

REVISED MEMORANDUM

DATE: December 7, 2021; Revised January 18, 2022
TO: Gail Henrikson, Clatsop County
FROM: Ryan Farncomb, Nadine Appenbrink, Steffen Uhrich, and Jason Nolin
SUBJECT: Revised Technical Memo #5: Preferred Alternatives
CC: Michael Duncan, ODOT
PROJECT NAME: Clatsop County TEFIP

This memorandum documents the preferred evacuation facility improvements, derived from the alternatives developed in Technical Memo #4, *Analysis of Evacuation Routes and Trail Options* (TM4). The preferred improvements reflect input from the Project Advisory Committee (PAC), County staff, public feedback, and from the County Board of Commissioners. The preferred improvements are summarized in this memo and accompanying maps. Alternatives considered, but rejected, are also noted.

Cost estimates are “order of magnitude” estimates based on engineer’s judgement, improvement assumptions, and unit prices from recent bid tabs in Oregon. Cost estimating details are contained in Appendix A.

COMPANION MAP

An interactive map supplements this memorandum, and it provides more detail than the static maps (Figure 5, Figure 6, and Figure 7). The interactive Companion Map is available at:

<https://parametrix.maps.arcgis.com/apps/webappviewer/index.html?id=97a42dc9b5a34057962b6fca19be75eb>

TRAILS

A primary focus of the TEFIP is to establish tsunami evacuation routes along existing trails in Clatsop County. This section discusses trail alternatives and their characteristics: the trail type, recommended amenities, crossing improvements (if any), structure improvements (if any), and cost estimates. Trail alternatives and recommendations are listed at the end of this section in **Table 4**. Alternatives are mapped in Figure 5, Figure 6, and Figure 7, as well as in the [Companion Map](#).

Trail Types

Trails are classified into three types for the purposes of this TEFIP. This planning effort prioritizes more developed trails for evacuation routes because they are easier to travel and are accessible to more people. However, less developed trails are recommended in areas where a recreational hiking trail is appropriate or in areas that lack other evacuation options.

On Street Trail

A sidewalk or roadway can provide pedestrian travel in case of an evacuation. On street trails that are recommended for the TEFIP are all on the roadway surface, not on sidewalks. Because they are at grade on the roadway, they generally can comply with Americans with Disabilities Act (ADA) accessibility guidelines.

- **Shared roadway.** On quieter roads, an on-street trail can share the travel lane, as shown in **Figure 1**. This facility is appropriate for volumes of less than 2,000 average trips per day and speeds under 30 miles per hour. Shared roadways may encourage drivers to travel slower, though these roads are already low speed, low volume, and likely being used by pedestrians already.
- **Paved shoulder.** On roads with moderate to high volumes and speeds, the trail can follow a paved shoulder, as seen in **Figure 2**. A paved shoulder is appropriate for volumes of less than 12,000 average trips per day and speeds under 55 miles per hour. Paved shoulders will have minimal effect on the roadway through traffic.

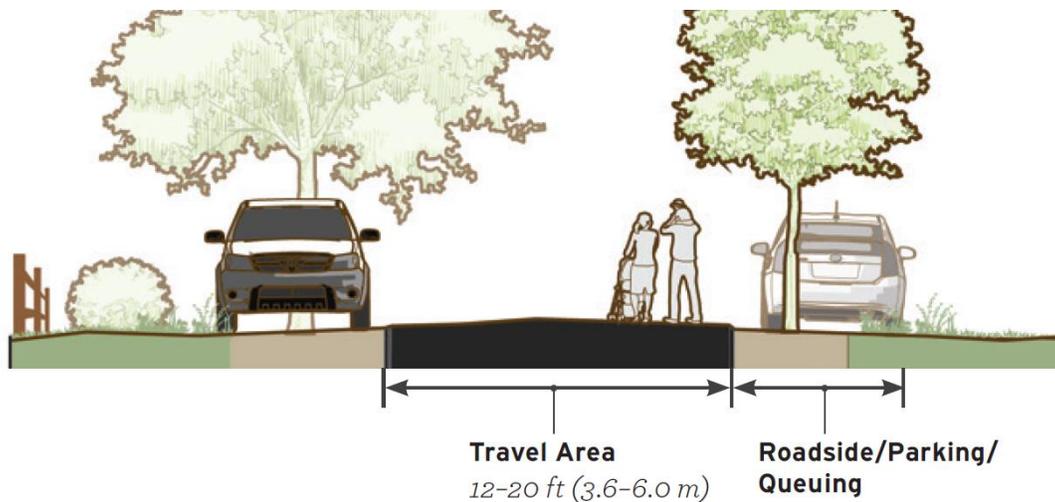


Figure 1. On Street Trail: Shared Roadway

Source: FHWA Small Town and Rural Multimodal Networks

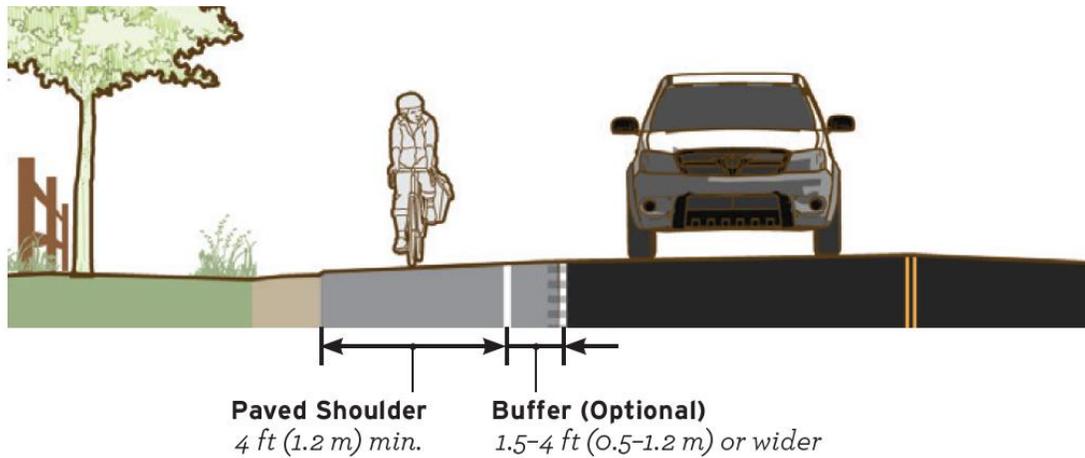


Figure 2. On Street Trail: Paved Shoulder

Source: FHWA Small Town and Rural Multimodal Networks

Multi-Use Path

Multi-use paths (MUPs) are off-street trails that are highly developed and paved, as shown in **Figure 3**. MUPs would be built to comply with ADA guidelines. MUPs are paved with concrete or asphalt, making them practical for biking, walking, and mobility devices, such as wheelchairs and canes. MUPs tend to be popular because they feel safe and comfortable for a wide range of people. MUPs are practical for evacuation – so long as the facility remains passable after the earthquake – because they are ADA accessible and their narrow cross section allows them to be built in areas where a road will not fit.

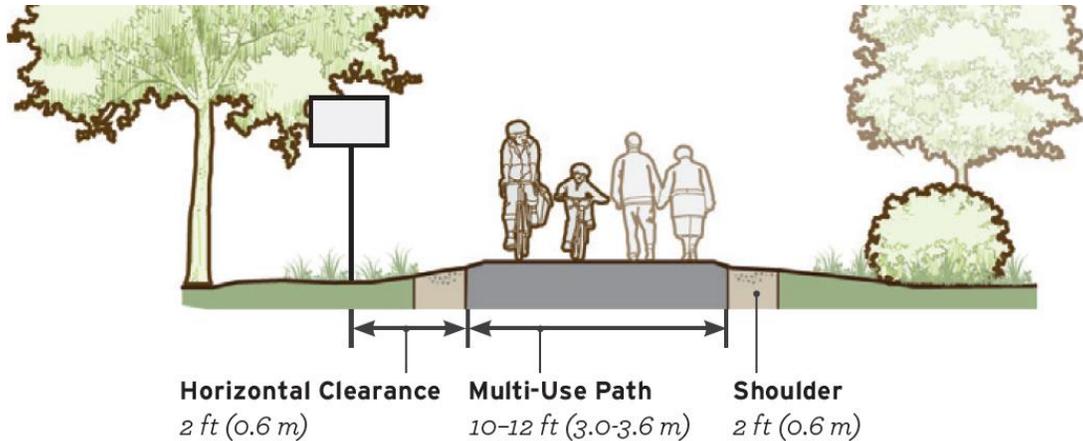


Figure 3. Multi-Use Path (MUP)

Source: FHWA Small Town and Rural Multimodal Networks

Recreational Trail

Recreational trails are less developed and unpaved, as shown in **Figure 4**. Recreational trails are not built to comply with ADA guidelines. Recreational trails tend to be steeper and more challenging to traverse.

