Section 1: Planning Process

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Plan Process Requirements

Code of Federal Regulations 44

Plan Requirements – Requirement §201.6(a)(4).

> (4) Multi-jurisdictional plans (e.g., watershed plans) may be accepted, as appropriate, as long as each jurisdiction has participated in the process and has officially adopted the plan. State-wide plans will not be accepted as multi-jurisdictional plans.

Planning Process – Requirement §201.6(b)(1) and §201.6(b)(2). The planning process must include:

> (b) **Planning process.** An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process must include:
>
> > (1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;
> >
> > (2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and nonprofit interests to be involved in the planning process; and

Plan Content – Requirement §201.6(c)(1): The plan must include the following:

> (c) **Plan content.** The plan must include the following:
>
> > (1) Documentation of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

Section 1: Plan Process

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Base Plan

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Plan Process

Section 1

Table 1-1 "Section 1: Plan Process" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 1: Plan Process" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annexes**
Section 1: Plan Process	Changes Since 2020 Pierce County Hazard Mitigation Plan
	Plan Process
Section 2: Profile Process	
Section 3: Capability Identification	
Section 4: Risk Assessment	
Section 5: Mitigation Strategy	
Section 6: Infrastructure	
Section 7: Plan Maintenance	

The 2025 Pierce County Regional Hazard Mitigation Plan (RHMP) is an update of the previous Federal Emergency Management Agency (FEMA) approved 2020 Pierce County Region 5 Hazard Mitigation Plan. Coordinated by the Pierce County Department of Emergency Management (PCDEM), the Pierce County RHMP is updated to meet the current Federal Law (Code of Federal Regulations (CFR), Title 44, Part 201.6) criteria for Local and Multi-Jurisdictional Hazard Mitigation Plans. FEMA-approved hazard mitigation plans must be reviewed, revised if appropriate, and resubmitted for approval every five years following the expiration of a previous hazard mitigation plan.

Upon approval, this document – the Pierce County RHMP Base Plan "Section 1: Plan Process" – will become the Pierce County RHMP Base Plan and the guiding document for the plan's organization of and methodology behind the Pierce County RHMP Base Plan and Jurisdictional Annexes. The previous 2020 Pierce County Region 5 Hazard Mitigation Plan had a total of 76 local jurisdictions – cities, towns, fire districts, school districts, educational institutions, medical institutions, utility providers, and others – participate in the planning process and write a local Jurisdictional Annex to the greater county-level plan. 36 of those jurisdictions brought finished plans before governing boards to be adopted locally (see Table 1-2).

Table 1-2 Jurisdictions Who Adopted the 2020 Region 5 Hazard Mitigation Plan

2020 Region 5 Hazard Mitigation Plan Jurisdictions: Adopted and Approved Plans	
Carbonado Historical School District	Ohop Mutual Light Company
Central Pierce Fire & Rescue	Orting School District
City of Bonney Lake	Parkland Light and Water
City of Buckley	Peninsula School District
City of Edgewood	Pierce Transit
City of Fife	Port of Tacoma
City of Lakewood	Riverside Fire & Rescue
City of Orting	Riviera Community Club
City of Puyallup	Spanaway Water Company
City of Sumner	Sumner-Bonney Lake School District
City of University Place	Town of Carbonado
Clover Park School District	Town of Eatonville
Dieringer School District	Town of South Prairie
Firgrove Mutual Water Company	Town of Steilacoom
Gig Harbor Fire & Medic One	Town of Wilkeson
Graham Fire & Rescue	Unincorporated Pierce County
Kaiser Permanente	West Pierce Fire & Rescue
Mt. View-Edgewood Water Company	White River School District

The Change Matrix: 2020 to 2025

The 2025 Pierce County RHMP Base Plan has changed in process, content, and format in comparison to the 2020 Base Plan. The purpose of the following change matrix is to advise the reader of these changes between plan updates. Each of the Jurisdictional Annexes in the Pierce County RHMP Base Plan has a summary change matrix in each Jurisdictional Annex's "Section 1: Plan Process" that highlights the most significant change in each section between plan updates.

The Base Plan Change Matrix (see Table 1-3) and Jurisdictional Annex Change Matrix (see Table 1-4) documents pertinent changes made from the 2020 to the 2025 Pierce County RHMP updates. Most changes were completed to make the plan more accessible format-wise and bring the content of the plan up to date. This 2025 version represents a complete review and update by PCDEM using a detailed process for development and following an established format. All Jurisdictional Annexes under this Base Plan have also reviewed and updated their plans. Specifically, the appendices for each Jurisdictional Annex were reorganized for cohesion and to mitigate duplication of information in the 2025 update. The Jurisdictional Annex Change Matrix for Appendix A, B, C, and D (Table 1-5) detail the consolidation of information for each of the old Appendix A, B, C, D, E, and F into this new format's Appendix A, B, C, and D.

Table 1-3 Base Plan Change Matrix

Base Plan Change Matrix	
2020 Hazard Mitigation Plan	**NEW 2025 Hazard Mitigation Plan**
The previous plan often **grouped cities and towns** together for consistency.	The current plan often groups **cities, towns, and Pierce County** together for consistency.
The previous plan was named the **"2020 Region 5 Hazard Mitigation Plan."**	The current plan is named the **"2025 Pierce County Regional Hazard Mitigation Plan."**
The previous plan listed **six Discipline Planning Team Groups** that all jurisdictions were organized into: the Cities and Towns Group, Fire Group, Schools Group, Utility Group, Medical Group, and Special Purpose District Group.	The current plan lists **five Discipline Planning Team Groups** that all jurisdictions were organized into: the Cities and Towns Group, Fire Group, Education Group, Utility Group, and Other Group.
The previous plan referred to jurisdictions as **Addendums** to the greater Pierce County Hazard Mitigation Plan.	The current plan refers to jurisdictions as **Jurisdictional Annexes** to the greater Pierce County Hazard Mitigation Plan.
The previous plan's Risk Assessment hazard list contained 21 hazards: **Abandoned Mines, Active Threat/Attack Tactics, Avalanche, Civil Disturbance, Climate Change, Cyberattack, Dam Failure, Drought, Earthquake, Energy Emergency, Epidemic and Pandemic, Flooding, Hazardous Materials, Landslide, Pipelines, Severe Weather, Terrorism, Transportation Accidents, Tsunami, Volcanism, and Wildland Urban Interface (WUI).**	The current plan's Risk Assessment hazard list contains 14 hazards. **Civil Unrest, Cyber, Dam Failure, Drought, Earthquake, Epidemic-Pandemic, Flood, Hazardous Materials and Transportation Accidents, Landslide, Severe Weather, Terrorism and Extremism, Tsunami and Seiche, Volcano and Lahar, and Wildfire.**
The previous plan utilized a **stagged plan review process** where the completed plan was reviewed first by Washington State Emergency Management Division (EMD), and then it was sent to FEMA Region X for review.	The current plan utilized a **concurrent plan review process** where the completed plan was reviewed at the same time by Washington State Emergency Management Division (EMD) and FEMA Region X for review.
Formatting and stylistic changes between the 2020 plan and 2025 plan for clarity and consistency.	

Table 1-4 Jurisdictional Annex Change Matrix

Jurisdictional Annex Change Matrix | Section 1: Plan Process	
2020 Hazard Mitigation Plan	**NEW 2025 Hazard Mitigation Plan**
76 jurisdictions participated in the planning process as a part of the greater Pierce County Hazard Mitigation Plan.	**64 jurisdictions** participated in the planning process as a part of the greater Pierce County RHMP.
36 jurisdictions adopted each Jurisdictional Annex with the relevant governing board for that jurisdiction after plan approval by FEMA.	At the time of submittal to FEMA, **it is unknown** how many jurisdictions have adopted each Jurisdictional Annex with the relevant governing board for that jurisdiction after plan approval by FEMA.
Jurisdictional Annex Change Matrix | Section 2: Profile	
2020 Hazard Mitigation Plan	**NEW 2025 Hazard Mitigation Plan**
The previous plan's population data analysis for each jurisdiction looked at two categories of vulnerable populations based on available U.S. Census data: individuals **65-years-old and older** as well as individuals who were **younger than 20-years-old**.	The current plan's population data analysis for each jurisdiction looked at two categories of vulnerable populations based on available 2020 U.S. Census data: individuals **65-years-old and older** as well as individuals who were **younger than 18-years-old**.
The previous plan **incorporated the "Profile Section" of the 2020 Hazard Identification and Risk Assessment (HIRA)** into the Base Plan and each jurisdiction's addendum.	The current plan **does not incorporate the "Profile Section" of the 2020 Hazard Identification and Risk Assessment (HIRA)** into the Base Plan and each jurisdiction's addendum.
Jurisdictional Annex Change Matrix | Section 3: Capability Identification	
2020 Hazard Mitigation Plan	**NEW 2025 Hazard Mitigation Plan**
The previous plan consistently referred to the **Disaster Mitigation Act of 2000 for CFR Requirements.**	The current plan **added on the recent amendments** to those the Disaster Mitigation Act of 2000 for CFR Requirements.

The previous plan referred to jurisdictional partners to this hazard mitigation plan effort as being a part of the **Planning Team**.	The current plan refers to jurisdictional partners to this hazard mitigation plan effort as the part of the **Pierce County RHMP Planning Team**.
The previous plan had **extensive resource pages with website links** to relevant online content.	The current plan **removed resource pages and validated and updated website links** if needed.
The **joint planning** between the Pierce County RHMP and other existing plans, studies, reports, and technical information was **extensively described in each jurisdiction's addendum.**	The **joint planning** between the Pierce County RHMP and other existing plans, studies, reports, and technical information was **extensively described in the Pierce County RHMP Base Plan and referenced in each Jurisdictional Annex**.
Each city, town, and Pierce County's compliance to the NFIP was detailed extensively in each jurisdiction's addendum and was **certified as being in good standing by the Washington State Department of Ecology as of August 27th, 2010**.	Each city, town, and Pierce County's compliance to the NFIP was detailed in each Jurisdictional Annex and more extensively detailed in the Pierce County RHMP Base Plan. Each jurisdiction was **certified as being in good standing by the Washington State Department of Ecology as of December 3rd, 2025.**
Jurisdictional Annex Change Matrix | Section 4: Risk Assessment	
2020 Hazard Mitigation Plan	**NEW 2025 Hazard Mitigation Plan**
The previous plan's Risk Assessment hazard list contained 21 hazards.	The current plan's Risk Assessment hazard list contains 14 hazards.
In the previous plan, changes in local jurisdiction's **development patterns were updated as of 2020.**	**Changes in local jurisdiction's** development patterns were updated as of 2025.
In the previous plan, **Disaster Declaration tables** in each jurisdiction's **addendum was updated as of 2020.**	In the current plan, **Disaster Declaration tables** were **moved to the Pierce County RHMP Base Plan and updated as of 2025**.
In the previous plan, data sources and methodologies were **updated based on the best available science and data available as of 2020.**	In the current plan, data sources and methodologies were **updated based on the best available science and data available as of 2025.**
The previous plan **did not include wildfire data or maps.**	The current plan **does include wildfire data and maps.**

Jurisdictional Annex Change Matrix | Section 5: Mitigation Strategy	
In the previous plan, **mitigation strategies were guided by goals and objectives and executed through actionable mitigation measures.**	In the current plan, **mitigation strategies are guided by goals and objectives and executed through actional mitigation actions.**
Jurisdictional Annex Change Matrix | Section 6: Infrastructure	
In the previous plan, **infrastructure was updated as of 2020 and matched the plan's Risk Assessment.**	In the current plan, **infrastructure was updated as of 2025 and matches the plan's Risk Assessment.**
Jurisdictional Annex Change Matrix | Section 7: Plan Maintenance	
The previous plan utilized a **stagged plan review process** where the completed plan was reviewed first by Washington State EMD and then it was sent to FEMA Region X for review.	The current plan utilized a **concurrent plan review process** where the completed plan was reviewed at the same time by Washington State EMD and FEMA Region X for review.
Formatting and stylistic changes between the 2020 plan and 2025 plan for clarity and consistency.	

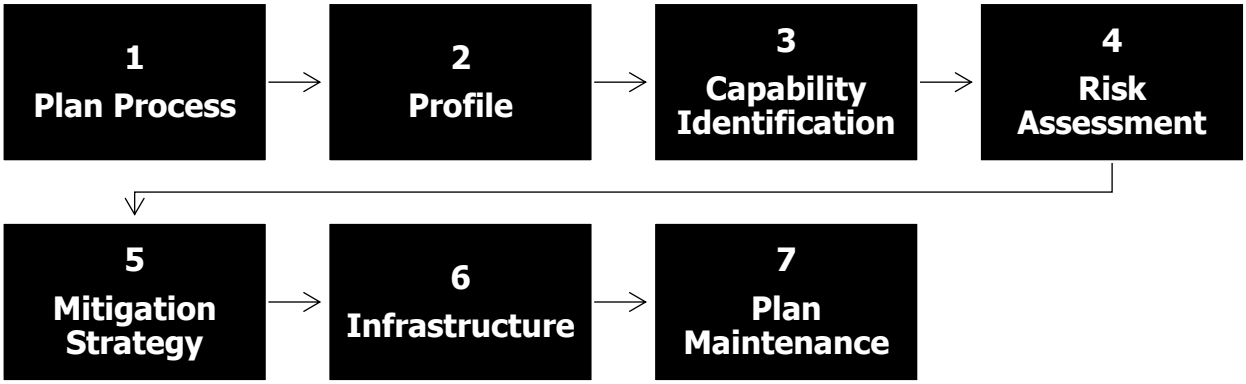
Table 1-5 Jurisdictional Annex Change Matrix for Appendix A, B, C, and D

Jurisdictional Annex Appendices Change Matrix		
2020 Plan Format	**Changes**	**2025 Plan Format**
Appendix A: Plan Adoption		**Appendix A:** Plan Adoption
Appendix B: Region 5 Hazard Mitigation Planning Team		**Appendix B:** Mitigation Planning Partners*
Appendix C: Plan Revisions		**Appendix C:** Plan Revisions
Appendix D: Hazus Risk Assessment Scenario	Moved to the Pierce County RHMP Base Plan "Section 4: Risk Assessment"	
Appendix E: Documentation Records		**Appendix D:** Documentation Records
Appendix F: Completed and Deferred Mitigation Strategies	Each jurisdiction's completed and deferred mitigation strategies were integrated into each Jurisdictional Annex's "Section 5: Mitigation Strategies	
** This indicates that this appendix in particular had a name change, but no update to the structure or organization of the appendix comparing the 2020 and 2025 plans*		

Plan Process Overview

The 2025 Pierce County RHMP Process Section is a discussion of the planning process used to update the Pierce County RHMP, including how the process was prepared, who aided in the process, and how the public was involved. The Pierce County RHMP update involves an update of both the Pierce County RHMP Base Plan – a county-level mitigation plan – and individual Jurisdictional Annexes – local, place-based mitigation plans. All of which follow the same organizational structure (see Figure 1-1). Altogether, the Pierce County RHMP Base Plan and all Jurisdictional Annexes are developed to meet the requirement identified in 44 CFR §201.6 for local mitigation planning.

Figure 1-1 Pierce County RHMP Base Plan and Jurisdictional Annex Organization



Public Involvement Process

Public participation is a key component to strategic planning processes. Community participation offers community members the chance to voice their ideas, interests, and opinions. Public participation sets the foundation for the Pierce County RHMP's short-term and long-term strategies for reducing risk.

> *"Involving [partner]s who are not part of the core team in all stages of the process will introduce the planning team to different points of view about the needs of the community. It will also provide opportunities to educate the public about hazard mitigation, the planning process, and findings, and could be used to generate support for the mitigation plan."*[1]

In order to accomplish this goal and to ensure that the updated Pierce County RHMP be comprehensive, Pierce County RHMP planning groups in conjunction with PCDEM developed a public participation process with three primary components:

1. A Pierce County RHMP Planning Team comprised of knowledgeable individual representatives of Pierce County RHMP area and its hazards;
2. Hazard Meetings to target the specialized knowledge of individuals working with populations or areas at risk from all hazards; and
3. Public Meetings to identify common concerns and ideas regarding hazard mitigation and to discuss specific goals, objectives, and measures of the mitigation plan.

This subsection discusses each of these components in further detail below with public participation outlined in each. Integrating public participation into the development of the Pierce County RHMP update has helped to ensure an accurate depiction of Pierce County's risks, vulnerabilities, and mitigation priorities.

Planning Team

The Pierce County RHMP Planning Team was organized in 2024. The individual Pierce County RHMP Planning Team members understand the portion of Pierce County containing their specific jurisdiction including how residents, businesses, infrastructure, and the environment may be affected by all hazard incidents. The members are experienced in past and present mitigation activities and represent those entities through which many of the mitigation actions would be implemented. The Pierce County RHMP Planning Team guided the update of the plan, assisted in reviewing and updating goals and strategies, identified stakeholders, and shared local expertise to create a more comprehensive plan.

The Pierce County Planning Team was organized into five Discipline Planning Groups of like jurisdictions: Cities and Towns, Education, Fire, Utility, and Other. Team meetings were also held geographically through regional groups by subdividing Pierce County into five geographic areas. These geographic areas share similar hazards and allow for relationship building amongst the different jurisdictions during the overall process. This collaborative planning will allow integrations of ideas and potential future projects to have shared funding costs. These regional groups are as follows: North (N), West (W), Southwest (SW), Northeast (NE), and Central (C).

Tables 1-4, 1-5, 1-6, 1-7, and 1-8 detail all the Planning Teams for each of the Pierce County RHMP's Discipline Planning Groups. Each Pierce County RHMP Jurisdictional Annexes, is also color-coded to match the jurisdiction's discipline group. For navigability in this large, multi-jurisdictional plan, a reader should be able to open any page in each Jurisdictional Annex and know what discipline group the page belongs to. From an accessibility perspective, PCDEM utilized the "Guide to Accessible Color Palettes"[2] to choose colors that had enough contrast with text colors to accommodate readers with color vision deficiencies.

Cities and Towns Group

Table 1-6 Planning Teams – Discipline Cities and Towns Group

Name	Title	Jurisdiction or Department
Raejean Kreel	Emergency Manager	City of Bonney Lake
Eric Skogen	Fire Chief/Emergency Manager	City of Buckley
Barb Kincaid	Director of Community Development	City of DuPont
Bryan Moore	Chief of Police	City of DuPont
Jason Youngman	Chief of Police	City of Edgewood
Jeremy Metzler	Community Development Director	City of Edgewood
David Claridge	Police Chief	City of Fife
Doug Newman	Assistant Police Chief	City of Fife
Tyler Bemis	Public Works Director	City of Fircrest
Dawn Masko	City Manager	City of Fircrest
Eric Baker	Community Development Director	City of Gig Harbor
Serena Rotondo	Emergency Management Coordinator	City of Lakewood
Tiffany Speir	Planning Director	City of Lakewood
Patrick Smith	Chief of Police	City of Lakewood
Jeff Alwine	Police Captain	City of Lakewood
Trisha Summers	City Clerk/ HR Manager	City of Milton
Angelie Stahlnecker	Planning Manager	City of Milton
Timothy Bauer	Emergency Management Coordinator	City of Orting
Kirstin Hofmann	Emergency Manager	City of Puyallup
Pat Donovan	Project Specialist	City of Puyallup
Chief Antista	Police Chief	City of Roy
Ryan Fuller	Public Works Director	City of Roy
Evan Brazitis	Emergency Management and Safety Coordinator	City of Sumner
Doug Beagle	Development Services Director	City of Sumner
Robert Wright	Engineering Specialist	City of Sumner
Tieka Adeogun	Chief Emergency Management Officer	City of Tacoma / Tacoma Fire Department
Arianna Topbjerg	Emergency Analyst	City of Tacoma / Tacoma Fire Department
Lisa Petorak	Human Resources Manager	City of University Place
Serena Rotondo	Emergency Management Coordinator	City of University Place / City of Lakewood / Town of Steilacoom
Eric Skogen	Fire Chief (Buckley)	Town of Carbonado
Nick Moore	Town Planner	Town of Eatonville
Eric Phillips	Town Administrator	Town of Eatonville
Terry Berry	Clerk-Treasurer	Town of South Prairie
Emily Terrell	Town Planner	Town of South Prairie

Name	Title	Jurisdiction or Department
Tom Yabe	Police Chief	Town of Steilacoom
Marie Wellock	Town Clerk	Town of Wilkeson

Education Group

Table 1-7 Planning Teams – Discipline Education Group

Name	Title	Jurisdiction or Department
Jessie Sprouse	Principal/Superintendent	Carbonado Historical School District
Mona Planesi	Risk Manager	Clover Park School District
Paula Dawson	Superintendent	Dieringer School District
Brandon Jumper	Manager of Maintenance & Operations	Eatonville School District
Ben Ramierez	Superintendent	Fife School District
Katie Gillespie	Safety, Security/EM Supervisor	Franklin Pierce School District
Aaron Lee		Orting School District
Seth Carlson	Director of Campus Safety	Pacific Lutheran University
Patrick Gillespie	Director of Facilities	Peninsula School District
Gus Wessel	Executive Director of Safety, Security and Risk Management	Puyallup School District
Susanne Beauchaine	Executive Director of Human Resources	Steilacoom School District No. 1
Cheryl Collins	Risk Manager	Sumner School District
Brian Scheerer	Safety and Security Director	Sumner School District
Jeffrey Rogers	Safety Manager	Tacoma Public Schools
Torey Heidelberg	Preparedness/Safety Coordinator	University Place School District
Michelle Bradshaw	Director of Safety & Security	White River School District

Fire Group

Table 1-8 Planning Teams – Discipline Fire Group

Name	Title	Jurisdiction or Department
Zane Gibson	Deputy Chief / Interim Fire Chief	Central Pierce Fire & Rescue / South Pierce Fire & Rescue
Eric Skogen	Fire Chief	City of Buckley Fire
Bill Sandlian	Assistant Chief, Health / Safety - Prevention - Emergency Management	East Pierce Fire & Rescue
Scott Booth	Deputy Chief of Health & Safety	Gig Harbor Fire & Medic One
Chris Beswick	Assistant Chief	Key Peninsula Fire Department
Jim Wassall	Fire Chief	Browns Point Fire Department 13
Matt Medford	Fire Chief	Pierce County Fire District 23
J Wiggins	Fire Chief	Anderson Island Fire & Rescue
Arron Reynolds	Division Chief	Anderson Island Fire & Rescue
Kira Thirkield	Fire Chief	Riverside Fire & Rescue
Hallie McCurdy	Deputy Chief	West Pierce Fire & Rescue
Serena Rotondo	Emergency Management Coordinator	West Pierce Fire & Rescue

Utility Group

Table 1-9 Planning Teams – Discipline Utility Group

Name	Title	Jurisdiction or Department
Robert Popek	Board Member	Clear Lake Water District
Larry Jones	General Manager	Firgrove Mutual Water Co.
Steve Sacksteder	Water Quality	Firgrove Mutual Water Co.
Ed Jidas	Chair	Fruitland Mutual Water Co.
Ben Ames	Cross Connections Specialist	Fruitland Mutual Water Co.
Martin Blochberger	General Manager	Graham Hill Mutual Water Co.
John DeVore	General Manager	Lakeview Light & Power
Kelly Butt	Operations Supervisor	Lakeview Light & Power
Don Stanley	Operations Department Head	Lakewood Water District
Mike Craig	General Manager	Mt. View – Edgewood Water Co.
Joel Hansen	Supervisor	Ohop Mutual Light
Hannah June	Office Assistant	Ohop Mutual Light
Dale Budzinski	Water Superintendent	Parkland Light & Water Co.
Dale Butcher	Electric Superintendent	Parkland Light & Water Co.
Susan Cutrell	General Manager	Parkland Light & Water Co.
Amy Grice	Systems Engineering Manager	Peninsula Light Co.
Ronda Farmer	General Manager	Spanaway Water Co.
Darryl Scott	General Manager	Summit Water Co.
Jason Anderson	Construction Foreman	Summit Water Co.
Courtney Rose	Chief Emergency Manager	Tacoma Public Utilities
Lisa Millus	Assistant Emergency Manager	Tacoma Public Utilities
Steve Walter	C.E.O.	Tanner Electric
Lisa Peabody	Administrative Assistant	Tanner Electric
Sean Vance	General Manager	Valley Water District
Deanne Lawrence	Office Supervisor	Valley Water District

Other Group

Table 1-10 Planning Teams – Discipline Other Group

Name	Title	Jurisdiction or Department
Curt Simonson	President HOA	Crystal River Ranch Association
Gary Castell	President HOA	Crystal Village Homeowners Association
Erich Sachs	Asset Management/Sustainability Manager	Parks Tacoma
Rod Chandler	Emergency Management Administrator	Pierce Transit
Samuel Hudson	Associate Planner	Port of Tacoma
John Cammon	Maintenance Superintendent	Riviera Community Club
Mitzi McCart	President HOA	Taylor Bay Beach Club

Tables 1-9, 1-10, 1-11, 1-12, and 1-13 detail all the Pierce County RHMP Planning Teams for each of the Pierce County RHMP's Regional Planning Groups.

Northeast Region Group

Table 1-11 Planning Teams – Northeast Region Group

Name	Title	Jurisdiction or Department
Raejean Kreel	Emergency Manager	City of Bonney Lake
Eric Skogen	Fire Chief/Emergency Manager	City of Buckley, Town of Carbonado
Scott Larson	City Manager	City of Orting
Timothy Bauer	Emergency Management Coordinator	City of Orting
Terry Berry	Clerk-Treasurer	Town of South Prairie
Emily Terrell	Town Planner	Town of South Prairie
Evan Brazitis	EM and Safety Coordinator	City of Sumner
Doug Beagle	Development Services Director	City of Sumner
Robert Wright	Engineering Specialist	City of Sumner
Marie Wellock	Town Clerk-Treasurer	Town of Wilkeson
William (Bill) Sandlian	Assistant Chief – Health/Safety, Prevention, Emergency Management	East Pierce Fire & Rescue
Zane Gibson	Emergency Management Chief / Interim Fire Chief	Central Pierce Fire & Rescue / South Pierce Fire & Rescue
Jessie Sprouse	Principal/Superintendent	Carbonado Historical School District
Paula Dawson	Superintendent	Dieringer School District
Aaron Lee	Executive Director	Orting School District
Cheryl Collins	Risk Manager	Sumner School District
Brian Scheerer	Safety and Security Director	Sumner School District
Michelle Bradshaw	Director of Safety & Security	White River School District
Curt Simonson	HOA President	Crystal River Ranch Association
Gary Castell	HOA Resident	Crystal Village Homeowners Association

North Region Group

Table 1-12 Planning Teams – North Region Group

Name	Title	Jurisdiction or Department
Jason Youngman	Chief of Police	City of Edgewood
Jeremy Metzler	Community Development Director	City of Edgewood
David Claridge	Assistant Chief	City of Fife (Police Department)
Doug Newman	Chief	City of Fife (Police Department)
Tyler Bemis	Public Works Director	City of Fircrest
Dawn Masko	City Manager	City of Fircrest
Trisha Summers	City Clerk/ HR Manager	City of Milton
Angelie Stahlnecker	Planning Manager	City of Milton
Tieka Adeogun	Chief Emergency Management Officer	City of Tacoma / Tacoma Fire Department
Arianna Topbjerg	Emergency Analyst	City of Tacoma / Tacoma Fire Department
Jim Wassall	Fire Chief	Browns Point Fire Department 13
Kira Thirkield	Fire Chief	Riverside Fire & Rescue
Ben Ramirez	Superintendent	Fife School District
Jeffrey Rogers	Safety Manager	Tacoma Public Schools
Mike Craig	General Manager	Mt. View – Edgewood Water Co.
Darryl Scott	General Manager	Summit Water Co.
Jason Anderson	Construction Foreman	Summit Water Co.
Courtney Rose	Chief Emergency Manager	Tacoma Public Utilities
Lisa Millius	Assistant Emergency Manager	Tacoma Public Utilities
Erich Sachs	Asset Management/Sustainability Manager	Parks Tacoma
Samuel Hudson	Associate Planner	Port of Tacoma

Central Region Group

Table 1-13 Planning Teams – Central Regional Group

Name	Title	Jurisdiction or Department
Eric Phillips	Town Administrator	Town of Eatonville
Nick Moore	Town Planner	Town of Eatonville
Kirstin Hofmann	Emergency Manager	City of Puyallup
Pat Donovan	Emergency Management Planner	City of Puyallup
Chief Antista	Police Chief	City of Roy
Ryan Fuller	Director of Public Works	City of Roy
Matt Medford	Fire Chief	Pierce County Fire District 23
Zane Gibson	Deputy Chief / Interim Fire Chief	Central Pierce Fire & Rescue / South Pierce Fire & Rescue
Brandon Jumper	Manager of Maintenance & Operations	Eatonville School District
Katie Gillespie	Safety, Security/EM Supervisor	Franklin Pierce School District
Seth Carlson	Director of Campus Safety	Pacific Lutheran University
Gus Wessel	Executive Director of Safety, Security and Risk Management	Puyallup School District
Robert Popek	Board Member	Clear Lake Water District
Larry Jones	General Manager	Firgrove Mutual Water Co.
Steve Sacksteder	Water Quality	Firgrove Mutual Water Co.
Ed Jidas	Chair	Fruitland Mutual Water Co.
Ben Ames	Cross Connections Specialist	Fruitland Mutual Water Co.
Martin Blochberger	General Manager	Graham Hill Mutual Water Co.
Joel Hansen	Supervisor	Ohop Mutual Light
Hannah June	Office Assistant	Ohop Mutual Light
Tim Wells	General Manager	Spanaway Water Company
Sean Vance	General Manager	Valley Water District
Deanne Lawrence	Office Supervisor	Valley Water District

Southwest Region Group

Table 1-14 Planning Teams – Southwest Region Group

Name	Title	Jurisdiction or Department
Barb Kincaid	Director Community Development	City of DuPont
Bryan Moore	Chief of Police	City of DuPont
Serena Rotondo	Emergency Management Coordinator	City of University Place / City of Lakewood / Town of Steilacoom
Jeff Alwine	Assistant Police Chief	City of Lakewood
Tiffany Speir	Planning Director	City of Lakewood
Patrick Smith	Chief of Police	City of Lakewood
Tom Yabe	Police Chief	Town of Steilacoom
John Ecklund	Director of Engineering	City of University Place
Lisa Petorak	Human Resources Manager	City of University Place
Hallie McCurdy	Deputy Chief	West Pierce Fire & Rescue
J Wiggins	Fire Chief	Anderson Island Fire & Rescue
Arron Reynolds	Division Chief	Anderson Island Fire & Rescue
Mona Planesi	Risk Manager	Clover Park School District
Susanne Beauchaine	Executive Director for Human Resources	Steilacoom Historical School District
Torey Heidelberg	Preparedness/Safety Coordinator	University Place School District
Don Stabley	Operations Department Head	Lakewood Water District
Linda Horey	Emergency Management Program Specialist	Western State Hospital
John Cammon	Maintenance Superintendent	Riviera Community Club
Rodney Chandler	Emergency Management Administrator	Pierce Transit

West Region Group

Table 1-15 Planning Teams – West Region Group

Name	Title	Jurisdiction or Department
Eric Baker	Community Development Director	City of Gig Harbor
Scott Booth	Deputy Chief of Health & Safety	Gig Harbor Fire & Medic One
Chris Beswick	Assistant Chief	Key Peninsula Fire Department
Patrick Gillespie	Director of Facilities	Peninsula School District
Amy Grice	Systems Engineering Manager	Peninsula Light Co.
Mitzi McCart	President HOA	Taylor Bay Beach Club

Planning Team Meetings

Each Discipline Group held Planning Meetings over the course of the planning process. Between all the Discipline Planning Groups, five to six Planning Team Meetings were held. Each Regional Planning Group also held Planning Meetings over the course of the planning process. Between all the Regional Planning Groups, four to five Planning Team Meetings were held.

The Planning Teams Discipline Groups consist of the Cities and Towns Group, Fire Group, School Group, Utility Group, and Other Group. There was a total of fifty meetings from September 2024 to June 2025 between all Planning Groups. Additional working group drop-in workshops were provided for jurisdictions to continue to work on and update their plans.

Meeting in Regional Planning Groups supported a whole community planning approach which either developed new or stronger relationships amongst jurisdictions. This allowed for an integration of mitigation strategies for regions sharing common hazards. The Planning Team Regional Groups are broken down into five geographical areas in Pierce County: West Group (all of Gig Harbor, Key Peninsula, Herron Island, Fox Island and Raft Island), SW Group (Lakewood, Anderson Island, DuPont, Steilacoom), Central Group (Puyallup, Graham, Eatonville), NE Group (Buckley, Carbonado, Bonney Lake, Wilkeson, Orting), North Group (Tacoma, Fife, Edgewood, Milton, Sumner). The Regional Groups were developed based on geographic location and the commonality of hazards shared and continued with this update. This provides for better community planning, relationship building, and collaboration of mitigation strategies ultimately leading to community resiliency.

Elected Officials Meetings

Following approval of the Pierce County RHMP by Washington EMD and FEMA Region X, the Pierce County RHMP Team will assist all jurisdictional partners with Jurisdictional Annexes in the plan in bringing their plans before their governing boards and elected officials for adoption.

Data Limitations

For all Pierce County RHMP Base Plan and Jurisdictional Annex Sections, if there is a “TBD” written in any table or narrative, this indicates that there were data limitation gaps at the time of publishing.

Profile Process

Section 2

Table 1-16 "Section 2: Profile" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 2: Profile" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
History	Mission Statement
	Services Summary
Demographics & Natural Environment	Geo-Political Summary & Population Summary
Transportation Infrastructure	Infrastructure Summary
Economy	Economy Summary

The Pierce County RHMP Base Plan "Section 2: Profile" brings together an overview of Pierce County's history, demographics, natural environment, transportation infrastructure, and economy. Each Jurisdictional Annex's "Section 2: Profile" paints a comprehensive and place-base picture of each jurisdiction through a series of informational tables, a base map, and the jurisdiction's Mission and/or Vision Statement. The contents of each Jurisdictional Annex's "Section 2: Profile" came from documents and information provided by the jurisdiction, collaboration with other agencies, and relevant research. Jurisdictions provided Mission and/or Vision Statement, a list of the services they provide, an infrastructure summary, and general budgetary information. Other information was acquired leveraging existing Pierce County documents. All this information was reviewed and updated according to any new information brought forth by each jurisdiction.

History

The "History" Subsection of the Pierce County RHMP Base Plan was compiled from a variety of local historical resources. The narrative identifies early economic sectors in Pierce County, initial transportation infrastructure, and increasing military operations in the region. This section demonstrates how Pierce County has grown and developed from time immemorial to the modern day.

Pierce County Base Map

The Pierce County Base Map is a product of CountyView Pro (2025). Updated information on individual jurisdiction's boundaries was incorporated to create the current maps and to provide the most current information for this review. Furthermore, all Jurisdictional Annexes will include a Base Map in this subsection. Because of the land use and/or zoning authority for cities, towns, and Pierce County, these jurisdictions' profiles may include an additional Land Use Map and/or Zoning Map. Current information was provided by the individual cities and towns for use in this project, but similar information is not available for the other jurisdictions.

Demographics

The "Demographics" Subsection for the Pierce County RHMP Base Plan "Section 2: Profile" views Pierce County's demographics through a population, accessibility, and language lens. Data from the 2020 U.S. Census, 2024 Washington State Office of Financial Management (OFM) Estimate, and Pierce County 2021 Buildable Lands Report was used for demographic data in this RHMP Base Plan Section. The accessibility and language data for Pierce County residents in this RHMP Base Plan Section was derived from the 2024 OFM Estimate, the 2020 U.S. Census, and Pierce County Human Services. Additionally, Pierce County Human Services provided data for the 2025 Point-in-Time Count information.

Beyond the Pierce County RHMP "Demographics" Subsection, a demographic analysis was conducted for each of the Jurisdictional Annexes as well under each Jurisdictional Annex's "Demographics" and "Special Populations" Subsections. Each Jurisdictional Annex's "Demographics" Subsection has a "Comparing Population and Population Density: 2020 to 2025" table that compares the 2020 population, 2020 population density, 2025 population, 2025 population density, and percent change in population from 2020 to 2025 for both the jurisdiction and Pierce County as a whole.

Each Jurisdictional Annex's "Special Populations" Subsection has a "65-Years-Old and Older Populations and Under 18-Year-Old Populations as of 2025" table that compares 65-year-old and older as well as 18-year-old and younger populations for both the jurisdiction and Piere County. The population data in each Jurisdictional Annex's "Demographics" Subsection sets the foundation for each Jurisdictional Annex's Risk Assessment in the jurisdiction's corresponding "Section 4: Risk Assessment." Demographics data is necessary for assessing vulnerability and exposure to hazards.

