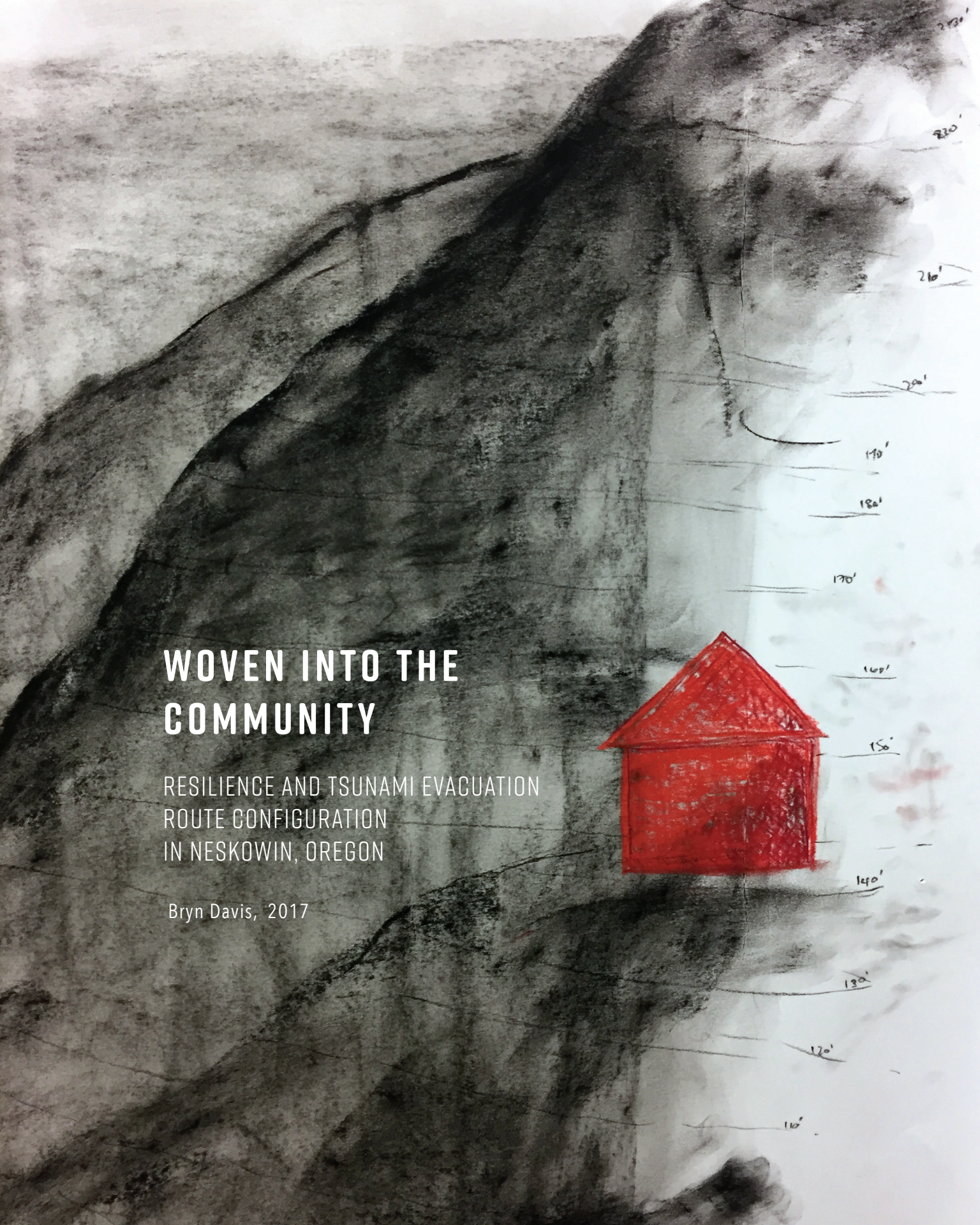
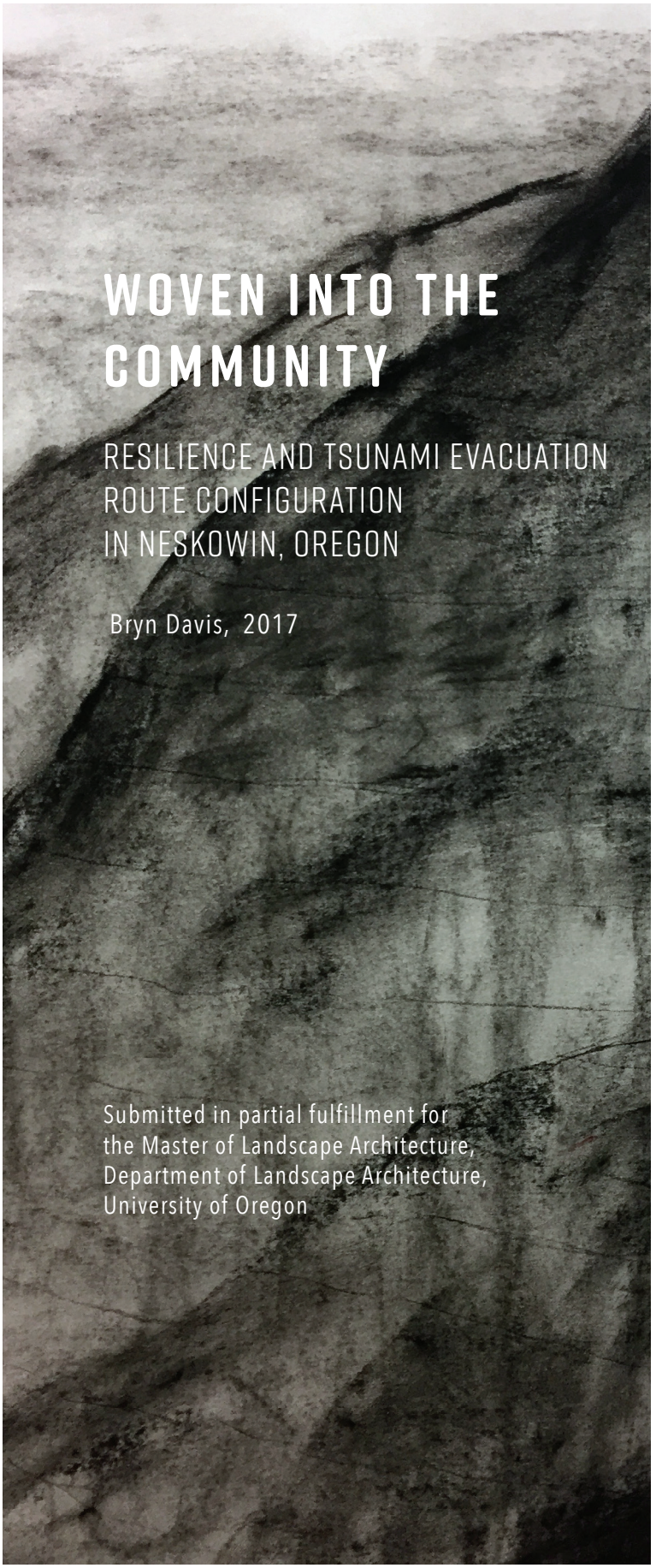


WOVEN INTO THE COMMUNITY

RESILIENCE AND TSUNAMI EVACUATION ROUTE CONFIGURATION IN NESKOWIN, OREGON

Bryn Davis, 2017



WOVEN INTO THE COMMUNITY

RESILIENCE AND TSUNAMI EVACUATION ROUTE CONFIGURATION IN NESKOWIN, OREGON

Bryn Davis, 2017

Submitted in partial fulfillment for
the Master of Landscape Architecture,
Department of Landscape Architecture,
University of Oregon

APPROVAL

MASTER'S PROJECT COMMITTEE:

PROJECT CHAIR: Chris Enright, PhD

PROJECT COMMITTEE MEMBER: Prof. David Hulse

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ABSTRACT

The Problem- The threat of a Cascadia Subduction Zone (CSZ) earthquake and tsunami on the Oregon Coast has prompted coastal communities to update and re-evaluate disaster resilience management plans. Most plans are based on a preparation-and-response model, which addresses the disaster immediately before, during, and after. The issue with these strategies is that they do not aim to have a deeper impact on human behavior, they play to a "business-as-usual" lifestyle. An approach that weaves together the immediate needs of a community at the time of disaster with the long-term goal of improving the resilience of the coastal community can contribute to the long-term creation of safer and more secure communities[1]. The purpose of this project is to identify how tsunami evacuation routes can contribute to the resilience of a coastal community.

Methodology- The meta-framework of resilience proposed by Aldunce et al.[2]; in combination with literature reviews of government and peer reviewed articles and interviews with regional experts, contributed to defining resilience in operational terms and to identifying elements of tsunami evacuation routes and community resilience strategies.

Findings - The design response for improving the resilience of Neskowin, Oregon was created through the synthesis of the community resilience strategies and elements of tsunami evacuation routes. The tsunami evacuation route elements were chosen based on what could be addressed in Neskowin, what could be affordable for that community, and what contributions they would make to resilience.

1 Hayashi, Yoshitsugu, et. al."Disaster Resilient Cities: Concepts and Practical Examples". Butterworth-Heinemann, March 2016. 4.

2 Aldunce, Paulina, Ruth Beilin, John Handmer, and Mark Howden. 2014. *Framing disaster resilience: The implications of the diverse conceptualisations of "bouncing back".* Vol. 23. 3 vols. Melbourne: Emerald Group Publishing.

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KEY ACRONYMS

CSZ: Cascadia Subduction Zone

DOGAMI: Oregon Department of Geologic and Mineral Industries

DRM: Disaster Risk Management

NDRP: Natural Disaster Resilience Program

OEM: Oregon Emergency Management

OSSPAC: Oregon Seismic Safety Policy Advisory Commission

PURAL: Portland Urban Architecture Research Lab

KEY TERMINOLOGY

Adaptation: The action or process of adapting one thing to suit specified conditions, especially a new or changed environment[1].

Community: A body of people who live in the same place, usually sharing a common cultural or ethnic identity. Hence: a place where a particular body of people lives[2].

****Community Resilience Strategies:*** Actions undertaken by a community to become more resilient.

Disaster: The outcome of hazard and vulnerability coinciding. Disaster is a state of disruption to systemic functions. Systems operate at a variety of scales, from individuals' biological and psychological constitutions or local socio-economies to urban infrastructure networks and the global political economy[3].

Disaster Resilience: The capacity of a society to "bounce back"; cope; withstand, resist, and recover quickly from the impacts of hazards.[4]

Hazard: The potential of natural, physical or environmental elements, to harm individuals or human systems[5].

Risk: To be threatened by harm. To be at risk is to be under threat of harm[6].

Resilience: The capacity of individuals, communities, and systems to cope with, adapt to, and recover quickly from impacts of hazards.

Transformation: The action of changing in form, shape, or appearance[7].

****Tsunami Evacuation Elements:*** An element is a quality or set of qualities intentionally designed into an evacuation route to help meet the route's goals.

Vulnerability: Denotes exposure to risk and an inability to avoid or absorb potential harm[8].

* Defined for this project.

1 Oxford English Dictionary. "Adaptation". Oxford University Press, 2017. Accessed on 02/20/2017. http://www.oed.com/

2 Oxford English Dictionary. "Community". Oxford University Press, 2017. Accessed on 04/10/2017. http://www.oed.com/

3 Pelling, Mark. "The Vulnerability of Cities: Natural Disasters and Social Resilience." Earthscan Publications, 2003. 5

4 Aldunce, et al., "Framing disaster resilience" 257.

5 Pelling, "The Vulnerability of Cities". 5.

6 Pelling, "The Vulnerability of Cities". 5.

7 Oxford English Dictionary. "Transformation". Oxford University Press, 2017. Accessed on 02/20/2017. http://www.oed.com/

8 Pelling, "The Vulnerability of Cities". 5.

Figure1.1: Location of Neskowin, Oregon

1 INTRODUCTION

PROJECT OVERVIEW

The threat of a Cascadia Subduction Zone (CSZ) earthquake and tsunami on the Oregon Coast has prompted coastal communities to update and re-evaluate disaster resilience management plans. Most cities and towns have online resources (maps, evacuation procedures), evacuation routes marked by signs, and warnings posted on major highways and beach access areas. These measures are based on a preparation-and-response model, which addresses the disaster immediately before, during, and after. The issue with these strategies is that they do not aim to have a deeper impact on human behavior, they play to a "business-as-usual" lifestyle. An approach that weaves together the immediate needs of a community at the time of disaster with the long-term goal of improving the resilience of coastal communities can contribute to the "...shift from a "short-term perspective focusing on economic growth" to "long-term creation of safe and secure societies" [1].
The purpose of this project is to identify how tsunami evacuation routes can contribute to the resilience of a coastal community, using Neskowin, Oregon as a case study (Figure1.1: Location of Neskowin, Oregon).
The main objectives of this project are to:

1. Define resilience in operational terms that apply to tsunami evacuation routes;
2. Critique the present tsunami evacuation routes in Neskowin; and lastly,
3. Propose a design adaptation for one of Neskowin's tsunami evacuation routes that responds to the critique.

The 2011 Tohoku tsunami in Japan and associated rebuilding projects provide examples of what a CSZ tsunami might look like on the Oregon coast and what lessons have been learned. A literature review of research from government agencies and peer reviewed papers was undertaken to define and operationalize resilience, as applied to the scope of a CSZ instigated tsunami in an Oregon coastal town. Interviews with five regional experts contributed to identifying the goals and tsunami evacuation route elements. The interviews also identified community resilience strategies. The methods used to critique Neskowin's tsunami evacuation routes were spatial analysis and information from the regional expert interviews.

The design response is the synthesis of what has been learned from the literature review, regional expert interviews and the critique of Neskowin. The findings of this project identify potential community resilience strategies that tsunami evacuation routes can contribute to and present a process for creating design adaptations that incorporate them. The findings are intended to be transferable for CSZ event planning in other Oregon coastal communities.

1 Hayashi, Yoshitsugu, et. al."Disaster Resilient Cities: Concepts and Practical Examples". Butterworth-Heinemann, March 2016. 4.

Figure 1. 2: Cascadia Subduction Zone context map

THE CASCADIA SUBDUCTION ZONE:
What it is and how it will affect Oregon

The threat of a major earthquake caused by the Cascadia subduction zone (CSZ), a 600-mile-long fault which runs along the Pacific Northwest coast, has risen to the attention of many communities and government agencies (Figure 1.2: CSZ context map). It has been 317 years since the last CSZ event struck the Oregon coast. The high profile New Yorker article, The Really Big One[2], raised national attention to this future disaster and helped fuel the often-lagging conversation among local residents. The scientific community on the other hand, has been aware of the possibility of its eruption for the past 30 years, and currently predicts a 40% chance that a megathrust earthquake, of either a 8.0 or 9.0+ magnitude, will occur in the next 50 years[3]. Over the last 10,000 years, there have been 41 earthquakes within the CSZ. The time between these eruptions has been as little as 190 years or as many as 1200 years. The last earthquake along this fault was on January 26, 1700, the magnitude of which has been estimated at 9.0. Scientists used the geologic records and the flow of the Pacific Ocean to link a tsunami in Japan to the 1700 Pacific Northwest earthquake. The timing also matches that of Oregon Coast tribe oral histories, which tell of a big wave that swept over coastal communities[4].

What is a subduction zone?

The geology of the Northern Japan coast and that of Oregon are similar; where in both places the Pacific Ocean floor is sliding under the adjacent

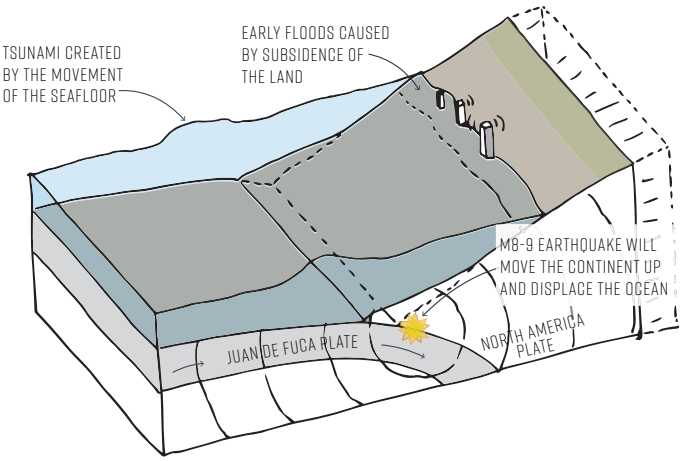


Figure 1.3: Subduction Zone Diagram
Diagrams adapted from: Wasington State Department of Natural Resources
http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/tsunamis

continental plates. The tectonic plates (continent-sized slabs of hard, rigid rock) slowly slide along the malleable mantle of the earth below. The plates move at speeds of only a few inches per year; the plates can be pulled apart, slip past each other, or collide straight on. The collision of an oceanic plate with a continental plate forms a subduction zone, where one plate is forced beneath the other, down into the soft mantle rock below[5]. In the case of the Pacific Ocean floor, it is simultaneously moving westward colliding with Japan, as well as slowly inching eastward, slipping down underneath Oregon, Washington, and Northern California (Figure 1.3: Subduction zone diagram). This fault line is the Cascadia Subduction Zone (CSZ), which lies 70-100 miles off the Pacific coast shoreline.

What is a tsunami?

Tsunamis form out in the deep ocean before heading towards shoreline. A tsunami can affect hundreds to thousands of kilometers of coastline[6]. The warning of an approaching tsunami is commonly the earthquake that precedes it, meaning it may be only a matter of minutes before the first waves hit.

2 Schultz, Katherine. "The Really Big One." The New Yorker, July 20, 2015.

3 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management. Accessed on Jan. 27, 2017. http://www.oregon.gov/oem/hazardsprep/Pages/Cascadia-Subduction-Zone.aspx

4 Yonker, Jason. "Weaving Long Ropes: Oral Tradition and Understanding the Great Tide". Oregon Historical Quarterly, vol. 108, no. 2. Summer 2007, pp. 193-201

5 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management, February 2013.

6 Nirupama, N. and T.S. Murty."Similarities and differences in tsunami and storm surge mitigation."

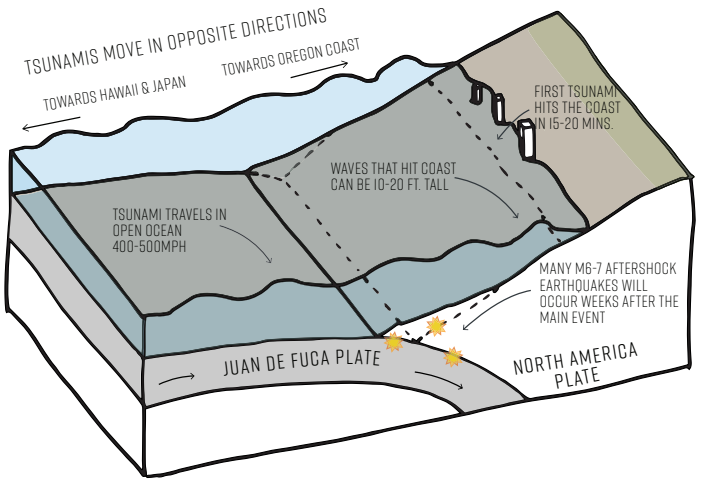


Figure 1.4: Tsunami diagram
Diagrams adapted from: Wasington State Department of Natural Resources
http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/tsunamis

As a tsunami approaches the shallower waters of a shoreline, the height of the waves is amplified (Figure 1.4: Tsunami diagram). The coastal inundation from a tsunami may only last a few hours. Tsunamis may have a phenomenon called initial withdrawal, where the ocean may recede up to a kilometer or more at certain locations, as the wave approaches the shoreline.

Estimated Impacts in Oregon

The effects of a CSZ earthquake and tsunami in Oregon will be unprecedented. The scope of damage encompasses every aspect of life in Oregon, as well as the rest of the Pacific Northwest. The coast will especially feel its effects and those within the tsunami hazard zone are likely to face severe to devastating damage. While it is difficult to accurately predict the impacts, several studies have created estimates of possible outcomes (e.g. damages, casualties) and how far reaching they might be[7]. For example, the Oregon Resilience Plan estimated possible outcomes that include:

- Earthquake deaths: 650-5,000 and tsunami related deaths: 600-5,000
- 24,000 buildings completely destroyed, with another 85,000 having extensive damage
- $32 billion estimated economic losses
- 27,600 displaced households
- 10 million tons of debris (approximately)

The amount of time it will take to restore Oregon to pre-disaster conditions is a great concern for local agencies. The longer basic services (e.g. transportation, electricity, water) are unavailable, the longer it will be until the state's economy and its citizens recover. If the earthquake and tsunami were to take place today, estimated times to restore functions for the Oregon coast are[8]:

- 1-3 years for drinking water and sewer Infrastructure
- +3 years for healthcare facilities
- 3-6 months for electricity service

The predicted time for the recovery of essential functions for the Oregon coast are shocking and may lead to a sense of overwhelming hopelessness. What is important to remember is that these predictions were created with a "business-as-usual" model. We have the opportunity to change how the state has approached natural hazard planning and management in the past.

CSZ Planning in Oregon

In 2011 the Oregon legislature passed House Resolution 3, which noted the need to address the impact of a Cascadia earthquake and tsunami through the creation of a statewide resilience plan. The resolution lead to the creation of the Oregon Seismic Safety Policy Advisory Commission (OSSPAC), which was charged with preparing an Oregon Resilience Plan that,

"...reviews policy options, summarizes relevant

7 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management February 2013, pp.14.

8 The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management. February 2013, pp 14.

reports and studies by state agencies and makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia earthquake and tsunami" [9].

OSSPAC looked to other earthquake resilience plans that have been put forth, particularly from San Francisco, California and the state of Washington[10], to form an appropriate approach. The formation of a set of working groups, staffed by experts, were tasked with determining impacts of the CSZ earthquake scenario on different sectors (e.g. business and workforce, energy, transportation, coastal communities). The coastal working group was also tasked with predicting the impacts of a tsunami. Each working group then made recommendations based on their research, as how best to achieve resilience for each sector.

The scenario predictions of the working groups lead OSSPAC to divide the state into four zones based on the expected patterns of damage: The Tsunami Zone, The Coastal Zone, The Valley Zone, and The Eastern Zone (Figure 1.5: Oregon Hazard Zone Map). These zones help agencies and researchers focus their efforts towards specific damage conditions, rather than trying to tackle everything at once. The Tsunami Zone is characterized by the near total damage of coastal communities by both the severe shaking caused by the earthquake and the subsequent tsunami inundation, which places thousands of lives in jeopardy. Current approaches to addressing these hazards include extensive mapping of tsunami inundation predictions, warning systems, educational programming and training, and evacuation measures (e.g. education, signage and route planning).

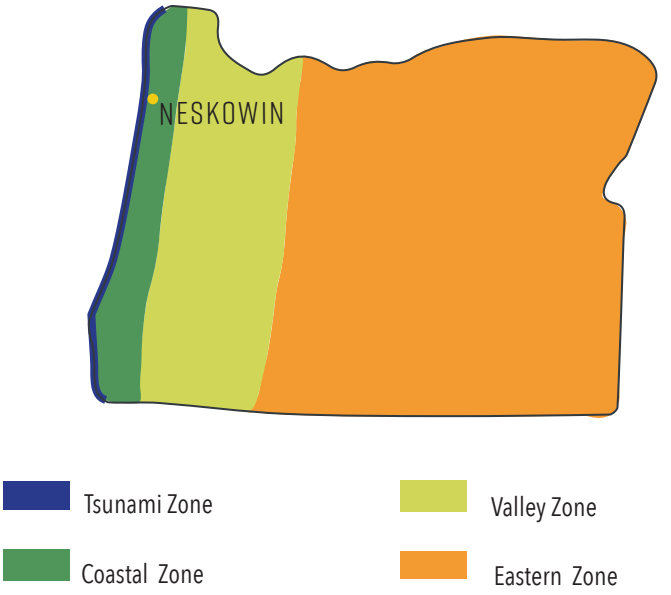


Figure 1.5: Oregon Hazard Zone Map
Adapted from The Oregon Resilience Plan. Accessed on 05/15/17
https://multco.us/em/oregon-resilience-plan

TSUNAMI EVACUATION PLANNING

Current efforts concerning tsunami evacuation in Oregon focus on providing maps, signs and educational programs for residents and visitors. A few communities (such as Seaside, Oregon) have begun modeling evacuation routes and timing that is based on population (e.g. age, vulnerabilities-physical limitations) and distance to higher ground (generally 100ft above sea level) [11]. Unfortunately, this is a very expensive process and not all coastal communities have the funds to support this important research. Marking tsunami evacuation routes with clear signage is an affordable step in improving evacuation measures and a few research projects have been implemented in Oregon. These projects include the Tsunami Blue Line coordinated by the Oregon Office of Emergency Management (OEM) and Up and Out, a design project lead by the University of Oregon's Portland Urban Architecture Research Lab (PURAL)). But signs alone are not enough to ensure that evacuation routes are accessible or will function properly during an evacuation. We can look to other communities that have experience with similar hazards, such as those in Japan, to broaden our knowledge base on strategies to promote effective evacuation during a tsunami.