Recreational trails have an unpaved surface of soil, grass, wood chips, or other material. They cost less to construct than a paved MUP and can more easily fit in a natural or undeveloped context. Recreational trails are enjoyable for hiking but may be more difficult to travel along than an MUP. These are appropriate for remote areas that are expected to serve small numbers of people during an evacuation.

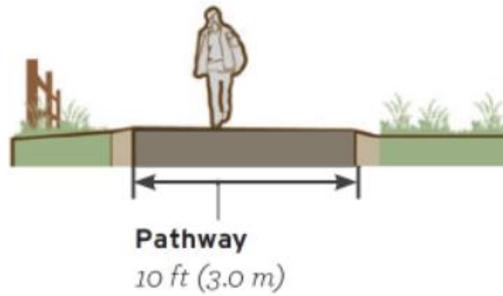


Figure 4. Recreational Trail

Source: Adapted from FHWA Small Town and Rural Multimodal Networks

Trail Amenities

Additional amenities can make trails more attractive and practical for everyday use and can also improve their usefulness as evacuation routes. Wayfinding signs, for example, can point toward high ground and can include information about earthquake and tsunami resilience.

Preferred trail amenities are listed in **Table 1** along with considerations relevant to implementation and tsunami evacuation. Amenities should be provided as appropriate for each trail; not all amenities are recommended for every trail. See **Table 4** for amenity recommendations for each of the preferred trail projects. Some existing trails may already have amenities.

Table 1. Trail Amenities and Considerations

Amenity	Benefits or Constraints	Example
Benches and seating	<p>Generally appropriate for heavily used trails.</p> <p>Provides opportunities for resting, especially helpful for people with mobility impairments.</p>	 <p>Seating options on the Seaside Promenade (source: Google Streetview)</p>
Fencing	<p>Useful for separating public right of way from private property.</p> <p>Can impact accessibility of the evacuation route from adjacent areas.</p>	 <p>Fence along the Fort to Sea Trail (source: Google Streetview)</p>

Amenity	Benefits or Constraints	Example
Wayfinding and information signs	<p>Helpful for indicating evacuation route and direction and assembly areas or high ground.</p> <p>Can increase tsunami awareness.</p> <p>Can also include recreational wayfinding and information about the trail system.</p> <p>Signs need to be inventoried on a regular basis to ensure they are still in place and legible.</p>	
Shelters or pavilions	<p>Shelters can be practical amenities to protect trail users from rain or sun.</p> <p>Shelters outside of the inundation zone may also be used for assembly areas.</p> <p>Shelters within the assembly areas should include clear signage indicating the evacuation route.</p>	
Lighting	<p>Useful for trailheads and trails used at night.</p> <p>Solar-powered lighting can be more seismically resilient than hard-wired, and it avoids the risk of fallen power lines in a seismic event.</p> <p>Balance lighting provision with wildlife and light pollution impacts and employ “dark sky” strategies.</p>	

Tsunami info sign on the Astoria Riverwalk (source: project team)

Astoria Riverwalk Trolley Stop (Astoria Recreational Trail Master Plan 2013)

Pedestrian-scale lighting along the Seaside Promenade (source: Google Streetview)

Amenity	Benefits or Constraints	Example
Bicycle racks and fix-it stations	<p>Appropriate for trails with expected frequent use by people biking.</p> <p>Consider overlap with or proximity to the Oregon Coast Bike Route.</p>	
Motor vehicle parking	<p>Requires space.</p> <p>May be used as an assembly area if out of the inundation zone.</p>	
Restrooms and water fountains	<p>Toilets and water are practical for popular trails, trailheads and assembly areas.</p> <p>Providing toilets can help protect sensitive ecosystems.</p> <p>Plumbing is vulnerable to a seismic event.</p> <p>More substantial ongoing maintenance needs and costs.</p>	

Bike parking, fix it station, and solar charging at Hagg Lake (source: Washington County Parks)

Trailhead parking lot for Tillamook Head, Seaside (source: Google Streetview)

Vault toilets at the Fort to Sea Trail trailhead (source: Google Streetview)

Amenity	Benefits or Constraints	Example
Viewpoints	<p>Unique viewpoints can draw people to a trail, which can increase awareness of it as a potential evacuation option.</p> <p>Viewpoints can also be used to survey the area below after a seismic event.</p>	 <p data-bbox="1047 562 1523 653"><i>View from the Neah-Kah-Nie Mountain Trail, Oswald West State Park (source: Google Streetview)</i></p>

Crossing Improvements

Crossing improvements were considered for trails that cross US 101 or other roads with high traffic speeds or volumes. Because roads are not expected to be drivable after an earthquake, these crossing improvements are primarily intended to serve recreational, non-emergency uses. Proposed crossing improvements depend on the type of road, the type of trail, and the broader context.

Only two proposed trail improvements cross roads with high traffic speeds or volumes:

- [Alternative T-02](#) crosses US 101 at Oceanview Lane. The alternative proposes a new pedestrian overcrossing because of the steep embankments on both sides of the highway.
- [Alternative T-03](#) improves a trail with an existing pedestrian undercrossing of US 101. This undercrossing allows for people to cross the highway without interacting with traffic. However, it requires people to walk from street level down to below grade, then back up to street level again. This out of direction travel is impractical during an evacuation, especially when few people are expected to be driving on US 101. Improvements are recommended to ensure the undercrossing is seismically resilient so that US 101 above will stay passible. Additionally, signs are recommended to indicate that the most effective evacuation route is to cross US 101 at grade instead of using the undercrossing (for evacuation purposes only).

These crossing improvements can be viewed on Figure 7.

Structures

Some of the proposed trail projects include improvements to structures, such as bridges, boardwalks, and retaining walls. Projects with a possibility of needing structure improvements are described here by structure type. Structure improvements are also listed in **Table 4**. This assessment is preliminary. More investigation and engineering is required as projects are developed after the completion of this TEFIP.

Bridges, Overcrossings, and Undercrossings

- T-02: A new elevated pedestrian overcrossing of US 101 is included as part of the MUP trail project to allow people to cross the highway more easily.

- T-03: The existing pedestrian undercrossing of US 101 is likely to require seismic upgrades.
- T-06: Would need a new bridge over the creek.
- T-08: Adds a new pedestrian bridge over Skipanon River parallel to the existing roadway bridge. A new pedestrian bridge would be more cost effective than seismically retrofitting the existing bridge.
- T-10: Would need a new bridge over Skipanon River.
- T-15 meets T-16 at an undercrossing of Burma Road in Fort Stevens State Park. The undercrossing is an easier route to high ground than climbing up the steep road embankment and back down to trail level again. T-16 includes estimated costs for seismic upgrades for the undercrossing.

Retaining Walls

- T-01: Steep terrain could require switchbacks and retaining walls.

Boardwalks

- T-06: Proposed trail appears to traverse wetlands. An elevated boardwalk is included to reduce potential wetland impacts from a new trail.