Natural Environment

Geology

The Geology narrative details the geologic composition, geography, and topography of Pierce County. Included in the "Geology" Subsection is information about Pierce County's glacial history, river system, port, lakes, and islands. This overview was compiled from local geological and geographical resources.

Weather

The Weather portion of the "Natural Environment" Subsection describes Pierce County's climate. It explains how weather is influenced by the landscape, the seasonal precipitation trends, and predicted weather changes in the next century.

Transportation Infrastructure

The "Transportation Infrastructure" Subsection outlines the various modes of transportation and relevant infrastructure utilized throughout Pierce County. Major transportation methods include roadways (interstates, state highways, and arterial roadways), rail lines, regional airfields, ferry service, and public transportation. The Puget Sound Regional Council was used for a portion of the transportation data for Pierce County.

Economy

The Economy section provides an overview of Pierce County's major economic sectors, the City of Tacoma's role as an economic hub, educational resources supporting the local workforce, household incomes, and work to promote a more sustainable economy. Data for this section was compiled from the 2020 U.S. Census and the Economic Development Board for Tacoma-Pierce County.

Capability Identification Process

Section 3

Table 1-17 "Section 3: Capability Identification" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 3: Capability Identification" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
Capability Identification Process	
Federal Capabilities	
State Capabilities	
Local Capabilities	Legal and Regulatory Capability
	Administrative Capability
	Administrative Capability - Regional
	Technical Capability
	Fiscal Capability
	Specific Capability
	National Flood Insurance Program (NFIP) Capability
	Joint Planning Requirement

The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act 2000, Sandy Recovery Improvement Act of 2013, and the Water Infrastructure Improvements for the Nation Act of 2016, requires a "review and incorporation, if appropriate, of existing plans, studies, reports, and technical information" (44 CFR §201.6(b)(3)). For the purposes of the Jurisdictional Annexes, these elements are referred to as capabilities and the "review and incorporation" as a capability identification. The capability identification provides a scope for what mitigation actions can and cannot be implemented and identifies specific capabilities that each jurisdiction has which support the implementation of mitigation strategies. This includes mitigation strategies within the jurisdiction, as well as at the county, state, federal and Tribal government levels. Further, it identifies actions already undertaken to reduce hazard risk, regardless of whether formally labeled as mitigation actions or not. The identification therefore evaluates all aspects of each jurisdiction's governance that relate both directly and indirectly to mitigation activities.

Forms were developed and distributed to jurisdictions with five categories of capabilities identified: Legal and Regulatory, Administrative, Technical, Fiscal, and Specific Capabilities. Each

capability category provided information from previous mitigation plans and studies conducted by the Municipal Research and Services Center of Washington for consideration. The Pierce County RHMP Planning Team also provided supplemental information on federal and state programs, grants, and other assistance to support identification of local capabilities.

Each jurisdiction then completed the form by indicating whether the listed capability exists within the jurisdiction. The "Specific Capabilities" category provided a free response space for jurisdictions to expand their list of capabilities beyond the four standard capability categories. Once the information was reviewed by the local jurisdictions, it was compiled into a table for the individual jurisdiction's sections and finalized with them. Not all capability types are relevant to each jurisdiction, which was captured accordingly in the jurisdiction's table.

National Flood Insurance Program (NFIP) Requirement

The NFIP is a Federal Emergency Management Agency (FEMA) managed program that provides flood insurance to property owners, renters and businesses. This insurance coverage can help communities recover faster when floodwaters recede. The NFIP works with communities required to adopt and enforce floodplain management regulations that help mitigate flooding effects.[iii]

NFIP Compliance is relevant only to Pierce County RHMP cities, towns, and Pierce County itself. The Pierce County RHMP Base Plan "Section 3: Capability Identification" and each Jurisdictional Annexes' "Section 3: Capability Identification" has more detail on each jurisdiction's NFIP compliance standing.

Joint Planning Requirement

Natural and human-caused hazards occur across jurisdictional boundaries, and the mitigation strategies developed by jurisdictions to improve resilience and reduce hazard risks require collaboration across several disciplines (urban planning, engineering, emergency management, education, etc.). The implementation of hazard mitigation plans requires coordination between existing plans, studies, and reports. The Pierce County RHMP Base Plan's "Joint Planning Requirement" Subsection describes the plans, studies, reports, and technical information coordinated across all Jurisdictional Annexes.

Risk Assessment Process

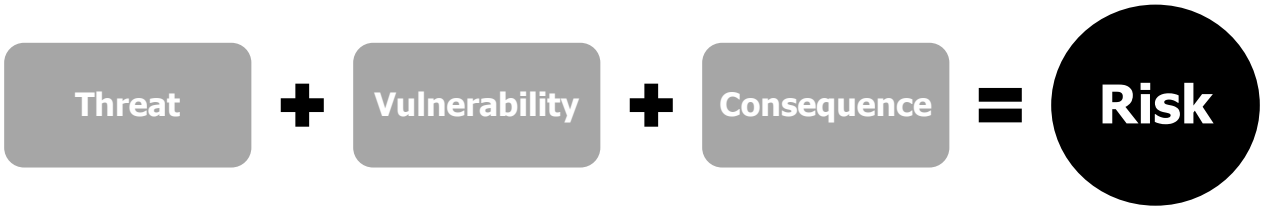
Section 4

Table 1-18 "Section 4: Risk Assessment" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 4: Risk Assessment" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
Risk Assessment Introduction	Section Overview
Hazard Subsection (one subsection per hazard)	Hazard Identification (one summary per hazard)
Identification Description	
Profile	
	Vulnerability and Consequence Analysis
	Hazard Maps

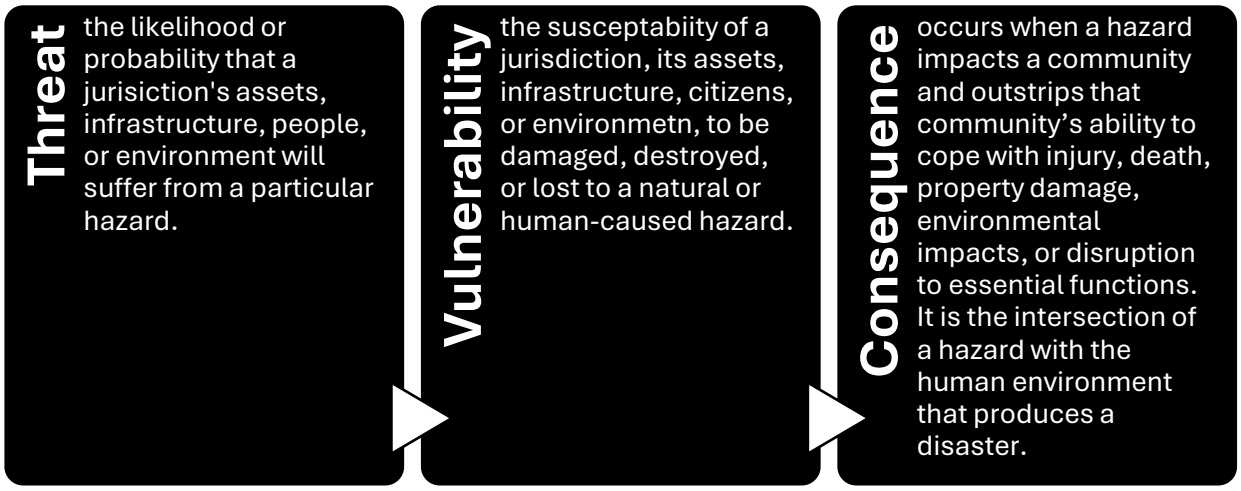
The Pierce County RHMP Risk Assessment uses multiple methods to quantify the risk that natural and human-caused hazards pose to communities. This Risk Assessment is consistent with local mitigation planning requirements outlined in 44 CFR §201.6(c)(2). The Pierce County RHMP Planning Team assessed risk using the following three components: threat, vulnerability, and consequence (Figure 1-2).

Figure 1-2 Risk Assessment Methodology



Threat, vulnerability, and consequence are defined in Figure 1-3. These elements of risk form the foundation for the Pierce County RHMP Risk Assessment methodology. Threats, including natural and human-caused hazards, are identified in the "Hazard Identification" Subsection of the Pierce County RHMP Base Plan "Section 4: Risk Assessment" and Jurisdictional Annexes. Vulnerability to these hazards is evaluated in the "Vulnerability Analysis" Subsections of the plans. Consequences, defined as seven areas of potential impacts to a jurisdiction, are analyzed in the "Consequence Analysis" Subsection of the plans.

Figure 1-3 Risk Definitions: Threat, Vulnerability, and Consequence



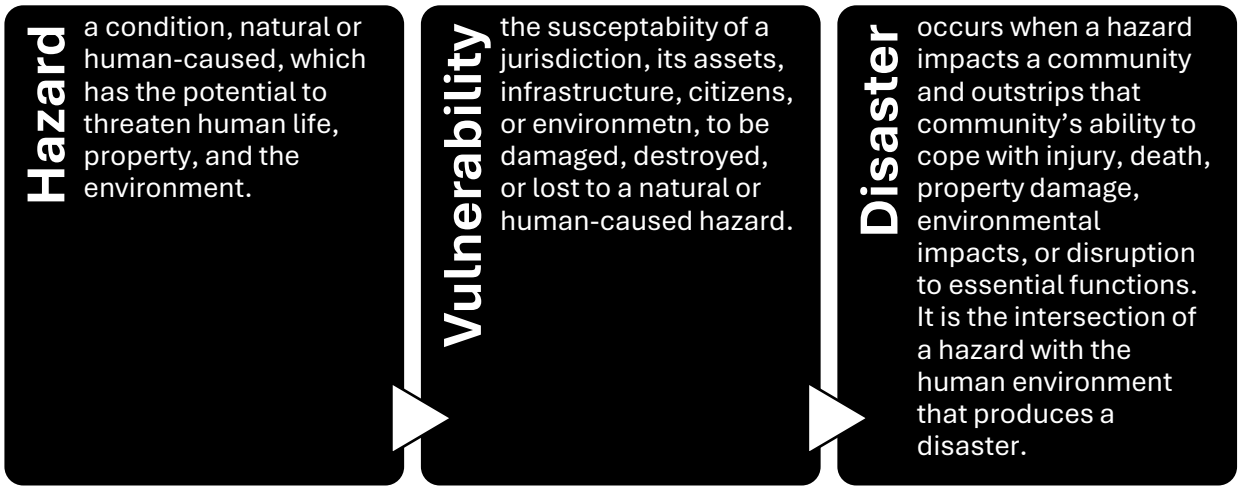
Hazard Identification Overview

The Base Plan and Jurisdictional Annexes

A critical function of the Risk Assessment is identifying Pierce County's hazards. The hazard identification process for this assessment references the 2020 PCDEM Hazard Identification and Risk Assessment (HIRA) process. Each of the 14 hazards included in the 2025 Pierce County RHMP were discussed and validated for frequency of occurrence, impacts to local jurisdictions, environmental impact, and economic impact.

Some natural and human-caused hazards have the potential to cause loss of life, property damage, and environmental impacts. However, not all hazards will overwhelm a community's capacity to cope and become disasters. The definitions of hazard, vulnerability, and disaster, presented in Figure 1-4, were developed and used to determine which hazards should be addressed in the Pierce County RHMP.

Figure 1-4 Hazard, Vulnerability, and Disaster Definitions



Natural and Human-Caused Hazard List

The purpose of a hazard mitigation plan is to reduce disaster risk and the impacts of hazards. PCDEM refined the Pierce County hazard list to include:

- Single, infrequent incidents which cannot be anticipated or predicted, and whose potential for loss of life, property, and environment is significant to the community, and;
- Repetitive incidents that can be predicted with reliability within days or hours, and cause injury or death, property damage, or environmental impacts.

The Pierce County RHMP's list of eight natural hazards is informed by Pierce County's computer mapping software, interviews with County officials, and interviews with local hazard subject matter experts, as detailed in the Pierce County RHMP Natural Hazard List Table (Table 1-19).

Table 1-19 Pierce Couty RHMP Natural Hazard List

Natural Hazards	
Drought	Severe Weather
Earthquake	Tsunami and Seiche
Flood	Volcano and Lahar
Landslide	Wildfire

Pierce County identified six human-caused hazards, which are listed in the Pierce County RHMP Human-Caused Hazard List Table (Table 1-20).

Table 1-20 Pierce County RHMP Human-Caused Hazard List

Human-Caused Hazards	
Civil Unrest	Epidemic and Pandemic
Cyber	Hazardous Materials and Transportation Accidents
Dam Failure	Terrorism and Extremism

PCDEM evaluated the natural and human-caused hazards present in Pierce County and developed the final hazard list by consolidating hazards with similar impacts on communities and similar mitigation approaches. For example, the severe weather hazard includes various types of inclement weather extremes: hail, ice storms, snowstorms, thunderstorms, windstorms, and heat hazards. Decisions regarding hazard consolidation were made by the Pierce County RHMP Planning Team and are explained in the "Types" Subsection of each hazard in the Pierce County RHMP Base Plan "Section 4: Risk Assessment." Once the list of hazards were determined, extensive research was conducted to update the Pierce County RHMP Base Plan "Section 4: Risk Assessment" with the best available science.

Hazard Occurrence and Recurrence

Recurrence probabilities in the Risk Assessment were based on the best available science at the time of publication, historic records when available, and information from local hazard experts. For some hazards, such as severe weather or floods, historic records are more frequent. For other hazards, such as volcanic eruptions or spontaneous lahars, recurrence can only be determined over time through scientific study and geologic inference. Recurrence of human-caused hazards is difficult to predict, as these events are immediate and often unpredictable. Despite the long and varied history of these hazards in Pierce County, accurately forecasting when human-caused hazards will occur again remains challenging.

Vulnerability Analysis Overview

The Base Plan and Jurisdictional Annexes

Once the updated Hazard Identification list was finalized, hazard evaluations were conducted for all Jurisdictional Annexes in the Pierce County RHMP. New hazard maps and hazard vulnerability data tables were developed at the county-level for the Pierce County RHMP Base Plan and at the local-level for each Jurisdictional Annex. These maps and data tables were only produced for the hazards with spatial data available to do so.

Hazard Vulnerability Table and Hazard Map Sources

The Pierce County RHMP Planning Team produced a series of hazard maps and hazard vulnerability data tables for the Pierce County RHMP Base Plan "Section 4: Risk Assessment" and each Jurisdictional Annex's "Section 4: Risk Assessment" using data from the following agencies: The National Drought Mitigation Center (NDMC), U.S. Department of Agriculture (USDA), National Oceanic and Atmospheric Administration (NOAA), Washington State Department of Natural Resources (DNR), Pierce County Planning and Public Works (PPW), Environmental Systems Research Institute (ESRI), Federal Emergency Management Agency's (FEMA) National Risk Index (NRI), ESRI U.S. Census Population Characteristics, Washington State Department of Ecology (DOE), U.S. Department of Transportation (USDOT), and Washington State Office of Financial Management (OFM) Small Area Estimates Program.

The Vulnerability Analysis Data Sources Matrix Table (Table 1-21) details all natural and human-caused hazards in the Pierce County RHMP, the sub-hazards considered in the Vulnerability Analysis, what hazard severity attributes were used for quantifying risk, and the data sources supporting the analysis. This data is utilized both on the county and local levels.

Table 1-21 Pierce County RHMP Vulnerability Analysis Data Sources and Maps Matrix

Vulnerability Analysis Data Sources Matrix			
Hazard Name	**Sub-Hazard**	**Hazard Severity Attributes**	**Data Source**
Drought		*Severe Drought*	NDMC, USDA, and NOAA
		Moderate Drought	
Earthquake	Tacoma Fault		WA DNR Geologic Survey
	Liquefaction	*High*	WA DNR and Pierce County PPW
		Moderate to High	
		Moderate	
		Low to Moderate	
		Low	
		Very Low	
		Bedrock	
		Peat	
		Ice	
		Water	
Flood	Floodplain		
Landslide		*Deep Landslides*	WA DNR Geologic Survey and Pierce County PPW
		Shallow Landslides	
	Steep Slopes	*Very High Slope*	Pierce County PPW and ESRI
		High Slope	
		Moderate Slope	
Severe Weather	Severe Weather Risk Index	*Very High*	FEMA NRI
		Relatively High	
		Relatively Moderate	
		Relatively Low	
		Very Low	
	Ice Events	*More than 3 Ice Events*	
		2 to 3 Ice Events	
		1 to 2 Ice Events	
	Winter Weather	*10 to 20 Events*	
		3 to 10 Events	
		1 to 3 Events	
		0 to 1 Events	
	Wind Event	*South Wind Event*	Pierce County PPW
		East Wind Event	
Tsunami and Seiche			WA DNR Geologic Survey

Vulnerability Analysis Data Sources Matrix			
Hazard Name	**Sub-Hazard**	**Hazard Severity Attributes**	**Data Source**
Volcano and Lahar			WA DNR Geologic Survey
Wildfire		*Very High Risk Probability*	Pierce County PPW
		High Risk Probability	
Civil Unrest		*Based on Population*	U.S. Census, ESRI, and WA State OFM
Cyber		*Based on Population*	U.S. Census, ESRI, and WA State OFM
Dam Failure		*1 Mile Buffer*	WA State DOE
Epidemic and Pandemic		*Based on Population*	U.S. Census, ESRI, and WA State OFM
Hazardous Materials and Transportation Accidents	Hazardous Materials	*NPMS Pipelines*	US DOT and Pierce County PPW
		NPMS Tanks	
		Tier II Sites	WA State DOE and Pierce County PPW
	Transportation Accidents	*Railroads*	US DOT and Pierce County PPW
Terrorism and Extremism		*Based on Population*	U.S. Census, ESRI, and WA State OFM

Vulnerability Analysis Methodology

The Pierce County RHMP Geographic Information Systems' (RHMP-GIS) analysis followed all standard GIS practices and tools to achieve high quality data analysis and results. The best available data was utilized for all portions of the process. Users of the data should be mindful of the limitations and proper use of the data. The data used, particularly parcels and natural resources layers, are ever-changing, and the RHMP-GIS analysis presents the best snapshot available of Pierce County as of the data of publication.

The first step in the process required identifying spatial data layers for both jurisdictions and hazards. The effort was focused on those layers not managed within the Pierce County Spatial Services Library of Spatial Data. Standard practices were incorporated to align outside data resources with Pierce County systems, including clipping, reprojecting, and stripping data as necessary.

Three different streams of data analysis and mapping occurred for the RHMP-GIS portion of the project: Maps; Parcels, Jurisdiction, and Hazard Analysis; and Population, Jurisdiction, and Hazard Analysis

Maps

The HMP-GIS process created a series of countywide and jurisdiction maps for each hazard for the Pierce County RHHMP using the collected data. The process of updating the Pierce County RHMP map series was scripted to increase production efficiency, storage and consistency of the maps.

Parcels, Jurisdiction, and Hazard Analysis

Pierce County tax-parcel data was intersected and joined with jurisdiction and hazard layers. The desired output was to find the number of parcels, parcel assessed tax value and land value, within each jurisdiction. Next, each hazard, and hazard area (acres/square miles) within each jurisdiction was calculated to find the hazard affected area of each jurisdiction and parcel value.

Population, Jurisdiction, and Hazard Analysis

The population affected within each jurisdiction, within each hazard, and within each jurisdictions hazard area was calculated for population totals and density per square mile. Population data provided by the U.S. Census was used to compare 2020 to 2025 population statistics, including age specific population groups that may be more vulnerable in an event. The process of combining jurisdiction layers, with each hazard, and intersecting with the population data was used.

GIS Processes

All data layers were minimally modified to maintain data integrity. Unrelated attributes were removed, and a common naming convention was applied across all layers to support processing of jurisdiction names, hazard names, and related attributes. The analysis involved a series of spatial joins and intersects, with calculations performed for area in acreage/square miles. Summary outputs were produced for each jurisdiction and hazard for their respective analysis stream.

Many GIS processes were scripted with ArcPy/Python – ArcPy/Python refers to automated GIS analysis using Python-based scripting tools in ArcGIS – to improve efficiency, repeatability and knowledge transfer. RHMP-GIS data processing is time-intensive due to the large file size and complexity of hazard datasets. Scripting reduces the potential for human-error and maximizes processing efficiencies. The data input layers included nine jurisdiction layers and twenty-one hazard layers, not including results outputs and temporary layers. These scripts followed the basic process flow outlined below.

- Base datasets, including jurisdictions and hazards, were stored and stored in separate geodatabases to support clear data organization and management.
- Parcels per jurisdiction were calculated and stored in an additional geodatabase.
- Jurisdiction layers were intersected/spatially joined with all hazard layers.
- A results geodatabase stored the outputs for the parcels-per-jurisdiction-per-hazard data layers.
- A similar workflow was used for the second data analysis stream for population data, which involved spatially joining jurisdiction and hazard data with the U.S. Census block group data.

The final phase of the analysis was to create usable data tables from the raw output layers. Summary tables of parcels, hazards, and population per jurisdiction and hazard were produced, including the sum totals of desired fields (value/size) per jurisdiction and hazard.

Final outputs were exported to XLSX spreadsheets to support use by non-GIS users and incorporate into the Jurisdictional Annex Vulnerability Analysis Tables. GIS datasets (geodatabases/scripts) were made available to the PCDEM team. The scripting process is available for repeatable analysis of hazards in future hazard mitigation plan updates.

Limitations and Data Considerations

The methodology described above represents PCDEM's approach to quantifying risk from natural hazards impacting Pierce County and all jurisdictions within the county. The methodology relies on proxy hazards to help quantify risk from certain hazards. For example, The Pierce County RHMP uses liquefaction risk in combination with proximity to the Tacoma Fault to approximate earthquake vulnerability.

Population Data Limitations

This methodology also prioritized consistency in quantifying risk across a wide range of jurisdictions from cities and towns, fire districts, utility service provider service areas, and other jurisdictional boundaries. All population estimates for 2020 and 2025 in each Jurisdictional Annex's "Section 2: Profile" and "Section 4: Risk Assessment" use U.S. Census block group data rather than census tracts for population data. To maintain geographic consistency across jurisdictions, PCDEM determined block groups to be the most appropriate unit of analysis.

As a result, population estimates in the Pierce County RHMP may differ from census tract-based estimates commonly used for jurisdictions. This creates a degree of variation in population data in comparison to the census tract population estimates for the jurisdictions in the Pierce County RHMP; however, the nature of quantifying risk and aligning it with consistent population data relies on estimation.

Map Data Limitations

Notably, when quantifying risk to hazards, risk cannot be measured in the same way for each hazard because of each hazard's unique qualities. Drought and severe weather are hazards that the Pierce County RHMP Risk Assessment – in both the Base Plan and Jurisdictional Annexes – measures through a "snapshot in time" lens due to the unique nature of these two hazards. Drought exposure is heavily dependent on the current drought conditions for when the drought data was collected; this is a data limitation. In the Pierce County RHMP Base Plan "Section 4: Risk Assessment," drought in Pierce County is measured through the U.S. Drought Monitor's Drought Severity Index and the Historical Standardized Precipitation Index. Drought risk for each jurisdiction is quantified in each Jurisdictional Annex "Section 4: Risk Assessment" with 2025 U.S. Drought Monitor Spatial Data.

Severe Weather data for each Jurisdictional Annex "Section 4: Risk Assessment" utilizes the FEMA NRI to quantify general severe weather risk, ice incidents, and winter storm incidents. Similar to drought, there are data limitations with severe weather as this data is heavily dependent on the current severe weather conditions for when the data was collected. In each Jurisdictional Annex, severe weather risk is also quantified through South Wind and East Wind Events. These metrics are not as heavily depended on current severe weather conditions.

Vulnerability Analysis

The Base Plan

The Pierce County RHMP Planning Team conducted a county-level vulnerability assessment for Pierce County as part of the Pierce County RHMP Base Plan "Section 4: Risk Assessment." Both threat-based and asset-based methods were used to determine the vulnerability of infrastructure to identified hazards. The Pierce County RHMP Base Plan "Section 4: Risk Assessment" includes detailed threat-based vulnerability, location, extent, and historical impact descriptions for each hazard.

Vulnerability Analysis

The Jurisdictional Annexes

The Pierce County RHMP Planning Team conducted a vulnerability assessment for local jurisdictions in the Pierce County RHMP "Section 4: Risk Assessment" for each Jurisdictional Annex. Vulnerability to natural and human-caused hazards is evaluated using data from the RHMP-GIS Mapping System and analyzed through four tables for each jurisdiction – along with a series of hazard maps. The Pierce County RHMP Base Plan "Section 4: Risk Assessment" includes threat-based vulnerability, location, extent, and historical impact descriptions for each hazard. Hazard frequently is also referenced in each Jurisdictional Annex.

Jurisdictional Annex Vulnerability Tables

Each Jurisdictional Annex includes the following vulnerability analysis tables:

- General Exposure to Natural and Human-Caused Hazards;
- Population Exposure to Natural and Human-Caused Hazards;
- General Infrastructure Exposure to Natural Hazards; and
- General Infrastructure Exposure to Human-Caused Hazards.

Due to the variable nature of hazards across Pierce County, risk exposure differs among jurisdictions. For example, the City of Gig Harbor may be at risk from a tsunami but have no risk from railroad transportation accidents, while East Pierce Fire & Rescue experiences the opposite. Both jurisdictions, however, have similar risks from severe weather hazards.

To determine jurisdictional vulnerability, the location and extent of each hazard was applied spatially to the jurisdiction's profile. The Jurisdictional Annex Vulnerability Analysis describes exposure of the population, both generally and categorically, to each hazard. It also describes exposure of general infrastructure in terms of property and value. Using this spatial analysis,

jurisdictions can track the overall effects of vulnerability reduction measures (e.g., mitigation strategies) by measuring the change in population and property exposure to hazards.

Risk Assessment Levels: Jurisdiction, Population, and Infrastructure

The Risk Assessment considers three components of risk and is conducted at three levels: the jurisdiction level, the population level, and the infrastructure level.

At the jurisdiction level, the assessment considers the fundamental characteristics population and property within the jurisdiction to determine vulnerability and consequence of each hazard. The Vulnerability Analysis: General Exposure Table in each Jurisdictional Annex shows the jurisdiction's area in square miles and the number of parcels, then breaks those values down by hazards affecting the jurisdiction.

At the population level, the Vulnerability Analysis: Population Exposure for General and Special Populations Table in each Jurisdictional Annex shows the total population of the jurisdiction and breaks it down by specific hazard and sub-hazard. This process is described in the Pierce County RHMP Vulnerability Analysis Data Sources and Maps Matrix Table (Table 1-21). This information was updated using the 2020 U.S. Census and to the current Pierce County RHMP hazard list.

At the infrastructure level, the assessment evaluates land value, improved value, and total assessed value for each jurisdiction using RHMP-GIS spatial analysis to calculate the values for each hazard. The "Vulnerability Analysis: General Infrastructure Exposure to Natural Hazards" Tables and "Vulnerability Analysis: General Infrastructure Exposure to Human-Caused Hazards" Tables in each Jurisdictional Annex show the updated general infrastructure exposure.

For all Vulnerability Analysis tables, if a hazard value is "N/A," it indicates that the Pierce County GIS Mapping System methodology did not quantify substantial risk for the hazard in that jurisdiction. An "N/A" value does not imply no risk; rather, the hazard did not meet the threshold for substantial risk according to the current Pierce County GIS Mapping System methodology.

Hazard Consequence Analysis

After each hazard was profiled in the Risk Assessment, a Consequence Analysis of hazard effects on different portions of Pierce County was added to each Jurisdictional Annex's "Section 4: Risk Assessment." The "Consequence Analysis" Subsection in each Jurisdictional Annex consists of two tables that prompt each jurisdiction to evaluate how natural and human-caused hazards could potentially impact their jurisdictions. When assessing the effects of an incident, consideration is given to both immediate damages and short and long-term consequences of

the disruption. Each jurisdiction responded with either a “yes” or “no” to indicate whether impacts would occur for each question listed below.

Consequence Analysis Questions

- How is the health and safety of persons in the affected area at the time of the incident affected?
- How is the health and safety of personnel responding to the incident affected?
- How is the jurisdiction’s continuity of operations affected, and can it continue to deliver services to the impacted area?
- What is the effect on the jurisdiction’s property, facilities, and infrastructure?
- What are the effects on the environment?
- How will the jurisdiction’s economic/financial environment be impacted?
- How will the public’s confidence in a jurisdiction be impacted or changed?

Hazus-MH

The Base Plan

The Pierce County RHMP Planning Team incorporated Hazus-MH 2.1 for enhanced earthquake risk analysis. Hazus-MH is a nationally-recognized standardized methodology that models potential losses from earthquakes, floods, and hurricanes. Hazus-MH uses GIS technology to estimate physical, economic, and social impacts of disasters. Hazus-MH was developed by Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). NIBS maintains committees of wind, flood, earthquake, and software experts to provide technical oversight and guidance for Hazus-MH development. Loss estimates produced by Hazus-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods, and earthquakes. Estimating losses is essential for decision-making at all levels of government, providing a foundation for developing mitigation plans and policies, emergency preparedness, response, and recovery efforts.

Mitigation Strategy Process

Section 5

Table 1-22 "Section 5: Mitigation Strategy" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 5: Mitigation Strategy" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
Mitigation Overview	Mitigation Strategy Overview & Mitigation Strategy Matrix Table
Mitigation Strategy Table Development	
Mitigation Strategy Narrative Development	Mitigation Strategy Narrative Description

Mitigation actions are short and long-term actions to reduce hazard-related risk. The process of developing and implementing mitigation actions relies on community risks and vulnerabilities, planning team expertise, public participation, community needs and capabilities, a cost/benefit review, and input from governing elected officials. Each Jurisdictional Annex's "Section 5: Mitigation Strategy" details actionable ways for jurisdictions to reduce loss of life and property following a disaster and build lasting community resilience to natural and human-caused hazards.

Definitions

Figure 1-15 Mitigation Strategy Formula

Mitigation Strategy = Pierce County Mitigation Goals +
Pierce County Mitigation Objectives +
Local Mitigation Goals +
Mitigation Actions

The Pierce County RHMP defines each Jurisdictional Annex's Mitigation Strategy (Figure 1-15) as being the combination of Pierce County Mitigation Goals, Pierce County Mitigation Objectives, Local Mitigation Goals, and Mitigation Actions. These terms are further defined in the Critical Mitigation Strategy Definitions Table (Table 1-23).

Table 1-23 Critical Mitigation Strategy Definitions

Mitigation Strategy Definitions	
Mitigation Strategy	**Jurisdictional Annex – Mitigation Strategy** Each Jurisdictional Annex identifies: • Pierce County Mitigation Goal • Pierce County Mitigation Objectives • Local Mitigation Goals • Mitigation Actions Combined, these four elements create the jurisdiction's overall mitigation strategy – a cohesive strategy to reduce short and long-term risk to natural and human-caused hazards. **Base Plan – Mitigation Strategy** The overall Regional Pierce County Mitigation Strategy combines all Jurisdictional Annex Mitigation Strategies.
Pierce County Mitigation Goals and Objectives	**Pierce County Mitigation Goals** A County-level desired result to reduce or avoid short and long-term vulnerability to hazards through mitigation strategies. **Pierce County Mitigation Objectives** Unlike goals, objectives are specific, measurable, and narrower in scope.
Local Mitigation Goal	Each jurisdiction's desired result to reduce or avoid short and long-term vulnerability to hazards through mitigation strategies.
Mitigation Action	Mitigation actions are short and long-term actions a community can take to reduce hazard-related risks.

Jurisdictional Annex Organization

Each Jurisdictional Annex's "Section 5: Mitigation Strategy" is organized into a "Mitigation Strategy Overview" Subsection and "Mitigation Strategy: Narrative Description" Subsection. An overview of these Subsections can be found in the Mitigation Strategy Core Elements Table (Table 1-24). A comprehensive list of mitigation actions is listed in the Mitigation Strategy Matrix Table of each Jurisdictional Annex and further described in the "Mitigation Strategy: Narrative Description" Subsection.

Table 1-24 Mitigation Strategy Section Core Elements

Jurisdictional Annex: Mitigation Strategy Organization Overview		
	"Mitigation Strategy Overview" Subsection	**"Mitigation Strategy: Narrative Description" Subsection**
Core Element	**"The Mitigation Strategy Matrix" Table** *A comprehensive list of all of a jurisdiction's mitigation actions*	**A more detailed description of each mitigation action** *A narrative mitigation action description, relevant status updates, and a mitigation strategy feasibility evaluation*

Mitigation Strategy Table Development

The Mitigation Strategy Matrix Table provides a high-level overview of all mitigation actions for each jurisdiction and collectively forms the jurisdiction's overall mitigation strategy. The jurisdiction's overall mitigation strategy describes a cohesive approach to reducing short and long-term risk to natural and human-caused hazards. The Mitigation Strategy Matrix Table in each Jurisdictional Annex describes the following elements:

- **Implementation Mechanism Category:** Groups of similar mitigation strategies that describe how each mitigation action will be implemented on the local level;
- **Mitigation Action and Hazard Type:** Identifies the natural or human-caused hazards each mitigation action addresses, as defined in the Hazard Code Key Table (Table 1-25);
- **Lead Jurisdiction/Department:** Identifies the entity responsible for completing the mitigation action and tracking progress;
- **Timeline:** Indicates the estimated duration to complete the action; and
- **Plan Goals Addressed:** Specifies how many of the Pierce County RHMP Planning Team goals are addressed by the mitigation action.

Implementation Mechanism Categories

Mitigation actions in the Mitigation Strategy Matrix Table are grouped by similar local implementation strategies. Implementation Mechanism Categories support each Jurisdictional Annex's overall mitigation strategy by organizing actions into implementable categories of related mitigation actions.

The Mitigation Strategy Matrix Table is organized by the following categories:

- **Completed and Deferred Mitigation Strategies:** These mitigation actions were either completed or put on hold in prior updates of the Pierce County RHMP. In the 2020 update, completed and deferred actions were documented in "Appendix F" of each Jurisdictional Annex. Integrating the completed and deferred actions into the primary mitigation actions section allows jurisdictions to quickly identify actions completed in previous years and more easily remove outdated deferred actions or elevate them to full mitigation actions during the five-year plan update cycle;
- **Continued Mitigation Strategies:** This category includes three categories that are common across all Jurisdictional Annexes: *Existing Mitigation Actions, Plan Maintenance,* and *Pierce County Hazard Mitigation Forum (HMF)*;
- **Organization-Wide Mitigation Strategies**: Most mitigation actions fall within this category and are implemented by the jurisdiction or entity represented in each Jurisdictional Annex; and
- **Public Education Mitigation Strategies:** This category includes mitigation actions focused on public education and community engagement.

Mitigation Action Name and Hazard Type

Hazard codes (Table 1-25) are used to streamline the Mitigation Strategy Matrix Tables and improve ease of navigation. In the "Endnotes" Subsection of each Jurisdictional Annex, a comprehensive Hazard Code and Implementation Mechanism Code Table connects each hazard analyzed in the Pierce County RHMP to the corresponding shorthand code.

Table 1-25 Hazard Code Key

Hazard Code Key			
EQ	Earthquake	**T**	Tsunami and Seiche
FL	Flood	**V**	Volcanic (Lahar or Tephra-Specific)
D	Drought	**WF**	Wildfire
LS	Landslide (deep or shallow)	**HC**	Human-Caused Hazards
SW	Severe Weather (wind-specific)	**MH***	Multi-Hazards (where only natural hazards are addressed, it is noted)
** This code is only used for mitigation action prioritization (see "Mitigation Action Status Update" Subsection).*			

Lead Jurisdiction/ Department

The lead jurisdiction and/or department identified for each mitigation action is responsible for implementation and oversight of progress.

Timeline

Mitigation action timelines describe the anticipated duration for full implementation. In each jurisdiction's "Mitigation Strategy: Narrative Description" Subsection, mitigation actions are categorized as ongoing, completed, or deferred. Within the Mitigation Strategy Matrix Table, actions are further categorized as ongoing, short-term, and long-term.

- **Ongoing Actions:** These actions are currently being implemented by the jurisdiction.
- **Short-Term Actions:** These actions can be implemented within one to two years using existing resources and authorities.
- **Long-term Actions:** These actions may require new or additional resources or authorities and are expected to take between one and five years to implement.

Plan Goals Addressed

The Jurisdictional Annex's Mitigation Strategy Matrix Table includes descriptions of Pierce County Mitigation Goals and Local Mitigation Goals, which aim to reduce or avoid short and long-term vulnerabilities to all natural and human-caused hazards identified in the Pierce County RHMP Base Plan's "Section 4: Risk Assessment". The list of county-level and local goals is the same but differ based on who is implementing the goals. The goals are consistent with FEMA and Washington State Emergency Management Division's (WA EMD) mitigation goals. The Pierce County RHMP Planning Team has identified the following goals for inclusion in the Pierce County RHMP:

Protect Life and Property;
Ensure Continuity of Operations;
Establish and Strengthen Partnerships for Implementation;
Protect the Environment;
Increase Public Preparedness for Disasters and
Promote a Sustainable Economy.

