2024
Community Risk Assessment
and Standards of Coverage

South Whidbey
Fire/EMS
Langley, Washington

Introduction

The following document functions as South Whidbey Fire/EMS (SWFE) All Hazard Community Risk Assessment and Standards of Cover Statement. The Commission on Fire Accreditation International (CFAI) defines the process, known as "deployment analysis," as a written procedure which determines the distribution and concentration of fixed and mobile resources of an organization. The purpose of completing such a document is to assist the District in ensuring a safe and effective response force for fire suppression, emergency medical services (EMS), hazardous materials incidents and technical rescues, and in facilitation activities for domestic preparedness, emergency planning and disaster response.

Creating a Standards of Cover (SOC) document requires the research, study and evaluation of a considerable array of community features. The following report will begin with a descriptive overview of South Whidbey Fire/EMS and the area that it serves. Following this overview, an all-hazards risk assessment provides an analysis of potential risks and describes activities the District employs to mitigate those risks. Current deployment and performance were assessed to determine the capabilities and capacities that are available. Benchmark statements and baseline performance support SWFE's ability to meet distribution and concentration metrics. The report concludes with plans for maintaining and improving capabilities, as well as policy recommendations to address gaps in performance or desired outcomes.

Core Competency or Performance Indicator

Description of the core competency or performance indicator with <u>the most important phrases or words</u> underlined for emphasis.

Throughout the document, several "accreditation building blocks" will be highlighted, drawing a direct link between the community risk assessment standards of coverage and the requirements of the fire department accreditation process as administered through the Commission of Fire Accreditation International.

This SOC is demonstrative of South Whidbey Fire/EMS's continued commitment to regular community risk assessment (CRA). The District has adopted a formal process of reviewing and assessing risk as an annual process. SWFE anticipates that regularly revisiting and revising the SOC and CRA will allow the District to stay on top of changes in the community as well as enable staff to efficiently distribute and plan for resources allocated throughout the jurisdiction.

South Whidbey Fire/EMS would like to thank all members for their continued dedication to the citizens and visitors to the District and for the commitment to continuous improvement embodied by the accreditation process.

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Standards of Coverage Process

A Fire District's Standards of Cover (SOC) document is defined by the Commission on Fire Accreditation International (CFAI) as the "adopted written policies and procedures that determine the distribution, concentration and reliability of fixed and mobile response forces for fire, emergency medical services, hazardous materials and other technical types of responses." For the elected body and district administrators to have confidence that their fire district is meeting the needs of the community, a complete assessment of the risks must be honestly undertaken. Only after the application of a proven and consistent risk assessment model is made, can a fire district develop an SOC performance contract.

It is the responsibility of district's decision makers to provide an educated calculation of the expected risk, what resources are available to respond to that risk and what outcomes can be expected. All of these factors play a role in providing the community's emergency services. It is best practice that communities set response standards based on the identified risks within their jurisdictions. Fire districts that do not apply a valid risk assessment model to their community are not able to adequately educate their community leaders of their true needs. The application of a tested risk assessment model allows the fire district and elected officials to make educated decisions about the level of emergency service they desire.

Section A- Documentation of Area Characteristics

South Whidbey Fire/EMS (SWFE) is a full-service fire district providing fire suppression (structural and wildland), basic life support emergency medical services (EMS), hazardous materials, marine and technical rescue, public education and fire prevention services for approximately 17,356 residents occupying over 66 square miles on South Whidbey Island, Washington. SWFE proudly serves the citizens of South Whidbey Island and the numerous guests of the community.

Island County Fire District #3 or as it is known today as South Whidbey Fire/EMS was formed in 1950. SWFE is in compliance with the Revised Code of Washington (RCW) Title 52, which outlines the regulations applicable to fire districts, their formation, annexations, dissolution, powers, commissioners, finances, benefit charges, provisions, etc., as well as performance measures.

South Whidbey Fire/EMS utilizes a tiered strategy to organize response areas into geographical planning zones. The first is at the first due area. These areas have specific resource allocation strategies based on measured risks.

Section B- Description of Agency Programs and Services

South Whidbey Fire/EMS provides exceptional professional fire suppression, emergency medical, technical rescue, and hazardous materials services from six fire stations staffed with dedicated career and volunteer firefighters. Additionally, the organization delivers a full spectrum of fire and life safety services supported by an administrative staff that ensures the first responders are well prepared for the all hazards situations of the modern fire service.

Section C- All-Hazard Risk Assessment of the Community

A comprehensive risk assessment analyzed the physical, economic, sociologic and demographic aspects of the jurisdiction. The factors that drive the service needs were examined in a precise and scientific manner to determine the capabilities of necessary to adequately address the risks that are present.

Each of the major natural and manmade risks evaluated received a clearly defined probability and consequence ranking. Service areas that either had little quantitative data, or did not require that level of analysis, were evaluated through both retrospective analysis as well as structured interviews with District staff members. Final call types from the 2016-2021 CAD date file were classified into the program areas of EMS, Fire, Hazmat, Other and Technical Rescue based on district leadership decisions, and were assigned a risk classification based on district leadership criteria.

Section D- Program Goals and Objectives

The major programmatic goals and objectives for SWFE have been captured in the latest planning process. The goals, objectives and associated sub tasks have been organized into three main sections.

The goals will be reviewed and addressed by stake holders in regular leadership reviews, including a quarterly review conducted with the executive leadership team. Annually, a documented report -out will be created by the Fire Chief to share with the Fire Commissioners. The annual reviews will identify gaps in current capabilities, capacity and the level of service provided within each service delivery area.

Section E- Current Deployment and Performance

This section analyzed the emergency response history of the District, taking a systems level view of current performance, established formal benchmark (what SWFE strives to attain) performance measures, and analyzed actual (baseline) performance. Projected growth of the emergency call volume was also evaluated, along with an in depth look at each first due fire station area to identify areas of concern with elevated risks and lagging performance.

Simultaneous calls (call concurrency, Distribution (first unit on scene), Concentration (arrival of the full effective response force), Reliability (how often a unit can answer their own calls), and several other measures were used to paint a clear picture of SWFE’s emergency response performance as balanced against community risk and internally developed response time goals.

Section F– Conclusion and Recommendations

South Whidbey Fire/EMS is an organization with a dedicated staff of personnel who are committed to saving lives, protecting property, safeguarding the environment and taking care of their people. This is accomplished by providing a full spectrum of emergency and non-emergency services that align with the risks present in the community.

A succinct list of strengths, weaknesses, opportunities, threats and recommendations can be found in this section, further aiding SWFE in charting a path towards continuous improvement.

Section A – Documentation of Area Characteristics

Introduction to Whidbey Island

Documentation of Area Characteristics as it relates to Criterion 2A

The agency collects and analyzes data specific to the distinct characteristics of its legally defined service area(s) and applies the findings to organizational services and services development.

Whidbey Island is a large island in Possession Sound, a section of Puget Sound. It is part of Island County, Washington, and is located between Camano Island and the Olympic Peninsula. It is bounded by Saratoga Passage to the east and Admiralty Inlet to the west. The island has one road connection to the mainland via State Route 20 over the Deception Pass Bridge at the north end of the island, connecting to Fidalgo Island, which in turn is connected by bridges to the mainland west of Burlington WA. There are also two ferry connections to the mainland, one from the community of Clinton to Mukilteo in Snohomish County and the other from Coupeville to Port Townsend in Jefferson County. The island has a total area of 169 square miles, making it the largest island in the state of Washington.

Introduction to South Whidbey Fire/EMS

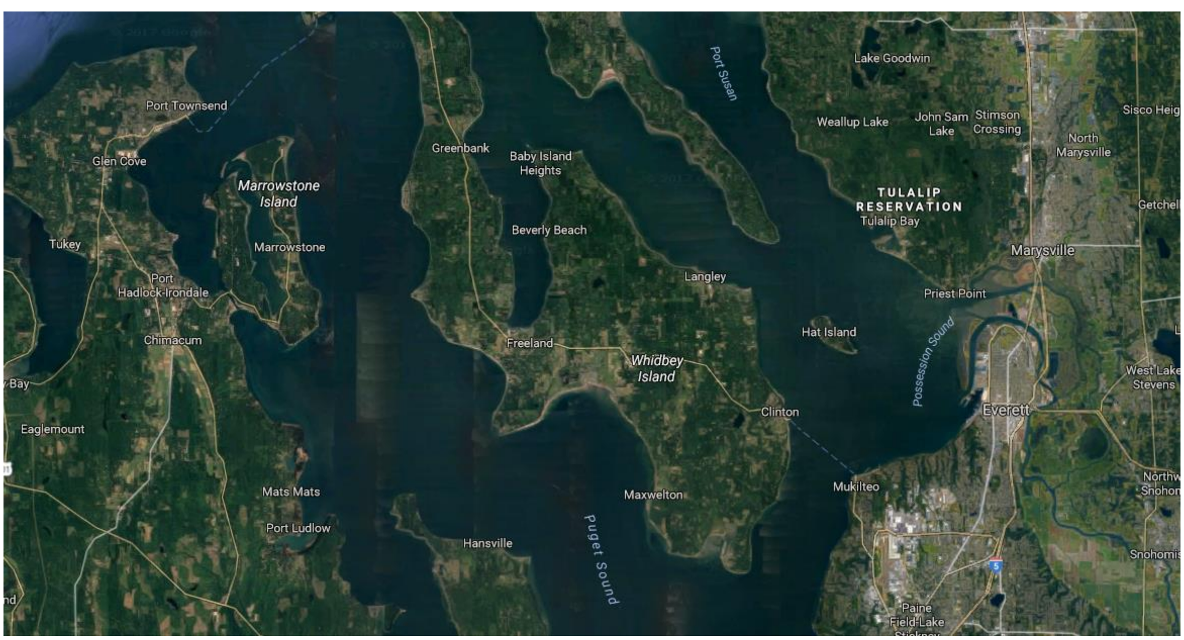
South Whidbey Fire/EMS (SWFE) is a full-service fire district providing fire suppression (structural and wildland), basic life support emergency medical services (EMS), hazardous materials, marine and technical rescue, public education and fire prevention services for approximately 16,000 residents occupying 66 square miles on the south end of Whidbey Island, Washington. SWFE proudly serves the citizens of South Whidbey Island and the numerous guests of the community from six stations, staffed by a career staff of 19 sworn personnel, 5 support staff and an average of 40 volunteers. Daily staffing is a paid crew of one lieutenant and four firefighter/EMT's, working a 24/48 schedule. There is also one of the four paid chief officers on call at all times.


South Whidbey Fire/EMS
Location Context
SWFE District
Langley
Port Susan
Tulalip Indian Reservation
Admiralty Inlet
Oak Bay
Possession Sound
Everett
Useless Bay
Mukilteo
Port Ludlow
Hansville
I 5
Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri
Pacific Rim National Park Reserve
Victoria
SWFE District
Mt. Baker National Forest
Colville National Forest
Olympic National Park
Seattle
Wenatchee National Forest
Spokane
Washington
Olympia
Snoqualmie National Forest
Kennewick
Gifford Pinchot National Forest
Umatilla National Forest
Portland
WA State Parks GIS, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

Environmental Overview

Natural Environment

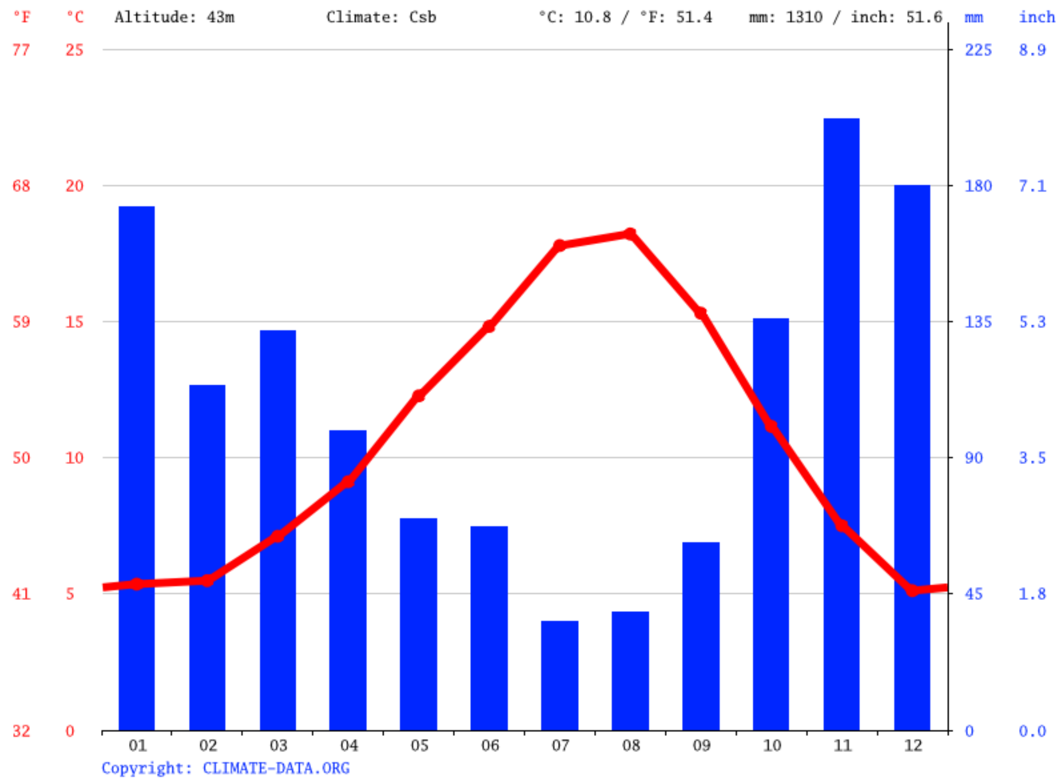
South Whidbey Fire/EMS is a rural fire district in Island County, Washington. It is comprised of 66 square miles. Its boundary is easily defined, as only two miles of boundary line exist, along a straight east-west axis, where it adjoins Central Whidbey Island Fire and Rescue to the north. The rest of the boundary of SWFE is the 57 miles of Puget Sound shoreline. The elevation ranges from sea level to approximately 500 feet. There are three lakes on the south end, which all have public access and are used for fishing and recreational boating. There are also two salt-water marinas, and many shoreline parks, boat launches and beaches. There is a significant wildland-urban interface, but due to the marine climate this is not a high-risk threat from a fire protection standpoint.


Port Townsend
Glen Cove
Marrowstone Island
Marrowstone
Tukey
Port Hadlock-Irondale
Chimacum
Eaglemount
Mats Mats
Port Ludlow
Greenbank
Baby Island Heights
Beverly Beach
Freeland
Whidbey Island
Langley
Clinton
Maxwelton
Hansville
Puget Sound
Port Susan
Lake Goodwin
Weallup Lake
John Sam Lake
Stimson Crossing
North Marysville
TULALIP RESERVATION
Tulalip Bay
Marysville
Priest Point
Hat Island
Possession Sound
Everett
West Lake Stevens
Mukilteo

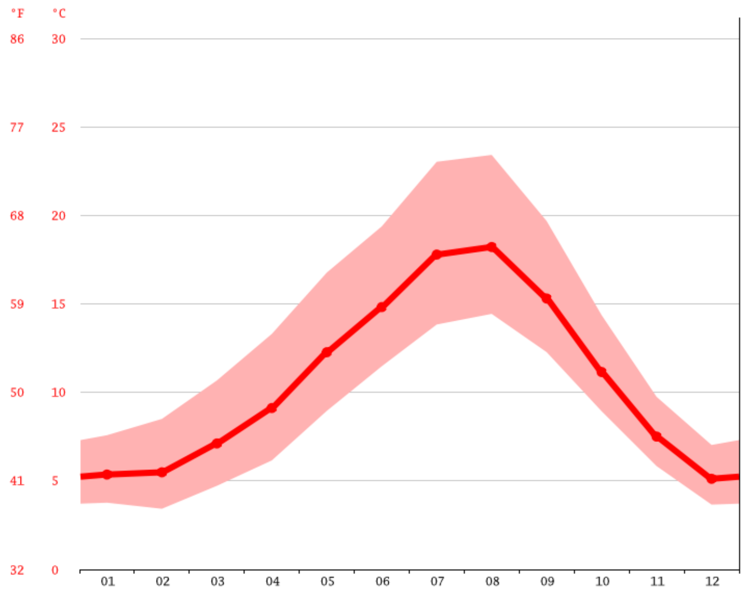
Weather

Weather data is for Langley, as it is the only climate-data.org reporting station within the district.

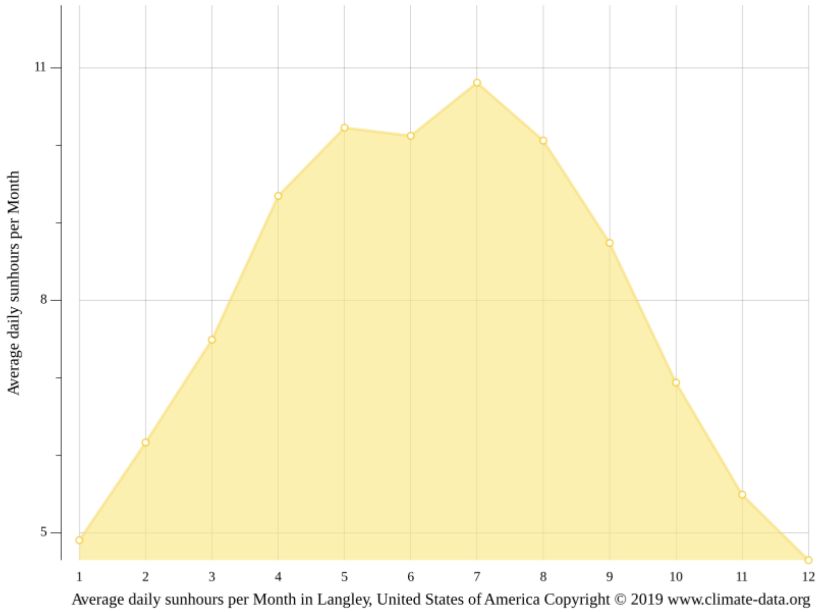
Average Temperature and Rainfall by Month



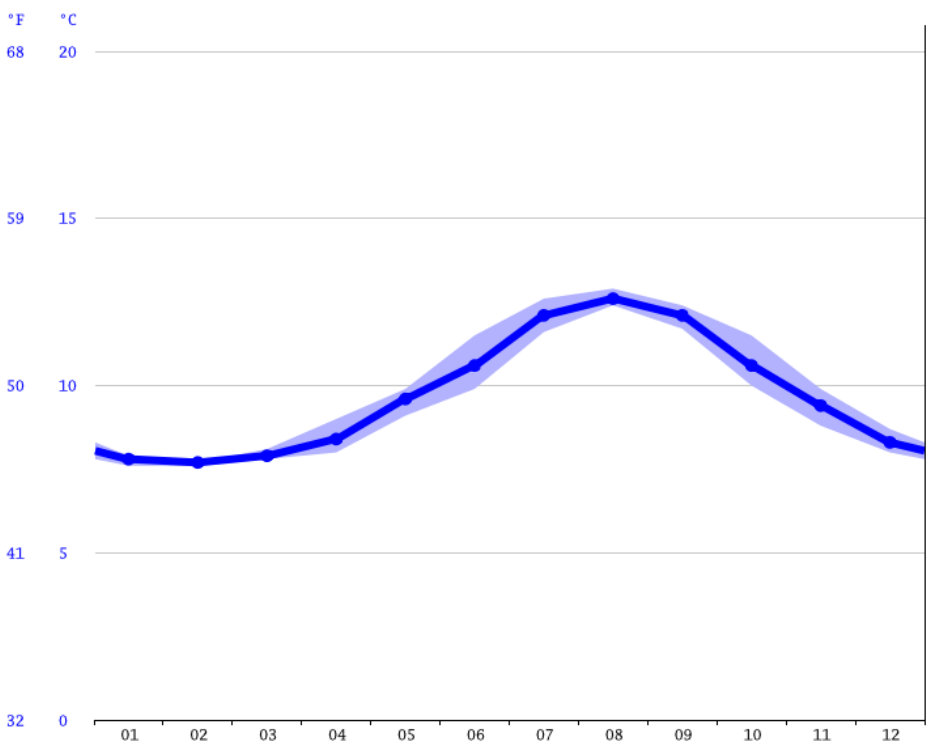
Temperature Range by Month



Hours of Sunshine by Month



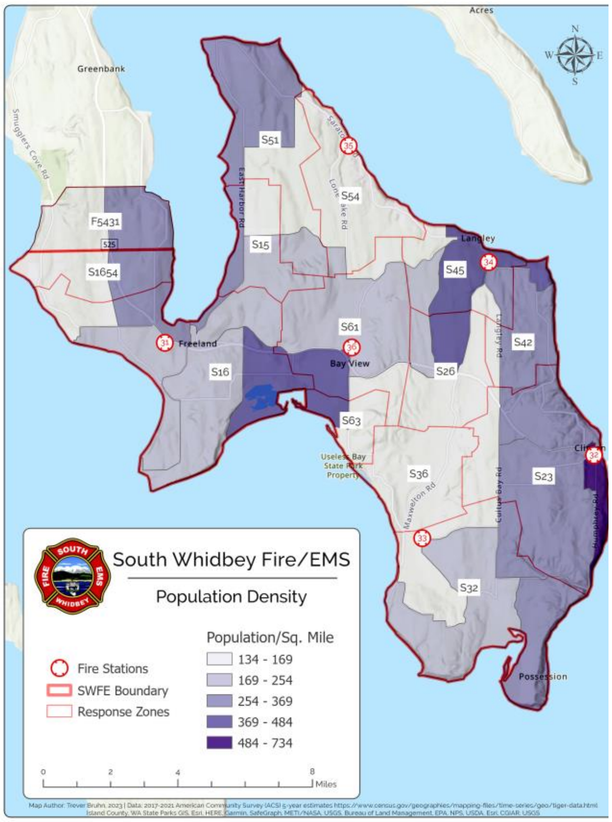
Water Temperature at Langley by Month

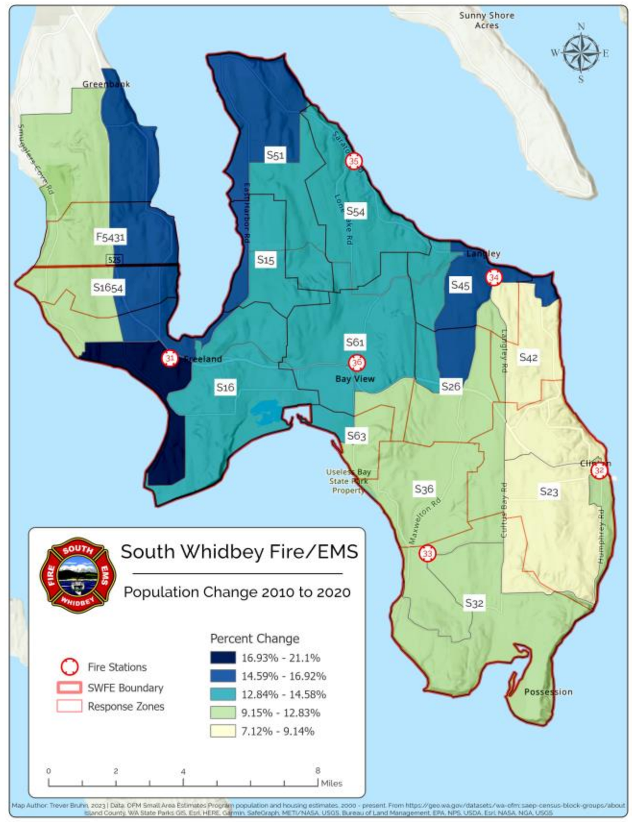


Population Overview

Population Overview

The district is predominately rural in nature. The only incorporated municipality in the district is the City of Langley, which has a population of 1,180. In addition to the City of Langley, two other communities, Clinton and Freeland, have their own post offices and zip codes.





Race and Age Demographics

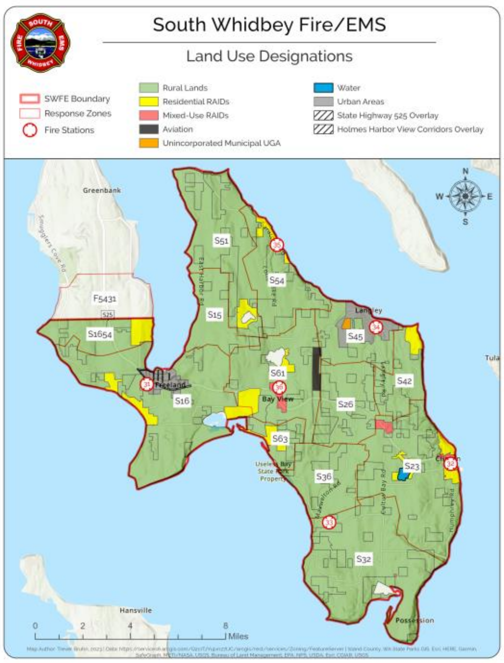
The district has a permanent population of 16,000, but due to an influx of tourists and employees, the effective daily population can be as high as 25,000.

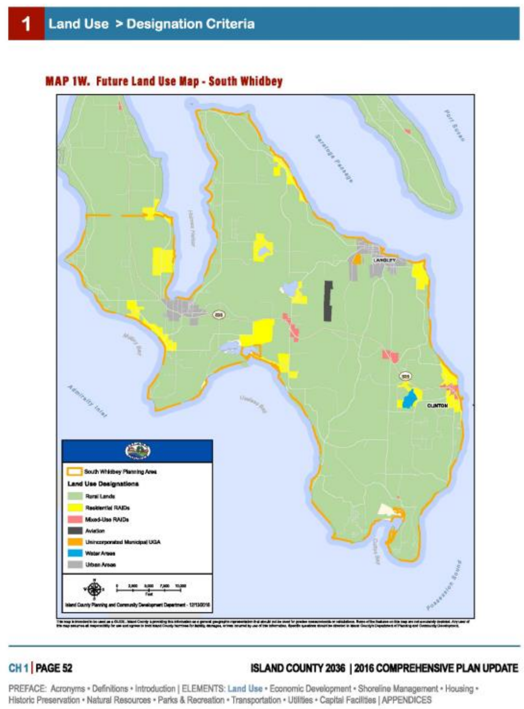
Location	White	Black	Hispanic	Asian	Native American	Median age
South Whidbey	93.9%	0.6%	2.7%	1.6%	0.9%	55.1 years
WA State	78.2%	3.6%	11.7%	7.5%	2.0%	37.4 years
United States	73.9%	12.6%	16.9%	5.0%	1.0%	37.4 years

It is noteworthy that the district population is so predominately white, and that the median age is nearly 20 years older than the median age state-wide or nationally.

Core Competency 2A.4
The agency assesses the community by planning zone and considers the population density within planning zones and population areas, as applicable, for the purpose of developing total response time standards.

Zoning and Land Use





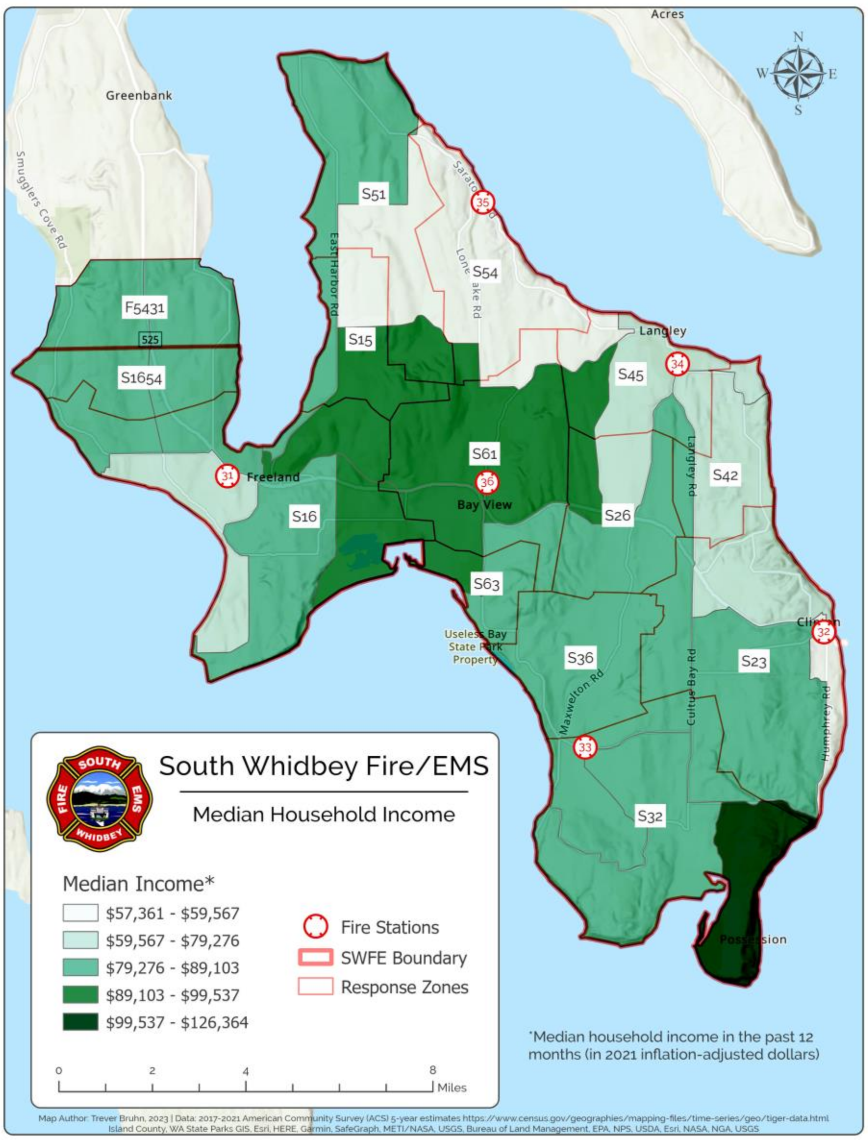
Housing Demographics

Location	total units	occupied	owner occ	renter occ	seasonal/vacation
South Whidbey	9563	74.6%	36.5%	17.8%	18.0%
WA State	-----	90.6%	56.8%	33.8%	3.2%
United States	-----	87.6%	56.3%	31.2%	3.8%

It is noteworthy that over 25% of the housing units in the district are vacant, compared to 10% state-wide, and that 18% of them are seasonal or vacation homes, which is about 5 times the rate of vacation homes state-wide or nationally. Many of these vacation homes are short-term/vacation rentals, which cater to the tourist population.

Socio-economic Demographics

The citizens of South Whidbey Fire/EMS are typically well-educated, with the number of citizens per capita with Bachelor's degrees about 50% higher than the national average rate, and the number with Master's, Doctorate's, or Professional degrees being nearly double that of the national average rate. Per capita income is approximately 25% higher than the national average. However, the cost of living is also higher, particularly housing costs, with the median value of owner-occupied homes more than double the national average. There are 7,136 households, with an average household size of 2.2 persons, compared to the national average household size of 2.63. This is consistent with the median age of the population, as older residents are more likely to not have children at home, resulting in two-person households.



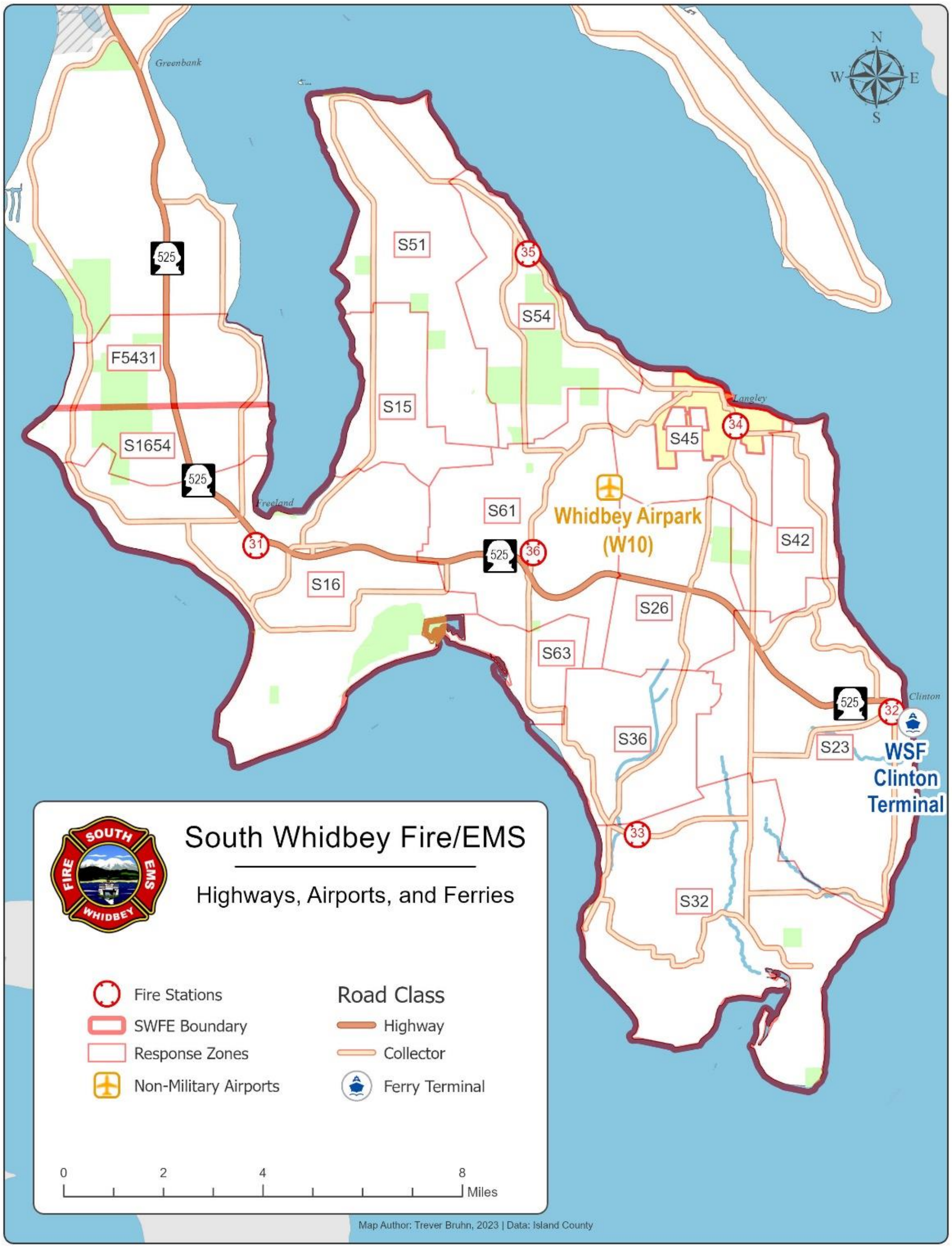
About 93% of the households speak English in the home, and nearly all of the remaining 7% are bilingual, so there is no significant population in which a language barrier is likely to be encountered. The small businesses that typically pay service-worker wages have a significant issue finding employees. The demographic that would normally fill these types of jobs have a very hard time finding housing, and if they do find it, they have an even harder time affording it. There is more affordable housing to be found in Oak Harbor, a city of 25,000 which is 27 miles towards the north end of the island, but since Oak Harbor is home to Naval Air Station Whidbey, a large percentage of the apartments and lower-priced housing is occupied by many of the 8,700 military personnel stationed there, and the vacancy rate is low (active duty personnel are required to live closer to the base than our district). Living in the mainland cities such as Everett is complicated by the need to commute via ferry to reach the South Whidbey area. A foot passenger ticket on the ferry is around $6.00 each way, and a vehicle with driver is around $10.00 each way, which adds significantly to commuting expenses.

The upshot of this combination of housing costs and housing shortages is that the percentage of young people in the 20-24-year age group is about 3% of the total population, compared to the Washington and national averages in the 7% range. Presumably this is because the young people have difficulty finding suitable housing, and move off the island to live and work. This shortfall continues up through the working ages until the 45-54-year age category, where the local numbers catch up with the state and national averages. This contributes to the skew in the median age of the population, and also contributes to the dearth of employees for entry-level jobs.

Built Environment

Highways, Airports and Ferries

Highway 525 transects the fire district primarily in an east-west manner before turning north to eventually connect with Highway 20 south of Coupeville. The Washington State Ferry terminal in Clinton has ferries running every 30 minutes to connect Hwy 525 with the mainland terminal in Mukilteo. There is a private airport in the center of the district that provides landing and hanger facilities for small private planes.



Port of South Whidbey, Langley Marina

Washington State Ferry Clinton Terminal

Whidbey Airpark

Highway 525

Shopping Center, Freeland

First Street, Langley

South Whidbey High School

Clinton

Ken's Korner Shopping Plaza, Clinton

Bayview Center Shopping Plaza, Langley

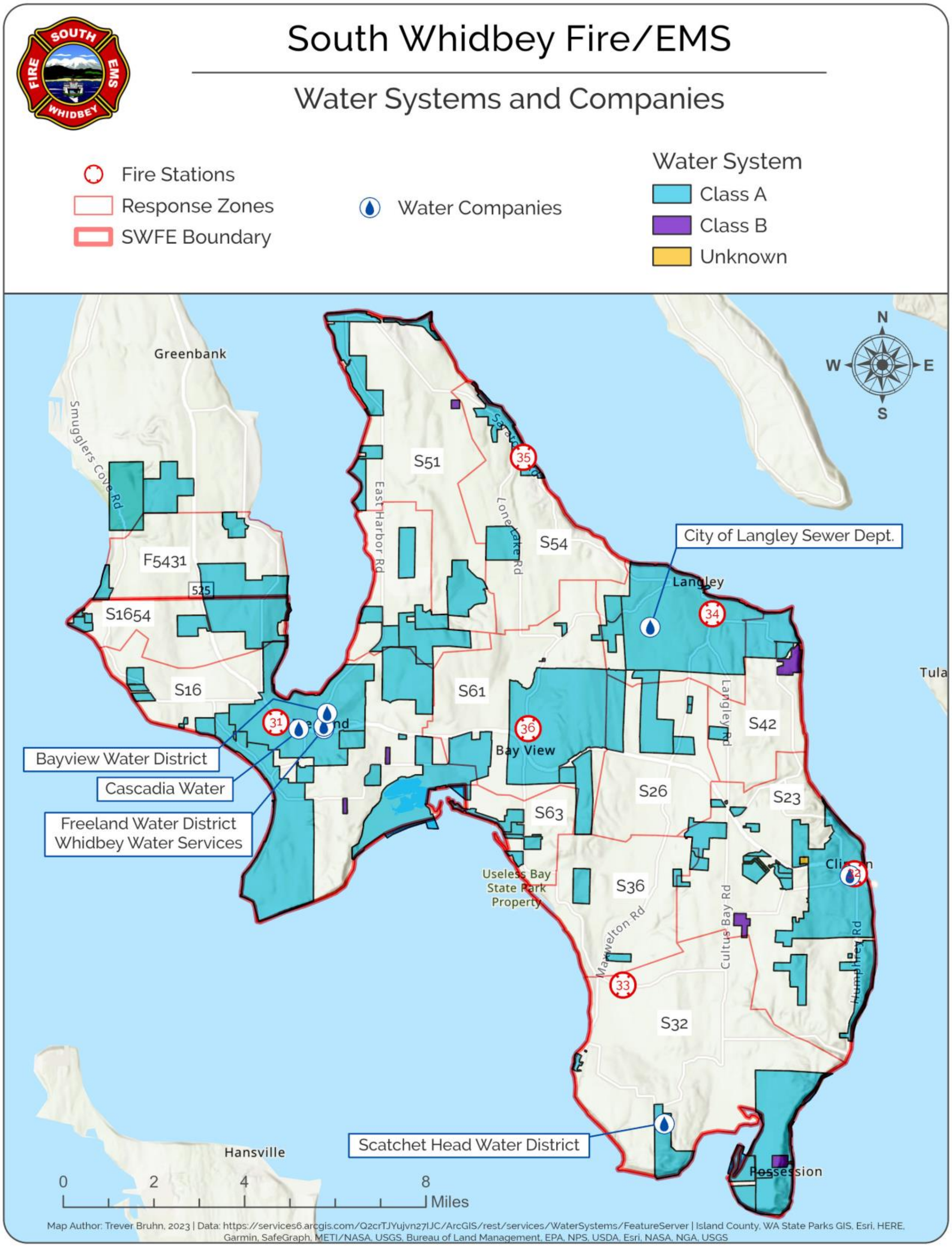
Maple Ridge Assisted Living, Freeland

Maple Ridge is a 59,500 square foot retirement community built in 2007. It has a basement, a 10,100 square foot main floor, and 4 occupied floors above grade. Island County has it appraised at $8,509,432.

Nichols Brothers Boat Builders, Freeland

Sandy Hook Subdivision and Marina, Clinton

Water Systems

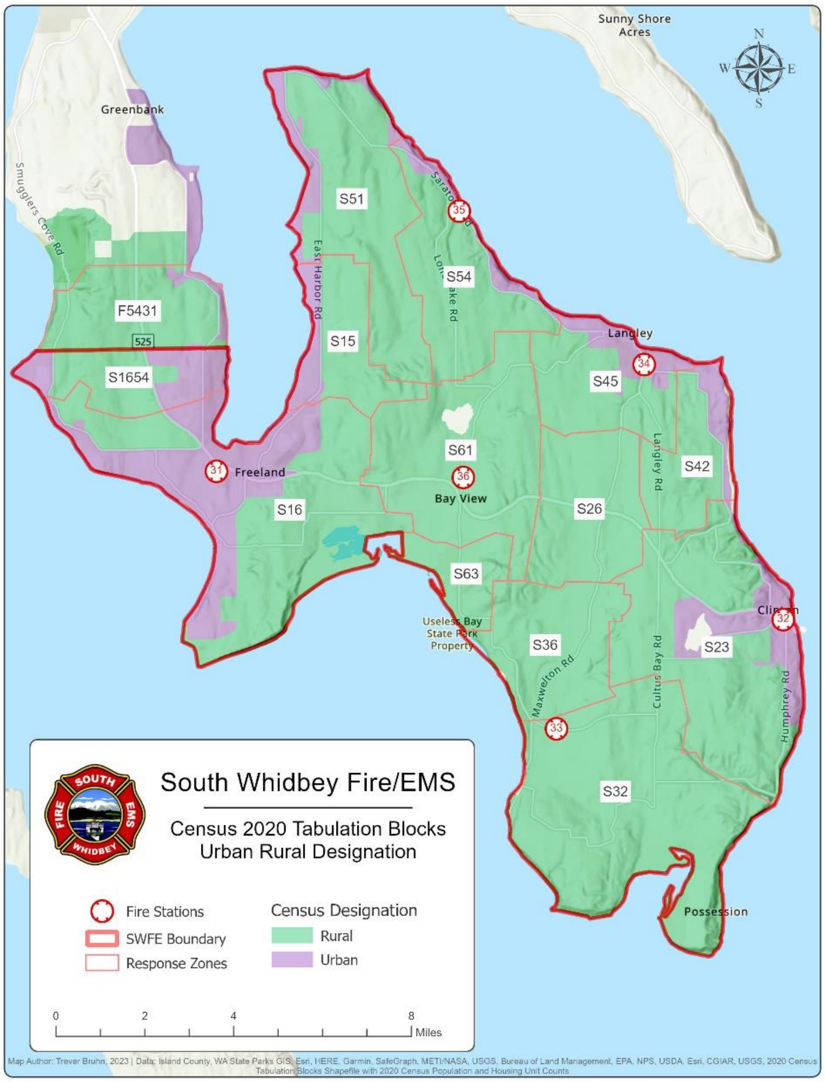


Section B – Description of Agency Programs and Services

South Whidbey Fire/EMS Facilities and Apparatus

Stations

South Whidbey Fire/EMS serves this population with one fully staffed fire station (Station 36) located more or less centrally in the district, one intermittently staffed fire station (Station 31) located in the NW part of the district, and four volunteer stations spread out towards the perimeter of the district. SWFE provides BLS first response, with ambulance transport being provided by Whidbey Health Hospital. Although the hospital is located in Coupeville, 15 miles north of the district, there is an ambulance station in the district with a normal staffing of two ALS ambulances.



STATION 31 – FREELAND

5535 CAMERON RD.
FREELAND, WA 98249

Station 31 has four apparatus bays, two offices, a workout room, and a medium-sized classroom. It has living facilities (bedrooms, dayroom, and kitchen) for up to six personnel, but is only staffed with two when a shift is staffed with four or more. A small cadre of volunteers also responds out of this station.

ENGINE 31- Type 1, Rosenbauer, 1500 GPM Fire pump, 750 gallon water tank, Purchased 2010

Aid 3—BLS transport-capable, 2017 E450 Ford, purchased used 2022

TENDER 31- Freightliner/Rosenbauer, 2,800 gallon water tank, Purchased 2019

AID 31- BLS non-transport, Ford Explorer, Purchased 2021

Reserve ENGINE 362—TYPE 1, Freightliner/Smeal, 1250 GPM pump, 750 gallon water tank, purchased 1994

MCI trailer, used for large scale multi casualty incidents, Purchased 2012

STATION 32 - CLINTON

6435 CENTRAL AVE
CLINTON, WA 98236

Station 32 has two apparatus bays, a classroom, a workout room, and a dayroom. It does not have living quarters at this time, however, the classroom could be remodeled to provide two bedrooms in the event that staffing it is desired. It is on a septic system which limits the expansion. A cadre of volunteers responds out of this station.

ENGINE 32- TYPE 1, Rosenbauer, 1500 GPM Fire pump, 750 gallon water tank, Purchased 2010

TENDER 32- Freightliner/Rosenbauer, 750 GPM pump, 2,800 gallon water tank, Purchased 2016

MCI Trailer, used for large scale multi casualty incidents, Purchased 2012

STATION 33 - MAXWELTON

3405 FRENCH RD
CLINTON, WA 98236

Station 33 has two apparatus bays and a small classroom/office space. It is on a septic system which is not adequate for future expansion and the property has wetland areas which preclude the expansion of that septic system.

ENGINE 33- TYPE 1, Rosenbauer, 1500 GPM Fire pump, 1000 gallon water tank, Purchased 2012

TENDER 33- Freightliner/General Fire, 750 GPM pump, 2,500 gallon water tank, Purchased 1998


on

STATION 34 - LANGLEY

820 CAMANO AVE.
LANGLEY, WA 98260

Station 34 does not have sleeping quarters. It does have four drive-thru apparatus bays, an office, a small workout room which could be a second office, a small classroom, a toolroom, a laundry space and an upstairs storage mezzanine. There is sufficient space on the property to expand the station by adding living quarters, and it is on municipal water and sewer systems which would support such an expansion.

