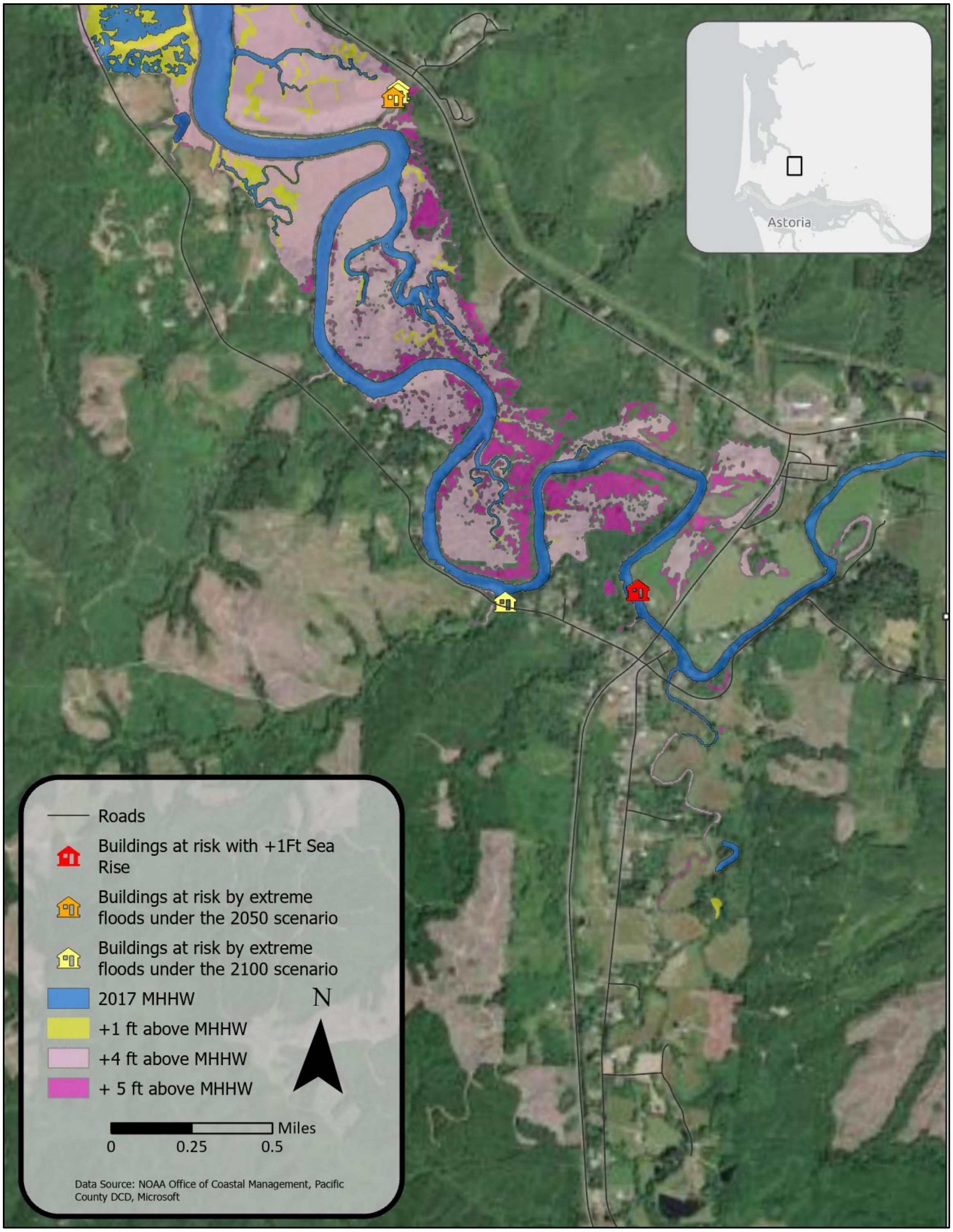

Figure 25. Buildings in Naselle at risk of inundation under the 2050 and 2100 mapping scenarios.