Mitigation Objectives

A mitigation objective serves as the link between an overarching mitigation goal and the completion of the mitigation action associated with that goal. Jurisdictions used the following questions to guide the development of specific mitigation objectives:

- What is the jurisdiction trying to protect?
- Who is the jurisdiction trying to protect?
- Who does the jurisdiction provide service to?

- Who does the jurisdiction rely on for service?
- What existing plans are in the jurisdiction?

To support this process, PCDEM provided example objectives and potential mitigation actions to assist jurisdictions with developing mitigation actions.

Mitigation Goal: Protect Life and Property

Mitigation objectives that address this goal include, but are not limited to:

- Implementing activities protect lives by making homes, businesses, infrastructure, critical facilities, and other property more resistant to all hazards;
- Reducing losses and repetitive damages for chronic hazard incidents while promoting insurance coverage for catastrophic hazards; and
- Improving hazard assessment information to make recommendations for encouraging preventative measures for existing development in areas vulnerable to all hazards.

Mitigation Goal: Ensure Continuity of Operations

Mitigation objectives that address this goal include, but are not limited to:

- Establishing policies to ensure mitigation projects for critical facilities, services, and infrastructure;
- Strengthening emergency operations by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry; and
- Coordinating and integrating hazard mitigation activities, where appropriate, with emergency operations plans and procedures.

Mitigation Goal: Establish and Strengthen Partnerships for Implementation

Mitigation objectives that address this goal include, but are not limited to:

- Strengthening communication and coordinating participation among and within public agencies, citizens, non-profit organizations, business, and industry to ensure interest in implementation; and
- Encouraging leadership within public and private sector organizations to prioritize and implement local, county, and regional hazard mitigation activities.

Mitigation Goal: Protect the Environment

Mitigation objectives that address this goal include, but are not limited to:

- Balancing watershed planning, natural resource management, and land use planning with hazard mitigation to protect life, property, and the environment; and
- Preserving, rehabilitating, and enhancing natural systems to serve hazard mitigation functions.

Mitigation Goal: Increase Public Preparedness for Disasters

Mitigation objectives that address this goal include, but are not limited to:

- Developing and implementing education and outreach programs to increase public awareness of the risks associated with all hazards; and
- Providing information on tools, partnership opportunities, and funding resources to assist in implementing mitigation activities.

Mitigation Goal: Promote a Sustainable Economy

Mitigation objectives that address this goal include, but are not limited to:

- Providing incentives and resources for mitigation planning and continue critical business operations.

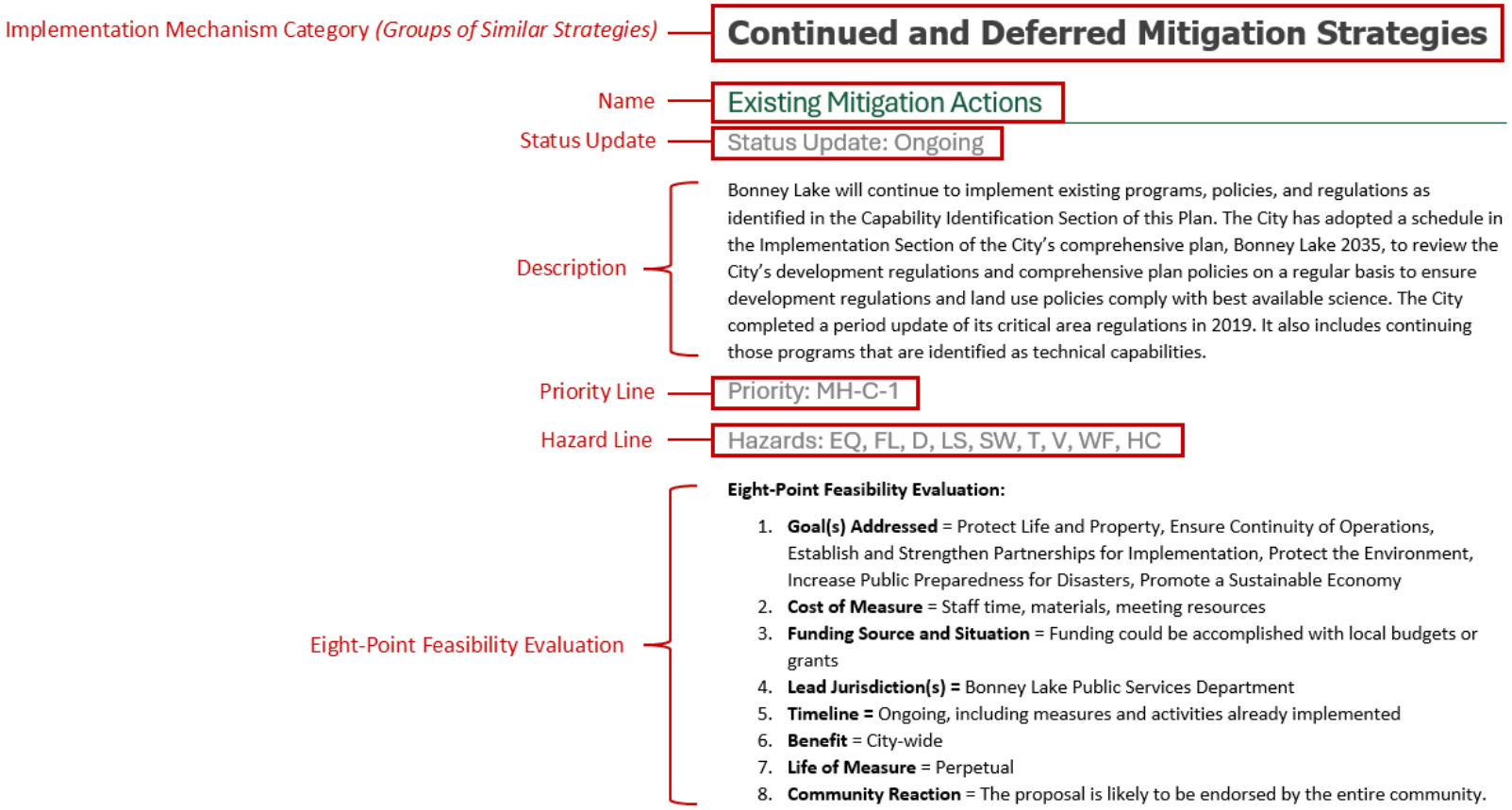
Mitigation Strategy Narrative Development

Building upon the Mitigation Strategy Matrix Table, each jurisdiction's mitigation actions are described in greater detail in the "Mitigation Strategy: Narrative Description" Subsection. Each narrative description addresses four components of the mitigation action.

- **Mitigation Action Description:** What are all the hazards that this action mitigates, and how does this mitigation action accomplish mitigating these hazards?
- **Mitigation Action Status Update:** What is the general status update of this action?
- **Eight-Point Feasibility Evaluation**: How feasible is this mitigation action to implement with each jurisdiction's existing resources?
- **Mitigation Action Prioritization**: What priority is this action in comparison to other actions in the same implementation mechanism category?

An example of how a Jurisdictional Annex's "Section 5: Mitigation Strategy" Subsection narrative addresses all four components of a mitigation action is provided below in Figure 1-6.

Figure 1-6 Sample Mitigation Action Organization



Mitigation Action Descriptions

For each mitigation action, a *Hazard* line lists all the hazards addressed by that action and is coded according to Table 1-25. Each action also includes a narrative description explaining how it effectively mitigates the hazards in the *Hazard* line.

Mitigation Action Status Update

Each mitigation action has a *Status* line indicating one of three options: Ongoing, Completed, or Deferred. Ongoing actions are still in progress, completed actions require no additional work, and a deferred actions are not currently active but may be revisited in the next Pierce County RHMP update.

Eight-Point Feasibility Evaluation

Mitigation actions were developed through the planning process and require data-collection, research, and public participation. The Pierce County Base Plan "Section 4: Risk Assessment" and each Jurisdictional Annex "Section 4: Risk Assessment" were critical to this process, as they identified the hazards that each jurisdiction is most vulnerable to and guided the creation of mitigation actions to address those vulnerabilities. A review of existing mitigation actions was also conducted to determine which mitigation actions were accomplished in the past five years and to assess new or additional actions that should be added.

Once mitigation actions are identified, each jurisdiction conducts an *Eight-Point Feasibility Evaluation*. Using the capabilities identified in the Jurisdictional Annex, "Section 3: Capability Identification," each jurisdiction evaluated how feasible the proposed mitigation actions are with existing resources.

Through meetings with partners and review of other local mitigation plans, the Pierce County RHMP Planning Team identified eight categories to comprehensively assess each mitigation action.

1. **Goal(s) Addressed**

   What mitigation goals, as developed by each jurisdiction, does the action address?

2. **Cost of Measure**

   How much will the action cost to implement?

3. **Funding Source and Situation**

   What is the potential funding source? Choose the statement(s) below that most accurately defines the funding situation for the proposal.

   - Funding could be obtained through local budget.
   - Funding could be obtained through state or federal grants.
   - Funding could be accomplished with local budgets or grants.
   - No potential funding sources can be readily identified.

4. **Lead Jurisdiction**
5. **Timeline**

   How long will it take to implement? Actions included ongoing, short-term, and long-term activities. Each action included an estimate of the timeline for implementation.

   - Ongoing actions are activities which the jurisdiction is already implementing.
   - Short-term actions are activities which the jurisdiction is capable of implementing with existing resources and authorities within one to two years.
   - Long-term actions may require new or additional resources or authorities and may take between one and five years to implement.

6. **Benefit**

   Does it benefit all jurisdictions and/or is it facility specific?

7. **Life Expectancy of Measure**

   How long will the action last?

8. **Community Reaction**

   Choose the statement(s) that most accurately describes how the community would react to the implementation of the proposal.

   - The proposal is likely to be endorsed by the entire community.
   - The proposal would benefit those affected, with no adverse reaction from others.
   - The proposal would be somewhat controversial.
   - The proposal would be strongly opposed by most.
   - The proposal would be strongly opposed by nearly all.

An action's ability to be implemented is assessed in Categories 2 (Cost of Measure), 3 (Funding Source and Situation), and 4 (Timeline). The extent to which an action mitigates one or more hazards is captured in Category 1 (Goals Addressed), reflecting the jurisdiction's specific vulnerabilities and needs. Category 5 (Benefit) also addresses the number of hazards mitigated. For cost-benefit considerations, Categories 2, 3, and 5 focus on cost, while Category 6 (Life Expectancy of Measure) directly addresses benefit. Category 7 (Community Reaction) indirectly considers both potential costs and potential benefits by evaluating public opinion.

The evaluation process included meetings where the Pierce County RHMP Planning Team reviewed all mitigation actions, with specific attention paid to action definitions, the ability of the actions to be implemented, alignment with jurisdictional hazards, and cost-effectiveness.

Mitigation Action Prioritization

Once a mitigation action has been identified, defined, and evaluated, the next step is prioritization. This process considers the identified risks and vulnerabilities, local expertise, public participation, jurisdictional needs and capabilities, a cost/benefit review, and input from the chief elected officials. Over several weeks, the Pierce County RHMP Planning Team presented, outlined, categorized, and prioritized each mitigation action.

In each Jurisdictional Annex's "Section 5: Mitigation Strategy," every mitigation action has a *Priority* line indicating the priority of the action compared to other actions in the same implementation mechanism category. Each *Priority* line has two codes and a number:

- The first code is a hazard code and represents all the hazards the mitigation action addresses (see Table 1-25);
- The second code is an implementation mechanism code and represents what implementation mechanism is utilized to accomplish this mitigation action (see Table 1-26); and
- Each number represents the priority ranking of that mitigation action where 1 is the highest priority and higher numbers have lower priority.

Table 1-26 Implementation Mechanism Code Key

Implementation Mechanism Code Key			
CD	Completed and Deferred	**SD**	School District
C	Continued	**U**	Utility
CG	City Government	**O**	Other*
FD	Fire District	**PE**	Public Education
** When a jurisdiction falls into the "Other" Discipline Group, instead of using "O" as their code, some use a code closer to the jurisdiction's name. This code is recorded in the "Endnotes" of the Jurisdictional Annex, "Section 5: Mitigation Strategy"*			

For consistency, the planning process's *Eight-Point Feasibility Evaluation* served as the basis for prioritizing mitigation actions, with emphasis on cost-effectiveness. While positive benefit-cost review is important, prioritization also considers local political factors, community needs and values, historic properties, and habitat and environmental concerns. Overall, the prioritization process addresses each jurisdiction's unique needs, the action's ability to be implemented, and the extent to which it would mitigate one or more relevant hazards.

Infrastructure Process

Section 6

Table 1-27 "Section 6: Infrastructure" Base Plan and Jurisdictional Annex Subsection Organization Comparison

"Section 6: Infrastructure" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
Infrastructure Section Format	Infrastructure Overview
Public Disclosure	Infrastructure Summary and Vulnerability*
	Comprehensive Infrastructure Table*
** These Subsections are not publicly available*	

"Section 6: Infrastructure" is not a required element of a local hazard mitigation plan. The Pierce County RHMP Planning Team determined that including infrastructure strengthens the plan as a comprehensive blueprint for reducing potential losses identified in "Section 4: Risk Assessment." Existing infrastructure sections were reviewed and updated for this plan update.

Jurisdictional Annex's "Section 6: Infrastructure" is exempt from public disclosure pursuant to RCW 42.56.420. Requests for public disclosure of this section, or parts thereof, should be referred to the appropriate jurisdiction representative.

Definition

The Pierce County RHMP Planning Team determined that the plan should include infrastructure that meets FEMA's definition of a *critical facility*[4], as well as other infrastructure that play a key role in disaster response and recovery. Jurisdictions identified infrastructure that must be operational, are essential to community welfare, or are required for daily functioning, such as sewage treatment plants and schools, which may also serve as shelters.

Identification

Over five years, changes can occur across all planning groups, such as buildings being torn down and new structures being constructed. A template was provided to each jurisdiction to document their infrastructure and any changes for this plan update. Members of the Pierce County RHMP Planning Team, together with facility representatives, completed the templates for new structures or systems and identified infrastructure to be removed. This process

informed the updated hazard identification and risk information for each location, relying on professional judgment of the facilities, environment, and operational status. Each jurisdiction reviewed and updated their critical infrastructure section as part of this plan update.

Profile

To better understand the capabilities of existing infrastructure, a template was developed to identify and document essential components. The template included the following:

- Address of Infrastructure;
- Shelter: Yes Or No;
- Auxiliary Power Source;
- Year Built;
- Number of Floors (If Structure);
- Major Remodels, Upgrades, Or Additions;
- Insured Value;
- Occupancy Day and Night;
- Population Served;
- Homeland Security Infrastructure Category[5]; and
- Critical Within 72 Hours or Not.

Each Jurisdictional Annex includes a Comprehensive Infrastructure Table that summarizes the essential components of the jurisdiction's infrastructure, as outlined in the template. These details are organized using codes, which are explained in the Jurisdictional Annex Comprehensive Infrastructure Code Table (Table 1-28).

Table 1-28 Jurisdictional Annex Comprehensive Infrastructure Code Table

Code	Explanation
C	Infrastructure critical in first 72 hours after disaster
AP	Infrastructure has auxiliary or backup power
(#)	Homeland Security Infrastructure Category Number
S	Infrastructure is a designated community shelter

Once the infrastructure was identified, the Pierce County RHMP Planning Team visited each jurisdiction, met with the facility representative, toured the site, photographed infrastructure, and assessed the facility's hazard vulnerabilities. The assessment did not require detailed engineering studies, on-site inspections, or measurements; however, it did rely on the professional judgment of the facility representatives regarding the building, system,

environment, and operational status. Each jurisdiction reviewed, validated, and updated their infrastructure inventory for this plan update.

Infrastructure Summary

"Section 6: Infrastructure" for each Jurisdictional Annex begins with a summary table showing the total number of infrastructure assets and their value, as assigned by the jurisdiction's budgetary process. These values were updated to reflect the current infrastructure inventory and the most recent assessed or insured values.

Infrastructure Category Summary

Using the Homeland Security Infrastructure Sectors, each jurisdiction's infrastructure was categorized by sector, with some being further broken down by infrastructure type. This information is depicted in the Comprehensive Infrastructure Table of each Jurisdictional Annex and is current as of this plan update.

Dependency Matrix

In addition to the capability categories of each jurisdiction, each Jurisdictional Annex illustrates the external departments, agencies, and organizations that the jurisdiction relies on for daily operations. This information is visualized in the Infrastructure Dependency Matrix. This Matrix has been updated to reflect changes to services and is current as of this plan update.

Vulnerability Assessment

The Pierce County RHMP Planning Team conducted vulnerability assessments throughout the planning period. The assessments built on the eight previously identified hazards, the additional hazards added during this update, and the risk they pose to each jurisdiction's infrastructure. The process specifically evaluates how identified hazard events could damage or disrupt existing facilities.

To standardize the assessments, the Pierce County RHMP Planning Team developed a form using qualitative numeric criteria. Each piece of infrastructure was evaluated against all identified hazards and the five primary dependencies considered in this review. Ratings ranged from 0 to 3, with 0 indicating no vulnerability and 3 indicating the most vulnerability. These ratings are summarized in the Comprehensive Infrastructure Table in each Jurisdictional Annex, with the full basis for the ratings provided in the Comprehensive Infrastructure Table Key – Hazard Ratings Table and the Comprehensive Infrastructure Table Key – External Dependency Category.

The following scale was devised for the ratings.

0-1 → Low Hazard/Dependency Vulnerability Rating (L)

2 → Medium Hazard/Dependency Vulnerability Rating (M)

3 → High Hazard/Dependency Vulnerability Rating (H)

The Infrastructure Section is a summary of composite vulnerability scores and ratings for each piece of infrastructure, compiled and updated by the infrastructure owners and the Pierce County RHMP Planning Team. For some infrastructure, information was unavailable due to time and resource constraints. This data will be collected over the next five years, and "TBD" (To Be Determined) is used to indicate infrastructure for which information is pending.

Plan Maintenance Process

Section 7

"Section 6: Infrastructure" | Subsection Organization Comparison	
Base Plan	**Jurisdictional Annex**
Plan Maintenance Procedures Overview	Plan Maintenance Procedures Overview
Plan Adoption	Plan Adoption
Maintenance Strategy	Maintenance Strategy
Continued Public Involvement	Continued Public Involvement

Hazard mitigation plans must be reviewed and updated at least once every five years to remain eligible for Federal Emergency Management Agency (FEMA) mitigation funding (44 CFR § 201.6(d)(3)). Updates include changes in development, mitigation actions, and hazard priorities or vulnerabilities. Implementing this plan maintenance process ensures that the Pierce County Regional Hazard Mitigation Plan (RHMP) remains a living document that is eligible for FEMA mitigation funding.

"Section 7: Plan Maintenance" of the Pierce County RHMP Base Plan and Jurisdictional Annexes further describe the processes to keep the plan current, focusing on three elements: plan adoption, plan maintenance strategy, and continued public involvement.

Plan Adoption

Plan adoption involves submitting the Pierce County RHMP to Washington State Emergency Management Department (EMD) and FEMA during each five-year planning cycle. Before the plan is adopted, the Pierce County RHMP and Jurisdictional Annexes undergo a "Pre-Adoption Review" by Washington State EMD and FEMA Region X. This review may require changes prior to final approval. Once approved by Washington State EMD and FEMA, each jurisdiction must formally adopt the plan through its governing board.

The Pierce County RHMP will go through this adoption process during each five-year planning cycle.

Plan Maintenance Strategy

The Pierce County RHMP is maintained through a coordinated, multi-jurisdictional process to ensure the plan is current, effective, and compliant with lawful requirements. Pierce County Department of Emergency Management (PCDEM) coordinates the plan maintenance process for the Pierce County RHMP Base Plan and the Jurisdictional Annexes.

The maintenance strategy for the Pierce County RHMP Base Plan and the Jurisdictional Annexes establishes methods to implement, monitor, and evaluate the plans. This strategy promotes collaboration, information sharing, and innovation. Through a multi-tiered approach, jurisdictions provide a localized strategy for loss reduction while advancing coordinated policies and programs that address their community needs.

Hazard Mitigation Forum

The Pierce County Hazard Mitigation Forum (HMF) is composed of representatives from unincorporated Pierce County and all jurisdictions, partially or wholly, within its boundaries that have participated in mitigation planning efforts. The Pierce County HMF serves as the coordinating body for multi-jurisdictional mitigation initiatives and provides a mechanism to share best practices, strengthen coordination, and advance efforts to build a more disaster-resilient Pierce County.

Continued Public Involvement

Continued public involvement is essential to the review and update process. The three-tiered implementation approach supports ongoing public participation throughout the planning cycle. Prior to submitting the Pierce County RHMP to Washington State EMD and FEMA for review, participating jurisdictions will hold public information and comment meetings.

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Endnotes

[1] State and Local Mitigation Planning How-to Guide, Getting Started: building support for mitigation planning, FEMA 386-1, September 2002, p. 3-1.

[2] Jessie Strongitharm, Guide to Accessible Colors, Guide to Accessible Colors Palettes [Templates Included]

[iii] Overview on the NFIP, obtained from FEMA, https://www.fema.gov/flood-insurance

[4] Critical Facilities: Can be broken into 5 categories: **Essential Facilities** are critical to the health and welfare of the population and that are especially important following hazard events. They include hospitals and other medical facilities, police and fire stations, EOCs, evacuation centers, and schools. **Transportation Systems** include airways – airports, heliports; highways – bridges, tunnels, roadbeds, overpasses, transfer centers; railways – trackage, tunnels, bridges, rail yards, depots; and waterways – canals, locks, seaports, ferries, harbors, dry-docks, and piers. **Lifeline Utility Systems** include potable water, wastewater, oil, natural gas, electric power and communication systems. **High Potential Loss Facilities** include such things as dams, nuclear power plants and military installations. **Hazardous Materials Facilities** include facilities housing industrial/hazardous materials, August 2001, p. 3-9

[5] Not all Homeland Security Categories were given as options, only those that the jurisdictions would fall under. These included: Emergency Services, Telecommunications, Transportation, Water, Energy, Government, and Commercial.

Section 2: Profile

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Profile Requirements

Code of Federal Regulations 44

No Code of Federal Regulations Requirements in this Section.

Section 2: Profile

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Base Plan

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History

While Indigenous peoples have lived in the Pierce County area since time immemorial. In regard to the foundation of Pierce County, British Captain George Vancouver explored and mapped the Puget Sound in 1792. Spending time in what is now Pierce County, he named its most prominent geographic and geologic feature, Mount Rainier. Indigenous peoples had long known the mountain as “Tahoma," "Tacobet," "Tuwouk," and "Tacoba”.[1]

Between Vancouver’s voyages and the establishment of fur-trading operations in the 1830s, the area remained largely unknown. Fort Steilacoom, established in 1849, was the first military base on Puget Sound and became the first incorporated town in what would later become Washington State in 1854. Immigration increased from the late 1840s and in 1852, the Territorial Legislature of Oregon created the County of Pierce out of Thurston County. Pierce County was named after the newly elected President, Franklin Pierce.

The Medicine Creek Treaty of 1854 significantly curtailed Indigenous land rights in the Puget Sound Basin. The loss of treaty-recognized lands and access, combined with other grievances, led to armed conflicts from 1855 to 1856. Chief Leschi, a leader in the resistance, was controversially executed in 1858 and later exonerated in 2004 by a special historical court that ruled, as a combatant in war, he “should not, as a matter of law, have been tried for the crime of murder.”[2]

In 1887, the Northern Pacific Railroad completed the first northern-route transcontinental railroad, establishing its western terminus in Tacoma. This development spurred the growth of the shipping and manufacturing industries throughout the Puget Sound region.

Lumber and farming were central to Pierce County’s early economy. Old-growth forests were logged, with the timber used to construct homes, businesses, infrastructure, or burned as fuel.[3] Much of the lumber and raw logs were shipped to other cities and, eventually, overseas. Agriculture evolved from subsistence farming to commercial production. Farms ranged from small family operations to large-scale businesses producing vegetables, berries, hops, rhubarb, eggs, and dairy products. Coal mining also began in eastern Pierce County in the late 1870s, supporting several small towns near Mount Rainier.

Interest in Pierce County’s recreational potential also developed early on. In 1883, James Longmire camped near several soda and iron springs at the base of Mount Rainier and later established the area’s first hotel. On March 2, 1899, President McKinley signed an act establishing Mount Rainier National Park, the nation's fifth national park.

The development of a major military complex has also shaped economy of Pierce County. Fort Lewis was established in 1917, followed by McChord Air Force Base in 1938. On February 1,

2010, the two bases were combined to form Joint Base Lewis-McChord. In addition to a large active-duty military population, many service members have returned to the area as permanent residents after completing their military service.

Cities and towns throughout Pierce County developed in response to the region's primary economic drivers, including logging, coal mining, agriculture, lumber, shipping and the military. Today, the county's economy continues to evolve. Coal is no longer mined, many farmlands have transitioned to industrial warehousing, and while lumber remains an important contributor, economic activity is no longer dominated by a single industry.

Understanding Pierce County's historical development, including its Indigenous heritage, settlement patterns, economic drivers, and infrastructure growth, provides context for the distribution of population, land use, and critical facilities. These are key factors in assessing current hazard exposure and planning for effective mitigation strategies.

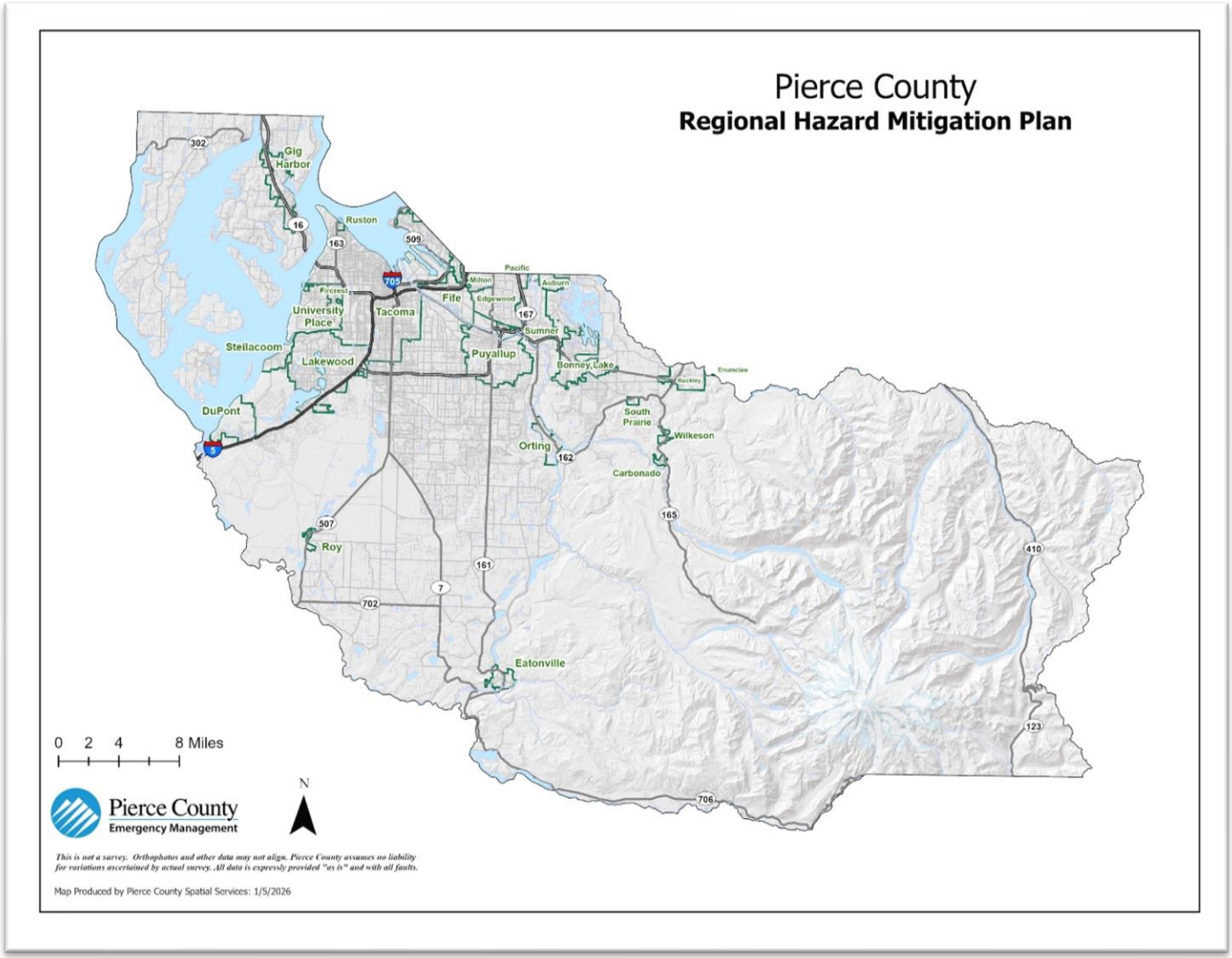
Plan Organization

The 2025 Pierce County Regional Hazard Mitigation Plan (RHMP) includes a total of 65 jurisdictions grouped by the following disciplines: Cities and Towns, Fire, Education, Utility, and Other. These 65 jurisdictions all began the 2025 Pierce County RHMP planning process together. See the 2025 Pierce County RHMP Jurisdictions Organized by Discipline Groups Table (Table 2-1) and the Pierce County Base Map (Map 2-1) for representation of jurisdictions. Each jurisdiction has an individual Jurisdictional Annex that serves as their jurisdiction's Hazard Mitigation Plan.

Table 2-1 2025 Pierce County RHMP Jurisdictions Organized by Discipline Groups

2025 Pierce County RHMP Jurisdictions				
Cities and Towns	**Fire**	**Education**	**Utility**	**Other**
City of Bonney Lake	Anderson Island Fire & Rescue	Carbonado Historical School District	Crystal River Ranch Association	Community Health Care
City of Buckley	Pierce County Fire District #23	Clover Park School District	Firgrove Mutual Water Company	Parks Tacoma
City of Dupont	Central Pierce Fire & Rescue	Dieringer School District	Fruitland Mutual Water Company	Pierce Transit
City of Edgewood	East Pierce Fire & Rescue	Eatonville School District	Graham Hill Mutual Water Company	Port of Tacoma
City of Fife	Gig Harbor Fire & Medic One	Fife School District	Lakeview Light and Power Company	Unincorporated Pierce County
City of Fircrest	Key Peninsula Fire Department	Franklin Pierce School District	Lakewood Water District	
City of Gig Harbor	Pierce County Fire Protection District #13	Orting School District	Mt. View-Edgewood Water Company	
City of Lakewood	Riverside Fire & Rescue	Pacific Lutheran University	Ohop Mutual Light Company	
City of Milton	West Pierce Fire & Rescue	Peninsula School District	Parkland Light and Water Company	
City of Orting		Puyallup School District	Peninsula Light Company	
City of Puyallup		Steilacoom Historical School District	Riviera Community Club	
City of Roy		Sumner-Bonney Lake School District	Spanaway Water Company	
City of Sumner		Tacoma School District	Summit Water and Supply Company	
City of Tacoma		University of Puget Sound	Tacoma Public Utilities	
City of University Place		University Place School District	Valley Water District	
Town of Carbonado		White River School District		
Town of Eatonville				
Town of South Prairie				
Town of Steilacoom				
Town of Wilkeson				

Map 2-1 Pierce County Base Map



Demographics

Pierce County is the second most populous county in Washington, with 11.83% of the state's population[4]. Pierce County's estimated population on April 1, 2025, was 959,900 based on data from the Washington State Office of Financial Management (OFM) – see the Pierce County RHMP Cities, Towns, and Pierce County OFM Population Breakdown (Table 2-2)[5]. This population estimate is used for the allocation of selected State revenues and differs from the U.S. Census population estimate.

In this plan, risk to natural and human-caused hazards uses the 2020 U.S. Census population estimates. The 2020 U.S. Census population estimate – according to the population data methodology described in the Pierce County RHMP Base Plan "Section 1: Plan Process" – was 920,393 for Pierce County and 540,115 for unincorporated Pierce County.[6] Furthermore, following the same population data methodology – the 2025 population estimate for Pierce County is 959,900 and 576,689 for Unincorporated Pierce County.[7]

Notably, natural and human-caused hazards in Pierce County pose risk to unhoused individuals within Pierce County's jurisdiction. According to the 2025 Point-In-Time Count for Pierce County, there were approximately 2,955 individuals experiencing homelessness. Not all individuals experiencing homelessness sleep outside[8]. Of the total individuals counted, 1,522 individuals (52%) were sheltered, and 1,433 individuals (48%) were unsheltered. Overall, the number of individuals experiencing homelessness in Pierce County rose from 1,897 individuals in 2020 to 2,955 individuals in 2025[9].

Table 2-2 Pierce County RHMP Cities, Towns, and Pierce County 2020 and 2025 OFM Population Breakdown[10]

Pierce County RHMP Cities, Towns, and Pierce County OFM Population Breakdown		
Jurisdiction	**Population in 2020**	**Population in 2025**
Pierce County	920,393	959,900
Unincorporated Pierce County	430,248	450,750
Incorporated Pierce County	490,145	509,150
City of Bonney Lake	21,750	23,450
City of Buckley	5,114	5,785
City of Dupont	10,151	10,190
City of Edgewood	12,327	14,120
City of Fife	10,999	11,300
City of Fircrest	7,156	7,240
City of Gig Harbor	12,029	13,110
City of Lakewood	63,612	64,670
City of Milton (part)	7,057	7,155
City of Orting	9,041	9,125

Pierce County RHMP Cities, Towns, and Pierce County OFM Population Breakdown		
City of Puyallup	42,973	43,730
City of Roy	816	820
City of Sumner	10,621	11,080
City of Tacoma	219,346	228,400
City of University Place	34,866	36,140
Town of Carbonado	734	750
Town of Eatonville	2,845	2,930
Town of South Prairie	373	625
Town of Steilacoom	6,727	6,860
Town of Wilkeson	499	495

Accessibility

An individual's ability to cope with natural and human-caused hazards can be impacted by underlying disabilities. Using data from the 2024 American Community Survey, Pierce County's total noninstitutionalized population with a disability is 133,030 individuals (14.6%)[11]. This assessment addressed six disability categories: hearing difficulties, vision difficulties, cognitive difficulties, ambulatory difficulties, self-care difficulties, and independent living difficulties. A breakdown of Pierce County's total noninstitutionalized population by these six disability categories is provided[12] in Table 2-3.

Table 2-3 Pierce County Populations with Disabilities

Disability Category	Number and Percentage of Individuals
Hearing Difficulty	33,748 individuals (3.7%)
Vision Difficulty	20,623 individuals (2.3%)
Cognitive Difficulty	61,715 individuals (7.2%)
Ambulatory Difficulty	59,007 individuals (6.9%)
Self-Care Difficulty	27,826 individuals (3.3%)
Independent living difficulties	52,271 individuals (7.5%)

Languages

There are 77 different languages spoken in Pierce County. RCW 43.62.030 states that the Washington State Office of Financial Management (OFM) shall annually determine, on April 1 of each year, the Limited English Proficiency (LEP) populations of all cities and towns in Washington State, including the primary languages spoken by these populations. OFM's 2024 LEP Population Estimates identify the number of individuals with limited English proficiency at the state and county-levels and specifies the languages that Pierce County is required to provide regular communications (see Table 2-4 Pierce County LEP Population Languages).

Using the 2024 OFM LEP Population Estimates, Pierce County identified additional languages for regular communications. To ensure that the languages selected were accurate and verifiably representative of the LEP populations in Pierce County, the determination of the selected languages was a collaborative effort vetted by key stakeholders and several County departments that provide services to LEP populations on a regular basis[13].

As detailed in the 2020 Pierce County Inclusive Emergency Communications Plan[14]:

"'Effective Communication ensures that the person with a vision, hearing, or speech disability can community cate with, receive information from, and Convery information to' service providers such as Pierce County."

The purpose of ensuring a variety of languages is integrated into both long-range planning processes and emergency response processes are to provide meaningful access to critical information, programs, and services.[15] Reducing risk to hazards in the short-term and long-term relies on reliable communication of those risks between community members and subject matter experts.