9 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management. February 2013, pp. 1.

10 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management pg 2. February 2013.

11 Priest, George, et. al. "Beat-the-wave evacuation mapping for tsunami hazards in Seaside, Oregon, USA." Natural Hazards. 2016. 80:1031-1056.

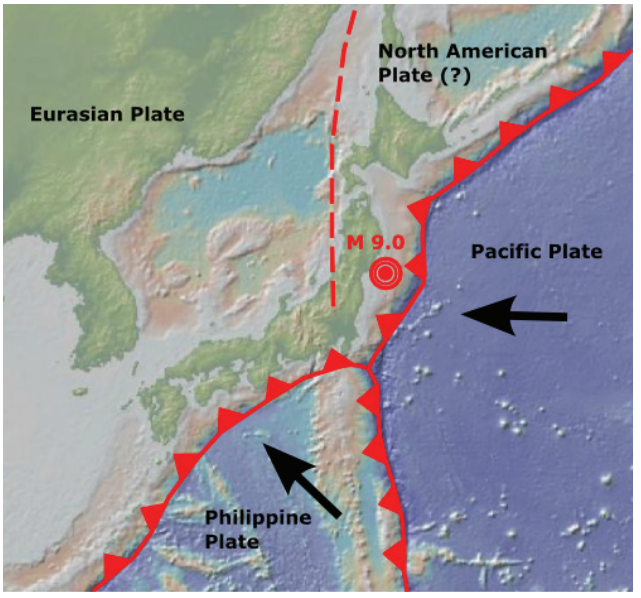


Figure 1.6: Subduction zone map of Japan
Image from Scientific American Online Publication. Accessed on 05/15/17
https://blogs.scientificamerican.com/guest-blog/japan-earthquake-the-explainer/

Lessons from Japan

On March 11, 2011, a 9.0 (Mw) megathrust earthquake struck Japan at 2:46pm local time. The earthquake (the Great East Earthquake) originated from a subduction zone off the eastern coast of Japan, which had been locked and building up stress for over a century (Figure 1.6: Subduction zone map of Japan). When released, the intense shaking lasted for 6 minutes; after which 1000+ aftershocks were experienced (some reaching over 6-7 (Mw)). A series of tsunamis hit the coast soon after the earthquake. The tsunami waves reached inland 128 feet above sea level, while land subsidence along the northern Japan coast ranged from 1.5 feet to 4 feet. The 2011 Tohoku tsunami, as it is now known, killed an estimated 20,000 people. The damages sustained by the earthquake and tsunami were immense, with approximately 300,000 people still living in temporary housing two years after the disaster[12].

The catastrophic 2011 Tohoku earthquake and tsunami event is one that will be mirrored in Oregon in the future. The lessons that can be taken from Japan are invaluable as the state and other agencies move to create a more resilient Oregon. One of many take-a-ways is that most if not all structural tsunami countermeasures failed in 2011. The tsunami towers, seawalls and breakwaters, were not designed to resist an earthquake of that magnitude nor the tsunamis that followed[13]. An emphasis on technology and hard infrastructural measures (such as seawalls, towers) to reduce damage, has translated into many believing that these interventions will protect them[14]. The danger with placing so much of our faith in technology is that we are more likely to behave in ways that put ourselves at risk. The big lesson from Japan is that there is no replacement for evacuation and education. Soft infrastructural measures (education, land use planning, etc.) should be emphasized in collaboration with hard infrastructural measures[15].

The importance of the role that tsunami evacuation plays in preserving life cannot be stressed enough[16]. In the Sanriku areas in Japan, there is a saying, tsunami tendenko, which can be translated as "you should protect your life by yourself" [17]. The phrase came from past tsunami experiences of people losing their lives in a tsunami because they waited at their homes for family members or were helping others evacuate. In the 2011 Tohoku tsunami, a group of school children

12 "Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities." The Department of Land Conservation and Development. April 2015.

13 Suppasri, Anawat, et. al. "Lessons Learned from the 2011 Great East Japan Tsunami: Performance of Tsunami Countermeasures, Coastal Buildings, and Tsunami Evacuation in Japan". Pure and Applied Geophysics. 170 (2013), 993-1018.

14 Suppasri, Anawat, et. al., "Lessons Learned from the 2011 Great East Japan Tsunami", 1017.

15 Suppasri, Anawat, et. al., "Lessons Learned from the 2011 Great East Japan Tsunami", 1017.

16 "Preparing for a Cascadia Subduction Zone Tsunami: A Land Use Guide for Oregon Coastal Communities." The Department of Land Conservation and Development. April 2015.

17 Suppasri, Anawat, et. al., "Lessons Learned from the 2011 Great East Japan Tsunami", 1013-1014.

all survived because they used tsunami tendenko and started their evacuation by themselves[18]. Another evacuation strategy includes the building of tsunami memorials. In areas where tsunamis have occurred, memorials have been built to remind residents of the danger that tsunamis present, as well as to mark locations that are deemed safe (Figure 1.7: Tsunami Memorial Stones).

It is clear from these experiences that evacuation measures work best when residents are cognizant of past events (e.g. through memorials, education, signs) and by stressing that structural measures are secondary to self-evacuation in the effort to save lives,

"Evacuation is the act of preparation of primary importance to protect human lives, rather than an act that is taken just because the embankment is insufficient. Whether the residents understand the importance of voluntary evacuation and mutual assistance and can take autonomous action affects the basis of resilience." [19]

While much can be taken from the Japanese experience, it is important to remember that these strategies may not work within the cultural bounds of the United States. The west coast (Washington, Oregon and California) does not have the same history of frequent tsunamis as Japan, nor is there the same level of tsunami understanding here in the U.S. The draw of the Oregon coast maybe very different than that of the Japanese coast. Building 6 meter tall seawalls along the striking, iconic Oregon coastline is not going to be an option. Last, the majority of coastal communities do not have the resources for undertaking such massive infrastructural building projects. What can be taken away from the 2011 Tohoku

Figure 1.7: Tsunami Memorial Stones
Image From: Subselfie. Accessed on 05/15/17
https://subselfie.com/2015/03/25/after-the-tsunami-what-we-can-learn-from-sendai-japan-by-george-gamayo/

tsunami, is the importance of tapping into local knowledge, culture, and resources.

RESILIENCE:
The operationalization of a slippery concept

The first step that OSSPAC took, when creating the Oregon Resilience Plan, was to define resilience in context of a CSZ earthquake and tsunami:

"Oregon citizens will not only be protected from life threatening physical harm, but because of risk reduction measures and pre-disaster planning, communities will recover more quickly and with less continuing vulnerability following a Cascadia subduction zone earthquake and tsunami." [20]

The timeline that this definition outlines encompasses before, during, and after a disaster. Figure 1.8 Disaster Cycle, is an illustrated summary of Hayashi, et al.'s work of defining quality of life standards at the time of a disaster. The post-disaster portion extends all the way to the next occurrence of an

18 Suppasri, Anawat, et. al., "Lessons Learned from the 2011 Great East Japan Tsunami", 1013.

19 Hayashi, et. al."Disaster Resilient Cities: Concepts and Practical Examples". Butterworth-Heinemann, March 2016. 8.

20 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management. February 2013. 2.

earthquake/tsunami scenario, which shows an effort to focus on the long-term safety of communities in Oregon. A similar idea was presented at the 2007 Science Council of Japan, which stipulated that the Japanese government should "...shift from a "short-term perspective focusing on economic growth" to "long-term creation of safe and secure societies" [21].

In comparison, the Rockefeller Foundation put forth a definition, as a part of the 100 Resilient Cities program in 2015, which defines resilience as,

"The capacity of individuals, communities, and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it. Building resilience is about making people, communities, and systems better prepared to withstand catastrophic events – both natural and manmade – and able to bounce back more quickly and emerge stronger from these shocks and stresses." [22]

Both definitions emphasize the requirement of quick recovery post-disaster and the lessening of vulnerability to future catastrophic events. The Rockefeller definition, unlike the one given by OSSPAC, points out that having the ability to adapt and transform as conditions change is a contributing factor of resiliency. Not directly addressing qualities of adaptation and transformation in the Oregon Resilience Plan's definition I feel, is a missed opportunity to emphasize the need for creative approaches to risk-reduction and recovery.

I see the role of evacuation routes in the context of resilience, as being able to fill the "adaptation/transformation gap". Evacuation routes currently do this in many ways–they are neighborhood streets, hiking trails, main thorough fares–but all are still just functioning as modes of circulation. Could they contribute more towards creating resilient coastal communities? Think of the transformation that a street undergoes during a block party. A place that was meant just for cars and other modes of transportation, is now providing gathering spaces for people. Businesses set up stalls, stages are erected for musical performances and neighbors are brought together face-to-face. I believe, with this example in mind, that tsunami evacuation routes have the potential to make a greater contribution to safe and adaptable communities.

Disaster Risk Management and Resilience Meta-Frames

Disaster risk management (DRM) in broad terms, is the process of addressing the possibility of negative changes using risk reduction measures, risk management plans and actions. DRM encompasses all types of technological and "natural" hazards and risks and all phases of the temporal disaster cycle. The adoption of resilience into DRM, starting in the 1970s, has given rise to much research and debate over the usefulness of a term that does not lend itself easily to the transferring of information or scientific findings[23]. The Oregon Resilience Plan's use of resilience is one example of how the concept has been adopted into the DRM community.

The difficulty is operationalizing a concept, the meaning of which changes depending on who is providing the definition. A strategy that has gained traction in the DRM community, comes from embracing part of the haze surrounding the term. The resolution is not trying to determine which constructed meaning is "right" or "wrong", but in understanding what can be achieved depending on which resilience "storyline"[24] is invoked. The flexibility of design, to mold itself to situation and place, to be both specific and broad, fits well with a concept that can be both. If we restrict

21 Hayashi, Yoshitsugu, et. al."Disaster Resilient Cities: Concepts and Practical Examples". Butterworth-Heinemann, March 2016. 4.

22 Sanderson, David. "Urban Disaster Resilience: New Dimensions from International Practice in the Built Environment." Routledge, 2016. 4.

23 Fekete, Alexander, et al. "Benefits and Challenges of Resilience and Vulnerability for Disaster Risk Management". International Journal of Disaster Risk Science. (2014). 3-4.

24 Aldunce, et al., "Framing disaster resilience", 252.

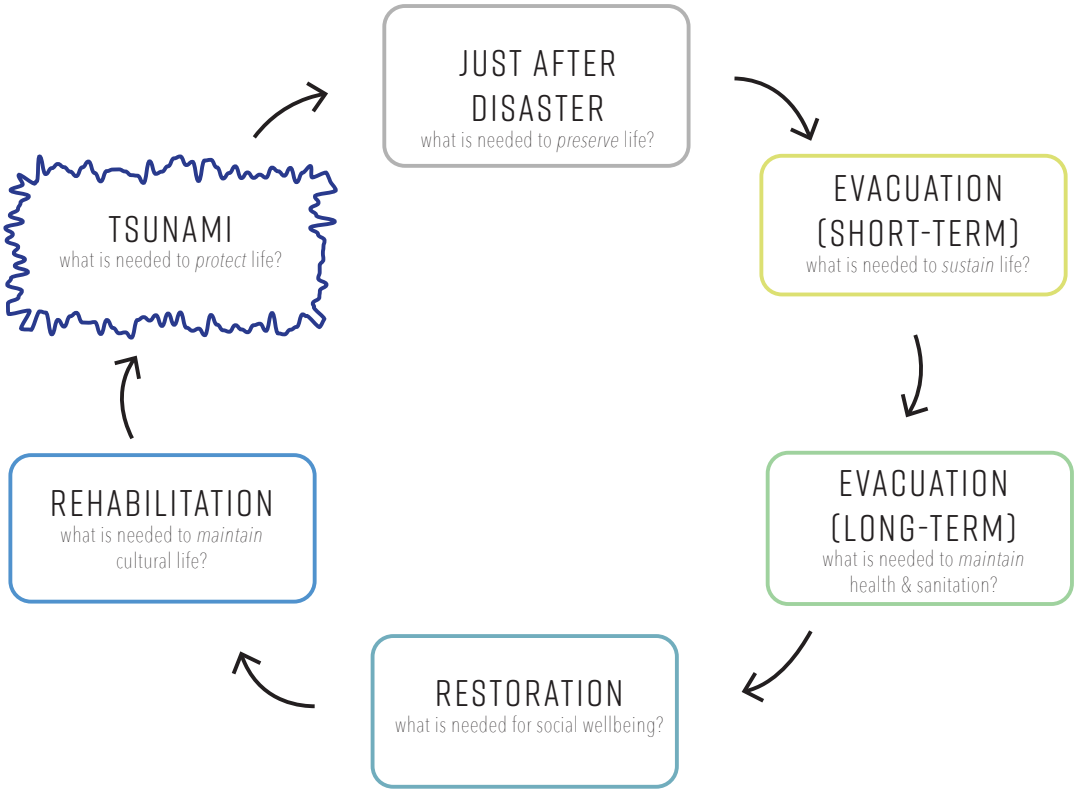


Figure 1.8: Disaster Cycle

Adapted from Hayashi, et. al."Disaster Resilient Cities", 100.

ourselves to viewing a problem from one definition of reality, we could be overlooking valuable contributions that other realities could potentially make. The concept of resilience storylines is from the work of Aldunce et al. 2014, where they organized the threads of practitioners meanings of resilience into three major camps: definitions that have origins in engineering, psychology and ecology.

The origins of resilience come into play when speaking about the storylines of resilience. As mentioned before, the three disciplines that have been represented in the evolution of resilience theory (engineering, psychology, and ecology) constitute the three major storylines[25]. In the context of DRM, each storyline focuses on specific aspects within the domain of policy (Figure 1.9 Resilience Definition Origins Diagram). The storyline which has origins in engineering focuses on resilience as "the ability of a material or system to bend or resist without breaking...bouncing back"; for the storyline psychology, it is "the capacity of individuals and communities to resist, recover, and return to baseline functioning"; and lastly, for ecology an emphasis is placed on "systems... as capable of self-organization, learning, renewal, and continuous development."[26]

Through the work of Aldunce et al. and the Natural Disaster Resilience Program (NDRP), the resilience storylines were related to three Resilience Meta-Frames:

- **Mechanistic/technocratic**
- **Community-based**
- **Sustainability**

where the mechanistic/technocratic meta-frame is connected to engineering, community-based with psychology, and sustainability with ecology. Each documents a different approach to how resilience is achieved (Figure 1.10 Resilience Meta-Frame Diagram), and thus each Resilience Meta-Frame focuses

25 Aldunce, et al., "Framing disaster resilience", 261.

26 Aldunce, et al., "Framing disaster resilience", 255.

RESILIENCE ORIGIN: ENGINEERING

Ability of a material or system to bend or resist without breaking, and the speed at which it returns or "bounces back" to equilibrium after a displacement.
(Bodin and Witman, 2004; Gordon, 1978; Norris et al., 2008)

RESILIENCE ORIGIN: PSYCHOLOGY

The process, outcome or capacity of individuals and communities to resist, recover and return to baseline functioning after a misfortune, stress or external shock.
(Norris et al. 2008; Pfefferbaum et al. 2005)

RESILIENCE ORIGIN: ECOLOGY

The ability of a system to adsorb perturbation and persist without changing its fundamental structure.
(Holling, 1973)

The capacity to adapt... capable of self-organization, learning, renewal and continuous development.
(Adger et al., 2005; Gunderson and Folke, 2005; Liu et al., 2007; Resilience Alliance, 2012)

Figure 1.9 Resilience Definition Origins Diagram
Referenced from Aldunce et al. 2014

MECHANISTIC/TECHNOCRATIC

Expects to control the environment

Promotes "business as usual"

Stresses stability and restricting change

Methods are based on rational ordering and technical knowing

Creates logically objective predictable outcomes

Origins of resilience: *Engineering*

Examples:

Warning Systems, risk assessments, improved zoning and infrastructure

COMMUNITY-BASED

Focuses on community self-reliance and participation

Resilience is both an individual and collective response

Emphasizes a sense of "belongingness" in a community–helping one another

Engages the social fabric of community knowledge

Origins of resilience: *Psychology*

Examples:

Networks, connnections and relationships between individuals and organizations to build social resilience

SUSTAINABILITY

Promotes values of living with "nature" and the unpredictable changes and uncertainty attached to such changes

Belief that social problems are rooted in the disconnection of humans from "nature"

Requires stressing practices that enable opportunities for learning and adaptation

Emphasis on how humans relate to the environment and its systems

Origins of resilience: ***Ecology***

Examples:

Informational/educational signs/talks/lesson plans, people align behavior with known environmental hazards and conditions

Figure 1.10 Resilience Meta-Frame Diagram
From Aldunce et al. 2014

on different solutions. The mechanistic/technocratic frame looks to engineered approaches; the community-based meta-frame focuses on community participation; and sustainability stresses practices that enable learning and adaptation that emphasize how humans relate to the environment and its systems[27].

The differences in the approaches of each Resilience Meta-Frame, presents issues of contradiction, but also reveals the spectrum of realities where resilience can be manifested. Aldunce et al. saw this exposure of differences as a chance to create synergies, that "...all positions contribute to a more complete understanding of a policy issue (DRM)" and that "...practitioners may benefit from understanding these different storylines in future development of policy and programmes"[28]. Taking this to heart, this project uses the Resilience Meta-Frames to operationalize the concept of resilience of coastal communities and the design adaptation applied to one of Neskowin's tsunami evacuation routes.

TSUNAMI EVACUATION ROUTES AND RESILIENCE:
Neskowin, Oregon and The Design Response

Why Neskowin, OR?

Every spring, for the past twenty-seven years, my family has made the wet, foggy trip over the Coast Mountains, through the Van Duzer Forest State Corridor, down to Neskowin. What began as a one-off family vacation has become a yearly pilgrimage to the Pacific Ocean. We even began a ritual of refilling a glass jar with seawater and sand each time we visit. We stay in the same collection of beachfront condominiums, which over the years, have gotten closer and closer to the breakers. Neskowin has become a second home to me and my family. It was this connection that helped me decide where to physically locate my research design.

Neskowin is an unincorporated community located in Tillamook County, Oregon (Figure 1.11: Land Use Map of Neskowin). There are 170 permanent residents, but like most coastal communities, this population swells during the summer and holidays. The closest cities are Lincoln City (13 miles south) and Pacific City (10 miles north). Neskowin is 90 miles southwest from Portland. Prominent features include: Slab, Kiwanda and Hawk Creeks, (the latter runs through Neskowin's main neighborhood, the former empties into the Pacific Ocean); a designated wetland habitat managed by U.S. Fish and Wildlife, next door to which is a golf course that is flooded much of the year; and just off shore is a large basalt sea-stack known as Proposal Rock (Figure 1.12: Context Map of Neskowin). The beach, like many on the Oregon coast, is framed by rocky cliffs topped with wind-battered, coniferous trees. Highway 101 runs along the eastern edge of the community and separates Neskowin from the higher elevation of the surrounding hills. This is the only major highway that provides north-south access to the community.

The challenges facing Neskowin, in terms of tsunami evacuation, are like many of the coastal towns in Oregon. The majority of rental properties are within the tsunami hazard zone, as are all the commercial businesses (Figure 1.13: Tsunami Inundation map of Neskowin). The highway presents a barrier between the community and higher ground, and tsunami evacuation route signs are few and far between. The two tsunami evacuation routes that have been marked cross several potentially hazardous barriers–a wetland, bridge and the highway. The area is also estimated to experience 1-2 feet of subsidence, caused by the earthquake[29].

Neskowin does have tsunami inundation and evacuation maps, produced by the Oregon Department of Geology and Mineral Industries (DOGAMI), that are available

27 Aldunce, et al., "Framing disaster resilience", 261.

28 Aldunce, et al., "Framing disaster resilience", 262.

29 "The Oregon Resilience Plan - Cascadia: Oregon's Greatest Natural Threat." Oregon Office of Emergency Management. February 2013.

Figure 1.11: Land use Map of Neskowin

online and in hard copy for residents. A preparedness plan has been created by the community that outlines the overall goal (enhance the safety of residents and visitors) and a list of objectives, for example, developing and implementing a comprehensive plan for response and evacuation for short-term and long-term survival[30].

The choice to focus on tsunami evacuation routes came from my personal observation of the two routes that currently exist. As mentioned before, each route currently presents barriers and potential dangers for residents and visitors during an evacuation. The opportunity to apply an approach that operationalizes resilience when designing tsunami evacuation routes, will benefit Neskowin and other Oregon coast communities.

30 "Neskowin Preparedness Plan". Neskowin Community Association. Accessed on Jan. 28, 2017
http://www.neskowincommunity.org/images/neskowinpreparednessplan.pdf

Figure 1.12: Context Map of Neskowin

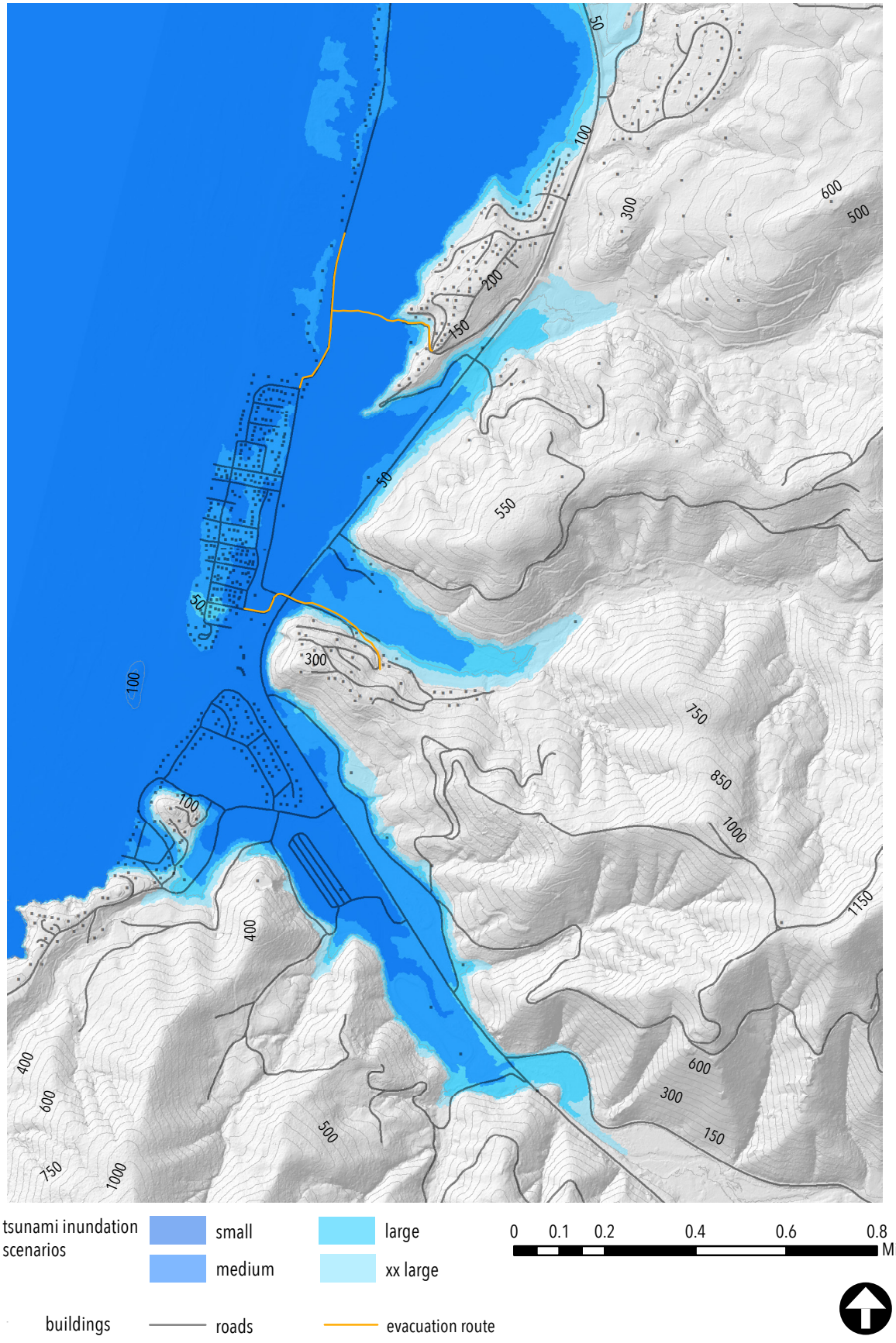


Figure 1.13: Tsunami Inundation map of Neskowin. Elevations are measured in feet above mean sea level.