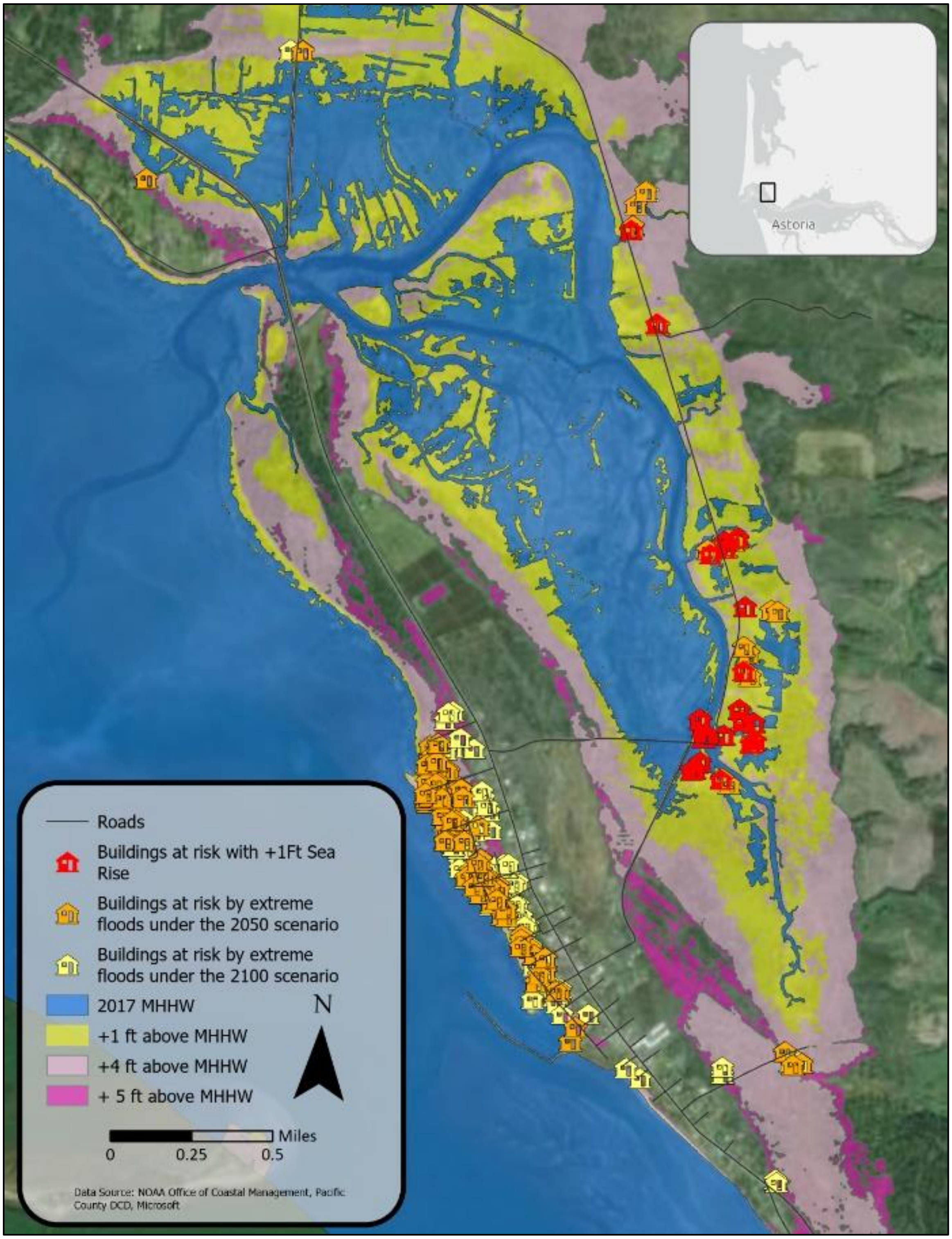

Figure 26. Buildings in the City of Chinook at risk of inundation under the 2050 and 2100 mapping scenarios.