Table 2-4 Pierce County LEP Population Languages[16]

Pierce County LEP Population Languages	
Languages Included from OFM Estimate Assessment (2024)	
Arabic	Samoan
Cambodian (Khmer)	Spanish
Korean	Tagalog
Punjabi	Ukrainian
Russian	Vietnamese
Additional Languages Included from the Inclusive Emergency Communication Plan (2020)	
German	
Chinese (traditional and simplified)	
American Sign Language (ASL)	

Natural Environment

Geology

Figure 2-1 Mount Rainier National Park Landscape, Part I

In the western and central area of the county, the upper crustal materials are predominantly glacial deposits (drift) consisting of sediments laid down during multiple cycles of glacial advance and retreat. Vashon Age deposits cover most western and central parts of the county, except for the walls and floors of major valleys, where isolated mudflow deposits and peat bogs are present. Bedrock, with a thin mantle of outwash and sand, is predominant in the eastern part of the county.[17]

The Vashon Drift consists of water-laid, stratified, granular material deposited in front of the advancing glacier (advance outwash) overlain by unsorted clay, silt, sand, and gravel (till), and in turn overlapped by another blanket of granular stream deposits (recessional outwash).[18]

During the retreat of the glacier, glacial damming formed large temporary lakes. One of these ice-dammed lakes, occupied the Puyallup and White River valleys during the retreat of the Vashon ice and discharged water and material across the plain between Tacoma and Eatonville. Deep channels, as long as a mile wide, were carved by torrential discharge streams, and a layer of coarse–grained, poorly sorted material was deposited in a fan-shaped area extending from Chambers and Clover Creeks on the north to the Nisqually River and Muck Creek on the south.

Geography/Topography

Pierce County's varied topography ranges from sea level to 14,410 feet at the summit of Mount Rainier. The county is in the west-central part of the state and encompasses a land area of 1,157,120 acres (1,808 square miles), with an additional 118 square miles of water, excluding the Puget Sound.[19] The Puget Sound divides the county, with the portion west of the Puget Sound located on the Kitsap Peninsula. Several islands in the southern Puget Sound are also incorporated within the county.

Figure 2-2 Mount Rainier National Park Landscape, Part II[20]

The Puyallup and White River valleys are fertile regions comprising one of the most intensively cultivated areas in the state, although these areas are gradually giving way to commercial development. Apart from the Cowlitz River and its tributaries draining in the southeast corner of Mt. Rainier, all major rivers with headwaters on the mountain flow into Puget Sound. These rivers include the Puyallup, White, Nisqually, Mowich, and Carbon Rivers. Of these, only the Nisqually and Puyallup Rivers directly enter the Puget Sound. The White, Carbon, and Mowich

Rivers are tributaries of the Puyallup River and join it before it enters the Puget Sound. The White River borders Pierce County to the north and drains to the east side of the Mt. Rainier. The Nisqually River forms the county's southern boundary and drains to the south side of the Mt. Rainier. Together with its tributaries, the Carbon and Mowich Rivers, the Puyallup River contains runoff from the north and west sides of Mt. Rainier and discharges the combined waters into Commencement Bay. Numerous other rivers and creeks are located throughout the county.

Commencement Bay, Pierce County's principal port, is an arm of the Puget Sound that provides direct access to the Pacific Ocean. Much of the county's developed area is located near the Puget Sound on gently rolling terrain formed by glacial outwash and till. The eastern portion of the county consists of foothills rising to the crest of the Cascade Range, including Mount Rainier National Park, and is used primarily for timber production and recreation.

Pierce County contains 361 lakes greater than one acre in size, 162 of which are located above 2,500 feet in elevation. National forests, 225 miles of saltwater shoreline, numerous lakes, and other recreational opportunities contribute to a high quality of life in Pierce County.[21]

Anderson Island, McNeil Island, and Fox Island are the three major islands within the Pierce County and are located west of Tacoma and Steilacoom. Anderson Island and McNeil Island are accessible only by ferry or boat, while Fox Island is connected to the mainland by a bridge. McNeil Island is primarily used for a state-operated secure facility with limited civilian access, while Anderson Island and Fox Island are primarily residential.

Weather

The climate of Pierce County is generally mild. The Cascade Mountains to the east block cold winter air, while the Willapa Hills and the Olympic Mountains to the west remove much of the moisture from Pacific storms before they reach the county's lowland areas.

Distinct seasons are evident, with the rainy season generally occurring from October through April. Precipitation in the western and central portions of the county typically falls as rain, with occasional snowfall during the winter months. In contrast, the eastern portion of the county is subject to substantial winter snowpack. This snowpack melts each spring, except for the upper slopes of Mt. Rainier, where snow and ice persist year-round within an extensive glacier system.

Looking toward the end of the 21st century, Pierce County's average annual air temperatures are projected to continue increasing. The number and duration of extreme heat events are expected to rise, along with shifts in the amount, timing, and form of precipitation.[22] Summer precipitation is expected to increasingly fall as rain rather than snow. In addition, more atmospheric river events are likely to increase in both intensity and frequency in Pierce County.[23]

Figure 2-3 Pierce County Department of Emergency Management (PCDEM) Warming Center in Parkland[24]

Transportation Infrastructure

Major transportation routes tend to run, with a few exceptions, close to the Port of Tacoma. The movement of goods to and from Pierce County is by water, rail, and road with a very limited amount by air.

Interstate 5 and Highway 99 run north and south through the County and State Highway 16 connects the western portions of the County across the Tacoma Narrows with the rest of the County. State Highway 410 runs east through Sumner, Bonney Lake, and Buckley and then climbs over the Cascades to Yakima. Highway 512 acts as a loop highway, moving traffic around the more congested portions of the County, to Puyallup where it merges with Highway 167. Highway 167 initially begins at the southeast edge of Tacoma and follows the south side of the Puyallup River to Puyallup. Once joined by Highway 512 it continues east to Sumner and then

into King County. Many other arterials and minor highways move traffic through the rest of the County.

Rail lines follow three routes out of Pierce County. The first follows the coast south to the Nisqually River and then south to Oregon and California. The second follows the Puyallup Valley first to the east and then north into King County and points north. The third runs south through the hills to Elbe on the Nisqually River. It crosses the river there into Lewis County and continues south to Morton. Two transcontinental railroad systems connect the County with the rest of the nation as do 30 interstate trucking companies.

Airline transportation is 25 miles away, at Seattle/Tacoma International Airport, or at the small Tacoma Narrows Airport on the Kitsap Peninsula. There are also seven public airfields in the county. Transportation by water runs up Puget Sound either by large cargo ship or barges.

Ferry service is necessary both for commuting and for the transportation of goods. Washington State Department of Transportation (WSDOT) and Pierce County operate ferries to Vashon Island, Anderson Island, and Ketron Island. The Washington State Department of Corrections operates both the McNeil Island Ferry and the McNeil Island Barge and Tug. Herron Island is serviced by a private ferry service.

Regional transportation includes bus service extending from the state capital, Olympia, to the City of Seattle. The major transit hub near the Tacoma Dome connects the County with jurisdictions to the north and south. Also included in the Tacoma Dome Station is the Sounder which is light rail operated by Sound Transit from Tacoma to Seattle with stops in Puyallup, Sumner, Auburn, Kent, and Tukwila. About 5 percent of Pierce County households are car-free (as reported by the Puyallup Watershed Initiative Active Transportation using data from the Puget Sound Regional Council).

Economy

Pierce County has a diverse and connected economy that serves as a critical component of the south Puget Sound region. Supported by a variety of industries, the County's economic base provides regional influence and employment stability for the local workforce. The strategic location, access to major transportation resources, and proximity to critical infrastructure support continued growth in industrial, commercial, and residential areas.

Tacoma, the county seat and third largest city in Washington State, serves as Pierce County's primary urban and economic center. With access to three major transcontinental railroads, federal and state highways, and a deep-water port, Tacoma is the County's hub for industry, trade, and transportation.

According to the 2024 Pierce County Comprehensive Plan, the three primary industries in Pierce County's economy are healthcare and medical services, commerce related to the Port of Tacoma, and military operations at Joint Base Lewis-McChord. The service sector and manufacturing industry follow as significant contributors through employment and exports, respectively. The impact of the military, healthcare system, government, and education system can be seen in the Pierce County Top 20 Employers – 2020 Table (Table 2-4)..

Pierce County also benefits from well-established educational resources that support workforce development and economic adaptability. Higher education institutions include the University of Puget Sound, Pacific Lutheran University, Evergreen State College Tacoma Campus, Tacoma Community College, Pierce College, and the University of Washington-Tacoma. Additionally, Pierce County is home to several private business colleges and vocational technical schools, further supporting a local skilled labor force.

In 2020, the U.S. Census estimates indicated that the median Pierce County household income was $76,438, which was $568 lower than the median for Washington State. Approximately 9.5 percent of Pierce County household residents lived below the poverty level, which is 0.7 percent lower than the State average.[25]

In recent years, Pierce County has increased its focus on promoting a more sustainable economy. One aspect of sustainability is the implementation of new economic development policies related to land use development, climate change, and improved quality of life for the County's workforce. These initiatives aim to further support Pierce County's healthy economy and complement the County's regional growth strategy.

Table 2-4 Pierce County Top 20 Employers - 2020[26]

Pierce County Top 20 Employers in 2020			
Rank	**Jurisdiction**	**2020 Full-Time Employees**	**Industry**
1	Joint Base Lewis-McChord	54,000	Military
2	MultiCare Health System	8,264	Healthcare
3	State of Washington	7,859	Government
4	CHI Franciscan Health System	5,682	Healthcare
5	Tacoma Public Schools	3,649	Education
6	City of Tacoma and Tacoma Public Utilities	3,623	Government
7	Pierce County Government	3,304	Government
8	Puyallup School District	2,711	Education
9	Bethel School District	2,689	Education
10	Safeway & Albertsons	2,153	Retail
11	Emerald Queen Casino	2,146	Gaming
12	Fred Meyer Retail & Distribution Center	1,802	Retail & Distribution
13	Amazon Distribution Centers	1,800	Distribution
14	Clover Park School District	1,782	Education
15	Boeing	1,550	Manufacturing Aerospace
16	U.S. Postal Service	1,336	Government
17	Costco	1,318	Retail
18	Peninsula School District	1,284	Education
19	Puyallup Tribe	1,274	Government
20	Sumner School District	1,270	Education

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Section 3: Capability Identification

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Capability Identification Requirements

Code of Federal Regulations 44

Planning Process – Requirement §201.6(b)(3). The planning process must include:

> (b) **Planning process.** An open public involvement process is essential to the development of an effective plan. In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process must include:
>
> > (3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.

Plan Content – Requirement §201.6(c)(2)(ii)(C). The plan should describe vulnerability in terms of:

> (C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

Plan Content – Requirement §201.6(c)(3)(ii). This section must include:

> (ii) A section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure. All plans approved by FEMA after October 1, 2008, must also address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.

Section 3: Capability Identification

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Base Plan

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Capability Identification Process

The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act 2000, Sandy Recovery Improvement Act of 2013, and the Water Infrastructure Improvements for the Nation Act of 2016, requires a "review and incorporation, if appropriate, of existing plans, studies, reports, and technical information" (44 CFR §201.6(b)(3)). For the purposes of the Jurisdictional Annexes, these elements are referred to as capabilities and the "review and incorporation" as a capability identification. The capability identification provides a scope for what mitigation actions can and cannot be implemented and identifies specific capabilities that each jurisdiction has which support the implementation of mitigation strategies. This includes mitigation strategies within the jurisdiction, as well as at the county, state, federal, and Tribal government levels. Further, it identifies actions already undertaken to reduce hazard risk, regardless of whether formally labeled as mitigation actions or not. The identification therefore evaluates all aspects of each jurisdiction's governance that relate both directly and indirectly to mitigation activities.

For the update of the Base Plan and the Jurisdictional Annexes, a complete review was done for each capability section. Previous plans included a system of charts developed by each group that listed plans, studies, reports, and technical information relevant to the jurisdiction. The diversity of the Pierce County RHMP Planning Team jurisdictional partners required that some charts be updated and adapted to better represent each jurisdiction.

Types of Capabilities

Developing an effective hazard mitigation plan depends upon the jurisdiction's type, the capabilities maintained, and the ability to implement policies and programs.

Legal and regulatory capabilities refer to the laws, regulations, authorities, and policies that govern current and potential mitigation actions. This can be broken down into two basic areas: local and extra-local. Local laws, regulations, authorities, and policies are generated by the local governing agency that the jurisdiction has control over. Extra-local laws, regulations, authorities, and policies are from a different level of government.

Administrative and technical capabilities refer to a jurisdiction's staff and technical resources, as well as completed plans and studies that have considered, directly or indirectly, the mitigation of natural hazards. Technical capabilities also include existing electronic and systemic resources.

Fiscal capabilities refer to the financial resources available to achieve the identified mitigation strategies.

- For purposes of this plan, administrative capabilities are organizations, agencies, or departments responsible for implementing, or partnering to implement, mitigation actions. Fiscal capabilities at the city-level are correlated to budgets and expenditures of departments, as well as the separate funds available for mitigation-related activities.
- For special purpose districts, fiscal capabilities rely on levies, contracts, and grants.

Jurisdictions that participated in the Pierce County RHMP were placed into five categories or groups of jurisdictions: Cities and Towns, Fire, Education, Utilities, and Other. Each jurisdiction filled out a series of tables, specific to the individual group, listing local-level capabilities. Jurisdictions with capabilities not identified in the tables could add capabilities to the list or place them on a final table labeled *Specific Capabilities*. The tables include:

- **Local Legal and Regulatory:** This section identifies the legal parameters within which the five categories of jurisdictions operate. For cities, towns, and Pierce County there is particular emphasis on the Comprehensive Plans and Development Regulations, as these guide land use and building decisions. For other jurisdictions, these authorities are limited and rely on land use and development regulations enacted in the cities, towns, and Pierce County where they do business.
- **Local Administrative:** This section identifies segments of a jurisdiction that conduct activities related to mitigation and the studies, programs and projects in which the jurisdiction is engaged. A comprehensive list includes regional and local associations, relationships developed, and collaborative programs with shared resources.
- **Local Technical:** This section identifies the plans, studies, and reports that address risk and mitigation, either directly or indirectly, as technical capabilities. These provide a mechanism through which mitigation actions are implemented in the future.
- **Local Fiscal:** For cities, towns, and Pierce County, this section identifies the fiscal capabilities, as well as department budgets. Project funding dictates much of what can be accomplished and can depend on fees, bonds, levies, or grants.
- **Local Specific:** Each jurisdiction has listed, in their respective plans, specific capabilities not otherwise identified in the other four types of capabilities. The order of the individual jurisdiction capabilities follows that of the general capability identification and the same format as the initial four types of capabilities: Legal and Regulatory, Administrative, Technical, and Fiscal.

In addition to the initial four capabilities for each jurisdiction, there are state and federal capabilities. State and federal capabilities are the regulations that dictate what a jurisdiction in Washington can and cannot pursue regarding mitigation, as well as what assistance is available. They cover the same four capability areas that are identified in local capabilities: Legal and Regulatory, Administrative, Technical, and Fiscal.

State and federal capabilities are not listed in the individual jurisdictional plans. Instead, they are identified in this section of the Base Plan, see Major Federal Funding Resources Table (Table 3-1), Washington State Agencies and Departments Mitigation Capabilities Table (Table 3-2), and Other Washington State Mitigation Capabilities Table (Table 3-3). Many of these capabilities identify or modify mechanisms that are the basis for the local level. The individual jurisdiction's capability tables identify existing actions, including land use regulations and building codes, that directly mitigate hazards and establish the framework necessary to implement future mitigation actions.

In summary, the capability information from each jurisdiction identifies existing mitigation actions, potential funding sources, and the mechanisms needed to support implementation, while ensuring consistency with existing plans, policies, and studies. The Pierce County RHMP has established a comprehensive inventory of capabilities addressing both natural and human-caused hazards to strengthen regional disaster resilience. This information provides a baseline for future planning and will be updated as capabilities evolve over time.

Federal Capabilities

A key issue when implementing mitigation actions is finding sufficient monetary resources to do so. Grants are fiscal resources available to jurisdictions that pursue hazard reduction activities. Grants may be administered at the federal or state level, and in some instances, by the private or non-profit sector. Each grant has specific requirements and elements used to conduct benefit-cost analysis. The purpose of the benefit-cost analysis is to determine if the benefits of the project exceed the costs of the project. Jurisdictions coordinate with the administering agency to understand the program-specific requirements and conduct the required analyses.

For example, if Hazard Mitigation Grant Program (HMGP) funds are involved in a hazard mitigation project, the recipient jurisdiction conducts a benefit-cost analysis based on guidelines from the U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA), and Washington Emergency Management Division (EMD). The analysis determines the cost-effectiveness of the mitigation projects and calculates the benefit-cost ratio. HMGP requires a benefit-cost ratio of at least 1.0 for a project to be considered for funding.

The Major Federal Funding Resources Table (Table 3-1) contains current federal resources that are used to secure funding for implementation of mitigation actions. In addition, there is a list of Washington State agencies that have mitigation capabilities and funding to assist with mitigation projects. As funding types, sources, availability, and requirements are constantly changing, this plan does not identify all potential grants or the detailed requirements. The information presented here is current as of the last update to this plan.

Table 3-1 Major Federal Funding Resources

Major Federal Funding Resources		
Program	**Description**	**Website**
Flood Mitigation Assistance (FMA)	FEMA provides FMA funds to assist States and communities with implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program (NFIP).	http://www.fema.gov/flood-mitigation-assistance-program
Repetitive Flood Claims Program (RFC)	Up to $10 million available annually for FEMA to provide RFC funds to assist States and communities with reducing flood damage to insured properties that have had one or more claims to the National Flood Insurance Program (NFIP).	http://www.fema.gov/flood-mitigation-assistance-program
National Earthquake Hazards Reduction Program (NEHRP)	In establishing NEHRP, Congress recognized that earthquake-related losses could be reduced through improved design and construction methods and practices, land use controls and redevelopment, prediction techniques and early-warning systems, coordinated emergency preparedness plans, and public education and involvement programs.	http://www.nehrp.gov/index.htm
National Weather Service (NWS)	The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure that can be used by other governmental agencies, the private sector, the public, and the global community.	http://www.weather.gov/
Port Security Grant Program (PSGP)	The PSGP provides grant funding to port areas for the protection of critical port infrastructure from terrorism. PSGP funds help ports enhance risk management capabilities, domain awareness, training and exercises, and capabilities to prevent, detect, respond to, and recover from attacks involving improvised explosive devices (IED) and other non-conventional weapons.	http://www.fema.gov/port-security-grant-program
Transit Security Grant Program	TSGP provides funds to owners and operators of transit systems (which include intracity bus, commuter bus, ferries, and all forms of passenger rail) to protect critical surface transportation	http://www.fema.gov/transit-security-grant-program

Major Federal Funding Resources		
	infrastructure and the traveling public from acts of terrorism and to increase the resilience of transit infrastructure.	
Rural Development-Housing & Community Facilities Programs	Community Programs provides grants to assist in the development of essential community facilities in rural areas and towns of up to 20,000 in population. Grants are authorized on a graduated scale. Applicants located in small communities with low populations and low incomes will receive a higher percentage of grants.	http://www.rurdev.usda.gov/rhs/cf/brief_cp_grant.htm
Fire Management Assistance Grant	Fire Management Assistance Grant (FMAG) Program is available to states, local, and tribal governments for the mitigation, management, and control of fires on publicly or privately owned forests or grasslands, that threaten destruction constituting a major disaster.	https://www.fema.gov/assistance/public/fire-management-assistance
Community Wildfire Defense Grants (CWDG)	CWDG helps communities and Tribe's plan for and reduce wildfire risk and implement the National Cohesive Wildland Fire Management Strategy.	https://www.fs.usda.gov/managing-land/fire/grants/cwdg
Hazard Mitigation Grant Program (HMGP)	FEMA's HMGP provides funding to state, local, tribal and territorial governments to develop hazard mitigation plans. The purpose of this grant and these plans are to help communities rebuild in ways that reduce or mitigate future disaster losses.	https://www.fema.gov/grants/mitigation/learn/hazard-mitigation

State Capabilities

Various laws and rules in Washington State support hazard mitigation planning. These can be found in Revised Code of Washington (RCW) and Washington Administrative Code (WAC). The Washington State Constitution further identifies who does what and basic rights in state.

State agencies and departments have mitigation capabilities as described in the Washington State Agencies and Departments Mitigation Capabilities Table (Table 3-2) and the Other Washington State Capabilities Table (Table 3-3). For example, the Washington State Department of Natural Resources (DNR) helps communities become Firewise and Wildfire Ready Neighbors by offering expertise, support, and resources for wildfire mitigation. DNR provides customized guidance through the Wildfire Ready Neighbors program, giving residents free, personalized action plans.[1] Additionally, DNR's Service Forestry Program assists small forest landowners with technical help and cost-share opportunities for implementing treatments like thinning and pruning to reduce wildfire risk.

Table 3-2 Washington State Agencies and Departments Mitigation Capabilities

Washington State Agencies and Departments Mitigation Capabilities	
Title and Description	**Website Link**
Community, Trade, Economic Development	http://www.cted.wa.gov/
Department of Fish and Wildlife	http://wdfw.wa.gov/
Department of Ecology	http://www.ecy.wa.gov/
Department of Labor and Industries	http://www.lni.wa.gov/
Department of Natural Resources	http://www.dnr.wa.gov/
Department of Transportation	http://www.wsdot.wa.gov/
Governor's Office	http://www.governor.wa.gov/
Military Department (Emergency Management Division)	http://www.emd.wa.gov/
Office of Superintendent of Public Instruction	http://www.k12.wa.us/
Washington State Patrol	http://www.wsp.wa.gov/

Table 3-3 Other Washington State Capabilities

Other Washington State Capabilities	
Title and Description	**Website Link**
Association of Washington Cities	http://www.awcnet.org/
Association of Washington Counties	http://www.wacounties.org/
Cascade Land Conservancy	http://www.cascadeland.org/
Master Builders Association	www.mbapierce.com/
Municipal Research of Washington	http://www.mrsc.org/
Structural Engineers Association of Washington	http://www.seaw.org/
WA Association of Building Officials	http://wabo.org/
WA Association of Fire Chiefs	http://www.wsafc.org/
WA Association of Maintenance & Operations Administrators	http://www.wamoa.org/
WA Association of Sheriffs & Police Chiefs	http://www.waspc.org/
WA Emergency Management Association	http://www.wsema.com/
WA Firefighter Association	http://www.wsffa.org/
WA Fire Commissioners Association	http://www.wfca.wa.gov/default.asp
Washington Public Ports Administration	http://www.washingtonports.org/
Washington Schools Risk Management Pool	http://www.wsrmp.com/

Local Capabilities

Each jurisdiction has extensive local capabilities. A description of local capabilities and associated information can be found in the specific Jurisdictional Annex.

Implementation and Partnerships

Flood Control Zone District

RCW 86.15.025 gave the Pierce County Council the authority to establish either countywide or a basin-level flood control zone district (FCZD) that creates additional opportunities for new, dedicated funding sources.[2] On April 3, 2012, the Pierce County Council passed Ordinance 2011-95s, creating the Pierce County Flood Control Zone District (FCZD). The purpose of the FCZD is to construct, operate, and maintain flood control projects to reduce flooding and channel migration risks. The district is governed by a Board of Supervisors and an Executive Committee with input and recommendations from an Advisory Committee. Funding for the FCZD comes from a countywide property levy. In 2023, the property tax levy for the FCZD is approximately $19.1 million countywide which is ten (10) cents per $1,000 of assessed value.[3]

Floodplains for the Future

Floodplains for the Future is a cross-sector and inter-organizational partnership in the Puyallup watershed. Twenty-two partner organizations meet to plan, fund, and implement floodplain projects to attain the shared vision of restored connections between rivers and land to improve habitat for salmon, and protect communities and infrastructure from flooding while preserving agricultural lands.[4] Partners include:

- American Rivers;
- City of Orting;
- City of Puyallup;
- City of Sumner;
- Floodplains by Design;
- Forterra;
- King-Pierce Farm Bureau;
- Muckleshoot Indian Tribe;
- PCC Farmland Trust;
- Pierce Conservation District;
- Pierce County;
- Pierce County Agricultural Program;

- Port of Tacoma;
- Puget Sound Partnership;
- Puyallup Tribe of Indians;
- Strategic Conservation Partnership;
- South Puget Sound Salmon Enhancement Group;
- The Nature Conservancy;
- UW Climate Impacts Group;
- Washington State Department of Ecology;
- WRIA 10/12 Lead Entity; and
- WSU Extension.

Some of the projects that this group is working on are the Orville Road Protection project, Clear Creek Floodplain Reconnection project, Neadham Road Acquisition and Revetment, South Prairie Creek Restoration Project, Alward Road Acquisition and Floodplain Restoration, Pacific Point Bar, Ball Creek, White River 24th Street Point Bar, and South Fork Side Channel Reconnection Project. For additional information, please visit: https://floodplainsforthefuture.org/.

National Flood Insurance Program (NFIP) Capabilities

Figure 3-1 Flooding from the December 2025 Flood, Landslide, and Severe Weather Incident in Pierce County[5]

The NFIP provides flood insurance to property owners to help with flood recovery when floodwaters recede.[6] All National Flood Insurance Program (NFIP) capabilities are detailed in each Jurisdictional Annex. The Washington State Department of Ecology's letter dated December 3rd, 2025, (see Figure 3-1 and Figure 3-2), states that the jurisdictions listed in the Pierce County NFIP Capabilities Table (Table 3-4) are in good standing with the NFIP. Table 3-4 details each jurisdiction's NFIP Community Number, data from the last Community Assistance Visit (CAV), and any unresolved issues with NFIP Status. A CAV is a major element of the NFIP Community Assistance Program (CAP). A CAV is when a FEMA staff member, or state agency staff member on behalf of FEMA, visits a jurisdiction to provide technical assistance and ensure that the jurisdiction is adequately enforcing floodplain management regulations.[7]

Table 3-4 NFIP Capabilities for Pierce County Cities, Pierce County Towns, and Pierce County[8]

Pierce County NFIP Capabilities			
Community Name	**Community Number**	**Last Community Assistance Visit Date**	**Unresolved Issues?**
City of Bonney Lake	530274	08/15/2013	No
City of Buckley*	530139	07/12/2001; 09/2009	No; No
Town of Carbonado	530243	Not participating in NFIP	N/A
City of Dupont	530245	Not participating in NFIP	N/A
Town of Eatonville	530283	06/2001	No
City of Edgewood	530328	10/16/1998	No
City of Fife	530140	08/02/2012	No
City of Fircrest	530141	09/21/2005	No
City of Gig Harbor	530142	09/27/2005	No
City of Lakewood*	530333	09/15/2015; 08/15/2023	No; No
City of Milton	530294	08/02/2012	No
City of Orting	530143	12/11/2017	No
Pierce County	530143	09/29/2015	Yes
City of Puyallup	530138	03/17/2020	No
City of Roy	530144	07/17/2013	No
Town of South Prairie*	530262	09/05/2013; 07/2020	No
Town of Steilacoom	530145	03/17/2020	No
City of Sumner	530146	12/12/2012	No
City of Tacoma	530148	08/03/2012	No
City of University Place	530332	11/30/2015	No
Town of Wilkeson	530268	08/28/2013	No
** The dates listed for these jurisdictions are sourced both from the Washington State Department of Ecology and the city or town itself.*			

Figure 3-2 NFIP Certification Letter from December 3rd, 2025, Page 1 of 2

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Southwest Region Office
PO Box 47775, Olympia, WA 98504-7775 • 360-407-6300

December 3, 2025

Vivien Coop
Pierce County Emergency Management
2501 S 35th St. Suite D
Tacoma, WA 98409

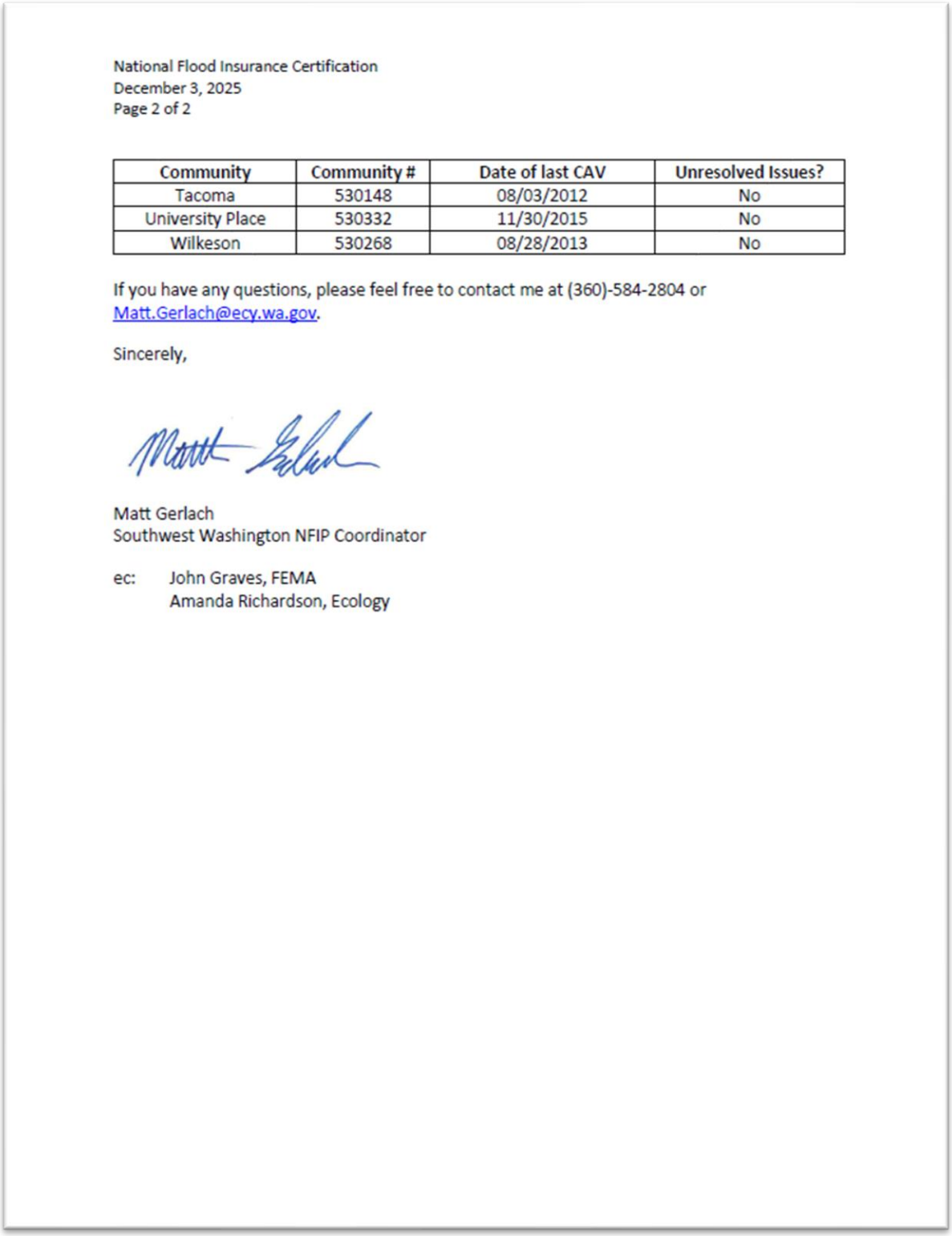
RE: National Flood Insurance Program Certification

Dear Vivien,

This letter is to certify that the communities in Pierce County listed in the table below are in good standing in the NFIP. The table shows each NFIP community number, date of last CAV, and any unresolved issues as available in FEMA's Community Information System database on 12/02/2025.

Community	Community #	Date of last CAV	Unresolved Issues?
Bonney Lake	530274	08/15/2013	No
Buckley	530139	07/12/2001	No
Carbonado	530243	Not participating in NFIP	N/A
Dupont	530245	Not participating in NFIP	N/A
Eatonville	530283	Unknown	No
Edgewood	530328	10/16/1998	No
Fife	530140	08/02/2012	No
Fircrest	530141	09/21/2005	No
Gig Harbor	530142	09/27/2005	No
Lakewood	530333	09/15/2015	No
Milton	530294	08/02/2012	No
Orting	530143	12/11/2017	No
Pierce County	530138	09/29/2015	Yes
Puyallup	530144	03/17/2020	No
Roy	530262	07/17/2013	No
South Prairie	530145	09/05/2013	No
Steilacoom	530146	03/17/2020	No
Sumner	530147	12/12/2012	No

Figure 3-3 NFIP Certification Letter from December 3rd, 2025, Page 2 of 2



National Flood Insurance Certification
December 3, 2025
Page 2 of 2

Community	Community #	Date of last CAV	Unresolved Issues?
Tacoma	530148	08/03/2012	No
University Place	530332	11/30/2015	No
Wilkeson	530268	08/28/2013	No

If you have any questions, please feel free to contact me at (360)-584-2804 or Matt.Gerlach@ecy.wa.gov.

Sincerely,

Matt Gerlach
Southwest Washington NFIP Coordinator

ec: John Graves, FEMA
Amanda Richardson, Ecology

Community Outreach

Pierce County conducts ongoing community engagement and outreach efforts to inform parcel owners and property dwellers on flood insurance and flood preparedness. These efforts have been both stand-alone campaigns and part of larger campaigns to raise community awareness to prepare for significant weather events and natural hazards. The Pierce County Planning and Public Works (PPW) Surface Water Management (SWM) Division provides information on its website about flood insurance and flood preparedness in Pierce County.[9]

Joint Planning Requirement

Natural and human-caused hazards occur across jurisdictional boundaries, and the mitigation strategies developed by jurisdictions to improve resilience and reduce hazard risks require collaboration across several disciplines (urban planning, engineering, emergency management, education, etc.). The implementation of hazard mitigation plans requires coordination between existing plans, studies, and reports. This subsection describes the plans, studies, reports, and technical information coordinated across all Jurisdictional Annexes.

Joint Planning Efforts Tables

The Jurisdictional Annex Joint Planning Efforts Tables (Table 3-5, Table 3-6, Table 3-7, Table 3-8, Table 3-9, and Table 3-10) show how jurisdictions from the same discipline groups plan together. This list is not exhaustive but highlights some of the critical planning documents used by jurisdictions for hazard mitigation planning.