Data Source: John T. English and George R. Priest, DOGAMI

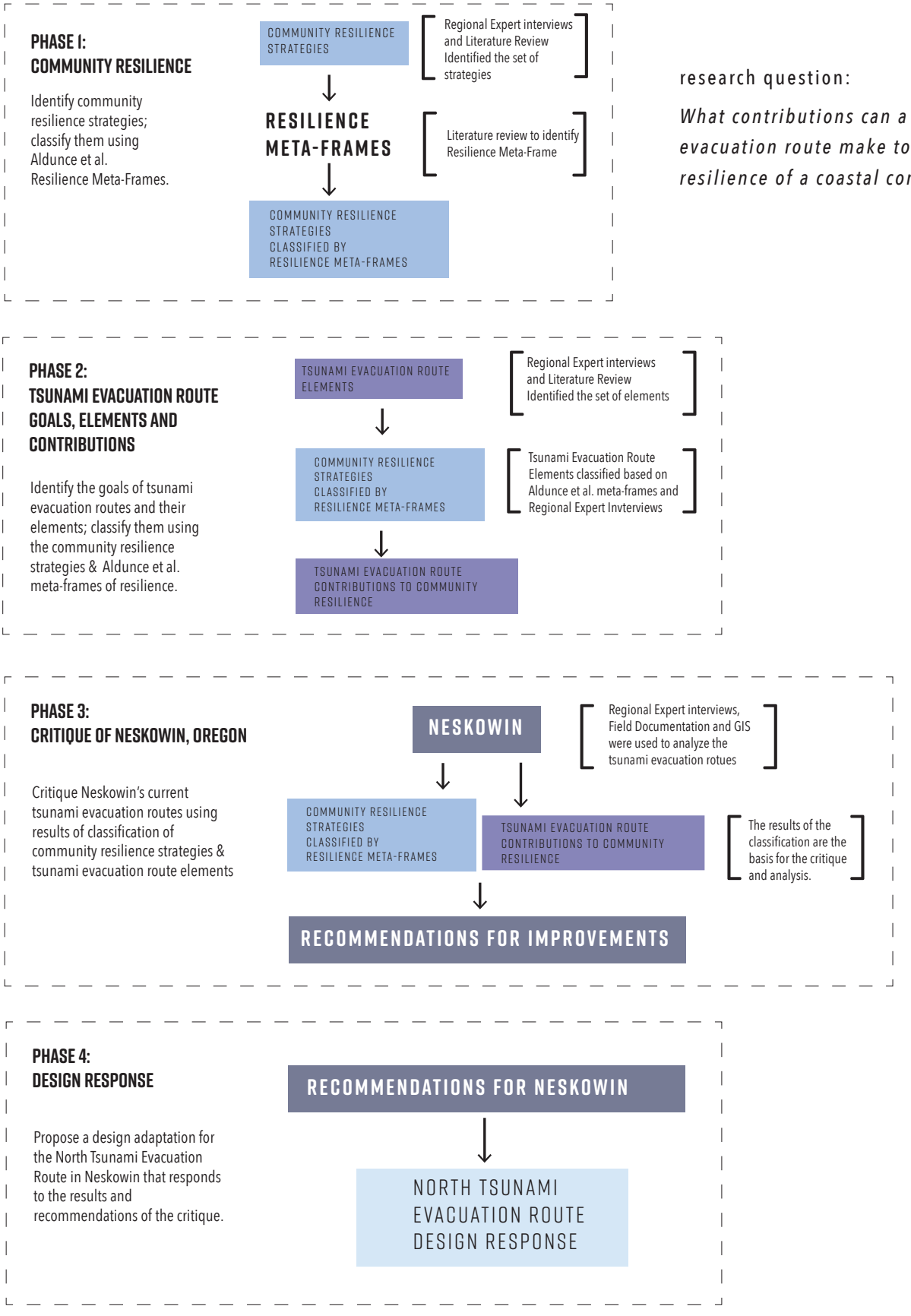
THE SCOPE OF THE PROJECT

The state of Oregon has made it a goal to incorporate resilience into the management and planning strategies that are to address the CSZ earthquake and tsunami. The Oregon Resilience Plan has outlined objectives for achieving resilience at the planning and land-use scale, but it is left up to the communities themselves to figure out what resilience looks like on the ground. The importance of the evacuation route in saving lives makes it a key contributor to the overall resilience of a coastal town or city.

The research question that this project addresses is:

What contributions can a tsunami evacuation route make to increase the resilience of a coastal community?

The scope of a project that attempts to offer any solution to the problem that is presented by a CSZ earthquake and tsunami is large. The variables that exist in natural disaster planning and design require many things that as a graduate student I do not have: ample time, a staff, the budget and 20+ years of experience working in the field. To make this project more manageable, I chose to focus on a specific aspect of CSZ disaster planning: the tsunami evacuation route. It is also in part why I have chosen a relatively small coastal community for the case study site (Neskowin). Even with the efforts to scale down the scope of the project, limitations still exist. For instance, I will not be specifically addressing the effects of the earthquake that precedes the tsunami. I am aware that the earthquake will alter the terrain that evacuees will traverse, but it is outside of my ability (time-wise and expertise-wise) to adequately tackle. Another limitation is that the design can only be evaluated on paper. It is unknown whether the tsunami evacuation route elements that I propose will have the intended effect, unless the design is built. Even modeling such a design will only create estimates of the success or failure of it. As with every design, the intention behind each decision can be fully researched and supported, but it is not truly tested until it is built.



research question:

What contributions can a tsunami evacuation route make to increase the resilience of a coastal community?

Figure 2.1: Methodology Process Diagram

2 METHODOLOGY

THE BROAD STRATEGY OF INQUIRY

The broad strategy of inquiry that this research project is situated within, is that of classification, "...which produces new knowledge by sorting and structuring data into a system of organization, using typical properties, patterns, behaviors, or themes[1]. In the context of this project the data being gathered and organized are community resilience strategies and tsunami evacuation route elements. The framework that the data is sorted by, are the Resilience Meta-Frames created by Aldunce et al. The organization and sorting of both the community resilience strategies and tsunami evacuation route elements is undertaken through the methods of literature review and interviews with five regional experts. By classifying both the community resilience strategies and the tsunami evacuation route elements using the framework provided by Aldunce et al., I seek to operationalize the concept of resilience.

The other components of this project are a critique of Neskowin's tsunami evacuation routes and the design response; the strategies used for these are: evaluation and interpretation (critique), and proposal (design response). The methods used to analyze Neskowin's tsunami evacuation routes for the critique were field documentation and GIS. The regional expert interviews also played part in Neskowin's analysis. The design response is the synthesis of what has been learned from the classification and critique components of the project. The progression from classification, to critique, and then design response, can be compared to the three-part structure of a site analysis where,

"The design process begins, simply enough, with an elaborate classification procedure... a site inventory...The second stage of analysis also involves classification through sorting and grouping, as well as spatial correlation of certain significant patterns. Evaluation methods weigh site information along certain categorical parameters and priorities, in order to rate portions of the site...Finally, site synthesis offers a realignment of these data, a redefinition of the site itself. Through describing new or existing patterns, limits and other themes based on values and intended performance." [2]

The value that the new and existing patterns (of behavior within the context of tsunami evacuation and CSZ event planning) are based on, is that of resilience, which is defined by the Resilience Meta-Frames, the literature review and the regional experts.

THE PROCESS

To answer the research question the project was broken into four phases (Figure 2.1: Methodology Process Diagram):

Phase 1:

Community Resilience - identify community resilience strategies and classify them using Aldunce et al. Resilience Meta-Frames.

Phase 2:

Tsunami Evacuation Route Goals, Elements & Contributions- identify tsunami evacuation route goals and elements. Use the Resilience Meta-Frames to organize the tsunami evacuation

1 Deming, M. Elen and Swaffield, S. Landscape Architecture Research: Inquiry, Strategy, Design. John Wiley & Sons Inc., 2011 (126).

2 Deming, M. Elen and Swaffield, S. Landscape Architecture Research: Inquiry, Strategy, Design. John Wiley & Sons Inc., 2011 (127-128).

route elements by their contributions to the community resilience strategies.

Phase 3:

Critique of Neskowin, Oregon - analyze and critique current tsunami evacuation routes using the results of the classification of the community resilience strategies and tsunami evacuation route elements.

Phase 4:

Design Response - A set of design adaptations that respond to the results of the critique.

In each phase of the project, methods were used that are common to the discipline of landscape architecture[3]. The methods are as follows: literature review, interviews with regional experts, spatial analysis (field documentation and GIS) and design response. The methods reflect the variety of ways of knowing that are inherent in the profession. The specific ways that the methods were applied during each phase of the project are outlined in the following section.

THE METHODS

Three methods were used in the project: literature review, regional expert interviews and spatial analysis. The following section is organized into three broad headings (underlined) using those methods. Subsections within each method heading discuss how that method was used in specific phases of the project. Some of the methods were used in more than one phase.

Literature Review

The sources used in the literature review consisted of peer reviewed articles from journals and government agency reports and research.

Phase 1: Community Resilience

The literature review in the first phase was used to define resilience in operational terms and identify community resilience strategies. The role of the community resilience strategies in answering the research question is to underline what contributions tsunami evacuation routes can make to increase community resilience. To do this, the concept of resilience needed to be expressed in working terms.

The emphasis being placed on resilience within the disaster planning community has brought to light the slipperiness of this term outside of its profession(s) of origin: psychology, ecology and physics[4]. The fact that there is no consensus for where the concept first originated, illustrates the flexibility of the term. Clarity is needed when using the term as a means for describing the quality of a disaster-risk reduction intervention[5]. In the context of a CSZ earthquake/tsunami event in Neskowin, is resilience defined as a desired outcome or as a process leading to desired outcomes or both? The ability to clearly define resilience within the context of a design project, was part of the criteria for scoping the literature review of Phase 1.

As mentioned above, the risk for confusion is high when there is a plethora of definitions that cross multiple disciplines; therefore, it was important to limit the scope of what definitions to use. The challenge of the literature review was to find sources that defined resilience in terms that could be operationalized. The sources consulted were peer reviewed journal articles that focused on the application of resilience in the context of natural hazards and disaster risk reduction programs, and peer reviewed books on urban disaster resilience. In the end the research conducted by Aldunce et al. provided a framework that best supported the goals and objectives

3 Deming, et al., "Landscape Architecture Research", 7.

4 Bernard Manyena, Siambabala. "The concept of resilience revisited". Disasters, Overseas Development Institute. 2006, 30(4): 433.

5 Ibid., 435.

of this project.

Phase 2: Tsunami Evacuation Route Goals, Elements and Contributions

The literature review during this phase of the project identified the goals and elements of a tsunami evacuation route. An example of a tsunami evacuation route element is having lighting along evacuation routes. Defining of the goals of a tsunami evacuation route makes visible the intention behind its design. It could be left to assumption (it seems pretty clear what the goal is), but the risk of misinterpretation or misunderstanding could occur. The tsunami evacuation route elements are key to understanding what contributions to increasing community resilience can be made. The literature review focused on definitions given by sources from urban disaster planning guides produced by government agencies and peer reviewed articles on disaster management.

Phase 3: Critique of Neskowin, Oregon

The literature review for this phase focused on finding information on Neskowin. That included population, history and disaster planning. The results of the review comprised of the disaster risk management plan for Neskowin and, though not strictly from Neskowin, an oral history of an Oregon coast tribe's experience of the last CSZ tsunami event.

Regional Expert Interviews

The regional experts interviewed are from USGS (United States Geologic Survey), Oregon SEA Grant, the Department of Oregon Emergency Management (OEM) and from the University of Oregon.

A review by the Institutional Review Board (IRB) at the University of Oregon of this research project was undertaken and approved. For this project to remain adherent to the IRB's protocols, a strict procedure for the interviews was followed. The interviews took place either in person or over the phone. The regional experts were given a choice of the preferred method of communication. If they choose to speak over the phone, I conducted an informed consent process at that time, which consisted of reading verbatim the consent form and receiving a verbal consent from the regional expert. If they chose to meet in person, I brought a hard copy of the form with me to the interview for them to read. The consent forms were stored in a secure cabinet along with any notes taken from the interview sessions. Each regional expert was asked a few guiding questions, but the conversation was meant to be exploratory.

The guiding questions were geared towards subjects that would help to answer the research question of this project. The questions are as follows:

- What is your involvement and/or role relating to CSZ tsunami evacuation planning?
- What role does resiliency play in current CSZ planning in Oregon? What is your definition of resilience?
- What role do tsunami evacuation routes play in coastal community resiliency?
- What can coastal communities do to become more resilient?

To document these conversations, notes were taken during the interviews, which were made available to the interviewee upon request. The interviews lasted between 30 and 90 minutes- depending on how the conversation evolved and/or the schedule of the regional expert.

Phase 1: Community Resilience

The regional expert interviews were central to identifying community resilience strategies and provided examples of Oregon coast communities currently employing them.

Phase 2: Tsunami Evacuation Route Goals, Elements and Contributions

Through the interviews, over-arching themes were identified that related to how tsunami evacuation routes could contribute to the resilience of coastal communities. These themes were used in organizing the tsunami evacuation route elements into Aldunce et al.'s Resilience Meta-Frames.

Phase 3: Critique of Neskowin, Oregon

The information gathered from the regional expert interviews provides a local viewpoint. The intention of providing a regionally specific perspective is to support and/or refute information found during the literature reviews. The interviews are a check and balance for those literary sources that were not specific to Neskowin or Oregon.

Spatial Analysis: Field Documentation and GIS Analysis

Field Documentation

Phase 3: Critique of Neskowin, Oregon

Without the details of what each tsunami evacuation route is like from the perspective of an evacuee, there can be no way of articulating, in a spatially explicit manner, what challenges people will face during an evacuation. Thus, the field documentation was a key component in critiquing Neskowin.

A week-long site visit of Neskowin was conducted in late September 2017. During this visit, the two tsunami evacuation routes were walked and documented. The documentation process included taking photographs along each route, and recording latitude, longitude, and elevation using an iPhone S6. Brief descriptions were written for each of the photographs highlighting character defining features, such as quality of the ground surface, topography, sounds, above head utilities and vegetation identification. Other parts of Neskowin were also documented in a similar fashion; entrance points to the beach, main roads, landmarks and any informational signs relating to tsunami evacuation or other hazards. The site information (photo number, description, lat./long., etc.) was then transferred into a spreadsheet in preparation for being converted into GIS point data.

GIS Spatial Analysis

Phase 3: Critique of Neskowin, Oregon

The purpose of the GIS analysis was to illustrate spatial features of Neskowin, and relationships (proximity and where overlaps occur). The spatial features were chosen through the literature reviews, regional expert interviews and field work from Phases 1 &2, that identified tsunami evacuation route elements and community resilience strategies. The spatial features represented are:

- tsunami inundation levels,
- ground subsidence projections,
- topography and elevation,
- land use (vegetation communities, areas of development),
- buildings (both residential and commercial),
- roads,
- water (creeks and the ocean), and
- tsunami evacuation sign locations.

The important spatial relationships between the features listed above, were identified from Phases 1 & 2 literature reviews and regional expert interviews, and from the field documentation. The spatial relationships of importance were:

- location of tsunami evacuation routes and proximity to developed areas and buildings;
- elevation and the destination of tsunami evacuation routes (assembly areas);
- location of dead-end roads, creeks and the proximity to tsunami evacuation routes;

- location of tsunami evacuation signs and developed areas;
- land use and the path of tsunami evacuation routes- particularly wetland areas; and
- Areas of subsidence and the path of tsunami evacuation routes.

The GIS data came from multiple sources, including DOGAMI (tsunami inundation and evacuation routes, topography, and subsidence), Tillamook County (buildings, roads and creeks), The State of Oregon Geospatial Enterprise Office (land use) and the field work (tsunami signs).

Design Response

Phase 4: Design Response

After Phase 3, the critique of Neskowin's tsunami evacuation routes, the last component to the project is the design response. This final phase synthesizes the critique of Neskowin and the classification of significant elements of tsunami evacuation routes, into a set of design adaptations for the North Tsunami Evacuation Route in Neskowin. The design response draws on information gathered from the spatial analysis, literature review and the regional expert interviews.

Name	Title	Organization
Pat Corcoran	Coastal Hazards	Oregon Sea Grant, OSU
Andre LeDuc	Chief Resilience Officer	Safety and Risk Services, UO
Jay Raskin, FAIA	Vice Chair	Oregon Seismic Safety Policy Advisory Committee
Althea Rizzo	Geologic Hazards Program Coordinator	Oregon Emergency Management
Nathan Wood	Research Geographer	U.S. Geologic Survey

Table 3.1: Roster of Regional Experts

3 FINDINGS

PHASE I: COMMUNITY RESILIENCE

What are community resilience strategies?

The goal of this project is to identify what contributions tsunami evacuation routes make to increase the resilience of a coastal community. To address this goal, we must identify first what makes a communitiy resilient. What are strategies that coastal communities are using to become resilient? Through interviewing five regional experts, a set of community resilience strategies was compiled.

A list of the participants is found in Table 3.1 Roster of Regional Experts. The regional experts consisted of:

- **Pat Corcoran, Oregon Sea Grant**. Pat is the Extension Coastal Hazards officer for the Oregon Sea Grant, based at Oregon State University. His research focuses on educating Oregonians to be prepared for coastal hazards including earthquakes and tsunamis.
- **Andre LeDuc, University of Oregon**. Andre is the Chief Resilience Officer and Associate Vice President for Safety and Risk Services at the UO. Andre's professional and academic work focuses on developing community and organizational resilience.
- **Jay Raskin, FAIA, Oregon Seismic Safety Policy Advisory Commission (OSSPAC)**. Jay is a practicing architect out of Portland, who is also the Vice-Chair of OSSPAC and a former mayor of Cannon Beach.
- **Althea Rizzo, Oregon Emergency Management (OEM).** Althea is the OEM Geologic Hazards Program Coordinator and a part of DOGAMI's Oregon Tsunami Hazard Mitigation Program.
- **Nathan Wood, US Geologic Survey.** Nate is a Research Geographer at the Western Geographic Science Center. He has been influential in assessing community vulnerability to tsunamis, and was integral in the Beat the Wave project in Seaside, Oregon.

The community resilience strategies derived from the interviews are:

- Incentivize land use planning to move critical institutions outside of inundation zones
- Increase efforts for horizontal and vertical evacuation infrastructure
- Prioritize inexpensive, simple solutions
- Employ tsunami warning signs and maps
- Employ deep-ocean tsunami detection buoys
- Create off-the-grid systems for water, food and energy supplies
- Employ educational programming to familiarize community with evacuation procedures
- Create support systems that link community members together
- Develop redundancies within networks
- Publicize folklore surrounding the CSZ event
- Rely on geography and geological history of the site to dictate how the community is spatially organized.
- Create educational programs about the geologic history of tsunamis on the Oregon Coast.
- Capitalize on the economic role of tourism in relation to the geologic features of the community.

Based on the descriptions given by Aldunce et al., the community resilience strategies can be organized using the

Figure 3.1 Community Resilience Strategies derived from regional experts; Classified by the Resilience Meta-Frames

Resilience Meta-Frame, (Figure 3.1 Community Resilience Strategies Classified by the Resilience Meta-Frames). For example, the community resilience strategies that focus on building relationships between people, are sorted into the community-based Resilience Meta-Frame. Another example would be community resilience strategies that emphasize building infrastructure, which are sorted into the mechanistic/technocratic Resilience Meta-Frame. There are community resilience strategies that can be organized into more than one Resilience Meta-Frame. For example, developing redundancies within networks could apply to either the community-based or sustainable Resilience Meta-Frame, depending on what sort of network you are referring to (whether they are social networks or ecological networks). It is not surprising that there is such overlap, since the community resilience strategies are generated from the regional experts who all have slightly different definitions of what resilience means. It is also not surprising because of the inherent nature of what it means to be resilient.

The strategies serve the goals of preparing for, coping with, withstanding, and recovering quickly from the impacts of a CSZ event[1]. A tsunami evacuation route is just one of the systems and infrastructures that contribute to these goals. In the next phase of the project the contributions that tsunami evacuation routes make to community resilience will be outlined and discussed.

1 Aldunce, et al. "Framing disaster resilience". 257.

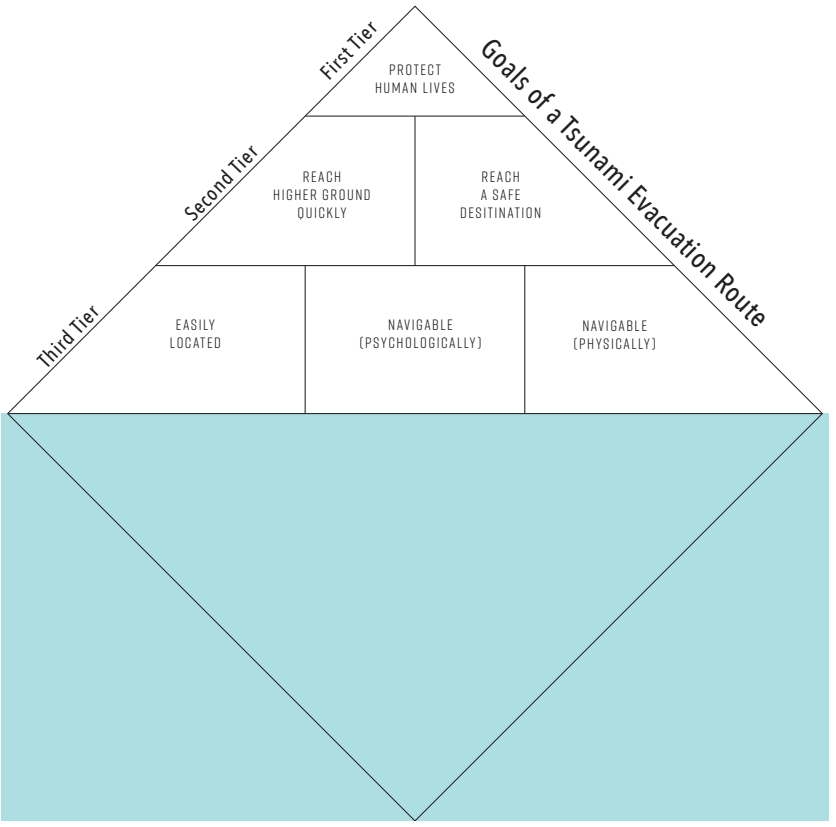


Figure 3.2 Goals of a Tsunami Evacuation Route

PHASE 2: TSUNAMI EVACUATION ROUTE GOALS, ELEMENTS & CONTRIBUTIONS

Evacuation is one of the most important factors in saving lives during a tsunami event, but it is one thing to have memorized instructions (get to high ground fast!) and another to experience an evacuation in real-time. The number of variables (for example terrain, population, demographics, time of day) and the unpredictability of human reactions in a disaster situation, can lead to failures in evacuation. Creating conditions that facilitate evacuation, before a disaster strikes will help reduce the risk of failure. The regional expert interviews and literature reviews have identified a range of tsunami evacuation route elements that facilitate favorable evacuation conditions. It is important to note that not every tsunami evacuation route element will work for every coastal community. The intention of calling out specific tsunami evacuation route elements is to provide communities choices. Ultimately, it is up to communities to decide which elements will best support the evacuation process for that location.