ENGINE 34- TYPE 1, HME/Central States, 1500 GPM Fire pump, 750 gallon water tank, Purchased 1997

MCI trailer, used for large scale multi casualty incidents, Purchased 2012

STATION 35 - SARATOGA

3982 SARATOGA RD
LANGLEY, WA 98260

ENGINE 35- TYPE 1, Freightliner/Smeal, 1250 GPM Fire pump, 750 gallon water tank, Purchased 1994

TENDER 35- Freightliner/Firehorse, 750 GPM pump, 2,500 gallon water tank, Purchased 1995

REHAB 3- Ford E-350, Purchased 2000, carries drinking water, snacks, shade tents and chairs for firefighter rest and rehabilitation on extended incidents such as structure fires.

STATION 36 - BAYVIEW

5579 Bayview Rd.
LANGLEY, WA 98260

This station has living facilities for six personnel. Normal daily staffing is 3-4 personnel.

District Administration Offices are located in the east wing of the building.

ENGINE 36- TYPE 1, E-One, 1500 GPM pump, 1000 gallon water tank, purchased 2022

TENDER 36- Freightliner/Rosenbauer, 750 GPM pump, 2,800 gallon water tank, Purchased 2016

AID 36—BLS non-transport, Ford Explorer, purchased 2021

RESCUE 3- Light rescue, Ford F-550 4x4, purchased 2013

MARINE 31- Rescue boat, RIB 16’, Purchased 1998, powered by 2014 60HP Yamaha outboard

Air 3- Ford F-350 4x4, Cascade Air system, generator, and light tower, Purchased 1996

BRUSH 36- TYPE 5 brush truck, Ford F550, 120 GPM pump, 400 gallon tank, purchased 2007

MARINE 3- TYPE 3 FIREBOAT, 35’ Catamaran, moored in the water at the Langley Marina, Purchased 2013.

Maintenance Facility

2874 VERLANE STREET
LANGLEY, WA 98260

The 3-bay building was previously used as Station 36 and was repurposed to provide an area for South Whidbey Fire/EMS's fire mechanic to maintain and service the district's apparatus.

Isuzu Box Truck, Service and Maintenance, Purchased 2014

Financial

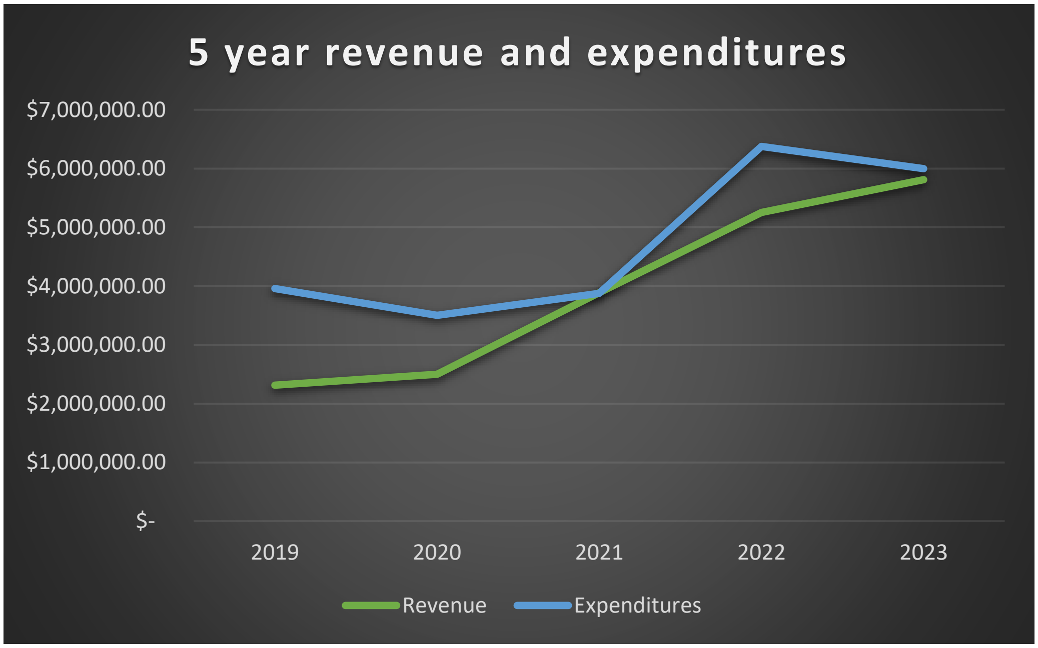
Revenue

Property tax revenues tend to be stable. They are based on the prior year's levy amount with optional increases of up to one percent, plus property tax on the value of new construction. Property taxes are levied on real property owned by individuals and businesses. In accordance with the Washington State Constitution and state law, property taxes paid by a property owner are determined by a taxing district's rate applied to the value of a given property. In the County, the total property tax levy varies based on the make-up of the various taxing districts that include cities, school districts, fire districts, other special purpose districts and the county-wide levy. SWFE operates with funding from property tax revenues generated through a fire levy at $0.84 per $1,000 for a total levy rate of $5.8 million in 2023. A contract with Whidbey Health (the primary ALS transport provider) for ems supplies provided approximately an additional $300,000.00 in 2023.

SWFE brings in some limited additional funding through EMS classes and payments in lieu of taxes from governmental agencies for an additional $5,000.00 dollars annually.

Debt

In 2019 SWFE built a new headquarters station at 5579 Bayview Road in Langley. This station was funded through a bond of $4.5 million. Debt service on this bond for 2023 was $321,760 with $258,380.00 going toward principal and $63,380.00 going to interest. This represents the only debt SWFE has at this time. This bond fully matures in 2036.



Auto/Mutual Aid

Performance Indicator 2A.2

Boundaries for other service responsibility areas, such as automatic aid, mutual aid and contract areas, are identified, documented, and appropriately approved by the authority having jurisdiction.

Through contracts and agreements, South Whidbey Fire/EMS continues to maintain a partnership with the following Island County agencies:

- Central Whidbey Island Fire & Rescue
- North Whidbey Fire & Rescue
- Oak Harbor Fire Department
- Naval Air Station Whidbey Island Fire Department
- Port of South Whidbey
- City of Langley
- Island County Sheriff's Office
- Island County Emergency Management
- Island County Public Health
- Island County Senior Services
- Whidbey Health EMS
- American Red Cross

Section C- All-Hazard Risk Assessment of the Community

Risk Assessment Process

The purpose of this section is to describe the process used in performing an analysis of the community it serves and its potential risks using real world factors that are both physical and theoretical. To perform a comprehensive risk assessment, it was necessary to analyze physical, economic, sociologic and demographic aspects of the area served. The factors that drive the service needs are examined in a precise and scientific manner to determine the capabilities necessary to adequately address the risks that are present. The assessment of risk is critical for the determination of the number and placement of resources, and the mitigation measures that are required by the community.

All-Hazard Risk Assessment and Response Strategies as it relates to Criterion 2B:

The agency identifies and assesses the nature and magnitude of all hazards and risks within its jurisdiction. Risk categorization and deployment impact considers such factors as cultural, economic, historical, and environmental values, and operational characteristics.

The risks that the district faces can be natural or human-made and fall in various locations on the consequence, probability and impact matrix. Where these risks are located on the matrix has a direct impact on how resources are located around the jurisdiction (distribution) and the overall amount of resources required to mitigate the incident (concentration) effectively through the use of the staffing and deployment model.

Core Competency 2B.1

The agency has a documented and adopted methodology for identifying, assessing, categorizing and classifying all risks (fire and non-fire) throughout the community or area of responsibility.

Each of the major natural and human-made risks evaluated received a clearly defined probability and consequence ranking. Service areas that either had little quantitative data, or did not require that level of analysis, were evaluated through both retrospective analysis as well as structured interviews with District staff members.

Core Competency 2B.4

The agency's risk identification, analysis, categorization, and classification methodology has been utilized to determine and document the different categories and classes of risks within each planning zone.

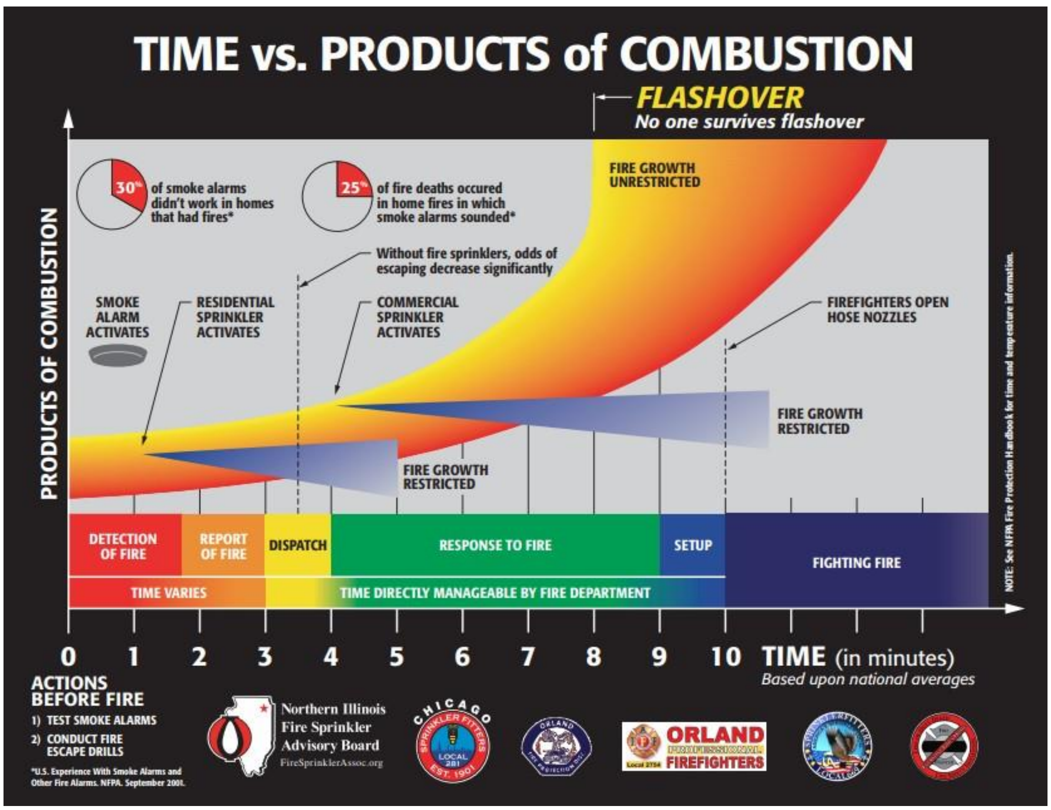
CAD call types from the 2017- 2022 CAD data file were classified into the program areas of EMS, Fire, Hazmat, Other, and Technical Rescue based on district leadership decisions, and were assigned a risk classification. This was accomplished through an internal accreditation team that evaluated each of the CAD event types and classified each by program areas and risk level low, moderate, high, and maximum. Results are provided in the following pages.

Human-made Risks

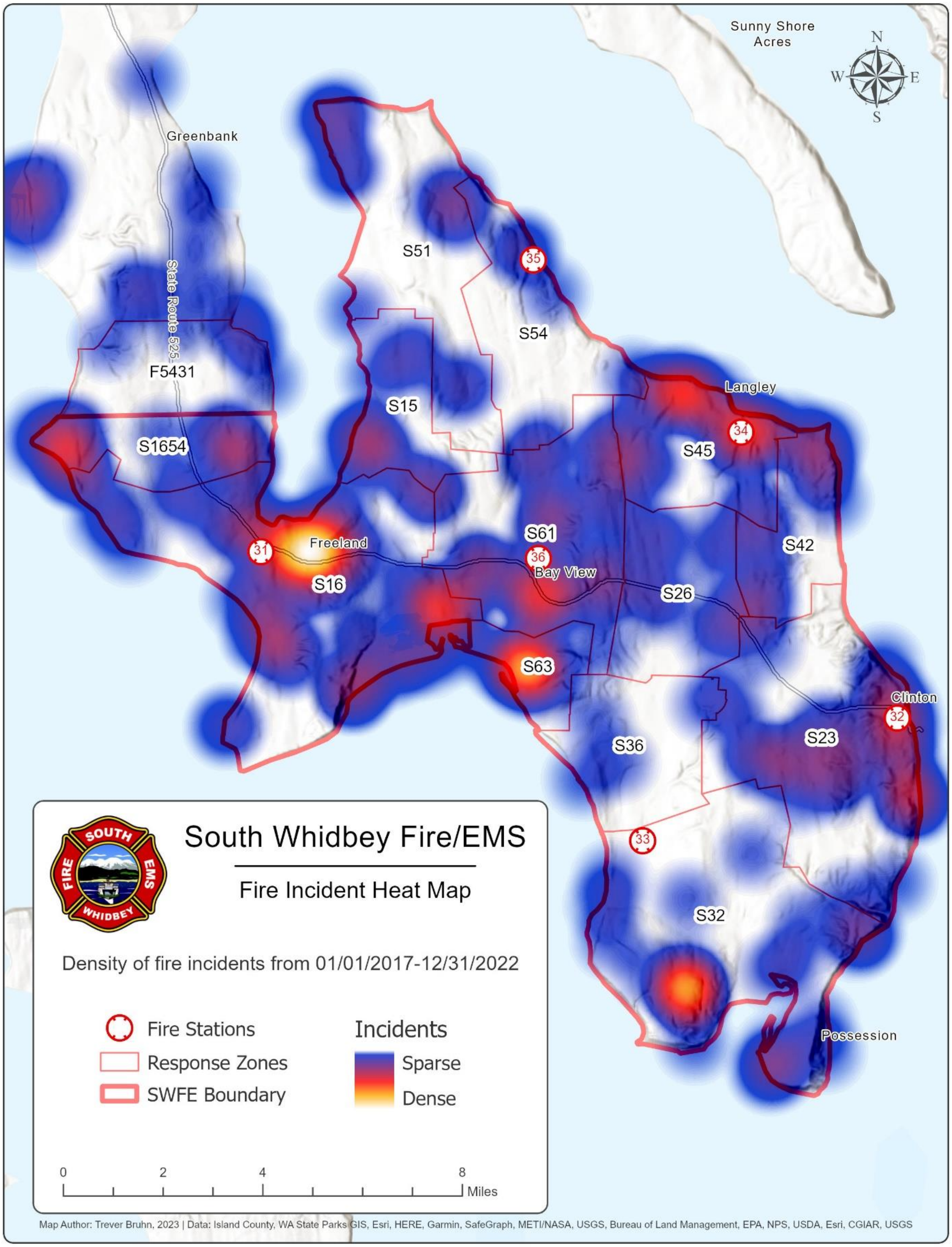
Structure Fires

High Risk **High Probability** **High Consequence**	**Structure Fire**

Fire suppression is one of the most visible response services that a fire District provides, and at the very core of our existence. As evidenced by the flashover curve and exacerbated by modern furnishings and construction methods, fires are an extremely time sensitive emergency.
The district has classified the risk of fires into four main categories: low, moderate, high and maximum. These rankings are applied to individual occupancies and to areas of like type buildings



Recent studies by Underwriter's Laboratories (UL) have found that in compartment fires such as structure fires, flashover occurs within four minutes in modern fire environment. In addition, the UL research has identified an updated time temperature curve due to fires being ventilation-controlled rather than fuel-controlled as represented in the traditional time temperature curve. While this ventilation-controlled environment continues to provide a high risk to unprotected occupants to smoke and high heat, it does provide some advantage to property conservation efforts, as water may be applied to the fire prior to ventilation and the subsequent flashover.


South Whidbey Fire/EMS
Fire Incident Heat Map
Density of fire incidents from 01/01/2017-12/31/2022
Fire Stations
Response Zones
SWFE Boundary
Incidents
Sparse
Dense
0 2 4 8 Miles
Sunny Shore Acres
Greenbank
State Route 525
S51
S54
F5431
S15
Langley
S1654
S45
S61
S42
Freeland
Bay View
S16
S26
S63
Clinton
S36
S23
S32
Possession
Map Author: Trever Bruhn, 2023 | Data: Island County, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, CGIAR, USGS

Critical Tasking and Effective Response Forces for Fire Incidents

General Description – The district approaches response to fires in a tiered fashion. Below is the description of what low, moderate, high or maximum response is, with corresponding critical tasking in the Effective Response Force for Fires Table.

Low – This type of fire is a low risk/value incident such as a dumpster, car, or brush fire. It requires a single unit with pumping capability to effectively respond and mitigate.

Moderate – This is a residential or small commercial structure fire and calls for eight apparatus for a total of 18 personnel.

High/Maximum – Large structures including multi-family complex fires, expansive industrial occupancies or other buildings requiring additional personnel to accomplish multiple simultaneous tasks. This type of response calls for 16 apparatus for a total of 36 personnel.

Effective Response Force For Fire Incidents

Task	High / Maximum	Moderate	Low
Command	**1**	**1**	**1**
Safety	1	1*	1*
Lobby Control and Accountability	1		2
Pump Operation	3	2	1
Fire Attack 1	3	2	
Fire Attack 2	3		
Water Supply / Secondary Search	6	4	
Search / Forcible Entry	4	2	
Ventilation / Utilities	3	2	
RIT	4	3	
Evacuation	3		
Medical Standby / Rehab	2	2	
ERF Personnel	**36**	**18**	**4**
ERF Units	**16**	**8**	**2**

* For low or moderate risk incidents, the command and safety tasks may be combined in one position.

Structural Fire Conflagration

This four-alarm fire occurred in downtown Friday Harbor on San Juan Island in April of 2022. It destroyed three historic buildings and damage three others. The total loss exceeded $10 million.

How similar is this to downtown Langley?

High Risk **Moderate Probability** **High Consequence**	**Limited or no access for firefighting**

Island County does not include fire department approval of access for residential building permits. As a result, there are a significant number of driveways that have restrictive corners, grades, or clearances that would prevent access by large fire apparatus. Some of these private roads access 10 or more homes. There are also groups of beach homes that do not have any road access at all, just boardwalks or paved pathways only big enough for a golf cart. In the latter instances, our only means of delivering adequate water supplies to fight a fire would be to pump to shore with our fireboat. This is a time-consuming process at best.


Witter Beach
Write a description for your map.
Legend
Saratoga Orchestra
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400 ft

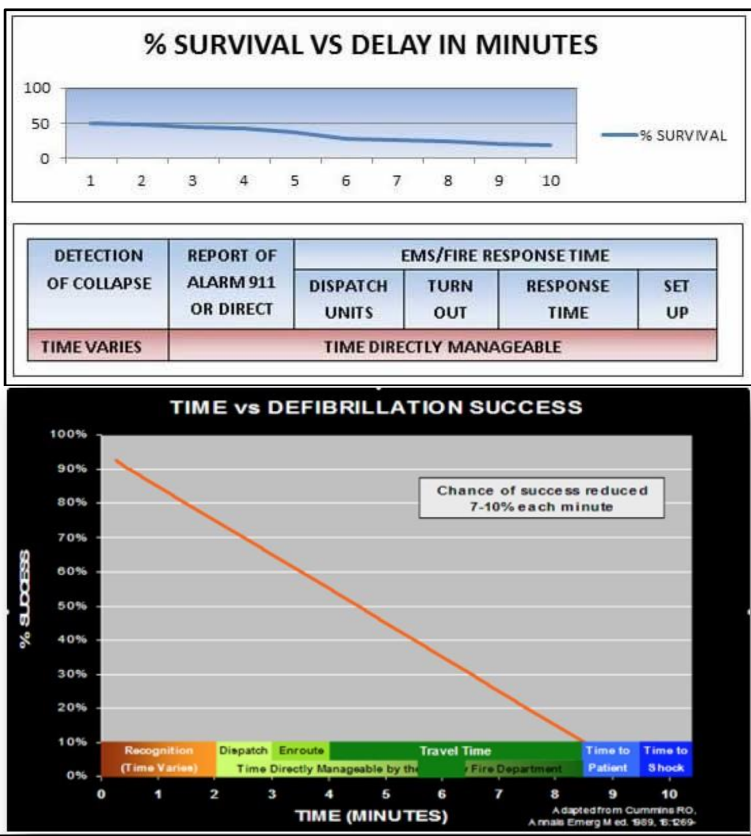
Emergency Medical Services

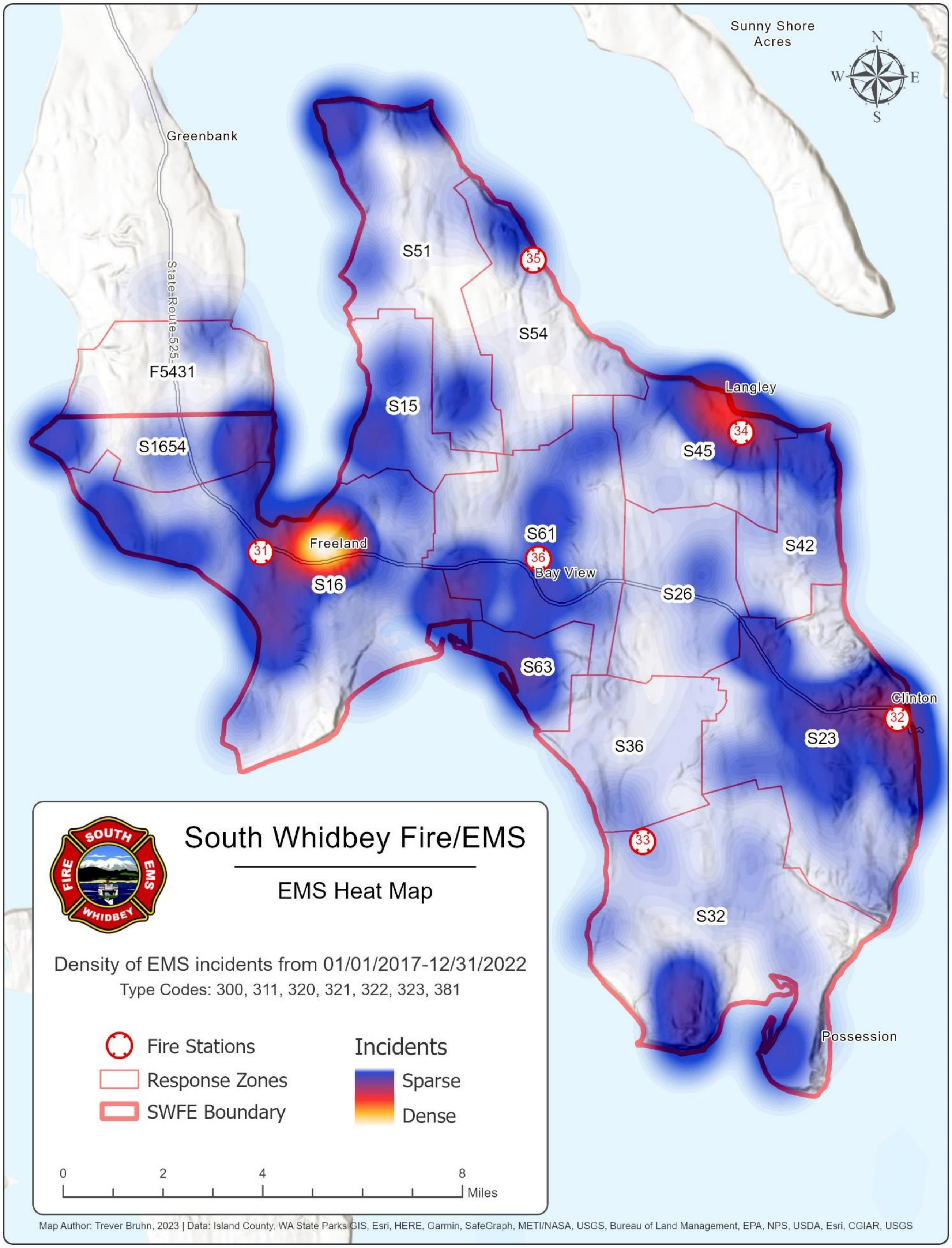
Moderate Risk **High Probability** **Low Consequence**	Emergency Medical Services

Time is a critical element when responding to true medical emergencies, with the chance of a survival for a cardiac arrest dropping precipitously with every passing minute.

The potential survival rate for cardiac arrests, which is one of the most serious medical emergencies an individual can experience, is only at 50% by the time a fire apparatus leaves the station, making prevention efforts of a crucial piece of achieving positive patient outcomes.

When evaluating the steady rise in emergency medical calls over the last few decades, it is readily apparent that the workload demand of these calls will continue to rise. The district is actively working with community partners to reduce or eliminate many of the lower risk/severity calls for help by channeling the patient into a more appropriate method of care.




Sunny Shore
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Langley
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S61
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Freeland
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Bay View
S16
S42
S26
S63
Clinton
32
S36
S23
33
S32
Possession
South Whidbey Fire/EMS
EMS Heat Map
Density of EMS incidents from 01/01/2017-12/31/2022
Type Codes: 300, 311, 320, 321, 322, 323, 381
Fire Stations
Response Zones
SWFE Boundary
Incidents
Sparse
Dense
0
2
4
8
Miles
Map Author: Trever Bruhn, 2023 | Data: Island County, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, CGIAR, USGS

Critical Tasking and Effective Response Forces for EMS

General Description – The district approaches an emergency medical incident in a tiered fashion. Below is the description of what a low, moderate, high or maximum response is, with corresponding critical tasking in the Effective Response Force of EMS Table.

Low – This type of medical incident is for all EMS incidents with two personnel to serve as medical first responders. This response is typically handled by an aid unit.

Moderate – This level of medical emergency includes difficulty breathing, chest pain, imminent child birth, falls over 10 ft., obese patients requiring lifting assistance or traumatic injuries. At least two units respond with a total of four personnel to this type of incident to accomplish critical tasks needed in a timely manner.

High/Maximum – Incidents involving three or more patients as the result of a shooting, vehicle accident or other type of catalyst that requires multiple units to respond. Critical tasking is personnel on three units for a total of 7 personnel.

Effective Response Force For EMS Incidents

Task	High / Maximum	Moderate	Low
Command Safety	**1**	**1***	**1***
Patient Information	1*		
Patient Treatment	3	2	1
Transport	3	2	1
ERF Personnel	**7**	**4**	**2**
ERF Units	**3**	**2**	**1**

* For low or moderate risk incidents, the command, safety and patient information tasks may be combined in one position.

Hazardous Materials

Maximum Risk **Low Probability** **High Consequence**	**Hazardous Materials**

The potential release of hazardous materials exists wherever that material may be located. A higher potential for release coincides with storage sites at fixed facilities and along transportation routes, such as major roadways. Hazardous materials are chemical substances which, if released or misused, can pose a threat to people, property, or the environment. These chemicals are used in industry, agriculture, medicine, research, and consumer goods.

As many as 500,000 products pose physical or health hazards and can be defined as "hazardous chemicals." Each year, over 1,000 new synthetic chemicals are introduced. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in manufacturing plants.

Hazardous materials are contained and used at fixed sites and are shipped by all modes of transportation.

Hazardous materials that are found within the district in reportable quantities include:

- Gasoline
- Diesel
- Propane
- Chlorine

Hazardous materials that are found in lesser quantities but are significant include:

- Carbon Monoxide
- Acetylene welding equipment
- Fertilizer

Contagious/Pandemic and Chronic Disease

High Risk **High Probability** **High Consequence**	**Contagious/Pandemic and Chronic Disease**

Contagious Disease

The Island County Department of Public Health investigates certain diseases to find the source of a disease or outbreak in order to stop any ongoing spread of illness.

To ensure the health and safety of the community, when a contagious disease is confirmed in a place where people are in close contact (such as schools, daycares, and nursing homes), we follow up with the people who might be exposed to the disease as a result.

Thanks to vaccines, medical care, clean water, and safe food sources and handling, deadly diseases are more rare in Island County than ever before. International travel and trade, however, mean contagious diseases are never far away. New diseases also pose a threat, as they can develop and spread rapidly.

Chronic Disease

Chronic diseases, including heart disease, stroke, cancer, and diabetes, rank among the most common, costly, and preventable of all health problems throughout the United States. The 5 leading causes of death in Island County in 2010 were heart disease, cancer, stroke, chronic obstructive lower respiratory disease, and unintentional injury.

According to the CDC, nearly 1 out of every 2 adults has at least 1 chronic illness and 7 out of 10 deaths among Americans each year are due to chronic diseases. Access to high-quality and affordable prevention measures, including screening and appropriate follow-up care, are also essential steps in disease prevention. For example, regular cancer screenings can diagnose new cases of cancer at an early stage, which may improve the prognosis of the patient.

Lithium-Ion Battery Fires

Moderate Risk **Moderate Probability** **Moderate Consequence**	**Lithium-ion Battery Fires**

Electric vehicles are becoming increasingly popular, and more so on South Whidbey Island. As of March 2022, there were 1,100 electric vehicles registered in Island County. Our neighboring counties also have a significant number, with 9,878 registered in Snohomish County, 1,086 in Skagit County, and 47,918 in King County.
How Common Are Electric Vehicle Battery Fires?

There are a few ways to look at electric vehicles and battery fires related to them, but it's important to remember that comparing apples to apples between EVs and traditional gas cars doesn't yield an accurate result. Electric vehicles accounted for less than two percent of vehicle sales in the United States in 2020, so there will naturally be far fewer electric vehicle fires.

A better way of looking at electric vehicle fires is to compare the number of fires per 100,000 vehicles sold. Researchers from insurance deal site *Auto Insurance EZ* compiled sales and accident data from the Bureau of Transportation Statistics and the National Transportation Safety Board. The site found that hybrid vehicles had the most fires per 100,000 sales at 3474.5. There were 1529.9 fires per 100k for gas vehicles and just 25.1 fires per 100k sales for electric vehicles.

The reason why it's easy to think that electric car fires are so common is because EVs are still novel and still unknown to a large portion of the public. News and media outlets report on electric car fires more often because of its, which can make it seem like they are a common occurrence. What's more, when there are highway vehicle fires, they can require a tremendous amount of effort from emergency personnel to extinguish the blaze. A chain reaction inside the batteries—sometimes called thermal runaway—can occur when the battery generates more heat than it can dissipate.

Lithium-ion batteries also burn hotter and can last much longer than gas, which tends to burn out quickly. Lithium-ion battery fires can take tens of thousands of gallons of water to extinguish. The National Fire Protection Association notes one EV fire in Texas required more than 30,000 gallons of water after a crash. Fire departments aren't always equipped with trucks and other gear to deal with that. Emergency responders and firefighters must follow different response guides than for gasoline fires, and need training to properly extinguish the blaze.

The National Transportation Safety Board (NTSB) has found that many automakers have incomplete or inadequate emergency response guide notes on EVs, but change will come in time. As electric cars become a larger part of the overall vehicle market, manufacturers, law enforcement powers, and product safety advocates will likely develop updated industry safety standards and response methods to cope with the vehicle fire issues.

Types of Electric Car Battery Fires

The most commonly reported types of electric vehicle battery fires tend to end up being one of two things. In some cases, batteries have caught on fire after the vehicle was involved in a collision or after the car batteries have been damaged in some way. Automakers have reinforced battery protection in recent years to reduce the safety risks in an EV after a collision.

Other fires occur during charging, which is the case with recent vehicle fires that have made the news recently and resulted in safety recalls, to the cost of billions of dollars. Investigation shows that the affected vehicles' battery cells had an identified manufacturing defect that increased fire risks when charging.

One area of concern is EVs that have been flooded by salt water. According to the NHTSA, **residual salt within the battery or battery components can form conductive "bridges" that can lead to short circuit and self-heating of the battery, resulting in fires.** The time frame in which a damaged battery can ignite has been observed to vary widely, from days to weeks.

For example, in the storm surge in Florida that accompanied Hurricane Ian in September 2022, many vehicles were submerged at least partially in salt water. In the following weeks, at least 12 EV fires were reported in Collier and Lee Counties. One on Sanibel Island burned 2 houses to the ground.

Structure fires related to Lithium-ion batteries:

Obviously, the risks of electric vehicle battery fires are compounded if the vehicle is inside a garage, especially a garage attached to a residence. The structure fire from this circumstance is probably not able to be extinguished before substantial damage occurs.

Similarly, some battery banks are now being installed in structures, including residential structures, as part of solar or wind powered alternative energy systems. These Lithium-ion battery banks pose the same, or even greater, risks as an electric vehicle fire, in that the water flow necessary to extinguish them may well exceed the capacity of the water system.

Transportation Network

Moderate Risk **High Probability** **Low Consequence**	**Transportation Network**

Highway

Whidbey Island has the unique feature of being an island with one bridge and two ferry routes providing access and egress. The only roadway onto the Island is from State Highway 20 across the Deception Pass Bridge from Fidalgo Island, which in turn is connected to the mainland by three bridges across the Swinomish Channel (two 'twin" bridges just east of Anacortes, and the "Rainbow Bridge" in LaConner). Highway 20 in the north and central parts of the island, and Highway 525 on the south end of the island, are maintained by the Washington Department of Transportation.
The Roads Division of Island County is responsible for the approximately 600 centerline miles of County-owned roads on Camano and Whidbey Islands. The risks associated with this transportation network is keeping access to the Island open. This can be disrupted by vehicle accidents and fires and roadway blockages from storms or strong winds.

Aviation

There is one privately owned airport in the fire district that is open to the public. This single airstrip is located in the center of the district just east of Station 36. In the central part of the island, there is the Out Lying Field Coupeville, operated as a training site by the Navy. On the north end of the island, there is Ault Field located north of Oak Harbor which is the home of Naval Air Station Whidbey Island, and a second privately owned airport called AJ Eisenberg Airport south of Oak Harbor. Associated risks that accompany this hazard are aircraft emergencies occurring over populated areas which can result in life and safety hazards.

Ferry system

The Washington State Ferry system, which is part of the Washington Department of Transportation, operates two ferries onto Whidbey Island. The one within SWFE's district runs between Clinton and Mukilteo. The second one runs between Coupeville and Port Townsend. Associated risks are service interruptions due to stormy weather causing high wind and/or rough sea states, however, these generally are not long-term interruptions. Longer interruptions could occur due to incidents blocking or damaging the ferry terminals, which has happened to other terminals in the system.

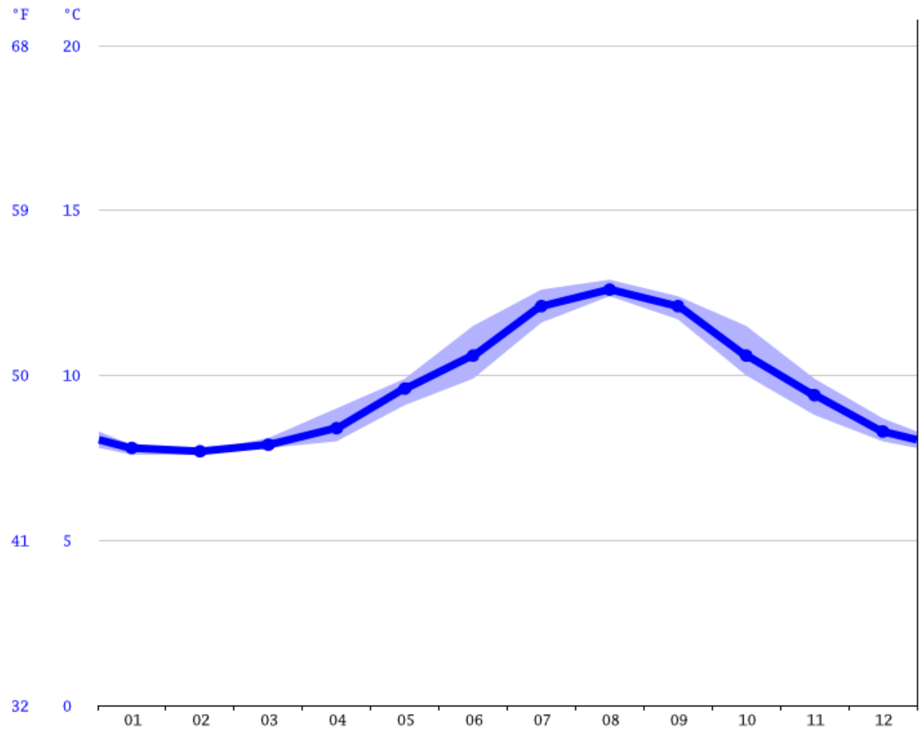
There are no railroads and no freeways on Whidbey Island.

Marine Activities

Moderate Risk **High Probability** **Low Consequence**	**Marine Activities**

With 57 miles of shoreline, it is inevitable that SWFE will be called on to perform rescue and firefighting for incidents related to recreational and commercial activities on the water. Although rescue in the marine environment is the primary duty of the United States Coast Guard, that agency's nearest stations are in Seattle, Bellingham, or Port Angeles. The USCG does have boats docked at times in Everett and Port Townsend, but these are not full-time stations. As a result, the fire agencies in Island County often are the closest resource, and co-respond with the USCG.

Time is a critical factor in marine rescues, due to the water temperatures. The graph below shows the average water temperatures by month at Langley. As you can see from the second graph, this equates to survival times of approximately 30 minutes in the winter and 90 minutes in the summer.


°F
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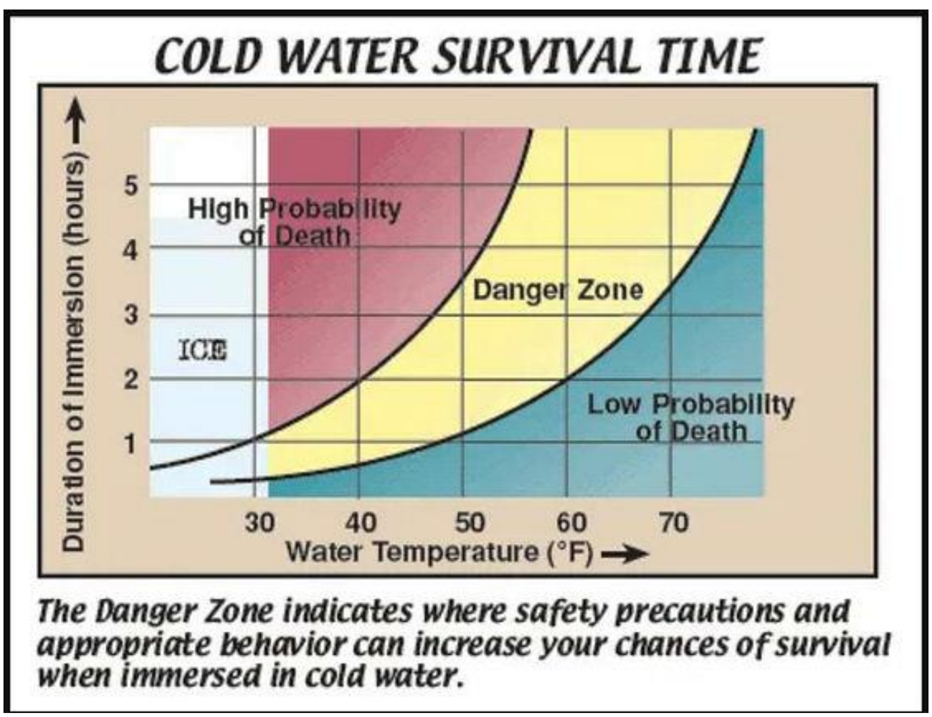

COLD WATER SURVIVAL TIME
Duration of Immersion (hours)
5
4
3
2
1
High Probability of Death
ICE
Danger Zone
Low Probability of Death
30
40
50
60
70
Water Temperature (°F)
The Danger Zone indicates where safety precautions and appropriate behavior can increase your chances of survival when immersed in cold water.

High Angle Rescue

Moderate Risk **High Probability** **Low Consequence**	**High Angle Rescue**

Because of the terrain and vegetation of the high bluffs around much of the shoreline of South Whidbey, we are called to perform rescues on these bluffs. Most commonly these are animal rescues, usually a dog, that has gone part way down the slope from the top of the bluff, or occasionally part way up from the beach, and cannot find their way back to flat ground. We have determined that if we don't rescue the pet, we will soon be called to rescue their owner who has attempted to do the rescue themselves, and now is just as stuck as the pet.

Natural Risks

Wildland Fire Conflagration

Moderate Risk **Low Probability** **High Consequence**	**Wildland Fire Conflagration**

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use and arson.

Wildland fire risk is scored based on several factors, including vegetation, topography, the built environment and available fire protection.

When identifying areas of fire concern, in addition to the Federal Register, the Washington Department of Natural Resources and its federal partners also determine communities at risk based on fire behavior potential, fire protection capability, and risk to social, cultural and community resources. These risk factors include areas with fire history, the type and density of vegetative fuels, extreme weather conditions, topography, number and density of structures and their distance from fuels, location of municipal watersheds, and likely loss of housing or business.

Windstorm/Severe Weather

Moderate Risk **High Probability** **Moderate Consequence**	**Windstorm/Severe Weather**

The climate of the District is heavily influenced by marine air masses, which tend to moderate temperatures with seasonal variations. Overall the weather is relatively mild on Whidbey Island. The average high temperature in August is 72°F and the average low temperature is 36°F in February. The area averages just over 47 inches of rainfall annually in addition to a small amount of snow generally totaling less than 2 inches each year. Wind speeds average 7 mph but maximum speeds of over 30 mph can occur.

The entire planning area is susceptible to the impacts of severe weather. Severe weather events customarily occur during the months of October to April, although they have occurred year-round. The County has been impacted by strong winds, tornadoes, rain, snow, or other precipitation, and often are accompanied by thunder or lightening (Island County, 2008). Considerable snowfall does not customarily occur throughout the region.

For Island County as a whole, wind events are one of the most common weather-related incidents to occur, often times leaving the area without power for extended periods. Severe storms affect transportation and utilities. Access across certain parts of the County is unpredictable as roads are vulnerable to damage from severe storms, storm surges, and landslide/erosion. Severe storms and storm surges can also cause flooding and channel migration. It has been said that, "Whidbey Island lives at the end of a single extension cord" referring to the fact that all the electrical power comes to the island via one set of overhead wires across Deception Pass. PSE has discussed adding submarine cables to link the south end of the island with the power grid on the mainland, but at this point, that is just a pipe dream. Meanwhile, there is a single choke point on the electrical infrastructure for all of Whidbey Island that is susceptible to storm damage.

Landslide/ Coastal Erosion

High Risk High Probability High Consequence	**Landslide / Coastal Erosion**

A landslide, or a mass of rock, earth or debris moving down a slope, may be minor or very large, and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, volcanic eruptions or human modification of the land. Landslides destroy property and infrastructure, and can have a long-lasting effect on the environment and can take the lives of people. Landslides typically occur during and after major storms, so the potential for landslides largely coincides with the potential for sequential severe storms and flood events that saturate steep, vulnerable soils. A specific recurrence interval has not been established by geologists, but historical data indicates several successive years of slide activities, followed by dormant periods. Landslides are most likely to occur during periods of higher than average rainfall. The ground in many instances is already saturated prior to the onset of a major storm, which increases the likelihood of significant landslides to occur. Most local landslides occur between October and April after water tables have risen. Water is involved in nearly all cases and human influence has been identified in more than 80 percent of reported slides.

A bluff is a cliff with a broad face, or a relatively long strip of land rising abruptly above surrounding land or water. Typically, it rises at least 25 feet above the water body at an average slope of 30 percent or greater. Bluff erosion is the erosion of these cliff sides or broad faces as a result of high waves, wind, groundwater or surface runoff and can lead to significant loss of land to the sea. Bluff erosion takes place from the top of the bluff down to the sea.

Whidbey Island is geologically unstable. It is made up of sedimentary soils that are constantly eroding along the shoreline bluffs. Much of the shoreline of the island is comprised of high bluffs, with a narrow beach along the water's edge. Island County has permitted building of houses along the top of these bluffs, which often have spectacular water views. They have also permitted building of houses and beach cabins at the foot of the bluffs, right at the edge of the beach. All of these houses (and roads accessing them) are at risk from landslides that occur on these unstable bluffs, usually due to heavy rains saturating the soils, but occasionally by seismic activity.

All of these houses are only accessible by a single road in and out, that snakes down the face of the bluff. These roads are difficult (or in some cases impossible) to navigate with large vehicles. In some cases, the road leads to a shared parking area, and access directly to the house is only via a path that is not navigable by full-size vehicles (golf cart type vehicles in some, footpaths only in others). SWFE does have a fireboat capable of supplying a 5" LDH supply line, so our plan for fire attack on these homes would be to hand-carry tools to the scene from the nearest parking area, and supplying the water from the boat.

We have identified the following neighborhoods as having these characteristics:

Neighborhood	# of homes	# of hydrants
East Point	73 homes	3 hydrants
Bell's Beach	74 homes	10 hydrants
Edgecliff Drive and Noblecliff Place	36 homes	7 hydrants
Witter Beach	10 homes	no hydrants
Norton Beach Lane and Hastings Rd	26 homes	2 hydrants
Brighton Beach Rd and Brighton Boardwalk	35 homes	5 hydrants
Possession Beach	25 homes	12 (1-1/2") hydrants
Scatchet Head	40 homes	1 hydrant
Mutiny Bay Shores	32 homes	no hydrants
Barr Beach	12 homes	no hydrants
Total homes at risk	363 homes	

East Point is accessed via Eastpoint Drive, which winds down the bluff from Fox Spit Road. The road does have a hairpin turn that is barely adequate for fire apparatus, requiring one "back and fill" maneuver to make the turn. Once at the beach level, there are 73 homes with access from a narrow one lane paved road. There are retaining walls along this road of varied construction, holding back the landslides with varying degrees of effectiveness. There is a water system with 3 hydrants present.

Bell's Beach is accessed via Bell's Beach Road from Saratoga Road. Once at beach level, there are 74 homes with access from a narrow one lane paved road. There are retaining walls along this road of varied construction, holding back the landslides with varying degrees of effectiveness. There is a water system with 10 hydrants present.