Table 3-5 Jurisdictional Annex Joint Planning Efforts: Pierce County

Jurisdictional Annex Joint Planning Efforts	
Pierce County	
Document Name	***Next Update***
2024 Pierce County Comprehensive Plan	2034
2023 Pierce County Shoreline Management Program Update *(Ordinance No. 2023-75)*	2029
2024 Shoreline Master Program Amendments: Public Participation Plan	2024
Pierce County Comprehensive Emergency Management Plan	2026
Pierce County Continuity of Operations Plan	2026
2023 Comprehensive Flood Hazard Management Plan	2033
2025 Comprehensive Plan of Development *(Pierce County Flood Control Zone District)*	To be determined
2026-2027 Pierce County Capital Facilities Plan	2028
2023 Washington State Enhanced Hazard Mitigation Plan	2028

Table 3-6 Jurisdictional Annex Joint Planning Efforts: Cities and Towns Group

Jurisdictional Annex Joint Planning Efforts	
City of Bonney Lake	
Document Name	***Next Update***
Comprehensive Emergency Management Plan	2029
Continuity of Operations/Continuity of Government Plan	2026
Comprehensive Plan	2025
• Cultural Arts and Heritage (now Historic Preservation Element)	2025
• Community Services and Facilities Element	2025
• Capital Facilities Element	2025
• Utilities Element	2025
• Community Mobility Element	2025
Centers Plan	2027
Parks, Trails, Recreation, and Open Space Plan	2034
City of Buckley	
Document Name	***Next Update***
Comprehensive Plan (GMA)	July 1, 2025
Shoreline Master Program	2026
Comprehensive Water System Plan	March 2029
Comprehensive Stormwater Management Plan	2030
Comprehensive Sewer Plan	Updates Tied to the Buildable Lands Report
City of Fife	
Document Name	***Next Update***
Comprehensive Plan	2025
City of Gig Harbor	
Document Name	***Next Update***
The City of Gig Harbor Comprehensive Plan	2025
City of Lakewood	
Document Name	***Next Update***
The City of Lakewood Comprehensive Plan	2034
City of Orting	
Document Name	***Next Update***
Pierce County Regional Hazard Mitigation Plan	2030
City of Puyallup	
Document Name	***Next Update***
Comprehensive Emergency Management Plan	2029

Jurisdictional Annex Joint Planning Efforts	
City of Sumner	
Document Name	***Next Update***
Comprehensive Plan (GMA)	June 2034
Shoreline Master Program	2027
Critical Areas Ordinance	June 2034
Comprehensive Water System Plan	2030
Comprehensive Storm Management Plan	2026
Comprehensive Sewer Plan	2030
Transportation Plan	2034
Capital Facilities Plan	2034
Parks and Trail Plan	December 2031
City of Tacoma	
Document Name	***Next Update***
Comprehensive Emergency Management Plan	2025
City of University Place	
Document Name	***Next Update***
City of University Place Comprehensive Plan	12/31/2026
Town of Carbonado	
Document Name	***Next Update***
Comprehensive Plan	June 2034
Town of Eatonville	
Document Name	***Next Update***
Comprehensive Plan	2030
Development Regulations & Water Comprehensive Plan	2023
Town of South Prairie	
Document Name	***Next Update***
2024-2044 Comprehensive Plan	2024
South Prairie 2023 GSP and Engineering Report	2041
2018 Water System Plan	2038
Town of Steilacoom	
Document Name	***Next Update***
Comprehensive Plan	2025
Pierce County Shoreline Master Plan Update	2029
Town of Wilkeson	
Document Name	***Next Update***
Comprehensive Plan	2034

Jurisdictional Annex Joint Planning Efforts	
Water Comprehensive Plan	2030

Table 3-7 Jurisdictional Annex Joint Planning Efforts: Education Group

Jurisdictional Annex Joint Planning Efforts	
Carbonado Historical School District	
Document Name	***Next Update***
Carbonado School District Strategic Plan	2026
Clover Park School District	
Document Name	***Next Update***
Clover Park School District Mult-Hazard Critical Incident Response Plan	To be determined
Capital Projects Facilities Plan	To be determined
Dieringer School District	
Document Name	***Next Update***
Dieringer School Strategic Plan	2025
Eatonville School District	
Document Name	***Next Update***
Comprehensive Emergency Management Plan	2026
Fife School District	
Document Name	***Next Update***
Fife School District Asset Preservation System (APS)	To be determined
Capital Facilities Plan	To be determined
Orting School District	
Document Name	***Next Update***
OSD Capital Facilities Plan	2023
Pacific Lutheran University	
Document Name	***Next Update***
PLU Major Institute Plan	2028
PLU Campus Master Plan	2028
Peninsula School District	
Document Name	***Next Update***
Masters Capital Facilities Plan	To be determined
Steilacoom Historical School District	
Document Name	***Next Update***
Multi-Hazard Critical Incident Response Plan	September 2023
Capital Projects Facilities Plan	October 2028
Sumner-Bonney Lake School District	
Document Name	***Next Update***
Capital Facilities Plan	August 2030

Jurisdictional Annex Joint Planning Efforts	
Tacoma School District	
Document Name	***Next Update***
Capital Facilities Plan	To be determined
University Place School District	
Document Name	***Next Update***
Multi-Hazard Critical Incident Response Plan	2025
Capital Projects Facilities Plan	Ongoing
White River School District	
Document Name	***Next Update***
To be determined	To be determined

Table 3-8 Jurisdictional Annex Joint Planning Efforts: Fire Group

Jurisdictional Annex Joint Planning Efforts	
Anderson Island Fire & Rescue	
Document Name	***Next Update***
Evacuation & Shelter In-Place Plan	2029
Community Wildfire Protection Plan (CWPP)	2025
Central Pierce Fire & Rescue	
Document Name	***Next Update***
Pierce County Regional Hazard Mitigation Plan (RHMP)	2030
Community Wildfire Protection Plan (CWPP)	2025
East Pierce Fire & Rescue	
Document Name	***Next Update***
Capital Improvement Plan	2030
Lahar Evacuation Plan	2029
Community Wildfire Protection Plan (CWPP)	2025
Gig Harbor Fire & Medic One	
Document Name	***Next Update***
Capital Facilities Plan	2028
Community Wildfire Protection Plan (CWPP)	2025
Key Peninsula Fire Department	
Document Name	***Next Update***
Capital Facilities Plan	2028
Community Wildfire Protection Plan (CWPP)	2025
Pierce County Fire District #23	
Document Name	***Next Update***
Community Wildfire Protection Plan (CWPP)	2025
Riverside Fire & Rescue	
Document Name	***Next Update***
Community Wildfire Protection Plan (CWPP)	2025
West Pierce Fire & Rescue	
Document Name	***Next Update***
Hazard Identification and Vulnerability Assessment	2030
Community Wildfire Protection Plan (CWPP)	2025

Table 3-9 Jurisdictional Annex Joint Planning Efforts: Utility Group

Jurisdictional Annex Joint Planning Efforts	
Crystal River Ranch Association	
Document Name	***Next Update***
2014 Crystal River Ranch Association HOW Reserve Study	To be determined
Parkland Light and Water Company	
Document Name	***Next Update***
Water System Plan	2030
AWIA Risk and Resilience Assessment	2026
AWIA Emergency Response Plan	2026
Water Use Efficiency Plan (Public Forum)	2031
Spanaway Water Company	
Document Name	***Next Update***
Water System Plan	2027
AWIA Risk and Resilience Assessment	2025
AWIA Emergency Response Plan	2025
Water Use Efficiency Plan (DOH Requirement)	2025
Coordinated Water System Plan Update (Pierce County)	2030
Tacoma Public Utilities	
Document Name	***Next Update***
Tacoma Public Utilities Biennial Budget 2025-2026	2027

Table 3-10 Jurisdictional Annex Joint Planning Efforts: Other Group

Jurisdictional Annex Joint Planning Efforts	
Other Group	
Community Health Care	
Document Name	***Next Update***
TBD	To be determined
Parks Tacoma	
Document Name	***Next Update***
Long-Range Strategic Plan Update	August 2024
Climate Action plan	May 2025
Urban Forestry and Wildfire Plan	2025
Pierce Transit	
Document Name	***Next Update***
Destination 2045 Long-Range Plan	2045
2025-2030 Transit Development Plan (TDP): A Short-Range Plan	2030
Port of Tacoma	
Document Name	***Next Update***
Port of Tacoma/Northwest Seaport Alliance Plans	
Port of Tacoma Strategic Plan	2026 Update nearly complete; 2031 is the next update
NWSA Strategic Framework	2030
NWSA Resilient Gateway Program	New Plan, ongoing
Partner Agency Plans	
City of Tacoma's Tideflats Subarea Plan	To be determined, New Plan Adoption 2025/2026
City of Tacoma's Container Port Element of the Comprehensive Plan	2035
City of Tacoma Climate Adaptation Strategy	2030

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Endnotes

[1] U.S. Department of Natural Resources, http://www.dnr.wa.gov/

[2] Washinton State Legislature, https://app.leg.wa.gov/rcw/default.aspx?cite=86.15.025

[3] Pierce County Flood Control Zone District, https://www.piercefloodcontrol.org/101/About-the-FCZD

[4] Flood Plains for the Future: Puyallup, White, & Carbon Rivers, Floodplains for the Future – Puyallup, White & Carbon Rivers

[5] Photo courtesy of the Pierce County Department of Emergency Management

[6] FEMA NFIP, https://www.fema.gov/flood-insurance

[7] Federal Emergency Management Agency (FEMA) Community Assistance Visit Page, https://www.fema.gov/about/glossary/community-assistance-visit-cav

[8] This Community Assistance Visit (CAV) information was collected from the Washington State Department of Ecology in December 2025 and from the cities and towns in the Pierce County RHMP

[9] Pierce County Planning and Public Works, https://www.piercecountywa.gov/CivicSend/ViewMessage/message/247758

Section 4: Risk Assessment

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Risk Assessment Requirements

Code of Federal Regulations 44

Plan Content – Requirement §201.6(c)(2)(i), §201.6(c)(2)(ii)(A), §201.6(c)(2)(ii)(B), §201.6(c)(2)(ii)(C), and §201.6(c)(2)(iii). This plan must include the following:

(2) A *risk assessment* that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. The risk assessment must include:

(i) A description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan must include information on previous occurrences of hazard events and on the probability of future hazard events.

(ii) A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description must include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008, must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:

(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B) An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate;

(C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

(iii) For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

Section 4: Risk Assessment

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Base Plan

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Table 4-5 Pierce County Regional Hazard Identification Summary 11

Risk Introduction

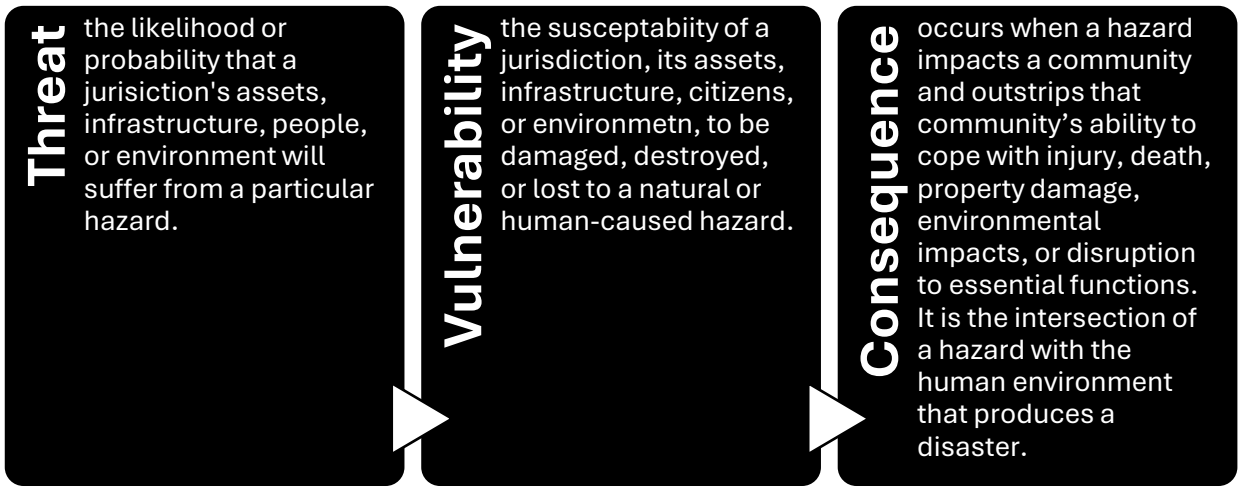
Figure 4-1 2023 Roy Wildfire Response in Pierce County[1]

The Pierce County Regional Hazard Mitigation Plan (RHMP) Risk Assessment uses multiple methods to quantify the risk that natural and human-caused hazards pose to communities. This Risk Assessment is consistent with local mitigation planning requirements outlined in 44 CFR §201.6(c)(2). The Pierce County RHMP Planning Team assessed risk using the following three components: threat, vulnerability, and consequence (Figure 4-2).

Figure 4-2 Risk Assessment Methodology

Threat, vulnerability, and consequence are defined in Figure 4-3 below. These elements of risk form the foundation for the Pierce County RHMP Risk Assessment methodology. Threats, including natural and human-caused hazards, are identified in the "Hazard Identification" Subsection of the Pierce County RHMP Base Plan and Jurisdictional Annexes. Vulnerability to these hazards is evaluated in the "Vulnerability Analysis" Subsections of the plans. Consequences, defined as seven areas of potential impacts to a jurisdiction, are analyzed in the "Consequence Analysis" Subsection of the plans.

Figure 4-3 Risk Definitions: Threat, Vulnerability, and Consequence



Risk Reduction Requirements

The Robert T. Stafford Disaster Relief and Emergency Assistance Act – as amended by the Disaster Mitigation Act 2000, the Sandy Recovery Improvement Act of 2013, and the Water Infrastructure Improvements for the Nation Act of 2016 – requires jurisdictions writing local hazard mitigation plans to meet the current Federal Law requirements (Code of Federal Regulations (CFR), Title 44, Part 201.6) in order for their plans to be approved by the Federal Emergency Management Agency (FEMA). Upon approval and local adoption, these plans become eligible for relevant hazard mitigation grant funds. CFR Requirement §201.6(c)(2) – in particular – sets the requirements for hazard mitigation plan risk assessments that this Pierce County RHMP Base Plan "Section 4: Risk Assessment" as well as each Jurisdictional Annex's "Section 4: Risk Assessment" satisfies.

Furthermore, Chapter 118-30 of the Washington Administrative Code (WAC) requires emergency management plans to be based on a written assessment and listing of the hazards to which the political subdivisions are vulnerable. State law also requires each political

subdivision to be part of an emergency management organization and maintain an emergency management plan.

Over twenty years ago, Pierce County Department of Emergency Management (PCDEM) began identifying the county's natural hazards and human-caused to assist with emergency planning. This work was formalized in the Pierce County's Hazard Identification and Vulnerability Assessment (HIVA) in 2009 and later the Hazard Identification and Risk Assessment (HIRA), which was most recently updated in 2020. The HIRA continues to serve as the foundation for Pierce County's emergency response and operations planning, and, because many jurisdictions rely on Pierce County for coordination in emergencies and disasters, it also informs local emergency planning across the county.

Hazard Identification Overview

Each Jurisdictional Annex "Section 4: Risk Assessment" describes local risks and vulnerabilities and is organized by hazard type. In both the Pierce County RHMP Base Plan and Jurisdictional Annex, "Section 4: Risk Assessment" is structured to present hazards in alphabetical order and divide these hazards into natural and human-caused hazards. Overall, Pierce County RHMP Risk Assessment includes eight natural hazards as identified below in the Pierce County RHMP Natural Hazard List Table (Table 4-1).

Table 4-1 Pierce Couty RHMP Natural Hazard List

Natural Hazards	
Drought	Severe Weather
Earthquake	Tsunami and Seiche
Flood	Volcano and Lahar
Landslide	Wildfire

In addition, the Pierce County RHMP identifies six human-caused hazards that are featured in the Pierce County Human-Caused Hazard List Table (Table 4-2).

Table 4-2 Pierce County RHMP Human-Caused Hazard List

Human-Caused Hazards	
Civil Unrest	Epidemic and Pandemic
Cyber	Hazardous Materials and Transportation Accidents
Dam Failure	Terrorism and Extremism

Pierce County Risk Assessment Overview

The Pierce County RHMP Risk Assessment – both the Base Plan and Jurisdictional Annexes – begins with two Regional Hazard Identification Summary Tables (see Table 4-4 on page 8 and Table 4-5 on Page 11). These tables list all hazards addressed in the Pierce County RHMP, organized by natural hazards and human-caused hazards, and include a historical record of locally significant incidents, formally declared disasters, and the probability of reoccurrence for each hazard.

Each hazard is further discussed in the Pierce County RHMP Base Plan's Risk Assessment Subsections (see Figure 4-3). For each hazard, there is a detailed *Identification Description*, which includes the hazard's definition and types, and a *Profile*, which includes the hazard's location, extent, occurrences, and impact. Based on this county-level assessment, each Jurisdictional Annex in the Pierce County RHMP then describes each jurisdiction's local vulnerability to each hazard. These detailed assessments of vulnerabilities affecting specific jurisdictions and infrastructure are discussed in the "Section 4: Risk Assessment" and "Section 6: Infrastructure" of each Jurisdictional Annex.

Table 4-3 Pierce County RHMP Base Plan "Section 4: Risk Assessment" Hazard Subsection Organization

Risk Assessment Hazard Subsection Organization	
Hazard Name	**Subsection Name and Number**
Drought	Natural Hazard 4.1
Earthquake	Natural Hazard 4.2
Flood	Natural Hazard 4.3
Landslide	Natural Hazard 4.4
Severe Weather	Natural Hazard 4.5
Tsunami and Seiche	Natural Hazard 4.6
Volcano and Lahar	Natural Hazard 4.7
Wildfire	Natural Hazard 4.8
Civil Unrest	Human-Caused Hazard 4.1
Cyber	Human-Caused Hazard 4.2
Dam Failure	Human-Caused Hazard 4.3
Epidemic and Pandemic	Human-Caused Hazard 4.4
Hazardous Materials and Transportation Accidents	Human-Caused Hazard 4.5
Terrorism and Extremism	Human-Caused Hazard 4.6

Regional Hazard Identification Summary

Natural Hazards in Pierce County

Table 4-4 Pierce County Regional Hazard Identification Summary

Hazard	Declaration Number, Date, and Place	Probability of Recurrence
Drought	Many dry seasons, but no FEMA declarations, but multiple USDA Drought declarations including: 2025, 2024, 2023, and 2022.	50 years or less occurrence
Earthquake	N/A – 7/22/2001 Nisqually Delta N/A – 6/10/2001 Satsop DR-1361-WA – 2/2001 Nisqually N/A – 7/2/1999 Satsop DR-196-WA – 4/29/1965 Maury Island, South Puget Sound N/A – 4/13/1949 South Puget Sound N/A – 2/14/1946 Maury Island	Mw 4.3 Mw 5.0—Intraplate Earthquake Mw 6.8—Intraplate Earthquake Mw 5.8—Intraplate Earthquake Mw 6.5—Intraplate Earthquake Mw 7.0—Intraplate Earthquake Mw 6.3 40 years or less occurrence Historical Record—About every 23 years for intraplate earthquakes
Flood	EM-3629-WA – 12/2025, December 2025 Winter Storms N/A – 02/2020, Flooding and Landslides* DR-4056 – 03/2012 DR-1825 – 03/2009 DR-1817-WA – 01/2009 N/A – 11/2008 DR-1682 – 02/2007 DR-1671-WA – 11/2006 DR-1499-WA – 10/2003	5 years or less occurrence Best Available Science--The frequency of the repetitive loss claims indicates there is approximately a 33 percent chance of flooding occurring each year.

Hazard	Declaration Number, Date, and Place	Probability of Recurrence
	DR-1159-WA – 12/96-2/97 DR-1100-WA – 1-2/1996	
Flood	DR-1079-WA – 11-12/1995 DR-896-WA – 12/1990 DR-883-WA – 11/1990 DR-852-WA – 1/1990 DR-784-WA – 11/1986 DR-545-WA – 12/1977 DR-328-WA – 2/1972 DR-185-WA – 12/1964 N/A – 11/1959 N/A – 12/1953 N/A – 12/1946 N/A – 12/1933 N/A – 12/1917 N/A – 11/1906	5 years or less occurrence Best Available Science--The frequency of the repetitive loss claims indicates there is approximately a 33 percent chance of flooding occurring each year.
Landslide	N/A – 02/2020, Flooding and Landslides* DR-1159-WA – 12/96-2/1997 DR-852-WA – 1/1990 DR-545-WA – 12/1977	Slides with minor impact (damage to 5 or less developed properties or $1,000,000 or less damage) 10 years or less. Slides with significant impact (damage to 6 or more developed properties or $1,000,000 or greater damage) 100 years or less.
Severe Weather	N/A – 02/2025, Winter Weather* N/A – 01/2024, Winter Storm and Cold* N/A – 12/2022, December Extreme Winter Weather* N/A – 07/2022, July Weather Heatwave* N/A – 12/2021, Winter Weather* DR-4056-WA – 01/2012 DR-1825- WA – 12/2008 – 01/2009 DR-1682-WA – 12/2006 DR-1159-WA – 12/96-2/1997	The recurrence rate for all types of severe storms is 5 years or less.

Hazard	Declaration Number, Date, and Place	Probability of Recurrence
	DR-1152-WA – 11/19/1996 DR-981-WA – 1/1993 DR-137-WA – 10/1962	
Tsunami and Seiche	N/A – 04/1949, Tacoma Narrows	There is too short of a historic record to give a definitive answer for a recurrence rate, but an estimate is around 100 years.
Volcano and Lahar	DR-623-WA – 5/1980	The recurrence rate for either a major lahar (Case I or Case II) or a major tephra eruption is 500 to 1000 years. The recurrence rate for either a major lahar (Case I or Case II) or a major tephra eruption is 500 to 1000 years.
Wildfire	N/A – 08/2023, Ft. Steilacoom Park Fire* EM-3427-WA/FM-5360-WA – 09/2020, Sumner Grade Fire	Based on information from WA DNR the probability of recurrence for WUI fire hazard to Pierce County is 5 years or less.
Any incidents with an "" indicates that this is not a federally declared disaster through FEMA, rather, it is a significant incident as recorded by Pierce County and other jurisdictions in the Pierce County RHMP*		

Human-Caused Hazards in Pierce County

Table 4-5 Pierce County Regional Hazard Identification Summary

Hazard	Declaration Number, Date, and Place	Probability of Recurrence
Civil Unrest	N/A – 06/2020, Pierce County Demonstrations*	Looking at the historical record, major civil unrest is a rare occurrence. Movement of military supplies from Port of Tacoma to Joint Base Lewis McChord
Cyber Incident	Not Applicable	
Dam Failure	Not Applicable	No occurrences in Pierce County 50+ years recurrence
Epidemic and Pandemic	DR-4481-WA, Washington Covid-19 Pandemic	Pandemics 2009-2010 "Swine Flu Recurrence Rate – 20 years
Hazardous Materials	N/A – 08/2021, Washington Cold Storage Inc. Fire*	Dalco Passage oil spill of October 13, 2004 Chlorine Spill Port of Tacoma February 12, 2007 Large Incidents 5-year recurrence Small Incidents 1 week recurrence
Transportation Accidents	N/A – 09/2025, White River Bridge Closure* N/A – 08/2018, Ketron Island Aircraft Crash* N/A – 12/2017, Amtrak Derailment*	Minor Incidents occur daily Major Incidents rare Recurrence Rate – 10 years
Pipeline Failure	Not Applicable	Northwest Pipeline Corporation natural gas incident May 1st, 2003, in Sumner 10 years recurrence
Terrorism and Extremism	N/A – 12/2022, Substation Attack*	Terrorism incidents occur regularly.

Any incidents with an "" indicates that this is not a federally declared disaster through FEMA, rather, it is a significant incident as recorded by Pierce County and other jurisdictions in the Pierce County RHMP*

Endnotes

[1] Photo courtesy of the Pierce County Department of Emergency Management

Civil Unrest

Human-Caused Hazard | 4.1

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Table 4.1-1 High Impact Civil Unrest Target Areas. 8

Identification Description

Definition

Civil unrest is a broad term often used interchangeably with 'civil disorder', 'civil disturbance', and 'civil disobedience'. Pierce County Department of Emergency Management's 'Know Your Hazards' website defines civil unrest as:

> *"Civil unrest is identified as the result of groups or individuals within the population feeling, rightly or wrongly, that their needs or rights are not being met, either by the society at large, a segment thereof, or the current overriding political system."*

When this results in community disruption to the extent that intervention is required to maintain public safety, it has become a civil disturbance. The potential for civil unrest or civil disturbance is highest in the larger cities of Pierce County, such as Lakewood, Puyallup, and Tacoma.[1]

Civil Unrest and the United States Code (USC)

Title 18 of the United States Code defines civil disorder. Under Title 18, Section 232(1) of Chapter 12, defines civil disorder as: "…any public disturbance involving acts of violence by assemblages of three or more persons, which causes an immediate danger of or results in damage or injury to the property or person of any other individual."[2]

The Federal Emergency Management Agency (FEMA) defines civil disturbance as "an activity such as a demonstration, riot, or strike that disrupts a community and requires intervention to maintain public safety."[3] Civil disobedience, also known as passive resistance, is a "refusal to obey the demands or commands of government…without resorting to violence or active measures of opposition…"[4] Civil disobedience is sometimes equated with protests or non-violent resistance. Acts of civil disobedience can start peacefully but can lead to violence. In this context, civil disobedience actions that turn violent and antagonistic toward public safety and civil authority manifest as rioting, vandalism, looting, and widespread uprisings.

While the federal government does not explicitly identify civil unrest within the USC, some federal agencies refer to civil unrest as a "period of social upheaval during heightened community tension or at mass gatherings such as sporting events, concerts and political convention"[5] or as "an activity such as a demonstration, riot, or strike that disrupts a community and requires intervention to maintain public safety."[6]

Civil Unrest and the Revised Code of Washington (RCW)

In Washington State, civil unrest is undefined in the Revised Code of Washington (RCW). For purposes of RCW 98.48.120 (Civil Disorder Training), civil disorder is ”any public disturbance involving acts of violence that is intended to cause an immediate danger of, or to result in, significant injury to property or the person of any other individual.”[7] Specifically, RCW 98.48.120 identifies a “person is guilty of civil disorder training if he or she teaches or demonstrates to any other person the use, application, or making of any device or technique capable of causing significant bodily injury or death to persons, knowing, or having reason to know or intending that same will be unlawfully employed for use in, or in furtherance of, a civil disorder” as a “class B felony.”[8]

Within the RCW, Washington State approaches potential legal options to respond to public disturbance incidents in existing civil and criminal codes such as:

- RCW 9A.84.010-.030: criminal mischief, failure to disperse, and disorderly conduct
- RCW 9A.48.010-.110: arson, reckless burning, malicious mischief, criminal street gang tagging and graffiti, and defacing a state monument
- RCW 9.91.025 and RCW 9.91.150: unlawful transit conduct, tree spiking
- RCW 9.05.030-.060: sabotage

Washington State equates civil unrest, civil disorder, and civil disturbance violent incidents interchangeably.

Types

Civil unrest can take many forms and may arise from a variety of political, social, and/or economic causes. According to the United Nations, “civil unrest may be triggered by the occurrence of various other hazards, or an ineffective or inefficient response to their occurrence, in particular in the case of other societal hazards, such as those involving violence, conflict or financial shock, but also various environmental, technological and other hazards.”[9]

Profile

Location and Extent

Civil unrest can happen anywhere, but the most likely locations are areas with large population groupings or gatherings.[10] Attracting many people to a specific event, place, or activity could be viewed as potential locations for the epicenter of civil unrest events. Disruption of critical infrastructure may occur during very severe civil unrest events.

Civil unrest scenarios can encompass small ad hoc gatherings to large, organized groups blocking access to buildings, facilities, events or disrupting normal activities. Public services such as water, power, communication, and transportation may be temporarily unavailable. Civil unrest situations can range from peaceful, non-violent demonstrations, marches, rallies, and other forms of civil disobedience to full scale riots involving extensive violence (including the introduction of weapons), property damage, looting, and widespread disorder.

Occurrences

Civil unrest may result from many situations and encompass a broad spectrum of public action that can range from peaceful events to disruptive or violent incidents (stemming from protests, demonstrations, and marches into riots and other forms of obstructions, public chaos, and criminal acts).

The severity of such unrest typically coincides with the level of public outrage.[11] The circumstances may be spontaneous or may result from escalating tensions as was demonstrated in Seattle following the police killing of George Floyd Jr. by Minneapolis, Minnesota police officers.

Relatively unobstructive occurrences of civil unrest may occur at any time for a variety of reasons. Situations where significant damage or harm is done during civil unrest are the exception, rather than the rule. Historically in Washington, major civil unrest leading to social disruption is a rare occurrence.

Port of Tacoma Protests | 2007

In response to shipments of military equipment being scheduled to ship through the Port of Tacoma, anti-war protesters demonstrated for 11 days, with some individuals attempting to interfere with the shipment. Throughout the event, 37 protesters were arrested.[12]

Northwest Detention Center Incendiary Devices | 2019

A King County man who had been arrested for assaulting a police officer during a protest outside the Northwest Immigration and Customs Enforcement (ICE) Processing Center in June 2018[13], returned to the Center in July 2019 amid a peaceful rally supporting detained immigrants outside the facility. The man threw incendiary devices at the detention facility. According to Tacoma police, the man attempted to ignite a large propane tank and set buildings on fire. The man was armed with a rifle. Police attempted to intervene, shots were fired, and the man was killed. Besides possessing a rifle, police found he also had a satchel with flares.[14]

Black Lives Matter | 2020

In Seattle, Black Lives Matter demonstrations against the killing of George Floyd by Minneapolis police officers resulted in several days of street protests, primarily in the Capitol Hill neighborhood. The intensity of these protests led to clashes with police, eventually prompting the Seattle Police Department to temporarily abandon its East Precinct building. Afterward, protesters claimed a six-block radius of the surrounding area. For the next 23 days, this zone – known as the Capitol Hill Autonomous Zone (or CHAZ), and later as the Capitol Hill Organized Protests (or CHOP), would attract national media and political debate.[15] During this time in the CHOP there were two deaths, four shootings, arson and several reports of sexual assault.[16]

Police Vehicle Violence Protests | 2021

In January 2021, in response to a Tacoma Police Officer deliberately driving their vehicle through a crowd after a street racing incident, protesters in Tacoma set a large fire, damaged buildings, and marched. Video of the incident was widely shared online and appeared to show at least one person being run over. The day after the incident, demonstrators gathered at a park, then marched through downtown Tacoma where windows were shattered, and multiple buildings were vandalized with spray paint. A trash can being used as part of an impromptu barricade was burned. Tacoma police arrested two protesters attempting to enter a building and found to be armed with a handgun and knives.[17]

Gaza War Protests in the Port of Tacoma | 2023

In November 2023, hundreds of pro-Palestinian protesters blocked the three road entrances to the Port of Tacoma. The protesters' goal was to stop port workers from loading what they believed to be an Israel-bound ship carrying US weapons and military equipment. Protesters parked dozens of cars in multiple blockades in front of port entrances, stopping workers from entering. One worker requested to leave the ship in solidarity, according to the protesters.[18] The Port of Tacoma blockade came after thousands demonstrated to call for a cease-fire in Gaza at the Washington State Capitol in Olympia two days earlier.[19]

Hands Off Protests | 2025

In April 2025, hundreds in Pierce County joined peaceful Hands Off! in Tacoma and Gig Harbor joining scores of other events nationwide organized as a "day of action"[20] protesting the Trump administration. Organizers described the series of demonstrations as the largest one-day, nationwide display of public resistance against the Trump administration.[21] Protests occurred not only in many cities and towns across Washington State, but drew millions of protesters nationwide.[22]

Immigrant and Workers Rights Protest | 2025

In May 2025, around 1,000 demonstrators took to the streets of Tacoma to rally for immigrant and workers' rights. The crowd marched through downtown and across the 11th Street bridge to the Northwest ICE Processing Center. Organizers claimed the rally as "the biggest May Day event in Tacoma history."[23]

No Kings Protest | 2025

In June 2025, thousands of protesters gathered in locations across Pierce County as part of a nationwide protest of President Trump. These protests and rallies were planned for the same day as a $25 to $40 million military parade in Washington D.C. and followed protests over ICE arrests across the country.[24] Rallies and protests gathered at People's Park in the Hilltop neighborhood of Tacoma, near Point Defiance Park in Tacoma, at the corner of Point Fosdick Drive and Olympic Drive in Gig Harbor, in Puyallup, and joining millions of protesters across the Country.[25]

Impacts

Although most instances of civil unrest or protest are peaceful, incidents of civil unrest may lead to a wide variety of community impacts.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Civil unrest can lead to injuries to or fatalities of individuals directly involved in the incident and uninvolved bystanders in the area. This can stem from conflict between demonstrators and law enforcement or between involved groups.

Health and Safety of Personnel Responding to the Incident

Civil unrest may lead to law enforcement injury or fatality as a results of their response to or escalation of an incident.

Continuity of Operations and Delivery of Services

Civil unrest may cause disruptions to continuity of government and continuity of operations of local agencies and businesses, largely depending on the focus and scale of the disturbance. Disruptions may impact the delivery of County services beyond the incident of unrest itself. Damage to property or equipment may limit the physical ability of the County to respond over a significant period of time. Safety concerns for staff and facilities may prevent employees from accessing their workplace or needed resources.

Property, Facilities, and Infrastructure

Individuals involved in civil unrest may intentionally or unintentionally cause damage to property, facilities, and other infrastructure. This can range from relatively minor impacts, like broken windows, litter, or graffiti to more severe impacts like widespread fires, damage to utilities, or intentional targeting of certain facilities or infrastructure.

The Environment

Environmental damage is highly dependent on the size and focus of the civil unrest. Generally, there is little or no damage to the environment due to civil unrest. Litter, broken windows, and spray-paint graffiti create little environmental damage.

Economic and Financial Condition

Damage to businesses or a loss in revenue due to civil unrest can cause significant economic impacts, especially to smaller businesses. Although physical damage to places of business tends to be relatively minor in most cases of civil unrest, it can lower economic growth rates and lead to ongoing economic impacts.[26]

Public Confidence in the Jurisdiction's Governance

Public confidence in government depends on a number of involved factors and will likely vary widely amongst the community. Low public confidence in government may also be a contributing factor to civil unrest to begin with. Generally, incidents of civil unrest with relatively little disruption to a community's daily routine will not lead to as much loss in public confidence as an incident that causes significant disruption would. The duration of a disruption due to civil unrest, and the visibility of governmental response, would also be significant contributing factors in public trust.

Priority Impact Areas

Priority Impact Areas include public spaces or community and critical infrastructure like transit, essential government services, businesses, schools, and special events or venues that attract large gatherings and can be impacted by civil unrest (see **Error! Reference source not found.**).

Table 4.1-1 High Impact Civil Unrest Target Areas.

High Impact Target Areas	
Commercial Buildings	Stadiums, concert venues, convention centers, theaters, parks, shopping malls, casinos, etc.
Cyber/Information Technology	Networks, power grids, communication industry, etc.
Special Events	Parades, festivals, concerts, sporting events, other planned celebrations, etc.
Government Buildings	Courthouses, federal buildings, schools, national laboratories, etc.
Law Enforcement and Emergency Services	First responders and all law enforcement facilities, equipment, personnel, etc.
Defense	Military bases, Department of Defense facilities, airfields, equipment, etc.
Transportation	Airports, bridges, ferries, interstate highways, passenger rail, tunnels, seaports, hazardous materials, pipelines, etc.
Dams, Water Reservoirs, and Power Distribution Networks	Operating systems, facilities, etc.
Financial Institutions	Banks and other financial institutions
Food and Agriculture	Food products at point-of-sale, distribution, and storage, etc.
Healthcare and Public Health	Hospitals, public health facilities, etc.
Historic Places and Sites	Historical landmarks, monuments, museums, and other iconic sites

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Endnotes

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[24] 'No Kings' protests draw thousands in and around Tacoma | Tacoma News Tribune ; accessed 1/7/2026
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Section 4: Risk Assessment

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Risk Assessment Requirements

Code of Federal Regulations 44

Plan Content – Requirement §201.6(c)(2)(i), §201.6(c)(2)(ii)(A), §201.6(c)(2)(ii)(B), §201.6(c)(2)(ii)(C), and §201.6(c)(2)(iii). This plan must include the following:

(2) A *risk assessment* that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. The risk assessment must include:

(i) A description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan must include information on previous occurrences of hazard events and on the probability of future hazard events.

(ii) A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description must include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:

(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B) An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate;

(C) Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

(iii) For multi-jurisdictional plans, the risk assessment section must assess each jurisdiction's risks where they vary from the risks facing the entire planning area.

Section 4: Risk Assessment

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Base Plan

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Cyber

Human-Caused Hazard | 4.2

Identification Description

Definition

"An attack, via cyberspace, targeting an enterprise's use of cyberspace for the purpose of disrupting, disabling, destroying, or maliciously controlling a computing environment/infrastructure; or destroying the integrity of the data or stealing controlled information."[1] Cyber-attacks are efforts to exploit targeted systems for personal, political, social or financial reasons.

Types

For the scope of this plan, cyber hazards are focused on cyber-attacks. Cyber-attacks are methods of action used within the greater context of the political, social, and criminal realms. They are conducted by actors under the general context of cyber warfare, cyber terrorism, and cyber crime.

Cyber Warfare

Politically motivated actions by a nation-state to penetrate another nation's computers or networks for the purpose of conducting espionage or causing damage or disruption of national systems.[2]

Cyber Terrorism

The intentional use of computers, networks and public internet to cause destruction and harm for personal objectives. These objectives may be political or ideological.[3]

Cyber Crime

A crime which a computer is the object of the crime (hacking, phishing, spamming, ransomware) or is used as a tool to commit an offense (e.g., child pornography, hate crimes, theft, stalking…).[4]

Profile

Location and Extent

Cyber-attacks can come in different forms based on the intended outcome and what is being attacked. Therefore, it is very difficult to define the specific methods, extent of the risk, or target location. Any computer, computer system, or electronic communications device/network is potentially vulnerable.