Trail Cost Estimates

Costs reported in this memo are conceptual, planning-level estimates and rounded up to the nearest 50,000 dollars. See **Appendix A** for cost estimating details. Cost estimates are to construct the trail, crossing treatments, anticipated structures, required fencing, and signage. Amenities are not included. However, smaller amenities such as signs and wayfinding are unlikely to substantially effect cost estimates at this conceptual level.

Estimates use unit costs from 2021. They include construction costs based on quantities derived from aerial imagery and unit costs from recent, similar projects. Surveying, mobilization, erosion control, and traffic control services are estimated as an additional percentage of unit costs. A 40 percent contingency was applied to account for unknowns at this high level of conceptual analysis. Engineering and design fees are included as an additional 20 percent of the project subtotal. Projects with a high likelihood of needing environmental permitting have additional costs to cover the permitting.

Costs do not include:

- Recommended amenities or features.
- Escalation or inflation for a future project year. Alternatives do not yet have a build date.

Cost Estimates for Each Trail Type

Each type of trail would be constructed differently and would therefore include different line items. Here are the assumptions and items that were used for each trail type.

On Street Trails

Cost estimates for on street trails assume one of three options:

- Marking an existing paved roadway with signs and pavement markings to indicate that it is a shared roadway and an evacuation route.
- Paving an unpaved roadway with a 20-foot-wide asphalt surface. This cost includes clearing and grubbing, excavation, subgrade stabilization, aggregate base, and asphalt pavement that is 4 inches thick.

- Extending the roadway on one side by paving an additional 8-foot-wide shoulder. This cost includes clearing and grubbing, excavation, subgrade stabilization, aggregate base, and asphalt pavement that is 4 inches thick.

Cost Estimates for MUPs

Cost estimates for MUPs assume paving a 12-foot-wide trail. The cost includes clearing and grubbing, excavation, subgrade stabilization, aggregate base, and asphalt pavement that is 4 inches thick.

Cost Estimates for Recreational Trails

Cost estimates for recreational trails assume a 10-foot-wide gravel path. The cost includes clearing and grubbing, excavation, subgrade stabilization, and aggregate base (gravel).

Trail Evaluation Criteria

The trails projects identified in Technical Memo 4: Evacuation Routes and Trail Options have been evaluated and prioritized based on the criteria defined in Technical Memo 2: Evaluation Criteria. Screening criteria in the table below were used to screen out those potential projects that do not meet enough needs; weighting indicates how some criteria were emphasized in determining which projects were recommended.

Table 2 Screening Criteria for Trails and Evacuation Routes

Subject	Criteria	Measure	Weighting
User experience	Provides the most comfortable and enjoyable user experience	Degree of separation from auto traffic and/or recreational value	
Safety and security	Provides a clear tsunami evacuation benefit	Follows existing evacuation route or facilitates new/enhanced evacuation connection; and/or project increases access to existing assembly areas	3x
Multimodal connectivity	Increases connectivity of the multimodal network	Increases network connectivity	
Planning, land use, and regulatory impacts	Aligns with the existing County land use plans	Project is compatible with the Comprehensive Plan and TSP	
Property ownership impacts	Minimizes impacts to private property owners	Project would rely on existing ROW and/or require minimal or no new ROW or easements	
Directness of travel	Supports directness of evacuation routes	Supports directness of evacuation routes or increases connectivity of the evacuation network so as to reduce evacuation clearance times	

Subject	Criteria	Measure	Weighting
Cost and funding availability	Relative cost and likelihood of funding with grants	Project is low-cost relative to benefit provided and/or has a high likelihood of being funded through grants	
Infrastructure hardening	Increases the resiliency of the existing infrastructure system	Project would increase infrastructure resiliency, including hardening of other transportation system features	
Phasing opportunities	Project may be phased to facilitate incremental benefit	Project could be phased to implement useable segment/elements incrementally (or not)	
Accessibility	Facilitates connections for people with physical disabilities	Project is ADA accessible (or not)	2x
Populations served	Enhances evacuation routes or connections for unincorporated communities	Project would provide an evacuation/recreation benefit to a relatively large number of people, and/or to vulnerable populations ¹	2x

Notes:

¹ “Vulnerable populations” includes Environmental Justice and Title VI communities, including those that are racial or ethnic minorities, have disabilities, are younger (<18) or older (>65) adults, do not have access to a car, are low income, or have limited English proficiency

Once trails and amenities were screened, these potential investments were prioritized based on the following criteria in the table below. These criteria are based on the TEFIP goals and objectives.

Table 3 Prioritization Criteria

Subject	Criteria
Timeframe for implementation	Relative implementation timeframe, based on ability to fund, design, permit, and implement the project: <ul style="list-style-type: none"> • Near-term (0-5 years) • Medium-term (5-10 years) • Long-term (10+ years)
Feasibility	Relative feasibility, based on assessment of: <ul style="list-style-type: none"> • Public support • Cost • Need for ROW or easements • Environmental/permitting considerations • Engineering complexity • Ability to phase the project

Subject	Criteria
Relative need	Addresses a documented evacuation and/or multimodal connectivity need, based on assessment of gaps in the existing evacuation and multimodal route network and on public/stakeholder feedback
Relative benefit to communities	<p>Provides a high level of benefit, based on assessment of:</p> <ul style="list-style-type: none"> • Degree of need • Evacuation and multimodal connectivity benefit relative to cost • Degree to which vulnerable populations would benefit • Public and stakeholder feedback
Potential for grant funding	Project has a high likelihood of being funded through one or more grant programs

Table 4. Proposed Trail Alternatives

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-01 On street (shared roadway)	Arch Cape	Continue evacuation route outside of inundation zone from E. Shingle Mill Lane, north on Fire Rock Road, and east to high ground. Pave 20-foot wide roadway to improve seismic resilience.	Wayfinding	This is an existing evacuation route to serve the southern area of Arch Cape, but the route does not go far enough to escape the Cascadia “XXL” inundation zone. Trail could connect with a future trail system in nearby forest land that is in the process of being acquired by the Arch Cape Water District.	Recommended. Criteria: Addresses evacuation need; directness of travel. Justification: T-01 extends an existing evacuation route out of the XXL inundation zone. It is located at the south end of Arch Cape, which is vulnerable to a tsunami and has a community of residents and has lodging for visitors. The route is relatively short and is along existing roads.	\$250,000
T-02 MUP	Arch Cape	Create a trail along Oceanview Lane right of way that leads to high ground.	Wayfinding	The County already has the right of way here, but it has not been built out and it is not maintained. The County owns four parcels at the end of Oceanview Lane that are outside the inundation zone. Trail could connect with a future trail system in nearby forest land that is in the process of being acquired by the Arch Cape Water District.	Recommended. Criteria: Addresses evacuation need; directness of travel. Justification: T-02 creates an evacuation route along existing County right of way. It is located toward the south end of Arch Cape, which is vulnerable to a tsunami and has a community of residents and has lodging for visitors.	\$400,000

ID & Trail Type	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-03 On street (shared roadway)	Arch Cape	Create a trail at the south end of Carnahan Road that continues east past US 101 along Buena Vista Drive to high ground. Improves the existing pedestrian underpass. Roadway is already paved, no additional paving included.	n/a	Evaluate condition of existing US 101 pedestrian underpass at Carnahan Road. Trail could connect with a future trail system in nearby forest land that is in the process of being acquired by the Arch Cape Water District. Should be coordinated with community along Buena Vista Drive. This is a private, gated road.	Not recommended. Criteria: Addresses evacuation need. Low feasibility because the road is privately owned. Justification: T-03 creates an evacuation route along existing roads, but these roads are privately owned. The evacuation route would cross US 101 at grade and not through the pedestrian underpass, which may not be passable following an earthquake. It is located toward the north end of Arch Cape, which is vulnerable to a tsunami and has a community of residents and has lodging for visitors. Existing roads are paved and would only require signage/wayfinding.	\$200,000
T-04 MUP	Arch Cape	Create a trail at the north end of Carnahan Road that continues north to high ground.	Wayfinding Fencing to delineate trail right of way from private property	Consider wooden steps for steep slope. Potential need for public easement. Requires coordination with owner of one parcel of private property.	Recommended. Criteria: Addresses evacuation need; low cost increases feasibility; possible need for public easement. Justification: T-04 creates an evacuation route with a new MUP extending to high ground. It is located at the north end of Arch Cape, which is vulnerable to a tsunami and has a community of residents and has lodging for visitors.	\$100,000