What are the goals of a tsunami evacuation route?

Before delving into what the tsunami evacuation route elements are, the goal of a tsunami evacuation route needs to be addressed. The goal ultimately drives the decision-making process when creating and designing a tsunami evacuation route. The core goal of a tsunami evacuation route is to protect human lives[2]. The core goal is supported by five sub-goals (Figure 3.2 Goals of a Tsunami Evacuation Route):

- To reach higher ground quickly[3]
- To reach a safe destination[4]

2 Hayashi, et. al. "Disaster Resilient Cities". 8.

3 Suppasri, et. al. "Lessons Learned from the 2011 Great East Japan Tsunami". 1017.

4 Cochran, Pat, Oregon Sea Grant, OSU. Phone Interview, 03/15/2017.

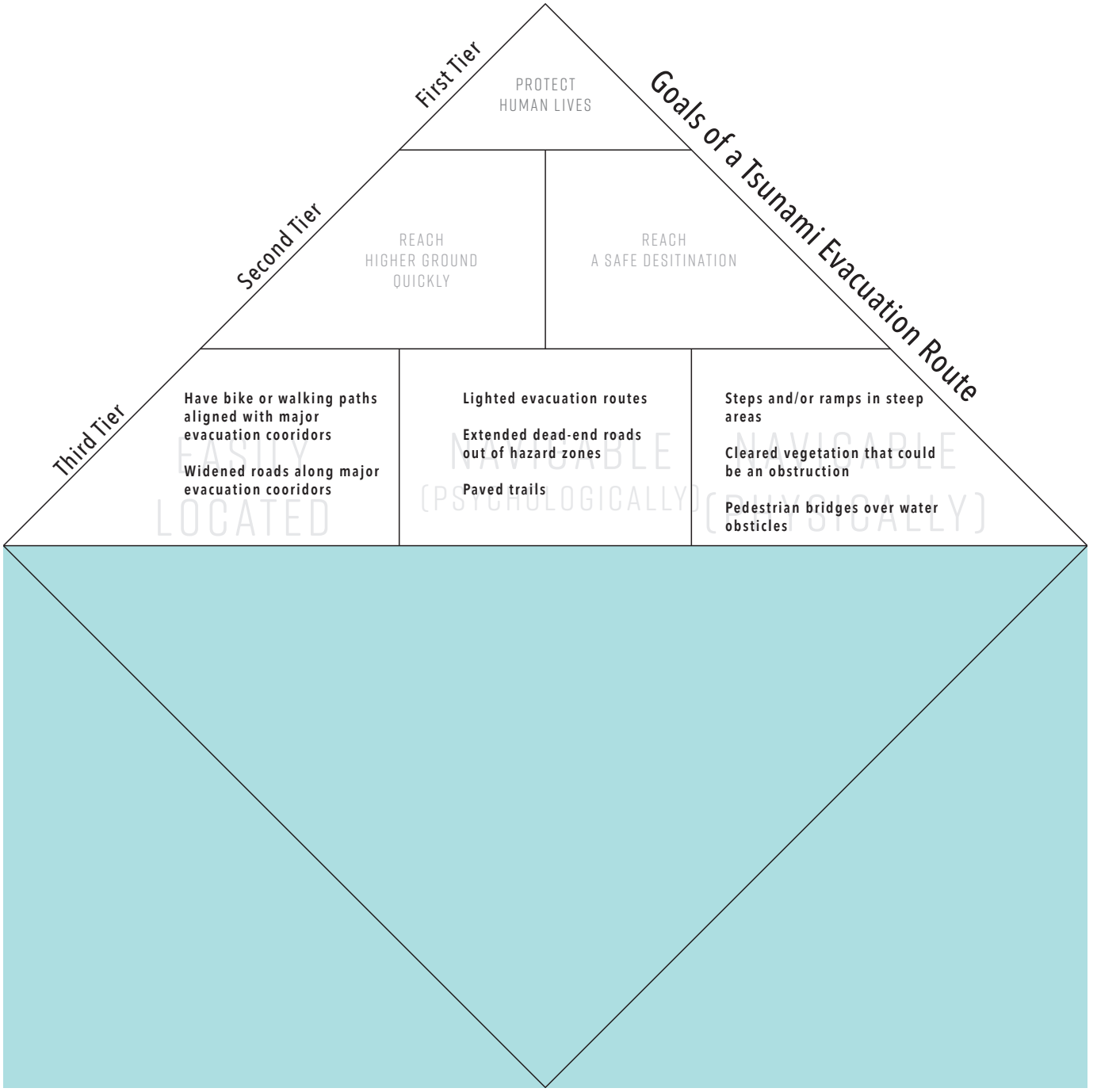


Figure 3.3 Tsunami Evacuation Route Elements and Goals

- Easily located[5]
- Navigable (psychologically)[6]
- Navigable (physically)[7]

The goals are arranged in a 3-tiered hierarchy. The first-tier is the core goal. The second tier calls out two specific qualities that are required from tsunami evacuation routes to "protect human lives", the first being getting people to high ground fast (estimates for the time before the first waves reach shore during a mega-thrust CSZ scenario are between 10-30 mins[8]) and the second being, arriving at a destination that is safe (e.g. is clearly marked, provides shelter, is a large enough space). The thrid tier support those preceding, by becoming even more specific about the qualities desired in an evacuation route. For instance, they must be easy to locate, so one does not waste time trying to find a route; the routes must be navigable - both mentally (easy to follow) and physically (easy to traverse). The heirarchy of goals creates a firm bridge between the broad, concept of "protecting human lives" and the operationalizing of how a tsunami evacuation route achieves that core goal.

What are the tsunami evacuation route elements?

Tsunami evacuation route elements are qualities or sets of qualities intentionally designed into an evacuation route to help meet the route's goals. The elements of a tsunami evacuation route work to achieve the goals outlined above. The list complied in this project is by no means complete; there is always room for others to contribute. The collection of tsunami evacuation route elements identified in this project are as follows (note: the first seven are from the work of Wood, et al.[9]):

1. Have bike or walking paths aligned with major evacuation corridors (e.g. parallel to or intersect with evacuation routes)
2. Lighted evacuation routes
3. Widened roads along major evacuation corridors
4. Extended dead-end roads out of inundation zones
5. Paved trails
6. Steps and/or ramps in steep areas
7. Cleared vegetation that could be an obstruction
8. Pedestrian bridges over water obstacles[10]
9. Emphasis on both the route and the destination- lessen the reliance on one way to evacuate[11]
10. Route supports community economic goals[12],[13]

The design of a tsunami evacuation route is more complex than moving people from point A to point B. The tsunami evacuation route elements work together to support the core goal of protecting human life. These elements do so by addressing the third tier (Figure 3.3 Tsunami Evacuation Route Elements and Goals). For example, having steps and/or ramps in steeper areas improves the physical navigability of a tsunami evacuation route. Other tsunami evacuation route elements cover multiple sub-goals, such as lighting evacuation routes helps people navigate, both physically (improved sight during a night evacuation scenario) and mentally (provides a visual cue that you are following an evacuation route).

The effort to associate the tsunami evacuation route elements with specific goals, is to show how they may be chosen during the designing of a tsunami

5 Portland Urban Architecture Research Lab. Up and Out: Oregon Tsunami Wayfinding Research Project. The PURAL Press, Portland. 2014. 22.

6 Raskin, Jay, FAIA, Vice-Chair, Oregon Seismic Safety Policy Advisory Commission. Phone Interview, 03/29/2017

7 Wood, Nate, Research Geographer, USGS. Phone Interview, 04/13/2017.

8 "Neskowin Preparedness Plan". Neskowin Community Association. Accessed on Jan. 28, 2017 http://www.neskowincommunity.org/images/neskowinpreparednessplan.pdf

9 Wood, Nathan, Jones Jeanne, Schmidtlein, Schelling, John, Frazier, Tim. "Pedestrian flow-path modeling to support tsunami evacuation and disaster relief planning in the U.S. Pacific Northwest." International Journal of Disaster Risk Reduction, 18 (2016) 41-55.

10 Wood, Nate, Research Geographer, USGS. Phone Interview, 04/13/2017.

11 Corcoran, Patrick, Extension Coastal Hazards, Oregon Sea Grant. Phone Interview, 03/15/2017.

12 LeDuc, Andre, Chief Resilience Officer and Associate Vice President, Safety and Risk Services, University of Oregon. In Person Interview, 03/20/2017.

13 Raskin, Jay, FAIA, Vice Chair, Oregon Seismic Safety Policy Advisory Commission. Phone Interview, 03/29/2017.

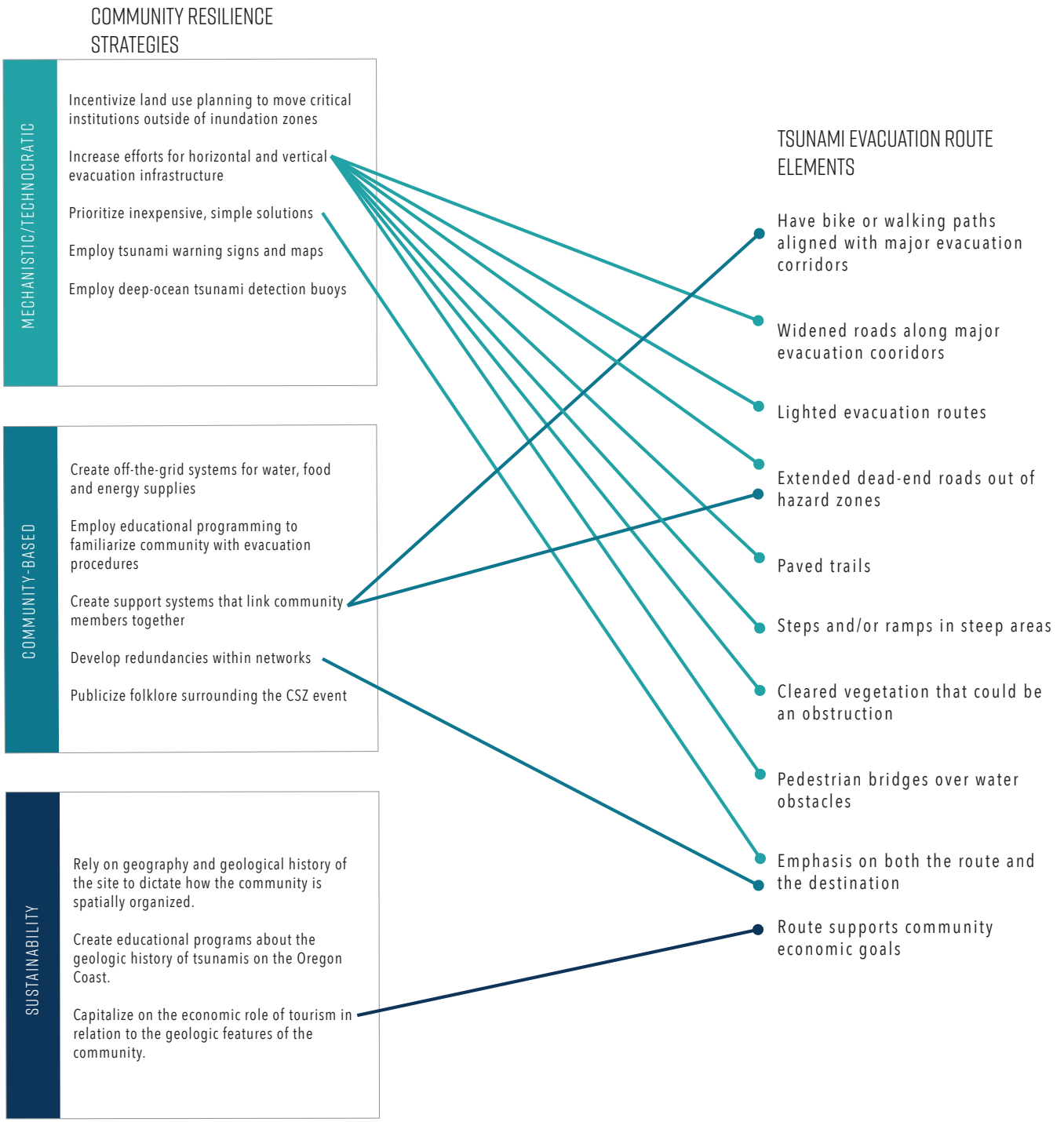


Figure 3.4 Community Resilient Strategies and Corresponding Tsunami Evacuation Route Elements

evacuation route. The consideration of community resilience should also play a part when designing a tsunami evacuation route. The contributions to community resilience that tsunami evacuation route elements make are addressed next.

Tsunami evacuation route element contributions to community resilience

The core goal of a tsunami evacuation route (protecting human life) is inherently a goal of a resilient community. The contribution that a tsunami evacuation route makes within a resilient community is revealed by comparing and connecting the tsunami evacuation route elements to corresponding community resilient strategies (Figure 3.4 Community Resilient Strategies and Corresponding Tsunami Evacuation Route Elements). The connections are based on my synthesis of the information provided by regional experts and the descriptions given by Aldunce et al. of the three categories of the Resilience Meta-Frames. For example, the tsunami evacuation route element "extended dead-end roads outside of inundation area" contributes to the community resilience strategy of "Develop redundancies within networks"; because it establishes multiple evacuation routes, so in case one or more routes are too hazardous to travel by, there will be other safer options. Another example is the tsunami evacuation route element "route supports community economic goals", which can apply to the community resilience strategy of " Capitalize on the economic role of tourism in relation to the geologic features of the community", because the evacuation route could be designed to function as a hiking or mountain bike trail, which draw visitors to the community.

As can be seen in Figure 3.4, the majority of tsunami evacuation route elements make contributions to community resilience strategies that are classified under the mechanistic/technocratic Resilience Meta-Frame. As discussed in the introduction of the project, relying on hard infrastructural measures is not enough. The challenge is that tsunami evacuation routes are inherently an infrastructural measure. This fact highlights the important role of programming components when designing a tsunami evacuation route. There can be many ways to add programming components (community events, educational activities, etc.) to a tsunami evacuation route that will increase its contributions to the other community resilience strategies. For example, the town of Cannon Beach, Oregon organized a 5k run that started at the beach, and followed a tsunami evacuation route to end at an assembly area[14]. This event addressed the community resilience strategy "Employ educational programming to familiarize community with evacuation procedures". The role of programming, in relation to the tsunami evacuation route elements, is to expand and/or enhance the element's contributions to resilience outside of the mechanistic/technocratic Resilience Meta-Frame into the community-based and sustainability Resilience Meta-Frames.

During the interviews with regional experts and the process of organizing the tsunami evacuation route elements into community resilience strategies, several underlying patterns emerged. These patterns were common, over-arching traits of the tsunami evacuation route elements that contribute to community resilience. The themes are: increase efforts to familiarize people with evacuation, engaging the community through education or recreational activities, and supporting local economic goals. These traits can be framed as additional goals of tsunami evacuation routes that contribute to community resilience (Figure 3.5 Additional Goals of Tsunami Evacuation Routes). The additional goals are,

- Increase Familiarity of people about the CSZ tsunami and evacuation procedures.
- Engage Community with the procedures for evacuation.
- Generate Revenue for the maintenance and building of

14 Raskin, Jay, FAIA, Vice Chair, Oregon Seismic Safety Policy Advisory Commission. Phone Interview, 03/29/2017.

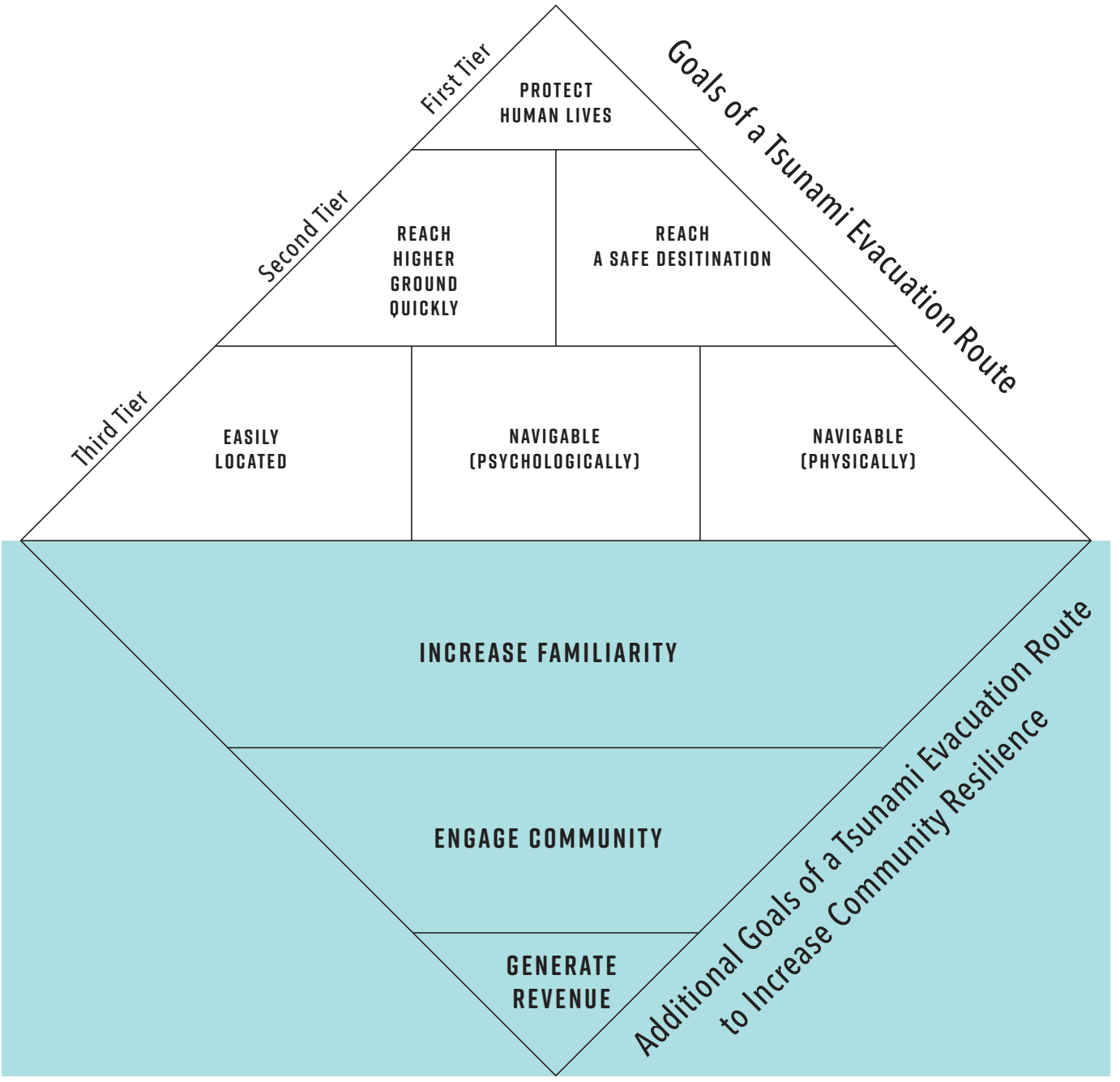


Figure 3.5 Additional Goals of Tsunami Evacuation Routes

infrastructure and programming related to CSZ event planning.

These additional goals are extensions to the first set of goals of tsunami evacuation routes identified earlier (Figure 3.2). For example, the additional goal of "increasing familiarity" is related to the goals of "easily located" and "navigable- psychological", because with an increased familiarity, tsunami evacuation routes become a part of the collective memory and knowledge-bank of a community and are thus easier to locate. The difference lies in the intention of familiarization, which in the context of this project, is to bring the tsunami evacuation route into the daily life of a coastal community[15]. The incorporation into daily life of a tsunami evacuation route, extends the traditional temporal scope of its intended use (e.g. during a tsunami evacuation). The incorporation into daily life is what can make an evacuation route a contributor to resilience[16].

The additional goals of community engagement and generating revenue address the need for long-term, economic stability and the need for the shift in thinking along the lines of "long-term creation of safe and secure societies"[17]. For example, community engagement can be used to establish a folklore around tsunamis on the Oregon coast and the CSZ, through the use of educational programming, like informational signs. Community engagement and it's role in creating a folklore, can be classified under the community-based Resilience Meta-Frame. It can also be sorted into the sustainable Resilience Meta-Frame, because it is encouraging people to adjust their behavior to adapt and prepare for a disaster. When communities can take ownership over solutions and preparations for these events, they become active participants, instead of passive victims.

The shift towards long-term saftey and security occurs because the community is not only being confronted with the fact of the future disaster, but they are also becoming aware of the history of the CSZs presence in the region. This is important because it forces people to realize that they must be flexible – the CSZ is not going to change course. One example of how community engagment can highlight history is through the use of oral histories from Oregon coast tribes that have been passed down that tell of a great wave that brought destruction upon many villages[18].

A point stressed in the regional expert interviews was the need for an economically resilient community. Most of the coastal towns and cities along the Oregon coast cannot afford to pay for large built projects that do not have impact on day-to-day life, and do not generate revenue. This is reflected in the addition of "generate revenue" in the goals of a tsunami evacuation route and the community resilience strategy of " Prioritize inexpensive, simple solutions". Therefore, the extension of tsunami evacuation route contributions to community resilience should include financial considerations. It must be noted that the regional experts brought up many interesting and important points, but not all were in direct relation to tsunami evacuation routes. The notes from each interview were broken into thematic categories to better organize and facilitate synthesis. The notes can be found in Appendix A.

With the identification of the additions to the goals of a tsunami evacuation route, the contributions that tsunami evacuation routes make to community resilience can be extended. The following section explores this.

15 Raskin, Jay, FAIA, Vice Chair, Oregon Seismic Safety Policy Advisory Commission. Phone Interview, 03/29/2017.

16 Corcoran, Patrick, Extension Coastal Hazards, Oregon Sea Grant. Phone Interview, 03/15/2017.

17 Hayashi, Yoshitsugu, et. al."Disaster Resilient Cities: Concepts and Practical Examples". Butterworth-Heinemann, March 2016. 4.