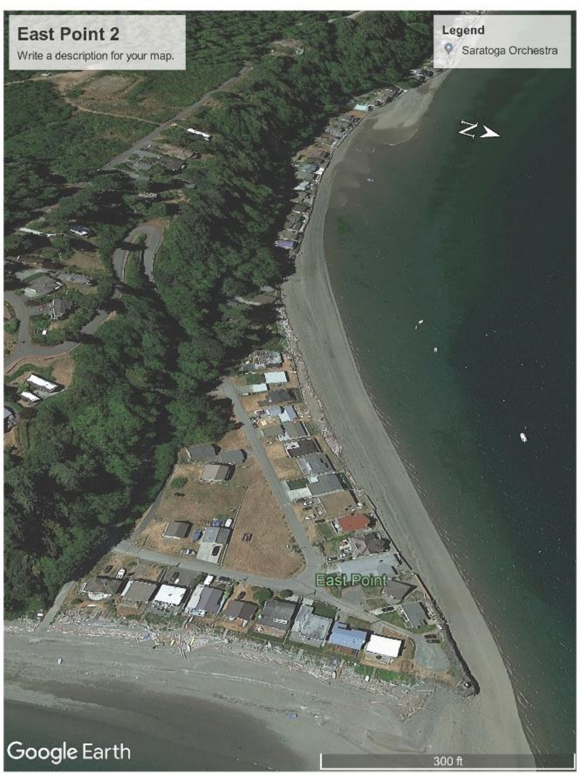
Edgecliff Drive and Noblecliff Place are within the city limits of Langley. They are at the top of the bluff, and are easily accessed via a two-lane paved street off of Camano Ave, with cross streets connecting to Sandy Point Rd. There are 36 homes on the bluff-top side of the road, many of which are at risk of sliding down the bluff and becoming beach homes. There are 7 hydrants that are part of the City of Langley water system.

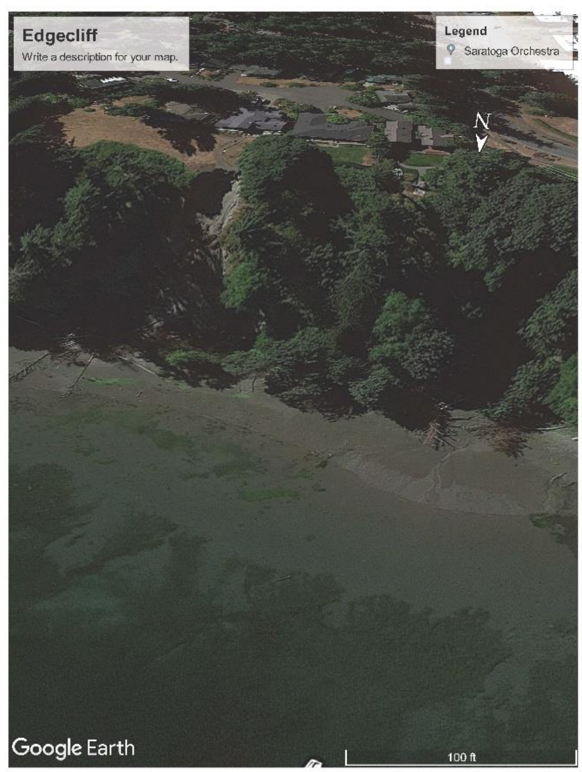
Witter Beach is accessed via Witter Road, which descends down a steep narrow concrete lane to Witter Beach Place. There are 10 homes along the beach. This access road is not adequate for fire apparatus, and there is no water system on Witter Beach Place, so we would either hand-stretch a supply down the bluff from a hydrant at the top of the bluff, or supply water from Marine 3 (fireboat). On a side note, there is 1 AED in a cabinet along Witter Beach Place.

Norton Beach Lane and **Hastings Road** are two steep narrow descents from Zimmerman Road, with a marginally accessible road along the base of the bluff. The access roads are not adequate for fire apparatus. There are two existing slides along the beach road, one of which is somewhat held in place by a wooden retaining wall. There are 2 fire hydrants at the level of the beach. The beach roads accessed by Norton Beach Lane and Hastings Road are connected by Campers Row Walk, which is not navigable by vehicles. There are a total of 26 homes along this beach.

Brighton Beach Road and **Brighton Boardwalk** are accessed by a two-lane paved road from Deer Lake Road. At beach level, there are 35 homes that are below the bluff and at risk from landslides, and 15 of these can only be accessed by a "boardwalk" which is actually more of a golf cart path. There are 5 hydrants along this road which are part of the Clinton Water District system.
Possession Beach is probably the highest risk locale in this category. It is located at the distant south end of the island so response times are long. There is a good, paved, two-lane road to the parking lot at the south end of the beach row, but the 25 houses on the beach are only accessed via a paved path passible by golf carts or ATV's, not fire apparatus. There are 12 small (1-1/2") hydrants in this neighborhood, so we would supply water from Marine 3 in the event of a major fire.
Scatchet Head is also located at the south end of the island, so again the response times are long. There is a good two-lane paved road down the bluff to Driftwood Drive, with 40 homes along the beach, all accessible by paved road. There is only 1 hydrant at beach level. On a side note, there are 3 cabinets with AED's maintained by the HOA.
Mutiny Bay Shores is located at the end of Wahl Rd, with a good two-lane paved access down the bluff, and a one-lane paved road at beach level. There are 32 homes along this road, with no hydrants.
Barr Beach is located just north of Mutiny Bay Shores, but is accessed by a steep one-lane paved road winding down the bluff, and a narrow, paved road at beach level. There are 12 homes along this road, with no hydrants.

This analysis only looked at neighborhoods that are at risk due to landslides. There are also a number of individually accessed homes that are along the bluffs and beaches, but due to issues of accessing private roads for non-emergency purposes the survey was limited to neighborhoods of 10 or more homes.





Earthquake

Moderate Risk Low Probability High Consequence	**Earthquake**

The ground in Island County and the surrounding areas conceals dozens of faults and folds that contribute to making the region one of the more seismically active places in North America.

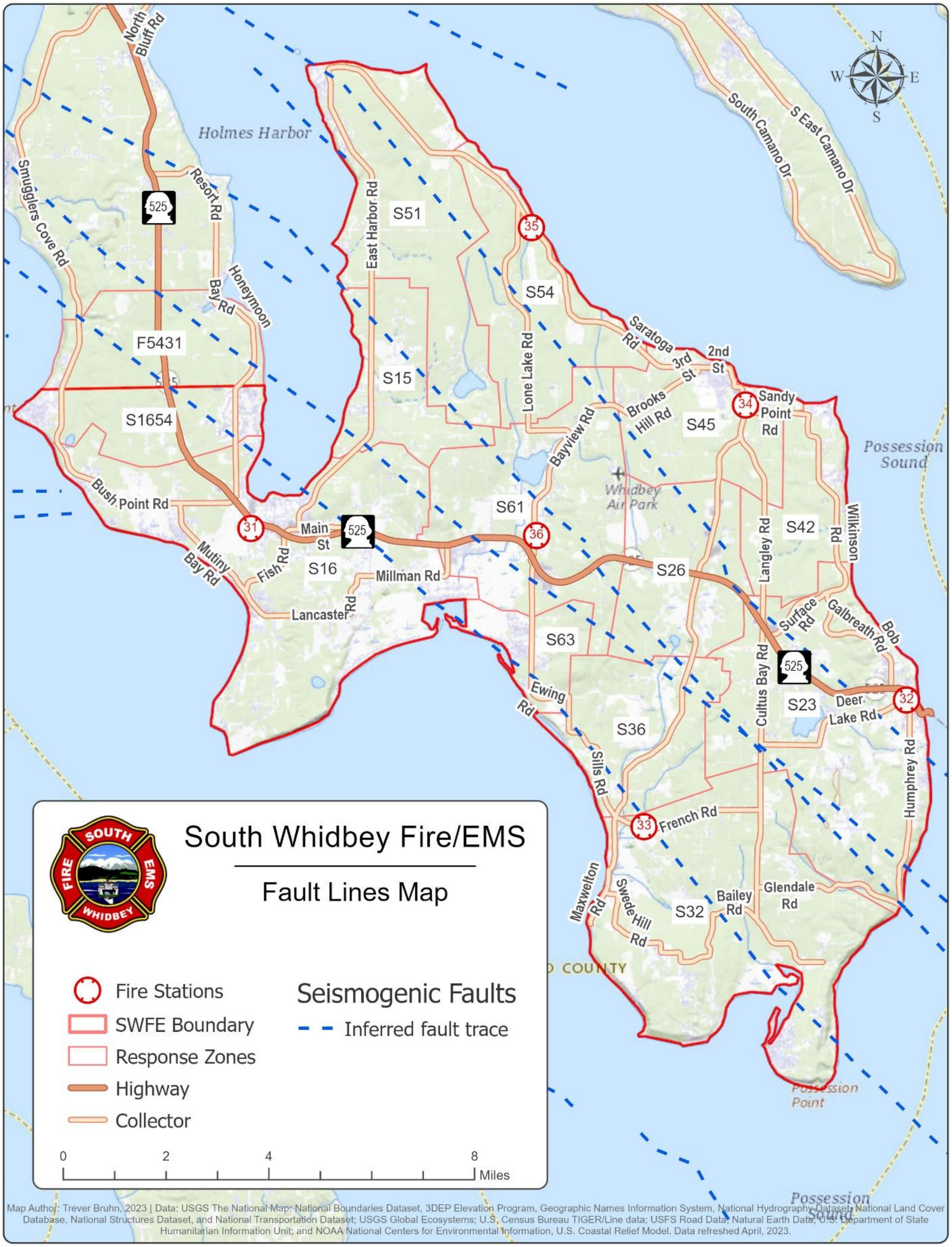
Hundreds of earthquakes occur in the Puget Sound region every year, most so small that they only can be detected using sensitive instruments. A major quake threat rests in the Cascadia subduction zone off the Washington Coast. If it lets loose, experts predict widespread damage to bridges and overpasses, likely shutting down the region's transportation system for weeks. Local emergency managers worry about the South Whidbey Island Fault which encompasses Whidbey Island.

While the area has a high probability of an earthquake event occurring within its boundaries, an earthquake does not necessarily have to occur in the fire district to have a significant impact as such an event would disrupt transportation to and from the region as a whole and impact commodity flow. As such, any seismic activity of 6.0 or greater on faults in or near the fire district would have a significant impact.

South Whidbey Island Fault

The South Whidbey Island Fault is a northwest-trending fault zone which extends more than 65 km across Possession Sound, southern Whidbey Island, and Admiralty Inlet into the eastern Strait of Juan de Fuca. The fault zone is as wide as 5 to 7 km, correlates with gravity and magnetic anomalies, and has been interpreted as a complex zone of transpressional deformation. Seismic tomography studies reveal that only the northwestern end of the fault zone in the southeastern Strait of Juan de Fuca is associated with a strong velocity contrast. The southeastern and central parts of the southern Whidbey Island fault zone form the southwest margin of the Everett basin and northeast boundary of the Seattle basin. The northwestern part of the fault zone forms the northeastern limit of the Port Townsend basin.

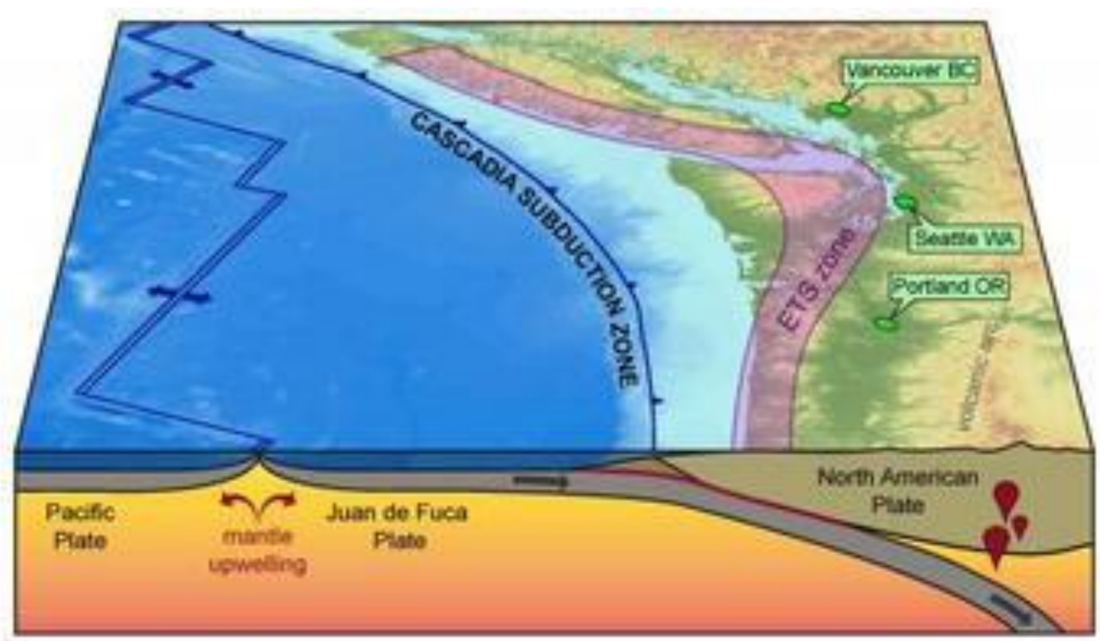
The offshore location of the southern Whidbey Island fault zone is relatively well-constrained based on interpretation of a dense network of industry and high-resolution seismic-reflection profiles. Onshore, strands of the southern Whidbey Island fault zone are generally concealed beneath a cover of dense vegetation and thick Pleistocene glacial and interglacial deposits.


South Whidbey Fire/EMS
Fault Lines Map
Fire Stations
SWFE Boundary
Response Zones
Highway
Collector
Seismogenic Faults
Inferred fault trace
0 2 4 8 Miles
Holmes Harbor
Possession Sound
Possession Point
S51
S54
S15
S45
S42
S61
S26
S16
S63
S23
S36
S32
F5431
S1654
Map Author: Trever Bruhn, 2023 | Data: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed April, 2023.

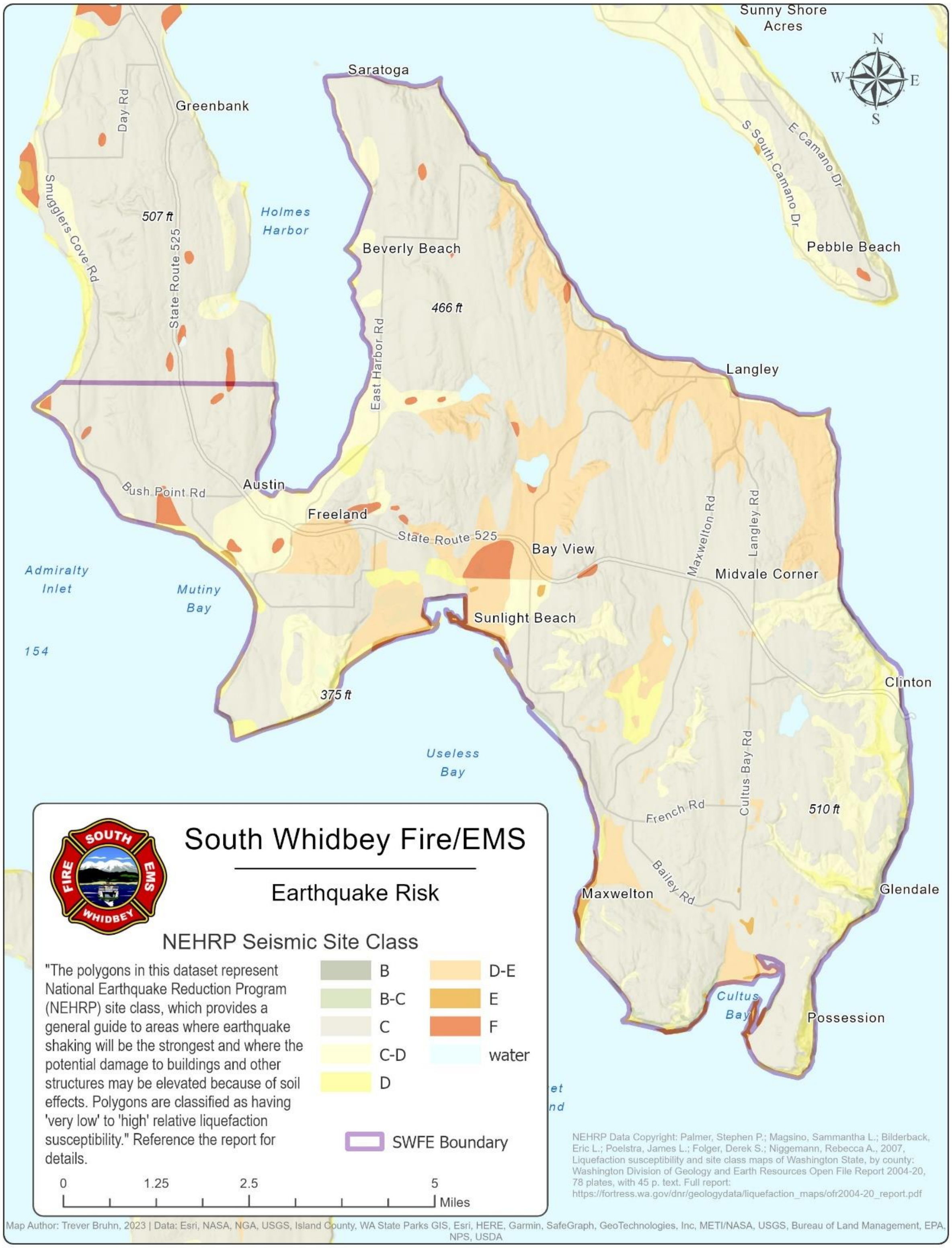
Cascadia Subduction Zone

The Cascadia Subduction Zone runs along the west coast from northern Vancouver Island to northern California, where it meets the San Andreas Fault. It is one of the world's most treacherous faults, capable of unleashing mega quakes and tsunamis on a par with the 2004 Sumatra disaster. Future Cascadia Subduction Zone-related earthquakes have been predicted to be Magnitude 8 or greater and could subject communities on the Washington ocean and Strait of Juan de Fuca coasts to intense ground shaking, subsidence, landslides, and liquefaction. Tsunami waves of 8 meters or higher are predicted to inundate the outer Washington coast 30 to 60 minutes after initial ground shaking in a Magnitude 8 or larger earthquake.

Research from USGS, University of Washington and Pacific Northwest Seismic Network gathered from 60 seismometers over the Olympic Peninsula indicate that the Juan de Fuca plate extends much further under the Olympic Peninsula than previously thought. The research suggests that rupture of the fault will occur 50 miles further inland than previously believed, right under Washington's most populous area, where vital infrastructure is concentrated. Such an earthquake would have devastating consequences.



South Whidbey Earthquake Risk Zones



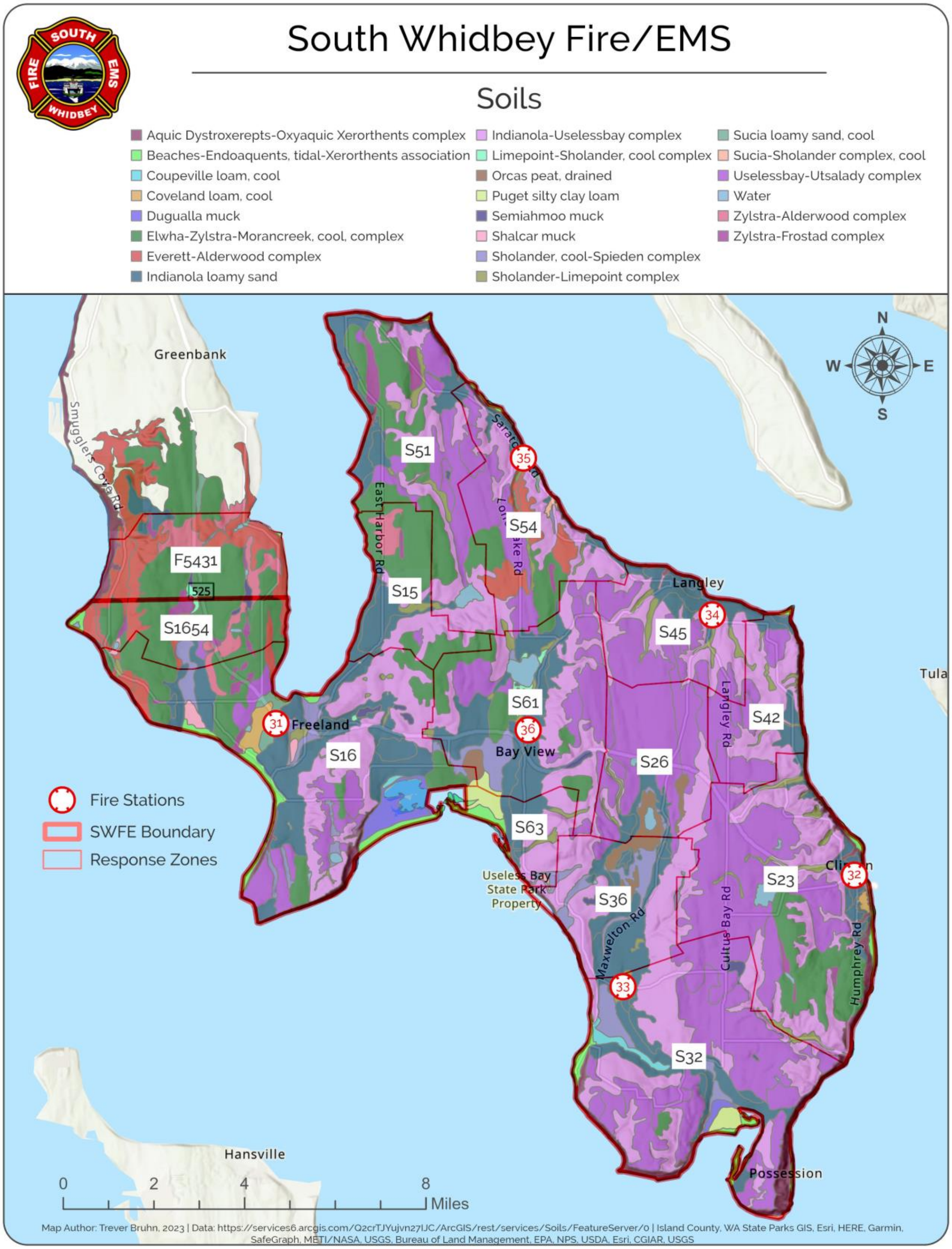
NEHRP Soil Maps

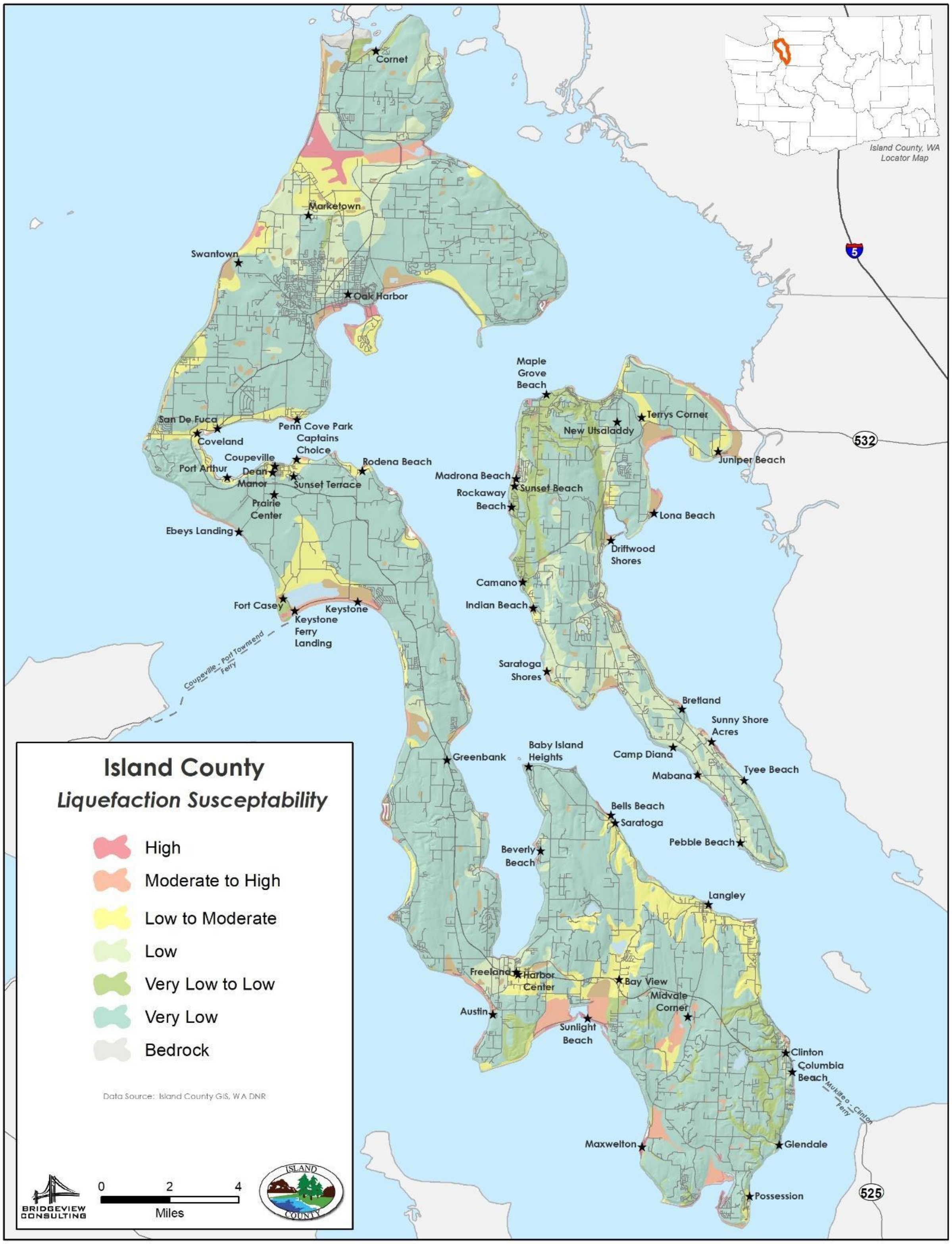
NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP Soils B and C typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP Soils D, E and F. The map on the following page illustrates NEHRP soil classifications in Island County.

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it and creating sand boils.

Areas of Whidbey Island susceptible to liquefaction are primarily low-lying marine or formerly tidal areas and filled areas. There are also extensive peat deposits on Whidbey Island. Peat does not “liquefy” like fill soil or mud, but earthquake shaking and vibration can cause it to fail and slump away from piling, supports, and foundations. One example of these types of land on Whidbey Island is the area roughly from Langley south across the island to Useless Bay. The map on the second following page shows liquefaction susceptibility throughout the County.


South Whidbey Fire/EMS
Soils
Aquic Dystroxerepts-Oxyaquic Xerorthents complex
Beaches-Endoaquents, tidal-Xerorthents association
Coupeville loam, cool
Coveland loam, cool
Dugualla muck
Elwha-Zylstra-Morancreek, cool, complex
Everett-Alderwood complex
Indianola loamy sand
Indianola-Uselessbay complex
Limepoint-Sholander, cool complex
Orcas peat, drained
Puget silty clay loam
Semiahmoo muck
Shalcar muck
Sholander, cool-Spieden complex
Sholander-Limepoint complex
Sucia loamy sand, cool
Sucia-Sholander complex, cool
Uselessbay-Utsalady complex
Water
Zylstra-Alderwood complex
Zylstra-Frostad complex
Greenbank
Freeland
Bay View
Langley
Possession
Hansville
Useless Bay State Park Property
F5431
S1654
S51
S54
S15
S45
S61
S42
S16
S26
S63
S36
S23
S32
Fire Stations
SWFE Boundary
Response Zones
0 2 4 8 Miles
Map Author: Trever Bruhn, 2023 | Data: https://services6.arcgis.com/Q2crTJYujvn27IJC/ArcGIS/rest/services/Soils/FeatureServer/0 | Island County, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, CGIAR, USGS


Island County
Liquefaction Susceptability
High
Moderate to High
Low to Moderate
Low
Very Low to Low
Very Low
Bedrock
Data Source: Island County GIS, WA DNR
0 2 4
Miles
BRIDGEVIEW CONSULTING
Island County, WA Locator Map
Cornet
Marketown
Swantown
Oak Harbor
San De Fuca
Coveland
Penn Cove Park
Captains Choice
Coupeville
Port Arthur
Dean Manor
Sunset Terrace
Rodena Beach
Prairie Center
Ebeys Landing
Fort Casey
Keystone
Keystone Ferry Landing
Coupeville - Port Townsend Ferry
Maple Grove Beach
Terrys Corner
New Utsaladdy
Juniper Beach
Madrona Beach
Sunset Beach
Rockaway Beach
Lona Beach
Driftwood Shores
Camano
Indian Beach
Saratoga Shores
Bretland
Sunny Shore Acres
Camp Diana
Tyee Beach
Mabana
Greenbank
Baby Island Heights
Bells Beach
Saratoga
Pebble Beach
Beverly Beach
Langley
Freeland
Harbor Center
Bay View
Midvale Corner
Austin
Sunlight Beach
Clinton
Columbia Beach
Mukilteo - Clinton Ferry
Maxwelton
Glendale
Possession
5
532
525

Tsunami

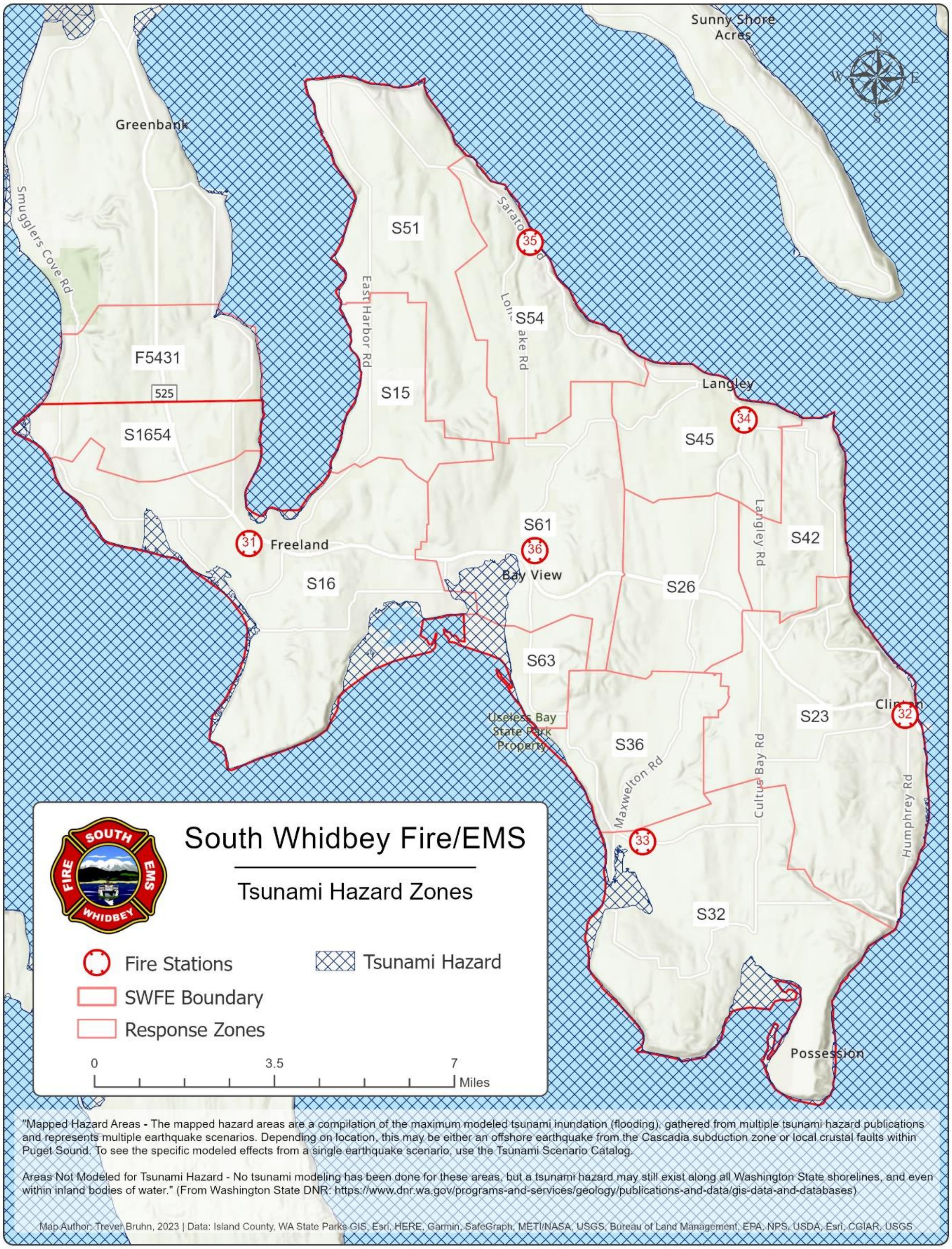
Moderate Risk **Low Probability** **High Consequence**	**Tsunami**

Tsunamis are giant waves caused by earthquakes or volcanic eruptions under the sea. Out in the depths of the ocean, tsunami waves do not dramatically increase in height. But as the waves travel inland, they build up to higher and higher heights as the depth of the ocean decreases. Washington's outer and inner coasts are highly vulnerable to tsunamis thanks to the presence of numerous crustal faults and the Cascadia Subduction Zone (CSZ) offshore. The CSZ has been responsible for 19 earthquakes of magnitude 9+ in the last 10,000 years. Evidence of the most recent Cascadia earthquake and tsunami to hit Washington's shores in 1700 remains in the form of ghost forests, tsunami sand deposits, and the oral traditions of Native Americans.

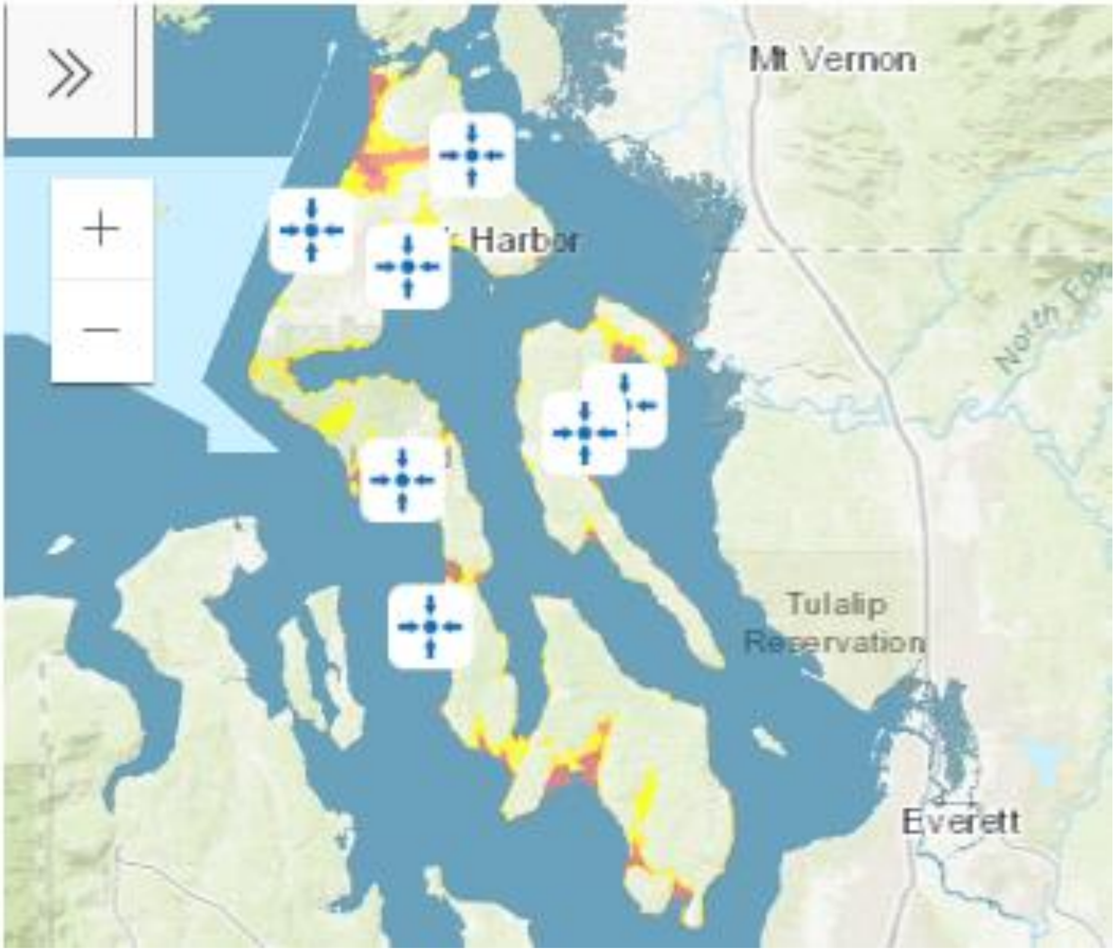
Whidbey Island has a tsunami funnel called Cultus Bay. The good news is that, at least so far, the tsunamis have been measured in centimeters, not meters. About a thousand years ago, the Seattle Fault snapped in an earthquake. Within a few seconds, portions of Bainbridge Island and West Seattle rose over 20 feet. Land that had been wet was suddenly dry. The residents of Whidbey Island undoubtedly felt it, too, so did the water. The sudden rise of the land caused a rise in the water. A tsunami surged north and south, up and down Puget Sound. Fortunately for Whidbey, the island is skinny from that angle and much of the water passed on either side. Unfortunately for Cultus Bay, it and the two headlands that bracket it, Scatchet Head and Possession Point, were pointed straight at the wave. The tsunami swept into the bay, channeled by the ridges, ran past the high tide line and began to climb the hill. Geologists have dug into the soil trying to understand the sequence of events. It looks like the tsunami charged in, hit the spit at the head of the bay, made the turn and continued up the hill toward what is now Bailey's Corner. The deepest deposit of silt was more than four feet thick.

Tsunamis are as unpredictable and as inevitable as earthquakes. An element of luck is involved. The difference between high and low tide can be as much as twelve feet. A tsunami at low tide may live up to the name tidal wave and do nothing more than be the subject of impressive videos. A tsunami at high tide would start 12 feet higher and start at the high tide line. For Cultus Bay, that's a difference of about a mile and a half.

Tsunamis on Whidbey Island are rare, but sufficient risk exists that signs are posted in critical areas around the island.


South Whidbey Fire/EMS
Tsunami Hazard Zones
Fire Stations
Tsunami Hazard
SWFE Boundary
Response Zones
0
3.5
7
Miles
Sunny Shore Acres
Greenbank
Smugglers Cove Rd
East Harbor Rd
Lone Lake Rd
F5431
525
S1654
S51
S54
S15
S45
S42
S61
S16
S26
S63
S23
S36
S32
Langley
Freeland
Bay View
Clinton
Possession
Useless Bay State Park Property
Maxwelton Rd
Cultus Bay Rd
Langley Rd
Humphrey Rd
31
32
33
34
35
36
"Mapped Hazard Areas - The mapped hazard areas are a compilation of the maximum modeled tsunami inundation (flooding), gathered from multiple tsunami hazard publications and represents multiple earthquake scenarios. Depending on location, this may be either an offshore earthquake from the Cascadia subduction zone or local crustal faults within Puget Sound. To see the specific modeled effects from a single earthquake scenario, use the Tsunami Scenario Catalog.
Areas Not Modeled for Tsunami Hazard - No tsunami modeling has been done for these areas, but a tsunami hazard may still exist along all Washington State shorelines, and even within inland bodies of water." (From Washington State DNR: https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases)
Map Author: Trever Bruhn, 2023 | Data: Island County, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, CGIAR, USGS

Tsunami High Ground Map



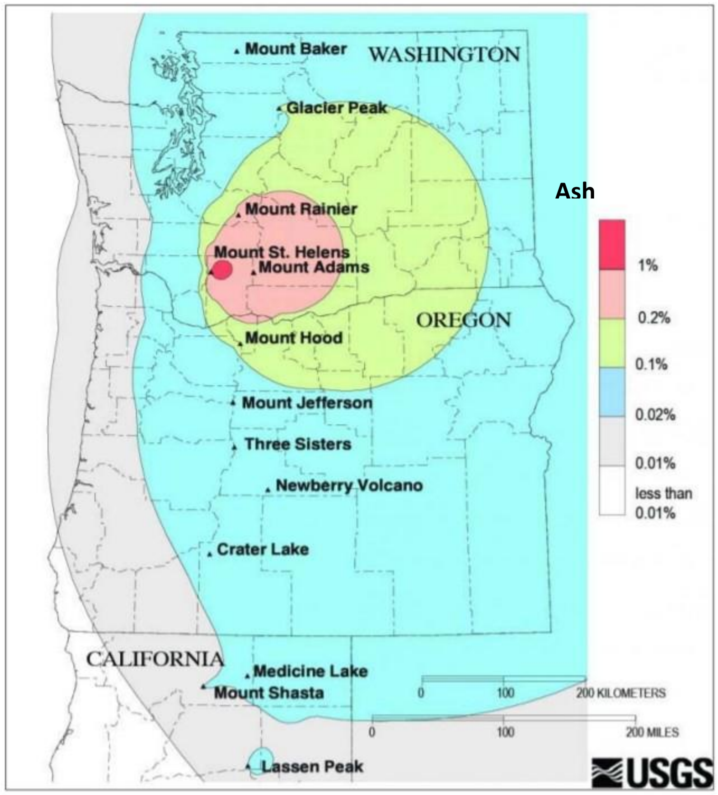
Volcanic Ash Fallout

Low Risk **Low Probability** **Low Impact**	**Volcanic Ash Fallout**

The Cascade Range of Washington, Oregon and California has volcanoes close to Island County. The primary effect of the Cascade volcanic eruptions on Island County would be ash fall, with some disruption of service due to impact on Whatcom and Snohomish Counties from Mt. Baker and Glacier Peak.

The distribution of ash from a violent eruption is a function of wind direction and speed, atmospheric stability, and the duration of the eruption. As the prevailing wind in this region is generally from the west, ash is usually spread eastward from the volcano. Exceptions to this rule do occur. Ash fall, because of its potential widespread distribution, suggests some limited volcanic hazards. Even 10 percent of ash reaching Island County or any of its coastlines could have a negative impact on the natural resources and the agricultural economy.

- Mount Baker—56 miles east/northeast Island County
- Glacier Peak— 72 miles east of Island County
- Mount Rainier—140 miles southeast of Island County


Mount Baker
WASHINGTON
Glacier Peak
Ash
Mount Rainier
Mount St. Helens
Mount Adams
OREGON
Mount Hood
Mount Jefferson
Three Sisters
Newberry Volcano
Crater Lake
CALIFORNIA
Medicine Lake
Mount Shasta
Lassen Peak
1%
0.2%
0.1%
0.02%
0.01%
less than 0.01%
0 100 200 KILOMETERS
0 100 200 MILES
USGS

Section D—Program Goals and Objectives

Mission Statement

To reduce the risk of fire, medical, and other emergencies that threaten the South Whidbey community through service, education, and excellence.

Philosophy and Goals

In order to fulfill our commitment to the citzens and visitors of South Whidbey, the commissioners, in conjunction with administration, staff and volunteers of the fire district, shall accomplish this with the following strategies:

1. Reduce the risk to the community, from an all hazards approach, by providing proactive services that specifically address those risks.

2. Support the adoption and enforcement of appropriate codes and ordinances to prevent situations that endanger life and property.

3. Provide a trained, competent force to effectively remove people from the danger of fire and other emergencies and provide the resources necessary to perform this task.

4. Provide a trained, competent force to effectively provide emergency medical services to the sick and injured.

5. Provide education and information to citizens regarding the risks that affect them and assist them in increasing their resilience.

In order to accomplish these strategies, the organization sections and divisions shall:

Administration

1. Provide effective management of district resources by establishing policies and procedures to meet organizational goals.

2. Provide and strive for improved working relations with other departments to obtain higher productivity and more efficient service delivery.

3. Provide for the establishment of long range (over one year) financial and operational plans for the district.

4. Provide a records system consistent with state and local requirements.

5. Provide all general administrative services for the district, including personnel services, accounting, and purchase recommendations.

6. Provide long range apparatus and facilities replacement planning.

Suppression/Emergency Medical Services

1. Provide a motivated, competent, innovative, and cost effective fire fighting force.

2. Provide adequate staffing and equipment to an alarm location within acceptable response times.

3. Provide a motivated, competent, innovative and cost-effective force for medical emergencies.

4. Provide state-of-the-art apparatus and equipment to enable personnel to effectively deal with emergencies.

Prevention/Education

1. Provide public education in fire prevention, life-saving methods, first aid, disaster preparedness, and other district services.

2. Provide a high-quality fire/life safety education program within the local school system.

3. Provide for the reduction of arson and to establish cause and origin of fires.

4. Provide a program to make the public aware of the importance of clear addresses.

Training

1. Provide coordination of Emergency Services Training for district members.

2. Provide up-to-date training in both the fire and EMS fields.

3. Provide for acceptable standards and levels of training.

4. Provide a system of advanced training for officers.

5. Provide updated training records for all personnel.

Resource Management

1. Provide for the district's fire stations and associated equipment to be maintained in a functional, clean, safe and respectable condition.

2. Provide safety inspections of all fire stations and facilities.

3. Provide for the district's assigned vehicles and apparatus to be maintained in a safe, reliable and operational level.

Excerpts of Relevant Objectives from the Strategic Plan 2020-2025

Strategic Initiative 1.1 – Improve Survivability for Victims of Fire, Hazardous Materials Release, Entrapment or other Crisis Incidents.

Objective 1.1.1 – Provide a minimum daily staffing level of at least five fire responders and one chief officer (six total) throughout the district.

Objective 1.1.2 – Contain structure fires to room of origin 20% of the time or better.

Objective 1.1.3 – Zero civilian fire fatalities or significant injuries measured annually.

Objective 1.1.4 – Arrive on scene of structure fires within 14 minutes, 80% of the time.

Strategic Initiative 1.2 – Improve Survivability of Patients Experiencing Acute Medical Emergencies.

Objective 1.2.1 – Maintain cardiac survival rate at or above 15% (ROSC).

Objective 1.2.5 – Explore the development of a BLS transport program.

Objective 1.2.6 – Arrive on scene of medical emergencies within 10 minutes, 80% of the time.

Objective 1.2.7 – Provide a minimum staffing level of at least two EMS responders for all emergency medical responses.