Attack methods are evolving and changing as technology changes and security efforts become steadily more advanced. For the purpose of this Pierce County Risk Assessment, attack methods fall into the following categories:

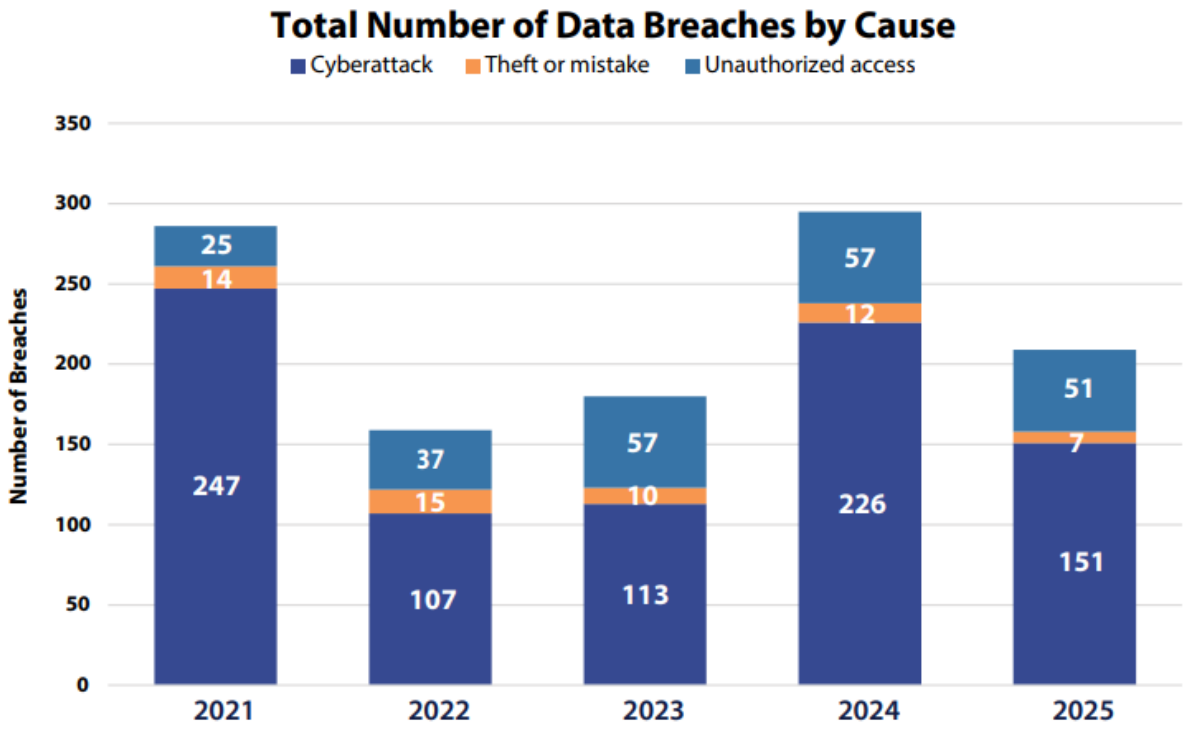
- **Penetration Attack.** This involves breaking into a system using a known security vulnerability to gain access.[5] Once access is gained the attacker can take control of the system, disrupt its functionality, incapacitate it, steal/gather information, conduct surveillance etc. These attacks can be very surreptitious and go undetected for extended periods, leaving the attacker ample time and opportunity to carry out their activities.
- **Denial of Service Attacks.** These affect a system by diminishing its ability to function and can eventually result in the incapacitation of that system.[6] The basic tactic is to overload the system's capability by flooding it with information such as e-mails, web site hits, significant increase in data streams etc.

Attacks can be designed to hit a specific target or accomplish a specific task then self-destruct. Others are intended to gain access and then "hide and report," quietly monitoring or reporting information over time. Some function like time-delayed mechanisms, activating when specific criteria are met, while others are designed to spread rapidly and broadly to maximize impact. Similar to the way biological contagions spread through contact between people, an electronic contagion can spread from each point of connection between an infected computer and other electronic systems capable of processing information, allowing it to grow exponentially over time. As a result, any networked or computer-controlled system that communicates with other systems may be exposed to varying degrees of cyber risk and potential exploitation.[7]

Occurrences

The 2025 WA State Attorney General's 2025 Data Breach Report showed 209 known data breaches in the state, impacting just over 8 million Washingtonians. Although this showed a slight increase from the year before, it still represents the third highest total recorded in Washington, with the others in 2024 and 2021.[8]

Figure 4.2-1 Total Number of Data Breaches by Cause in Washington State



Port of Tacoma Cyberattack | 2024

In August 2024, the Port of Tacoma (Port) became aware of a cyberattack causing system outages. While this attack did not impact the ability of travels to or from the Seattle-Tacoma International Airport (SEA), resulting outages caused significant delay in delivery of services at the airport and access to some personal information from Port systems. Outages lasted for almost two weeks.[9]

Pierce County Library System Data Security Incident | 2025

In April 2025, the Pierce County Library System (PCLS) became aware of unauthorized network access and copying of network files. After review, PCLS determined that personal information related to library patrons was subject to unauthorized access.[10]

CodeRED Data Breach | 2025

In November 2025, OnSolve CodeRED confirmed a cyberattack that disabled the nation-wide emergency alert notification system, impacting four jurisdictions in Pierce County who used CodeRED for internal and external emergency notifications, including the City of Lakewood, City of Sumner, City of University Place, and City of Puyallup.[11]

Recurrence Rate

Cyber incidents are occurring all over the nation at record high rates and are expected to continue to increase in severity and frequency. According to the Washington State Office of Attorney General, as of November of 2024, data breaches via cyber incidents have reached record high since these data breach incidents were first tracked over 10 years ago.[12] In 2024, over 11.6 million data breach notices were sent out across Washington State.[13]

Impacts

Health and Safety of Persons in the Affected Area at the Time of the Incident

Cyber-attacks can be used to target specific individuals or to obtain information that can be used to harm people. Cyber bullying, stalking, identity theft, fraud, compromise of personal information, are all forms of cyber-crimes that affect people directly. These attacks frequently have psychological impacts and can dramatically impact a person's well-being, and, in some cases, can even lead to suicide.

Some denial of services attacks seek to overload emergency communications systems. When successful, they can effectively shut down a community's 911 center leaving people without ready access to emergency services. If an attack of this nature were to occur in conjunction with another emergency, the potential for loss of life increases dramatically.

Some medical devices are drawing concern in recent media releases because they broadcast information wirelessly to other medical systems. This makes them vulnerable to interdiction by a hacker. Recent advances in pacemakers have included the ability to transmit data about a patient's heart directly to his or her doctor. There is growing concern that this may allow hackers to seize control over the device and disrupt its life saving function.[14] No further information was found to indicate that such an attack had taken place, however the potential exists.

Researchers at the University of Washington and University of San Diego demonstrated the ability to hack into a car's computerized systems and gain control over them, ignoring driver input.[15] Functional systems such as stability control, traction control, braking, navigation systems, anti-theft systems, monitoring systems etc., are essentially wireless computer systems on many high-end cars that communicate with each other as well as external systems like OnStar, a smart phone, or personal e-mail. This makes them vulnerable to intrusion and incapacitation.[16] An attack on these systems poses significant risks to motorists for serious accident, injury, and potentially death.

Successful attacks on critical infrastructure such as ground traffic control devices, railroad switches, and air traffic control systems can result in catastrophic accidents with significant loss of life. Water management systems at some of the state's largest dams are controlled by networked computers. If remotely accessed, it is possible that a hacker could open the flood gates and release massive amounts of water onto downstream communities with disastrous effects. People have become inextricably linked to technological systems. While this link can benefit them in many ways, it also makes them vulnerable.

Health and Safety of Personnel Responding to the Incident

Emergency responders are most at risk from an attack on their supporting communications systems. Most radio and dispatch systems today are essentially computer networks. Disruption of those networks poses great risk to responders as well as the public.

Continuity of Operations and Delivery of Services

Most county agencies rely on computer networks to function. Pay systems, personnel systems, social services, public works, judicial, emergency management, etc., all require significant automated capability to function in modern society. Disruption of those systems will cause a short-term impact on a department's ability to operate, unless there are back-up protocols in place. Destruction of systems will likely extend the period in which operations are reduced or suspended.

Depending on what type of service an organization provides, delivery may be partially or completely disrupted. Agencies may be forced to temporarily suspend services until an attack can be stopped and systems restored. If the attack erases essential information, it may be a long period of time before an agency can return to normal levels of service delivery.

Property, Facilities, and Infrastructure

There is significant potential for damage to facilities and infrastructure. Power generation and management systems, water movement and storage, wastewater treatment facilities and gas pipelines are all controlled by computerized systems. A successful attack to gain control over these systems could result in extensive damage that may seriously reduce capabilities for a period. Several incidents of damaging cyber-attacks on infrastructure have been reported throughout the world.[17] The potential for such an incident occurring in Pierce County is high. Incapacitated transportation management and control systems could result in accidents that can severely damage property and facilities as well as creating potentially serious hazardous material threats.

The Environment

As previously mentioned, hazardous materials spills are a real possibility if automated protection systems are taken over and incapacitated. Failed transportation control systems may result in fuel spills, as well as other hazardous cargo. Wastewater treatment facilities could be temporarily disabled leaving large amounts of untreated sewage to potentially flow into local bodies of water.

Economic and Financial Condition

Most notable cyber-attacks resulted in significant financial impacts. System outages, lost customer information, stolen funds, and stolen intellectual information have frequently cost companies of all sizes large amounts of money. In 2012, the Ponemon Institute completed a three-year study in which it tracked 56 large US corporate organizations. The study showed an average annual financial loss of $8.9 million, with the largest loss being $46 million. The study further noted that smaller organizations incurred a significantly higher per capita cost, presumably the result of a less robust financial margin.[18]

Companies can incur substantial costs in their efforts to protect themselves from cyber-attacks. Studies have shown that the stronger the security posture, the lower the costs associated with an attack.[19] However, these protective protocols and systems cost businesses money, which is eventually passed on to the client or consumer.

Identity theft costs people significant amounts of money each year as bank accounts are drained, credit cards are fraudulently used, or personal information is used to make fraudulent transactions. In 2010, 8.1 million Americans were reportedly victims of identity theft with a mean loss of $631.00 per victim.[20] This equates to an annual consumer loss of over $5 billion.

Loss of customer information frequently equates to loss of confidence and ultimately loss of business. Larger companies are postured to survive this type of event, but small businesses may lack the financial resources to rebound after an incident.

The recovery costs can be extensive, as well. Whether it is infrastructure damage, loss of funds, costs associated with correcting problems, or loss of productivity, there may be a significant cost associated with putting things back together after a successful attack. Loss of information poses one of the greatest risks, as the effects can linger long after the attack has been contained.

Public Confidence in the Jurisdiction's Governance

Cyber-attacks against the private sector will likely not impact on the public's confidence in their elected leaders, unless the targets of the attacks are of public interest such as a privately-owned utility or privately contracted public service. The greater the public impact, the greater potential that residents will question what their government is doing for them.

A loss of private information by a government agency has significant potential to impact public confidence. Residents expect that their private information will be protected. Just as a business, customer confidence will drop if that information is compromised.

A sustained loss or reduction of government provided services resulting from a cyber-attack may erode public confidence. While many individuals recognize that service interruptions can occur, the speed and effectiveness of an agency's recovery and return to normal operations can significantly influence public perception. Prolonged impacts may also prompt concern among otherwise unaffected individuals regarding the security and resilience of other government systems, particularly those that store personal or sensitive information.

Endnotes

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Dam Failure

Human-Caused Hazard | 4.3

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Identification Description

Definition

A dam is any "barrier built across a watercourse for impounding water.[1]" Dam failures are catastrophic events "characterized by the sudden, rapid, and uncontrolled release of impounded water.[2]

Definitions of Dam Inventory Terminology[3]

Crest Length: The crest length of the dam is listed to the nearest foot. Crest length is defined as the total horizontal distance measured along the axis of the dam at the elevation of the top of the dam between abutments or ends of the dam. Where applicable, this includes the spillway, powerhouse sections, and navigation locks where they form a continuous part of the water retaining structure.

Dam Height: The dam height is measured to the nearest foot. Dam height is defined as the vertical distance between the lowest point on the dam crest and the streambed elevation. If the dam is not across a stream or water course, the height is referenced from the lowest elevation of the outside limit of the barrier.

SEC-TWP-RGE: The government land subdivision within which the dam is located is listed by section, subsection, township north of the Willamette Base Line, and range east or west of the Willamette Meridian.

Maximum Discharge: The discharge rate of the spillway measured in cubic feet per second (cfs), when the reservoir is at its maximum designed water surface elevation.

Reservoir Purpose(s): Combinations of single letter codes are used to describe the purpose or purposes for which the reservoir is used (see Table 4.3-1).

Table 4.3-1 Reservoir Purpose and Code Matrix

Purpose	Code
Debris Control	D
Flood Control and Storm Water Management	C
Fish and Wildlife	F
Grade Stabilization	G
Hydroelectric	H
Irrigation	I
Navigation	N
Other	O
Fire Protection, Stock, or Small Farm Pond	P
Water Quality	Q
Recreation	R
Water Supply	S
Tailings	T

Storage Capacity – Maximum: Maximum storage capacity is the total reservoir volume below the maximum attainable water surface elevation.

Storage Capacity – Normal: Normal storage capacity is the total reservoir volume below the normal retention level.

Type of Dam: Combinations of two-letter codes are used to describe the type of dam construction (see Table 4.3-2).

Table 4.3-2 Dam Type and Code Matrix

Type	Code
Concrete	CN
Concrete Buttress	CB
Concrete Gravity	PG
Concrete Multiple Arch	MV
Concrete Single Arch	VA
Earth Fill	RE
Masonry	MA
Other Type	OT
Rock Fill	ER
Some Access	SA
Stone	ST
Timber	TI

Types

Dam failures may be caused by structural deficiencies in the dam itself. These may come from poor initial design or construction, lack of maintenance and repair, or the gradual weakening of the dam through the normal aging processes. However, they can also be caused by other factors including but not limited to debris blocking the spillway, flooding, earthquakes, lahars, landslides, improper operation, vandalism, cyber-attack or terrorism.

The Downstream Hazard Classification system (see Table 4.3-3) used in Washington provides simple characterization of the setting downstream of a dam to reflect the general nature of consequences if the dam were to fail and release the reservoir into the downstream valley.[4]

Table 4.3-3 Downstream Hazard Classification

Downstream Hazard Classification				
Downstream Hazard Potential	**Downstream Hazard Category**	**Population at Risk**	**Economic Loss General Description**	**Environmental Damage**
Low	3	0	Minimal. No inhabited structures. Limited Agricultural Development.	No deleterious material in reservoir contents.
Significant	2	1-6	Appreciable. 1 or 2 inhabited structures. Notable agriculture or work sites. Secondary highway and/or rail lines.	Limited water quality degradation from reservoir contents and only short-term consequences.
Significant	2D	1-6	Appreciable. 1 or 2 inhabited structures.	Limited water quality degradation from reservoir contents and only short-term consequences.
Significant	2E	0	Appreciable. Notable agriculture or work sites. Secondary highway and/or rail lines.	Limited water quality degradation from reservoir contents and only short-term consequences.
High	1C	7-30	Major. 3 to 10 inhabited structures. Low density suburban area with some industry and work sites. Primary highways and rail lines.	Severe water quality degradation potential from reservoir contents and long-term effects on aquatic and human life.

Downstream Hazard Classification				
Downstream Hazard Potential	**Downstream Hazard Category**	**Population at Risk**	**Economic Loss General Description**	**Environmental Damage**
High	1B	31-300	Extreme. 11 to 100 inhabited structures. Medium density suburban or urban area with associated industry, property, and transportation features.	Severe water quality degradation potential from reservoir contents and long-term effects on aquatic and human life.
High	1A	More than 300	Extreme. More than 100 inhabited structures. Highly developed, densely populated suburban or urban area with associated industry, property, transportation, and community lifeline features.	Severe water quality degradation potential from reservoir contents and long-term effects on aquatic and human life.

Profile

Location and Extent

The Washington Department of Ecology's inventory of dams, lists 58 dams or retention facilities either totally in Pierce County or shared jointly with another county. Of these, 46 have a peak storage capacity of 10 or more acre-feet. Of the 58 dams, 29 are categorized as having Significant or High Downstream Hazard Potential[5] (Table 4.3-3):

- 2 Significant Hazard Potential, Category 2E dams;
- 5 Significant Hazard Potential, Category 2D dams;
- 6 High Hazard Potential, Category 1C dams;
- 8 High Hazard Potential, Category 1B dams; and
- 8 High Hazard Potential, Category 1A dams.

Some of these dams, even though they are located in portions of the county with a low population base, are considered high or significant downstream hazards because of the quantity of water they impound (Table 4.3-3)

Figure 4.3-1 Reasons for Dam Failures Nationally [6]

OVERTOPPING – 34% of all failures

* Inadequate Spillway Design
* Debris Blockage of Spillway
* Settlement of Dam Crest

FOUNDATION DEFECTS – 30% of all failures

* Differential Settlement
* Sliding and Slope Instability
* High Uplift Pressures
* Uncontrolled Foundation Seepage

PIPING AND SEEPAGE – 20% of all failures

* Internal Erosion Through Dam Caused by Seepage– "Piping"
* Seepage and Erosion Along Hydraulic Structures Such as Outlet
* Conduits or Spillways, or Leakage Through Animal Burrows
* Cracks in Dam

CONDUITS AND VALVES – 10% of all failures

* Piping of Embankment Material Into Conduit Through Joints or Cracks

OTHER - 6% of all failures

This is the case with Alder, La Grande, and Mud Mountain Dams. A catastrophic failure of any of these dams could impact communities' miles downstream. Others are listed as hazardous not because of the quantity of water they could release, but rather because of their proximity to the public. There could be tens to hundreds of people or businesses located in a close proximity to the flow from a failure. It should be noted that a dam failure can happen at any time and be caused by anything. Map 4.3-2 Pierce County High and Significant Risk Dams illustrates the locations of all the dams in the county.

Others are listed as hazardous not because of the quantity of water they could release, but rather because of their proximity to the public. There could be tens to hundreds of people or businesses located in a close proximity to the flow from a dam failure. It should be noted that a dam failure can happen at any time and be caused by anything. The location of Pierce County High and Significant Risk Dams (Table 4.3-4) is further illustrated in Map 4.3-1 (see Map 4.3-1 below).

Table 4.3-4 Pierce County Dams Categorized as High or Significant Risk

Name	Hazard Class*	Owner	River or Stream	TWN RNGE SEC	Type**	Purpose†	Crest (ft)	Height (ft)	Normal Storage (acre-ft) ‡	Max Storage (acre-ft) ‡	Max Discharge (cfs)
Alder Dam	1A	Tacoma Public Utilities	Nisqually River	T15 NR04 ES09	VA	H, R	1,550	330	214,500	241,195	85,000
Mud Mountain Dam	1A	US Army Corps of Engineers – Seattle	White River	T19 NR07 ES17	ER	C	700	425	106,000	156,000	245,000
North Fork Clover Creek E1 Detention Basin	1A	Pierce County Public Works	North Fork Clover Creek	T19 NR03 ES14	RE	C, Q		10	40	170	749
Tapps Lake Dike No 1	1A	Cascade Water Alliance (CWA)	Diversion from White River		RE	R	280	18	467,000	536,000	0
Tapps Lake Dike No 4	1A	CWA	Diversion from White River	T20 NR05 ES09	RE	R	2,870	48	467,000	536,000	0
Tapps Lake Dike No 5	1A	CWA	Diversion from White River	T20 NR05 ES09	RE	R	520	28	467,000	536,000	0
Tapps Lake Dike No 6	1A	CWA	Diversion from White River	T20 NR05 ES10	RE	R	570	25	467,000	536,000	0
Tapps Lake Dike No 11	1A	CWA	Diversion from White River	T20 NR05 ES10	RE	R	2,115	25	467,000	536,000	0
Frozen Lake Dam	1B	National Park Service NW Region	Tributary from White River	T17 NR09 ES33	RE	R, S	215	19	64	76	0
Harbor Hill North Pond	1B	Harbor Hill HOA C/O the Property Group		T22 NR02 ES31	RE	C	900	20.5	17	51	

Name	Hazard Class*	Owner	River or Stream	TWN RNGE SEC	Type**	Purpose†	Crest (ft)	Height (ft)	Normal Storage (acre-ft) ‡	Max Storage (acre-ft) ‡	Max Discharge (cfs)
La Grande Dam	1B	Tacoma Public Utilities	Nisqually River	T16 NR04 ES33	PG	H, R	710	217	2,676	3,015	88,000
Latitude 47 Commerce Center Stormwater Pond	1B	Latitude 47 Commerce enter, LLC	Offstream, Wollochet Creek	T21 NR01 ES01	RE	C	400	14.99	10	13	
Leach Creek Stormwater Detention Dam	1B	City of Tacoma, Environmental Services	Leach Creek		RE	C	1000	13	1	183	280
North Fork Clover Creek W1 Detention Facility	1B	Pierce County Public Works	North Fork Clover Creek, West Branch	T19 NR03 ES14	RE	C		10	85	104	1,260
Steilacoom Lake Dam	1B	City of Lakewood	Chambers Creek	T20 NR02 ES42	PG	F, R	120	28	2,640	6,970	1,980
Tapps Lake Dike No 3	1B	CWA	Diversion from White River		RE	R	650	15	467,000	536,000	0
Bonney Lake WSU Infiltration Pond	1C	City of Bonney Lake	Offstream	T19 NR05 ES03	RE	C	1,000	9	0	53	0
Tapps Lake Backflow Prevention Structure	1C	CWA		T20 NR05 ES26	PG	R, S		21.5	46,700	53,600	0
Tapps Lake Dike No 2A	1C	CWA	Diversion from White River	T20 NR05 ES05	RE	R	290	9	46,700	53,600	0
Tapps Lake Dike No 2B	1C	CWA	Diversion from White River	T20 NR05 ES04	RE	R	280	15	46,700	53,600	0
Tapps Lake Dike No 10	1C	CWA	Diversion from White River	T20 NR05 ES10	RE	R	965	18	46,700	53,600	0

Name	Hazard Class*	Owner	River or Stream	TWN RNGE SEC	Type**	Purpose†	Crest (ft)	Height (ft)	Normal Storage (acre-ft) ‡	Max Storage (acre-ft) ‡	Max Discharge (cfs)
Tapps Lake Dike No 12	1C	CWA	Diversion from White River	T20 NR05 ES10	RE	R	1250	14	46,700	53,600	0
Lakeland South Pond No 1	2D	City of Auburn	Offstream – White River	T20 NR05 ES06	RE	C	550	13	18	22	70
Slavic Lake Dam	2D	City of Lakewood	Offstream – Unnamed	T22 NR01 WS35	RE	R	40	8	8	10	30
Tapps Lake Dike No 8	2D	CWA	Diversion from White River	T20 NR05 ES10	RE	R	360	20	46,700	53,600	0
Tapps Lake Dike No 9	2D	CWA	Diversion from White River	T20 NR05 ES10	RE	R	285	15	46,700	53,600	0
Tapps Lake Dike No 13	2D	CWA	Diversion from White River	T20 NR05 ES27	RE	R	330	5	46,700	53,600	0
Butterworth Dam	2E	WA Dept of Corrections (DOC)	Eden Creek	T20 NR01 ES21	RE	I, S	300	60	1,200	2,500	25
Sylvia Lake Dam Pierce Co	2E	Sylvia Lake Country Club	Tr-Puget Sound	T21 NR01 ES11	RE	R	390	16	60	142	160

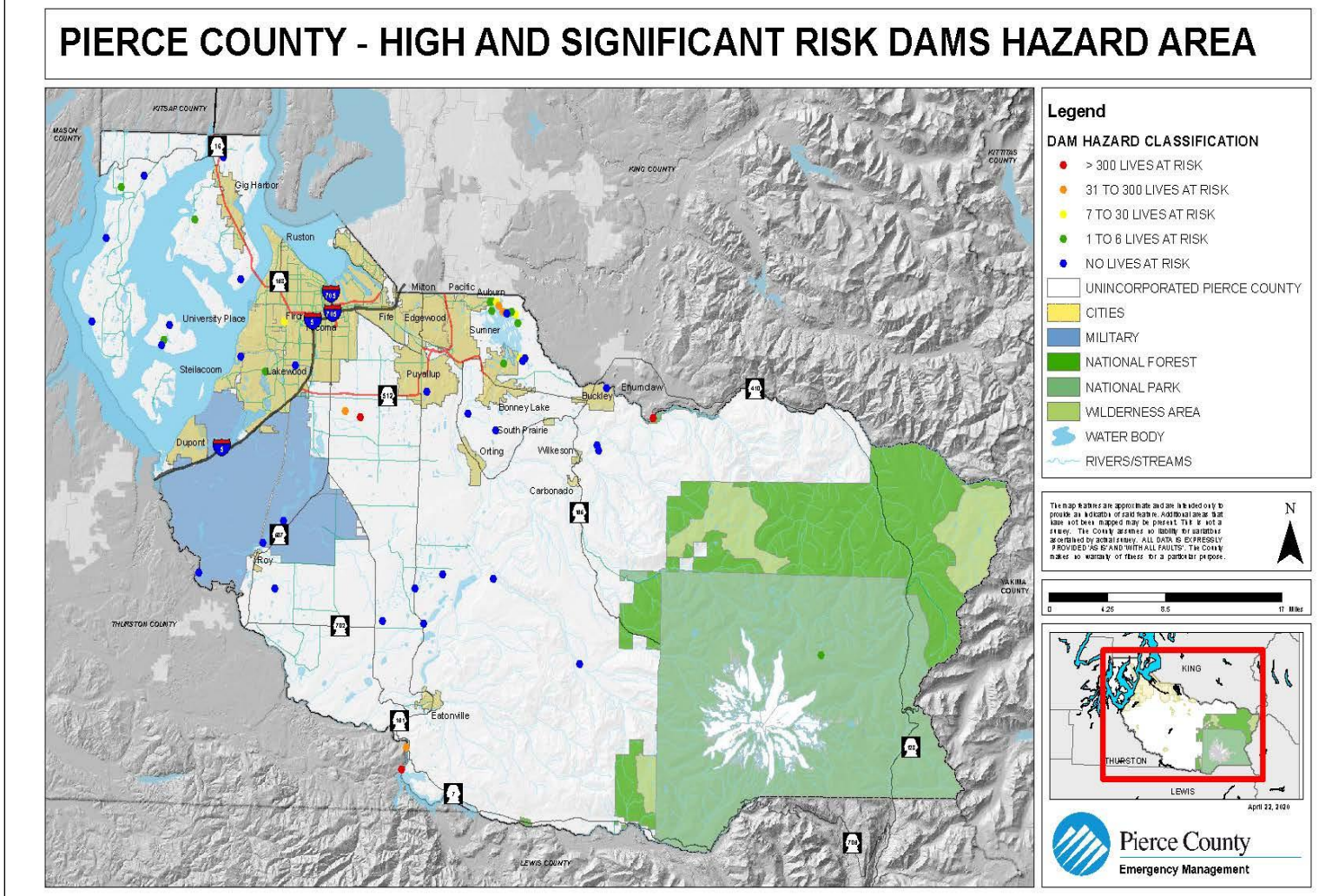
**Hazard Classes: 1 – High Hazard, 1A – greater than 300 lives at risk, 1B – 31 to 300 lives at risk, 1C – 7 to 30 lives at risk, 2D – 1 to 6 lives at risk, 2E – 0 population at risk but significant economic and/or environmental effects.*

***Type: ER – Rock Fill Dam, PG – Concrete Gravity Dam, RE – Earth Fill Dam, VA – Concrete Single Arch Dam.*

†Purpose: C – Flood Control & Storm Water Management, F – Fish & Wildlife, H – Hydroelectric, I – Irrigation, Q – Water Quality, R – Recreation, S – Water Supply

‡All dam storage numbers are in acre-feet. One acre-foot is the quantity needed to cover one acre to the depth of one foot or 43,560 cubic feet, or 325,851 gallons.

Map 4.3-1 Piece County High and Significant Risk Dams



Occurrences

There have been a number of dam failures in Washington State over the past 100 years, some of which are shown in Table 4.3-5, but a review of the literature has not turned up any in Pierce County.

Table 4.3-5 Select Dam Failures in Washington State [7,8]

Dam	Location	Failure Date	Nature of the Failure and Damage
Masonry Dam (Boxley Burst)	Near North Bend	12/23/1918	Excessive seepage through the glacial moraine abutment caused mud flow about one mi. from reservoir. It destroyed a RR line and village of Eastwick.
Eastwick Railroad Fill Dam	Near North Bend	02/1932	A landslide blocking a culvert caused a RR fill dam to fail destroying a portion of the RR tracks, the village of Eastwick and killing seven residents.
Loup Loup Dam	Near Malott	April 1938	A 50-foot-high hydraulic fill dam failed when emergency spillway was undercut during a flood. It destroyed ½ mile of state highway, 25 homes and left 75 people homeless.
Lake Dawn Dam	Port Angeles	February 1950	Heavy Rains caused overtopping and failure of the earthen dam. one home destroyed and $4000 damage
North Star Sand & Gravel Dams	Everett	December 1967	A 40-foot-high dam washed out by overtopping due to lack of spillway. 25-foot-high dam rebuilt, also failed, washed out Great Northern RR tracks and derailed a passing train
Pillar Rock Dam	Wahkiakum Co.	January 1970	A logging road fill culver was blocked by debris. It overtopped and failed. That caused a 25-foot-high concrete gravity dam to fail. three homes and a fish cannery were destroyed.
Sid White Dam	Near Omak	May 1971	Earthen dam failed due to seepage through animal burrows. Caused a second dam to fail and dumped debris into the town of Riverside.
Alexander Lake Dam	Near Bremerton	December 1982	Spillway undermined and failed during heavy rains. Caused damage at fish hatchery and homes in Gorst
Upriver Dam	Spokane	May 20, 1986	Hydropower facility failed by overtopping. Lightning struck the system causing the turbines to shut down. Water rose behind the dam while they were trying to restart the turbines. Backup power systems failed, and the spillway gated could not be raised in time. Caused $11 million in damage to the facility

Dam	Location	Failure Date	Nature of the Failure and Damage
Chinook Dam	Pacific County	Thanksgiving Weekend 1990	Heavy rains overtopped the embankment and undermined the spillway, leading to failure of the dam. Approximately $100,000 damage to the facility
Seminary Hill Reservoir	Centralia	October 05 1991	Failure along weak rock zone in a hillside caused a massive slide which breached the reservoir. three million gallons of water drained from the reservoir in three minutes. two homes were destroyed, many homes damaged, $3 million in damage.
Iowa Beef Processors Waste Pond Dam No. 1	Wallula near Richland	January 25, 1993	Failure of 15-foot-high embankment released 300 acre-feet of wastewater. Failure attributed to high reservoir levels due to snowmelt, entering animal burrows near the embankment crest, and eroding the dam. Washed out the Union Pacific RR tracks, derailed five locomotives and caused $5 million in damage.
Mill Creek Dam	Cosmopolis and Aberdeen	November 12, 2008	Pedestrian bridge washed out; residential areas flooded; ~12 homes received flood damages

Recurrence Rate

Failure is a possibility for any dam. While there have been occasional failures across the state, their lack in Pierce County over the past one hundred years would indicate a recurrence rate of fifty or more years.

Impacts

The impact from any individual dam failure depends on a number of factors:

- What is the maximum amount of water the dam can contain?
- What is the maximum amount of water the dam contains when it fails?
- Is the failure immediate and total or only partial and slowly developing allowing the water to gradually build in volume and power?
- Is the dam located in a populated area or is it removed from developed areas and critical infrastructure?
- Are there any other contributing factors that might limit the evacuation from a threatened area or the emergency response to the incident?
- Is there a warning?

Figure 4.3-2 Mud Mt. Dam Intake[1]

Health and Safety of Persons in the Affected Area at the Time of the Incident

Any individual dam has a very specific area that will be impacted by a catastrophic failure. The dams listed above in Table 4.3-2, will be a direct threat to the lives of individuals living in the inundation zone below the dam. Currently, populations who work in the inundation zone below the dam are not considered in the hazard classification process. Locals with data on businesses' number of employees and daily average customers can work with the Department of Ecology Dam Safety Office to identify hazard classification changes for weekdays.

The impact from any catastrophic failure would be similar to that of a flash flood. Just six inches of moving water can knock you down and one foot of moving water can sweep your vehicle away.[9] Lives can be lost. The water and landscape can be contaminated with hazardous materials such as sharp debris, pesticides, fuel and untreated sewage.[10] There could be injuries from impacts with debris being carried by the flood. With the cold water and cold air temperature for much of the year, hypothermia could exacerbate many of the problems for those rescued and contribute to the number of drowning deaths. Water may also be electrically charged from underground or downed power lines.[11] For more information see Flood chapter.

Because of their small size, or their location in uninhabited areas, thirty dams in Pierce County are not shown on Table 4.3-1. While it cannot be precluded, these dams are not expected to cause death or injury to individuals. However, it is possible that an individual or group of individuals could be in the wrong place at the wrong time and become a casualty of one of them failing.

Health and Safety of Personnel Responding to the Incident

Response to a dam failure is a response to a hazardous situation. Swift-water rescue of individuals trapped by the water puts the immediate responders at risk for their own lives. Later, after the water has receded, those involved in the cleanup may be at risk from the debris left behind.

Continuity of Operations and Delivery of Services

Continuity of operations for any jurisdiction outside the direct impact area could be very limited. Unlike most flood situations, a dam failure's impact will be constrained to an area within a single watercourse. In addition, the failure, while sending a surge of water down the individual watercourse will not usually continue to send water down over an extended period of time. There will be a surge of water and then with most dams the quantity will taper off relatively quickly.

Exceptions would include the partial failure of one of the large dams in the County, or the failure of a major dam during a major rain, or rain on snow event. In either of these cases, there could be a flood hazard already in existence when the dam fails.

Having the damage located within a single watercourse, while limiting the area directly impacted, could still cause major disruption of operations and the delivery of services. The heavy onrush of water associated with an event of this type could, through the destruction of infrastructure in the impacted area, put a total halt in a jurisdiction's ability to respond to many of the day-to-day needs of its citizens.

Property, Facilities, and Infrastructure

No matter the size of the dam, the large quantity of water associated with the failure of a dam creates a scouring force in the area immediately below it. For small dams this might only cover a few dozen to hundreds of yards not impacting much if any infrastructure. For large dams, like Alder, La Grande and Mud Mountain scouring could go for miles and damaged infrastructure may be found all the way to Puget Sound.

Depending on the quantity of water, the force caused by its onrush can take out buildings, power lines, sewage systems and roads. Damaged sewage systems are serious health hazards and need to be assessed as soon as possible. A large dam with a high head of water could effectively scour the terrain below it for miles, taking out all buildings and other infrastructure. This scouring force could also erode soil and any buried pipelines in the steeper portions of the valleys. Where the slope moderates and the rivers enter a wider plain the water would slow down and while still damaging the infrastructure it would act more like a very high, flood or small tsunami. There would still be some scouring in certain areas, but some other areas along the edges of the inundation zone might have a lot of debris deposition.

Failure of one of the major dams on the White or Nisqually Rivers when full could damage highways as far as I-5. Smaller roads and bridges closer to the actual failure could be totally removed due to the force of the water. Roads may have weakened and could collapse under the weight of a car. Floods in Washington damage bridges on a regular basis without anywhere near the quantity of water that could be released by a catastrophic dam failure on one of the County's major rivers.

The Environment

Any dam that fails has a detrimental impact on the environment. Of the 58 dams in Pierce County, seven are classified a significant risk to the environment only. The degree of the impact will vary depending on the size of the failure. Small dams will probably only impact a very small portion of the environment downstream. In the other extreme, the scouring action of a large quantity of water will destroy all vegetation in its path. A very large dam could hypothetically take out forested areas. Like any flash flood, this will destroy any wildlife caught in the flow. Fish habitats, including spawning beds, could be destroyed. Unlike most floods, the force of the water from a large dam failure will have a major scouring impact on portions of the valley. In some areas it will take off most if not all topsoil, limiting the ability of the environment to return to normal. It could take years for the natural restorative processes to bring back an ecosystem similar to what was there beforehand.

A large dam that fails, depending on the quantity of water released, could have an impact far beyond what is normally expected from a flood on its watercourse. Part of this is due to the volume of water that at peak may have a flow many times that of even a record flood. Added to this is the large quantity of material, both natural, like logs and other vegetation, and human related, like fertilizer, sewage, livestock, vehicles, and other hazardous materials. This material as it is deposited, may cause further pollution of not just the areas normally flooded, but also land that lies far above or away from the normal flood plain.

Economic and Financial Condition

The economic impact from the failure of many of the smaller dams in the County is negligible. Impacts would be to the owner of the dam and potentially to a small local group, probably geographically located directly downstream from the dam. The area they impact would be so small and, in most cases isolated, that a failure of one would go almost unnoticed by the rest of the County.

As the size of the dam increases and the proximity to the public and/or critical infrastructure increases, the severity of the impact to our economy increases. Any of the dams listed in Table 4.3-1 could have an impact on either the overall economy or on the financial condition of many of the businesses or homeowners located in the inundation zones from those dams.

A couple of the worst-case scenarios include a failure of Mud Mountain Dam or Alder Dam during peak storage. Either of these could not only kill many people but could irrevocably damage the infrastructure. The supply chain would be disrupted as roads and bridges would be lost. This includes damage to the main north-south corridor of Interstate 5. Businesses would be damaged or in many cases destroyed, and municipalities in the inundation zones would have a long-term process of rebuilding and reopening. Not all businesses will reopen, and some may choose to relocate. All of this would not only impact those areas in the inundation zone, but any area relying on either the infrastructure or businesses located in that zone.