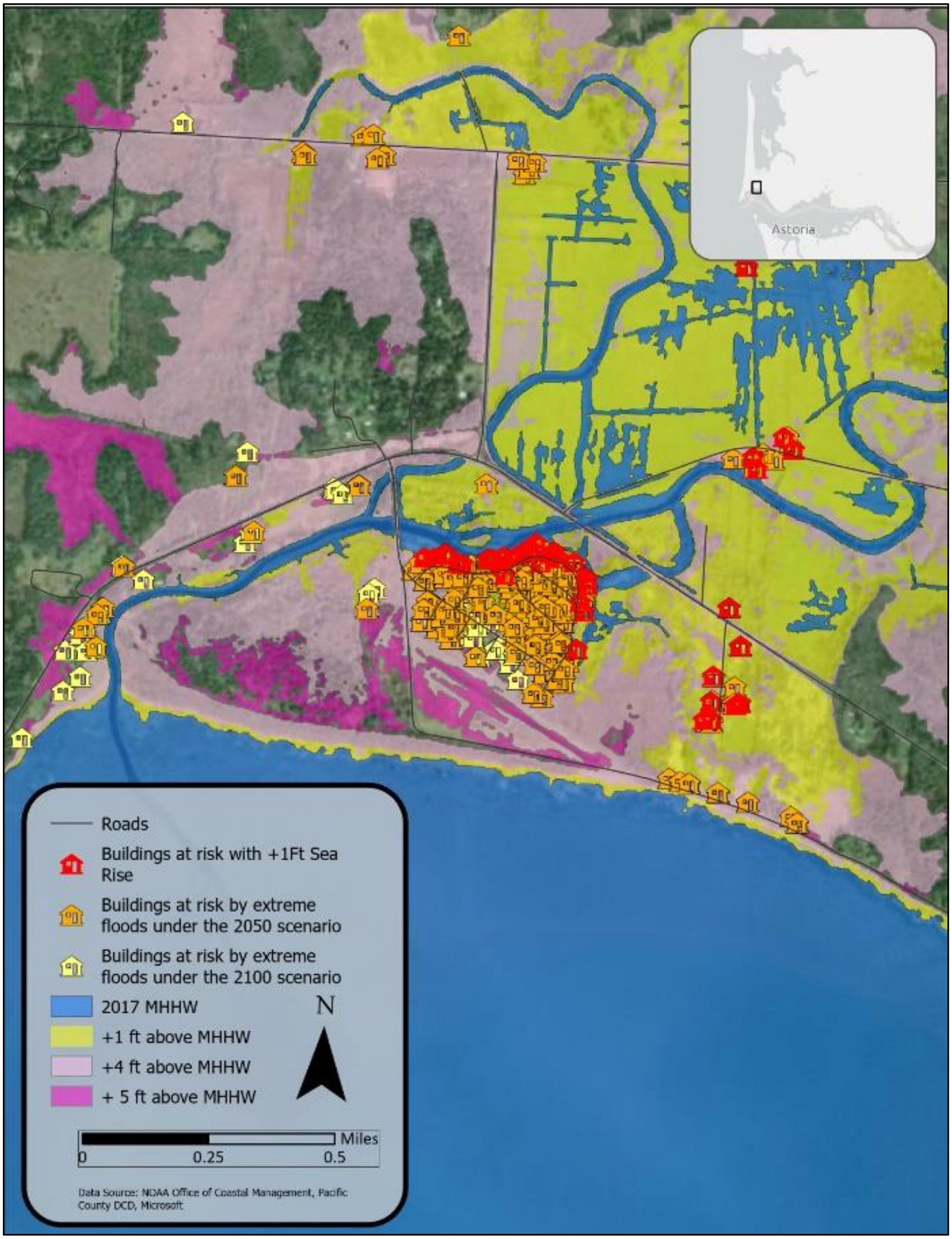

Figure 27. Buildings near the Port of Ilwaco at risk of inundation under the 2050 and 2100 mapping scenarios.