Strategic Initiative 2.1 – Reduce Financial and Legal Risk/Liability to SWFE

Objective 2.1.1 – Address fire station safety/seismic safety in current and future capital improvement plans.

Critical Tasks:

1. Based upon the coverage needs identified in the Standards of Coverage Study, develop a ten-year plan to acquire property to relocate Station 33 in an area to better serve the population of that catchment area and to also be in an area outside of the tsunami flood zone that would also be built to current seismic and fire suppression standards.

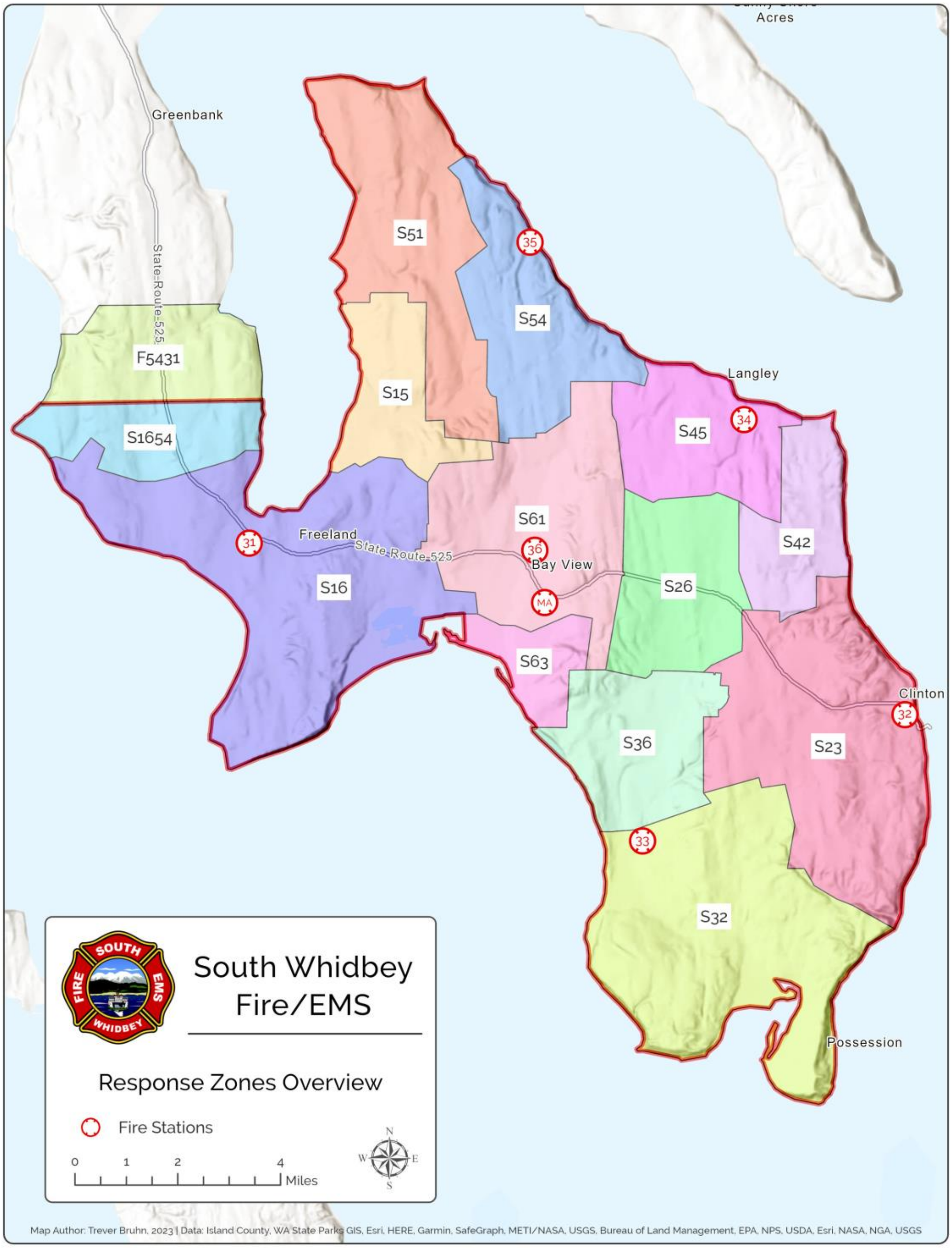
Objective 2.1.2 – Conduct a Standards of Cover study.

Objective 2.1.3 – Enhance fire station accommodations to better meet changing staffing patterns and programs.

Section E- Current Deployment and Performance

Response zones

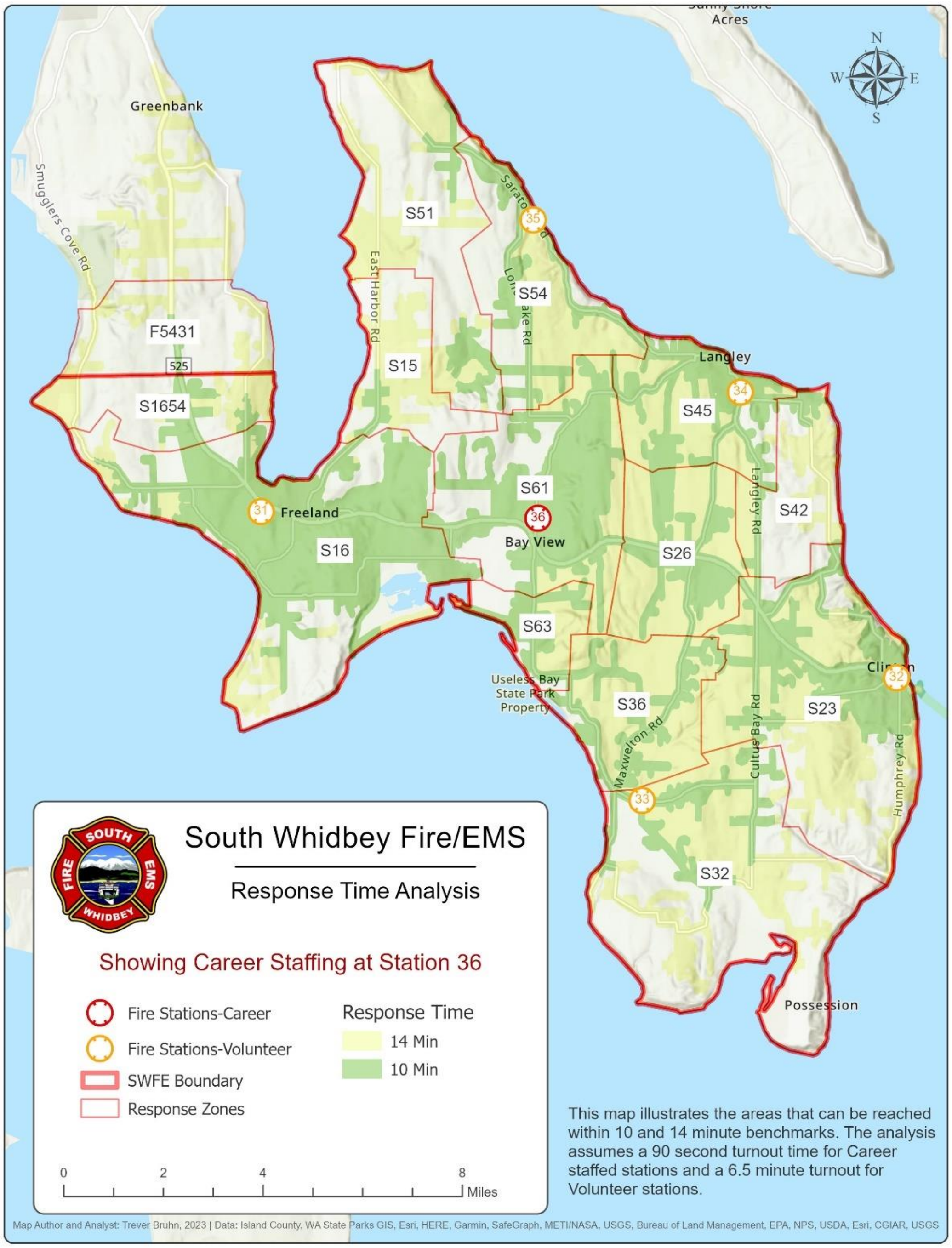
Response zones are numbered with the first digit being the primary station covering that zone, and the second digit being the secondary station into that zone. Appendix A has incident heat maps further broken down by incident type.



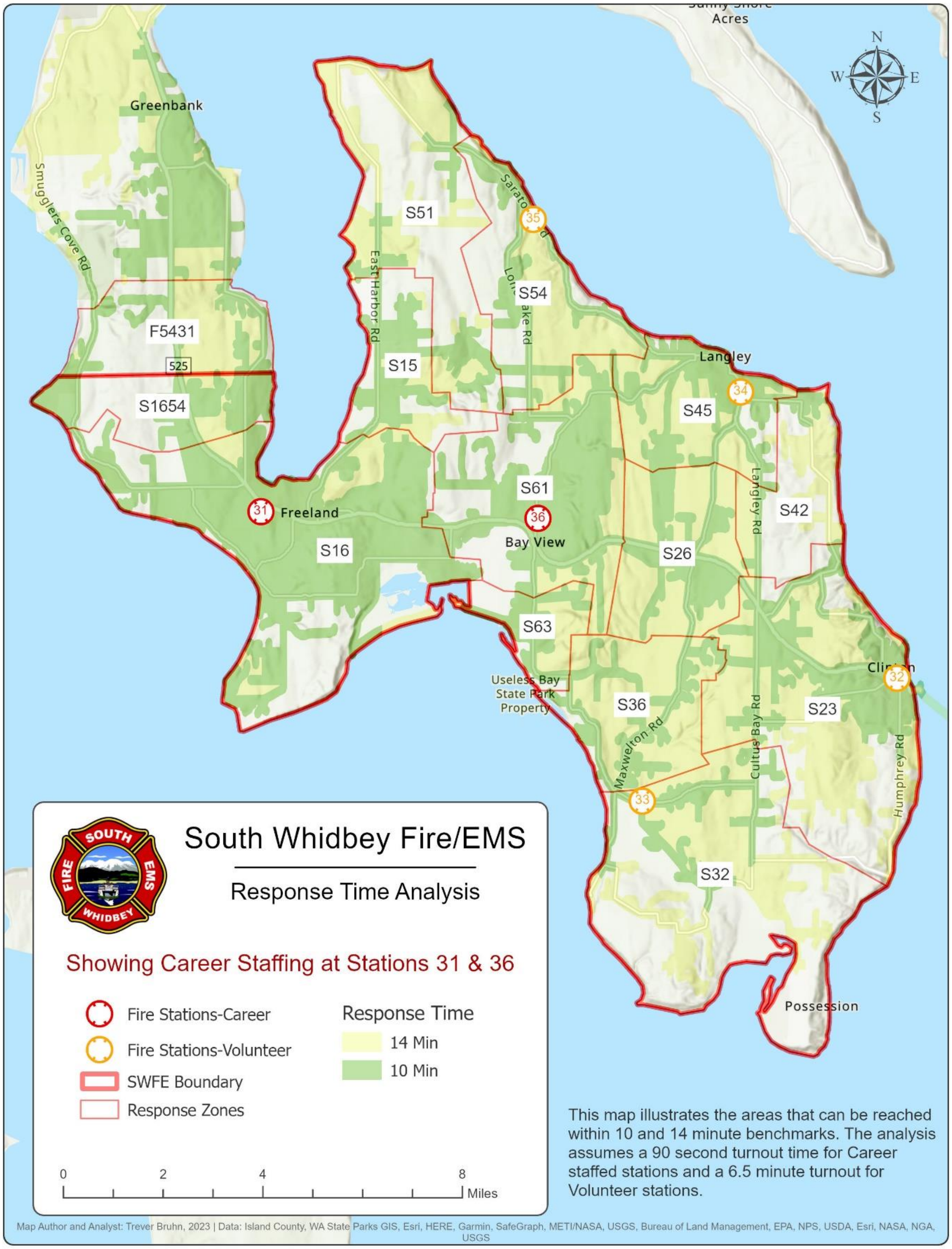
Response Time Analysis

Response times are based on the strategic plan objectives of arriving on scene of structure fires within 14 minutes, 80% of the time, and arriving on scene of medical emergencies within 10 minutes, 80% of the time. This includes a reflex time of 90 seconds for the career staff at station 36, and an average reflex time of 6.5 minutes for the volunteer stations.

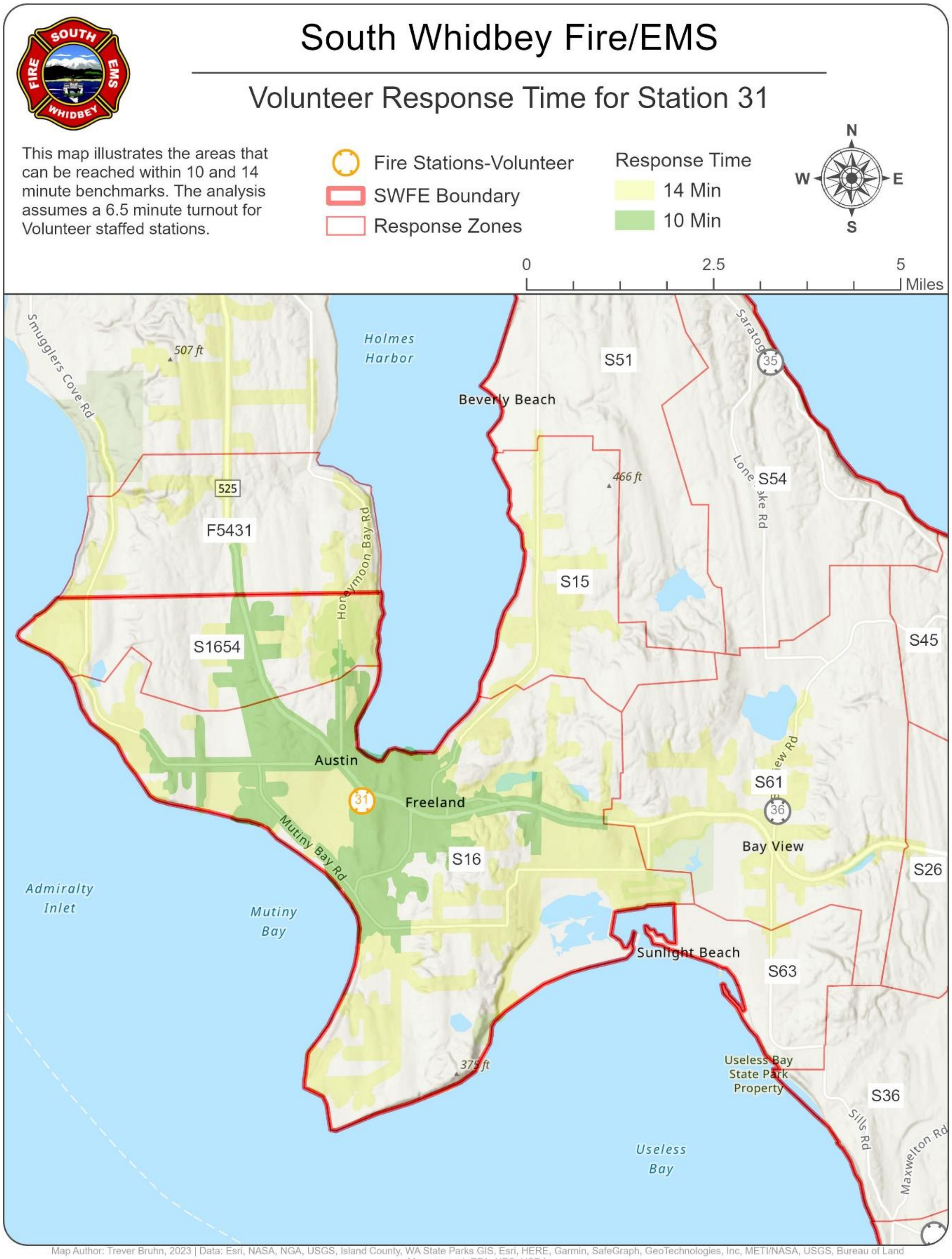
Station 36 career staffed and Stations 31, 32, 33, 34, and 35 volunteer staffed:



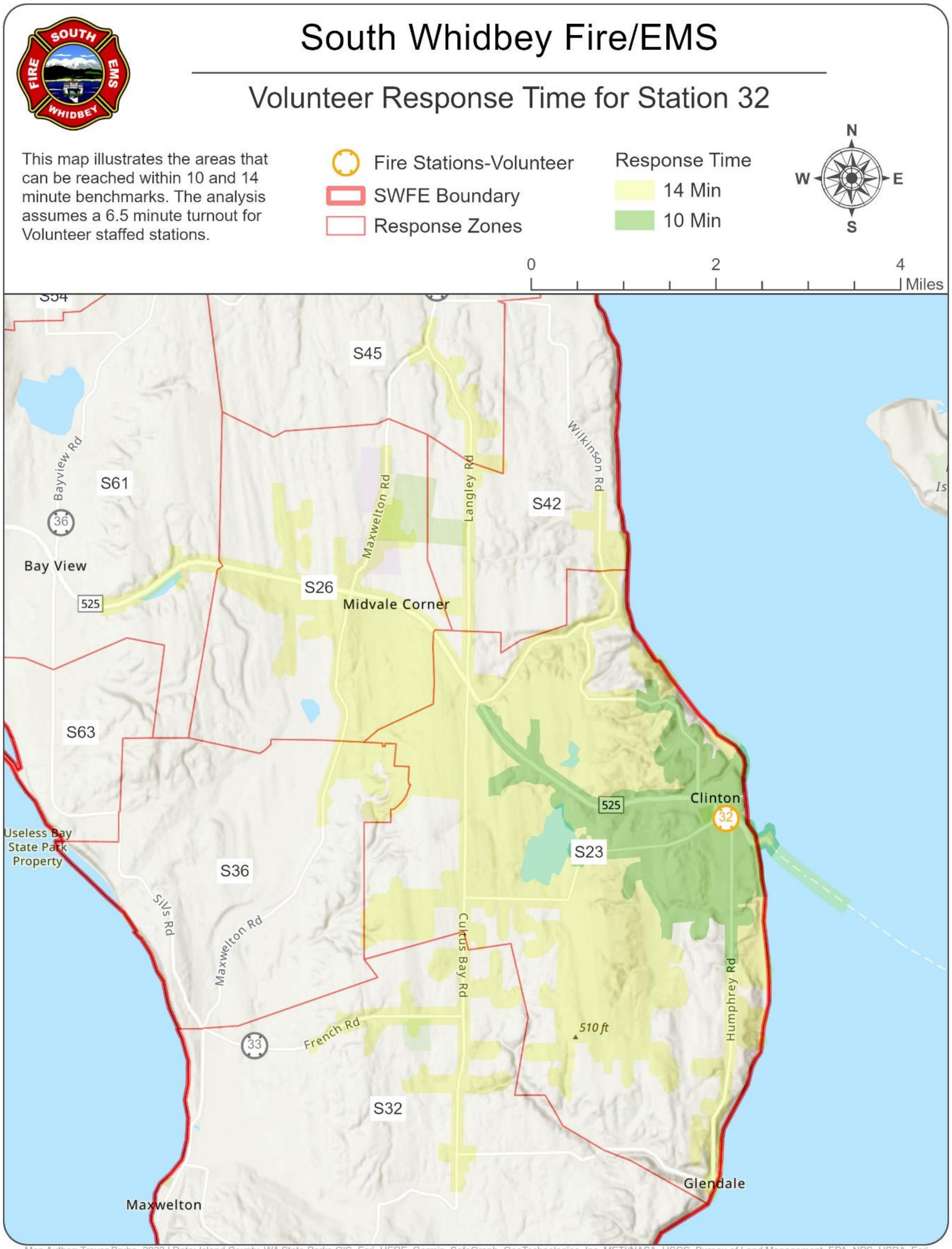
Stations 31 and 36 career staffed and Stations 32, 33, 34, and 35 volunteer staffed:



Station 31 volunteer response:

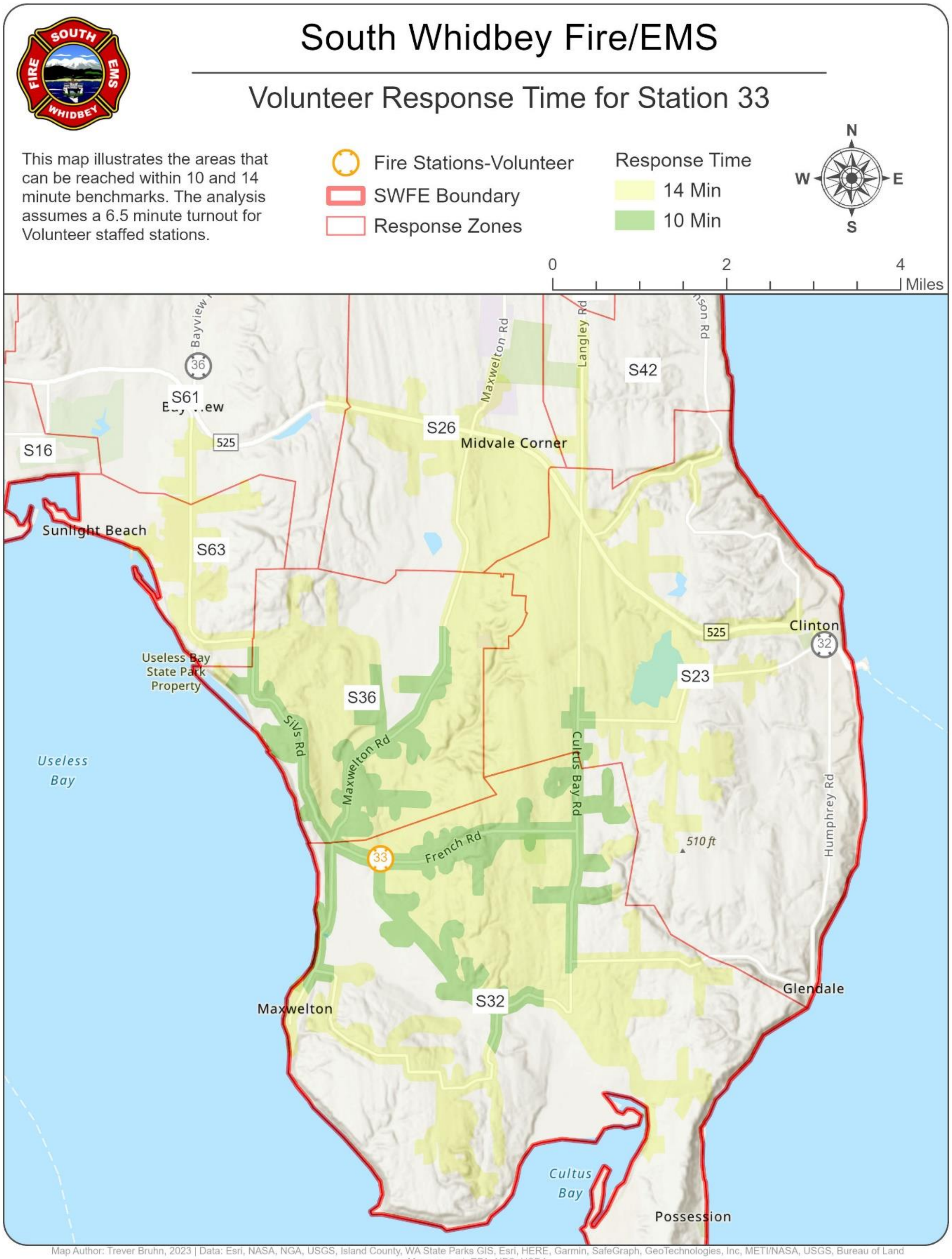


Station 32 volunteer response:

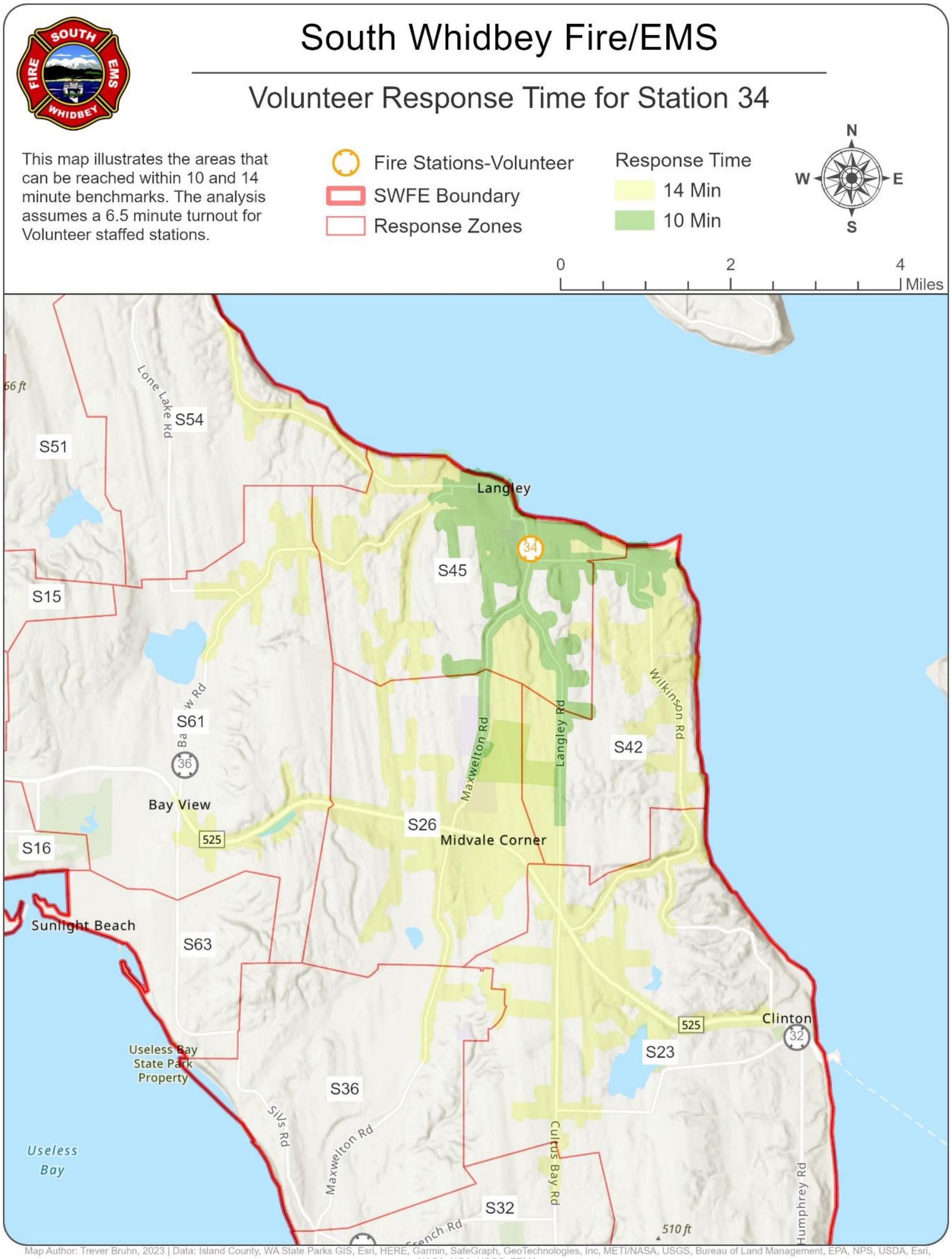


Map Author: Trever Bruhn, 2023 | Data: Island County, WA State Parks GIS, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, NASA, NGA, USGS, FEMA

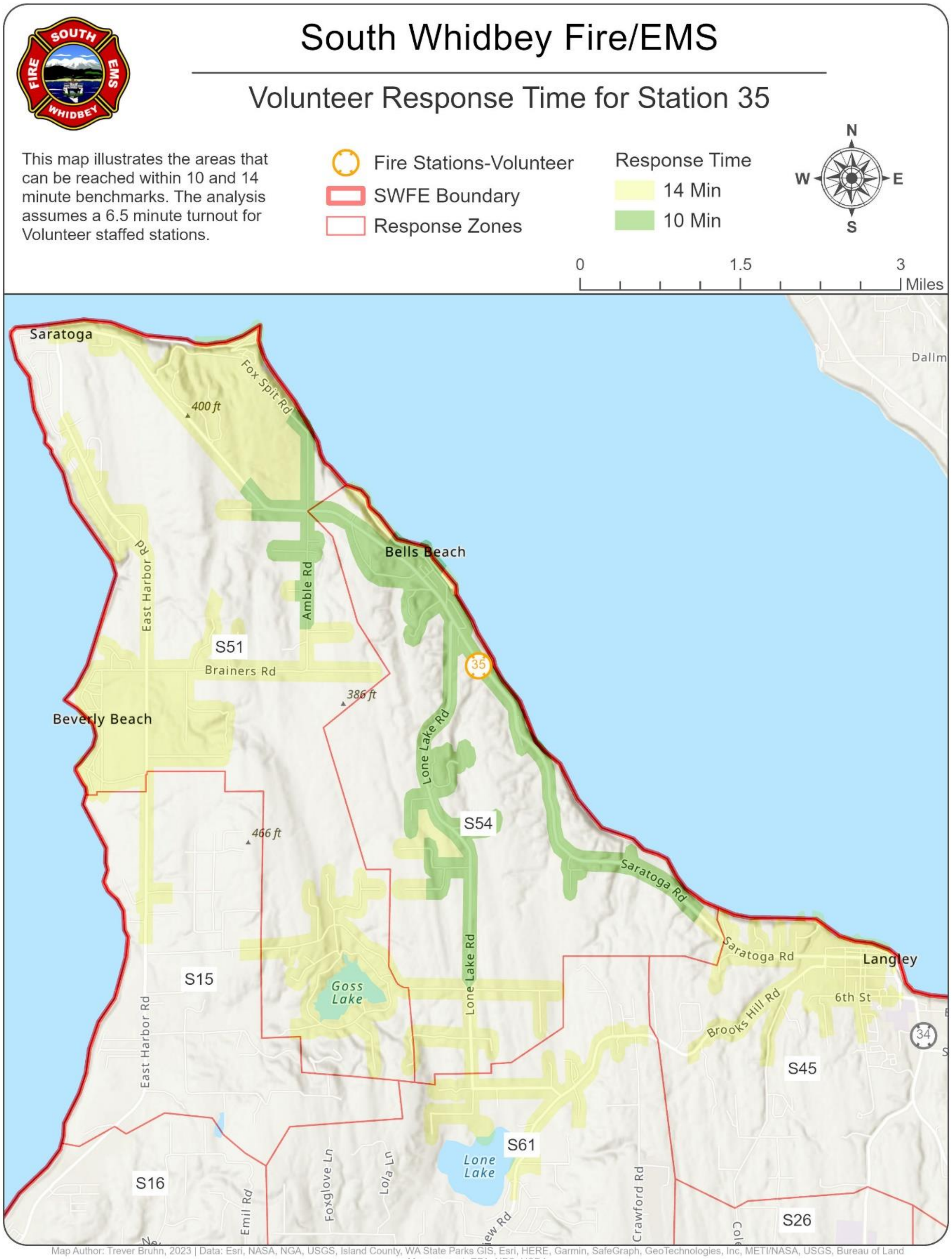
Station 33 volunteer response:



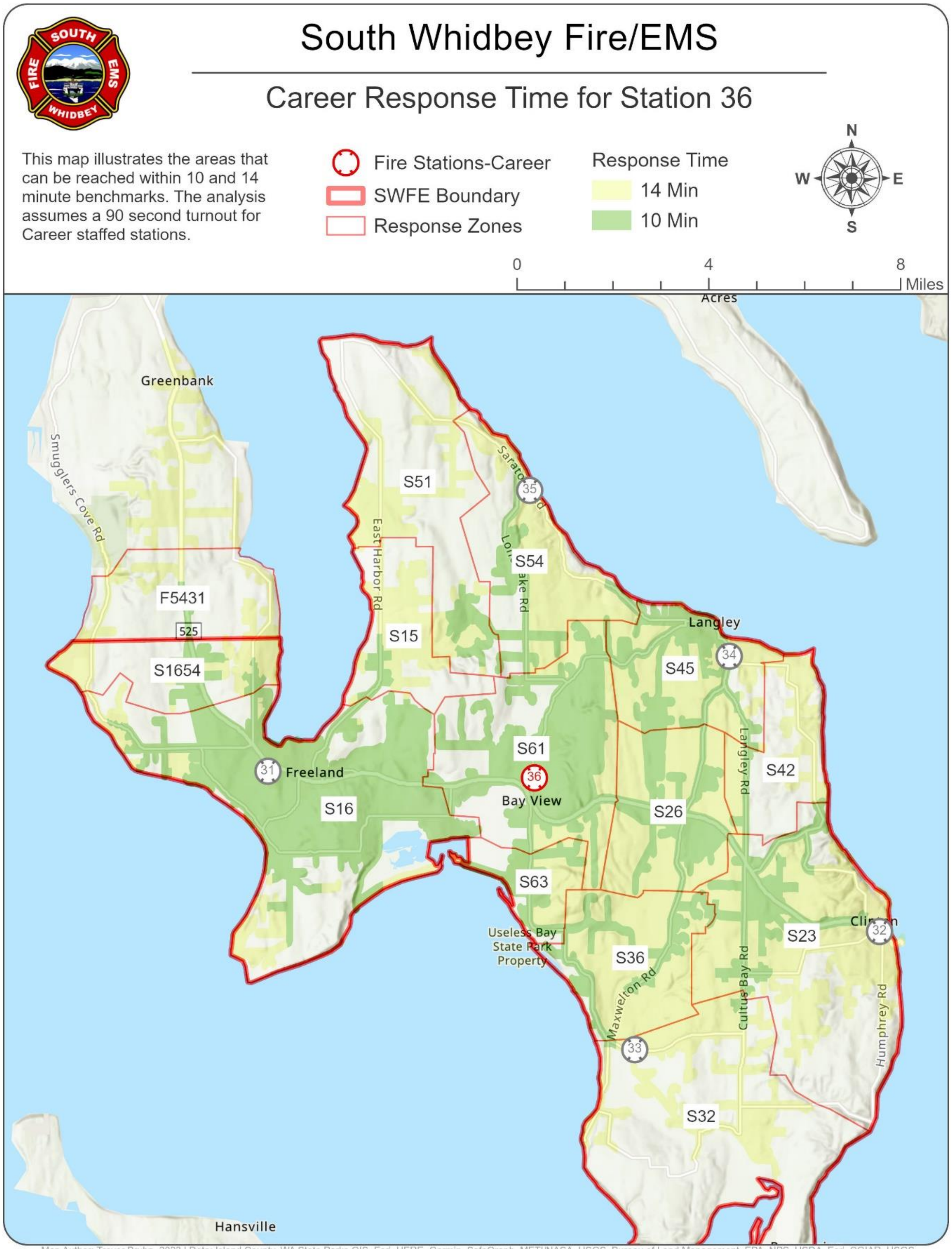
Station 34 volunteer response:



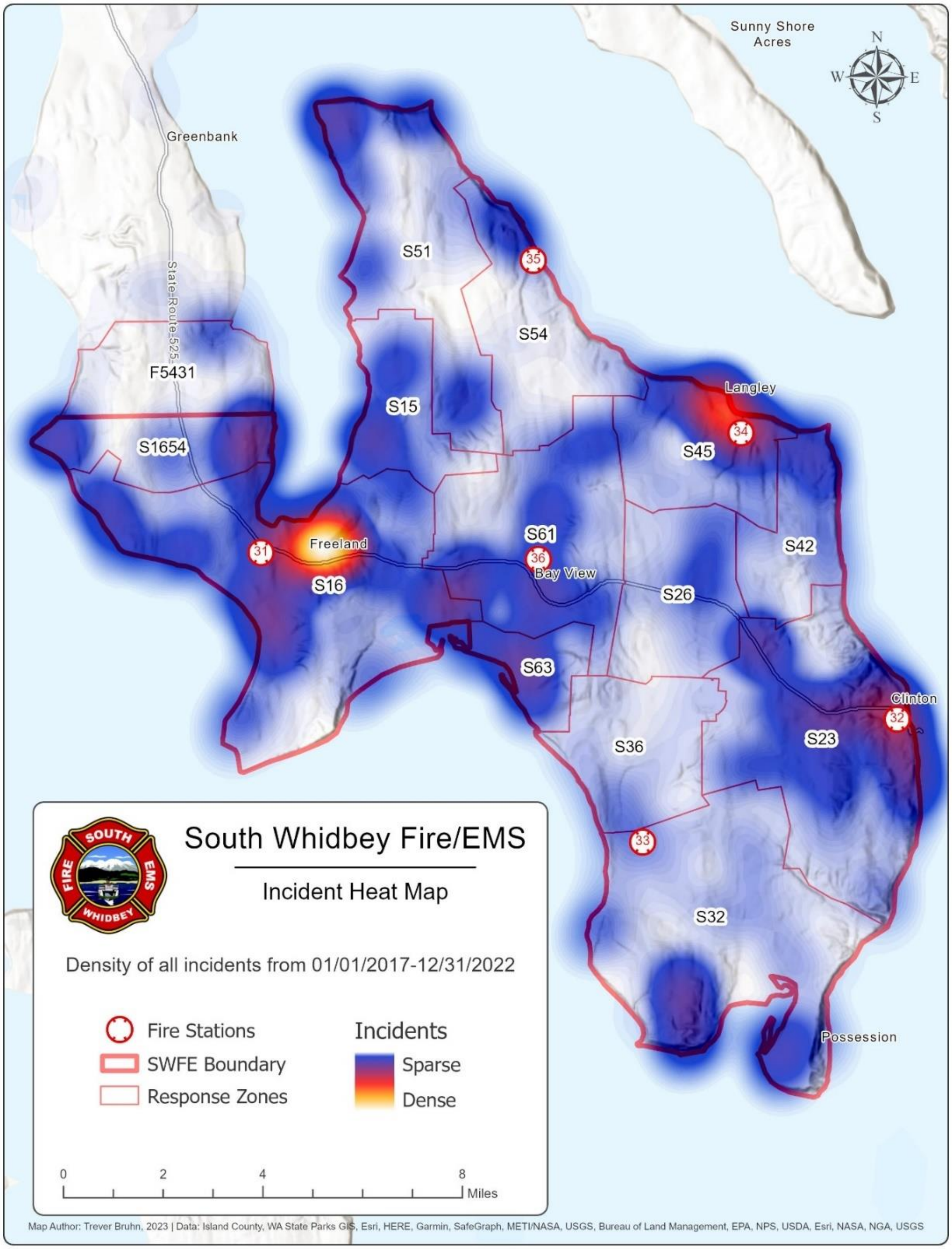
Station 35 volunteer response:



Station 36 career response:

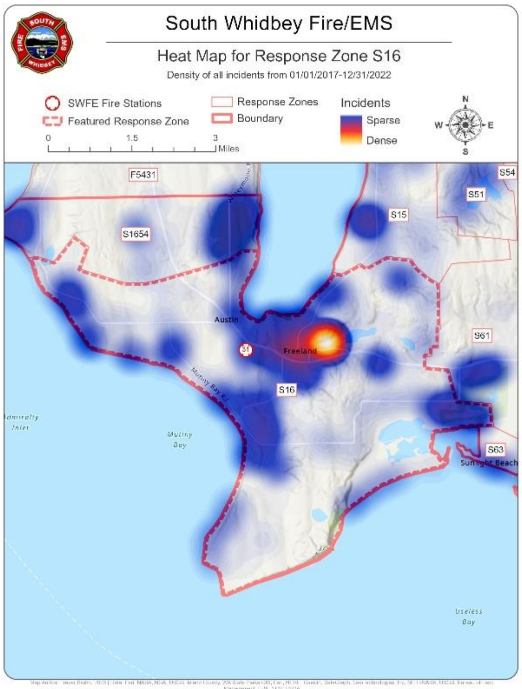


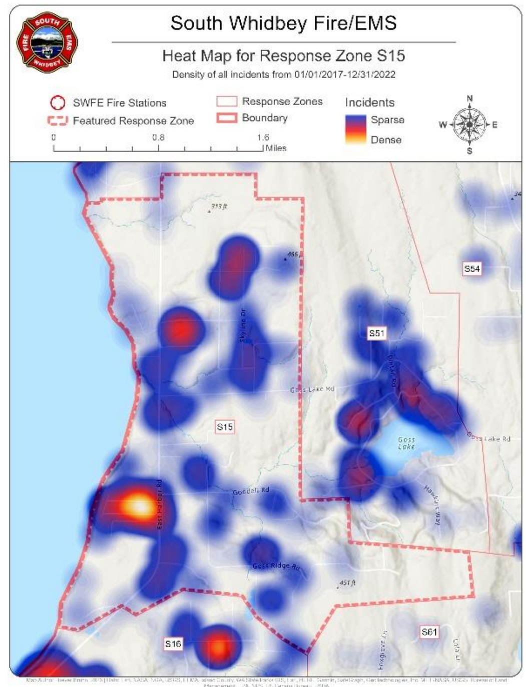
Call History by Response Zones

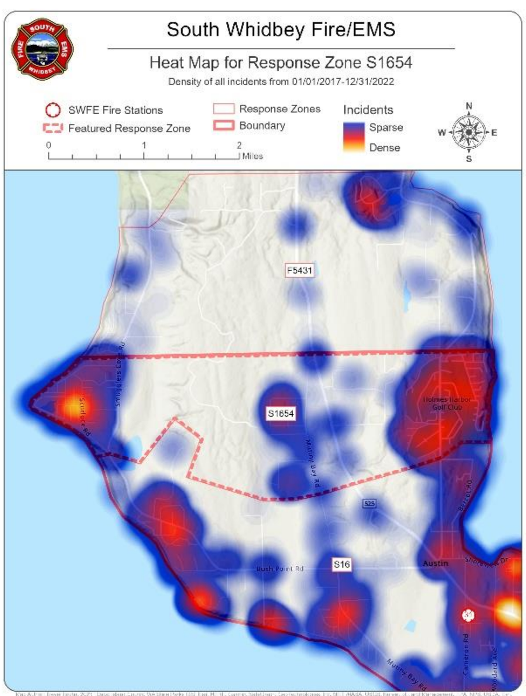


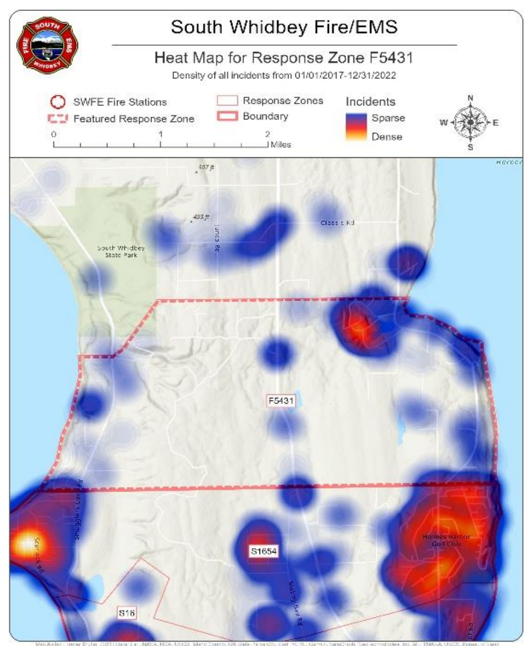
Station 31 primary zone incidents

Station 31, located on Cameron Road a block off of Hwy 525 on the north edge of Freeland, is the primary response station for three response zones within SWFE, as well as one automatic aid response zone of CWIFR.



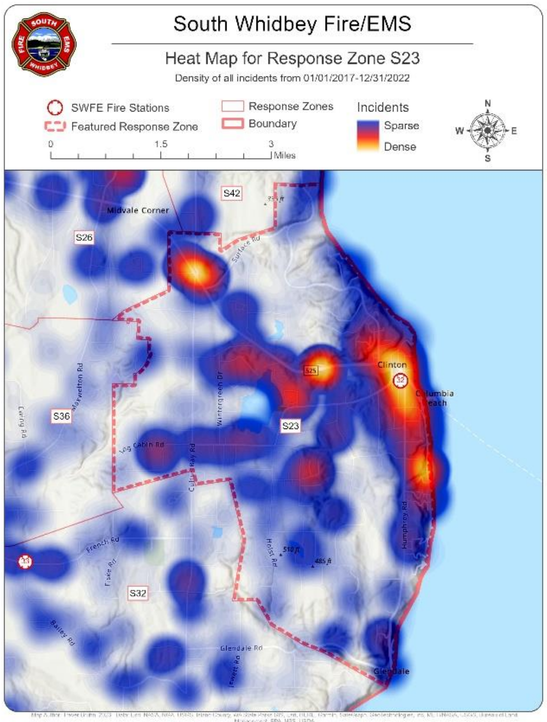


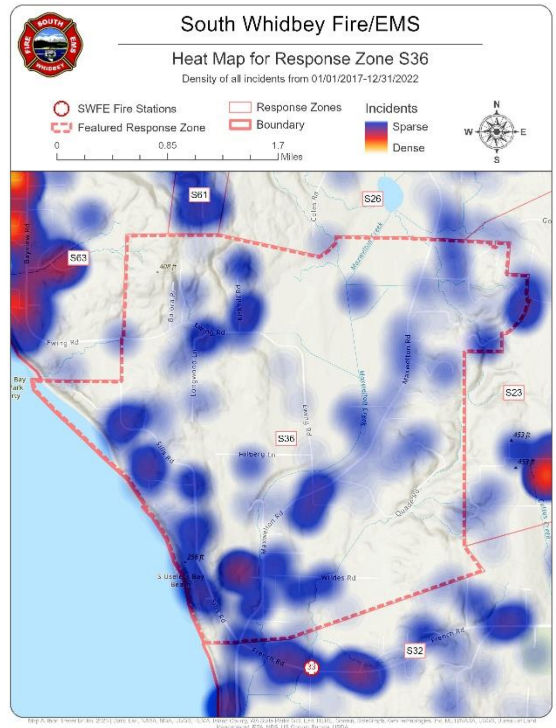




Station 32 primary zone incidents

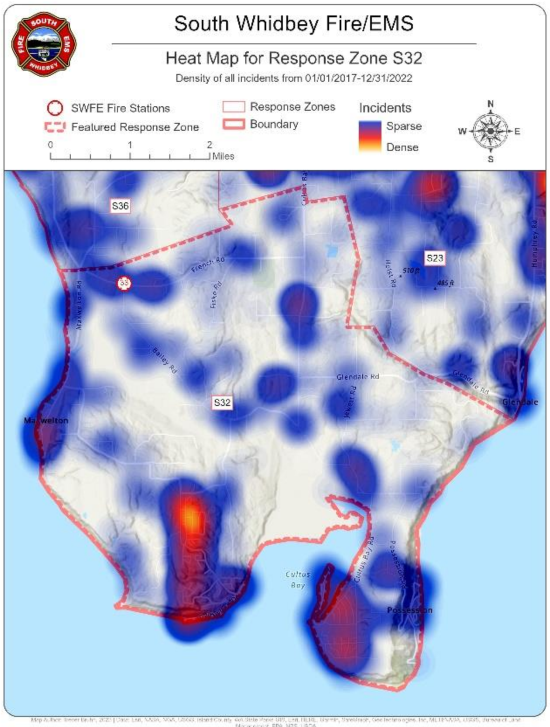
Station 32, located two blocks off of Hwy 525 in Clinton, is the primary response station for two fire response zones.