18 Yonker, Jason. "Weaving Long Ropes: Oral Tradition and Understanding the Great Tide". Oregon Historical Quarterly, vol. 108, no. 2. Summer 2007, pp. 193-201

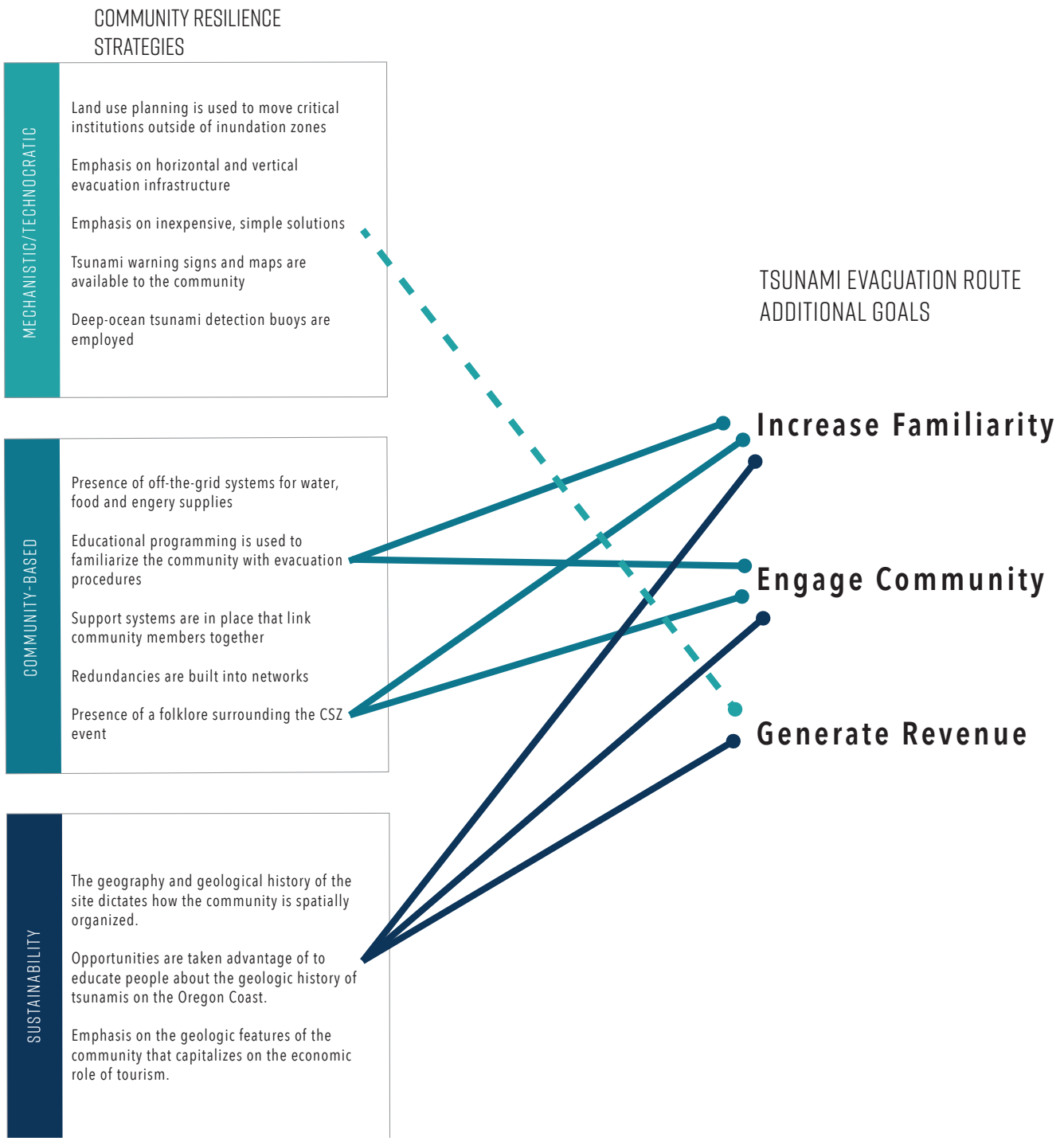


Figure 3.6 Tsunami Evacuation Route Additional Goals and Community Resilience Strategies

Additional contributions to community resilience by tsunami evacuation routes

The use of programming and education to increase community resilience, as discussed before, falls under the Resilience Meta-Frames of community-based and sustainability approaches. The additional contributions to community resilience that tsunami evacuation routes make, can be found by revisiting the community resilience strategies that were classified under the community-based and sustainability Resilience Meta-Frames. Based on the regional expert interviews we can organize the additional tsunami evacuation route goals with the community resilience strategies. This organization leads to the identification of potential community resilience strategies that tsunami evacuation routes can contribute to (Figure 3.6 Potential Community Resilience Strategies):

- Prioritize inexpensive, simple solutions
- Employ educational programming to familiarize community with evacuation procedures
- Support systems in the community, linking people together
- Publicize folklore surrounding the CSZ event
- Create educational programs about the geologic history of tsunamis on the Oregon Coast.

A common thread that runs through the list is education and community involvement. It also should be noted that these community resilience strategies fit well with the tsunami evacuation route goals of increased familiarity and engaging the community. Tsunami evacuation routes already include some level of education about the hazard of a tsunami simply by their presence. Similarly, the linear form of an evacuation route, one that transects across the community, automatically creates opportunities for linking people together. Opportunities to extend the tsunami evacuation route contributions to community resilience can be made with the addition of targeted programming of tsunami evacuation route elements that incorporate the community resilience strategies identified above.

The next phase of this project (Phase 3) is the critique of the current tsunami evacuation routes in Neskowin, Oregon. The critique incorporates the findings from Phases 1 and 2 (community resilience strategies and the goals, elements, and contributions to community resilience of tsunami evacuation routes), with the spatial analysis (field documentation and GIS) of Neskowin.

Figure 3.7: Neskowin Entry Tsunami Sign

Figure 3.8: Plenty Fish Entry Sculpture

PHASE 3: CRITIQUE OF NESKOWIN, OREGON

The entrance to Neskowin is marked by one of two tsunami evacuation signs that are present in the community. It points to a road through a residential community tucked away in the surrounding hillsides (Figure 3.7: Neskowin Entry Tsunami Sign). Once you turn west, off Highway 101 you are greeted by the wooden sculpture of a salmon (Neskowin means "Plenty Fish" in the language of the Nestucca band of the Tillamook tribe) (Figure 3.8: Plenty Fish Entry Sculpture). The parking lot nearby has an informational sign alerting visitors of the various hazards that exist at any Oregon beach (sneaker waves, rolling logs, etc.), but relegates a tsunami to the fine print near the bottom of the list (Figure 3.9: Visitor Parking Lot Informational Sign). The lack of emphasis on tsunami hazard is understandable. It is easy to forget about a future catastrophic event when the activities of the present day are much more tangible and, compared to the regular occurrence of other hazards, a tsunami can seem like a mythological beast. It is not until reaching the northern edge of Neskowin that one sees another tsunami evacuation route sign.

The two posted evacuation routes act as parentheses (Figure 3.10 Neskowin Tsunami Evacuation Route Locations),

Figure 3.9: Visitor Parking Lot Informational Sign

one to the North across a wetland (Figure 3.11 North Evacuation Sequence), and one to the South across Hawk Creek and Hwy 101 (Figure 3.12 South Evacuation Route). Both have stretches of paved surface, although the North route's stint through the wetland is compacted soil and gravel, with a wooden bridge over where Hawk Creek runs through. Both have moments where the elevation increases rapidly over short distances (no more than 30 feet), creating instances where the slope reaches 70% . Both cross over bridges, the South concrete bridge is approximately 6' above the water's surface accommodating cars and foot traffic (Figure 3.12). The North bridge is a wooden footbridge, 6' across, with a ramp on the east end (Figure 3.11). Both routes have undetermined ends if one is not consulting an evacuation map. There is no on-the-ground indication that you are outside of the tsunami inundation zone, or whether you have reached the designated assembly area.

In between the bracket of the two evacuation routes are rental houses, condominiums, hotels and a (very) small commercial area (the Hawk Creek Cafe and the general store). The location of the routes was determined by the community working in tandem with DOGAMI (Oregon Department of Mineral and Geological Industries). However, the routes traverse over terrain that could prove to be hazardous during an evacuation (both cross Hawk Creek and Hwy 101). There are few sidewalks, meaning that for most of the neighborhood, cars, pedestrians, and the occasional bicyclist, all share the same space. There are also several streets that are dead-end for car traffic, but some social trails have cropped up that allow pedestrians to move through. The configuration of the tsunami evacuation routes in Neskowin is typical for a small town on the Oregon Coast. Emphasis is on signs and mapping to address the goal of protecting human lives. This strategy is simple and inexpensive and requires very little maintenance on behalf of the community.

Figure 3.10 Neskowin Tsunami Evacuation Route Locations

To determine the contributions that Neskowin's tsunami evacuation routes make to community resilience, we must identify what tsunami evacuation elements currently exist and what community resilience strategies are being employed. This will be explored in the following section.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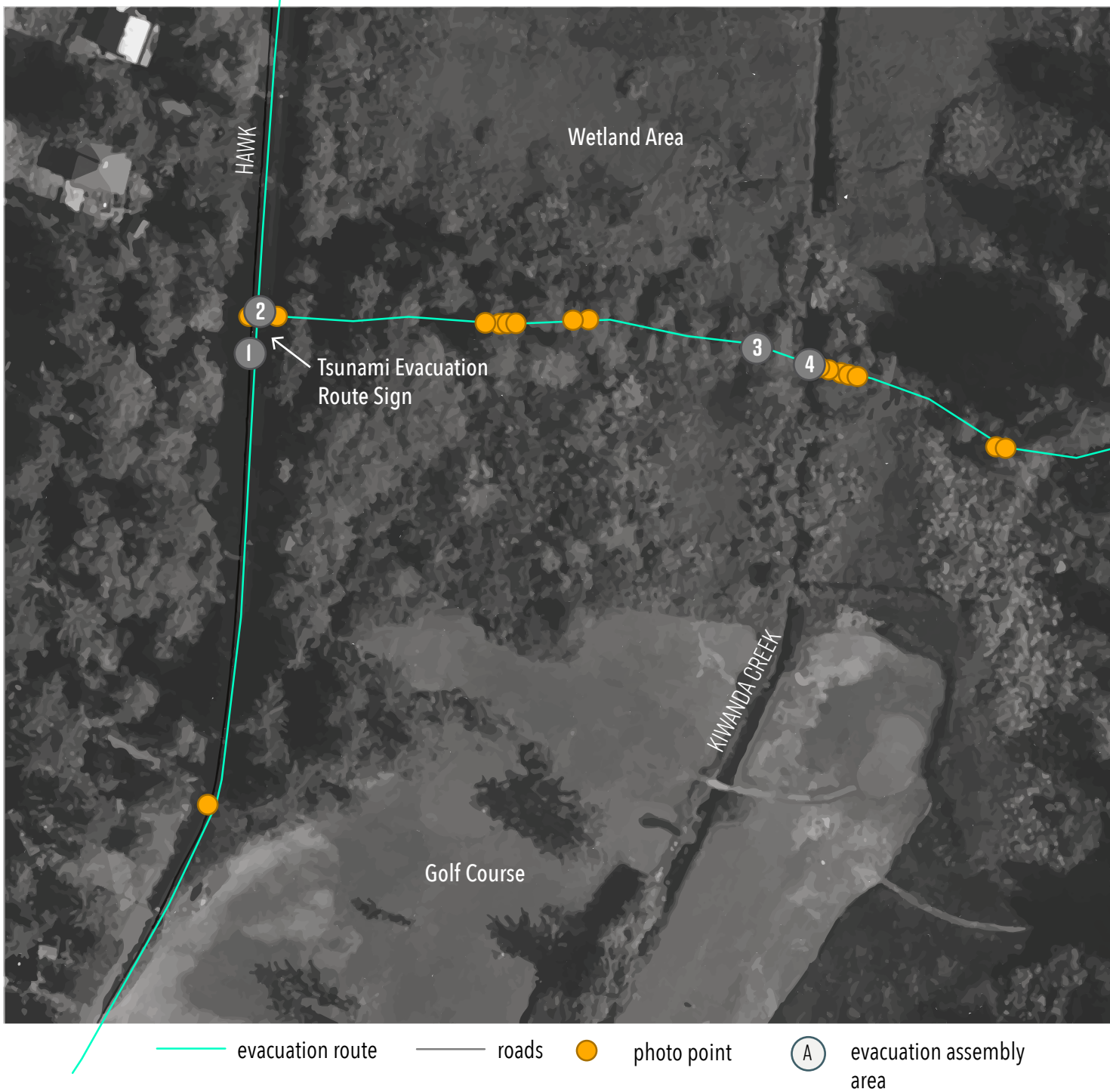
HAWK
Wetland Area
2
1
Tsunami Evacuation
Route Sign
3
4
KIWANDA CREEK
Golf Course
evacuation route
roads
photo point
A
evacuation assembly
area

Figure 3.11 North Evacuation Sequence

evacuation route

roads

photo point

A evacuation assembly area

5

6

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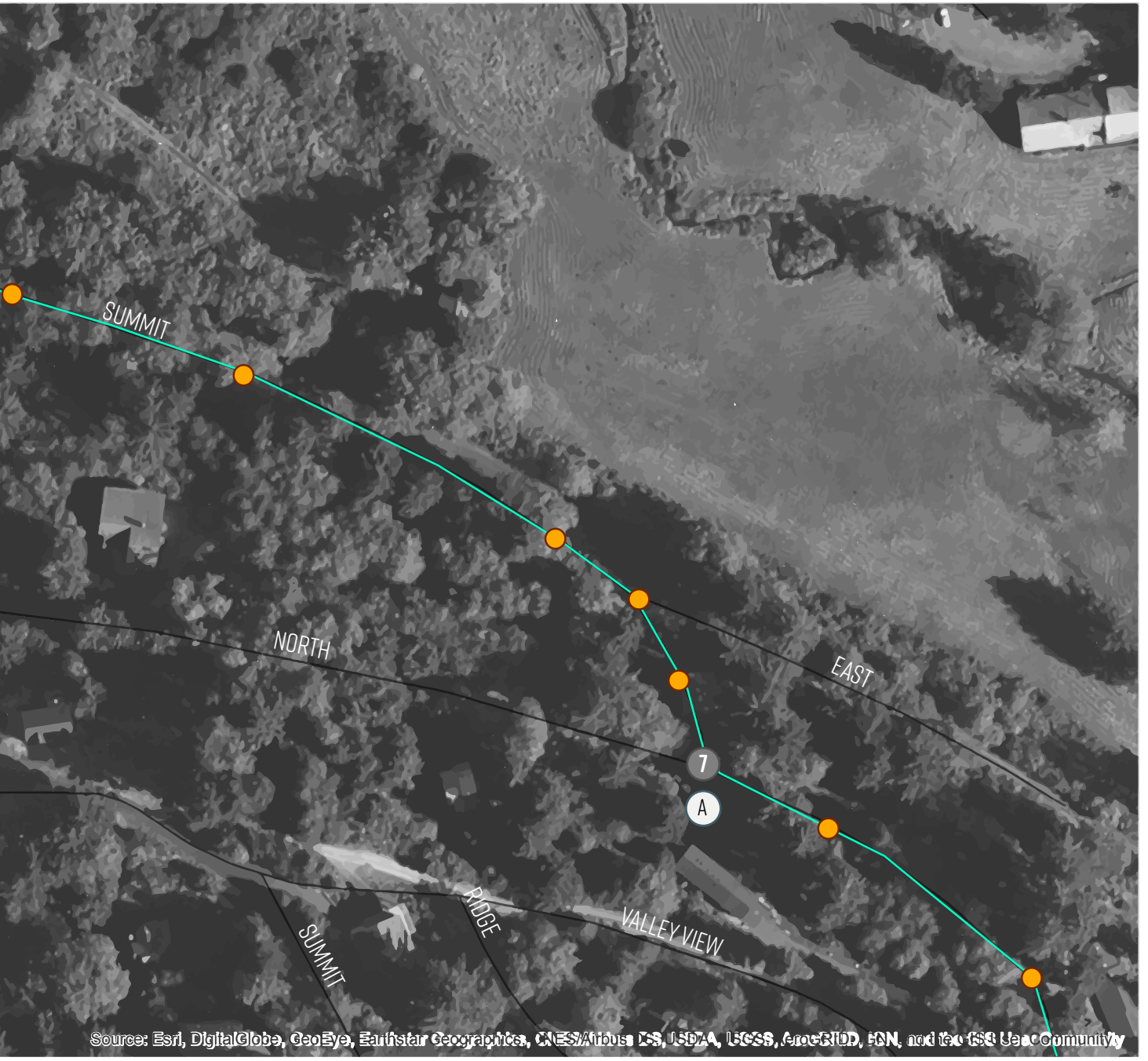


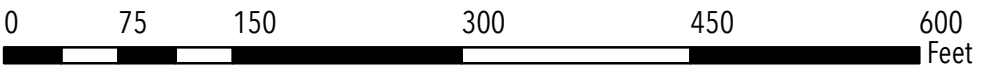


Figure 3.12: South Evacuation Sequence

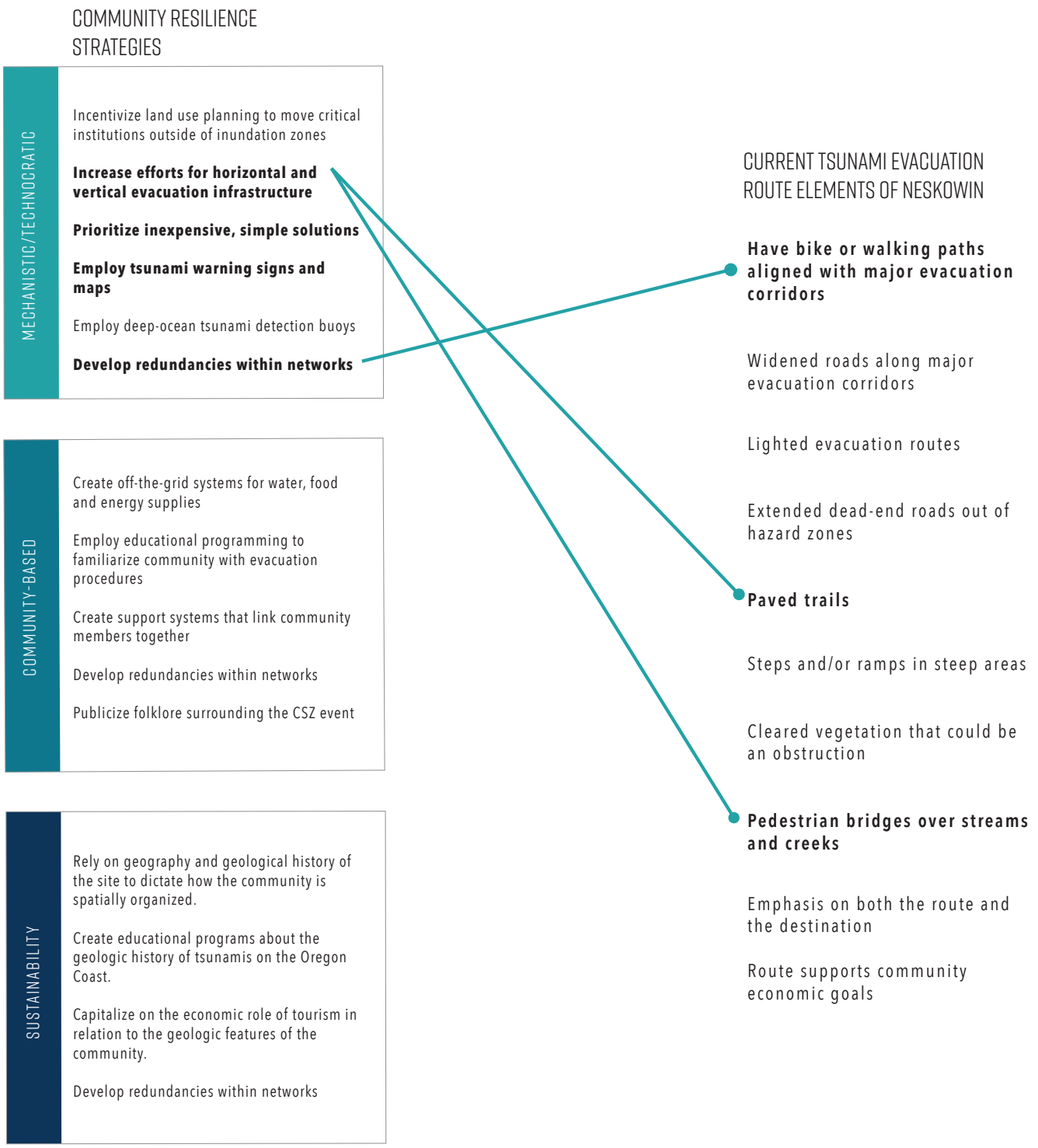


Figure 3.13 Current Tsunami Evacuation Route Elements of Neskowin

Neskowin's Tsunami Evacuation Elements and Community Resilience Strategies

Looking to the set of community resilience strategies identified in Phase 1, and based on the regional expert interviews, literature reviews and field documentation, the strategies that Neskowin currently employs are:

- Increase efforts for horizontal evacuation infrastructure
- Prioritize inexpensive, simple solutions
- Employ tsunami warning signs and maps
- Develop redundancies within networks

The tsunami evacuation route elements identified in Phase 2 that are present in Neskowin are (Figure 3.13 Current Tsunami Evacuation Route Elements of Neskowin) :

- Have bike or walking paths aligned with major evacuation corridors.
- Paved trails (Except for the segment of the North Evacuation Route that goes through the wetland).
- Pedestrian bridges over streams and creeks (whether they are seismically sound is a concern).

The sparsity of both the community resilience strategies and the tsunami evacuation route elements, could indicate the lack of funding for major interventions. The lack of funding stems from a larger issue of cost-to-benefit ratio, where government funding is allocated to areas of dense populations and areas of high risk, e.g. far from higher elevations, large populations of vulnerable groups (elderly, low income, etc.)[19].

Based on estimates of population and owner occupancy, Pat Corcoran estimates that 70 houses are occupied, on average, in Neskowin. Compared with larger cities, such as Seaside and Newport, Neskowin (like many other unincorporated territories) is a potential casualty in the aftermath of a CSZ disaster. Jay Raskin, made the point that "Some communities and cultures may disappear if they are not able to adapt or cope with post-disaster conditions" and smaller communities, like Neskowin, could end up fading away[20].

The tsunami evacuation route goals of increasing familiarity, engaging the community and generating revenue could help Neskowin, as a culture and community, to survive after a CSZ disaster. What tsunami evacuation elements can be added to Neskowin's current configuration to increase community resilience and achieve these goals? This can be answered by using the same classification process used in Phase 2, where by tsunami evacuation route elements are organized by the contributions to community resilience strategies.

19 Corcoran, Patrick, Oregon Sea Grant. Phone Interview. 03/15/2017.

20 Raskin, Jay, FAIA, OSSPAC. Phone Interview. 03/29/2017.

Figure 3.14 Map of Challenge areas in Neskowin

Recommendations for Neskowin's tsunami evacuation routes

The assumed answer to the question "what tsunami evacuation elements can be added to Neskowin's current configuration to increase community resilience?" would be: *all of them*. But there are site-based constraints that make implementation of some tsunami evacuation elements more appropriate than others. For instance, it would be a major under-taking to widen the road along the major evacuation corridors, especially the North evacuation route that runs through a wetland and is managed by U.S. Fish and Wildlife. Widening the main road into Neskowin would mean rebuilding the bridge over Hawk Creek and incorporating private property (portions of front yards would be needed). There is also the question of whether the small population requires the widening of roads or if there is a different tactic to addressing the issue of pinch-points along evacuation routes. The specific challenges with Neskowin's current tsunami evacuation routes include (Figure 3.14 Map of Challenge areas in Neskowin):

a. Dead-end streets that limit outlets outside of the inundation zone,
b. Steep slopes on portions of both evacuation routes,
c. No significant lighting on portions of the North and South evacuation routes, and
d. Encroaching vegetation on Social trails through the main neighborhood and on the North evacuation route.
e. Few pedestrian bridges over Hawk Creek.
f. Insufficient wayfinding for locating assembly areas.

These challenges were identified by the spatial analysis (field documentation and GIS analysis). The majority of challenges can be ameliorated by the implementation of the following tsunami evacuation route elements:

- **Extend dead-end roads out of hazard zones-** increases the options for evacuation throughout the community, increasing outlets to higher ground.
- **Lighted evacuation routes-** portions of both the North and South evacuation routes are lit by streetlamps, but if that system is damaged in the preceding earthquake, a separate lighting system, just for evacuation routes, would help increase the visibility during a night evacuation.
- **Steps and/or ramps in steep areas-** Both evacuation routes (North and South) swiftly climb in elevation, presenting challenges to portions of the population that need assistance.
- **Cleared vegetation that could be an obstruction-** the North evacuation route, when crossing the wetland, becomes a trail that is bordered by large vegetation. The clearing of vegetation may also be applied to maintaining social trails that already exist in the community.
- **Pedestrian bridges over water obstacles-** Currently there is only the main bridge over Hawk Creek.