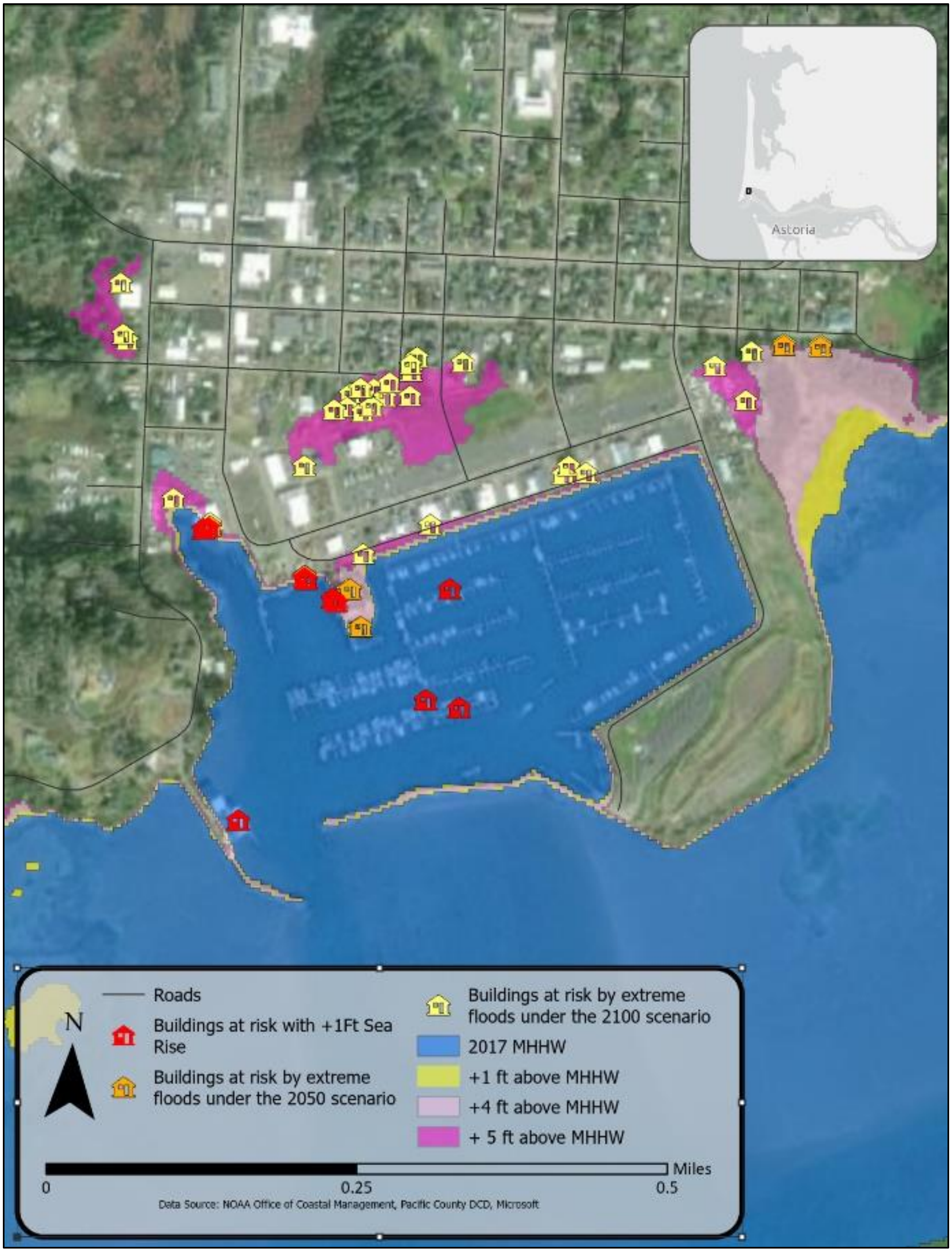

Figure 28. Buildings in the City of Ilwaco at risk of inundation under the 2050 and 2100 mapping scenarios.