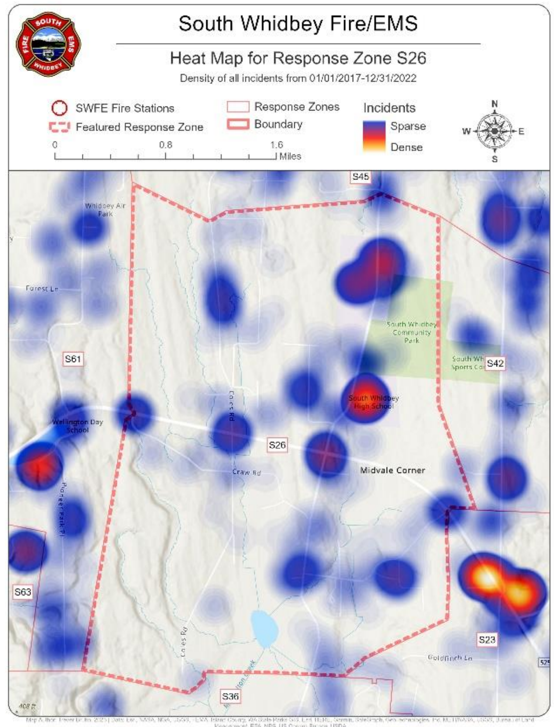




Station 33 primary zone incidents

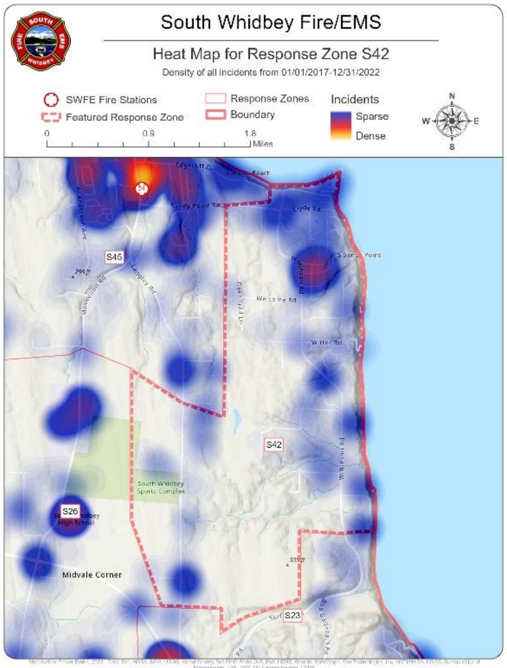
Station 33, located at the intersection of French Road and Bailey Road, is the primary response station for two fire response zones.

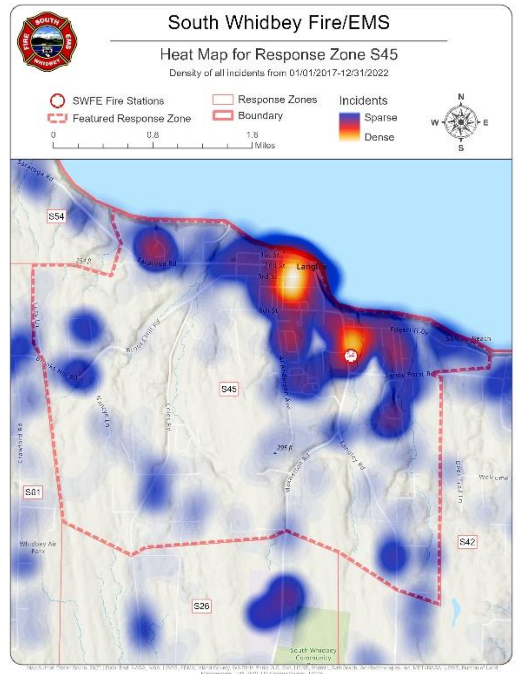




Station 34 primary zone incidents

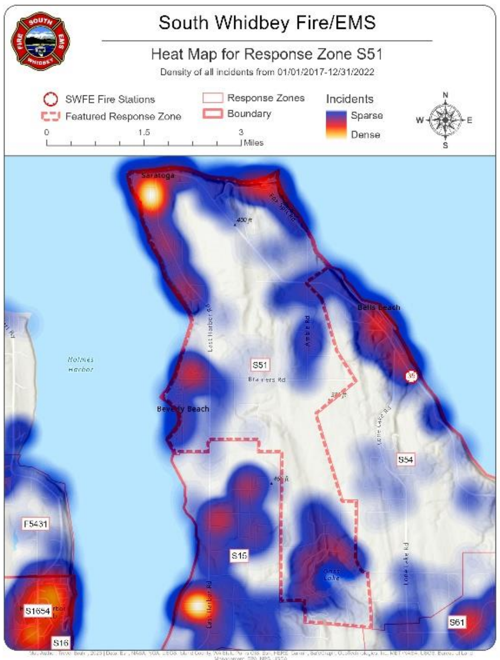
Station 34, located on Camano Avenue on the south edge of the City of Langley, is the primary response station for two response zones.

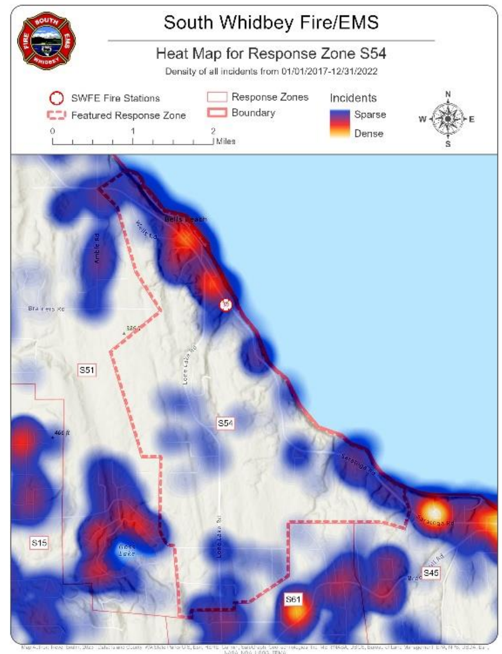




Station 35 primary zone incidents

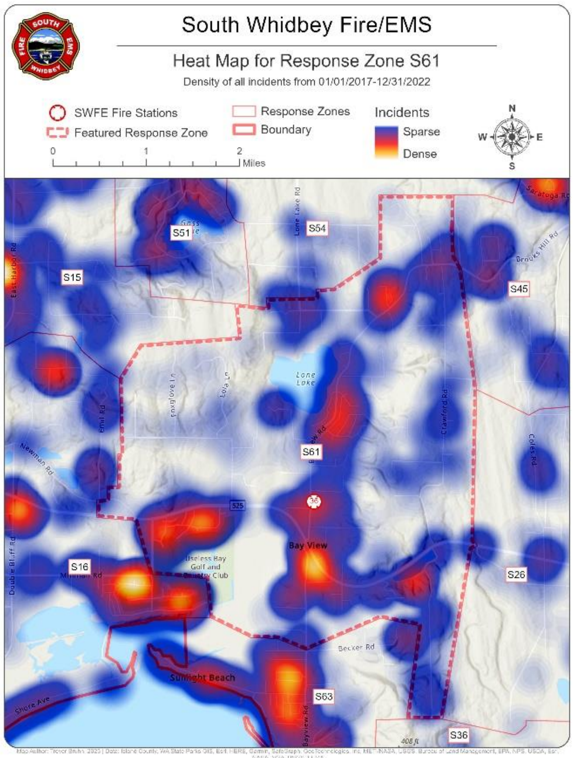
Station 35, located on Saratoga Road towards the north end of the district, is the primary response station for two response zones.

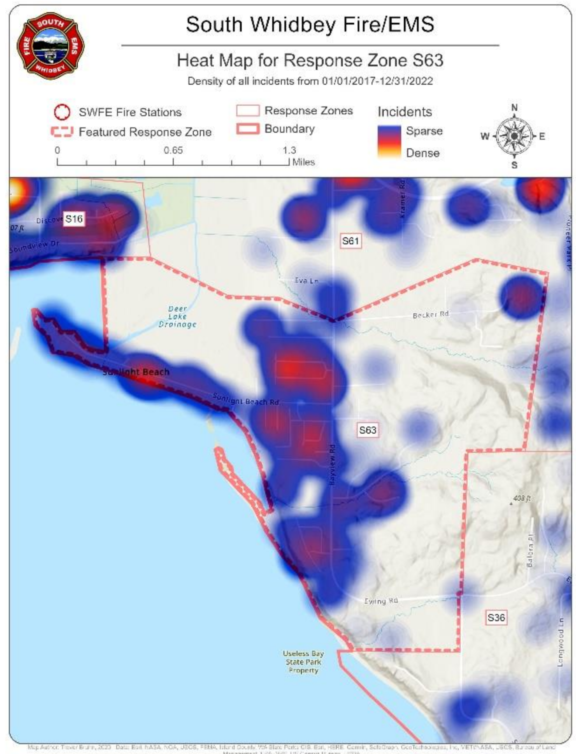




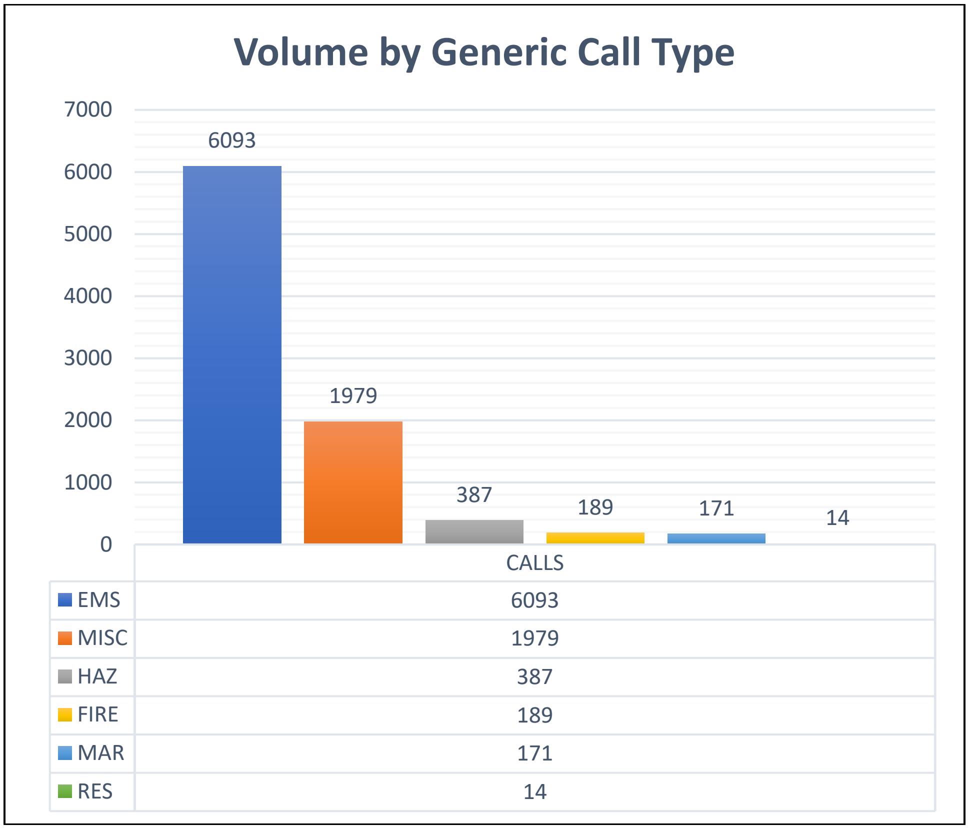
Station 36 primary zone incidents

Station 36, located near the center of the district on Bayview Road about 3 blocks off of Hwy 525, is the primary response station for two fire response zones. Additionally, as the primary staffed station, this station responds to back up the other five stations on most call types.





Call Volume History

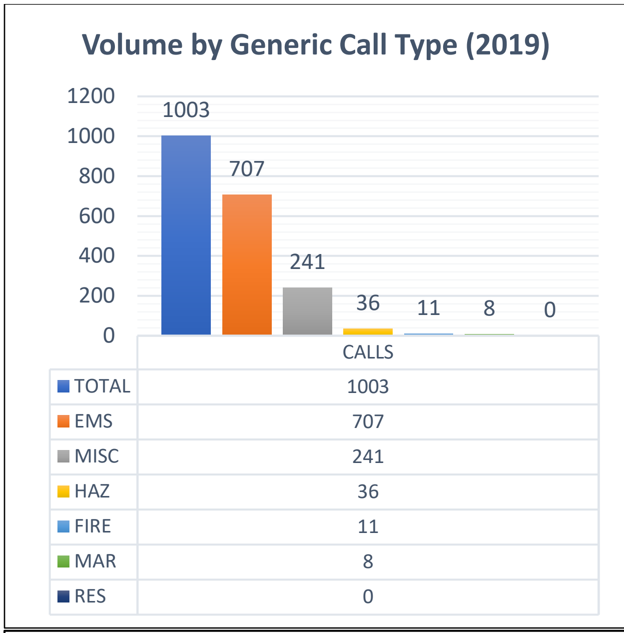


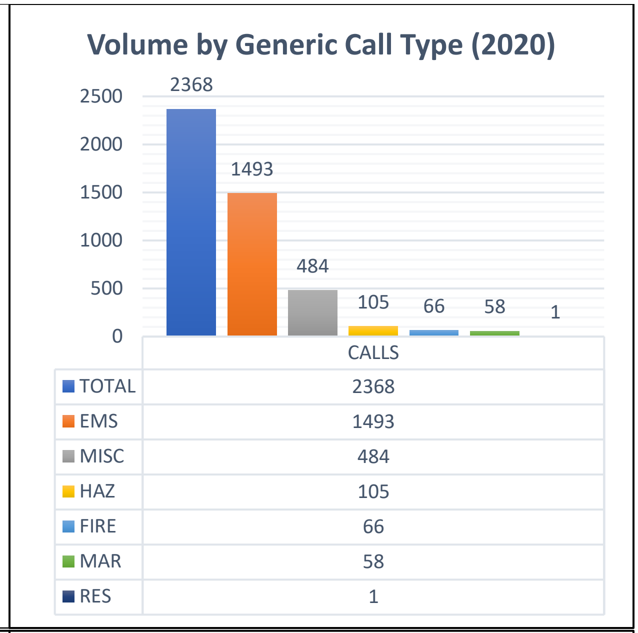
TYPE	CALLS	%
ALL	8998	
EMS	***6093***	***68%***
MISC	1979	22%
HAZ	387	4%
FIRE	189	2%
MAR	171	2%
RES	14	0.2%
x	165	2%

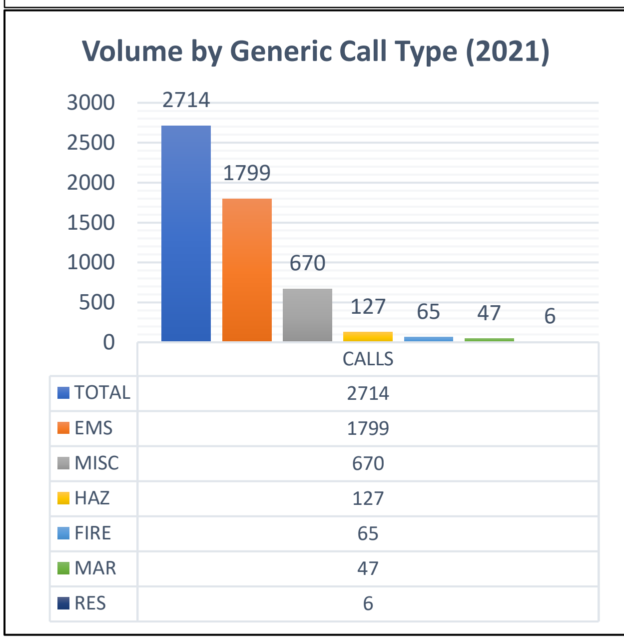
Criteria 1:

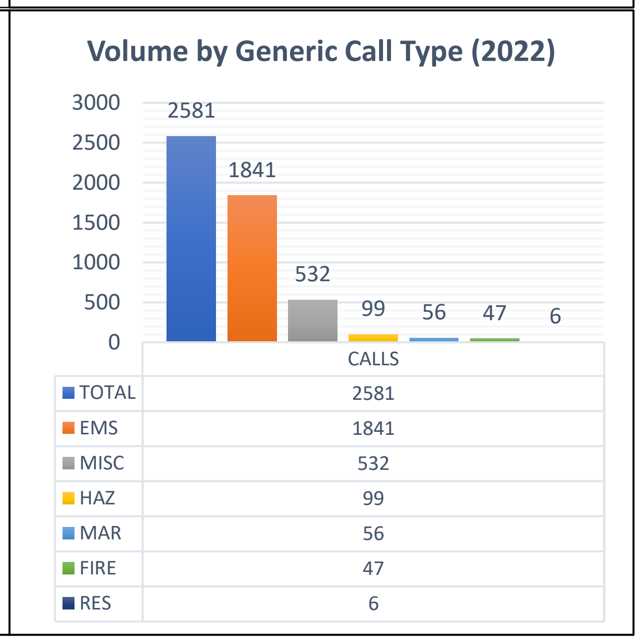
The above chart displays the total number of dispatches to general call types over the entire time period; 08/08/2019 through 12/31/2022.

The table above right contains the corresponding data and the percentage of the total number of generic call type dispatches over the total dispatches. (general call type dispatch/total dispatches)









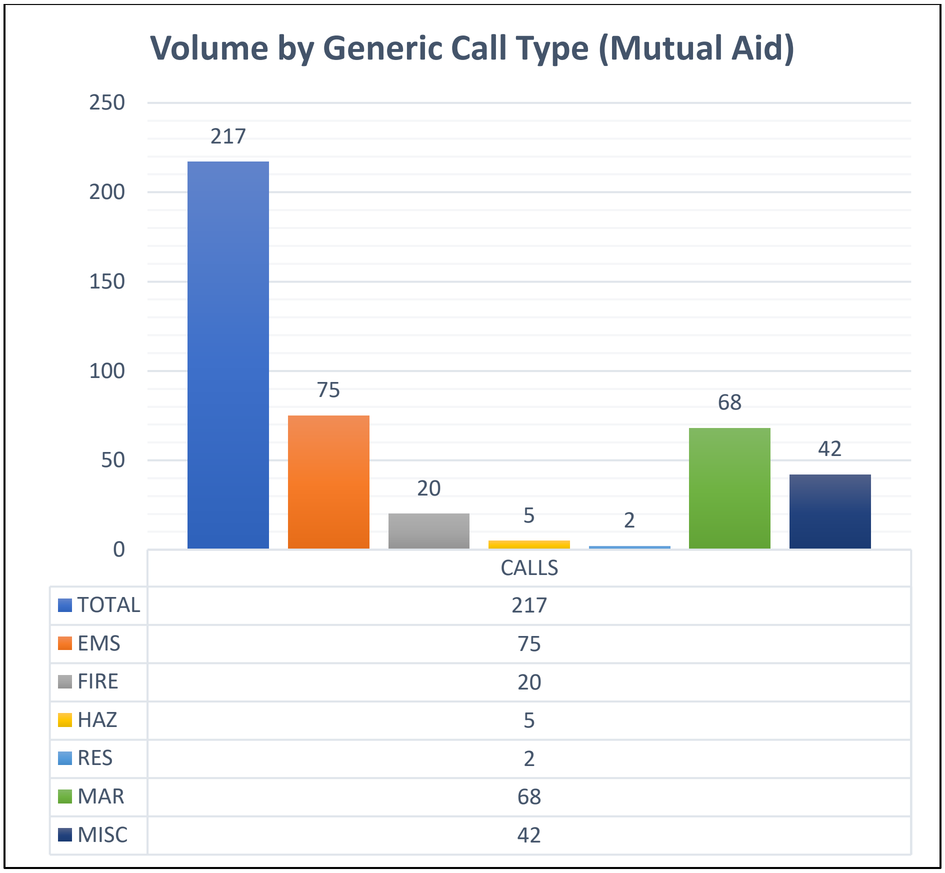
	2019*		2020		2021		2022	
	CALLS	%	CALLS	%	CALLS	%	CALLS	%
TOTAL	1003		2368		2714		2581	
EMS	***707***	***70%***	***1493***	***63%***	***1799***	***66%***	***1841***	***71%***
MISC	241	24%	484	20%	670	25%	532	21%
HAZ	36	4%	105	4%	127	5%	99	4%
FIRE	11	1%	66	3%	65	2%	56	2%
MAR	8	1%	58	2%	47	2%	47	2%
RES	0	0%	1	0.04%	6	0.2%	6	0.2%

*2019 – Partial year data.

Criteria 2:

The above charts reflect the total number of dispatches for each general call type in a specific year.

The table to the left contains the corresponding data and the percentage of dispatches for that year. (general call type dispatches per year/total dispatches per year)

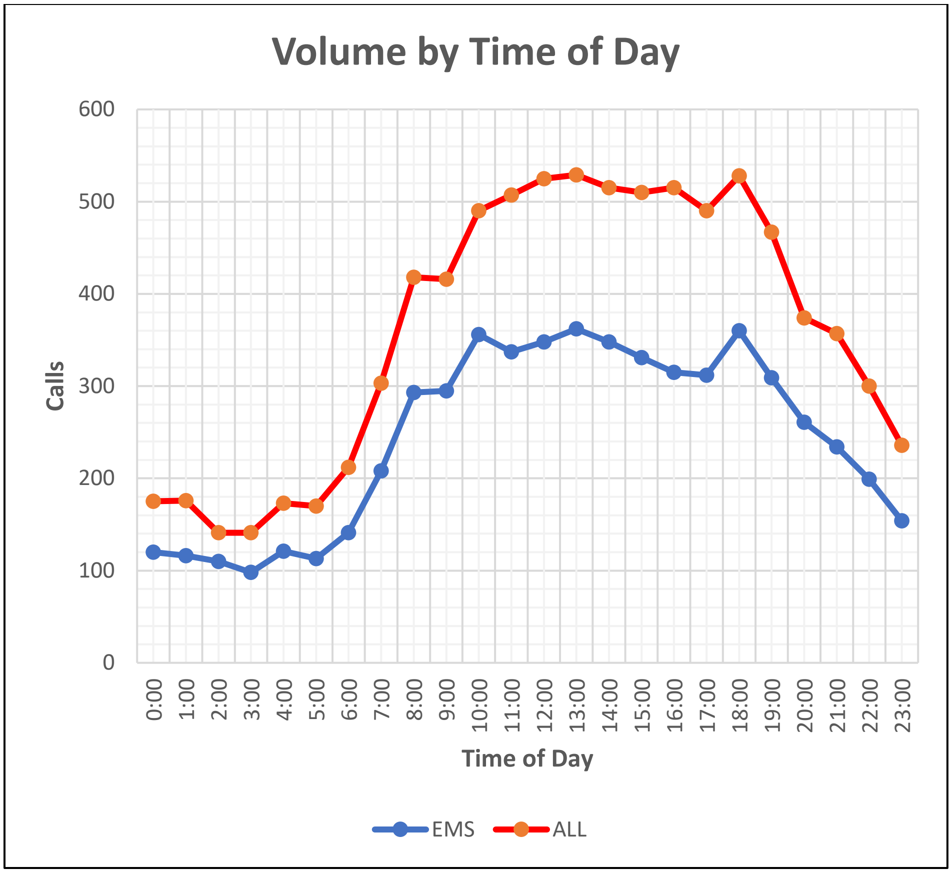


TYPE	CALLS	%
TOTAL	217	2%
EMS	75	35%
FIRE	20	9%
HAZ	5	2%
RES	2	1%
MAR	68	31%
MISC	42	19%

Criteria 3:

The above chart reflects the total number of mutual aid dispatches for each general call type.

The table above right contains the corresponding data and the percentage of general call types over the total number of mutual aid dispatches (mutual aid general call type dispatch/total mutual aid dispatches)



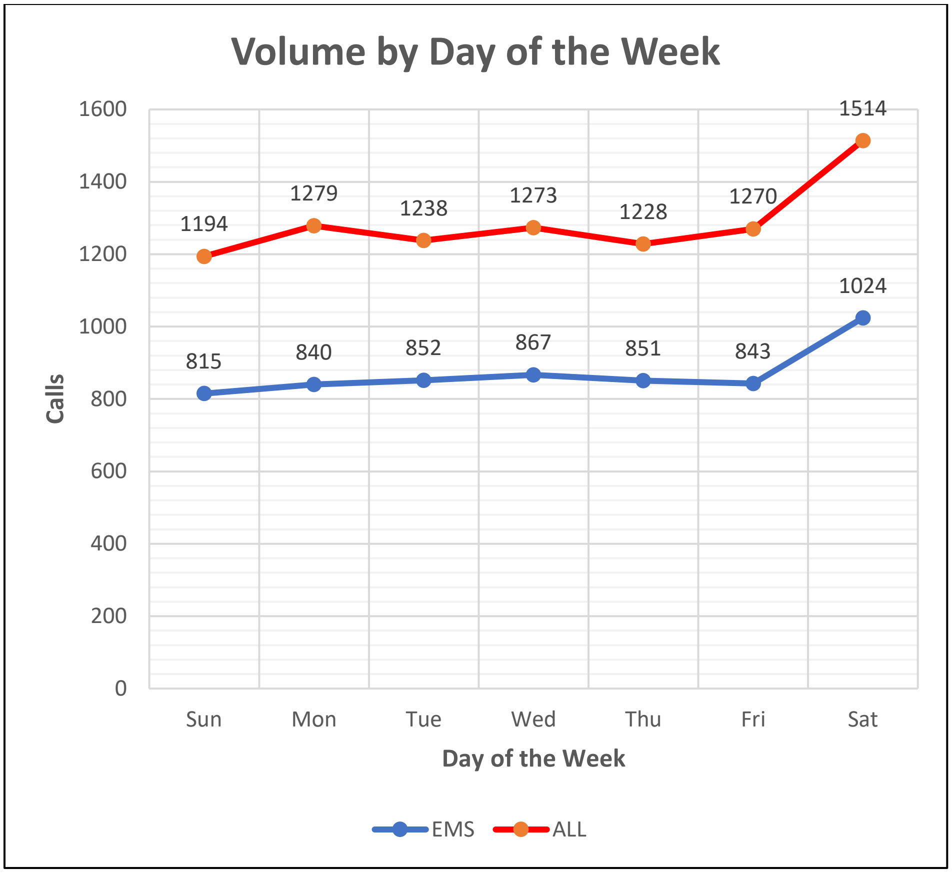
HOUR	CALLS	%
00:00	120	1.3%
01:00	116	1.3%
02:00	110	1.2%
03:00	98	1.1%
04:00	121	1.3%
05:00	113	1.3%
06:00	141	1.6%
07:00	208	2.3%
08:00	293	3.3%
09:00	295	3.3%
10:00	356	4.0%
11:00	337	3.7%
12:00	348	3.9%
13:00	362	4.0%
14:00	348	3.9%
15:00	331	3.7%
16:00	315	3.5%
17:00	312	3.5%
18:00	360	4.0%
19:00	309	3.4%
20:00	261	2.9%
21:00	234	2.6%
22:00	199	2.2%
23:00	154	1.7%

Criteria 4.1:

The above chart reflects the number of dispatches by hour for EMS calls and how it corresponds to all call types. Each “hour” corresponds to the hour of time of dispatch (i.e. 08:00 is all “time of dispatch” from 08:00:00 to 08:59:59).

The table above right contains the corresponding data and the percentage of dispatches during a given hour over the total dispatches. (dispatches by hour/total dispatches).

It is clear that the call volumes are significantly higher in the hours between 08:00 and 22:00, which we will address in the conclusions and recommendations.



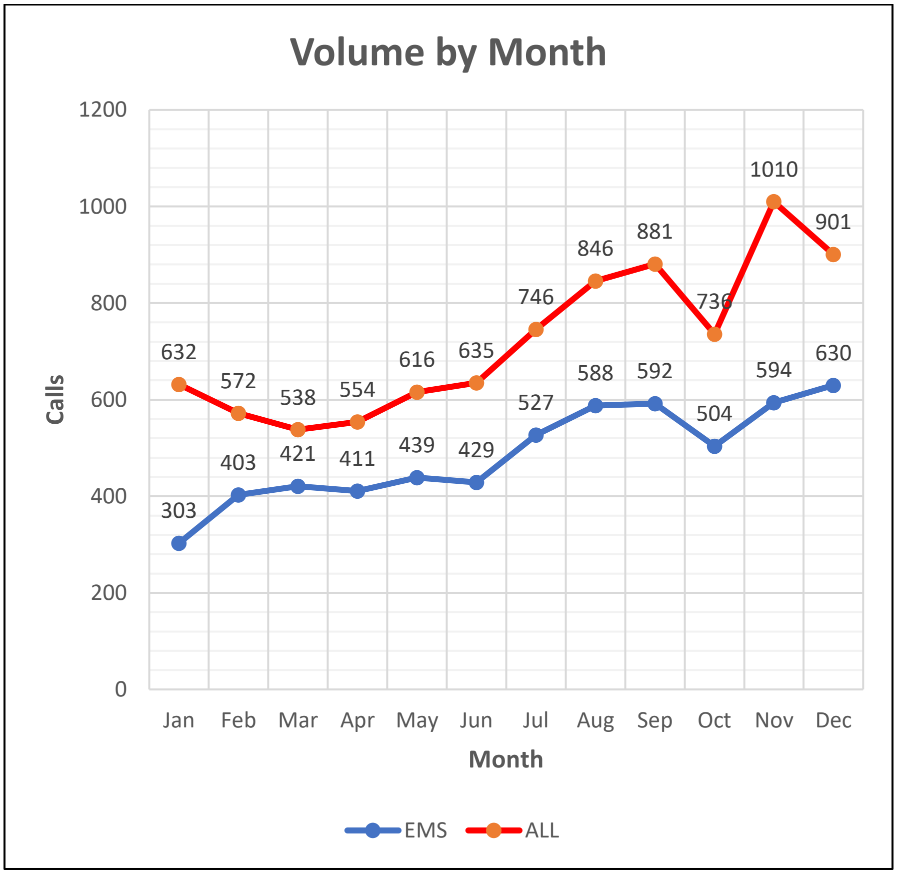
DAY	CALLS	%
Sun	815	9%
Mon	840	9%
Tue	852	9%
Wed	867	10%
Thu	851	9%
Fri	843	9%
Sat	1024	11%

<u>Criteria 4.2:</u>

The above chart reflects the number of dispatches by day of the week for EMS calls and how it corresponds to all call types.

The table above right contains the corresponding data and percentage of EMS dispatches by day of the week over total dispatches. (EMS dispatches by day/total dispatches).

There is a distinct uptick in call volume on Saturdays, which we will reference in the conclusions and recommendations.

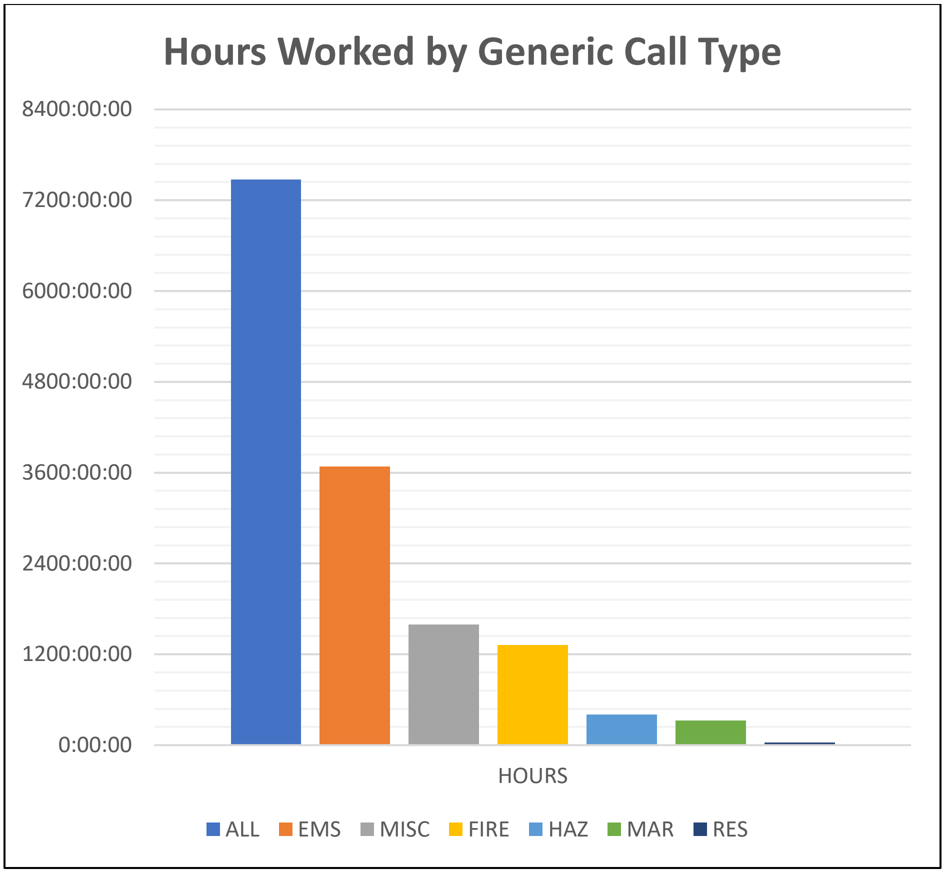


MONTH	CALLS	%
Jan	303	3.4%
Feb	403	4.5%
Mar	421	4.7%
Apr	411	4.6%
May	439	4.9%
Jun	429	4.8%
Jul	527	5.9%
Aug	588	6.5%
Sep	592	6.6%
Oct	504	5.6%
Nov	594	6.6%
Dec	630	7.0%

Criteria 4.3:

The above chart reflects the number of dispatches by month for EMS calls and how it corresponds to all call types. Note: There is missing data for January through July of 2019.

The table above right contains the corresponding data and percentage of EMS dispatches by month over the total number of dispatches. (EMS dispatches by month/total dispatches)

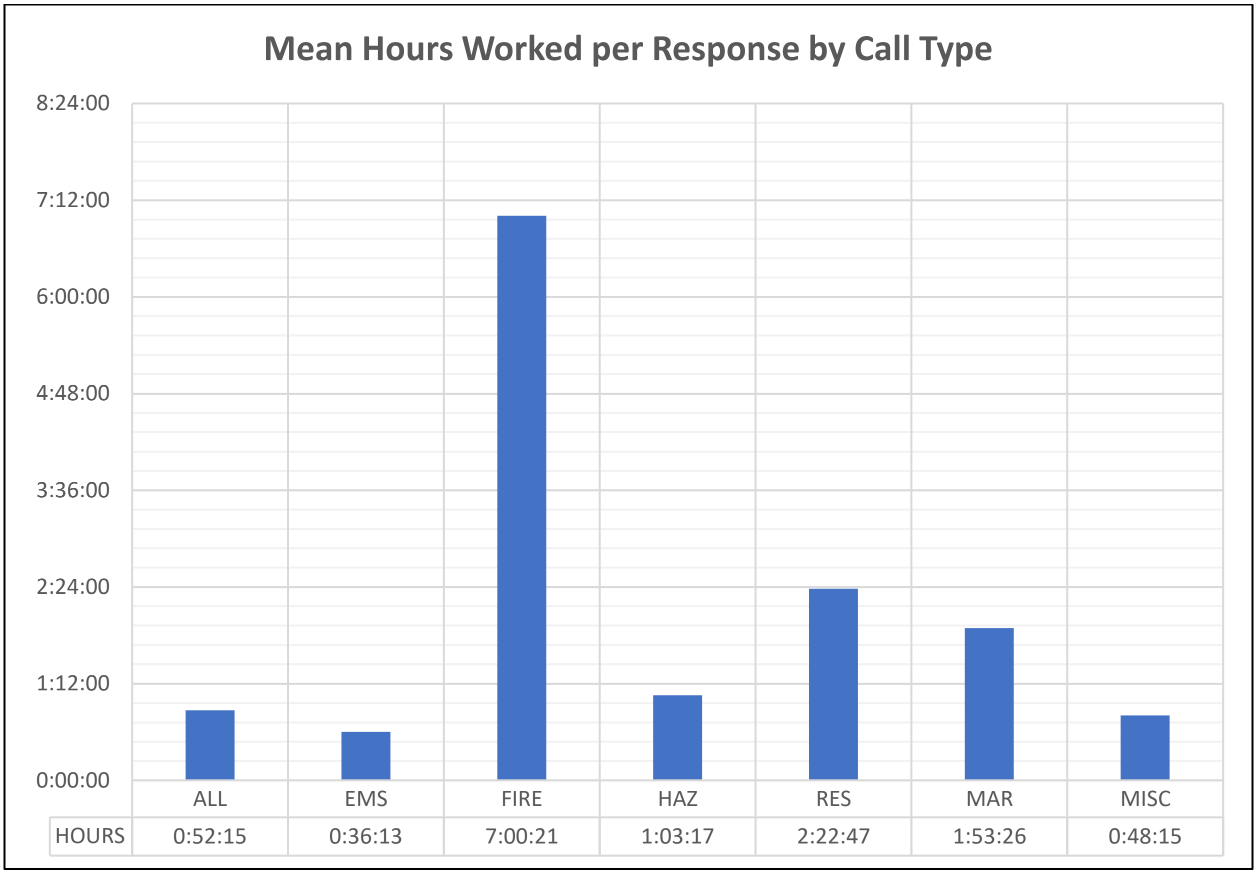


TYPE	HOURS	
ALL	**7475:15:38**	
EMS	3678:31:31	49%
MISC	1591:35:44	21%
FIRE	1324:06:24	18%
HAZ	408:10:33	5%
MAR	323:17:23	4%
RES	33:18:54	0.4%
x	116:15:09	2%

Criteria 5.2:

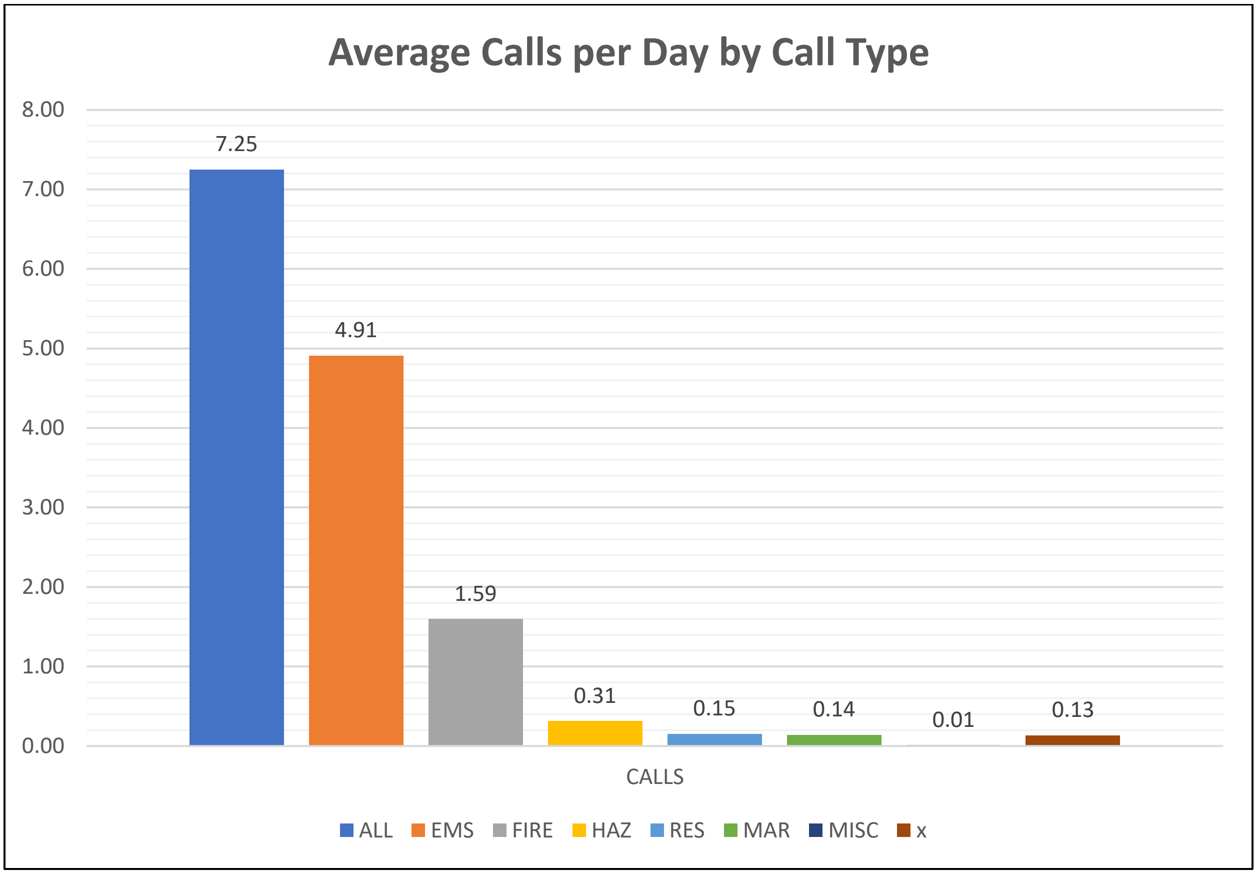
The above chart displays the total number of hours worked for all generic call types. Hours worked is calculated by the sum of the total time from dispatch time to the time the unit cleared the call for all units on all dispatches.

The table above right contains the corresponding data and the percentage of the total time worked by generic call type.



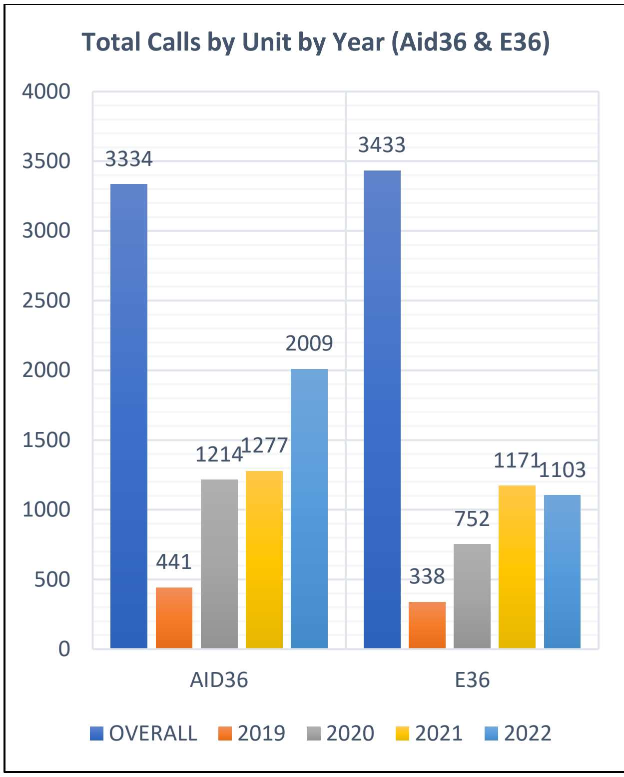
Criteria 5.3:

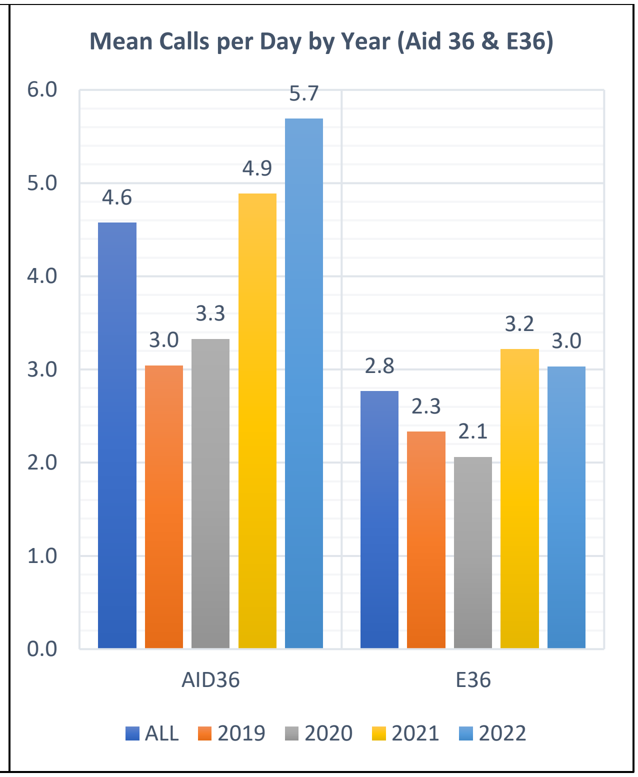
The above chart reflects the average number of hours worked per response to each generic call type.



Criteria 5.4:

The above table reflects the average number of dispatches per day by generic call type. (total generic call type/days in time period {1,242})





Criteria 6.1:

The above charts displays the total number of responses and the average number of responses per day for Aid 36 and Engine 36 by year.