By organizing the recommended tsunami evacuation route elements with the corresponding community resilience strategies, we can identify these opportunities (Figure 3.15 Community Resilience Strategy Opportunities for Neskowin). The community resilience strategies that the recommendations identify are:

- Increase efforts for horizontal and vertical evacuation infrastructure,
- Develop redundancies in networks.

Both of these strategies take a mechanistic approach to achieving resilience. This is not surprising knowing that tsunami evacuation routes are inherently a horizontal evacuation Infrastructure. To reach beyond the mechanistic approach, we must also look to the goals of a tsunami evacuation route (Figure 3.5) and the set of potential community resilience strategies that tsunami evacuation routes can contribute to (Figure 3.6) that were identified in Phase 2.

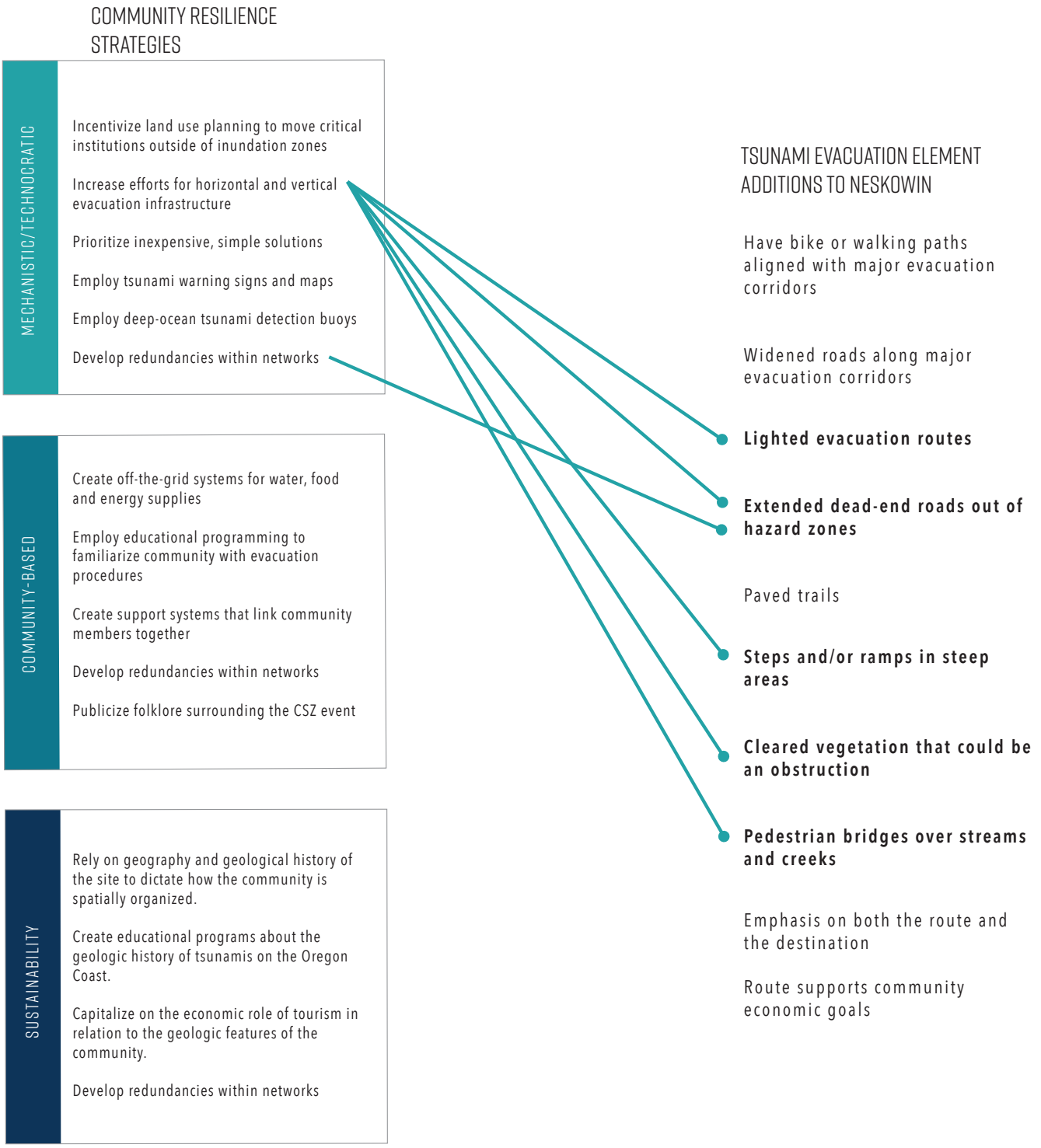


Figure 3.15 Community Resilience Strategy Opportunities for Neskowin

The recommended tsunami evacuation elements while being able to address the current challenges facing Neskowin, could present new challenges for the community:

- **Extend dead-end roads out of hazard zones-** a major hurdle for implementing this will be how to extend the roads through the golf course and across Hawk Creek without completely changing the character of those areas. It would also increase the number of points that cross Hwy 101 and require new trails and/or roads in the Hawk Creek Hills.
- **Lighted evacuation routes-** depending on the shape and size of the lights, they could block significant views and add to the visual clutter of infrastructure. Also, depending on size, they could become an obstruction to evacuation.
- **Steps and/or ramps in steep areas-** Ramps could require intrusions into private property, if grading requires switch-backs to keep the slope to a minimum. Having switch-backs could lead to an increase in the time it takes to evacuate. Steps and ramps will require a significant investment in the design, materials and labor.
- **Cleared vegetation that could be an obstruction-** The trees and shrubs along the North evacuation route, as it crosses through the wetland, make up the habitat of that area. Removing them will not only affect the character of the trail, but there is the danger that it will have negative impacts on the species and organisms present in the wetland.
- **Pedestrian bridges over water obstacles-** similar to the extension of dead-end roads, additional bridges over Hawk Creek will involve major vegetation removal, as well as the building of the bridges, which increases the cost of implementation.

The addition of any tsunami evacuation route element to Neskowin's current configuration, will change the character of the area in some way. That is the nature of design and a requirement for any resilient coastal community; it "requires people to take a step back and see what they want their community to look like afterwards (after a disaster)."[21]. The role of the landscape architect is to help communities visualize what could be; to help establish positive changes that will be sustainable over time.

What could Neskowin look like with the implementation of some of the recommendations? The next and final phase (Phase 4: Design Response) presents a set of design adaptations applied to the North tsunami evacuation route in Neskowin, that address this question.

21 Wood, Nathan, USGS. Phone Interview. 04/13/2017.

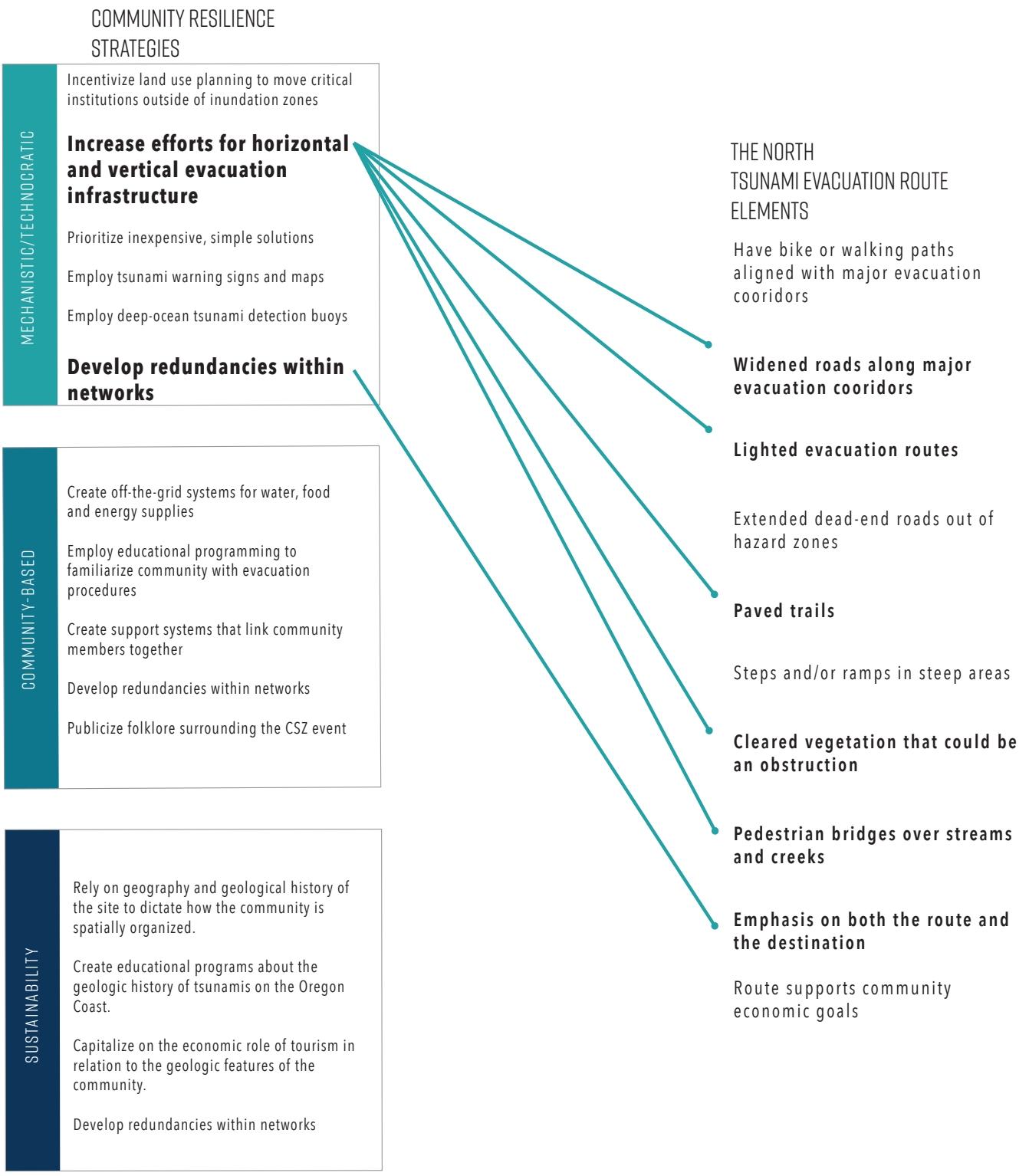


Figure 4.1 North Route Tsunami Evacuation Route Element Identification

4 DESIGN RESPONSE

PHASE 4: THE DESIGN RESPONSE

The Design Response Process

The design response first uses the results from the critique of Neskowin's tsunami evacuation routes to identify what tsunami evacuation elements can address the challenges listed in Chapter 3 and what their contributions to community resilience are (Figure 4.1 North Route Tsunami Evacuation Route Element Identification). The connections being made between the tsunami evacuation route elements of the North Route and the contributions to a resilient community, are based on my interpretation of the definitions given by Aldunce et al. for the Resilience Meta-Frames (Figure 1.10), discussed in Chapter 1, and the characteristics of a resilient community (Figure 3.5), discussed in Chapter 3.

Following the identification of tsunami evacuation route elements that address the challenges presented by the North Route, the design response took into consideration the potential community resilience strategies identified by the additional tsunami evacuation route goals (Figure 3.6), that were discussed in Chapter 3. The end results are a set of design adaptations that address the goals of a tsunami evacuation route and increase the resilience of Neskowin.

Challenges with the North Tsunami Evacuation Route

The North tsunami evacuation route (referred to in this chapter as the North Route) in Neskowin is approximately 1,500 feet long, beginning at the entry to the wetland trail and has an increase in elevation of 150 feet (Figure 4.2 North Route Elevation Section). The North Route will be the focus of the design response. The critique of Neskowin pointed out one of the current challenges of the North Route: the unpaved wetland trail that floods regularly during the winter and spring. The muddy terrain and uneven ground make it hard for anyone without sure-footing to traverse, let alone someone in a wheelchair. Therefore, the North Route presents a need for redesign when looking at the very basic function of a tsunami evacuation route – to move people outside of the inundation zone. The other challenges of the North Route are:

Insufficient wayfinding: only one tsunami evacuation route sign at the entrance to the wetland trail shows which way to go (Figure 4.3 North Route tsunami evacuation route entrance sign). There are no signs guiding people to the entrance and after crossing the wetland trail, people are on their own to determine how far they need to go until they reach safety.

Danger of fallen vegetation: The wetland trail runs through a highly-vegetated area, particularly through the wetland trail portion, as mentioned in Chapter 3. Many

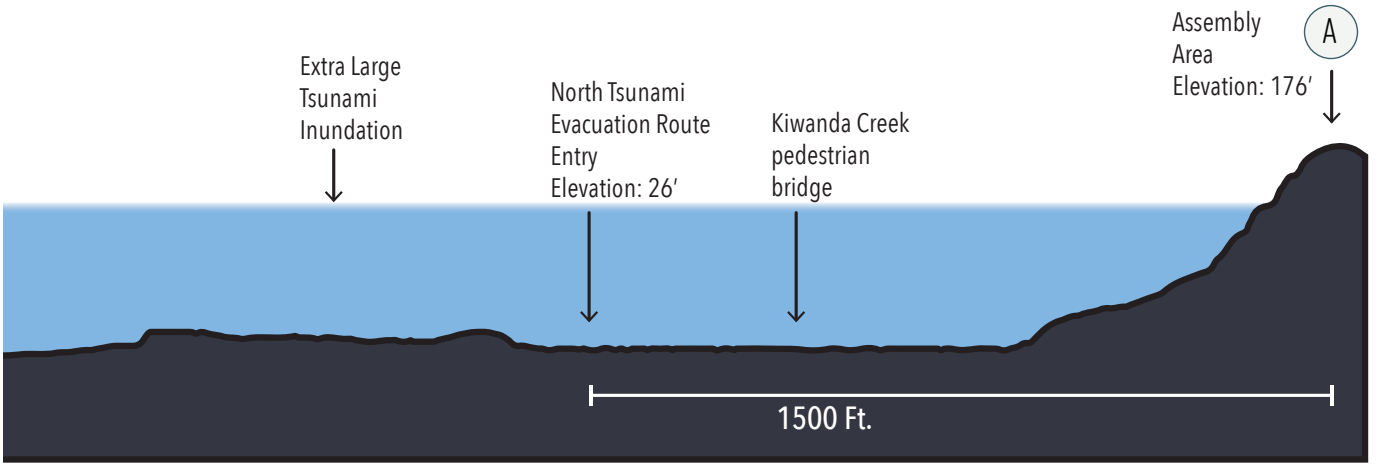


Figure 4.2 North Route Elevation Section

Figure 4.3 North Route tsunami evacuation route entrance sign

Figure 4.4 North Route wetland trail vegetation

of the trees are Alders and Spruce, with an understory of Salmonberry and Willow (Figure 4.4 North Route wetland trail vegetation). A few of the Alders lean over the trail and if they fell, would present a barrier for anyone trying to evacuate.

No ramp on pedestrian bridge: The wooden pedestrian bridge across Kiwanda Creek presents a challenge for anyone with a disability, because only one end of the bridge has a ramp; the western end has a 6" drop to the ground (Figure 4.5 North Route pedestrian bridge).

The goal of the design response is to address these challenges in a way that also increases the resilience of Neskowin.

Figure 4.5 North Route pedestrian bridge

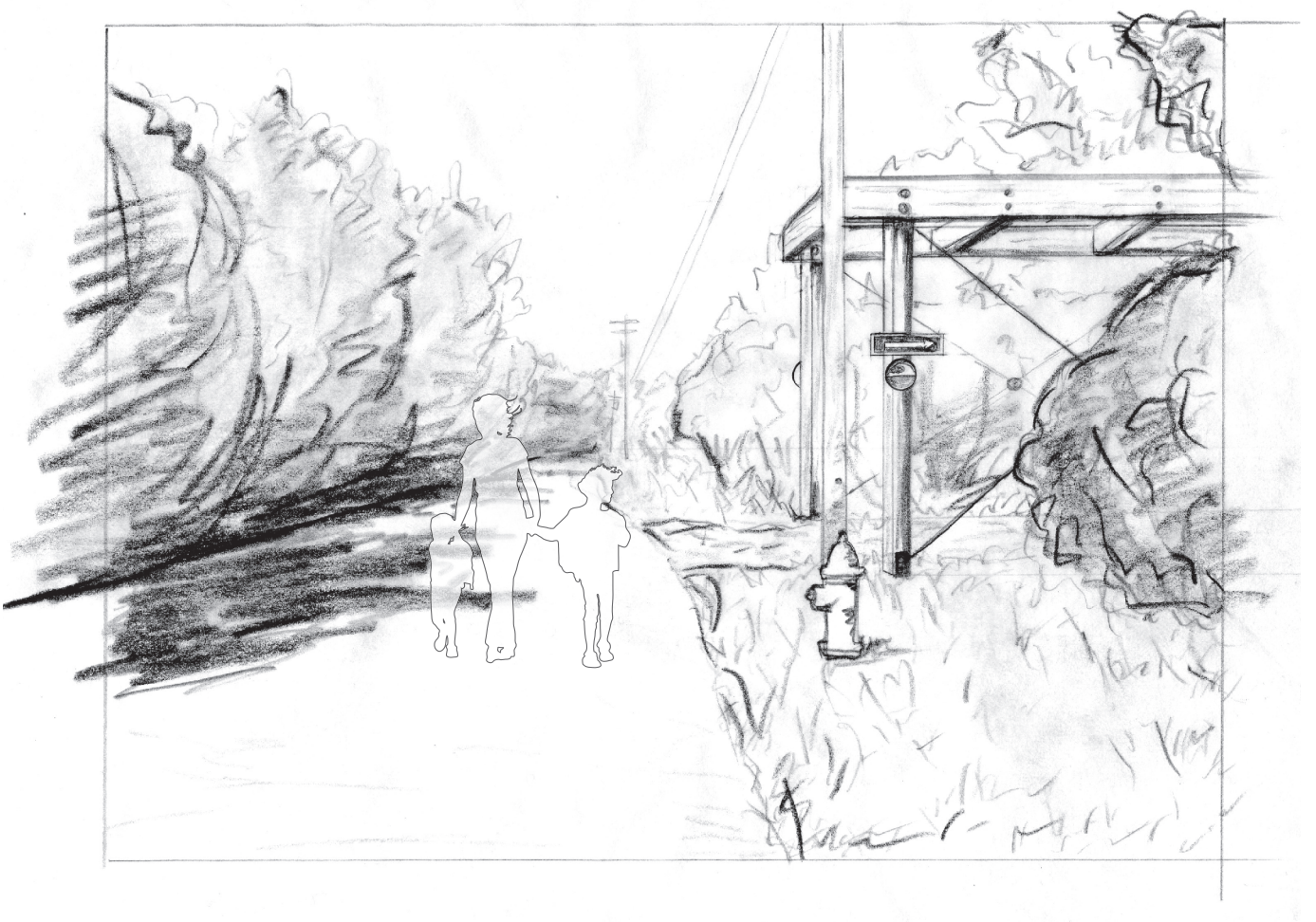
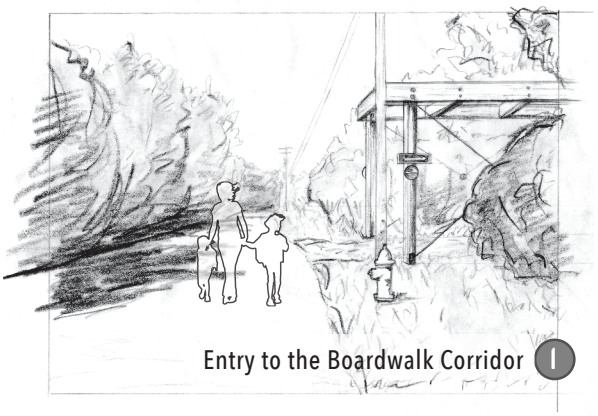


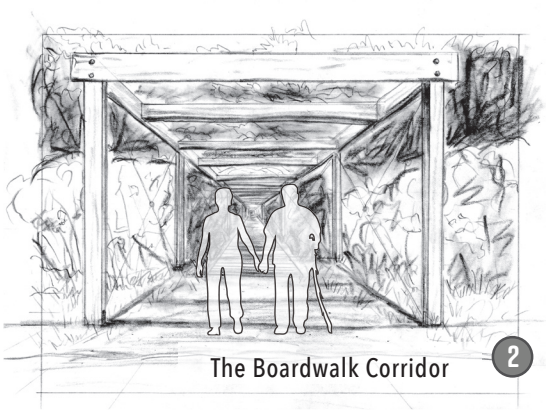
Figure 4.6 Hawk Rd. Entry to Boardwalk Corridor

THE DESIGN ADAPTATIONS

There are three proposed design adaptations for the North Route: a boardwalk corridor through the wetlands (Figure 4.6 Hawk Rd. Entry to Boardwalk Corridor), a series of paving markers depicting a narrative about tsunamis in Oregon, and a sculpture marking the assembly area (Figure 4.7 North Route Design). The three parts are on a spectrum of cost, labor and impact on the existing site. The intention behind this is to create opportunities to spread out implementation, where Neskowin could start with the least expensive and work up to the costlier, as funding becomes available.