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-05 MUP	South of Cannon Beach	Area has platted properties but is not yet developed. Consider placing trail(s) as conditions of development.	n/a	<p>This land is owned by ODOT and is zoned Agriculture Forestry (AF). It will likely not be developed as single-family homes.</p> <p>T-05 identified potential future need for evacuation routes if properties are developed. Evacuation routes to serve the new structures would be built as condition of development.</p>	<p>Not recommended.</p> <p>Justification: Reconsider if the area becomes more likely for housing development.</p>	\$100,000

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-06 Recreation	North of Gearhart	Create a trail to connect Shady Pine Road across Neacoxie Creek to higher ground to the west.	Wayfinding Fencing to delineate trail right-of-way from private property	<p>Potential need for easement. Requires coordination with owners of four parcels of private property.</p> <p>If easement for a trail cannot be obtained, consider vertical evacuation structure(s) for people west of Sunset Lake. Locations would need to be determined through analysis and with community input.</p> <p>Requires bridge over Neacoxie Creek, which is a Goal 5 wetland.</p> <p>Will require an elevated boardwalk to reduce impacts to wetland (300 foot boardwalk included in cost estimate).</p> <p>Likely to require environmental permitting. Will require environmental review; this area might be endangered species habitat (silverspot butterfly).</p>	<p>Recommended.</p> <p>Criteria: Addresses evacuation need; feasibility may be difficult because this route involves coordination with multiple property owner and potential environmental permitting.</p> <p>Justification: T-06 provides an evacuation route for residents in the west portion of the Surf Pines community. This area is currently constrained by Sunset Lake and private property ownership. T-06 would provide a more direct path for this community to reach high ground.</p> <p>Challenges: It would require coordination with owners of four properties, an environmental review, and structures to bridge the creek and wetlands. Even so, this trail connection would likely be more practical and more cost effective than building a vertical evacuation structure.</p>	\$1,250,000

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-07 Recreation	North of Gearhart	New trail to high ground from Cullaby Lake County Park parking areas and recreation areas.	Wayfinding Benches Shade structure Associated with potential assembly area A-10	Requires a new trail in wooded hill near the beaches and parking areas. Hill may have steep slopes in some areas.	Recommended. Criteria: Addresses evacuation need; provides multimodal connectivity; high feasibility. Justification: T-07 provides an evacuation route for visitors to Cullaby Lake County Park and creates a new recreational trail for visitors to enjoy.	\$250,000
T-08 Recreation	North of Gearhart	New trail to high ground from Cullaby Lake Lane. Adds a pedestrian bridge over Skipanon River parallel to the existing roadway bridge.	Wayfinding Associated with proposed assembly area A-11	Current evacuation route ends within inundation zone. Short trail segment needed to reach high ground. Hillside appears steep. Trail likely to need switchbacks. Retaining walls are not included in the cost estimate. Trail could be a feature of Carnahan County Park, which is owned by Clatsop County.	Recommended. Criteria: Addresses evacuation need; provides benefit to residents and park visitors; high feasibility because land is publicly owned. Justification: T-08 extends an existing evacuation route out of the XXL inundation zone into Carnahan County Park.	\$300,000

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-09 Recreation	South of Camp Rilea	Connect Fort to the Sea Trail to high ground with a trail spur at ridge.	Fencing to delineate trail right of way from private property	Existing trail stays in the inundation zone, while passing high ground. Short trail segment needed to reach high ground. Potential need for easement acquisition. The land above the inundation zone is privately owned.	Not recommended. Justification: Fort to the Sea trail is located very near to higher ground; formal trail spur is not needed. Consider wayfinding signage. Challenges: As an evacuation route, the Fort to Sea Trail is long and indirect (roughly 1 mile to high ground for the nearest community). It will require coordination with private property owners.	\$100,000
T-10 MUP	Southeast of Camp Rilea	Connect the neighborhood at Glenwood Village to high ground with trail to the east.	Benches or seating for recreational use Fencing to delineate trail right of way from private property	Requires a bridge over the Skipanon River. Potential need for easement acquisition. Likely to require environmental permitting.	Recommended. Criteria: Addresses evacuation need; direct route to higher ground; need for bridge and environmental permitting makes the project more challenging. Justification: T-10 connects the neighborhood at Glenwood Village to high ground.	\$450,000

ID & Trail Type	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-11 On street (shared roadway)	Camp Rilea	Improve Pacific Road to serve as an evacuation route.	Wayfinding Associated with proposed assembly area A-14	Needs to be coordinated with Camp Rilea.	<p>Recommended.</p> <p>Criteria: Safety and security for people in the area; uses existing roadway; high benefit for low cost of signage.</p> <p>Justification: T-11 would provide an evacuation route for visitors at Camp Rilea. At some areas of the camp, the shortest/easiest route to high ground is to the west, which is not intuitive and this trail would help clarify. Existing road is paved and would only require signage/wayfinding.</p>	<\$50,000
T-12 On street (shared roadway)	Camp Rilea	Improve Demo Road to serve as an evacuation route. Paves a 20-foot-wide roadway surface.	Wayfinding Associated with proposed assembly area A-15	Needs to be coordinated with Camp Rilea.	<p>Recommended.</p> <p>Criteria: Safety and security for people in the area; uses existing roadway; high benefit for low cost of signage.</p> <p>Justification: T-12 would provide an evacuation route for visitors at Camp Rilea. At some areas of the camp, the shortest/easiest route to high ground is to the west, which is not intuitive and this trail would help clarify. Existing road is gravel and would require paving.</p>	\$700,000

ID & Trail Type (See Map)	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-13 MUP	Camp Rilea	Connect the residential area along Douglas Lane to high ground at Camp Rilea with a short trail to 2nd Causeway Road.	Wayfinding	Potential need for public easement. Needs to be coordinated with private property owners and Camp Rilea.	Not recommended. Justification: Trail segment connects to assembly area; Douglas Lane leads to higher ground, so trail is not needed for evacuation.	\$100,000
T-14 On street (paved shoulder)	South of Warrenton	Delaura Beach Lane is an important connection from the beach to higher ground. Improve to be an effective evacuation route. Pave an 8-foot-wide shoulder.	Wayfinding	Consider how a seismic event may affect the road. Water is on both sides. Likely to require environmental permitting. North side of Delaura Beach Lane is in the City of Warrenton.	Not recommended. Criteria: Predominantly located within City of Warrenton; should be coordinated with the City. Justification: T-14 would improve Delaura Beach Lane, which provides an evacuation route for nearby residents. There are few alternative routes near here because the road has water on both sides: Cemetery Lake to the north and Smith Lake to the south.	\$350,000
T-15 MUP	Fort Stevens	Improve existing trail to serve as evacuation route for people in park or at beach.	Wayfinding	Trail is oriented east-west and provides fairly direct route to high ground.	Recommended. Criteria: Addresses evacuation need; multimodal connection; potential to serve many recreational users. Justification: T-15 would provide an evacuation route for visitors at Fort Stevens State Park and would improve the existing trail for everyday use.	\$450,000

ID & Trail Type	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation & Justification	Cost Estimate
T-16 MUP	Fort Stevens	New connection from existing trail to high ground.	Wayfinding	May be steep terrain.	<p>Recommended.</p> <p>Criteria: Addresses evacuation need; multimodal connection; potential to serve many recreational users.</p> <p>Justification: T-16 would provide an evacuation route for visitors at Fort Stevens State Park and would improve the existing trail for everyday use. Includes seismic upgrades to the Burma Road undercrossing.</p>	\$400,000
T-17 MUP	Fort Stevens	New connection from existing Jetty Road parking area to high ground.	Wayfinding	May be steep terrain.	<p>Recommended.</p> <p>Criteria: Addresses evacuation need; multimodal connection; potential to serve many recreational users from the Jetty Road parking area.</p> <p>Justification: T-17 would provide an evacuation route for visitors at Fort Stevens State Park and would improve the existing trail for everyday use.</p>	\$100,000