AVERAGE TIME ONSCENE

AID36	0:16:47
E36	0:16:11
ALL	0:17:27

TOTAL TIME WORKED

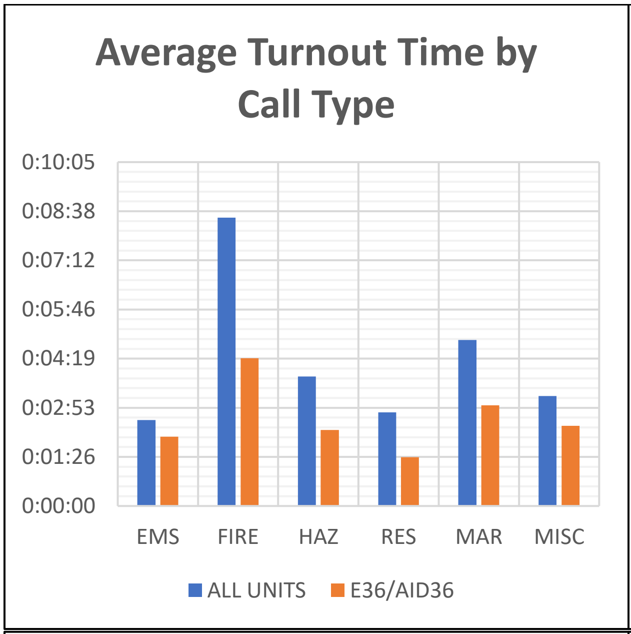
AID36	1421:38:43	19%
E36	1449:54:53	19%

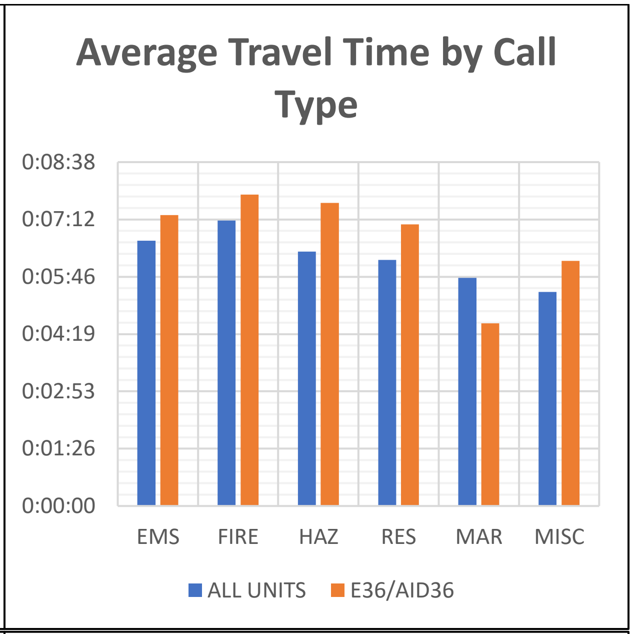
AVERAGE/DAY

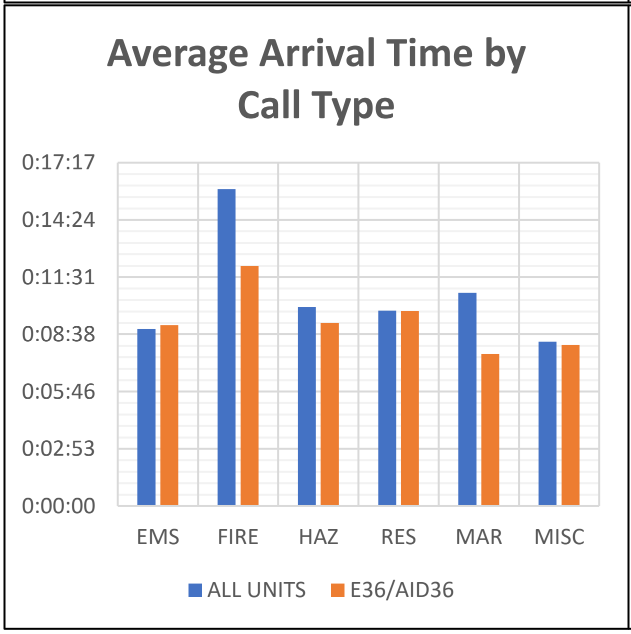
AID36	1:08:44
E36	1:10:06

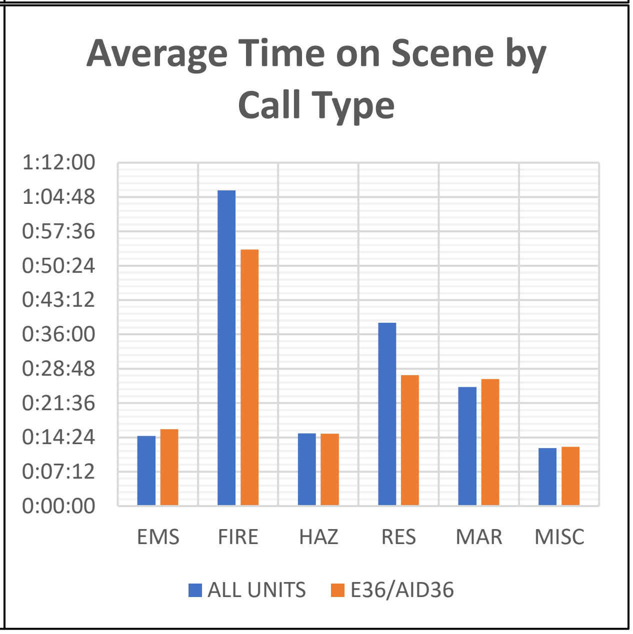
Criteria 6.2:

The above table displays the average time spent on scene of a response for AID 36 and Engine 36 compared to all units (including AID 36 and E36), the total hours worked and percentage of total hours overall for AID 36 and Engine 36, and the average hours worked per day for AID 36 and Engine 36.



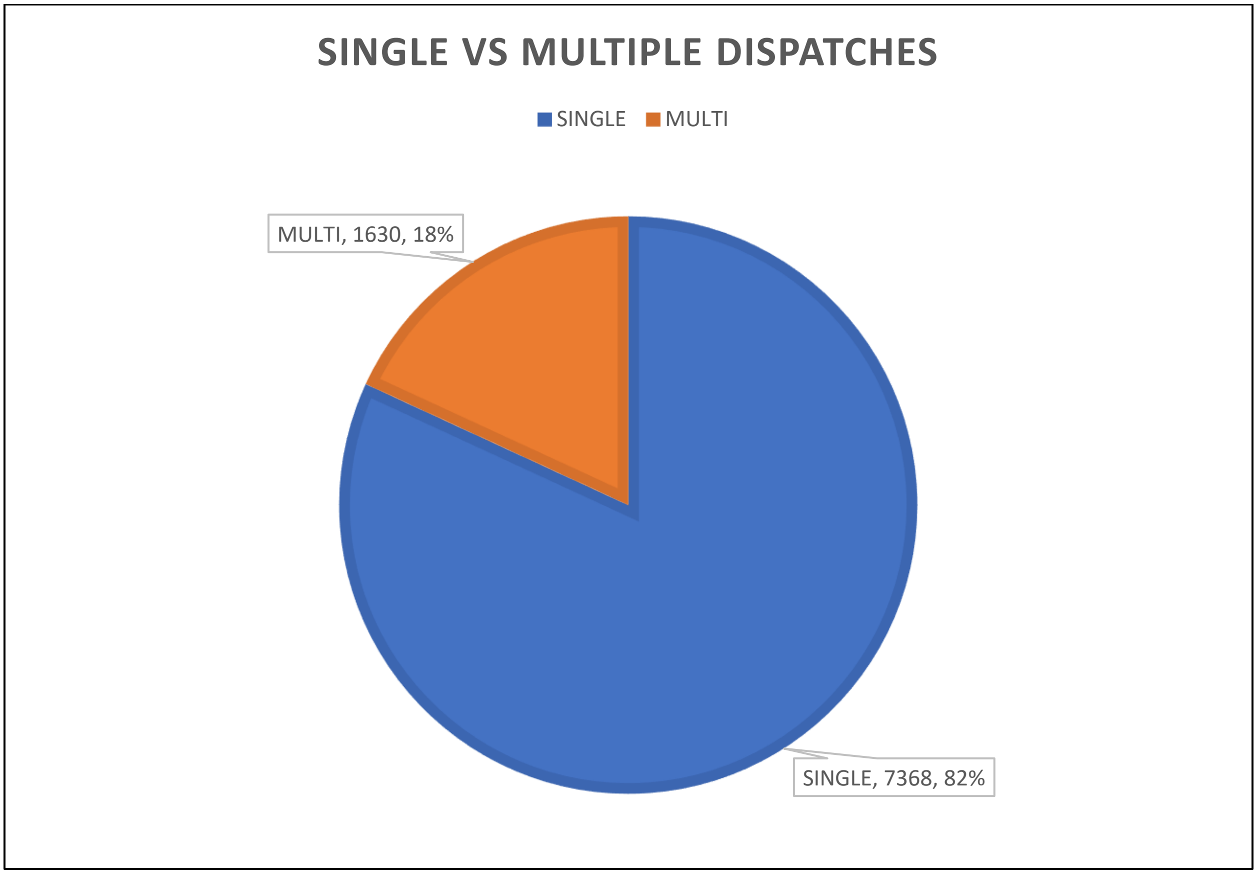






Criteria 7:

The above charts reflect the average times for turnout (dispatch to en route), travel (en route to arrived), arrival (dispatch to arrived), and time spent on scene for all SWFE units and E36/AID36 only.

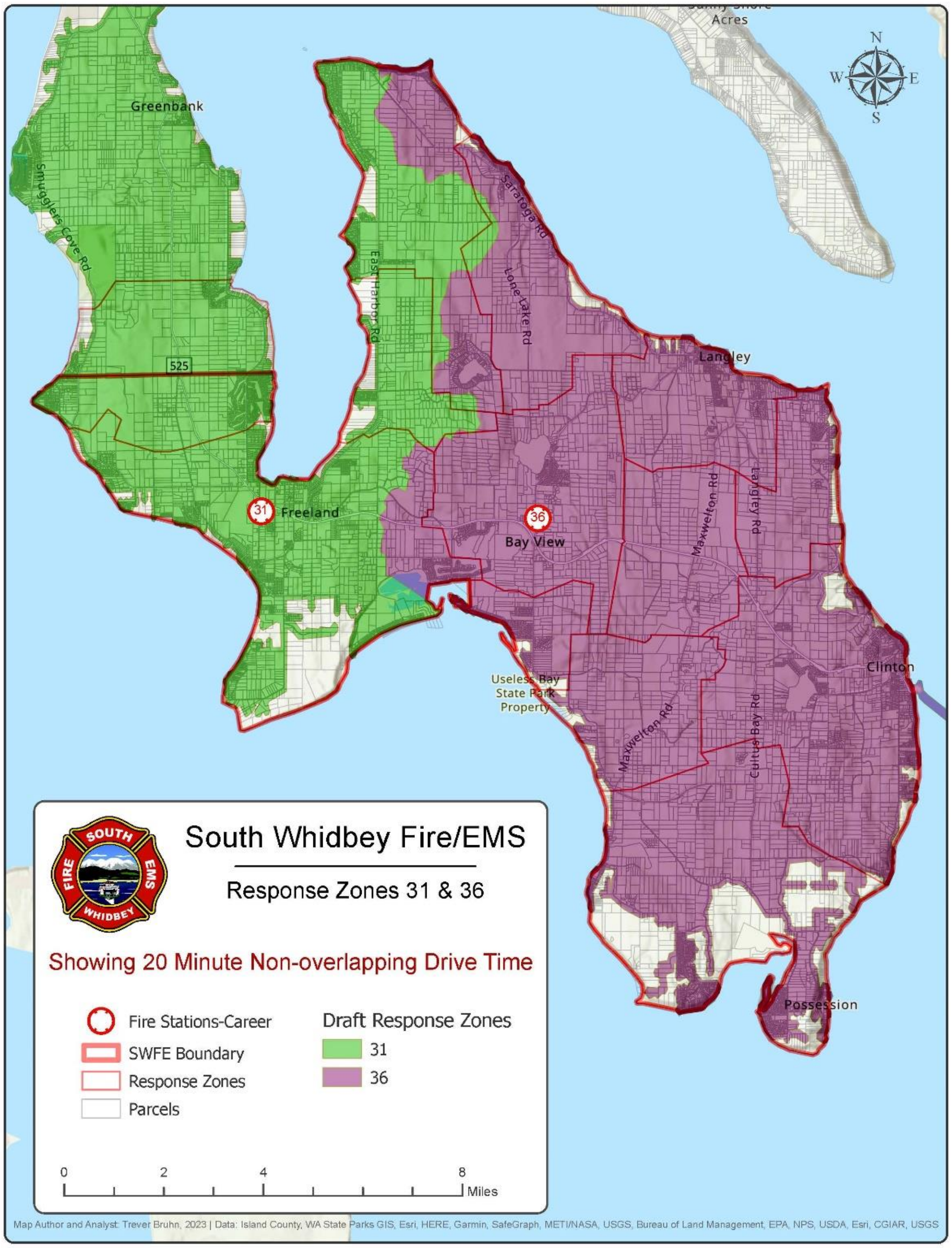


Criteria 8:

The above chart reflects the total number of "multiple dispatches" compared to the number of single dispatches. A "multiple dispatch" is defined as any dispatch that occurs after a prior unit has been dispatched, but before all units have cleared that dispatch (i.e. a dispatch that occurs while another call is active).

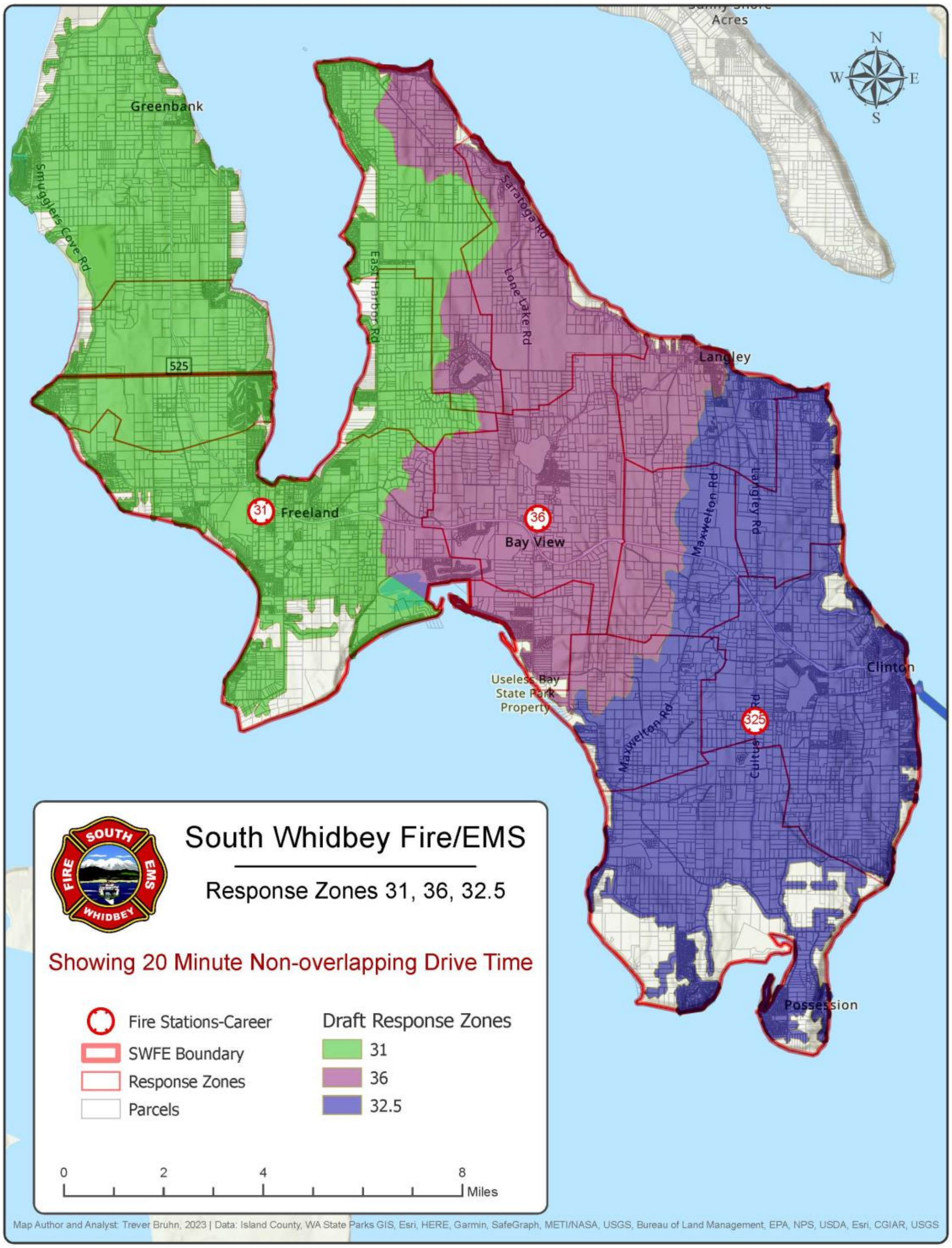
Section F—Conclusions and Recommendations

The current staffing model of staffing 2 at station 31 and 2 or 3 at station 36 causes an imbalance in the respective response areas, as seen in the following map:

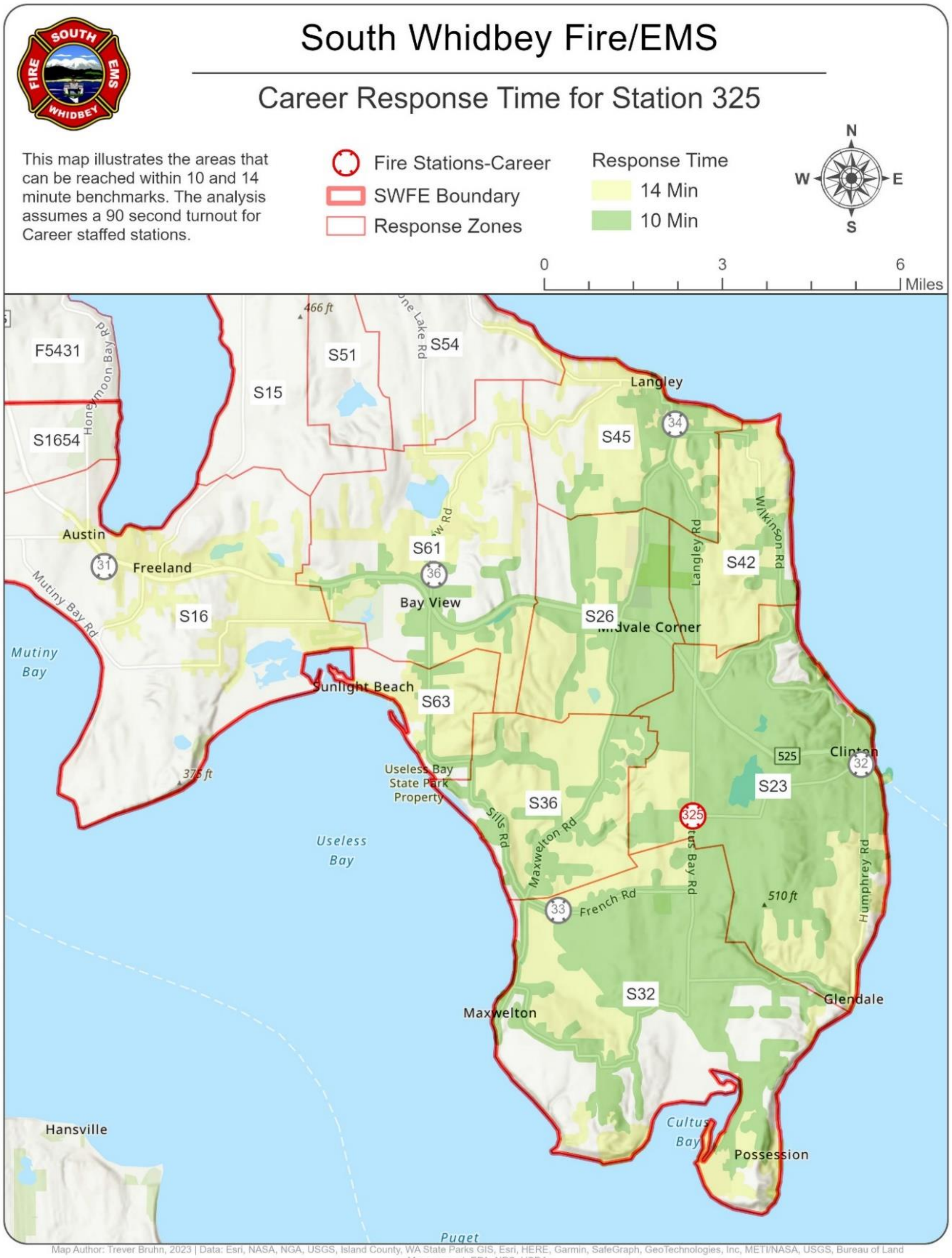


Recommendation #1: For the immediate future, continue staffing of Stations 36 and 31. It is clear that response zone S16 has the greatest call volume, and that zone is best served by this staffing model.

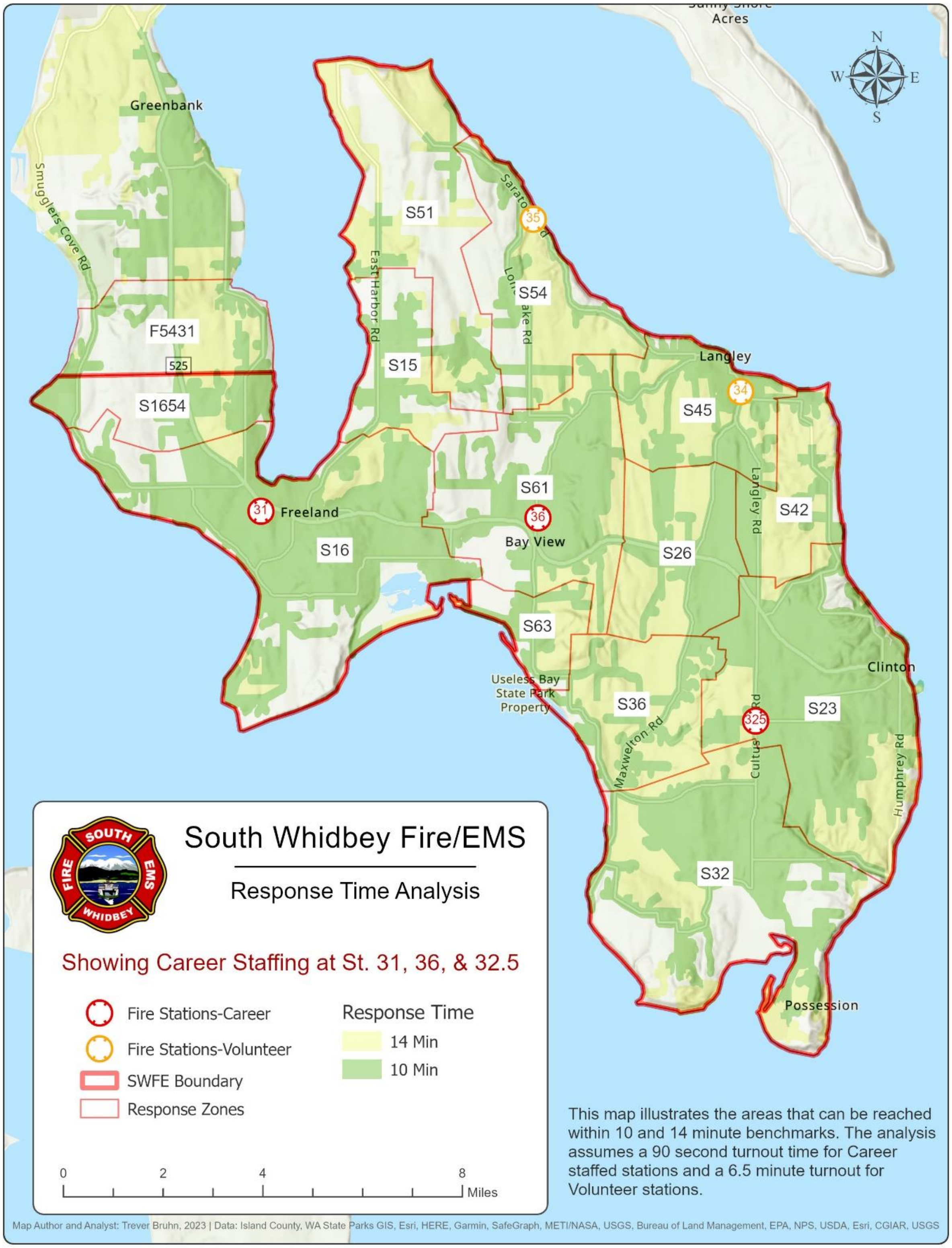
Recommendation #2: Consolidate Stations 32 and 33 into one station located in the area of Cultus Bay Road and Deer Lake Road. For study purposes, we have named this "Station 32.5".



Response times for the 10-minute and 14-minute goals would look like this out of Station 32.5:



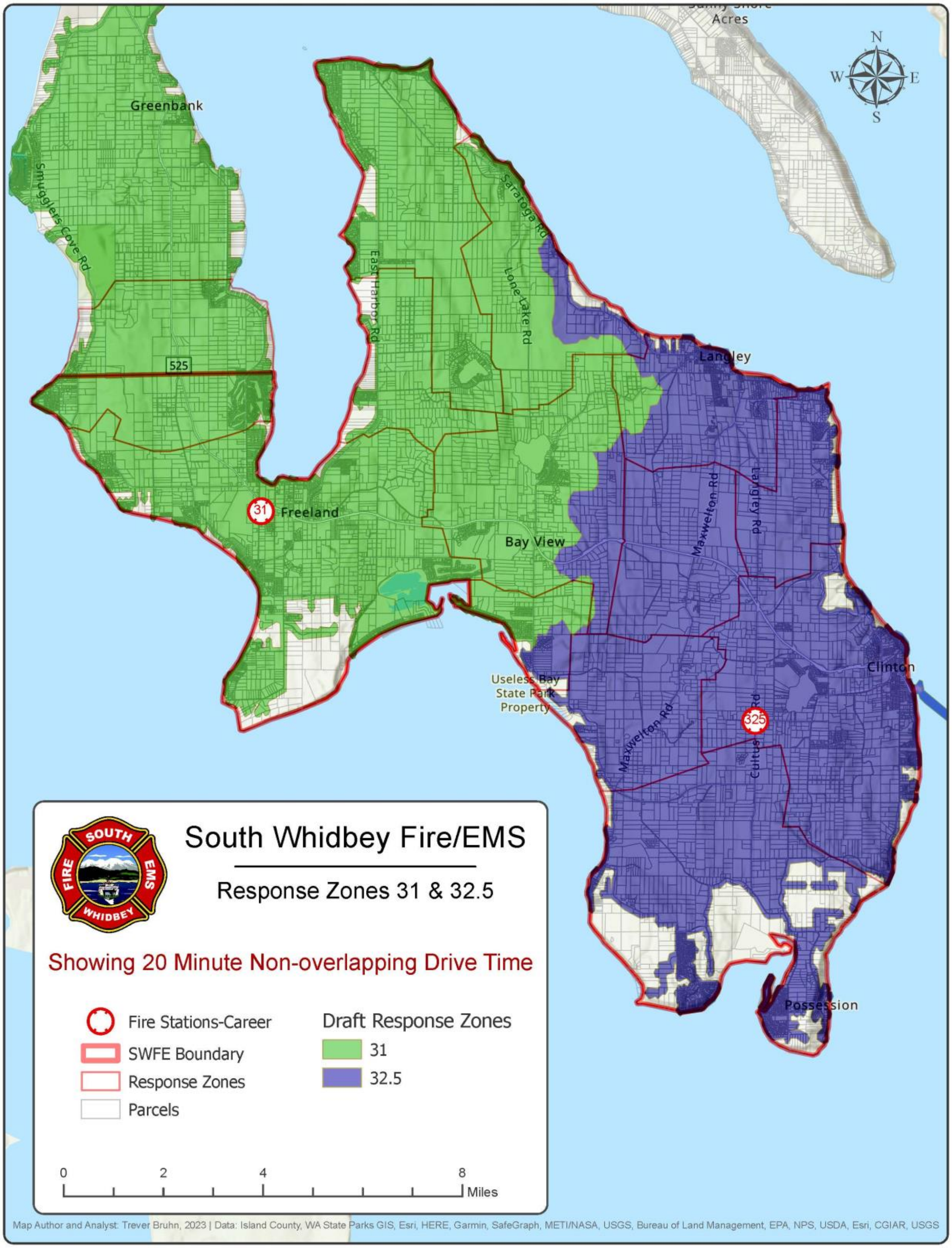
Stations 31, 32.5, 36 career-staffed, and Stations 34 & 35 volunteer response provides an overall response to the 10-minute and 14-minuted goals as seen below:



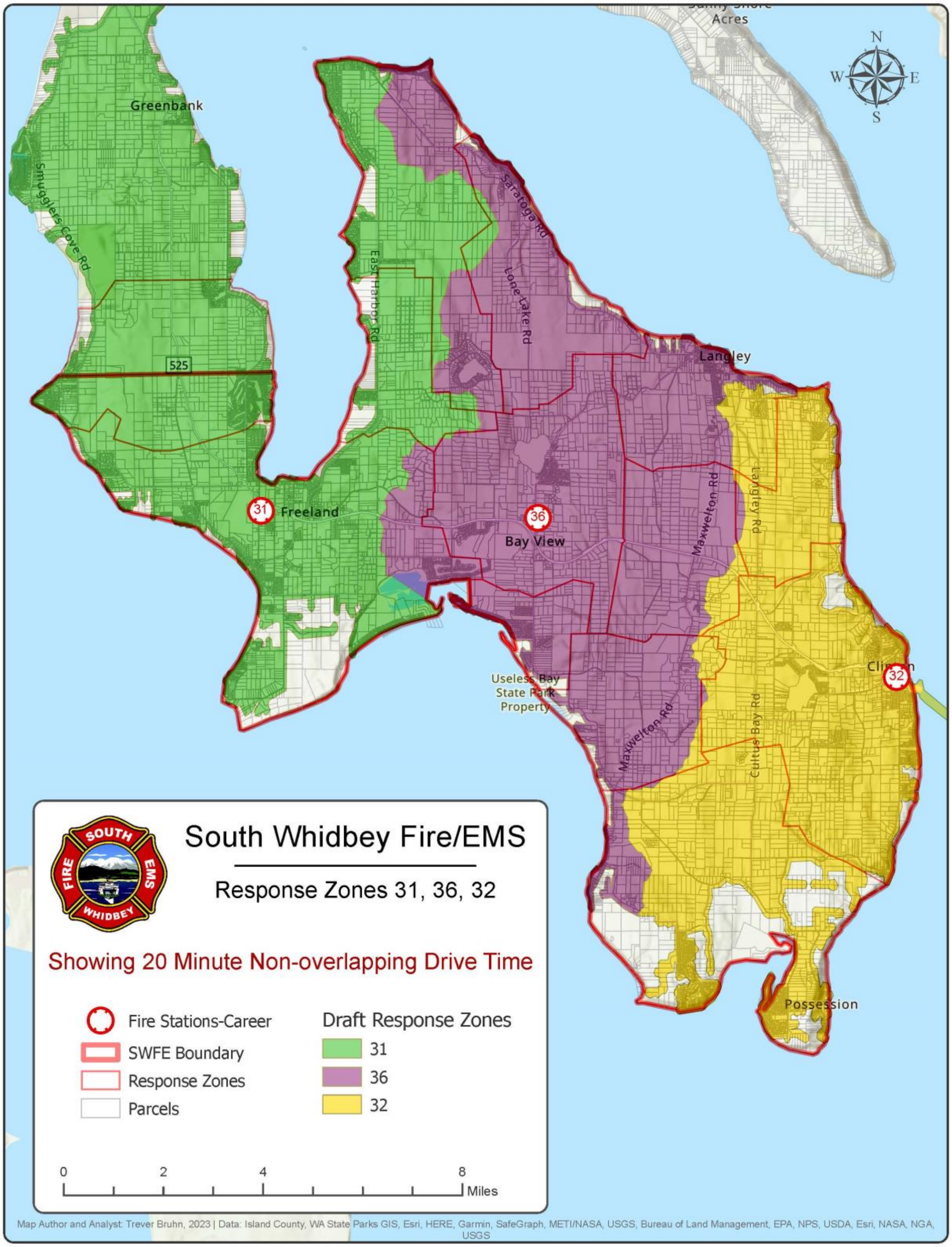
Comparison of district response times, current deployment versus adding new career-staffed Station 32.5:

The improvement in response times is most noticeable in the entire south and east parts of the district.

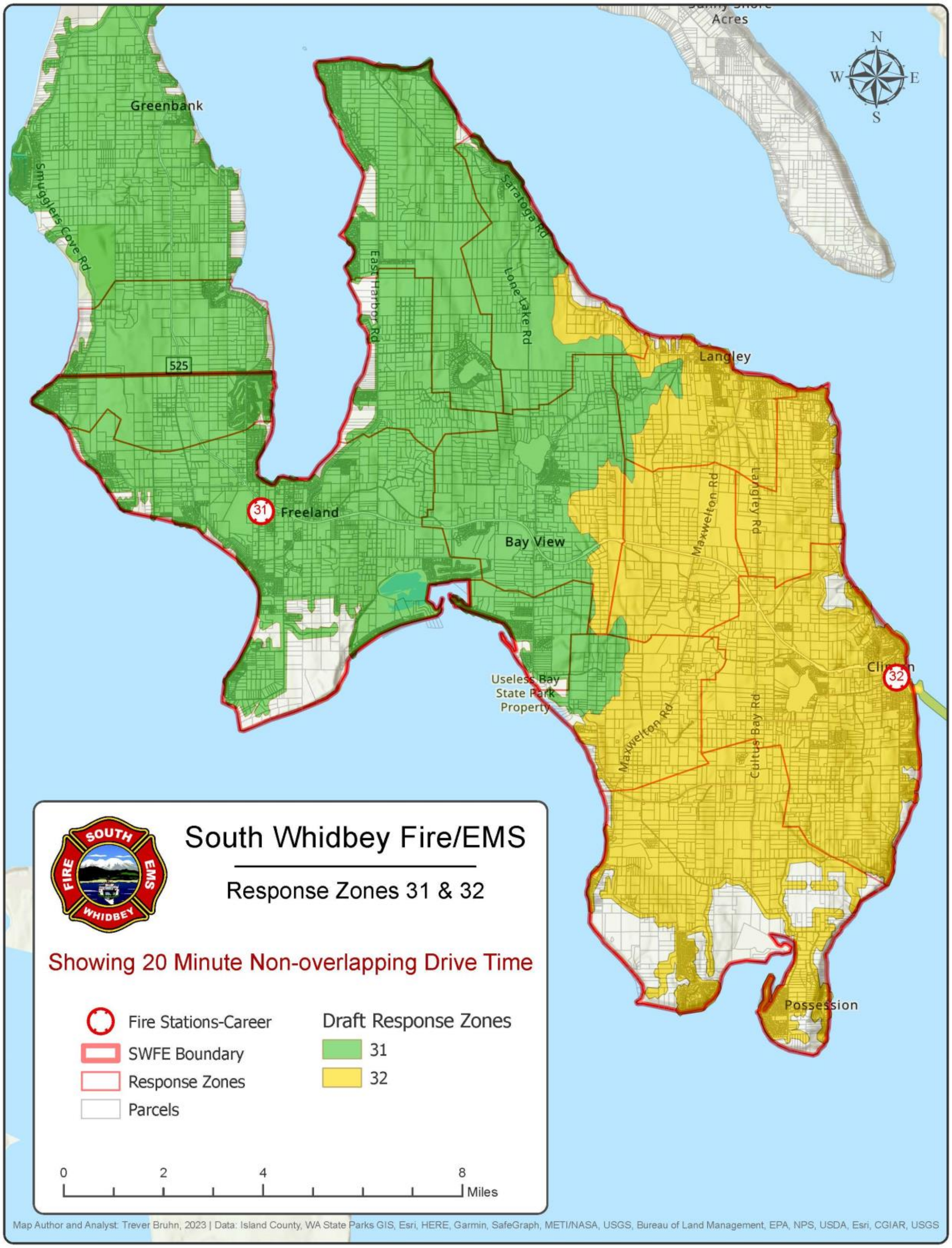
In the event of reduced daily staffing below six, the district would be best served by staffing stations 31 and 32.5, and not staffing station 36, as shown in the following model:



Recommendation #3: As an alternative to building station 32.5, the district could remodel Station 32 in Clinton to provide quarters for 2 paid staff per shift. The response model for staffing Stations 31, 32, and 36 would look like this:

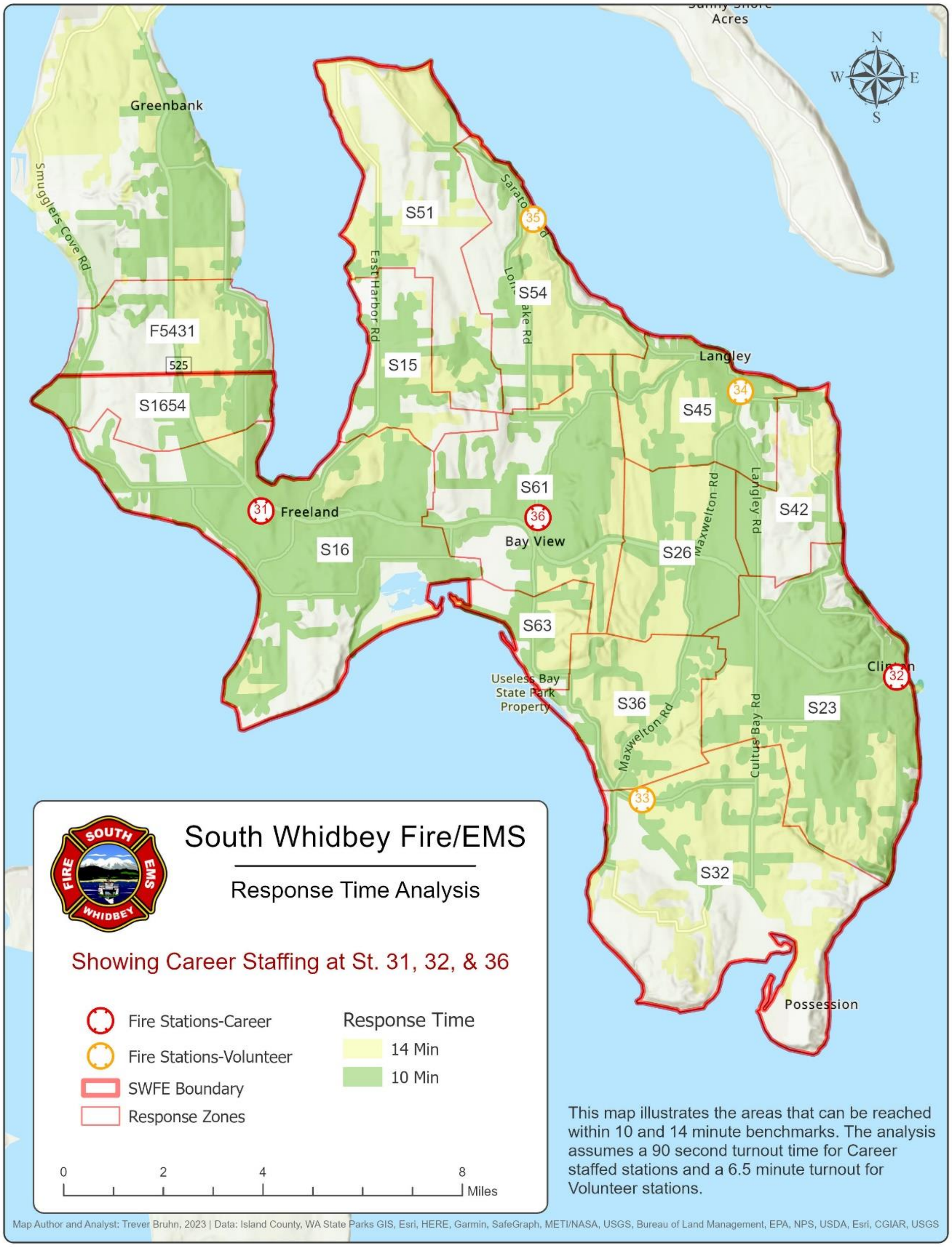


When reduced staffing prevents staffing of all 3 stations, the reduced staffing model would look like this, staffing Stations 31 and 32:

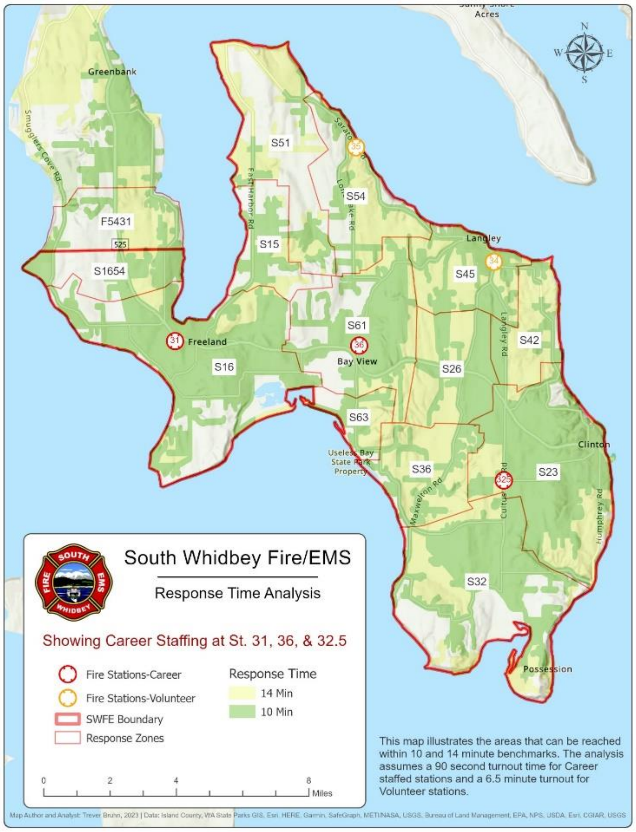


Response times for the 10-minute and 14-minute goals would look like this out of Station 32:

Stations 31, 32, & 36 career-staffed, and Stations 34 & 35 volunteer response provides an overall response to the 10-minute and 14-minuted goals as seen below:



Comparison of district response times, with the current staffing of Stations 31 and 36, plus adding new career-staffed Station 32.5 versus adding staff to existing Station 32:



The difference is apparent in the south part of the district, primarily the communities of Maxwelton Beach, Scatchet Head, Sandy Hook, and Possession Point, where we would not meet the response time goals due to slower, less direct road access from Station 32 in Clinton.

There are an estimated 568 addresses (primarily residential) in those communities that would be within the 14-minute response time from the proposed staffed Station 32.5, that would be outside of that response time from a staffed Station 32.

Summary

Overall, the District is performing well. The services provided to the community are professional and well received. There are however a few areas for service improvement, which have been identified in this report. Those are as follows:

Distribution of Resources

As noted above, the on duty staffing in the district is skewed toward the West and North portions of the district with on duty staffing in the Freeland station number 31 and Bayview station number 36. There is no staffed station to serve the South Eastern portion of the district, despite, there being a relatively even distribution of calls for service throughout that portion of the district.

Remedy:

Staff a station in the South East portion of the District in or near the community of Clinton

Response Time

The response time goals for South Whidbey Fire EMS, as stated in the current strategic plan are 14 minutes for Fire Responses and 10 minutes for EMS.

The current response times are averaging 15 minutes.

Remedy:

As demonstrated in the response time maps above, the best way to improve those response times is to distribute staffed units more evenly throughout the district. Continuing to staff station 36, 31 and staffing a third station in the South East portion of the district could accomplish this goal.

Staffing:

According to an analysis of working fire responses from 2021-2023 South Whidbey Fire EMS had an average firefighter turnout of 10.5-line personnel per incident and 3.05 command staff. The response standard set forth by the National Fire Protection Association (NFPA) standard 1710 for initial alarm assignment to a medium hazard is 28 firefighters in 8 minutes.

Remedy:

Increase on duty staffing to a minimum of 6 on duty firefighters. Increase volunteer shift participation, raising the on duty staffing to a minimum of 9 including 3 volunteers. This model still relies heavily on mutual aid response for Central Whidbey Island Fire Rescue (CWIFR) as well as a robust response from off duty volunteers.

Appendix A—Island County Emergency Plan Risk Assessment Methodologies

Risk Assessment

The risk assessment for this hazard mitigation plan evaluates the risk of natural hazards prevalent in Island County and meets requirements of the DMA (44 CFR Section 201.6(c)(2)). The methodology used to complete the risk assessment and supporting information is described below.

A hazard is an act or phenomenon that has the potential to produce harm or other undesirable consequences to a person or thing. Natural hazards can exist with or without the presence of people and land development. However, hazards can be exacerbated by societal behavior and practice, such as building in a floodplain, along a sea cliff, or on an earthquake fault. Natural disasters are inevitable, but the impacts of natural hazards can, at a minimum, be mitigated or, in some instances, prevented entirely.

The following chapters describe each hazard that affects the planning area, the likely location of natural hazard impact, the severity of the impact, previous occurrences, and the probability of future hazard events. These risk assessments provide risk-based information to assist the County and its planning partners in determining priorities for implementing mitigation measures. The risk assessment approach used for this plan entailed using geographic information system (GIS) and Hazus hazard-modeling software and data to develop vulnerability models for people, structures and critical facilities, and evaluating those vulnerabilities in relation to hazard profiles that model where hazards exist. This approach is dependent on the detail and accuracy of the data used. Some types of hazards are extremely difficult to model.

The DMA requires measuring potential losses to critical facilities and property resulting from natural hazards. In addition to the DMA requirements, the risk assessment approach taken in this study evaluated risks to vulnerable populations and also examines the risk presented by several human-caused hazards. The goal of the risk assessment is to determine which hazards present the greatest risk and what areas are the most vulnerable to hazards. Island County and its planning partners are exposed to many natural and human-caused hazards. The risk assessment and vulnerability analysis helps identify where mitigation measures could reduce loss of life or damage to property in the planning region.

The hazard profiles in the following chapters document the impact of past hazard events and identify the areas most at risk. To ensure a single set of terminology to describe the methodology and results of this analysis, the following is provided as the foundation for the standardized risk terminology:

- Hazard: Natural (or human caused) source or cause of harm or damage, demonstrated as actual (deterministic/historical events) or potential (probabilistic) events.