Public Confidence in the Jurisdiction's Governance

For many of the small dams located in the County whose failure would have no impact on the general public there would be little change in the public's confidence in local governments or any agency overseeing their safety or operation.

The failure of any dam that does considerable damage to the community will have a lot of scrutiny by the press and the public. The organizations most in the line of fire will be those responsible for the dam and those responsible for overseeing its licensing and safety. When the ownership of the dam is a public agency the confidence in that agency will be adversely affected. Dam safety inspections fall to the Dam Safety Office in the Washington State Department of Ecology.

When a dam fails that directly impacts the public, especially if there are deaths associated with it, there will be considerable scrutiny of why it happened. The next point will be to ask the date of the last inspection and what were its results. If an inspection was conducted multiple years ago questions will arise concerning why it was not done more recently. This will be especially critical if it is shown that the dam in question was not inspected at the rate recommended by FEMA.[12] This is summarized by the State of Washington:

"Guidelines for dam safety prepared by the Federal Emergency Management Agency recommend annual inspections of high hazard dams (3 or more homes at risk), a 2-year interval for significant hazard dams (1 or 2 homes at risk), and a 5-year interval for low hazard dams (no homes at risk)."[13]

Current inspection requirements as listed in the Washington Administrative Code [14] are:

(1) As authorized by RCW 43.21A.064, the department has the authority to conduct routine periodic inspections of all existing dams with high and significant downstream hazard classifications to reasonably secure safety to life and property.

- Dams with high downstream hazard classifications will be inspected every five years.
- Dams with significant downstream hazard classifications will be inspected every five years, or ten years if workload or staffing necessitates a longer cycle between inspections.
- Dams classified as low hazard are not included in the periodic inspection program.

A dam failure of a class one or two dam, especially when there are injuries or fatalities; combined with lengthy periods between inspections will bring unwanted scrutiny on the State of Washington. This will lead to a decrease in the public's confidence in the State's governance.

Endnotes

[1] Dam, Washington Department of Ecology, Glossary at http://www.ecy.wa.gov/programs/wr/cwp/images/pdf/legsrpt/chptr7_glossry_111506.pdf
[2] Dam Failure, NOAA, National Weather Service, Glossary at http://www.nws.noaa.gov/glossary/index.php?letter=d
[3] Department of Ecology, Inventory of Dams Report (2025). Department of Ecology - Water Resources Program - Dam Safety Office. Retrieved January 8, 2026, from https://apps.ecology.wa.gov/publications/documents/94016.pdf.
[4] Department of Ecology, Inventory of Dams Report (2025). Department of Ecology - Water Resources Program - Dam Safety Office. Retrieved January 8, 2026, from https://apps.ecology.wa.gov/publications/documents/94016.pdf.
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[6] Notable Dam Failures, Washington State Department of Ecology, http://www.ecy.wa.gov/PROGRAMS/wr/dams/failure.html
[7] Notable Dam Failures and Incidents in Washington State, Department of Ecology http://www.ecy.wa.gov/programs/wr/dams/Reports/damfailure_ws.pdf
[8] Information on the Mill Creek Dam failure came from Dam Failures, Dam Incidents (Near Failures), Association of State Dam Safety Officials, http://www.damsafety.org/news/?p=412f29c8-3fd8-4529-b5c9-8d47364c1f3e
[9] FEMA. Accessed February 2020 from https://Ready.gov/floods
[10] Floods 101, Christina Nunez, National Geographic access August 13, 2019 at https://www.nationalgeographic.com/environment/natural-disasters/floods/
[11] Ibid.
[12] Federal Guidelines for Dam Safety, prepared by the Interagency Committee on Dam Safety, Federal Emergency Management Agency, June 1979, reprinted April 2004, pp. 39-42.
[13] Water Resources Program Policy 5404, Washington State Department of Ecology, Dam Safety Office as shown at http://www.ecy.wa.gov/programs/wr/rules/images/pdf/pol5404.pdf
[14] WAC 173-175-705 Periodic inspection by the department, as shown at http://apps.leg.wa.gov/wac/default.aspx?cite=173-175-705

Drought

Natural Hazard | 4.1

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Identification Description

Definition

A drought is defined as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in an affected area."[1]

Unlike some states, Washington has a statutory definition of a drought emergency (Revised Code of Washington Chapter 43.83B.400 and Washington Administrative Code 173-166). According to state law, an area is in a drought condition when:

- The water supply for the area is below 75 percent of normal.
- Water uses and users in the area will likely incur undue hardships because of the water shortage.

Drought is a natural part of the climate cycle. However, it can have a widespread impact on the environment and the economy. Both agriculture and certain industries that require a dependable, continuous supply of water can be affected by drought. Since the impacts of drought vary highly depending on the local environment, the type of agriculture and industry, and the type of social systems that have developed in an area, people can have very different ideas about drought. This can lead to a wide range of drought definitions. The two definitions listed above are both useful in their own way but are by no means the only possible definitions.

Types

Because of the wide range of drought definitions available, 'drought' has been grouped into four main types. [2] The first three types measure drought as a physical phenomenon and the last types measures drought in terms of supply and demand, tracking the effects of water shortfall as it ripples through socioeconomic systems. This process can be seen in **Error! Reference source not found.**.

Meteorological Drought

This type of drought is defined as an expression of precipitation's departure from normal over some period of time. These definitions are usually region-specific, and presumably based on a thorough understanding of regional climatology. Meteorological measurements are the first indicators of drought.

Agricultural Drought

This type of drought is defined as an occurrence in which there isn't enough soil moisture to meet the needs of a particular crop at a particular time. Agricultural drought happens after meteorological drought, but before hydrological drought. Agriculture is usually the first economic sector to be affected by drought.

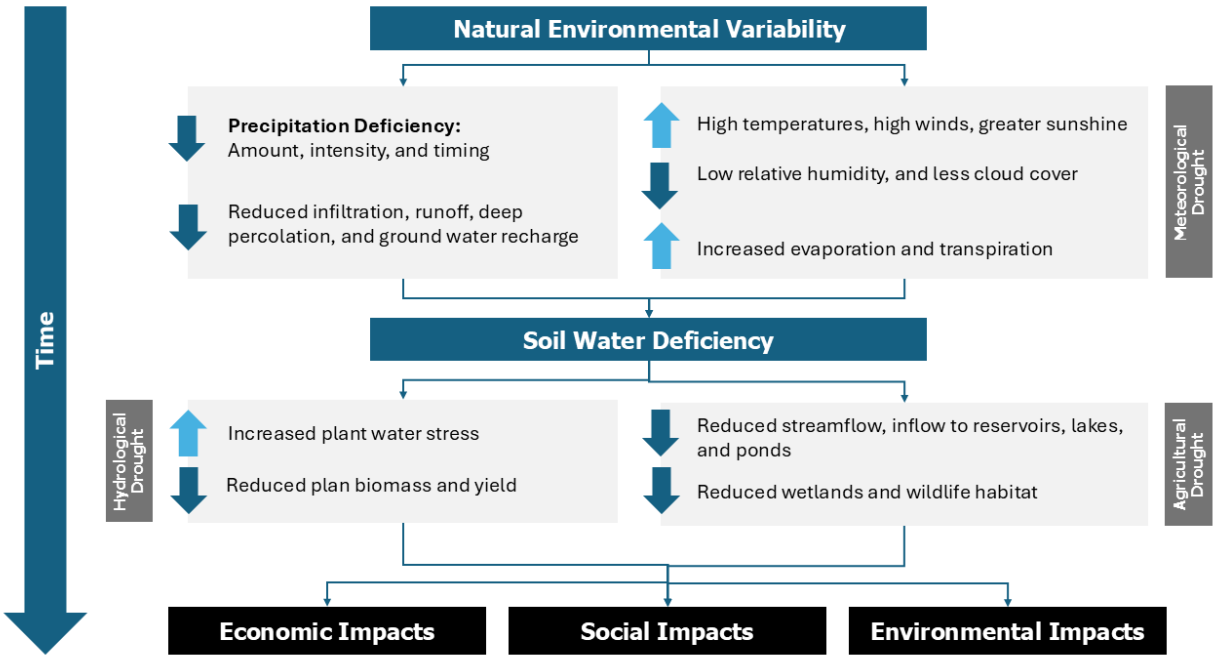
Hydrological Drought

This type of drought is defined by the deficiencies in surface and subsurface water supplies. It is measured as stream flow and as lake, reservoir, and groundwater levels. There is a time lag between the lack of rain and decreasing quantities of water in streams, rivers, lakes, and reservoirs, so hydrological measurements are not the earliest indicators of drought. When precipitation is reduced, or deficient, over an extended period of time, this shortage will be reflected in declining surface and subsurface water levels.

Socioeconomic Drought

This type of drought is defined as the occurrence when physical water shortage starts to affect people, individually and collectively. In more abstract terms, most socioeconomic definitions of drought associate it with the supply and demand of an economic good such as water, food grains, fish, or hydroelectric power.

Figure 4.1-1 Sequence of Drought Impacts[3]



The National Integrated Drought Information System (NIDIS) U.S. Drought Monitor (USDM) depicts the location and intensity of drought throughout the country using 5 categories of drought from D1 – the least intense, to D4 – the most. It also highlights areas with no drought and uses the D0 category to indicate abnormally dry areas that could be entering or recovering from drought. Wetter than normal conditions are also categorized. These categorizations are derived from the Standardized Precipitation Index (SPI), which measures water supply by capturing and quantifying how observed precipitation deviates from the climatological average over a given time period, typically 9 months before a given date.[4] (Table 4.1-1).

Table 4.1-1 USDM Drought Classification

Category	Description	SPI
D4	Exceptional Drought	-2.0 or less
D3	Extreme Drought	-1.9 to -1.6
D2	Severe Drought	-1.5 to -1.3
D1	Moderate Drought	-1.2 to -0.8
D0	Abnormally Dry	-0.7 to -0.5
None	Normal Conditions	-0.4 to 0.4
W0	Abnormally Wet	0.5 to 0.7
W1	Moderate Wet	0.8 to 1.2
W2	Severe Wet	1.3 to 1.5
W3	Extreme Wet	1.6 to 1.9
W4	Exceptional Wet	2.0 or more

Profile

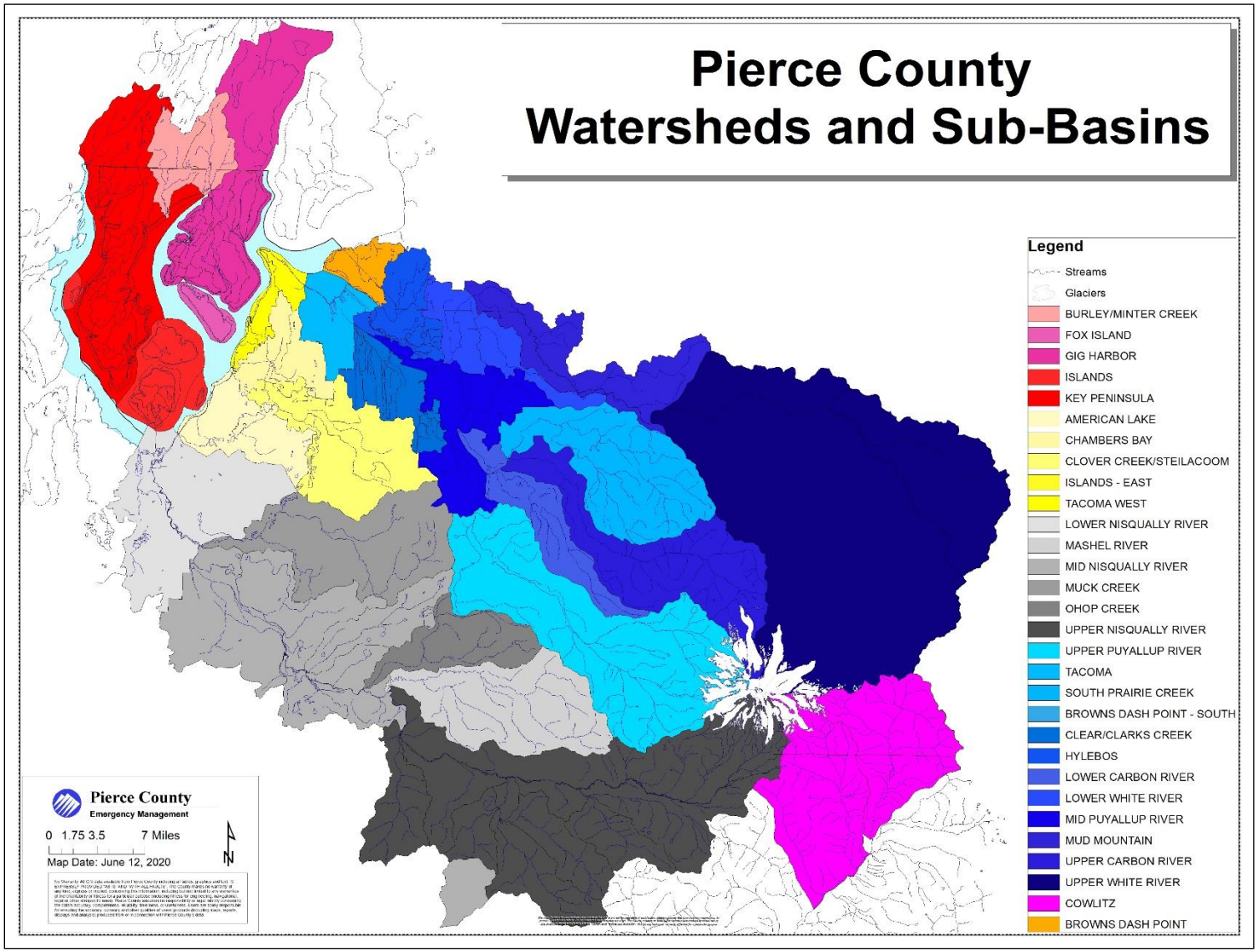
Location and Extent

Drought directly and indirectly affects all of Pierce County. While the entire region experiences drought, specific natural resources are the most impacted. These resources include, but are not limited to rivers, streams, ponds, fish habitat, forests and other natural resources. The impact on resources will vary depending on how each watershed is affected. A watershed that contains a lot of snow late into the summer, will not be affected the same as one that has no snow at all. In Pierce County, the distribution of resources can be tracked by watershed and these are found on Map 4.1-1.

The first noticeable indications of drought, besides lack of rain, are the decrease in soil moisture affecting the County's agricultural base. As time progresses, the effects begin to be felt across the community. Normally available sources of water, like reservoirs and lakes will begin to dry up. Their ability to cover the precipitation deficit can only do so for a limited time. The other option, wells, relies on the amount of ground water and is dependent on the long-term maintenance of the aquifer. Short term drought, from three to six months, usually does not affect these. However, long term drought conditions can affect them, drying up lakes and depressing the water table.

With the ending of drought conditions, the recovery will follow the same pattern. First to recover will be the soil water reserves and increases in stream flows. Reservoirs and lakes are next to refill, and finally, as water works its way down, the groundwater can be replenished. While the soil moisture content may rise rapidly following rain, the replenishment of groundwater may take many months or even years depending on the drought's duration, its intensity and the quantity of new precipitation over time.[5]

Map 4.1-1 Pierce County Watersheds



Occurrences

On average, the nationwide annual impact of drought is greater than the impacts of any other natural hazard. They are estimated to be between $6 billion and $8 billion annually in the United States and occur primarily in the agriculture, transportation, recreation and tourism, forestry, and energy sectors. Social and environmental impacts are also significant, although it is difficult to put a precise cost on these impacts.

The USDM compiles current and historical drought data. According to that data, portions or the entirety of Pierce County has experienced D2 – Severe and D3 – Extreme drought conditions multiple times in the last quarter of a century (Figure 4.1-2) and since the availability of records beginning in 1895 (Figure 4.1-3).[6]

Figure 4.1-2 Historical Drought Conditions for Pierce County, 2000 - 2026

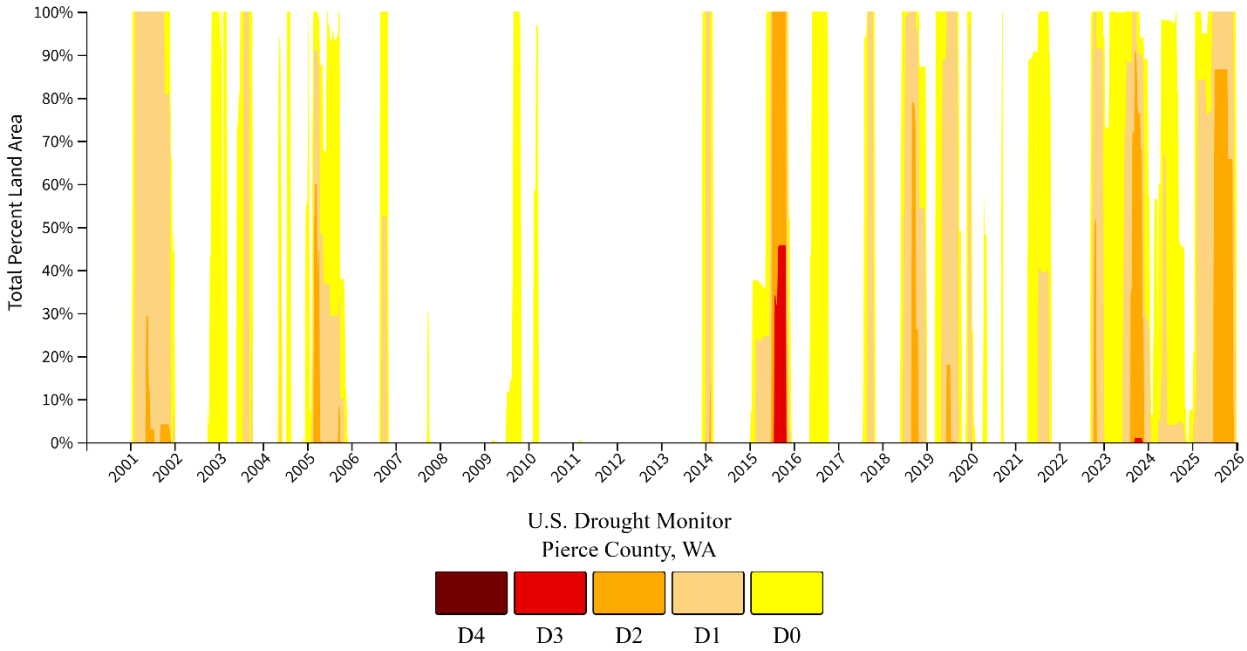
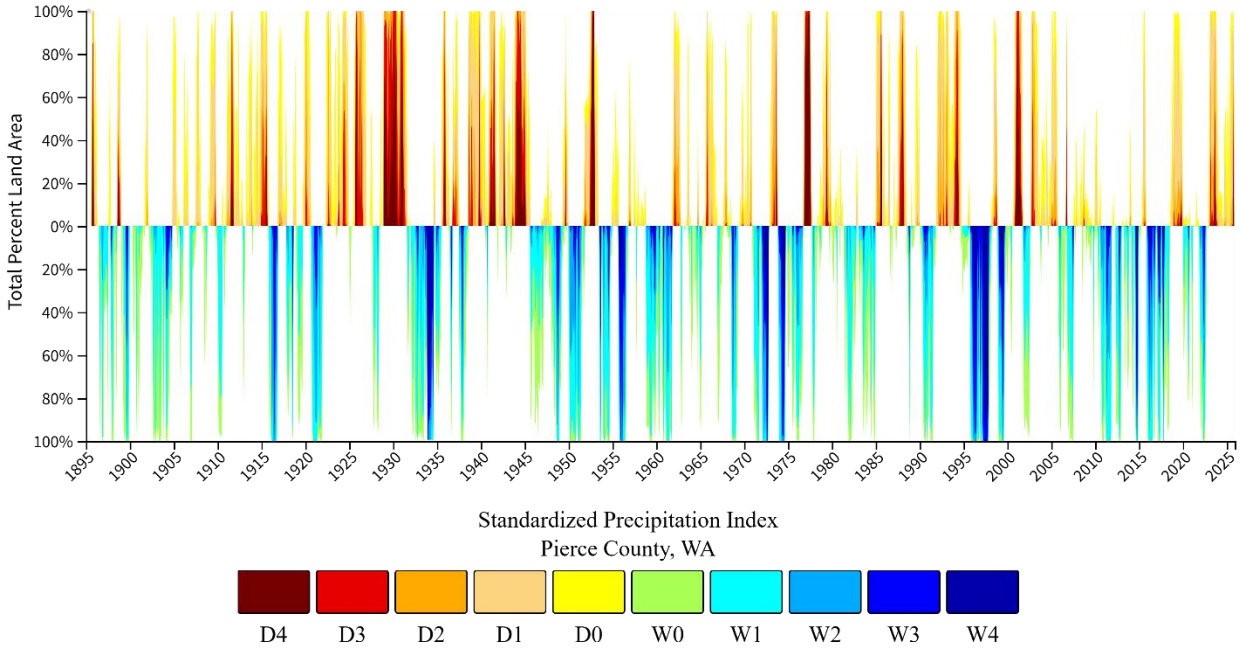


Figure 4.1-3 Historical Standardized Precipitation Index in Pierce County, 1895 to 2025



Portions of the County have experienced severe drought from five to ten percent of the time during the period from 1895 to 1995. For the decade from 1985 to 1995, the rate appears to have increased. During this period portions of the County had severe drought conditions between 10 and 20 percent of the time.

Historically, droughts have not usually been considered a problem in the area west of the Cascade Mountain Range. However, Pierce County and other west side communities have felt the effects of drought many times in the past and will continue to do so in the future. Table 4.1-2 catalogues a number of drought periods that have affected the County over the years. Note that several lasted for more than a single season and a few for more than a year.

Table 4.1-2 Notable Droughts Affecting Pierce County[7]

Date	Description
May 2019	Drought Emergency declared by Governor Inslee that includes half the state. Pierce County's intensity of drought ranges from abnormally dry to moderate drought. Abnormally dry impacts mean that the ski season is shortened, and visitation is lower. Moderate drought impacts include an increase in fire danger, possible dust storms, and river flow is low.[8]
April 17, 2015	Pierce watersheds added to Drought Declaration: Puyallup-White and Cowlitz.
November 2004 – Summer 2005	The winter of 2004-2005 was the driest winter in recorded history with record low snow packs of only 26% of average and stream flows as low as 22% of average. The drought conditions culminated in a February with no measurable precipitation in many parts of the state. Washington State declared a Drought Emergency on March 10, 2005.[9]

Date	Description
January – March 2001	The second driest winter on record in 106 years and second worst drought in State History. Stream flows approached the low levels of the 1976-1977 drought.
October 1976 – September 1977	The worst drought on record. Stream flows averaged between 30% and 70% of normal. Temperatures higher than normal resulted in algae growth and fish kills. Pierce County experienced severe-extreme drought conditions from 10-20 percent of the time.
April 1934 – March 1937	The longest drought in the region's history with PDSI maintaining values less than -1.[10] The driest periods were April-August 1934, September–December 1935, and July-January 1936-37.
July – August 1930	Drought affected the entire state. Most weather stations averaged 10% or less of normal precipitation.
June 1928 – March 1929	Most stations averaged less than 20% of normal rainfall for August and September and less than 60% for 9 months
July 1925	Drought occurred in Washington State.
July - August 1921	Drought in all agricultural sections of Washington State.
August 1919	Drought and hot weather occurred in Western Washington.
July – August 1902	No measurable rainfall in Western Washington.

Recurrence Rate

Scientists currently do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last is dependent on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

The future intensity and patterns of drought in Pierce County could be altered due to the expected changes in the global climate. Warming trends that will deliver less snow to the mountainous areas and threaten the possibility of drier summers could have a dramatic impact on the frequency and intensity of drought in Pierce County. The dwindling of the average annual snowpack will mean there is less available water for agriculture, the environment, citizens, businesses and industry, all leading to more frequent drought conditions.

Impacts[11]

The U.S. Drought Monitor (USDM) uses a five-category system, labeled Abnormally Dry or D0, (a precursor to drought, not actually drought), and Moderate (D1), Severe (D2), Extreme (D3) and Exceptional (D4) Drought. Drought categories show experts' assessments of conditions related to dryness and drought including observations of how much water is available in streams, lakes, and soils compared to usual for the same time of year.[12]

Depending upon its severity in Pierce County, drought typically does not result in loss of life or damage to property, as do other natural disasters. On the other hand, drought can lead to impacts on agriculture, water supply availability, the public's health and economic condition. However, it can be a magnifier of other natural disasters like wildfires or crop diseases.

Health and Safety of Persons in the Affected Area at the Time of the Incident

In Pierce County, based on historical precedent, drought will not by itself cause a decrease in the health and safety of its citizens. Rather damage will be done to the environment, business, agriculture, etc. However, problems frequently associated with drought can influence the health and/or safety of local citizens. These would include:

- high temperatures leading to heat related injuries including some deaths;
- mental and physical stress which can lead to a susceptibility to other diseases, such as heart disease;
- low moisture content in the forest leading to an increase in the number of forest fires threatening homes, citizens and firefighters;
- conflicts between citizens and government over water usage; and
- conflicts between citizens over water usage.

Health and Safety of Personnel Responding to the Incident

There should be no extra health or safety impacts from drought beyond those for the general public. Individual hazards exacerbated by the drought, such as an increase in wildfires, threaten the health and safety of responders; they are not a direct result of the drought.

Continuity of Operations and Delivery of Services

Drought, on the scale experienced in Pierce County, should not affect the ability of most agencies to continue operations. While services to the public for some operations may have to be cut back, the actual ability of agencies to continue operations in some form should not be compromised.

Delivery of services to the public will probably not be considered a problem for most local law enforcement agencies. Any increase in public tension regarding limiting the use of water or caused by layoffs from industry dependent on water should be within the ability of departments to handle.

For fire operations, however, impacts would be dependent on two factors, the actual quantity of water available and the dryness of the environment. If the drought is extreme enough and long lasting to the point that fire flow[13] is affected then fire departments and districts will not be able to fulfill their mission in relation to fire suppression. Related is the dryness of the environment in general. As the water supply decreases the probability of large-scale fires, wildland, urban, or on the wildland/urban interface become more probable. An increase in the number of fires as well as their size could tax the ability of departments to respond, causing them to rely on mutual aid or going to state mobilization. In either case, their operations will continue, albeit with support from outside agencies and possibly at a reduced level.

The ability to maintain service at a level required by the public can be threatened during drought for many utilities. Both electric and water utilities rely on a steady supply of water throughout the year.

Figure 4.1-4 Columbia River Basin Map

The foundation of northwest electricity is hydroelectric. Without a steady supply of water supplying the dams, utilities will either have to cut back production, possibly causing brownouts, or buy expensive power from other areas that have an excess. Much of this supply originates in the mountain snowpack that normally exists in the Cascades and Olympics, or in the case of the Columbia River, an area incorporating portions of seven states and one Canadian province (**Error! Reference source not found.**).[14]

Pierce County's water purveyors receive their water either from mountain watersheds or wells locally supported by the purveyor. Short term drought has caused limited problems in the past, usually rectified by volunteer water rationing. As the population grows and the demand for water to support that population increases the need for more extreme measures may also increase.

Lack of rain will directly affect the aquifers that many of the water purveyors rely on. Changes in the aquifers may require the drilling of new wells. Small water purveyors with wells that run dry and no intertie with another system may have to temporarily bring in water either by truck or in bottles to supply customers.

Lack of rain will also decrease the quantity of water flowing in the Green River, located in southern King County. The City of Tacoma relies on that supply for much of its water needs. While Tacoma also has a number of wells on its system, these could be taxed if the aquifer also begins to drop. The longer a drought continues the stronger its effects will be felt, not only from the Green River watershed, but also from the aquifers that could act as a backup. Eventually the point could be reached where in order to get water to the citizens not only would there be voluntary rationing, but also some mandatory controls implemented with fines for violators. Such controls would also affect industry. Many industrial processes require a quantity of water. To distribute enough water to citizens for health reasons, and critical infrastructure like fire hydrants and hospitals, some industry may have to either reduce or suspend operations.

Property, Facilities, and Infrastructure

Drought is a slowly developing problem with little immediate impact on any property, public facilities or the infrastructure. Many built up properties such as buildings, highways, and transmission towers will not be adversely affected by drought in any form. As a drought progresses however, from a short-term inconvenience to a long-term problem, certain portions of the infrastructure will begin to be affected. The lack of water in the reservoirs, streams and rivers will restrict how it can be used. For example, the need to use it for agriculture will conflict with the need to maintain an adequate flow for fish. Confounding the problem will be industries' need for a continuous supply and of the public for drinking, cooking and bathing water.

The decreasing water level in reservoirs used for hydroelectric generation creates two obstacles that limit the output of electricity. First, drought limits the amount of water available for generation. Without water behind the dams, they cannot generate power. Second, the amount of electricity generated depends on the pressure of the water on the turbines or how much head there is behind the intakes to the turbines. So, as the water level behind the dams drops

the pressure turning the turbines decreases. The result is that the dams are not getting as much electricity generated per cubic foot of water from a low water level as you would from a high-water level.

The water distribution system could also be impacted. Water purveyors may find their normal sources drying up. Water from the Green River, currently used by the City of Tacoma, may no longer be adequate or dependable. As the water table drops, shallow wells distributed throughout the County used mostly by small water purveyors may begin to dry up. Most of these do not have interties with other purveyors. The result could be that they will have to bring in outside resources to assist with getting an adequate supply to citizens.

The Environment

The environment that makes Pierce County an enjoyable place to live, work and play has its basis in the rainfall that supports the diverse ecosystems that exist across the County. Based as it is, on an abundance of water, the environment could be the most adversely affected portion of the County by a drought, especially long-term drought. Impacts on the Pierce County environment include:

- a reduction in viable habitat for fish and wildlife,
- an increase in both plant and animal diseases, and
- an increase in wildfires.

Habitat Reduction

Many of the plants, fish and wildlife native to Pierce County are used to periods of moderate drought which happens irregularly in Western Washington. However severe drought could stress the various environments or individual species within those environments. A decrease in rain and snow will not be uniform across any individual biotic zone and so the effects from a drought will not be universal throughout Pierce County. In some areas they could be much worse than in others.

Pierce County resides in the following watersheds: Chambers-Clover, Cowlitz, Kitsap, Nisqually, and Puyallup, see Map 4.7-1. A watershed is a basin-shaped area that drains into a river, lake, or the ocean. It includes freshwater, both ground and surface waters, as well as the saltwater of Puget Sound.

A Water Resource Inventory Area (WRIA)[15] may include more than one watershed and may overlap into more than one county. All of the WRIAs in Pierce County with the exception of the Chambers Creek have a portion of their watershed located in other counties and homeland security regions. Water Resource Inventory Areas are important for looking at the availability of

overall water resources and how a change in precipitation, either as rain or snow, will affect the other resources that depend on it. One of their key areas is looking at the availability of water to maintain fish habitats.

The most obvious immediate impact from drought is on fish populations. Drought can have a variety of negative impacts on salmon and other fish populations at several points of their life cycles. Drought can dramatically affect the ability of fish to thrive and reproduce. Streams that lack a continuous source of water tend to dry up leaving only pools for the fish to live in until the next rain brings a new flow of water down the channel. Many fish are sensitive to an increase in water temperature and a low stream flow can allow the water temperature to rise well above normal. According to the Washington Department of Fish and Wildlife:

The downstream migration of juvenile salmon in the spring is linked to the surge in stream flows created by runoff from melting snow in the mountains. With mountain snowpacks either well below average or completely gone, there could be some change on out-migration patterns as young fish attempt to reach saltwater to continue their life cycle. Adult salmon can have difficulties reaching upstream spawning grounds if river flows remain below normal.

Some salmon species spawn in channel margins, side channels and smaller tributaries. Spawning would have to occur in mainstream waters if those other areas are unavailable because of low flows. This could make salmon nests, known as redds, and the eggs incubating in them, more susceptible to bed scour during the fall and winter.

In other cases, instream flow can drop after the salmon spawn. Salmon nests are then dewatered and the eggs within them are lost. Impacts of drought can result in depressed salmons runs three to five years later, when those fish would be returning as adults.

Warmer-than-normal stream temperatures and low dissolved-oxygen levels in isolated pools can lead to fish deaths both in wild populations and at fish hatcheries[16]. Just as reduced water levels affect wild spawners, reduced water supply can lead to warmer water temperatures and thus result in increased fish disease, treatment costs and fish mortality. Some of the likely causes of problems are fungal and bacterial diseases, which can kill fish or lead to fewer fish eggs.

Many of our hatcheries depend on a clean and consistent source of water. So, during a drought, hatcheries can be at risk because of lack of water of sufficient quality and quantity to rear fish. The Washington Department of Fish and Wildlife (WDFW) sometimes might be required to pump water from wells, which adds significant costs to operations[17]

However, it must also be pointed out that while drought may be detrimental to some species, it may not be detrimental to all. “During droughts, the in-stream habitat conditions can actually be favorable for some fish species, such as certain minnows and darters, as well as fry and

fingerlings of larger species. Drought conditions allow these fish to compete with other fish, such as larger predators, which may be favored at higher flows. The result is a more robust and diverse fish community."[18]

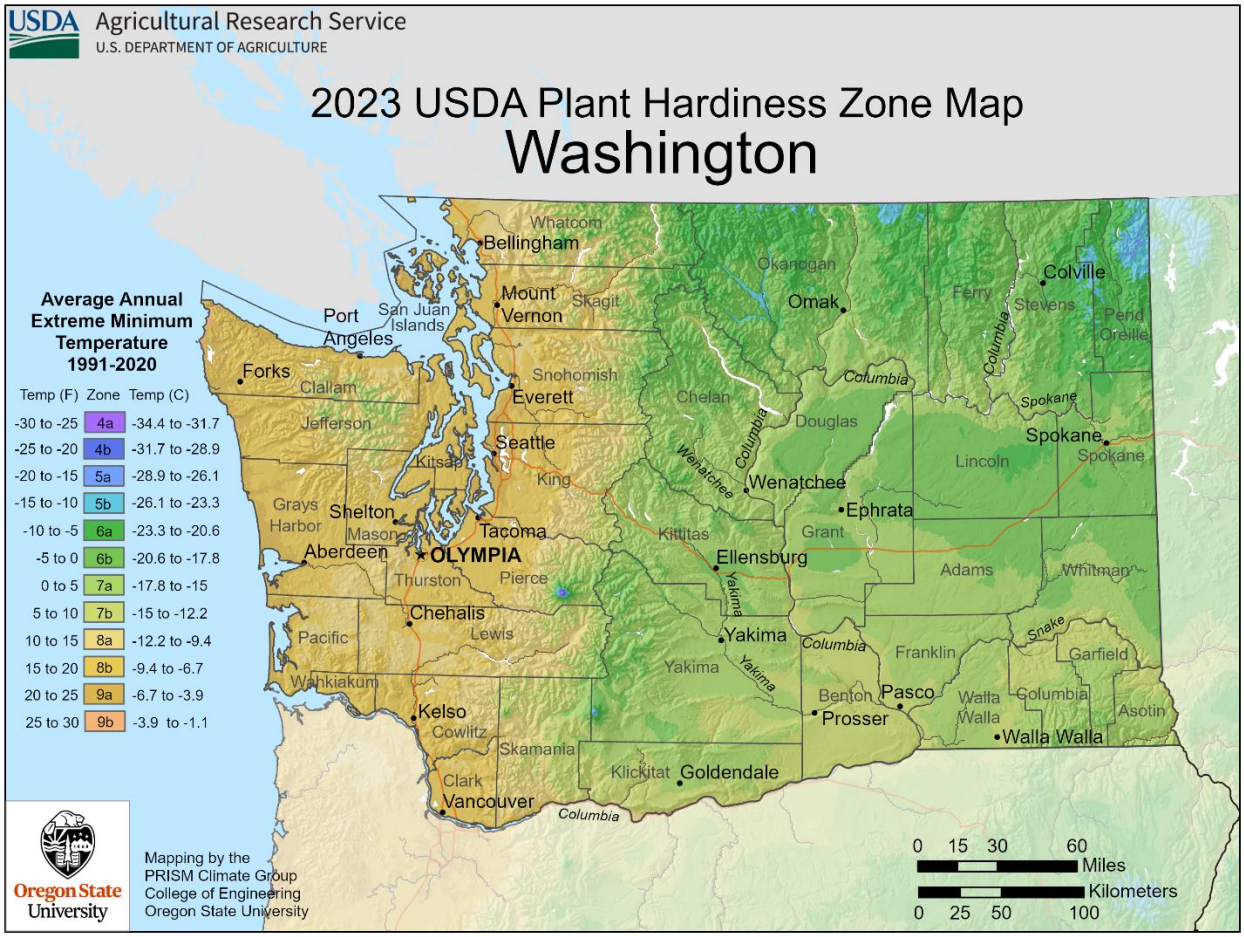
The impact on wildlife can also be dramatic and can vary considerably across the County. With topography ranging from sea level to over 14,000 feet there is a wide range of plants and animals that inhabit different areas.