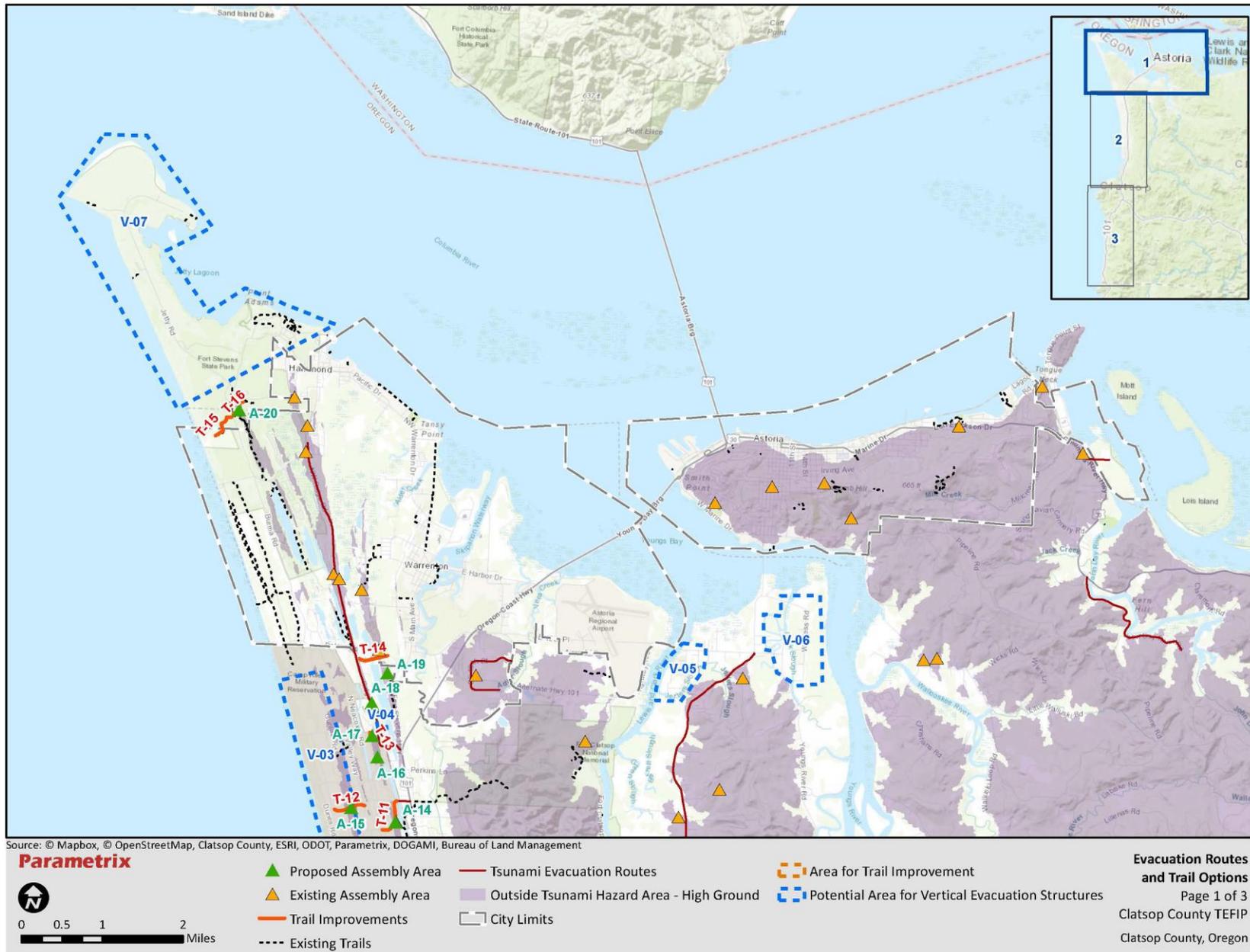


Figure 5. Evacuation Routes and Trail Options - North Area

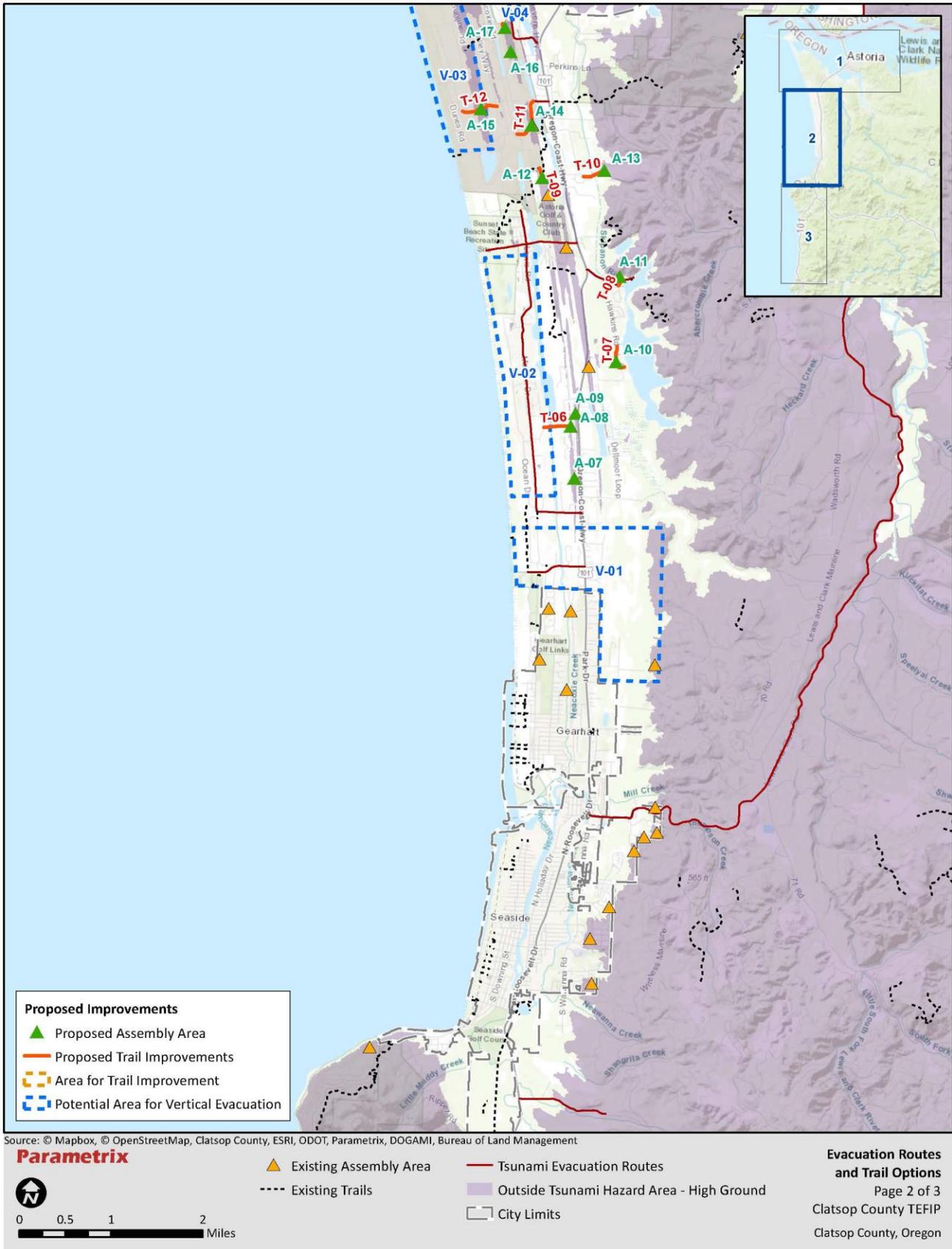


Figure 6. Evacuation Routes and Trail Options - Central Area

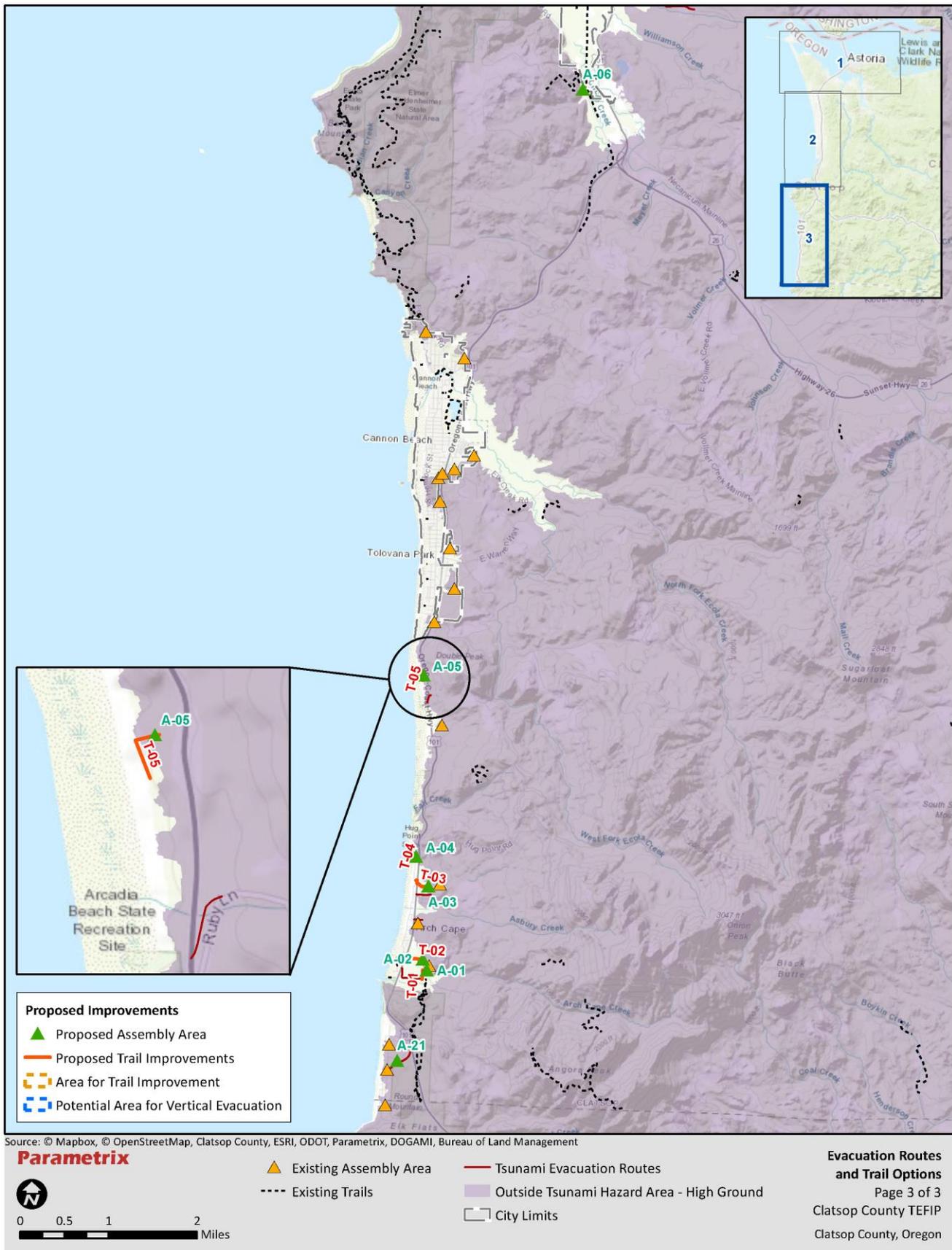


Figure 7. Evacuation Routes and Trail Options - South Area

ASSEMBLY AREAS

Assembly areas provide space on high ground outside the inundation zone for people to gather temporarily during a tsunami. At minimum, they provide a clear and safe place for people to come together until the high water recedes. At a minimum, this requires a plot of land outside the evacuation zone, effective wayfinding signs to get people there, and regular maintenance to keep it in good condition.

It is worth noting that it is not necessary for people to evacuate to assembly areas specifically. It is most important that people get to high ground, which does not need to be an assembly area. But assembly areas help by indicating to people that they are in a safe place on high ground and by bringing people together for collective support.

Assembly Area Locations

Assembly areas should be located such that everyone in the inundation zone can reach an area within the time between an earthquake and subsequent tsunami. This TEFIP assumes a maximum evacuation travel distance of one-half mile, which means the maximum distance between assembly areas is 1 mile. For a more thorough discussion of travel times, travel distances, and other siting considerations, see Technical Memo #4: *Analysis of Evacuation Routes and Trail Options*.

Assembly Area Size

Assembly areas need to be sized appropriately for the number of people they are likely to serve. Each assembly area should be analyzed to understand the number of residents and potential workers, students, and visitors who may use it. The assembly area—and amenities—need to be scaled to accommodate this total number of potential evacuees.

Assembly Area Investment Packages

The appropriate amount of investment in each assembly area depends on its evacuation shed and how accessible it is for emergency responders. Locations expected to serve a large number of residents or visitors will require more space and amenities than locations expected to serve a small number. Assembly areas in more remote or isolated locations would benefit from more amenities because it will take more time for emergency responders to reach them. Assembly areas that would be disconnected from resources during a tsunami could have amenities to keep people safe and comfortable, and to treat injuries incurred during the evacuation.