- Risk: The potential for an unwanted outcome resulting from a hazard event, as determined by its likelihood and associated consequences. For this plan, where possible, risk includes potential future losses based on probability, severity and vulnerability, expressed in dollar losses when possible. In some instances, dollar losses are based on actual demonstrated impact, such as through the use of the Hazus model. In other cases, losses are demonstrated through exposure analysis due to the inability to determine the extent to which a structure is impacted.

- Location: The area of potential or demonstrated impact within the area in which the analysis is being conducted. In some instances, the area of impact is within a geographically defined area, such as a floodplain. In other instances, such as for severe weather, there is no established geographic boundary associated with the hazard, as it can impact the entire area.

- Severity/Magnitude: The extent or magnitude upon which a hazard is ranked, demonstrated in various means, e.g., Richter Scale.

- Vulnerability: The degree of damage, e.g., building damage or the number of people injured or potentially injured and damaged.

- Probability of Occurrence and Return Intervals: These terms are used as a synonym for likelihood, or the estimation of the potential of an incident to occur.

PROBABILITY OF OCCURRENCE AND RETURN INTERVALS

Natural hazard events with relatively long return periods, such as a 100-year flood or a 500-year tsunami or earthquake, are often thought to be very unlikely. In reality, the probability that such events occur over the next 30 or 50 years is relatively high.

Natural hazard events with very long return periods, such as 100 or 500 or 1,000 years, have significant probabilities of occurring during the lifetime of a building:

- Hazard events with return periods of 100 years have probabilities of occurring in the next 30 or 50 years of about 26 percent and about 40 percent, respectively.

- Hazard events with return periods of 500 years have about a 6 percent and about a 10 percent chance of occurring over the next 30 or 50 years, respectively.

- Hazard events with return periods of 1,000 years have about a 3 percent chance and about a 5 percent chance of occurring over the next 30 or 50 years, respectively.

For life safety considerations, even natural hazard events with return periods of more than 1,000 years are often deemed significant if the consequences of the event happening are very severe (extremely high damage and/or substantial loss of life). For example, the seismic design requirements for new construction are based on the level of ground shaking with a return period of 2,475 years (2 percent probability in 50 years). Providing life safety for this level of ground shaking is deemed necessary for seismic design of new buildings to minimize life safety risk. Of course, a hazard event with a relatively long return period may occur tomorrow, next year, or within a few years. Return periods of 100 years, 500 years or 1,000 years mean that such events have a 1 percent, a 0.2 percent or a 0.1 percent chance of occurring in any given year.

METHODOLOGY

Hazard Identification and Profiles

For this plan, the planning partners and stakeholders considered the full range of natural hazards that could impact the planning area and then listed hazards that present the greatest concern. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, the planning team, at its October 28, 2019 meeting, identified the following natural hazards that this plan addresses as the hazards of concern:

- Erosion
- Earthquake
- Flood
- Landslide
- Severe weather
- Tsunami
- Volcano
- Wildfire

Risk Assessment Process

The hazard profiles and risk assessment describe the risks associated with each identified hazard of concern. Each chapter describes the hazard, the planning area's vulnerabilities, and probable event scenarios. The following steps were used to define the risk of each hazard:

- Identify and profile the following information for each hazard:
    - Geographic areas most affected by the hazard
    - Event frequency estimates
    - Severity estimates
    - Warning time likely to be available for response.

- Determine exposure to each hazard—Exposure was determined by overlaying hazard maps with an inventory of structures, facilities, and systems to determine which of them would be exposed to each hazard.

- Assess the vulnerability of exposed facilities—Vulnerability of exposed structures and infrastructure was determined by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and Hazus (discussed below) were used in this assessment.

• Where specific quantitative assessments could not be completed, vulnerability was measured in general, qualitative term, summarizing the potential impact based on past occurrences, spatial extent, and subjective damage and casualty potential. Those items were categorized utilizing the criteria established in the CPRI (discussed below).

• The final step in the process was to determine the cumulative results of vulnerability based on the risk assessment/CPRI schedule, assigning a final qualitative level of significance. It serves as a summary of the potential impact based on past occurrences, spatial extent, and damage and casualty potential based on the following levels of significance, with all of the results contained within Chapter 15:

- Extremely Low—The occurrence and potential cost of damage to life and property is very minimal to nonexistent.
- Low—Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
- Medium—Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster. Island County Multi-Jurisdiction Hazard Mitigation Plan 2020 Update Risk Assessment Methodology Bridgeview Consulting 4-4 September 2020
- High—Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
- Extremely High—Very widespread with catastrophic impact.

Calculated Priority Risk Index Scoring Criteria

For the 2020 update in the Island County Hazard Mitigation Plan, the Planning Team utilized a Calculated Priority Risk Index Score for each hazard of concern, addressing impact both at the county level, and at the Planning Partner level. The same process was followed for both the County and by each Planning Partner. While the base plan defines the process followed, each jurisdictional annex provides only the outputs rather than re-describing the entire process.

Vulnerabilities are described in terms of critical facilities, structures, population, economic values, and functionality of government which can be affected by the hazard event as identified in the below tables. Hazard impact areas describe the geographic extent a hazard can impact a jurisdiction and are uniquely defined on a hazard-by-hazard basis. Mapping of the hazards, where spatial differences exist, allows for hazard analysis by geographic location. Some hazards can have varying levels of risk based on location. Other hazards cover larger geographic areas and affect the area uniformly. Therefore, a system must be established which addresses all elements (people, property, economy, continuity of government) in order to rate each hazard consistently, and in a manner, which addresses the functionality of each Planning Partner involved (e.g., municipality, fire district, public utility district, etc.). The use of the Calculated Priority Risk Index allows such application, based on established criteria of application to determine the risk factor. For identification purposes, the six criteria on which the CPRI is based are probability, magnitude, geographic extent and location, warning time/speed of onset, and duration of the event. This is a slight modification from the last plan's risk assessment, in that this edition included the category "geographic extent and location," which is a new ranking criteria within the CPRI scoring for this 2020 update. The elements of the CPRI are further defined below.

CPRI Category	Degree of Risk: Impact/ Level ID	Degree of Risk: Description	Degree of Risk: Impact Factor	Assigned Weighting Factor
Probability	Unlikely	• Rare with no documented history of occurrences or events. • Annual probability of less than 1% (~100 years or more).	1	40%
	Possible	• Infrequent occurrences; at least one documented or anecdotal historic event. • Annual probability that is between 1% and 10% (~10 years or more).	2	
	Likely	• Frequent occurrences with at least two or more documented historic events. • Annual probability that is between 10% and 90% (~10 years or less).	3	
	Highly Likely	• Common events with a well-documented history of occurrence. • Annual probability of occurring. (1% chance or 100% Annually).	4	
Magnitude/ Severity	Negligible	• People – Injuries and illnesses are treatable with first aid; minimal hospital impact; no deaths. Negligible impact to quality of life. • Property – Less than 5% of critical facilities and infrastructure impacted and only for a short duration (less than 24-36 hours such as for a snow event); no loss of facilities, with only very minor damage/clean-up. • Economy – Negligible economic impact. • Continuity of government operating at 90% of normal operations with only slight modifications due to diversion of normal work for short-term response activity. Disruption lasts no more than 24-36 hours. • Special Purpose Districts: No Functional Downtime.	1	25%
	Limited	• People – Injuries or illness predominantly minor in nature and do not result in permanent disability; some increased calls for service at hospitals; no deaths; 14% or less of the population impacted. Moderate impact to quality of life. • Property – Slight property damage -greater than 5% and less than 25% of critical and non-critical facilities and infrastructure. • Economy – Impact associated with loss property tax base limited; impact results primarily from lost revenue/tax base from businesses shut down during duration of event and short-term cleanup; increased calls for emergency services result in increased wages. • Continuity of government impacted slightly; 80% of normal operations; most essential services being provided. Disruption lasts >36 hours, but <1 week. • Special Purpose Districts: Functional downtime 179 days or less.	2	
	Critical	• People – Injuries or illness results in some permanent disability or significant injury; hospital calls for service increased significantly; no deaths. 25% to 49% of the population impacted. • Property – Moderate property damages (greater than 25% and less than 50% of critical and non-critical facilities and infrastructure). • Economy – Moderate impact as a result of critical and non-critical facilities and infrastructure impact; loss of revenue associated with tax base, lost income. • Continuity of government ~50% operational capacity; limited delivery of essential services. Services interrupted for more than 1 week, but <1 month. • Special Purpose Districts: Functional downtime 180-364 days.	3	
	Catastrophic	• People – Injuries or illnesses result in permanent disability and death to a significant amount of the population exposed to a hazard. >50% of the population impacted. • Property – Severe property damage >50% of critical facilities and non-critical facilities and infrastructure impacted. • Economy – Significant impact - loss of buildings (content, inventory, lost revenue, lost income. • Continuity of government significantly impacted; limited services provided (life safety and mandated measures only). Services disrupted for > than 1 month. • Special Purpose Districts: Functional Downtime 365 days or more.	4	
Geographic Extent and Location	Limited	Less than 10% of area impacted	1	20%
	Moderate	10%-24% of area impacted.	2	
	Significant	25%-49% of area impacted.	3	
	Extensive	50% or more of area impacted	4	
Warning Time / Speed of Onset	<6 hours	Self-explanatory.	4	10%
	6 to 12 hours	Self-explanatory.	3	
	12 to 24 hours	Self-explanatory.	2	
	> 24 hours	Self-explanatory.	1	
Duration	< 6 hours	Self-explanatory.	1	5%
	< 24 hours	Self-explanatory.	2	
	<1 week	Self-explanatory.	3	
	>1 week	Self-explanatory.	4	

Probability

Probability of a hazard event occurring in the future was assessed based on hazard frequency over a 100-year period (where available). Hazard frequency was based on the number of times the hazard event occurred divided by the period of record. If the hazard lacked a definitive historical record, the probability was assessed qualitatively based on regional history and other contributing factors. Probability of occurrence was assigned a 40% weighting factor, and was broken down as follows:

		Frequency of Occurrence
1	Unlikely	Less than 1% probability in the next 100 years.
2	Possible	Between 1% and 10% probability in the next year, or at least one chance in the next 100 years.
3	Likely	Between 10% and 100% probability in next year, or at least one chance in the next 10 years.
4	Highly Likely	Greater than 1 event per year (frequency greater than 1).

Magnitude

The magnitude of potential hazard events was evaluated for each hazard. Magnitude is a measure of the strength of a hazard event and is usually determined using technical measures specific to the hazard. Magnitude was calculated for each hazard where property damage data was available, and was assigned a 25% weighting factor. Magnitude calculation was determined using the following: Property Damage / Number of Incidents) / $ of Building Stock Exposure = Magnitude. In some cases, the Hazus model provided specific people/dollar impact data. For other hazards, a GIS exposure analysis was conducted.

Magnitude was broken down as follows:

Rating	Magnitude	Percentage of People and Property Affected
1	Negligible	Less than 5% Very minor impact to people, property, economy, and continuity of government at 90%.
2	Limited	6% to 24% Injuries or illnesses minor in nature, with only slight property damage and minimal loss associated with economic impact; continuity of government only slightly impacted, with 80% functionality.
3	Critical	25% to 49% Injuries result in some permanent disability; 25-49% of population impacted; moderate property damage; moderate impact to economy, with loss of revenue and facility impact; government at 50% operational capacity with service disruption more than one week, but less than a month.
4	Catastrophic	More than 50% Injuries and illness resulting in permanent disability and death to more than 50% of the population; severe property damage greater than 50%; economy significantly impacted as a result of loss of buildings, content, inventory; government significantly impacted; limited services provided, with disruption anticipated to last beyond one month.

Extent and Location

The measure of the percentage of the people and property within the planning area impacted by the event, and the extent (degree) to which they are impacted. Extent and location were assigned a weighting factor of 20%, and broken down as follows:

Rating	Magnitude	Percentage of People and Property Affected
1	Negligible	Less than 10% Few if any injuries or illness. Minor quality of life lost with little or no property damage. Brief interruption of essential facilities and services for less than four hours.
2	Limited	10% to 24% Minor injuries and illness. Minor, short term property damage that does not threaten structural stability. Shutdown of essential facilities and services for 4 to 24 hours.
3	Critical	25% to 49% Serious injury and illness. Major or long term property damage, that threatens structural stability. Shutdown of essential facilities and services for 24 to 72 hours.
4	Catastrophic	More than 50% Multiple deaths Property destroyed or damaged beyond repair Complete shutdown of essential facilities and services for 3 days or more.

Warning Time/Speed of Onset

The rate at which a hazard occurs, or the time provided in advance of a situation occurring (e.g., notice of a cold front approaching or a potential hurricane, etc.) provides the time necessary to prepare for such an event. Sudden-impact hazards with no advanced warning are of greater concern. Warning Time/Speed of onset was assigned a 10% weighting factor, and broken down as follows:

Rating	Probable amount of warning time
1	More than 24 hours warning time.
2	12-24 hours warning time.
3	5-12 hours warning time.
4	Minimal or no warning time.

Duration

The time span associated with an event was also considered, the concept being the longer an event occurs, the greater the threat or potential for injuries and damages. Duration was assigned a weighting factor of 5%, and was broken down as follows:

Rating	Duration of Event
1	6-24 hours
2	More than 24 hours
3	Less than 1 week
4	More than 1 week

A later chapter summarizes all of the analysis conducted by way of completion of the Calculated Priority Risk Index (CPRI) process as incorporated into the hazard ranking worksheet. It should again be emphasized that each planning partner utilized the outputs from the risk assessment to compute their CPRI for their own respective jurisdiction, following the process identified. Such outputs included specific structure-impact data by way of an Excel Spreadsheet which identified impact or exposure to each critical facility identified. Because of the sensitivity of that list, it is not included within this document, but rather only the outputs are illustrated. General building stock data is contained within the base plan for each planning partner as that data is available.

Risk Assessment Tools - Hazus and GIS Applications
Earthquake and Flood Modeling Overview

In 1997, FEMA developed the standardized Hazards U.S., or Hazus, model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. Hazus was later expanded into a multi-hazard methodology, with new models for estimating potential losses from hurricanes and floods.

Hazus is a GIS-based software program used to support risk assessments, mitigation planning, and emergency planning and response. It provides a wide range of inventory data, such as demographics, building stock, critical facility, transportation and utility lifeline, and multiple models to estimate potential losses from natural disasters. The program maps and displays hazard data and the results of damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities.

- Provides a way to save data so that it can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.

- Facilitates the review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.

- Supports grant applications by calculating benefits using FEMA definitions and terminology.

- Produces hazard data and loss estimates that can be used in communication with local stakeholders. Island County Multi-Jurisdiction Hazard Mitigation Plan 2020 Update Risk Assessment Methodology Bridgeview Consulting 4-9 September 2020.

- Is administered by the tribal or local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

Levels of Detail for Evaluation

HAZUS provides default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. The model can carry out three levels of analysis, depending on the format and level of detail of information about the planning area:

> Level 1—All of the information needed to produce an estimate of losses is included in the software's default data. This data is derived from national databases and describes in general terms the characteristic parameters of the planning area.
>
> Level 2—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
>
> Level 3—This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

Hazus was used in the vulnerability analysis for the earthquake and flood analysis. Based on modifications of the data contained within the Hazus program, the County and its planning partners conducted a modified Level 2 analysis for the 2020 update. The Hazus version used for this plan was Hazus 4.2.

Building Inventory

For this plan a General Building Stock (GBS) approach was developed using best available Assessor's data as well as building inventory data developed and used in previous Island County planning efforts. Building and content replacement values were estimated using the latest information from the Island County Assessor's database. With use of the Assessor's data, it should be assumed that future development permitted at the time of this update is included in the analysis. A User Defined Facility approach was used to model exposure and vulnerability to critical infrastructure identified during the planning process. The critical facilities list was reviewed and updated by the planning partners at the beginning of the 2020 update process.

Hazus Application for This Plan

The following methods were used to assess specific hazards for this plan:
Flood—A Hazus Level 2 analysis was performed. Analysis was based on current FEMA regulatory 100- and 500-year flood hazard data. The 2017 Island County FIRM was utilized for this analysis.

Earthquake—A Hazus Level 2 analysis was performed to assess earthquake risk and exposure. Earthquake shake map data prepared by the U.S. Geological Survey (USGS) were used for the analysis of this hazard. A modified version of the National Earthquake Hazard Reduction Program (NEHRP) soils inventory was used. Two scenario events were modeled:

> – The scenario events used were the South Whidbey Fault (middle) M7.5 Earthquake Event and the Cascadia Subduction Zone M9.3 Earthquake Event. Island County Multi-Jurisdiction Hazard Mitigation Plan 2020 Update Risk Assessment Methodology
> Bridgeview Consulting 4-10 September 2020

Tsunami - The 2020 plan piggybacked the previous 2015 analysis which used a Level 2 Hazus flood protocol to assess the risk and vulnerability to the tsunami inundation area. A user-defined facility model was developed, incorporating a depth grid developed in GIS, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus default data was enhanced using local GIS data from the County, state and federal sources, as well as a comprehensive data management system update for critical facilities.

Appendix B—Island County Emergency Plan Earthquake Annex

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Its epicenter is the point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth. Earthquakes many times occur along a fault, which is a fracture in the earth's crust.

DEFINITIONS

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates.

Epicenter—The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Focal Depth—The depth from the earth's surface to the hypocenter.

Hypocenter—The region underground where an earthquake's energy originates

Liquefaction— Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

GENERAL BACKGROUND

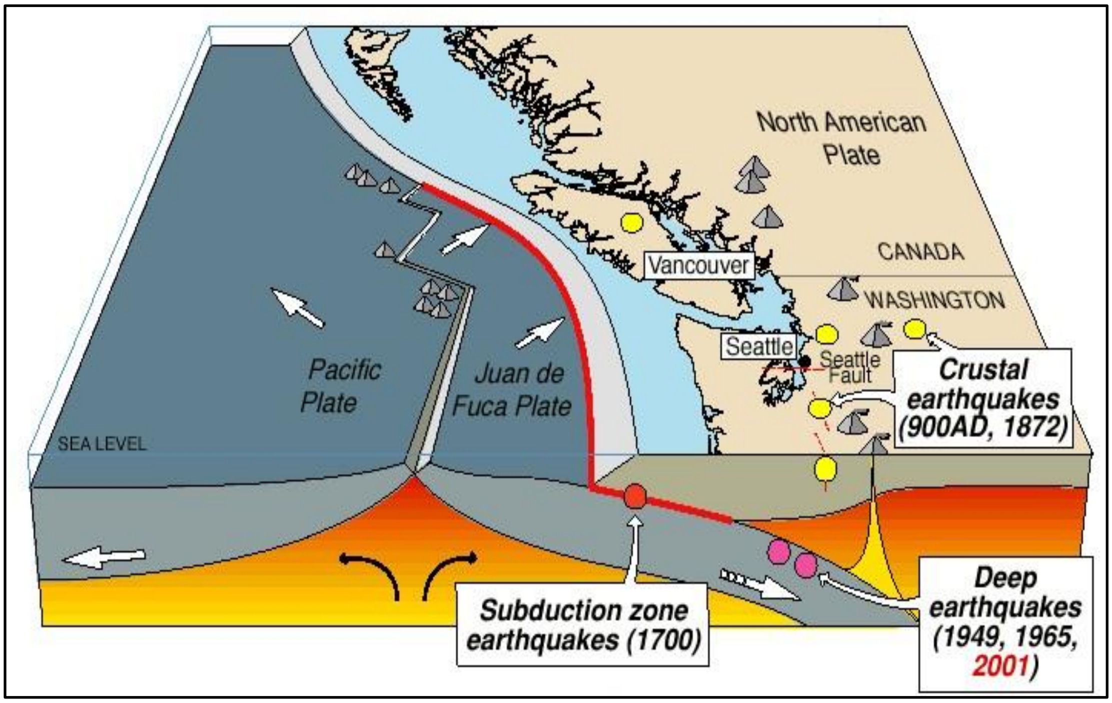
Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Earthquakes tend to reoccur along faults, which are zones of weakness in the crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur.

Geologists classify faults by their relative hazards. Active faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). Potentially active faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years). Determining if a fault is "active" or "potentially active" depends on geologic evidence, which may not be available for every fault.

Faults are more likely to have earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve accumulating tectonic stresses. A direct relationship exists between a fault's length and location and its ability to generate damaging ground motion at a given site. In some areas, smaller, local faults produce lower magnitude quakes, but ground shaking can be strong, and damage can be significant as a result of the fault's proximity to the area. In contrast, large regional faults can generate great magnitudes but, because of their distance and depth, may result in only moderate shaking in the area.

It is generally agreed that three source zones exist for Pacific Northwest quakes: a shallow (crustal) zone; the Cascadia Subduction Zone; and a deep, intraplate "Benioff" zone. These are shown in Figure 8-1. More than 90 percent of Pacific Northwest earthquakes occur along the boundary between the Juan de Fuca plate and the North American plate.



Earthquake Types in the Pacific Northwest

An earthquake will generally produce the strongest ground motions near the epicenter (the point on the ground above where the earthquake initiated) with the intensity of ground motions diminishing with increasing distance from the epicenter. The intensity of ground shaking at a given site depends on four main factors:

- Earthquake magnitude
- Earthquake epicenter
- Earthquake depth
- Soil or rock conditions at the site, which may amplify or de-amplify earthquake ground motions.

For any given earthquake, there will be contours of varying intensity of ground shaking with distance from the epicenter. The intensity will generally decrease with distance from the epicenter, and often in an irregular pattern, not simply in concentric circles. The irregularity is caused by soil conditions, the complexity of earthquake fault rupture patterns, and directionality in the dispersion of earthquake energy.

Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as *magnitude*; or by the impact on people and structures, measured as *intensity*. Magnitude is related to the amount of seismic energy released at the hypocenter of an earthquake. It is determined by the amplitude of the earthquake waves recorded on instruments. Magnitude is represented by a single, instrumentally determined value for each earthquake event. Intensity indicates how the earthquake is felt at various distances from the earthquake epicenter. Table 8-1 presents a classification of earthquakes according to their magnitude. Table 8-2 compares the moment magnitude scale to the modified Mercalli intensity scale.

TABLE 8-1. EARTHQUAKE MAGNITUDE CLASSES	
Magnitude Class	Magnitude Range (M = magnitude)
Great	M > 8
Major	7 <= M < 7.9
Strong	6 <= M < 6.9
Moderate	5 <= M < 5.9
Light	4 <= M < 4.9
Minor	3 <= M < 3.9
Micro	M < 3

Estimates of moment magnitude roughly match the local magnitude scale (ML) commonly called the Richter Scale. One advantage of the moment magnitude scale is that, unlike other magnitude scales, it does not saturate at the upper end. That is, there is no value beyond which all large earthquakes have about the same magnitude. For this reason, moment magnitude is now the most often used estimate of large earthquake magnitudes.

Intensity

There are many measures of the severity or intensity of earthquake ground motions. The Modified Mercalli Intensity scale (MMI) was widely used beginning in the early 1900s. MMI is a descriptive, qualitative scale that relates severity of ground motions to the types of damage experienced. MMI values range from I to XII (USGS, 2019):

TABLE 8-2. EARTHQUAKE MAGNITUDE AND INTENSITY		
Magnitude (Mw)	Intensity (Modified Mercalli)	Description
1.0—3.0	I	I. Not felt except by a very few under especially favorable conditions
3.0—3.9	II—III	II. . Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it is an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0—4.9	IV—V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably.

TABLE 8-2. EARTHQUAKE MAGNITUDE AND INTENSITY		
Magnitude (Mw)	Intensity (Modified Mercalli)	Description
5.0—5.9	VI—VII	VI. . Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
6.0—6.9	VII—IX	VIII. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII and higher	X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent. XI. . Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

More accurate, quantitative measures of the intensity of ground shaking have largely replaced the MMI and are used in this mitigation plan. These scales use terms that can be physically measured with seismometers, such as the acceleration, velocity, or displacement (movement) of the ground. The intensity may also be measured as a function of the frequency of earthquake waves propagating through the earth. In the same way that sound waves, earthquake waves contain ground motions of various frequencies. The behavior of buildings and other structures depends substantially on the vibration frequencies of the building or structure versus the frequency of earthquake waves. Earthquake ground motions also include both horizontal and vertical components.

Ground Motion

Earthquake hazard assessment is also based on expected ground motion. This involves determining the probability that certain ground motion accelerations will be exceeded over a time period of interest. A common physical measure of the intensity of earthquake ground shaking, and the one used in this mitigation plan, is peak ground acceleration (PGA). PGA is a measure of the intensity of shaking relative to the acceleration of gravity (g). For example, an acceleration of 1.0 g PGA is an extremely strong ground motion, which does occur near the epicenter of large earthquakes. With vertical acceleration of 1.0 g, objects are thrown into the air. With a horizontal acceleration of 1.0 g, objects accelerate sideways at the same rate as if they had been dropped from the ceiling. A PGA equal to 10% g means that the ground acceleration is 10 percent that of gravity, and so on.

Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures. The following generalized observations provide qualitative statements about the likely extent of damage for earthquakes with various levels of ground shaking (PGA) at a given site:

- Ground motions of only 1% g or 2% g are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
- Ground motions below about 10% g usually cause only slight damage.
- Ground motions between about 10% g and 30% g may cause minor to moderate damage in well-designed buildings, with higher levels of damage in more vulnerable buildings. At this level of ground shaking, some poorly built buildings may be subject to collapse.
- Ground motions above about 30% g may cause significant damage in well-designed buildings and very high levels of damage (including collapse) in poorly designed buildings.
- Ground motions above about 50% g may cause significant damage in most buildings, even those designed to resist seismic forces.

PGA is the basics of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. PGA values are directly related to these lateral forces that could damage “short period structures” (e.g. single-family dwellings). Longer period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). The amount of earthquake damage and the size of the geographic area affected generally increase with earthquake magnitude:

- Earthquakes below M5 are not likely to cause significant damage, even near the epicenter.
- Earthquakes between about M5 and M6 are likely to cause moderate damage near the epicenter.
- Earthquakes of about M6.5 or greater (e.g., the 2001 Nisqually earthquake in Washington) can cause major damage, with damage usually concentrated fairly near the epicenter.
- Larger earthquakes of M7+ cause damage over increasingly wider geographic areas with the potential for very high levels of damage near the epicenter.
- Great earthquakes with M8+ can cause major damage over wide geographic areas.
- An M9 mega-quake on the Cascadia Subduction Zone could affect the entire Pacific Northwest from British Columbia, through Washington and Oregon, and as far south as Northern California, with the highest levels of damage nearest the coast.

TABLE 8-3. COMPARISON OF MERCALLI SCALE AND PEAK GROUND ACCELERATION				
Modified Mercalli Scale	**Perceived Shaking**	**Potential Structure Damage**		**Estimated PGA[a] (%g)**
		Resistant Buildings	**Vulnerable Buildings**	
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17%—1.4%
IV	Light	None	None	1.4%—3.9%
V	Moderate	Very Light	Light	3.9%—9.2%
VI	Strong	Light	Moderate	9.2%—18%
VII	Very Strong	Moderate	Moderate/Heavy	18%—34%
VIII	Severe	Moderate/Heavy	Heavy	34%—65%
IX	Violent	Heavy	Very Heavy	65%—124%
X—XII	Extreme	Very Heavy	Very Heavy	>124%

a. PGA measured in percent of g, where g is the acceleration of gravity

Sources: USGS, 2008; USGS, 2010

Effect of Soil Types

Liquefaction is a secondary effect of an earthquake in which soils lose their shear strength and flow or behave as liquid, thereby damaging structures that derive their support from the soil. Liquefaction generally occurs in soft, unconsolidated sedimentary soils. The National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 8-4 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. Areas that are commonly most affected by ground shaking and susceptible to liquefaction have NEHRP Soils D, E and F.

TABLE 8-4. NEHRP SOIL CLASSIFICATION SYSTEM		
NEHRP Soil Type	**Description**	**Mean Shear Velocity to 30**
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

Fault Classification

The U.S. Geologic Survey defines four fault classes based on evidence of tectonic movement associated with large-magnitude earthquakes during the Quaternary period, which is the period from about 1.6 million years ago to the present:

- Class A – Geologic evidence demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is exposed by mapping or inferred from liquefaction or other deformational features.
- Class B – Geologic evidence demonstrates the existence of Quaternary deformation, but either (1) the fault might not extend deep enough to be a potential source of significant earthquakes, or (2) the currently available geologic evidence is too strong to confidently assign the feature Class C but not strong enough to assign in to Class A.
- Class C – Geologic evidence is insufficient to demonstrate (1) the existence of tectonic faulting, or (2) Quaternary slip or deformation associated with the feature.
- Class D – Geologic evidence demonstrates that the feature is not a tectonic fault or feature; this category includes features such as joints, landslides, erosional or fluvial scarps, or other landforms resembling fault scarps but of demonstrable non-tectonic origin.

HAZARD PROFILE

Seismic-related hazards in Island Count include ground motion from shallow (less than 20 miles deep) or deep faults; liquefaction and differential settling of soil in areas with saturated sand, silt or gravel; and tsunamis that result from seismic activities. Earthquakes also can cause damage by triggering landslides or bluff failure. High-magnitude (8 to 9+) earthquakes are possible in Island County when the Juan de Fuca slips beneath the North American plates. Deep zone or Benioff zone quakes have occurred within the San De Fuca plate (1949, 1965 and 2001) and can be expected in the future.

Extent and Location

There are a number of faults running near or through Island County (see Figure 8-4 and Figure 8-5). These faults are considered as part of the North American (continental) plate. The majority of them have been inactive for extended periods of time. Evidence suggests that the Devil's Mountain Fault and the Southern Whidbey Island Fault are capable of generating a quake of magnitude 7 or greater. The Utsalady Point and Strawberry Point faults are capable of a quake of magnitude 6.7 or greater.

Several other suspected faults may cross South Whidbey Island from south to north. Various sources indicate that parts of the North Whidbey fault run through a portion of Oak Harbor. One fault scarp is visible on NAS Ault Field at the Rocky Point area. Langley also sits very close to the plotted located of South Whidbey Fault. Several neighborhoods on South Whidbey Island – Clinton, Useless Bay and Freeland – are on or close to the South Whidbey Fault. Geologists have not determined likely earthquake occurrence intervals for these faults.

Hazard Mapping

Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide or wildfire. The impact of an earthquake is largely a function of the following factors:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically)

Mapping that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. The mapping used in this assessment is described below.

Shake Maps

A shake map is a representation of ground shaking produced by an earthquake (Peak Ground Acceleration). The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking resulting from the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A shake map shows the extent and variation of ground shaking in a region immediately following significant earthquakes.

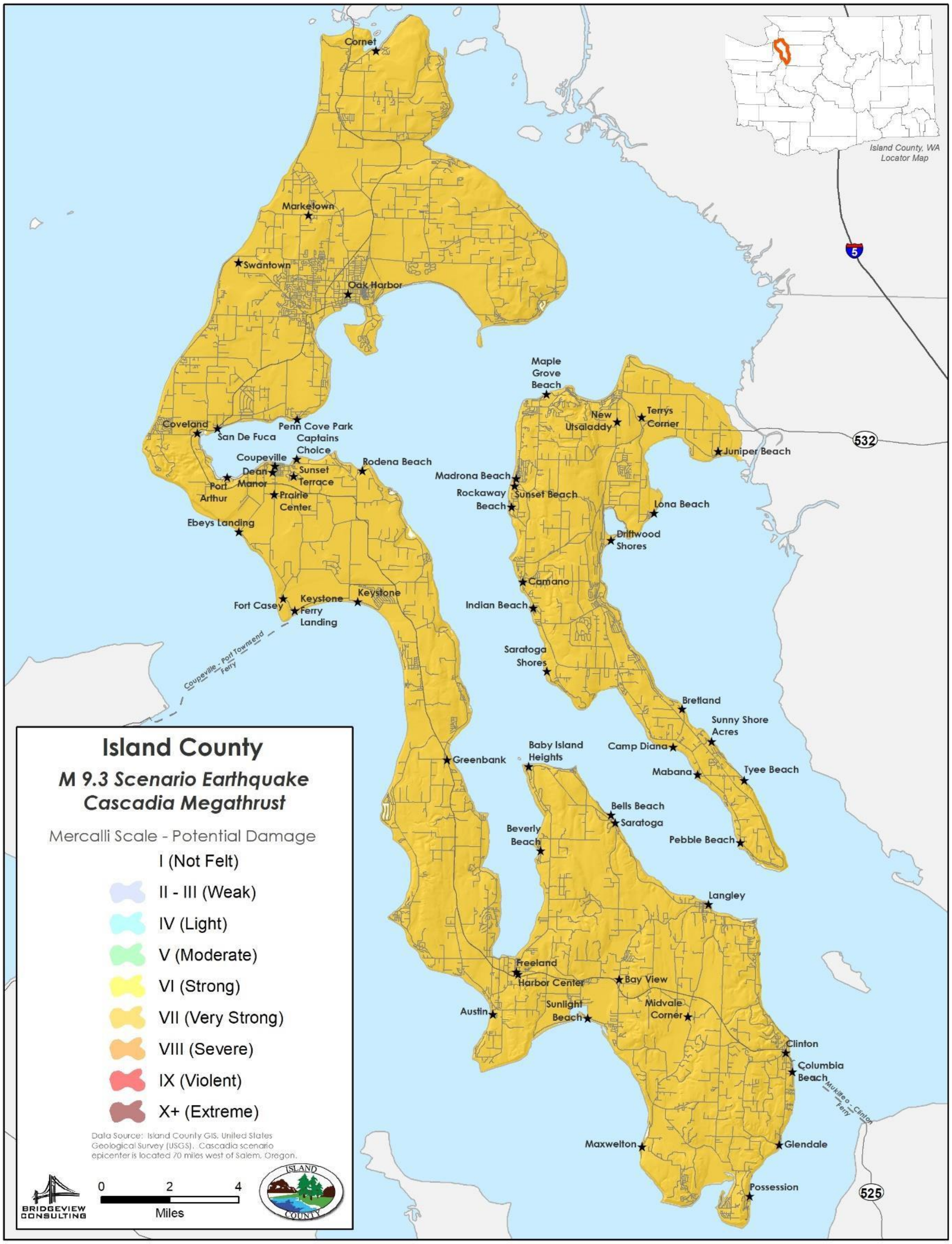
Ground motion and intensity maps are derived from peak ground motion recorded on seismic sensors, with interpolation where data are lacking and site-specific corrections. Color-coded intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. Two types of shake map are typically generated from the data:

- A probabilistic seismic hazard map shows the hazard from earthquakes that geologists and seismologists agree could occur. The maps are expressed in terms of probability of exceeding a certain ground motion, such as the 10 percent probability of exceedance in 50 years. This level of ground shaking has been used for designing buildings in high seismic areas.

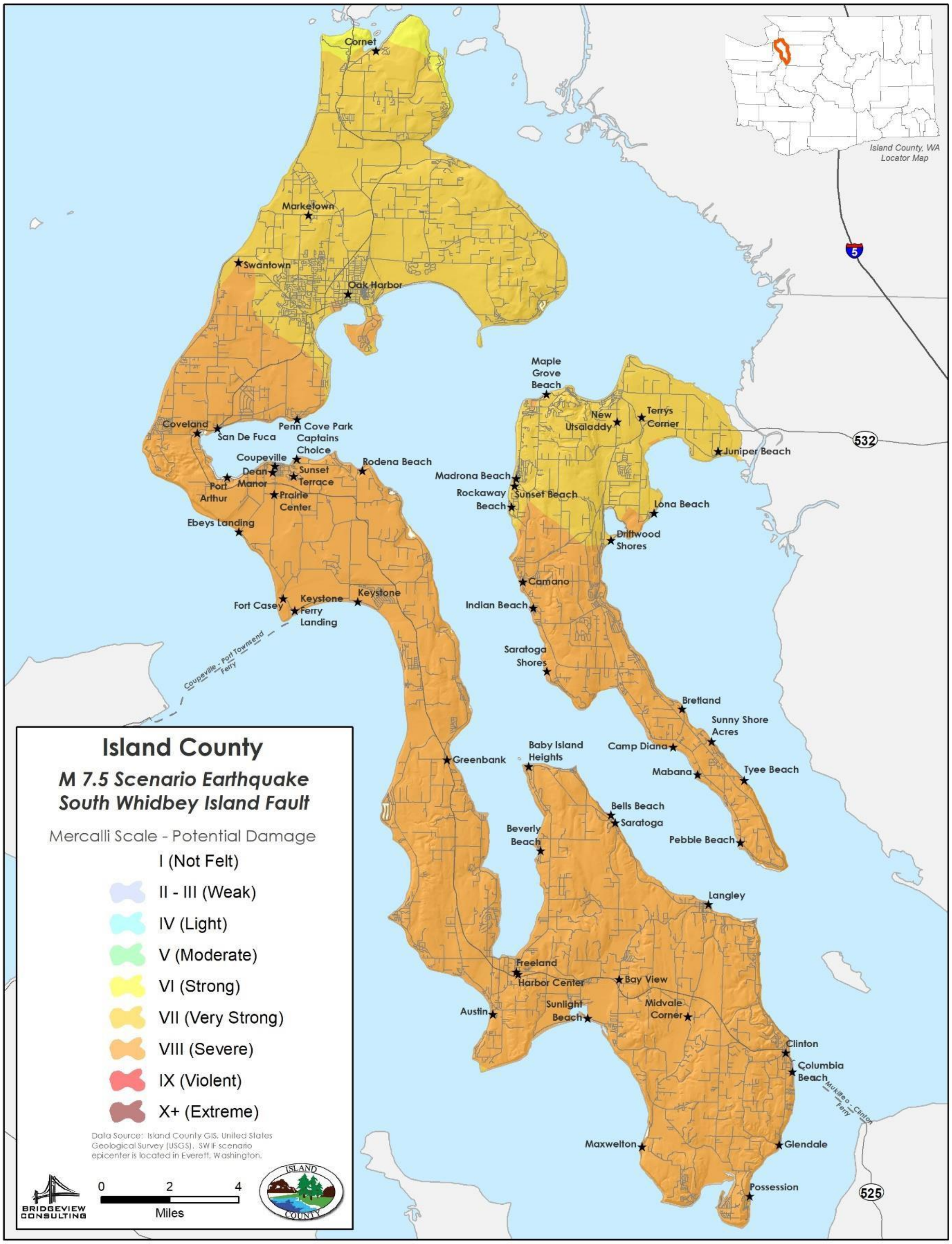
- Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. Maps of these scenarios can be used to support all phases of emergency management. Two scenarios were chosen for this plan:

    - South Whidbey Fault Scenario – This scenario created by USGS in 2014 is based on a magnitude 7.5 earthquake on the South Whidbey Fault, with an epicenter in the Everett area (see Figure 8-6).
    - Cascadia Subduction Zone Earthquake – This scenario was based on a USGS publication (2014) that estimates previous magnitude 9.3 occurrences from 100 to 500 years ago and 1,100 to 2,200 years ago and an offshore rupture that may have produced tsunami events (USGS, 2015c) (see Figure 8-7).

Cascadia Megathrust M9.3 Fault Scenario



South Whidbey M7.5 Fault Scenario



Previous Occurrences

Based on geologic evidence along the Washington coast, the Cascadia Subduction Zone has ruptured and created tsunamis at least seven times in the past 3,500 years and has a considerable range in recurrence intervals, from as little as 140 years between events to more than 1,000 years. The last Cascadia Subduction Zone related earthquake is believed to have occurred on January 26th, 1700 and researchers predict a 10 to 14 percent chance that another could occur in the next 50 years. The following table lists past seismic events that have affected the areas in and around Island County.

TABLE 8-5.
HISTORICAL EARTHQUAKES IMPACTING THE PLANNING AREA

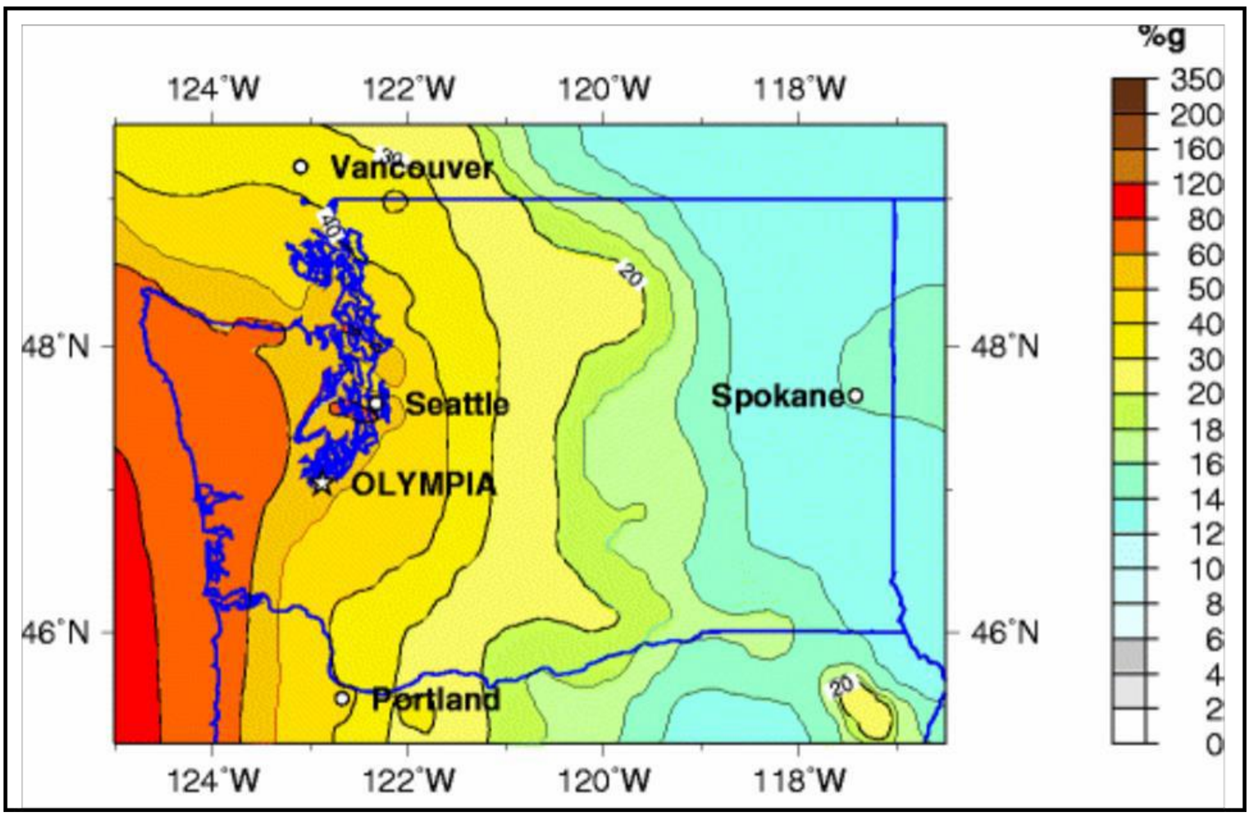
Year	Magnitude	Epicenter	Type
07/12/2019	4.6	Monroe	Crustal
01/20/2009	4.9	Poulsbo	Crustal
02/28/2001	6.8	Olympia (Nisqually)	Benioff
6/10/2001	5.0	Matlock	Benioff
7/3/1999	5.8	8.0 km N of Satsop	Benioff
6/23/1997	4.7	Bremerton	Shallow Crustal
5/3/1996	5.5	Duvall	Shallow Crustal
1/29/1995	5.1	Seattle-Tacoma	Shallow Crustal
2/14/1981	5.5	Mt. St. Helens (Ash)	Crustal
4/29/1965	6.6	18.3 KM N of Tacoma (Sea Tac)	Benioff
1/13/1949	7.0	12.3 KM ENE of Olympia	Benioff
6/23/1946	7.3	Strait of Georgia	Benioff
4/1945	5.7	Northbend (8 miles south/southeast)	Unknown
1939	5.8	Puget Sound – Near Vashon Island	Unknown
1932	5.3	Central Cascades	Unknown
1/23/1920	5.5	Puget Sound	Unknown
12/6/1918	7.0	Vancouver Island	Unknown
8/18/1915	5.6	North Cascades	Unknown
1/11/1909	6.0	Puget Sound	Unknown
4/30/1882	5.8	Olympia area	Unknown
12/15/1872	6.8	Pacific Coast	Unknown

Source: PNSN, 2019

Severity

Earthquakes can last from a few seconds to over five minutes; they may also occur as a serious of tremors over several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties generally result from falling objects and debris, because the shocks shake, damage or demolish buildings and other structures. Disruption of communications, electrical power supplies and gas, sewer and water lines should be expected. Earthquakes may trigger fires, dam failures, landslides or releases of hazardous material, compounding their disastrous effects.

The severity of an earthquake can be expressed in terms of intensity or magnitude. Intensity represents the observed effects of ground shaking on people, buildings and natural features. The USGS has created ground motion maps based on current information about several fault zones. These maps show the PGA that has a certain probability (2 percent or 10 percent) of being exceeded in a 50-year period. The PGA is measured in numbers of g's (the acceleration associated with gravity). Figure 8-10 shows the PGAs with a 2 percent exceedance chance in 50 years in Washington.



Small, local faults produce lower magnitude quakes, but ground shaking can be strong and damage can be significant in areas close to the fault. In contrast, large regional faults can generate earthquakes of great magnitudes but, because of their distance and depth, they may result in only moderate shaking in an area.

Frequency

Scientists are currently developing methods to more accurately determine when an earthquake will occur. Recent advancements in determining the probability of an earthquake in a given period use a log-normal, Brownian Passage Time, or other probability distribution in which the probability of an event depends on the time since the last event. Such time-dependent models produce results broadly consistent with the elastic rebound theory of earthquakes. The USGS and others are beginning to develop such products as new geologic ad seismic information regarding the dates of previous events along faults becomes available (USGS, 2015).

- Current estimates are that a magnitude 9 earthquake in the Cascadia Subduction Zone occurs about once every 500 years. The last one was in 1700. Paleo seismic investigations have identified 41 Cascadia Subduction Zone interface earthquakes over the past 10,000 years, which corresponds to one earthquake about every 250 years. About half were magnitude 9.0 or greater earthquakes that represented full rupture of the fault zone from Northern California to British Columbia. The other half were magnitude 8+ earthquakes that ruptured only the southern portion of the subduction zone.