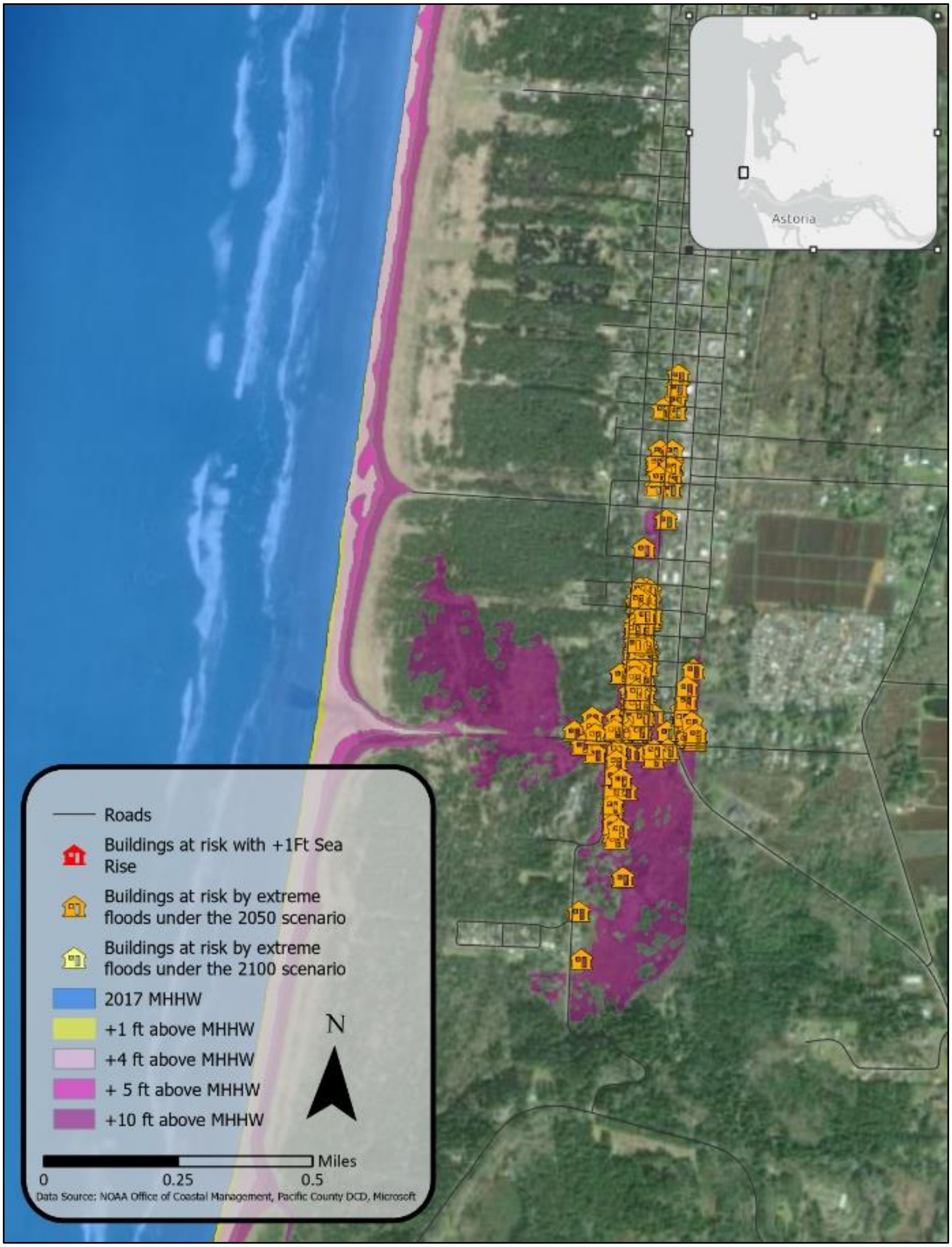

Figure 29. Buildings in Long Beach at risk of inundation under the 2050 and 2100 mapping scenarios