Assembly areas that are in neighborhoods or are connected by roads that lead to high ground outside the inundation zone would require less investment. Evacuees at assembly areas in neighborhoods on high ground would have access to resources from their neighbors. Assembly areas that are connected to other areas outside the inundation zone would be relatively easy to reach (assuming the area is still passable following the earthquake), and evacuees there could safely travel beyond their assembly area. Assembly areas that are connected to other areas require fewer amenities.

To ensure the correct level of investment for each assembly area, three investment packages are defined (**Table 5**). One package is proposed for each assembly area.

Table 5. Assembly Area Investment Packages

Minimum Investment Package	Medium Investment Package	High Investment Package
<p><i>The minimum investment package is the lowest cost and is just enough infrastructure to establish and declare the assembly area.</i></p>	<p><i>The medium investment package includes amenities to make people more comfortable without requiring much maintenance or management of the assembly area.</i></p>	<p><i>The high investment package is the highest cost and includes amenities to keep people safe and comfortable for some time after the tsunami. The high investment package requires the most ongoing maintenance and management.</i></p>
<p><i>Supplies could be provided by the county or other organization. Supplies could also be brought by residents and stored on site in a locked facility.</i></p>		<p><i>Supplies could be provided by the county or other organization. Supplies could also be brought by residents and stored on site in a locked facility.</i></p>
<ul style="list-style-type: none"> • Signs indicate that people are above the inundation zone and that they have reached the assembly area (with language such as “this is an official assembly area”). • Assembly area is the appropriate size for the expected evacuation shed. • Assembly area is maintained to be accessible and clear for evacuees. 	<ul style="list-style-type: none"> • Signs indicate that people are above the inundation zone and that they have reached the assembly area (with language such as “this is an official assembly area”). • Assembly area is the appropriate size for the expected evacuation shed. • Assembly area is maintained to be accessible and clear for evacuees. • Shelter. • Furniture, such as benches and seats. • Solar lighting. 	<ul style="list-style-type: none"> • Signs indicate that people are above the inundation zone and that they have reached the assembly area (with language such as “this is an official assembly area”). • Assembly area is the appropriate size for the expected evacuation shed. • Assembly area is maintained to be accessible and clear for evacuees. • Shelter. • Furniture, such as benches and seats. • Solar lighting. • Communication devices (radio transmitters or walkie talkies). • First aid supplies. • Blankets. • Drinking water. • Food.