- The 300+ years since the last major Cascadia Subduction Zone earthquake is longer than the average of about 250 years for magnitude 8 or greater and shorter than some of the intervals between magnitude 9.0 earthquakes.

- Scientists currently estimate the frequency of deep earthquakes similar to the 1965 magnitude 6.5 Seattle-Tacoma even and the 2001 magnitude 6.8 Nisqually event as about once every 35 years. The USGS estimates an 84 percent chance of a magnitude 6.5 or greater deep earthquake over the next 50 years.

- Scientists estimate the approximate recurrence rate of a magnitude 6.5 or greater earthquake anywhere on a shallow fault in the Puget Sound basin to be once in about 350 years. There have been four earthquakes of less than magnitude 5 in the past 20 years.

- Earthquakes on the South Whidbey Island and Seattle Faults have a 2 percent probability of occurrence in 50 years. A Benioff zone earthquake has an 85 percent probability of occurrence in 50 years, making it the most likely of the three types.

VULNERABILITY ASSESSMENT

Overview

Several faults within the planning region have the potential to cause direct impact. The area also is vulnerable to impact from an event outside the County, although the intensity of ground motions diminishes with increasing distance from the epicenter. As a result, the entire populate of the planning area is exposed to both direct and indirect impacts from earthquakes. The degree of direct impact (and exposure) is dependent on factors including the soil type on which homes are constructed, the proximity to fault location, the type of materials used to construct residences and facilities, etc. Indirect impacts are associated with elements such as the inability to evacuate the area as a result of earthquakes occurring in other regions of the state as well as impact on commodity flow for goods and services into the area, many of which are services only by one roadway in or out (Highway 20; State Route 532) or the Clinton or Port Townsend Ferries, each serving only one island. Impact from other parts of the state could require shipment of supplies via a barge. Evacuation points of potential concern include:

- The bridge at Deception Pass, which, if closed, requires a much longer evacuation via ferry.

- Landslides associated with an earthquake occurring along Highway 20, which connects Whidbey Island to Fidalgo Island.

Warning Time

There is currently no reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. The U.S. Geological Survey (USGS) along with a coalition of State and university partners is developing and testing the ShakeAlert System for the West Coast of the United States. Before general public alerting can begin long-term, operational funding must be secured and the speed and reach of mass alerting technologies must be tested and improved. The seconds to tens of seconds of advance warning can allow people and systems to take actions to protect life and property from destructive shaking. In the fall of 2018, the West Coast ShakeAlert Earthquake Early Warning System became sufficiently functional and tested to begin Phase 1 of alerting in California, Oregon and Washington. Several commercial and institutional users are alerting personnel and taking automated actions; an important step in a strategy of phased rollout leading to full public operation. (ShakeAlert, 2019)

Impact on Life, Health and Safety

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes. Two of the most vulnerable populations to a disaster incident such as this are the young and the elderly. Island County has a fairly high population of retirees. The need for increased rescue efforts and/or to provide assistance to such a large population base could tax the first-responder resources in the area during an event. Although many injuries may not be life-threatening, people will require medical attention and, in many cases, hospitalization. Potential life-threatening injuries and fatalities are expected; these are likely to be at an increased level if an earthquake happens during the afternoon or early evening.

The degree of exposure is dependent on many factors, including the soil type their homes are constructed on, quality of construction, their proximity to fault location, etc. Whether impacted directly or indirectly, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

Given the high dependence on the Deception Pass Bridge and the State Route 532 Bridge on the northeast coast of Camano Island, significant impact resulting from an earthquake would hinder and slow evacuation of the planning area, causing isolation. Impact or closure of the bridge could also diminish response capabilities of first responders if assistance from areas outside of Camano or Whidbey Islands were needed, as well as other parts of the planning area.

The number of people without power or water will be high, especially given the number of wells on which the County relies to supply water to individuals who most likely do not have generators to run pumps on the wells. This need will increase the number of individuals seeking shelter assistance.

Table 8-3 identifies the number of individuals and households impacted by the various earthquake events as identified by Hazus.

TABLE 8-3.
ESTIMATED EARTHQUAKE IMPACT ON PERSON AND HOUSEHOLDS

	Displaced Households	Persons Requiring Short-Term Shelter
Cascadia Subduction Zone Earthquake	695	357
South Whidbey Fault Earthquake	251	140

Impact on Property

There are 40,043 buildings in Island County, with an estimated total replacement and content value of ~$13.4 billion. Most of the buildings are residential and most of the building stock is of considerable age and not supported by building codes, which increase resilience to seismic events. Portions of these buildings are constructed out of unreinforced masonry; many have chimneys that may be in need of repair, and many, because of the age of the building stock, may contain some level of asbestos in building components such as the boiler room, ceiling tiles, carpeting or glue. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees (including liquefaction and landslides), these figures represent total numbers region-wide for property exposure to seismic events.

Property losses were estimated through the Level 2 Hazus analysis for two scenario events. A summary of the total building-related loss, which includes structure and content loss, is as follows:

- For the South Whidbey Island earthquake, the estimated potential is $456 million, or 3.4 percent of the total value for the planning area.
-
- For the Cascadia earthquake, the estimated potential is $1.1 billion, or 8.5 percent of the total value for the planning area.

Property losses were estimated through Level 2 Hazus analysis for the Cascadia Subduction Zone and South Whidbey Fault earthquake scenario events, utilizing the USGS/Washington State Department of Natural Resources scenario catalog data, FEMA 2017 GIS datasets, and 2020 updated Assessor's general building stock and the 2020 updated critical facilities lists. A summary of the building-related loss impact is illustrated in Table 8-4. Damage categories by occupancy type for both events are illustrated in Figure 8-11 and Figure 8-12.

TABLE 8-4.
HAZUS ESTIMATED EARTHQUAKE DAMAGES

	Number of Buildings Sustaining Moderate Damaged	Percent of Buildings in Region	Number of Buildings Sustaining Damaged Beyond Repair
South Whidbey Fault Earthquake	5,740	>14%	421
Cascadia Subduction Zone Earthquake	14,853	>37%	1,402

TABLE 8-5.
EARTHQUAKE EXPOSURE FOR SOUTH WHIDBEY ISLAND FAULT ZONE SCENARIO EVENT

Jurisdiction	Estimated 2019 Population (1)	Estimated Building Count (2)	Total Building Value (Structure and Contents) (2)	Potential Exposed Structure Impact (3)			
				Building Structure Damaged	Building Contents Damaged	Sum of Structure and Contents Damaged	% of Total Value
Coupeville	1,925	843	$440,648,701	$26,708,673	$7,691,475	$34,400,149	7.81%
Langley	1,195	714	$231,125,633	$20,505,049	$5,726,476	$26,231,525	11.35%
Oak Harbor	22,970	8,060	$4,016,992,564	$145,182,213	$41,640,490	$186,822,703	4.65%
County – Unincorporated	58,730	30,426	$8,681,024,425	$166,149,196	$42,620,929	$208,770,125	2.40%
Total	**84,820**	**40,043**	**$13,369,791,322**	**$358,545,132**	**$97,679,370**	**$456,224,502**	**3.41%**

Sources (1) 2019 State of Washington Department of Finance Estimated Populations
(2) Exposure numbers were estimated using Island County Parcel and Assessor data.
(3) Earthquake Scenarios describe the expected ground motions and effects of specific hypothetical large earthquakes.
(4) Results by jurisdiction are estimated using Census Tract data and do not match actual jurisdictional boundaries

TABLE 8-6.
EARTHQUAKE EXPOSURE FOR CASCADIA SUBDUCTION ZONE SCENARIO EVENT

Jurisdiction	Estimated 2019 Population (1)	Estimated Building Count (2)	Total Building Value (Structure and Contents) (2)	Potential Exposed Structure Impact (3)			
				Building Structure Damaged	Building Contents Damaged	Sum of Structure and Contents Damaged	% of Total Value
Coupeville	1,925	843	$440,648,701	$87,109,787	$24,842,657	$111,952,444	25.41%
Langley	1,195	714	$231,125,633	$96,444,296	$25,633,006	$122,077,302	52.82%
Oak Harbor	22,970	8,060	$4,016,992,564	$195,031,865	$57,642,834	$252,674,699	6.29%
County – Unincorporated	58,730	30,426	$8,681,024,425	$525,753,983	$130,180,143	$655,934,126	7.56%
Total	**84,820**	**40,043**	**$13,369,791,322**	**$904,339,931**	**$238,298,639**	**$1,142,638,570**	**8.55%**

Sources (1) 2019 State of Washington Department of Finance Estimated Populations
(2) Exposure numbers were estimated using Island County Parcel and Assessor data.
(3) Earthquake Scenarios describe the expected ground motions and effects of specific hypothetical large earthquakes.
(4) Results by jurisdiction are estimated using Census Tract data and do not match actual jurisdictional boundaries

Appendix C—Island County Emergency Plan Coastal Erosion Annex

Coastal Erosion

Coastal erosion is the loss or displacement of land along the coastline due to the action of waves, currents, tides, wind-driven water, waterborne ice, or other impacts associated with storms. It is also the loss or displacement of land due to the action of wind, runoff of surface waters, or groundwater seepage.

Coastal erosion is often attributed to major storm events and in particular to storm events where high wave energy, strong on-shore winds, and heavy rainfall coincide with a high tide. Large storm- generated waves often expedite coastal erosion processes, when wave action is high and water levels and coastal currents rapidly increase. Coastal erosion may change the shoreline over time through the long- term losses of sediment and rocks, or in other cases, may temporarily redistribute coastal sediment. Erosion in one location may result in accretion (deposition of sediments) nearby (see Figure 5-1). Deposition is the placement of sediment transported by wind, water, or ice.

The impact of waves along a coastline is dependent on storm surge, which is most severe if it coincides with high tide. Storm surge is an elevation of water levels, including tides, due to lower barometric pressure and wind stress in front of strong storms that push water toward the shoreline. Storm surge contributes substantially to coastal erosion. The three most important factors contributing to beach and dune erosion during storms are storm surge height, storm surge duration, and wave steepness (ratio of wave height to length).

Other factors that can increase erosion include fetch (the length of water over which a given wind has blown), wind direction and speed, wave length, height and period, nearshore water depth, tidal influence, increased lake or sea levels, overall strength and duration of storm events, and variability in sediment supply to the beach. Combinations of these factors can exacerbate their effects by increasing water levels, storm rise, wave run-up and wind setup, and producing damaging waves along the shore, scouring beaches and bluff areas, reducing sand from beaches, and allowing water and wave action further inland to erode dunes and bluffs (U.S. Army Corps of Engineers, 2009).

DEFINITIONS

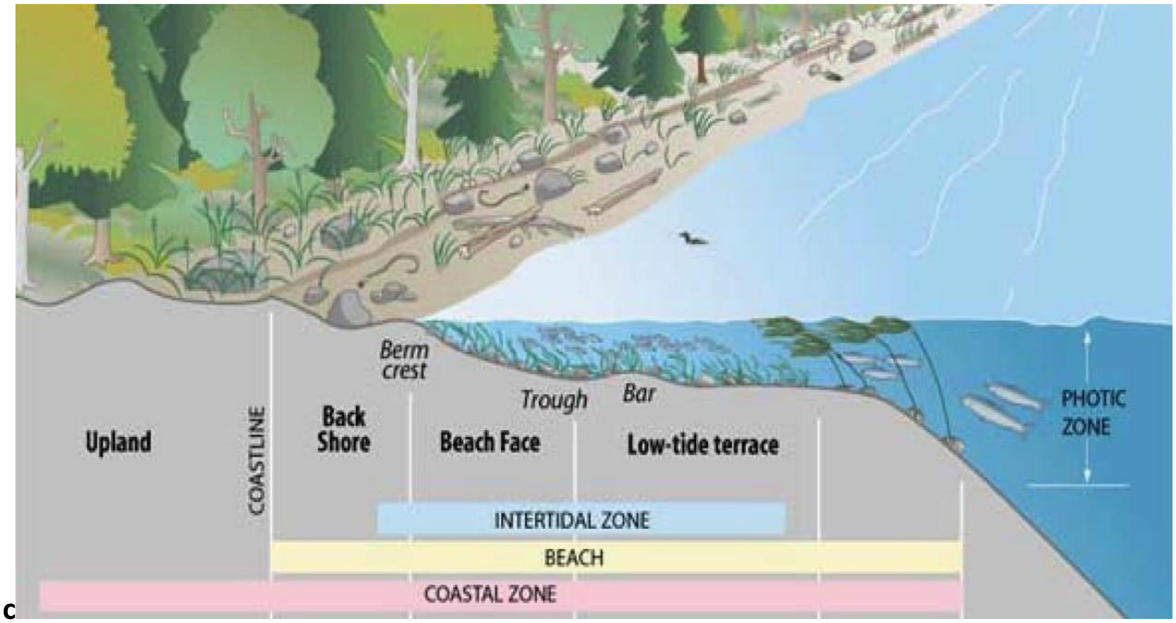
Beach Erosion—A beach is the accumulation of sand, gravel, silt or clay located at the transition zone between land and water. Beach erosion occurs through the removal of beach sediment caused by wind, wave action and longshore currents, causing offshore movement of sand from the beach.

Dune Erosion/Scarping—A dune is a hill of sand built by wind-related or man-made processes. Dune erosion is caused by wave-attack during a storm, swell or wind action. This process, known as scarping, releases sand stored in the dune to a beach or zone landward of the dune. The influx of dune sand to the active beach can be carried offshore to build temporary sand bars, helping attenuate incoming wave energy and assisting in beach recovery.

Overwash and Washover— Overwash and washover relate to the transport of sediment landward of the beach, which occurs from coastal flooding during a tsunami, high wind, or other event with extreme waves. Overwash occurs where water from the wave and storm surge go over the upper part of the beach, causing beach sediment to advance over the beach crest, dune or berm, and where the beach sediment does not directly return to the generating water body (ocean, sea, or lake) after water levels return to normal.

Tidelands – Tidelands are the lands now or formerly flowed over by the mean high tide of a natural waterway.

In addition, erosion can be exacerbated by man-made influences, such as shoreline hardening, seawalls, groins, jetties, navigation inlets, boat wakes, dredging and other interruptions of physical coastal processes which reduce or interrupt longshore sediment transport.



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Primary forms of coastal erosion affecting Island County are as follows:

- **Beach Erosion**—A beach is the accumulation of sand, gravel, silt or clay at the transition zone between land and water. Beach erosion occurs through the removal of beach sediment caused by wind, wave action and longshore currents, causing offshore movement of sand from the beach during storms. Beach erosion is a recurring, long-term problem, and it is a precursor of dune erosion, dune overwash, bluff erosion, failure of shoreline protection structures and destruction of shoreline development.

- **Dune Erosion/Scarping**—A dune is a hill of sand built by wind-related or man-made processes in deserts or near lakes and oceans. Dune erosion is caused by wave-attack during a storm or a large swell or by wind action. This process, generally known as scarping, releases sand that was stored in the dune to the active beach or to the zone just landward of the dune. The influx of this dune sand to the active beach is often carried offshore to build temporary sand bars, which help attenuate incoming wave energy and can assist in post-storm low profile beach recovery.

- **Overwash and Washover**—Overwash and washover are terms related to the transport of sediment landward of the active beach, which occurs from coastal flooding during a tsunami, severe wind, or other event with extreme waves. Overwash occurs where the flow of water (from wave and storm surge) over the upper part of the beach profile causes beach sediment to advance over the crest of the beach, dune or berm and where this beach sediment does not directly return to the generating water body after water level fluctuations return to normal. There are two kinds of overwash: overwash by run-up and overwash by inundation. Overwash begins when the run-up level of waves, usually coinciding with a storm surge, exceeds the local beach or dune crest height. As the water level in the ocean rises such that the beach or dune crest is inundated, a steady sheet of water and sediment runs over the barrier. Washover is the sediment deposited inland of a beach by overwash. Washover can be deposited onto the berm crest or as far as the back-barrier bay, estuary, or lagoon.

- **Bluff Erosion**—A bluff is a cliff with a broad face, or a relatively long strip of land rising abruptly above surrounding land or water. Typically, it rises at least 25 feet above the water body at an average slope of 30 percent or greater. Bluff erosion is the erosion of these cliff sides or broad faces as a result of high waves, wind, groundwater or surface runoff and can lead to significant loss of land to the sea. Bluff erosion takes place from the top of the bluff down to the sea. Several processes can lead to erosion on bluffs:
  - Groundwater can leak out the face of a bluff and wash sediments down the bluff face.
  - Surface water may flow directly over the face of a bluff or down a gully on a bluff and carry soil and sediment to the sea.
  - Freeze-thaw cycles can loosen sediment in a bluff that slumps downhill in the spring.
  - At the base of the bluff, high tides, coastal flooding and wave action can scour the bluff toe to remove sediment and undercut the slope.
  - Over-steepened slopes can move downward under the pull of gravity.

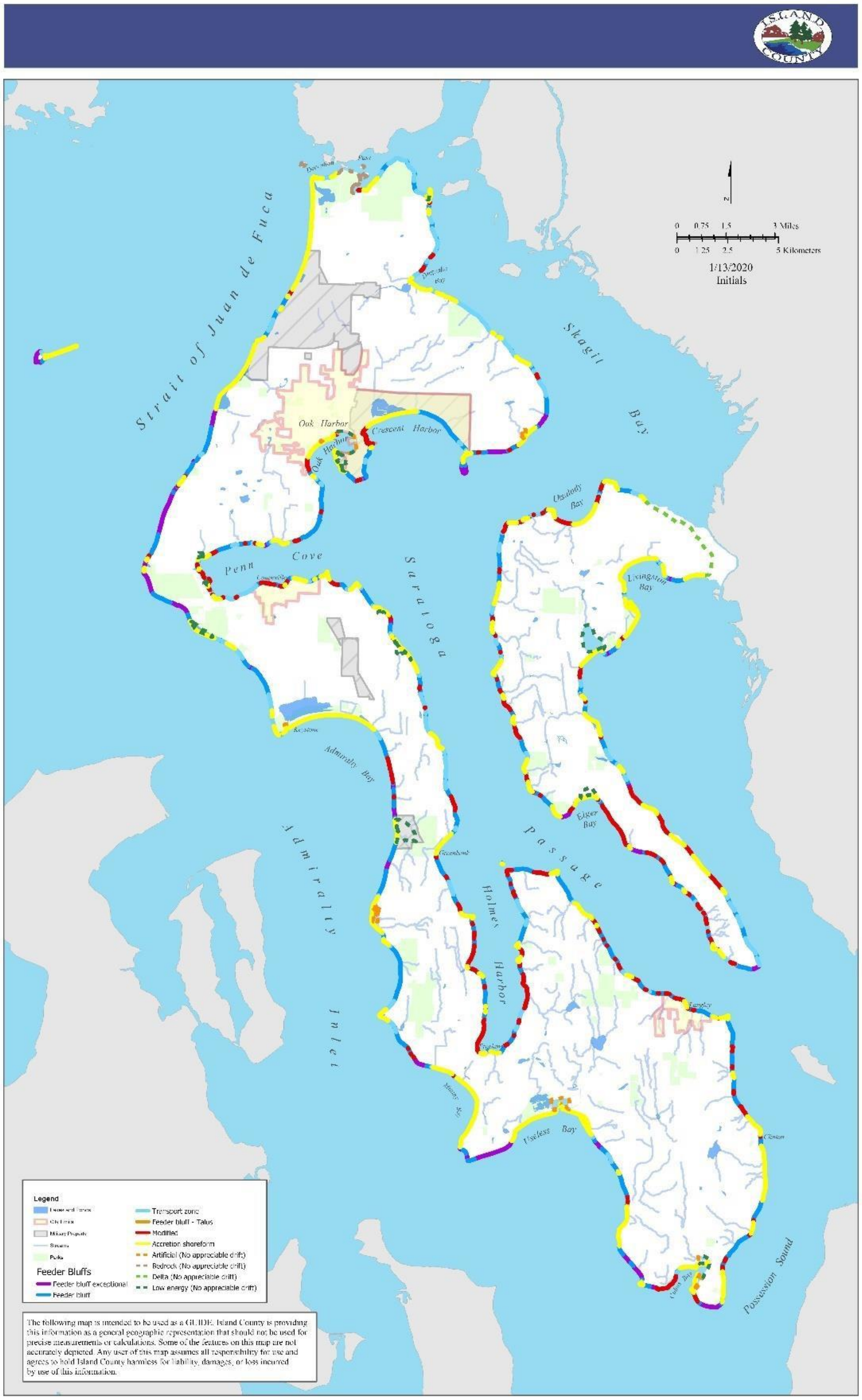
Coastal bluffs can be affected by all of these processes to some extent. The rate of bluff erosion may vary from one location to the next. Over time, erosion is often episodic with significant land loss one year and less the next. Bluff erosion leads to net land loss and the landward migration of the shoreline as well as the top of the bluff. Actively eroding bluffs are unstable and potentially unsafe for development near the bluff top. A bluff will retreat toward land as erosion occurs.

- **Feeder Bluff**—A feeder bluff is a coastal cliff or headland that provides sediment to down- current beaches as a result of wave action on the bluff. Feeder bluffs are more susceptible to erosion when they consist of unconsolidated sediments and more resistant when made of crystalline rocks such as granite. Rocks that are heavily fractured are also susceptible to erosion because water can flow between the cracks to speed up the process. Island County Feeder Bluff designated areas are identified in Figure 5-2.

Erosion can impact beaches, dunes, bluffs, barriers, bays, cliff sides, wetlands, marshes, parks, and other natural landforms and can lead to destructive forces upon nearby manmade structures. One of the major impacts of erosion processes is the permanent breaching or creation of inlets along barrier beaches and islands. Impacts associated with new inlets could include the following:

- Increased flooding and erosion on the mainland shoreline due to increased water levels and wave action in the bays
- Changes in shoaling patterns, water circulation, temperature and salinity that could significantly alter existing bay ecosystems
- Disruption of the longshore transport of sand along the ocean shoreline that would result in increased down-drift erosion
- Stabilized inlets provide benefits for recreational and commercial navigation.

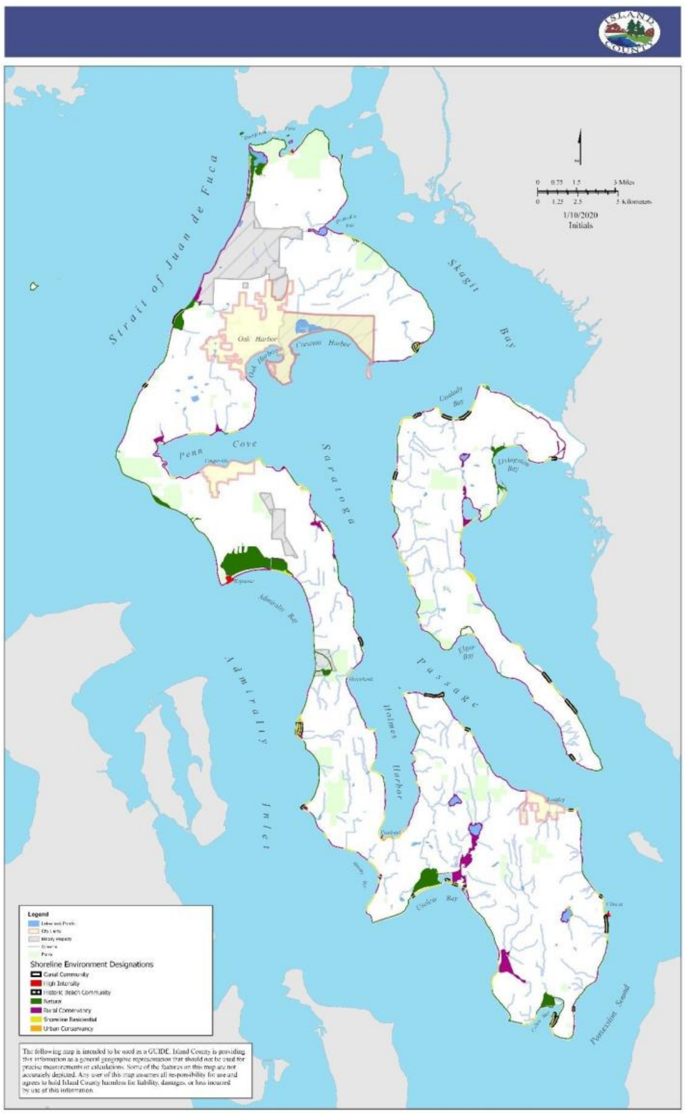
Island County Feeder Bluffs



Extent and Location

Areas identified for potential erosion may also coincide with the identification of landslide susceptibility areas based on the County's definition of potential landslide hazards areas within its Critical Areas Ordinance. As such, readers should also review the Landslide profile. At present, most of the county's coastlines are designated Residential. Figure 5-3 identifies the shoreline designations for all of Island County. Figure 5-4 further identifies slopes with degradation of nearshore reaches of coastline as identified by Schlenger, et al. (2010).

The Langley Marina and the area of Sandy Hook south of Langley are exposed to tidal surge, which exacerbates coastal erosion. Wave undercutting has led to instability along many of the islands' bluffs, increasing the potential for topple mass movement when the top of the bluff rotates as a result of the actions of gravity. At bluff areas subject to wave action, the water has changed the angle of repose (the angle when material on the slope face is on the verge of sliding due to erosion).



Severity

Bluff erosion and landslides contribute sediment to beaches in large quantities (Keuler, 1988). The volume of sediment and frequency of landsliding is variable and episodic. Two bluffs can be close together but differ greatly in erosion rates due to minor changes in shore orientation, stratigraphy, exposure or land use. Some bluffs supply sediment to many miles of down-drift shoreline, others are of only local significance.

Erosion tends to increase with decreasing tidal range. This is because a small tidal range focuses wave energy at a narrow vertical band, in comparison to higher tidal ranges which dissipate energy over a larger vertical band. The Strait of Juan de Fuca has a low-moderate tidal range, meaning wave energy is focused on the upper beach and bluff toe a substantial percentage of the time.

SWFE has 57 miles of coastline. Increases in sea level can make coastlines more vulnerable to the impacts of flooding, storm surges, tsunamis, and extreme astronomic tide. While tsunamis are rare in Washington, flooding from storm surges and extreme tides are issues that many residents are already experiencing. (Climate Central, 2016)

For Island County, measurable near-term sea level rise is possible, with a 5% chance of sea level change more than 0.5 feet by 2030. By 2100 there is a strong likelihood (50% probability) of sea level rise greater than 2 feet, and extreme projections far exceed that (e.g. a 1% chance of sea level rise of about 5 feet by 2100, and a 0.1% change of sea level rise of ~8 feet by 2100). (Miller, 2016).

Sea level rise will increase the severity of coastal erosion. According to the *Climate Impacts Vulnerability Assessment Report* (WSDOT, 2011) and the *Climate Impact Study* (Climate Impact Group, 2019), Island County can expect water levels to rise from 2 to 9 inches (depending on modeling methodology). As part of the 2017 Flood Insurance Study and associated Risk Report, FEMA identified potential areas of impact from sea level rise at varying degrees based on the 100-year flood zone, with incremental increases to illustrate potential areas of increased inundation. Figure 5-7 identifies FEMA’s data, illustrating the +1, 2 and 3 feet potential increased sea level rise. As sea levels continue to rise, more area is susceptible to potential erosion, or in some cases, accretion. Sea level rise is also discussed within the flood hazard profile of this document.

Human Influence

Natural events play a major role in the erosion process, but human actions can exacerbate the effects of these processes through poor land use, dredging operations, vegetation removal, construction of shoreline structures (for example, homes, boardwalks, piers, recreational structures), and misguided erosion control efforts. The desire to live along coastlines is a significant factor in increased coastal growth. There has been a coastal building boom of all types of structures, which can increase the potential for coastal erosion by disturbing the natural coastline and increase the inventory exposed to coastal erosion.

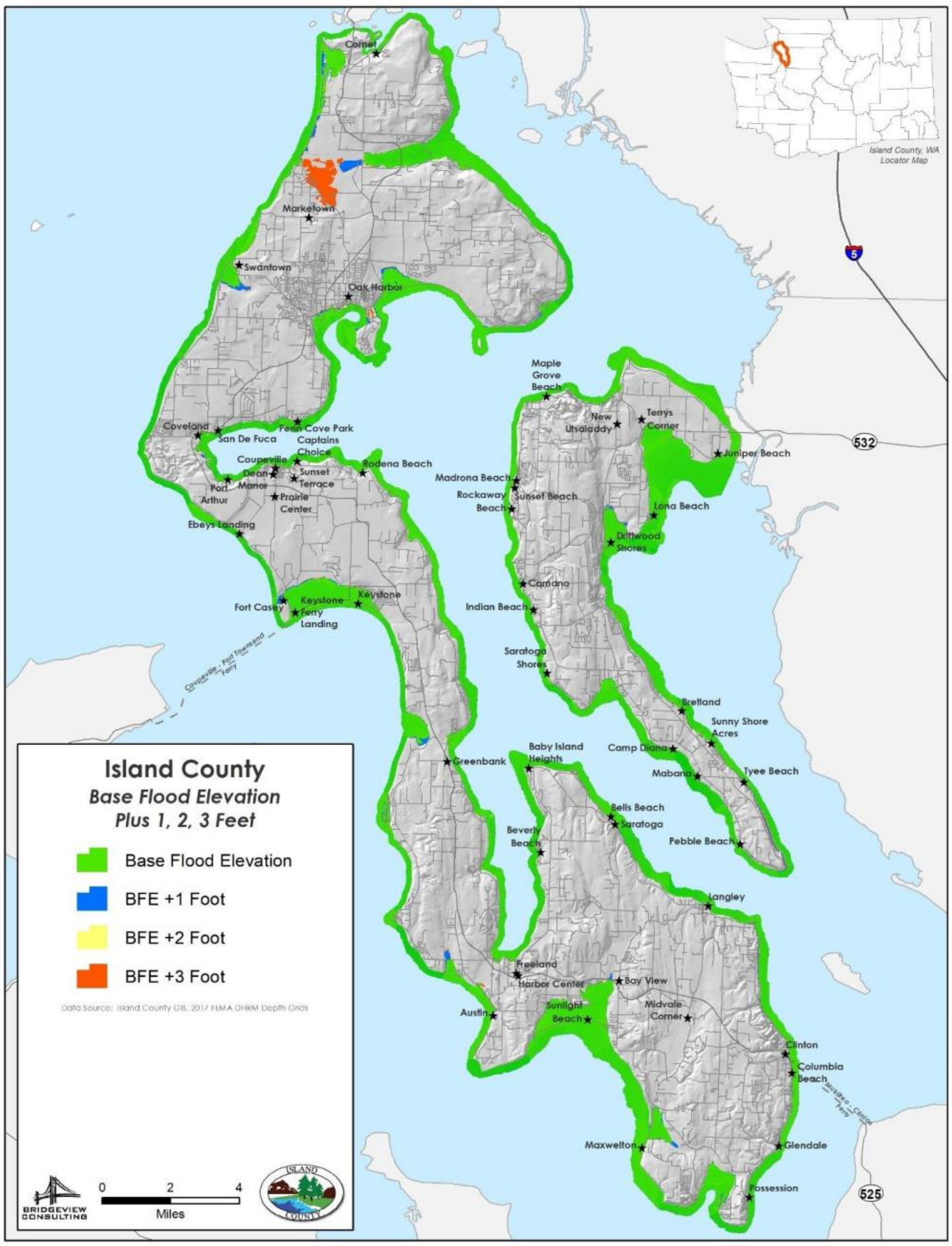
Humans contribute to erosion by removing vegetation, which allows wind and precipitation to directly erode the soil, or by directing runoff from streets, parking lots, roofs and other locations to areas such as bluffs where it can cause erosion. Humans also alter the coastline by constructing hardened structures on the shore, which blocks shoreline processes and can reflect wave energy onto adjacent shoreline areas or cause deepening of the nearshore area. Many development activities damage or alter natural features that protect the upland area from erosion and storm damage:

- Building without considering the potential for damage to property.
- Destroying natural protective features such as dunes or bluffs, and their vegetation.
- Building structures for erosion prevention at one location that exacerbate erosion conditions on nearby properties.
- Creating wakes from boats that produce erosive action on the shoreline.

Bells Beach Homes on Created Land at Toe of Bluff

Engineered structures can halt, slow, mitigate or accelerate shoreline erosion. Erosion and accretion of beaches, inlet opening and closing, alterations in bay environments, bluff slumping, dune loss, wetland loss and other changes to coastal environments have been occurring naturally on a routine basis since the glacial retreat. These events, whether occurring incrementally or in a single storm event, are part of a natural system. The placement of hard structures (e.g., groins, jetties, bulkheads, revetments, seawalls) or soft structures (e.g., beach nourishment, vegetation, beach scraping, dune building) on dynamic landforms and in floodplains adjacent to coastal waters may not always comply with the dynamic nature of the landform to produce the desired results of erosion control.

FEMA Defined Base Flood Elevation and Increased Potential Sea Level Risk

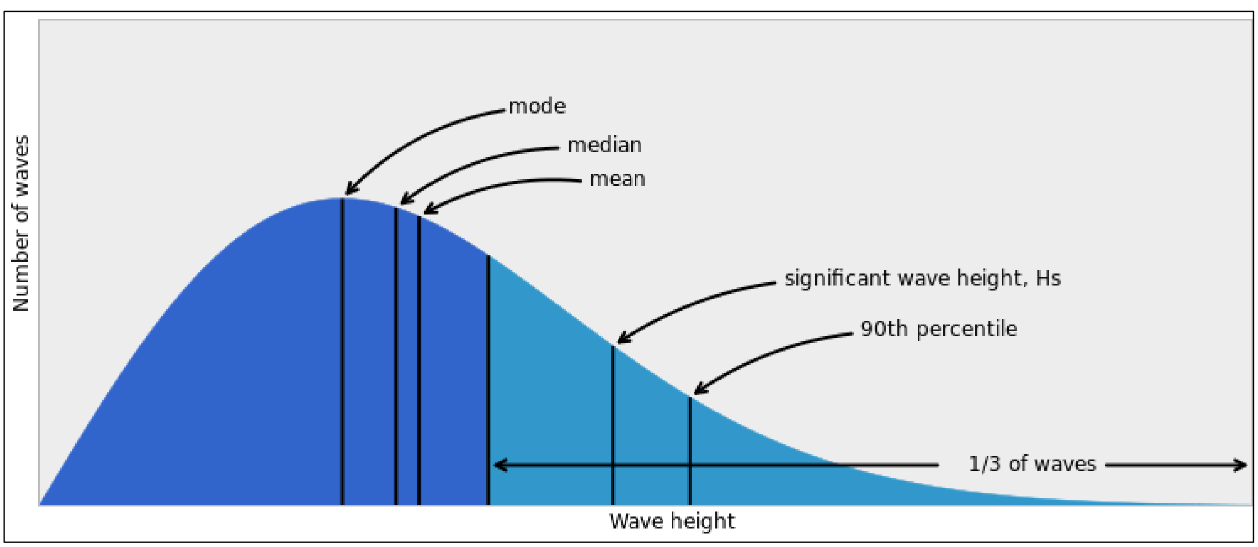


Frequency

In FEMA's *Multi-Hazard Identification and Risk Assessment Report*, coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a specific period, measured in nits of feet or meters per year. Erosion rates vary as a function of shoreline type and are influenced primarily by episodic events. Monitoring of shoreline change based on a relatively short period of record does not always reflect actual conditions and can misrepresent long-term erosion rates. Shorelines that are accreting, stable or experiencing mild rates of erosion over a long period are generally considered as not subject to the erosion hazard. However, short-term and daily erosion can expose a segment of coast to an episodic storm event and associated erosion damage at any time.

Return periods for coastal erosion are difficult to determine due to limited information and the relatively short period of recorded data in most areas. Long-term patterns of coastal erosion are difficult to detect because of substantial coastline changes in the short-term (that is, over days or weeks from storms and natural tidal processes). It is usually severe short-term erosion events, occurring either singly or cumulatively over a few years, that cause concern and lead to attempts to influence the natural processes. Analysis of both long- and short-term shoreline changes are required to determine which is more reflective of the potential future shoreline configuration (FEMA, 1997).

Coastal erosion can occur from short-term daily, seasonal, or annual natural events such as waves, storm surge, wind, coastal storms, and flooding or from human activities including boat wakes and dredging. The most dramatic erosion often occurs during storms, because the highest energy waves are generated under storm conditions. Scores of meters of beach width can be lost in a few hours or days due to a severe storm (Keqi Zhang, Bruce Douglas, and Stephen Leatherman, 1997). Figure 5-8 shows a typical distribution of wave height and frequency.



Statistical Wave Distribution

VULNERABILITY ASSESSMENT

Overview

Coastal erosion is exacerbated by multiple events. It is influenced by long-term climatic change effects such as sea-level rise, lack of sediment supply, subsidence, or long-term human factors such as the construction of shore protection structures and dams or aquifer depletion. As the sea level continues to rises, the shoreline

will continue to be displaced inland, except where sufficient sediment accumulates to building the shoreline seaward. In coastal locations where a shortage of sediment is accompanied by sea-level rise, the problem is compounded with increased shoreline displacement.

As sea-level rise continues over the next century, it is expected to contribute significantly to physical changes along open-ocean shorelines. Anticipated sea-level rise will lead to many effects:

- Flooding of low-lying coastal areas
- Extension of flood zone areas inland
- Loss and/or displacement of coastal wetlands and other types of coastal habitats
- Accelerated erosion of beaches
- Dune line recession
- Saltwater contamination of drinking water
- Decreased longevity of low-lying roads, causeways, and bridges
- Displacement of coastal habitats
- Decreases in the ability of natural barrier, bay and wetland systems to maintain themselves, especially in light of human shoreline alterations.

Warning Time

Coastal erosion is a gradual process, so structures threatened by it usually can be identified months to weeks before they are undermined and washed into the ocean. However, while a severe storm can be predicted days in advance, its impact on the coastline cannot. Depending on the severity of a storm, structures may be impacted more suddenly during severe weather events.

Impact on Life, Health and Safety

Population of the entire coastal area is exposed to coastal erosion. Sea level rise would increase wave height, increasing the rate and extent of erosion. Depending on the level of rise, population of some inland areas could be exposed to direct impact or secondary impact (such as loss of services or critical facilities).

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life- threatening illnesses, and residents of areas that are isolated from major roads. Coastal erosion can increase the risk of flooding and landslide activity, which can result in power outages which are life threatening to those dependent on electricity for life support. Isolation is a significant concern, as wave action can undercut roadways, or cause flooding, which impacts evacuation.

Impact on Property

Residential structures exist in areas which have the potential to be impacted by coastal erosion, especially in areas of high landslide risk and areas subject to storm surge or high wave action. What had previously been only nuisance flooding resulting in a foot of water or less on roads, parking lots and yards and deposition of logs and debris may in the future be serious flooding with damage to residents and roadways. With each winter storm, further erosion will occur. Continued narrowing, lowering or rising of the shoreline will expose the County's shoreline to increasing erosion, thereby increasing the frequency of flooding of upland area due to storm-generated overwash during periods of elevated water.

The erosion rates on Whidbey Island, the most populated island of Island County, is estimated to be 1.2 inches per year, which suggests the loss of one meter of bluff or bank every 33 years (Zelo et al 2000). High waves have been a major cause of increased erosion on Whidbey Island, particularly on the southeastern parts of the island and on large spits on Cultus Bay (Johannessen and MacLennan, 2007). Risk analysis conducted by Barton and Frink (2007) using Zillow suggests that along West Beach Road on northwest Whidbey Island approximately $32 million worth of property could be at risk due to increased bluff erosion and landslides with increasing sea level rise (Washington State Hazard Mitigation Plan, 2018).

Impact on Critical Facilities and Infrastructure

The County and its planning partners have limited critical facilities in the area subject to coastal erosion. Incapacity and loss of roads are the primary transportation failures resulting from coastal erosion that has previously been experienced. Secondary hazards resulting from erosion include flooding and landslides, which can cause significant damage, including to power lines, as well as blocking roads with debris, incapacitating transportation, isolating population, disrupting ingress and egress, and impacting the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly, reducing the ability to evacuate certain portions of the County. As in the case of Coupeville, erosion has impacted areas of its downtown historic area as well. The City has taken proactive measures to help reduce the impact, including installing pylons to reduce wave action. The flood and landslide profiles presented in later chapters of this hazard mitigation plan should also be reviewed for additional potential impacts, as the hazard assessment completed for both will provide additional information related to coastal erosion.

Impact on Economy

Economic impact from coastal erosion could be widespread. Cumulative economic effects larger than the sum of individual business sectors and regional effects may occur due to the interactions between industries and the economic sectors. For example, the loss or impact to Langley's economic hub in the historic district, which has a higher-than average number of tourists annually, would significantly impact not only the Town of Langley, but surrounding communities as well.

With the increase in sea level rise further impacting coastal erosion, costly impacts on structures and infrastructure and loss of land mass will have a significant economic impact on the region. The loss of land mass alone would be significant as the county is surrounded by water. As structure losses continue, the potential for diminished tax base will increase.

Washington State Ferry (WSF) terminal assets are also located in areas that are vulnerable to erosion, as well as abrupt seismic events and emerging risks related to sea-level rise and increasing intensity of storms.

Current closures due to low tides may not occur with higher sea levels as climate change continues to expand its impacts; however, erosion in those terminal areas will also increase as sea levels encroach further inland, impacting supporting structures. Currently, when terminals close now due to severe weather, vessels and users are rerouted to other terminals. Should long-term impact occur as a result of erosion, such re-routing would have an economic impact in the County. In addition, the Eagle Harbor ferry maintenance facility is located near sea level. If this facility is impacted or inundated permanently, other options would need to be explored. The WSF 2040 Long-Range plan currently prioritizes terminal maintenance needs with the most seismic risk and vulnerability to sea level rise, among other factors. (DOT, 2019)

As shorelines erode, the potential exists for wave action, tides, storm surges, and rivers to carry more debris and sediment into Puget Sound as a whole. This would have the potential to also increase operational expenses in order to remove debris that could damage ferries, docks, or boats, among other things. Large waves that come over decks can move cars, and ferry elevators do not work if vessels are rocked by large waves. With larger waves and more extreme storms, this risk for erosion to occur increases. With 4-foot and 6-foot sea levels, power lines to docks may also be impacted.

Impact on Environment

Natural habitats, wildlife and aquatic life are all exposed and risk major impact. Severe weather events and high tides can increase the rate of erosion and redistribute sediment loads. Environmental vulnerability accompanying coastal erosion is also associated with the narrowing and lowering of the landmass, increasing potential flooding and landslides due to storm wave run-up and overtopping of the shoreline during periods of extreme high tides. Materials that erode can to be carried into inter-tidal areas, eventually significantly altering the ecosystem.

FUTURE DEVELOPMENT TRENDS

All future development in coastal areas have the potential to be affected by coastal erosion storms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. The County utilizes the International Building Code in an effort to keep its citizens as safe as possible from the impacts of the flooding and landslide hazard associated with coastal erosion.

The County recognizes the need to comprehensively address the serious and growing issue of coastal erosion due to Pacific Ocean storms and sea level rise. In recent decades, citizens have witnessed considerable coastal erosion damage and loss along all Washington coasts. In December 2014, a vacation home was lost in Clinton as a result of storm surge and associated coastal erosion. Such incidents have the potential to increase in number as sea level rise and costal erosion continues;

however, regulatory is currently in place to reduce new construction in these high hazard areas to help ensure limited impact.

CLIMATE CHANGE IMPACTS

Coastal erosion may be a result of multi-year impacts and long-term climatic change such as sea-level rise, lack of sediment supply, subsidence, or long-term human factors such as the construction of shore protection structures and dams or aquifer depletion. As the sea level rises, the shoreline is displaced inland, except in those areas where sufficient sediment is accumulating to build the shoreline seaward. In coastal locations where a local shortage of sediment is accompanied by sea-level rise, the problem is compounded and the result is an increased rate of shoreline displacement. Sea-level rise can lead to the flooding of low-lying coastal areas; extension of flood zone areas inland; loss and/or displacement of coastal wetlands and other types of coastal habitats; accelerated erosion of beaches; dune line recession; saltwater contamination of drinking water; decreased longevity of low-lying roads, causeways, and bridges; displacement of coastal habitats; and decreases in the ability of the natural barrier, bay, and wetland systems to maintain themselves, especially in light of present human shoreline alterations. As sea-level rise continues over the next century, it is expected to contribute significantly to physical changes along open-ocean shorelines. While it is widely believed that changes in sea level over the last century have had some role in shoreline change and land-loss along the coast, it has been difficult to quantify this relationship. The difficulty is due to the range of processes that affect coastal areas, the frequency at which coastal changes occur.

ISSUES

A worst-case event would involve prolonged high winds during a winter storm. Such an event would have both short-term and long-term effects. Some areas would experience limited ingress and egress as a result of potential flooding due to overwash. Prolonged rain would further increase flooding, overtopping culverts with increased levels of ponded water on roads. Wave action would increase landslides, especially in the high bluff areas, further increasing the severity associated with the event, especially as it relates to evacuation routes.

Coastal flooding is the secondary hazard most intensified by coastal erosion. However, erosion can also cause landslides and mudslides, as has happened frequently throughout Island County coastlines. Likewise, stream and river valleys may become vulnerable to slope failure as a result of erosion, often as a result of loss of cohesion in clay-rich soils. Building and road foundations lose load-bearing strength and may collapse as the ground beneath is washed away. Hazardous materials can be released as a result of structural integrity being compromised, causing significant damage to the environment and people.

Important issues associated with the potential impacts from coastal erosion in the planning area include the following:

- Climate change and the associated sea level rise increase the area eroded by wave action.

- Older building stock in the planning area is built to lower code standards. These structures could be highly vulnerable to the impacts of coastal erosion through increased potential for flooding.
- Roadways running along shorelines or along bluff areas are susceptible to failure if the ground beneath them is eroded.
- Redundancy of power supply must be evaluated.
- The planning area has several isolated population centers.

IMPACT AND RESULTS

Based on historical evidence and events, the planning team determined that the probability for future issues associated with coastal erosion is high. The continued influence from climate change will only increase the vulnerability to this hazard. While limited critical infrastructure is at risk, residential dwellings and roadways do exist in areas highly susceptible to erosion. As such, the planning team determined the overall CPRI Score to be 2.15 with an overall ranking of medium.