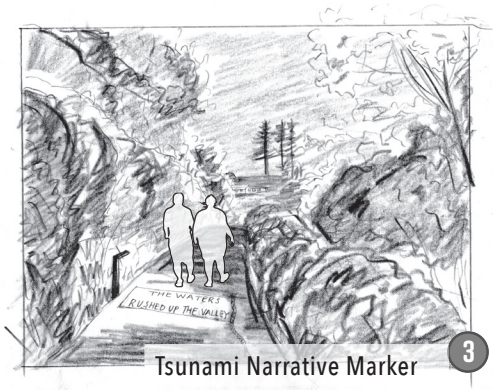


Entry to the Boardwalk Corridor 1

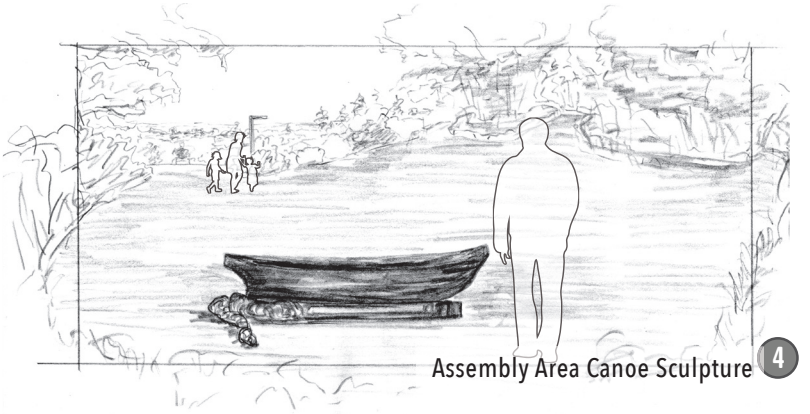


The Boardwalk Corridor 2

Figure 4.7 North Route Design



Tsunami Narrative Marker 3



Assembly Area Canoe Sculpture 4

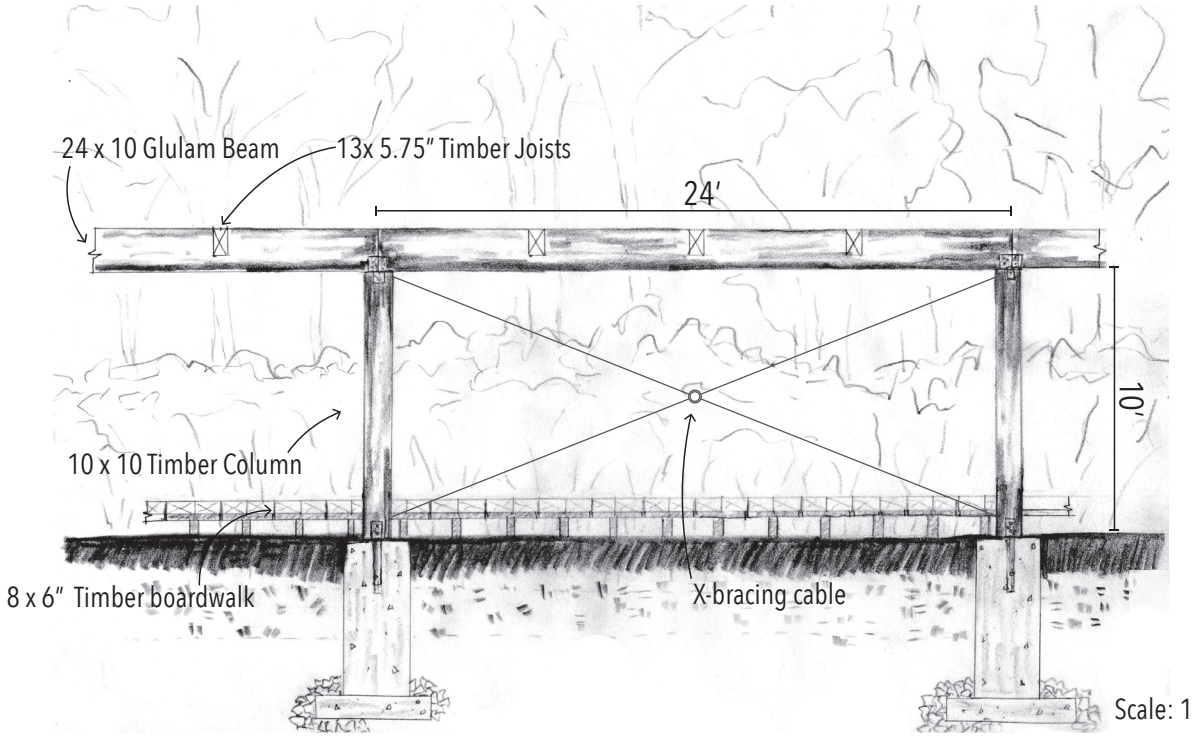


Figure 4.8 Detail of Boardwalk Corridor

THE BOARDWALK CORRIDOR

Tsunami Evacuation Route Elements: *Widened roads on major evacuation corridors; paved trails; cleared vegetation that could be an obstruction; pedestrian bridges over streams and creeks.*

Tsunami Evacuation Route Goals: *Reach Higher Ground Quickly; Easily Located; Navigable (Physically); Increase familiarity*

Resilience Meta-Frames Contribution: *Mechanistic/ Technocratic*

In response to the challenge of the terrain of the wetland trail being hard to cross, a boardwalk that starts from the entry by Hawk Rd. and finishes once the pavement begins (approximately 600 ft.) on the other end is proposed. At each end, there is a ramp to allow for easier access and allows the boardwalk to be elevated enough to replace the wooden bridge over Kiwanda Creek. The width of the walkway is also increased to 8' wide, instead of the original 5', allowing for more people to pass through at one time. The corridor is created by a pergola that runs the full length of the boardwalk. The beams are supported by columns that are attached to the bedrock below (Figure 4.8 Detail of Boardwalk Corridor). Attaching the pergola to bedrock will increase the stability of the structure during an earthquake, as well as the x-bracing cabling[1]. The columns are supported by x-bracing cables, which allow for the surrounding undergrowth to still be seen with minimal interruption (Figure 4.9 Boardwalk Corridor before a CSZ event). The joists are also spaced far enough apart so that the canopy can be seen. The function of this corridor is to protect the evacuation route and evacuees from the hazard of fallen trees. The beams and joists act as a cage to catch the largest of the fallen debris that could easily block the evacuation route (Figure 4.10 Boardwalk Corridor during a tsunami evacuation).

1 Exploratorium. "Damage Control: Engineering." Faultine: Seismic Science at the Epicenter. Accessed on 05/25/17. https://www.exploratorium.edu/faultline/damage/building.html

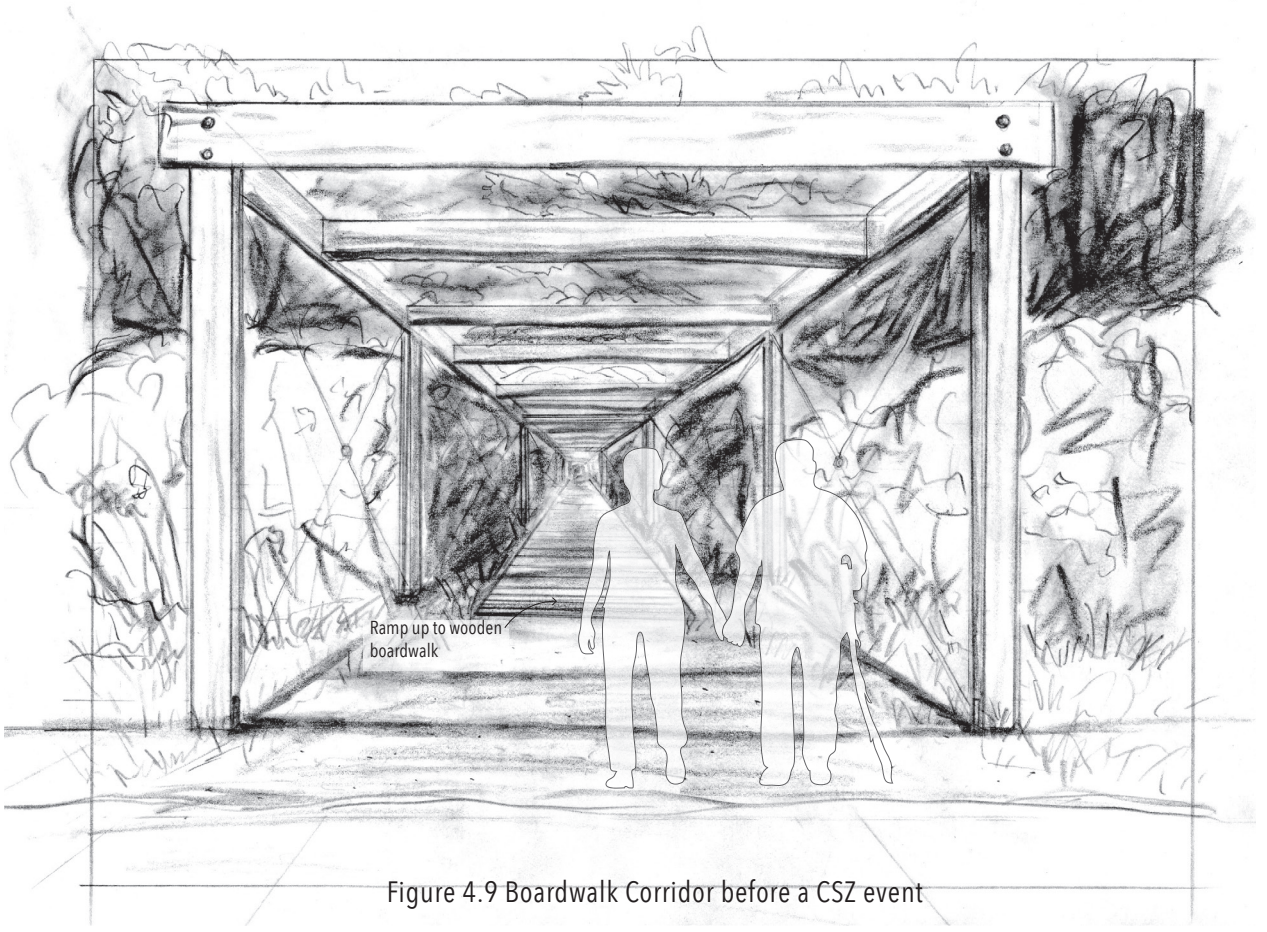


Figure 4.9 Boardwalk Corridor before a CSZ event

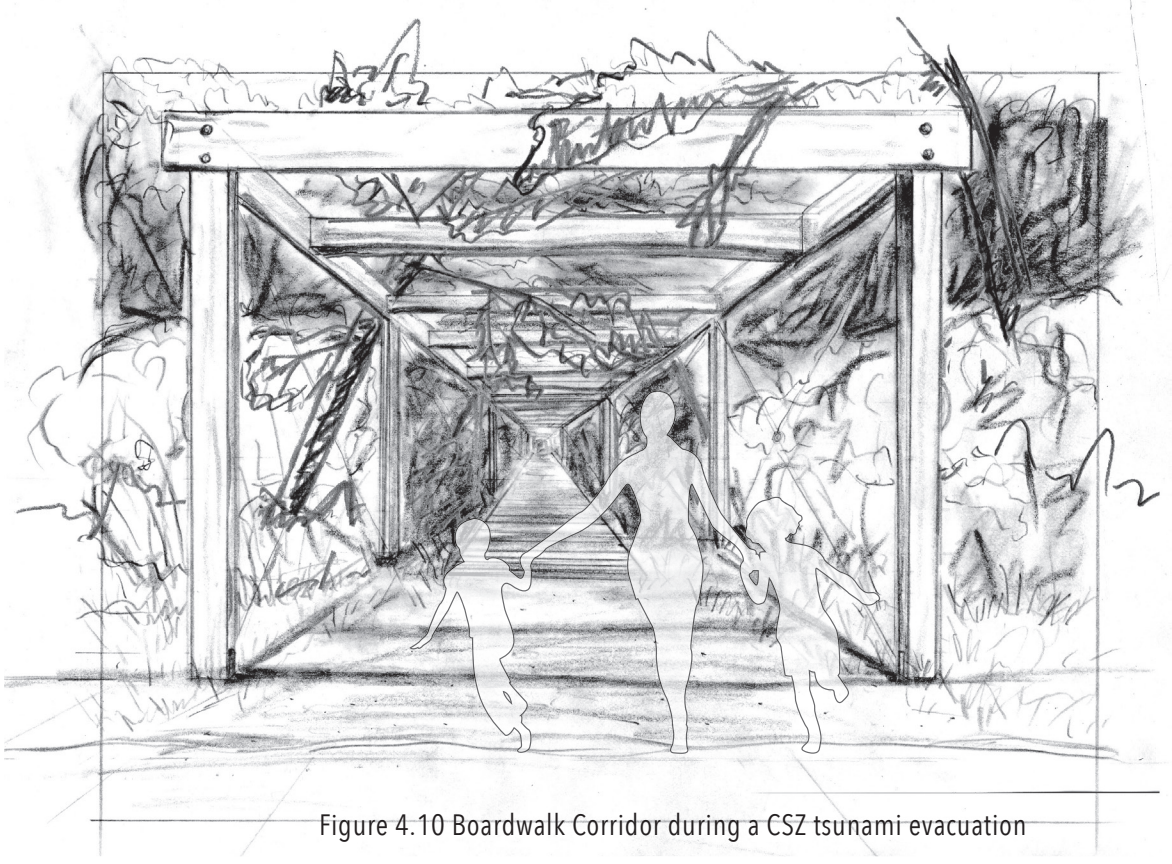


Figure 4.10 Boardwalk Corridor during a CSZ tsunami evacuation

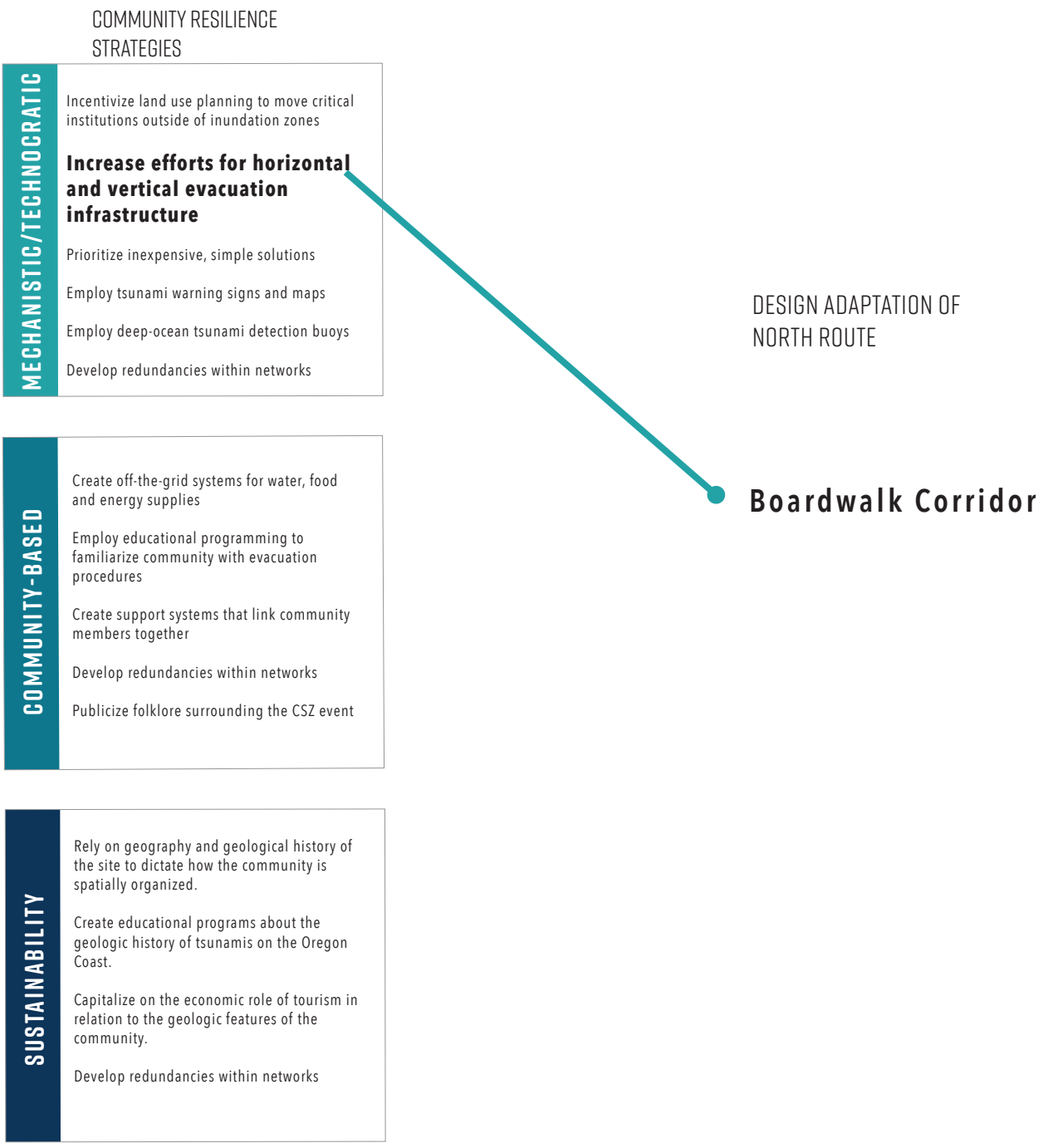


Figure 4.11 Boardwalk Corridor contributions to community resilience

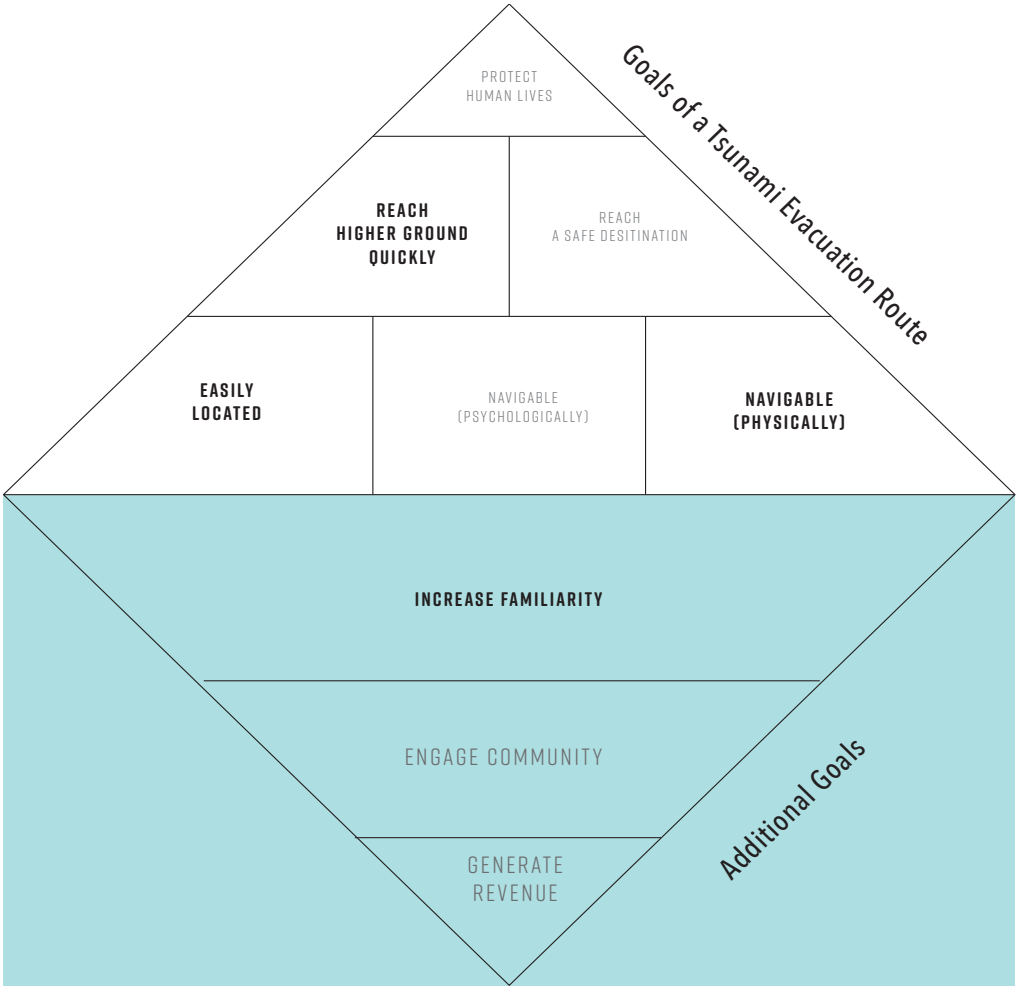


Figure 4.12 Goals addressed by the Boardwalk Corridor

EVALUATION OF THE BOARDWALK CORRIDOR

The Boardwalk Corridor's contribution to community resilience is the increase of horizontal evacuation infrastructure, which takes an engineered approach and thus is in the Mechanistic/Technocratic Resilience Meta-Frame (Figure 4.11 Boardwalk Corridor contributions to community resilience). The goals that the Boardwalk Corridor addresses are, reaching higher ground quickly, being easily located, physically navigable, and increasing the familiarity of the community with the effects of a CSZ event, such as downed trees and flooding due to subsidence (Figure 4.12 Goals addressed by the Boardwalk Corridor).

One of the goals that the Boardwalk does not directly address is the generation of revenue. This is a concern for the viability of implementation for this design adaptation. Neskowin, like many coastal communities, does not have a large income to spend on expensive infrastructural projects, such as this one. The expectation that they would be able to build the Boardwalk right away is not realistic. One approach to implementation, could be to progressively implement the Boardwalk Corridor. One could do so by breaking it into two components – first building the boardwalk itself and secondly building the pergola. The boardwalk addresses not only a future issue (flooding due to subsidence), but also is ameliorating the current issue of seasonal flooding and providing universal access across the wetland. The community might be more willing to put funding towards a project that is concerned with a daily life hazard, versus an unknown future hazard (CSZ tsunami).

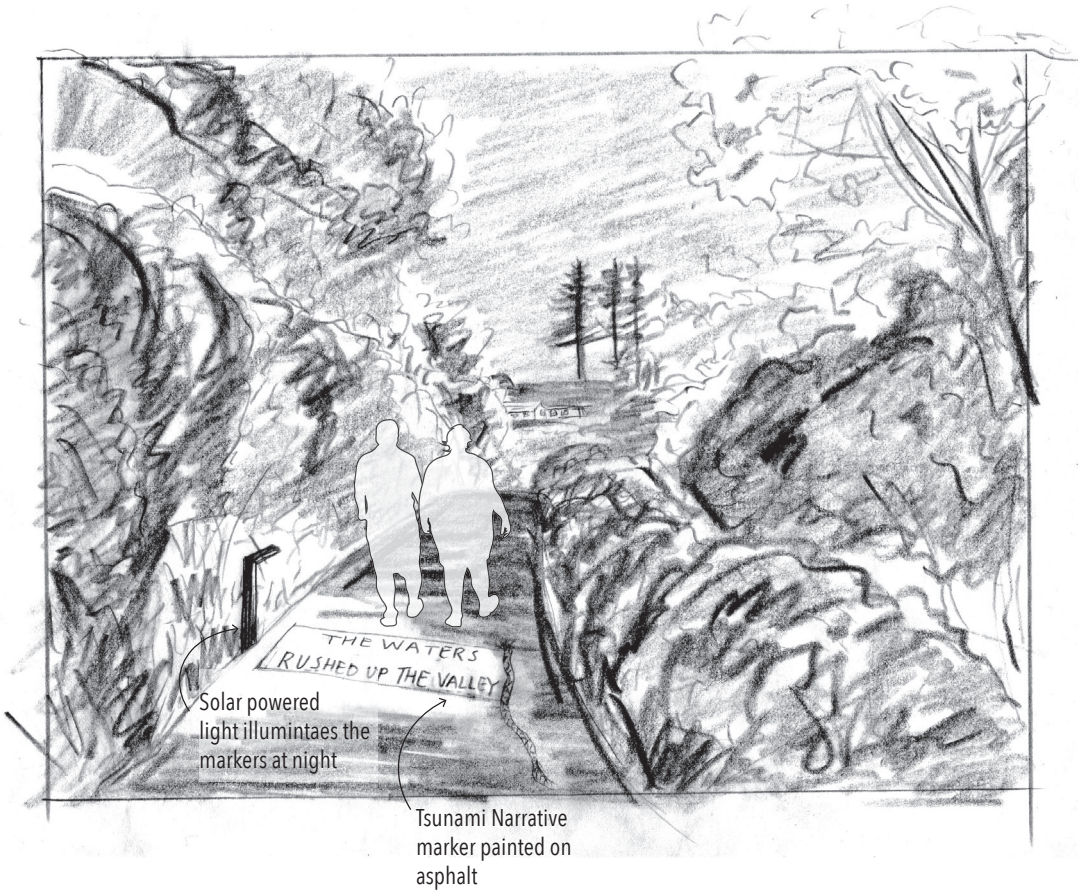


Figure 4.13 Tsunami Narrative Marker at night

THE TSUNAMI NARRATIVE AND ASSEMBLY AREA CANOE SCULPTURE

Tsunami Evacuation Route Elements: *Lighted evacuation routes; Emphasis on both the route and the destination*

Tsunami Evacuation Route Goals: *Easily Located; Navigable (Psychologically & Physically); Increase Familiarity; Engage Community*

Resilience Meta-Frames Contributions: *Mechanistic/Technocratic; Community-Based; Sustainability*

In response to the challenge of insufficient wayfinding a series of Tsunami Narrative markers is proposed to be installed along the North Route and throughout the neighborhood of Neskowin. The markers are painted onto the asphalt and depict portions of stories from Oregon coastal tribes, such as the one that tells of a village where the elders urged the community to weave long ropes to prepare for the 'great tide' that was to come[1]. Accompanying the Tsunami Narrative markers are solar-powered lamps that are close to the ground (3' high) and illuminate the markers at night (Figure 4.13 Tsunami Narrative Marker at night). Subsequently they also light the way along the evacuation route. The Tsunami Narrative markers work to educate the community about Oregon's history of tsunamis, as well as the history of the tribes that used to live on the coast. The idea of Tsunami Narrative markers can be used by other communities, the story can be easily changed.