Assembly Area Alternatives

Proposed assembly area alternatives are listed in **Table 6** and shown in **Figure 5**, **Figure 6**, and **Figure 7**, as well as in the [Companion Map](#).

Table 6. Proposed Assembly Area Alternatives

ID Map	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-01	Arch Cape	Establish a formal assembly area at the end of the trail from Option T-01.	High Arch Cape could be quite isolated following an earthquake. This location can take advantage of the fire station nearby by stocking water, food, supplies, and other amenities to serve the surrounding neighborhood.	Area is available on undeveloped right of way.	Recommended. Provides a place for nearby residents and visitors to evacuate to. Establishes a safe ending location for the existing evacuation route. This area could become quite isolated following an earthquake.

ID	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-02	Arch Cape	Establish a formal assembly area at the end of the trail from Option T-02.	Medium Shelters, benches, and lighting	Area is available on undeveloped right of way.	Recommended. Provides a place for nearby residents and visitors to evacuate to.

ID	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-03	Arch Cape	Establish a formal assembly area at the end of the evacuation route on Buena Vista Drive from Option T-03.	Minimum	<p>An assembly area would indicate that evacuees have made it to a safe place.</p> <p>Area appears to be privately owned but undeveloped.</p> <p>Should be coordinated with community along Buena Vista Drive.</p>	<p>Recommended.</p> <p>Provides a place for nearby residents and visitors to evacuate to.</p>
A-04	Arch Cape	Establish a formal assembly area at the end of the trail from Option T-04.	Minimum	<p>An assembly area would indicate that evacuees have made it to a safe place.</p> <p>Area appears to be privately owned but undeveloped.</p>	<p>Recommended.</p> <p>Provides a place for nearby residents and visitors to evacuate to.</p>
A-05	South of Cannon Beach	Area has platted properties but is not yet developed. Consider placing assembly area(s) as conditions of development, if the area develops in the future.	n/a	<p>Future assembly areas can be created with future development.</p> <p>Parcel owned by ODOT.</p>	<p>Not recommended.</p> <p>Reconsider if this area becomes more likely to develop.</p>

ID	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-06	South of Seaside	Establish a formal assembly area near Rippet Lane.	n/a	<p>Neighborhood adjacent to high ground, may be steep terrain.</p> <p>Area appears to be public right of way.</p>	<p>Not recommended.</p> <p>Just east of this location is floodway and 100-year flood zone; there can be heavy flooding during heavy rains.</p>
A-07	North of Gearhart	Establish one or multiple formal assembly areas along Polo Ridge Road.	<p>Medium</p> <p>Shelters, benches, and lighting could also serve as everyday amenities for residents of Pole Ridge Road. This area is surrounded by low ground expected to be inundated.</p>	<p>Polo Ridge Road is on a narrow ribbon of high ground above the inundation zone. This is the most accessible high ground for most of the Surf Pines community.</p> <p>Multiple assembly areas spaced along the road to maximize accessibility is preferred.</p> <p>Much of the property along the road is developed with homes.</p> <p>Some parcels of undeveloped land may be common spaces for the subdivision, opportune locations for assembly areas pending coordination with the landowner (Clatsop Estates LLC).</p>	<p>Recommended.</p> <p>Provides a place for nearby residents to evacuate to. Amenities could be features for everyday use by nearby residents. This area is surrounded by low ground expected to be inundated.</p>
A-08	North of Gearhart	Establish a formal assembly area at the end of the trail from Option T-06.	<p>Minimum</p> <p>Though this area is surrounded by low ground, it is approximately one half mile from A-07 on the same patch of high ground.</p>	Land appears to be privately owned but undeveloped.	<p>Recommended.</p> <p>This provides a place for nearby residents to evacuate to. Evacuees could walk to A-07 for additional amenities during non-emergency situations.</p>

ID	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-09	North of Gearhart	Establish one or multiple formal assembly areas near West Lake Acres Drive.	High This location can take advantage of the fire station by stocking water, food, supplies, and other amenities to serve the surrounding neighborhood. This area is surrounded by low ground expected to be inundated.	Could co-locate with Gearhart Rural fire station. Multiple assembly areas spaced along the road to maximize accessibility is preferred. Constraints: this area is near wetlands and potential habitat for a federally listed threatened species.	Recommended. Provides a place for nearby residents to evacuate to. The fire station is an ideal opportunity to also provide other amenities. This area is surrounded by low ground expected to be inundated.
A-10	North of Gearhart	Establish an assembly area on the wooded hill in Cullaby Lake County Park that connects with T-07.	Medium Shelters, benches, and lighting would also serve as everyday amenities for Cullaby Lake County Park.	A majority of the park land is owned by the Finlandia Foundation. A portion of the land is owned by Clatsop County.	Recommended. Provides a place to evacuate for visitors to Cullaby Lake. Also provides amenities for park visitors.
A-11	North of Gearhart	Establish a formal assembly area at the end of the trail from Option T-08.	Medium Shelters, benches, and lighting would also serve as everyday amenities for Carnahan County Park.	Land is Carnahan Park, owned by Clatsop County.	Recommended. Provides a place to evacuate for residents of North Cullaby Lake and visitors of Cullaby Lake Park. Amenities could be integrated into the park's trail system.
A-12	South of Camp Rilea	Establish a formal assembly area at the end of the trail spur from Option T-09.	n/a	Land appears to be privately owned but undeveloped.	Not recommended. This assembly area is too far from populated areas to be practical for evacuation.
A-13	East of Camp Rilea, east of Hwy 101	Establish a formal assembly area at the end of the trail from Option T-10.	Minimum	Well connected with existing roads. Could serve as evacuation point for several neighborhoods.	Recommended. Provides a place to evacuate for nearby neighborhood residents.

ID	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-14	Camp Rilea	Establish a formal assembly area along Pacific Road in Camp Rilea. Connects with Option T-11.	Medium Shelters, benches, and lighting can serve as features of Camp Rilea. This area is surrounded by low ground expected to be inundated.	Well connected with existing roads. Needs to be coordinated with Camp Rilea.	Recommended. Provides a place to evacuate for visitors to Camp Rilea. Amenities could be features for everyday visitors of Camp Rilea. This area is surrounded by low ground expected to be inundated.
A-15	Camp Rilea	Establish a formal assembly area along Demo Road in Camp Rilea. Connects with Option T-12.	Medium Shelters, benches, and lighting can serve as features of Camp Rilea. This area is surrounded by low ground expected to be inundated.	Well connected with existing roads. Needs to be coordinated with Camp Rilea.	Recommended. Provides a place to evacuate for visitors to Camp Rilea. Amenities could be features for everyday visitors of Camp Rilea. This area is surrounded by low ground expected to be inundated.
A-16	Camp Rilea	Establish a formal assembly area along 2nd Causeway Road near the south intersection with Cev Road in Camp Rilea.	Medium Shelters, benches, and lighting can serve as features of Camp Rilea. This area is surrounded by low ground expected to be inundated.	Well connected with existing roads. Needs to be coordinated with Camp Rilea.	Recommended. Provides a place to evacuate for visitors to Camp Rilea. Amenities could be features for everyday visitors of Camp Rilea. This area is surrounded by low ground expected to be inundated.
A-17	Camp Rilea	Establish a formal assembly area for Option T-13 along 2nd Causeway Road near the north intersection with Cev Road in Camp Rilea.	Minimum A-17 is approximately 1,500 feet north of A-16 and on the same patch of high ground.	Well connected with existing roads. Needs to be coordinated with Camp Rilea.	Recommended. Provides a place to evacuate for residents of Spirit Place and Douglas Lane as well as for visitors to Camp Rilea. A-17 is approximately 1,500 feet north of A-16 and on the same patch of high ground.

ID Map	General Location	Description	Recommended Investment Package	Benefits or Constraints	Recommendation & Justification
A-18	North of Camp Rilea	Establish a formal assembly area at the south end of Smith Lake County Park; provide signage identifying high ground.	Minimum	<p>Can be co-located with Smith Lake County Park.</p> <p>Potential wetlands in the west part of the park.</p> <p>The south end of the neighborhood is roughly one-half mile from the proposed assembly area, consider a vertical evacuation structure to serve this area (V-03)</p>	<p>Recommended; low priority.</p> <p>Provides a place to evacuate for residents of Smith Lake Road.</p>
A-19	North of Camp Rilea	Establish a formal assembly area along Whiskey Road to serve neighbors on the northeast side of Smith Lake.	Minimum	<p>Located on platted, but undeveloped right of way.</p> <p>Adjacent to Warrenton city limits. Coordinate with the City of Warrenton.</p>	<p>Recommended.</p> <p>Provides a place for nearby residents and visitors to evacuate to.</p>
A-20	Fort Stevens	Establish a formal assembly area on this ridge of high ground to serve the trails in Options T-15, T-16, and T-17.	Medium	<p>Evacuation shed may be large for this location when the park hosts many visitors.</p>	<p>Recommended.</p> <p>Provides a place to evacuate for visitors to Fort Stevens State Park. Amenities can serve as everyday features of the park.</p>
A-21	Falcon Cove	Establish a formal assembly area for people in Falcon Cove to gather following a tsunami.	Minimum	<p>Located in a neighborhood above the inundation zone.</p> <p>The Falcon Cove area may be difficult to access after a seismic event.</p> <p>Located on Falcon Cove Water District land.</p>	<p>Recommended.</p> <p>Provides a place to evacuate for residents and visitors of Falcon Cove. Amenities could be features for everyday use by nearby residents. This area is surrounded by low ground expected to be inundated</p>

VERTICAL EVACUATION STRUCTURES

In locations where natural high ground is not available or is not practical to reach in time before the first tsunami wave arrives, vertical evacuation structures can be appropriately designed and constructed to serve as places of refuge where many people can evacuate and remain for up to 24 hours to escape the initial and subsequent tsunami waves.

Structure Types

Types of vertical evacuation structure include soil berms, towers, and buildings (Table 7).

Vertical evacuation structures of all three types can be designed and built to serve recreational or other community functions, in addition to providing refuge in areas too far from natural high ground. Berms can be incorporated into parks and recreational areas; tower can make for an accessible viewpoint to take in the coastal beauty of Clatsop County, and a rooftop evacuation platform could be located atop of a variety of multistory civic, commercial or residential buildings.

Table 7. Vertical Evacuation Structure Types

Structure Type	Cost Range	Considerations	Example
Soil berms	\$1,000,000 – \$5,500,000	Engineered earth mound created with soil or recycled construction materials. Can be integrated into parks and serve a recreational use. More cost effective than other types of vertical evacuation structures.	
Berm height and the number of refugees to accommodate are among main cost factors. The construction cost range is based on a refugee capacity of 250 to 850, with berm height less than 35 feet.			<i>A soil berm constructed in Tahara, Japan, in 2018 (Source: Disaster Prevention Bureau of Tahara, Japan)</i>

Structure Type	Considerations	Example
<p>Evacuation towers</p> <p>\$1,500,000 – \$11,000,000</p> <p>The number of refugees to accommodate is a main cost factor, and the construction cost range is based on a refugee capacity of 200 to 900 people.</p>	<p>Elevated platform, stairs, or ramps.</p> <p>Smaller physical footprint than berms.</p> <p>Space below platforms can serve multiple community uses, including parking.</p> <p>Consider equipping with amenities for communications and evacuees’ immediate needs.</p> <p>Could be designed to serve recreational purposes, including a viewing platform; space below could be programmed for community events.</p> <p>Should be constructed at a height substantially above expected tsunami wave height; height determined by structural engineers.</p>	 <p><i>Rendering of Tsunami Evacuation Tower in Tokeland, Washington (Source: Degenkolb Engineers)</i></p>
<p>Buildings with rooftop refuge areas</p> <p>Cost factor: 10% to 20% increase in total construction costs</p> <p>This cost estimate is based on limited data, including the Ocosta Elementary School, Westport, WA.</p>	<p>Multi-story building, typically with rooftop evacuation area.</p> <p>Can be integrated into buildings serving commercial or community uses.</p> <p>Lower levels typically designed with special features such as break-away walls.</p>	 <p><i>Ocosta Elementary School in Westport, Washington (Source: Degenkolb Engineers)</i></p>

Evacuees with limited physical ability may require assistance from more able-bodied people to climb stairs or ramps. Providing an elevator may seem like an attractive option to provide access for everybody, however elevators are not practical for evacuation uses. First, they require electricity, which will likely be severed by a seismic event. Second, the cost of a seismically resilient elevator would make a project prohibitively expensive. Third, and most important, elevators are slow and only move a few people at a time. They would create a bottleneck that is dangerous during an evacuation. Instead, ramps can be provided where feasible, like on a soil berm. Where only stairs are feasible, signs can be included to encourage evacuees to help one another reach the assembly area.

The type, height, and size (i.e., refugee capacity) of a tsunami evacuation structure are the main factors that impact the design and construction cost of a vertical evacuation structure. In many cases, tsunami evacuation structures may need to be constructed on a site with poor soil condition, where site-specific hazards such as liquefaction and lateral spreading can create special design challenges, and often require significant cost to improve ground conditions and/or construct robust deep foundation systems. Unlike Japan, designing and constructing a tsunami evacuation structure is relatively new in the Pacific Northwest. In order to develop a planning-level construction cost range (in 2021 dollars) for a tsunami refuge as indicated in **Table 5**, we have taken

a three-pronged approach, including (a) surveying recent tsunami evacuation feasibility studies, (2) compiling overall construction cost of a limited number of tsunami evacuation structures constructed in Oregon and Washington, and (3) leveraging our engineering experience and judgement. If the county wants to develop a construction cost for budgetary planning or grant application for an individual tsunami evacuation structure, we recommend the county retain a qualified consultant to perform a project-specific engineering study to develop such information.

Structure Locations

Vertical evacuation structures would provide needed refuge in low-lying coastal areas of Clatsop County. General areas that would benefit from vertical evacuation structures are identified in **Table 8** and shown in **Figure 5**, **Figure 6**, and **Figure 7**, as well as in the [Companion Map](#). Further study is recommended to determine the number of structures in each area, their sizes and types, and their exact location. The study should include robust community involvement. This level of planning for vertical evacuation structures is outside the scope of this TEFIP.

Table 8. Proposed Vertical Evacuation Structure Alternatives

Area ID	Type	General Location	Description	Recommended Amenities or Features	Benefits or Constraints	Recommendation
V-01	Vertical structure	North of Gearhart	Area north of Gearhart is not well connected and requires traversing long distances to reach high ground.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach.	Recommended.
V-02	Vertical structure	North of Gearhart	Area is separated from high ground by Sunset Lake. Requires traveling long distances to evacuate the inundation zone. Consider vertical evacuation structures.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach.	Recommended.
V-03	Vertical structure	Camp Rilea	Beach area is nearly one-half mile to high ground.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach and coordination with Camp Rilea.	Recommended.
V-04	Vertical structure	South of Warrenton	The community at the southwest end of Smith Lake is roughly one-half mile from high ground.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach. Option A-17 proposes an assembly area at the high ground on the north end of the community.	Recommended.
V-05	Vertical structure	Between Warrenton and Astoria	Area is surrounded by water and not well connected to high ground.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach.	Recommended.
V-06	Vertical structure	Between Warrenton and Astoria	Area is surrounded by water and not well connected to high ground.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach.	Recommended.
V-07	Vertical structure	Clatsop Spit	The Clatsop Spit is long, flat, and vulnerable to a tsunami. It is also popular with visitors of Fort Stevens State Park.	Wayfinding, solar charging, communications.	Placement should be considered through community outreach and coordination with Fort Stevens State Park.	Recommended.