The Assembly Area Canoe Sculpture works to mark both the end of the North Route and where the

1 Yonker. "Weaving Long Ropes". 196.

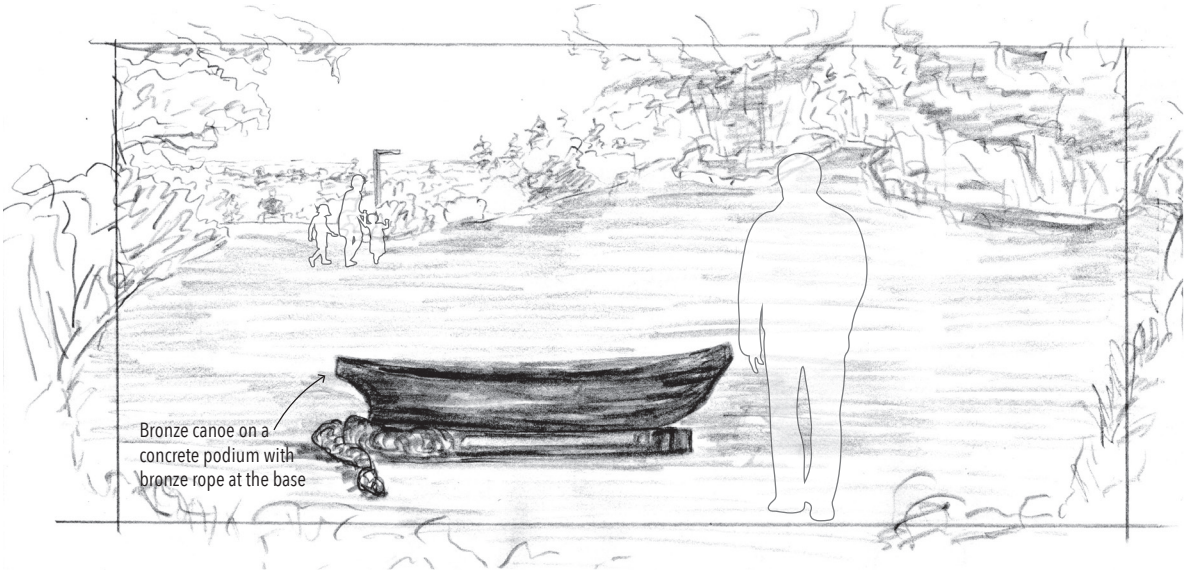


Figure 4.14 Assembly Area Canoe Sculpture before a CSZ tsunami evacuation

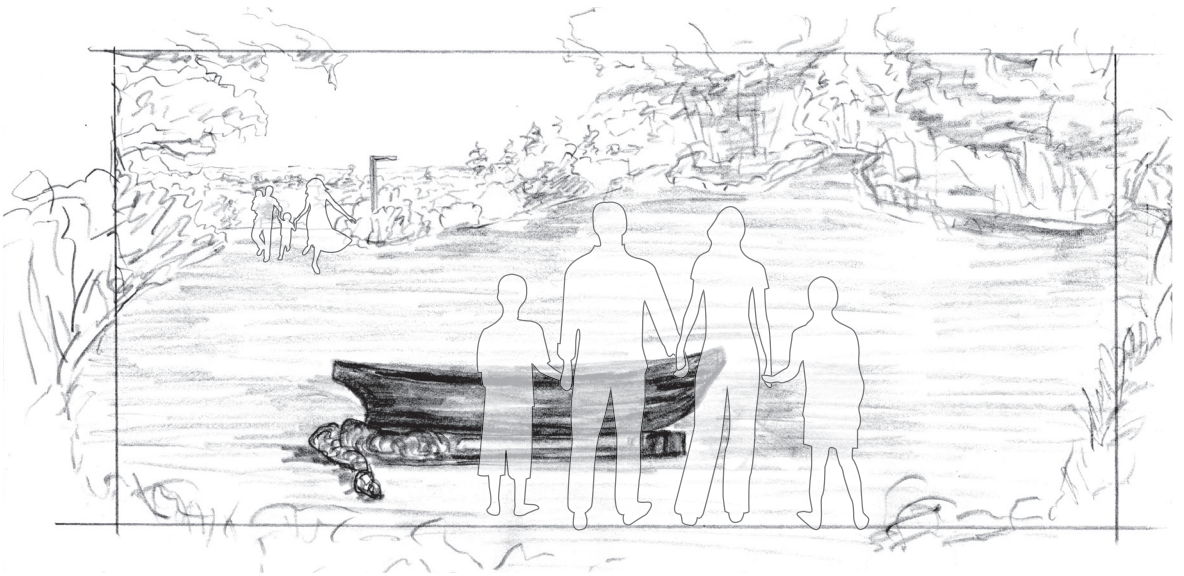


Figure 4.15 Assembly Area Canoe Sculpture during a CSZ tsunami evacuation

assembly area is (Figure 4.14 Assembly Area Canoe Sculpture before a CSZ tsunami evacuation). The form of a canoe is used because of the connection with the Tsunami Narrative markers, the ropes the elders urged people to weave were used to tether the canoes to the tops of the trees when the waves came, so that people would not be sucked out to sea[2]. The scuplture acts as a landmark for people to gather during a CSZ tsunami evacuation (Figure 4.15 Assembly Area Canoe Sculpture during a CSZ tsunami evacuation). The idea of an assembly area sculpture can also be easily translated by other communities and can be changed to reflect the story being told by the Tsunami Narrative markers.

2 Ibid., 196.

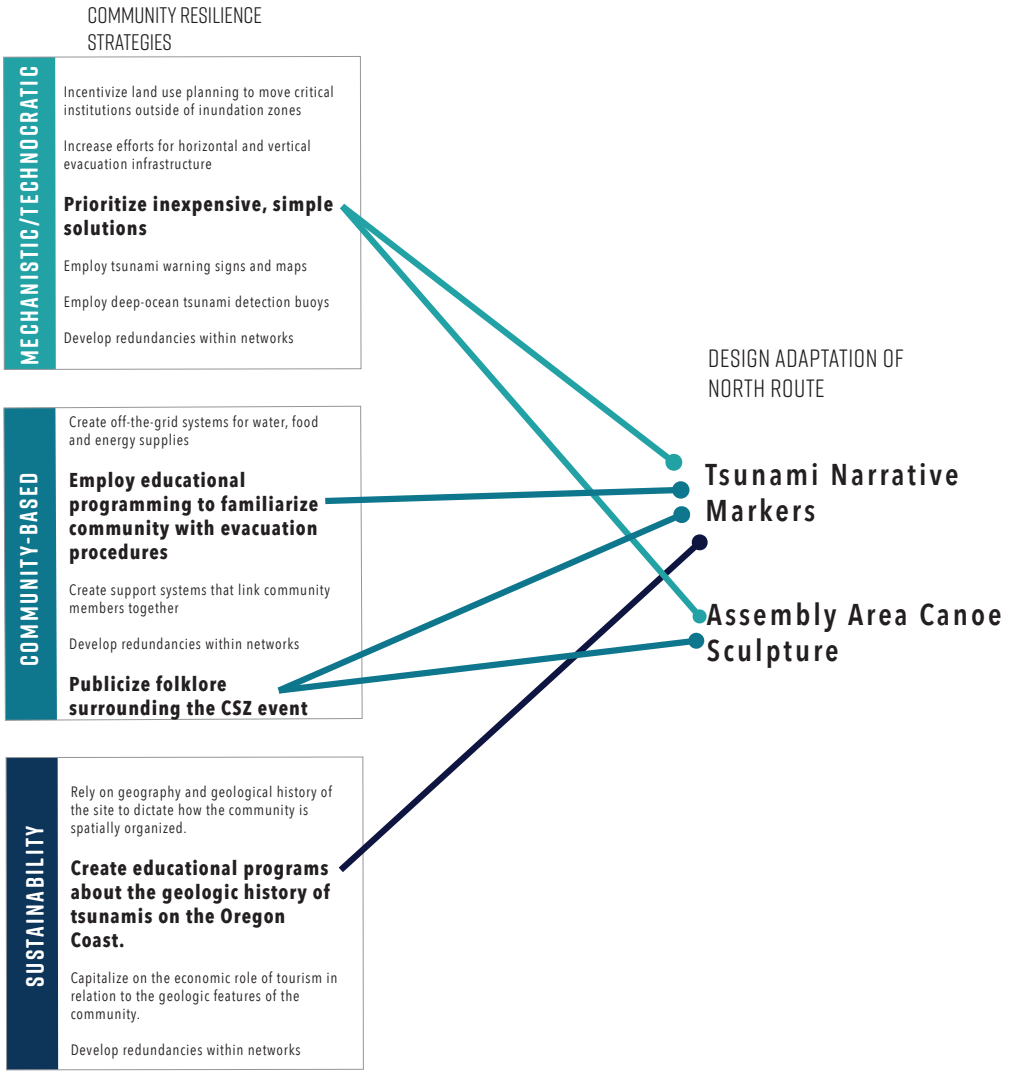


Figure 4.16 Tsunami Narrative Markers and Assembly Area Canoe Sculpture Contributions to Community Resilience

EVALUATION OF THE TSUNAMI NARRATIVE MARKERS AND ASSEMBLY AREA CANOE SCULPTURE

The Tsunami Narrative Markers and Assembly Area Canoe Sculpture's contributions to community resilience are prioritizing inexpensive, simple solutions, employ educational programming to familiarize community with evacuation procedures, publicize folklore surrounding the CSZ event, and create educational programs about the geologic history of tsunamis on the Oregon coast. These lie in the realm of the community-based and sustainable Resilience Meta-Frames, which emphasize community involvement, and education. These design adaptations also contribute to community resilience by prioritizing inexpensive, simple solutions, which approaches resilience from the mechanistic/technocratic Resilience Meta-Frames (Figure 4.16 Tsunami Narrative Markers and Assembly Area Canoe Sculpture Contributions to Community Resilience). The Tsunami Narrative Markers and Assembly Area Canoe Sculpture address the goals of being easily located, psychologically and physically navigable, increasing familiarity and engaging the community in learning about Oregon's history of tsunamis (Figure 4.17 Goals Addressed by the Tsunami Narrative Markers and Assembly Area Canoe Sculpture).

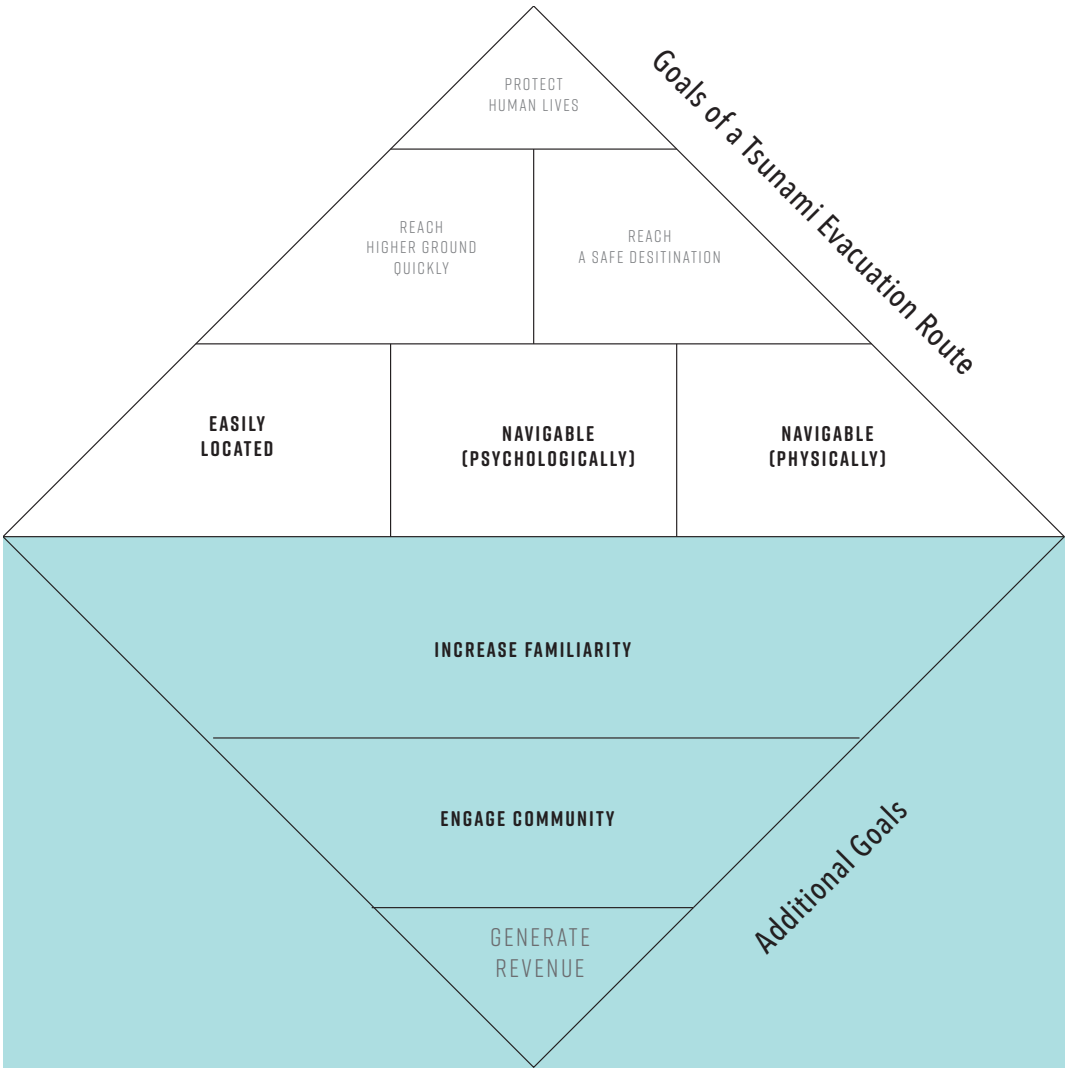


Figure 4.17 Goals Addressed by the Tsunami Narrative Markers and Assembly Area Canoe Sculpture

The Tsunami Narrative Markers and Assembly Area Canoe Sculpture, unlike the Boardwalk Corridor, work towards addressing the issue of tsunami evacuation on multiple temporal levels. They educate the community before a disaster, not only on where the tsunami evacuation route is, but also on the history of the CSZ event in Oregon. As I've mentioned before, the importance of advertising the history of tsunamis in Oregon is to encourage communities to change their own behaviors, such as moving important functions outside of the inundation zone (hospitals, fire stations, etc.). The Tsunami Narrative Markers and Assembly Area Canoe Sculpture also serve as talking points for the community to share with visitors. Instead of being threatening tsunami warning signs, they are unique artworks that raise people's curiosity. Why is this sculpture here at this spot? What is this story being told on some of the roads, but not all? The more that communities become actively engaged in advertising the history and future of tsunamis in the area, the more this hazard can become a part of the local folklore.

5 REFLECTION

Revisiting my research question at the end of this process, *what contributions can a tsunami evacuation route make to increase the resilience of a coastal community*? I find that the answer hinges on how we approach resilience. In the beginning, I felt I would need a narrow, specific definition to be able to operationalize the concept of resilience. Instead what I have found is that by using a framework that embraces the many faces of resilience, it has been easier to make the jump from concept to operable terms. This is not to say that the Resilience Meta-Frames are not specific in their addressing of resilience, instead they organize the breadth of definitions into manageable portions that can easily be connected to specific actions or qualities that an individual, community or system can exhibit that demonstrate their resilience. For this project, I was then able to present a clear understanding of how each tsunami evacuation route element, community resilience strategy, and finally how each design adaptation increased community resilience of Neskowin.

The answer to my research question is that there are many contributions tsunami evacuation routes can make to increase community resilience. A key factor in expanding the list of contributions, is looking at the underlying goals of what the tsunami evacuation routes are trying to achieve. This enables the designing of tsunami evacuation routes that approach resilience from the community-based and sustainability Resilience Meta-Frames, not just through a mechanistic/technocratic Resilience Meta-Frame.

The importance of addressing all three meta-frames, is the need to create resilient designs that address the specific challenges of a coastal community. These challenges can range from physical, economic, to social/cultural. If we only looked at resilience through the mechanistic/technocratic approach, then we would only be looking to build infrastructural measures or to government incentives to improve resilience. By expanding what it means to be resilient, we can start to incorporate systems that work on multiple temporal scales and at different organizational levels. The implementation of the Tsunami Narrative Markers and Assembly Area Canoe Sculpture are one example of how engaging the community with history of tsunamis, creates opportunities for conversation and advertises to visitors that the coast is shaped by these larger forces. They are also an example of building resilience within a community over a longer period. In contrast, the Boardwalk Corridor approaches creating resilience by addressing the physical conditions right before and during an evacuation.

A final consideration for landscape architects at the end of this project is to become more involved in disaster risk management. I believe that we have an obligation to not only design for today's challenges, but also the larger future hazards that each landscape contains. We can no longer ignore the tsunami when designing a park or trail system. We are uniquely trained to consider the whole context of a site – soils, geomorphology, weather, etc. – why not include tsunamis, earthquakes and other disasters?

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APPENDIX A

NOTES FROM REGIONAL EXPERT INTERVIEWS

Pat Corcoran, Oregon Sea Grant, Oregon State University. Phone Interview. 03/15/2017

Resilience:

- living your life like you know what's going to happen; aligning your behavior with what you know is going to happen
- When your brain overrides your culture
- Doing what we should, not what we can: Just because we have the technology, or the engineers and insurance companies sign off on a decision, doesn't mean that it is the right thing to do (maybe the easiest & instantly gratifying; but in the long run not sustainable).

Evacuation Routes:

- Communities ground-truthed DOGAMI maps
- Reliance on signs and maps to point the way can be misleading- North Arrows not always pointing up, reliance on just one way to do it (what if it is blocked?)
- Where do you stop? Wayfinding should insist on the destination not on how you get there
- Evacuation should be like jazz: you're playing response to everyone else around you
- Personal agency: you have to be able to improvise

Neskowin:

- 30% owner occupancy
- if population is 170, that means that about 70 houses are occupied on average
- What is the benefit cost ratio then for bigger engineering projects? Not that much.
- Most locals do not live right by the ocean
- Must rely on geography of the site- can't spend money on putting in a dynamic bridge up and over the hwy

Human Psychology:

- danger in over planning- people become frozen and attached to the plan "there is a right and wrong way"
- we're not Japan- not the same culture
- people are motivated by their children
- why can't people live outside of tsunami zone and come down to the beach?
- "Time goes fast, learning goes slow"- Jimmy Buffet

CSZ Event:

- 9.0 vs 8.0: both a 50/50 chance that it could be either one- 42 past events in last 10,000 and split between the two magnitudes
- 37% chance in next 50 years

Next Steps:

- Incentives in land use planning codes
- Increase scrutiny in tsunami inundation zones
- Increase efforts for horizontal infrastructure improvements not vertical (roads, bridges vs. tsunami towers)
- focus geographically on hot spots
- cheap is smart when attacking this issue: communities are poor and won't build like Japan does (like those ocean views)

Andre Le Duc, Safety and Risk Services, University of Oregon. In-Person Interview. 03/20/2017

Resilience:

- indicators: adaptive change; learning from environment organizational resilience (New Zealand) 13 indicators
- 3 core elements: Leadership and culture; change ready; networks
- Know vulnerabilities? don't try to fix; what is the adaptive capacity?
- Network Capacity? Does another community have components that you are missing?
- Where is the depth?

- How do you think about sustainability? How do you use resources already present so you can operate after the fact?

Design Idea:

- Cascadia Trail- connection trails
- What can we connect to the points that have a value?
- Nodes evacuation spots, but also tourist attractions (such as helicopter access)
- Currently there are segments of trails along the coast range- connect like the PCT
- Tie in with community economic goals
- Needs to be a partnership between public and private investors
- Egress for evacuation emergency
- Larger critical structures outside the inundation zone to create backbone for rebuilding efforts
- Should be something that's a highlight, not just about the function
- Tillamook floodplain- mountain biking?
- How can you accent the geography to your advantage?
- Community competitions for park design?
- Step destination models- trail system

Considerations:

- Look at the economics of the situation
- What do you invest in? What draws people to the coast? The views! Recreation!
- Leading with the wrong point (CSZ we're all going to die)- it's about the 365 days per year
- It's not about disasters, it's about the fabric of the community
- How do you work with the system? Need to start talking about the day-to-day
- What's the volume of people that can be in a node area?
- Get audience to go along with you- describe future opportunity

Jay Raskin, FAIA, Oregon Seismic Safety Policy Advisory Commission. Phone Interview. 03/29/2017

Resilience:

- Need redundancies in the system- people might not act rationally or move quickly or know where to go during a tsunami/earthquake evacuation
- CSZ is a rare event- need to make sure people have a folklore of this event
- How do you create something that will be sustainable over the long term? Sustainable design should include disaster mitigation/resilience

Evacuation:

- Effective evacuation routes are integrated into something bigger within a community
- Tied to recreational activities on the coast- get a lot of daily usage
- Create something that people use on a regular basis
- Use evacuation route to help transition communities to higher ground permanently- relocate communities

Design Idea:

- Park coast-wide: Cascadia Park, run along the coastline
- Have elements that educate public on geologic history- what's happened before (ghost forests, landslide evidence)
- Teaching you about evacuation, but also as paths to see the ocean
- Tourism is the main industry- use that to your advantage
- Master plan- how to connect towns to larger trail system? Commercial areas- where could these go? Give communities more agency for redevelopment if you start planning ahead of a disaster, instead of post-disaster.

Issue:

- Some communities and cultures may disappear if they are not able to adapt or cope with post-disaster conditions
- Each town is idiosyncratic- unique, will lose character of Oregon coast if too many towns are lost.

Althea Rizzo, Oregon Emergency Management. Phone Interview. 03/13/2017

Resilience:

- Look at San Francisco's SPUR definition
- Instead of planning 3 days for your emergency supplies, plan for two weeks (at a minimum)
- Expand out from individual emergency kits to engage the community on different scales
- Look at how communities and neighborhoods can create off-the-grid solutions to things like food, water and utilities (solar panels on houses, water catchment, community gardens)
- Resilience feeds into broader stability issues: e.g. if a community currently suffers from food scarcity, then that will be exacerbated by a catastrophe, so make moves that go towards addressing this current issue that will balloon into a larger one later.
- No way to make the tsunami inundation zone resilient- has to be about moving the things that are important to communities outside of the inundation zone.

Evacuation Routes:

- Community designates where the routes are
- Meetings held with DOGAMI and city officials and residents

Assembly Areas:

- Just a predesignated meeting spot where rescue workers know to go there to look for survivors.
- Expensive to cache food there: vandalism, maintenance of storage, keeping things dry, etc.

Community Cases:

- Cannon Beach: Tsunami Buddy Families- two families are matched, one inside and one outside the inundation zone. The inside family can store food and supplies at the outside family's house.
- 5k run along evacuation route ending at assembly area; preparedness fairs
- Lincoln County: (Sue Graves, Lincoln County Schools). Moving schools outside of inundation zone; make students and families educated on emergency preparedness
- Dark Horse Comic Books: series on earthquakes and tsunamis

Next Steps:

- Keep bring the message to communities at risk
- get more events happening in communities
- stress resources available

Challenges:

- Coastal towns are poor-lack resources for big moves

Nathan Wood, U.S. Geologic Survey. Phone Interview. 04/13/2017

Resilience:

- Nation-wide level (generally): How can we recover? Do you put things back into place?
- Engineered resilience- things built to bend and shift and snap back
- Ecological resilience- objects might be broken or destroyed, but the system is functioning still
- Place-based indicators of resilience: not easy, but easier proxies for what that means/can be measured
- Example: Katrina: 20,000 people leave (mostly poor are shipped out) in the end the population of the city is smaller, leaving a smaller footprint- does this make New Orleans more resilient?
- How does the individual, community thrive?
- Certain towns may disappear, but the individuals may thrive (just elsewhere). Does this make them resilient?
- Resilience depends on who gets to define it

Disaster & Recovery plan:

- Disaster aid should be used wisely and for planning what the new 2.0 city look like.
- Requires people to take a step back and see what they want their community to look like afterwards.
- A "Reset" button
- Spend money on disaster kits for the community- 3 weeks of supplies for each home
- Let people make their own decisions

Social Vulnerability Indexes:

- Do not tell you what it really is like/means
- Are you measuring individuals or subpopulations?
- Social capital: individuals of a subpopulation might not

have strength, but as a group they can become a force/ support system
- Community support is key, as well as empowering subgroups (elderly, retired populations, minorities, etc.)

Evacuation:

- Tsunami 5k runs- raise social capital and networks- gather community together
- Beat the Wave project:
- Treat locals as smart people- they are very supportive if you're not sugar coating the message
- more pedestrian bridges a long evacuation routes are an option for some communities
- be pragmatic and practical about where you spend your $
- Frame everything as choices
- Decisions are made depending on your risk tolerance