The United States Department of Agriculture (USDA) has developed climate zones (also called hardiness zones) based on temperature for the entire United States. These zones are based on the mean of the lowest temperature recorded each year. Pierce County is divided into various climate zones (Figure 4.1-5). Since these zones are based on temperature, other factors need to be taken into account when looking at the effects of drought on the County.

Eastern Pierce County, as can be seen from the USDA Climate Zones map, has a very different range of temperatures from western Pierce County. Temperatures are cooler and because of the rise in elevation precipitation is much higher. This creates a different series of zones called life, or biotic zones. These zones are not just related to temperature, but include precipitation, are very variable, contain different animal and plant species and generally are located at different elevations.

A number of different categorizations of life zones have been utilized or defined over the years. Some more detailed and others simpler. The one shown here has been in use for over 50 years and is a variation of one first developed in the late 1800s.

Figure 4.1-5 USDA Plant Hardiness Climate Zones for Washington State[19]



Pierce County has four of the seven Washington State biotic zones established within it.[20] Listed from lowest elevation to highest elevation, these include:

- Coast Forest Zone - This zone encompasses the lowlands of Pierce County up to the foothills of the Cascades and climbing their lower slopes.
- Mountain Forest Zone - This zone is also called the Canadian Zone. It includes the evergreen forests that range up to approximately 5,000 feet in elevation.
- Sub-Alpine Zone - This zone includes the species that exist near tree line and ranges from 5,000 to 7,000 feet in elevation.
- Alpine Zone - This zone includes all terrain above timberline. Most of this is located on Mt. Rainier; however, there is a portion of it lying along the highest portions of the Cascade crest.

The marine climate associated with these zones provides the moisture to maintain them. Within the different zones the various species of plants and animals are more or less tolerant of drought conditions.

Animals that have an association with water resources, like amphibians (frogs, salamanders, etc.), ducks, geese, herons, and many others, will find their habitats drying up and will not have their normal food source available. Waterfowl and other birds have the ability to move elsewhere, however many smaller non-flying species do not. They in turn may attempt to migrate. While some may be successful others will not.

Deer and elk will find their normal food sources decreasing and may have to change their normal migration patterns. Voles, mice and others will find their populations decreasing, a situation that can put stress on the predators that rely on them. As water sources dry up animals will tend to congregate near water sources that are still viable. This concentration leaves many of them vulnerable to predators also congregating at the water source.

The result of extended drought in particular, is a total change in the distribution of the flora and fauna that currently inhabit Pierce County. This can push many species into conflict with people as they leave their normal habitats and migrate into more populated areas. The change in habitat limiting food and water can push some marginal species into localized decline or even eliminate them from the local environment decreasing the biodiversity.

Plant and Animal Disease

Maritime forests, like we have in Western Washington, in drought conditions tend to become stressed. Initial effects will be to the tree root system. Lack of water in the top 12-18 inches of the soil will begin to dry up and kill the root hairs that normally take up water. This causes a water deficit in the tree. Trees stressed like this are unable to grow properly, begin to lose their resistance to disease and also become susceptible to attacks by insects.[21] This can lead to wide areas having diseased or dead trees all of which can increase the potential for wildfire.

Research into the effects of drought on local environments shows that it can alter the effects of other disasters. A recent example is the loss of wetlands due to drought along the Gulf Coast. The weakening and killing of marsh grass by drought allowed periwinkle snails to further destroy the wetlands. This loss of coastal wetlands exacerbated the destructive tendencies of Hurricane Katrina.

“It’s important to note that drought was the trigger that initiated these events – and because drought stress is becoming more extreme with global warming, events like this could become both more frequent and intense,”[22]

In drought conditions, the lack of water and food supply will put extra stress on wildlife. Because of this stress, the combination of dehydration, hunger and in some cases heat, many animals may become susceptible to disease.[23]

Wildfire

The heavy forest growth, and resulting duff, existing on the west side of the Cascades has the potential during prolonged drought of creating conditions conducive to wildfires. Once started, the steep terrain combined with the heavy load of fuel can make these fires hard to put out. As with a wildfire in any part of the state, a large-scale wildfire within Pierce County could leave a lasting impression on the local environment that may not rebound for years if not decades or longer. Animal and fish habitat would be destroyed. The loss of the forest canopy would eliminate the shade needed for many species of both plant and animals. Streams would be polluted with burnt material and there would be an increase in erosion leading to silt deposits that could destroy fish habitat.

In contrast, it must be understood that while fire is destructive, it opens up new environmental opportunities. Forests go through a cycle of growth, decay and destruction. Fire is a natural part of the forest ecology. Previous attempts to eliminate all fires proved counterproductive for a healthy environment. Burning the understory in many cases increases the health of a mature forest. The newly burnt landscape would allow the introduction of other species, tolerant of the open spaces and increased sunshine. Many plants are intolerant of the deep shade that exists in the heavily forested areas. These newly burned areas allow them an opportunity to thrive. With them will come animals that thrive on those particular plants. The result is a new ecological niche will have been created.

Summary

The impact of drought on the environment and County will follow a sequence of events. These begin with relatively minor inconveniences and as time progresses can get much worse leading to major environmental degradation. This can eventually lead either directly or as a result of fire to major changes in the local ecosystems that exist within Pierce County.

Economic and Financial Condition

Drought will impact the agricultural and industrial bases as well as the population in Pierce County. Most previous periods of drought have been, at their worst, an inconvenience. However, a prolonged severe drought could impact the agricultural and industrial basis of the local economy.

Economic impacts become apparent as we move from a strictly meteorological drought to an agricultural drought. Crops are damaged due to lack of water. These crops are highly variable in

Pierce County, ranging from the rhubarb farms near the City of Sumner to the forests supporting our logging industry. As crops are damaged, farmers lose money, and the citizens who rely on these crops, either for jobs or part of their regular diet begin to feel the effects. Damaged crops and closed national forests mean that processors, including canneries and lumber mills, shippers and their staff who move agricultural products, as well as retailers, begin to lose business. Layoffs can begin leading to financial and mental, stress on individuals and families.

Damaged crops may lead to a decrease in food quality as well quantity causing more food importation. This results in higher costs for the distributors and therefore higher food prices for consumers.

Pierce County industries that rely on a large supply of water for manufacturing goods could have a similar predicament in that as supplies of water dwindle, they may have to cut back some processes and also lay off workers with consequences down the chain of distribution.

A lack of water in the rivers and streams will result in lower levels behind dams used for hydroelectric power generation. Power bought from other sources will be more costly than that locally generated. These costs will eventually be passed on to the consumer.

Recreation will also be affected. As a drought intensifies, recreation resources will be closed to the public. Dry conditions creating fire danger will limit the use of National Forest and both State and National Park lands. Communities acting as entry points to the recreation areas would be affected by the National Forest and Park closures. As lakes dry up and the flow in rivers and streams decrease, water recreation will also diminish. Boat ramps and docks may be high and dry. Recreational fishing could be curtailed.

Public Confidence in the Jurisdiction's Governance

Public dissatisfaction with government regarding drought response can erode confidence in local governments. This is especially true if a portion of the public feels that it is being denied a legitimate share of the water available. Required rationing, while necessary, must be scrupulously carried out to ensure that no bias is felt by others, especially the low- or middle-income portions of the population. If this is not done, it can lead to a lack of confidence in either local utilities or local government or both. Eventually this can lead to unrest.

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Endnotes

[1] What is meant by the term drought? Referenced by the National Weather Service, Western Region Headquarters from Glossary of Meteorology, 1959 edition. http://www.wrh.noaa.gov/fgz/science/drought.php The current edition lists it as "A period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance." http://amsglossary.allenpress.com/glossary/search?p=1&query=Drought&submit=Search&def=on
[2] University of Nebraska. (n.d.). *Types of drought*. Types of Drought | National Drought Mitigation Center. https://drought.unl.edu/Education/DroughtIn-depth/TypesofDrought.aspx
[3] 2020 Pierce County Hazard Mitigation Plan
[4] NOAA. (n.d.-b). *U.S. gridded standardized precipitation index (SPI) from nClimGrid-Monthly*. Drought.gov. https://www.drought.gov/data-maps-tools/us-gridded-standardized-precipitation-index-spi-nclimgrid-monthly
[5] What is Drought: Understanding and Defining Drought., The National Climatic Data Center (NCDC), http://www.ncdc.noaa.gov/sotc/drought/
[6] NOAA. (n.d.). *Pierce County Conditions*. Drought.gov. https://www.drought.gov/states/washington/county/pierce
[7] Much of this table was taken from the Washington State 2001 Hazard Identification and Vulnerability Assessment, Washington State Military Department, Emergency Management Division, April 2001, p. 7.
[8] Information from U.S. Drought Monitor. Accessed Sept. 23, 2019 at https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?WA
[9] Washington State Hazard Mitigation Plan, Washington State Military Department, Emergency Management Division http://www.emd.wa.gov/plans/documents/DroughtNov2007Tab5.3.pdf
[10] Pierce County Hazard Identification and Vulnerability Analysis, Pierce County Department of Emergency Management, September 2002, p. 18.
[11] Portions of this section on impacts were taken from http://library.thinkquest.org/16132/html/droughtinfo/effects.html and http://library.thinkquest.org/16132/html/droughtinfo/effects1.html and then modified to fit more accurately the Pierce County experience.
[12] U.S. Drought Portal accessed Sept. 23, 2019 at https://www.drought.gov/drought/data-gallery/us-drought-monitor
[13] Fire flow is the quantity of water needed to put out a fire of expected size. It can be specified by the equation (quantity = rate x duration). This means that the specific quantity of water for an individual fire in a combination of the rate the water can be applied to the fire and the length of time that flow must be maintained. Distribution system requirements for fire protection, by American Water Works Association, AWWA Manual M31, pps. 1-2.
[14] British Columbia. (n.d.). Columbia Basin. *Columbia River Treaty*. map. Retrieved January 9, 2026, from https://engage.gov.bc.ca/columbiarivertreaty/map/.
[15] Established by the Watershed Management Act of 1998 (ESHB2514) and formalized under Washington Administrative Code (WAC) 173-500-040 and authorized under the Water Resources Act of 1971, Revised Code of Washington (RCW) 90.54. The Water Resource Inventory Areas were created to complete an inventory of water resources and develop strategies for their future use. Within Pierce County these include the Puyallup-White River Basin, (WRIA 10), the Nisqually (WRIA 11), the Chambers/Clover (WRIA 12), the Kitsap (WRIA 15) and the Cowlitz (WRIA 26).
[16] This can be the case at both private and state hatcheries run by the Washington Department of Fish and Wildlife.
[17] Drought Planning, Washington Department of Fish and Wildlife, http://wdfw.wa.gov/
[18] Young, Leroy, Fish Habitat and Flow: What's the Connection? Aquatic Resources Section in the Commission's Division of Environmental Services, http://www.fish.state.pa.us/anglerboater/2001/ma2001/habtflow.htm
[19] US Department of Agriculture. (n.d.). 2023 USDA Plant Hardiness Zone Map. *USDA Plant Hardiness Zone Map*. map. Retrieved January 9, 2026, from https://planthardiness.ars.usda.gov/.

[20] C.P. Lyons, J.M. Dent & Sons Trees, shrubs and flowers to know in Washington, , Canada, Limited, Toronto, 1977, pp7-11.
[21] Terrell, Cindy The Damaging Effects of Drought, monograph published by the Morton Arboretum., July 1, 2005.
[22] Research: Snails were overlooked contributors to marsh destruction, University of Florida News,12/15/05 http://news.ufl.edu/2005/12/15/snail-marsh/
[23]National Drought Mitigation Center, http://www.drought.unl.edu/risk/environment.htm

Earthquake

Natural Hazard | 4.2

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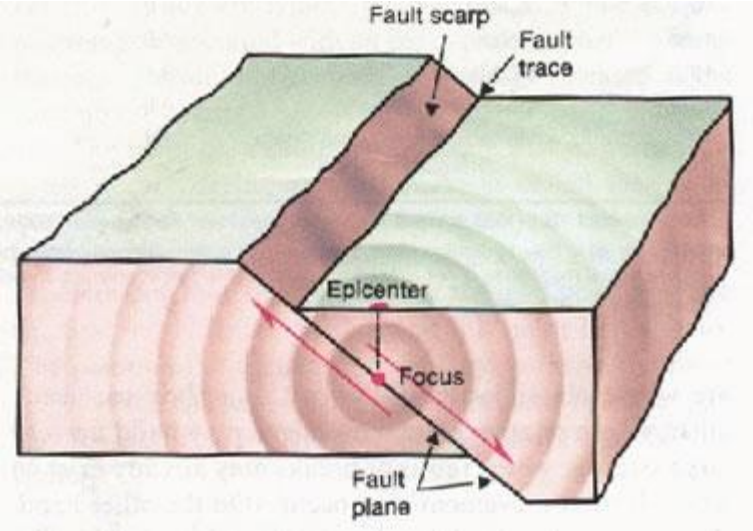
Identification Description

Definition

An earthquake is what happens when two blocks of the earth suddenly slip past one another. The surface where they slip is called the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the earth is called the epicenter. Seismic waves radiate spherically from the focus of the earthquake (Figure 4.2-1).

Figure 4.2-1 Diagram of an earthquake occurring at depth on a fault

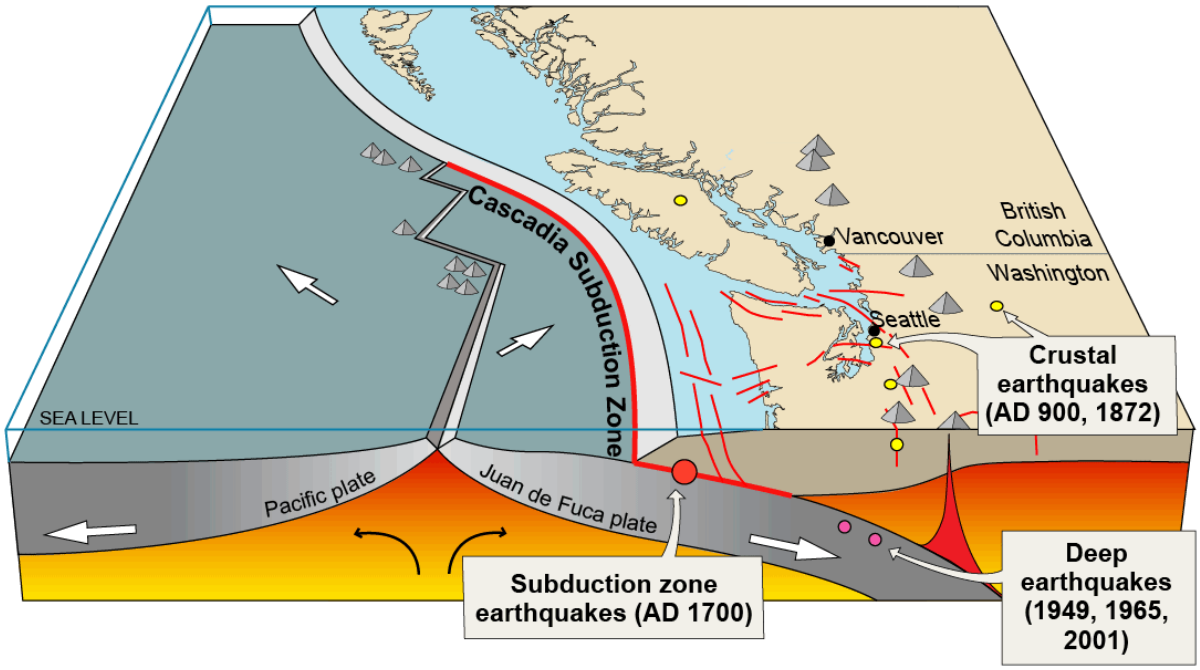


Sometimes an earthquake has foreshocks. These are smaller earthquakes that happen in the same place as the larger earthquake that follows. Scientists can't tell that an earthquake is a foreshock until the larger earthquake happens. The largest, main earthquake is called the mainshock**.** Mainshocks always have aftershocks that follow. These are smaller earthquakes that occur afterwards in the same place as the mainshock. Depending on the size of the mainshock, aftershocks can continue for weeks, months, and even years after the mainshock.[1]

Types

Washington's west coast is situated along the Cascadia Subduction Zone (CSZ), where the Juan de Fuca oceanic tectonic plate collides with and subducts, or moves, beneath the North American continental tectonic plate and sinks into the earth's mantle. The convergent plate boundary lies approximately 50 miles offshore and extends from the middle of Vancouver Island in British Columbia to northern California. The collision of the Juan de Fuca and North American Plates produces the three main types of earthquakes (Figure 4.2-2).[2] A fourth type of earthquake not covered in detail here is produced by the movement of magma inside a volcano.

Figure 4.2-2 Types of Earthquakes[3]



Source	Max. Size	Recurrence
Subduction zone	M 9+	200–600 years
Deep Juan de Fuca plate	M 7+	30–50 years
Crustal faults	M 7+	Hundreds of years?

Volcano

Active crustal fault

Active plate boundary fault

*figure modified from USGS Cascadia earthquake graphics at http://geomaps.wr.usgs.gov/pacnw/pacnweq/index.html

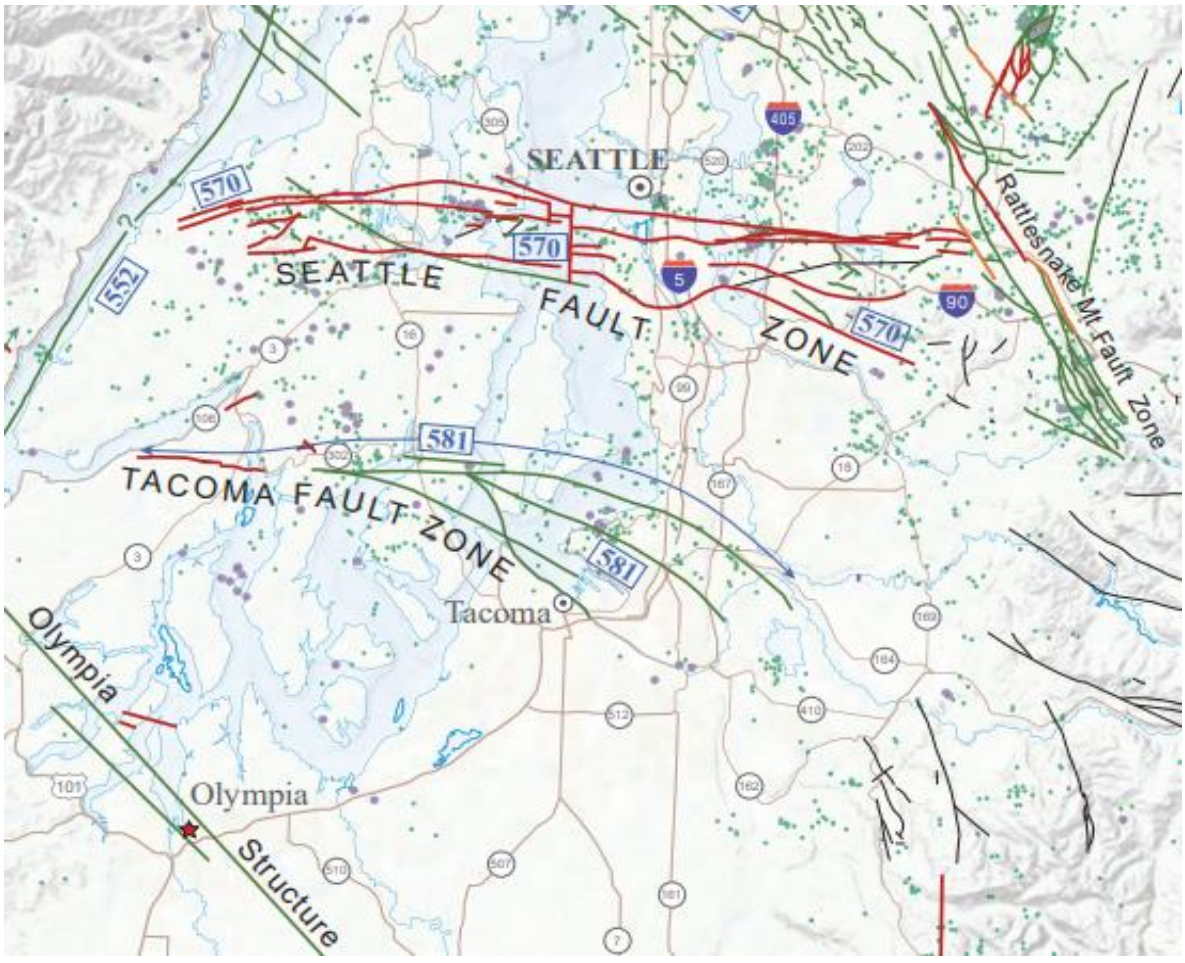
Deep Earthquakes (Benioff Zone)

Deep earthquakes can also be referred to intraplate or Benioff Zone earthquakes. They are capable of magnitudes 6.0 – 7.5, they typically occur between approximately 15 to 60 miles in depth and are within the subducting Juan de Fuca plate. Most of the ones that impact Pierce County occur near or in an area where the Juan de Fuca Plate bends slightly as it slips beneath the North American plate. These deep events typically have few, if any aftershocks. Deep earthquakes are the most frequent large events that strike Pierce County. The Nisqually earthquake is the most recent example that impacted Pierce County.

Crustal Faults Earthquakes

Shallow crustal earthquakes occur primarily in western Washington, the northeastern flanks of the Cascade Range, and in the Columbia Plateau. These earthquakes are associated with movement on a fault. These earthquakes occur primarily at depths of 20 miles or less. Active faults in the greater Pierce County area include Tacoma, Seattle, and the Rattlesnake Mountain Fault zone are capable of magnitudes 6.0 – 7.5 (See Figure 4.2-3)[4].

Figure 4.2-3 Earthquake Sources in Pierce County - Seattle and Tacoma Fault Zones



Cascadia Subduction Zone Earthquakes

The Cascadia Subduction Zone is a 1,000 km long fault that stretches from northern Vancouver Island to Cape Mendocino, California. It separates the Juan de Fuca and North America plates. The Juan de Fuca oceanic plate moves toward and subducts beneath the North American continental plate. Cascadia Subduction zone earthquakes occur less frequently than deep earthquakes. The CSZ has produced magnitude 9.0 or greater earthquakes in the past and is still an active fault, meaning it will cause future earthquakes. The last known subduction zone earthquake in the northwest was in January 1700, just over 300 years ago. Geological evidence indicates that such great earthquakes have occurred at least seven times in the last 3,500 years, an average recurrence interval of 400 to 600 years. Because Cascadia earthquakes have a very large source (the fault could rupture along its entire length from Vancouver Island to northern California) the ground motion and strong shaking could last for three-six minutes in Pierce County .These long periods of sustained ground motion, especially when combined with long period waves and soft soils, may be more damaging to large structures such as the Tacoma Narrows Bridge. Ground motion can be especially damaging to large buildings with complex designs, and also to many smaller buildings and homes.

Secondary Hazards

Liquefaction

Soft soils or human-made fills can subside or experience liquefaction or lateral spreading in an earthquake. Liquefaction commonly causes lack of support for structures located on the liquefiable soils. Earthquake shaking can cause ground failures, ground cracking or boils from layers of sand sometimes located a number of meters under the surface. Lateral spreading is in fact a landslide that occurs on very shallow slopes due to the liquefiable nature of the soil. Noteworthy liquefaction took place in Puyallup during the 1949 earthquake and there were examples of it in both the 1965 and 2001 earthquakes. Liquefaction is directly related to the level of soil saturation combined with layers of sand. The sands that failed in Pierce County in many cases were sand deposits from Mount Rainier lahars.

Landslides, Avalanches, and Mudflows

Earthquakes can trigger land movement and debris flow along steep slopes. Earthquakes have caused large and disastrous landslides, including debris flows from volcanoes. Loss of strength in sensitive, clay-rich soils can also cause landslides and other ground failures.

Dam Failure

This is also a possibility during an earthquake. Likely causes are either a fracture of the retention wall or the failure of the soils under the structure. The Department of Ecology's inventory of dams lists 56 dams in Pierce County that, at peak storage, hold over ten acre-feet of water. This includes Mud Mountain Dam on the Pierce/King County border. In addition, Howard Hanson Dam on the Green River in King County could impact portions of Pierce County if it had a catastrophic collapse.

Levee Failure

Levees in their role as a flood control feature exist to protect the land and the facilities on it from flood waters. Being largely built on liquefiable valley soils, damage to the levees is a real possibility. If an earthquake with resulting damage to levees happens during flood season, extensive flooding could occur before the levees were repaired. The real threat here is not to the levees themselves but if the river floods before the levee damage can be corrected the resulting threat is to the population, facilities and infrastructure situated behind those levees.

Tsunami and Seiches

Vertical ground displacement, co-seismic subsidence, or earthquake induced landslides can all cause tsunamis and seiches.

Fires

Fire following earthquake (FFE) scenarios are not fully yet up to the standards that can be used by city authorities for decision making. Limited structural analyses of individual buildings under FFE scenarios have been completed. Results show that the drift demand on the building frame increases during post-earthquake fires. Causes of FFE "ignitions and the consequent conflagrations can be listed as follows:

- Natural gas, as a flammable fuel, can be the cause of 20-50 percent of the total post-earthquake fire ignitions (SSC, 2002).
- Local fire ignitions can spread through vegetation and inadequate building separation.
- Chaos following an earthquake, blocked transportation or communications, and reduced water supplies lower response time of the firefighters. Following an earthquake, firefighters also have to respond to structural collapses and medical emergencies.
- Tall buildings would also be at risk and the presence of a sprinkler system does not guarantee fire prevention after an earthquake (Taylor, 2003).

Profile

Location and Extent

Earthquakes directly and indirectly affect all of Pierce County. Two measurements that describe the size of an earthquake are intensity (a measure of the degree of earthquake shaking at a given locale based on the amount of damage) and magnitude (estimates the amount of energy released at the source of the earthquake).[5]

To illustrate the earthquake risk in the County and region, Figure 4.2-2 on page 4-3 shows the location of the various types of earthquakes that affect the Pacific Northwest. Figure 4.2-3 on page 4-4 shows the major faults in the Puget Sound. For more information see the Washington Department of Natural Resources Seismic Scenarios Catalog.[6]

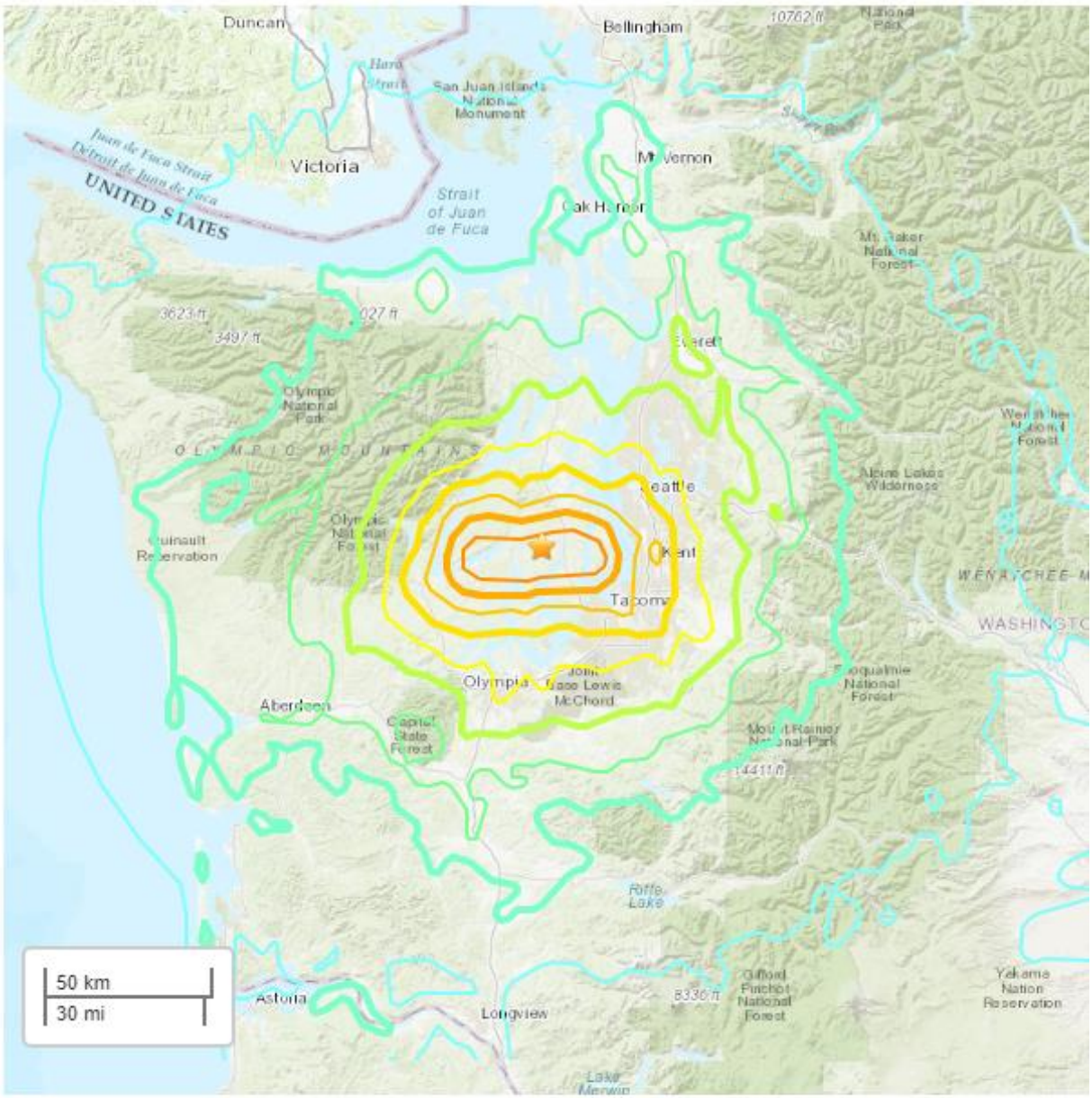
Pierce County could experience earthquakes from all three sources (subduction zone, crustal fault, and deep earthquakes) and therefore the entire region is at risk to the earthquake hazards described in this chapter. Light Detection and Ranging (LIDAR) mapping "uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth."[7] New data (such as lidar, geologic mapping, geophysical studies, and paleo seismology) help scientists to better understand earthquake sources.

The Modified Mercalli Intensity (MMI) Scale describes the observed effects of ground shaking at each corresponding shaking intensity level, designated by Roman Numerals. This scale is used for estimating the intensity of shaking for different earthquake scenarios and can be generated after a major earthquake to show where the shaking was the strongest.

Below is a scale published in January 2015 that was developed for the purpose of a 2016 Magnitude 9.0 Cascadia Rising subduction zone earthquake full-scale exercise. Damage descriptions were based upon modeling of a seismic event of a particular magnitude, location, and faulting mechanism. They should not be read as a definitive statement of likely damages from any one of many possible Cascadia Subduction Zone events. This scale and earthquake measurement tool is useful because it depicts what a person could experience from an earthquake. The magnitude scale is based on energy released. For example, you could have a deep magnitude 7 earthquake and people living above the epicenter may feel MMI intensity III (weak shaking), and a magnitude 7 in the same area but on a shallow crustal fault could have a MMI of V-VIII (strong- very strong shaking).

Figure 4.2-4, Figure, 4.2-5, and Figure 4.2-6 below show the shake maps developed by the USGS, with scenario modeling for the Tacoma Fault, Seattle Fault, and Cascadia Subduction Zone respectively.[8]

Figure 4.2-4 Magnitude 6.9 Scenario Earthquake – Tacoma Fault Zone 9.0 km depth



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

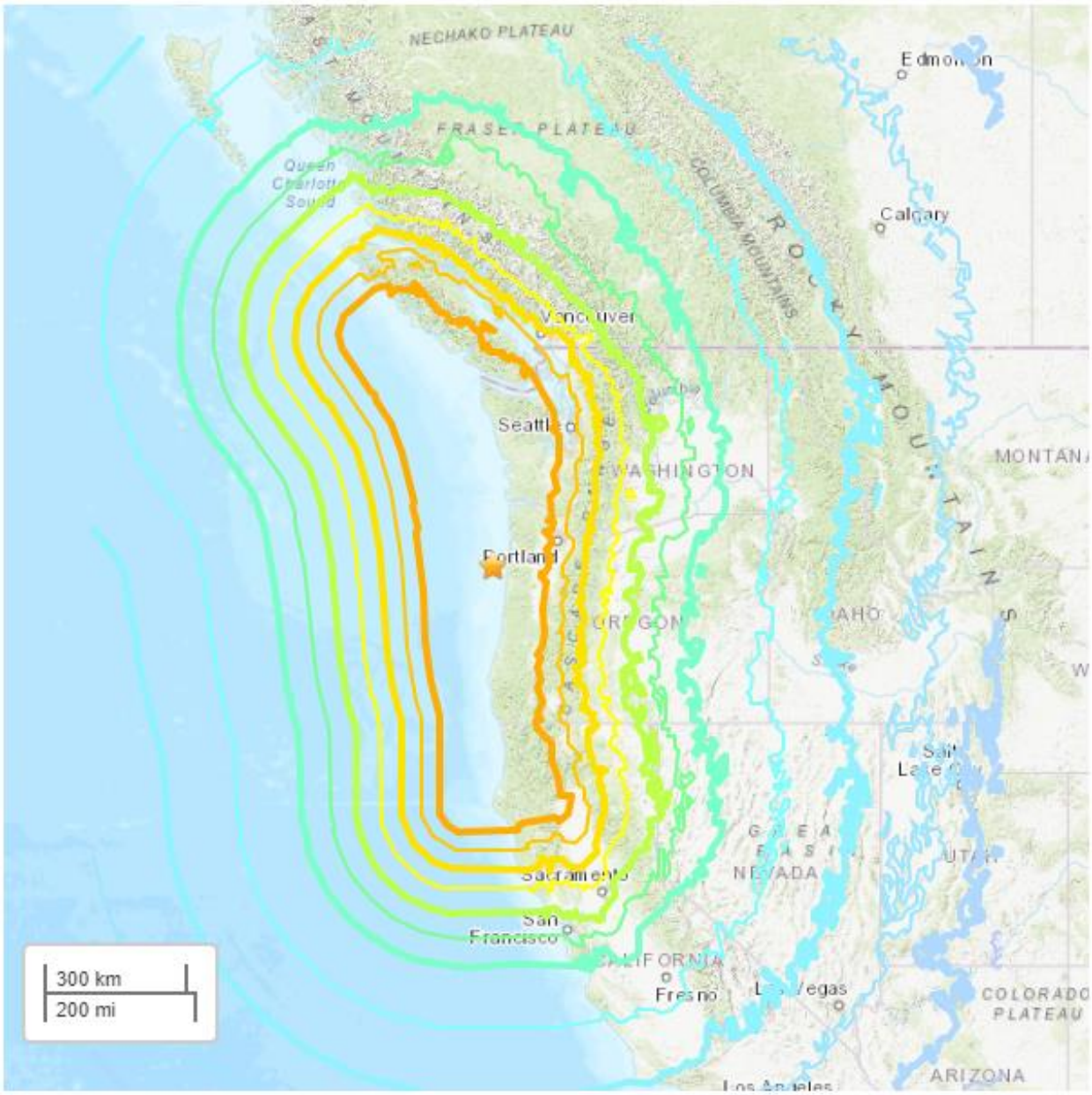
Scale based upon Worden et al. (2012)

Figure 4.2-5 Magnitude 7.2 Scenario Earthquake – Seattle Fault Zone – Northern 9.0 km depth

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Figure 4.2-6 Magnitude 9.3 Scenario Earthquake – Cascadia Megathrust – 21.4km depth



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Map 4.2-1 illustrates the location and extent of Pierce County's liquefaction susceptibility/hazard. As illustrated, the majority of liquefiable soils in Pierce County are located in the County's river valleys. The largest area of liquefiable soils is the Puyallup River Valley while the Carbon, White, and Nisqually River Valleys are also liquefaction hazard areas. The areas with the highest liquefaction hazard are located in both incorporated and unincorporated areas of the County. Auburn, Buckley, Eatonville, Fife, Milton, Puyallup, Orting, South Prairie, Sumner, and Tacoma all have at least some of their land located in these areas.

Another earthquake risk is in areas of high landslide susceptibility and potential. Earthquake shaking can induce landslides as a secondary hazard. This can be especially true during periods when the soils are saturated. In Pierce County this can go from October through June depending on the fall and winter weather. The landslide potential can be seen in the Landslide.

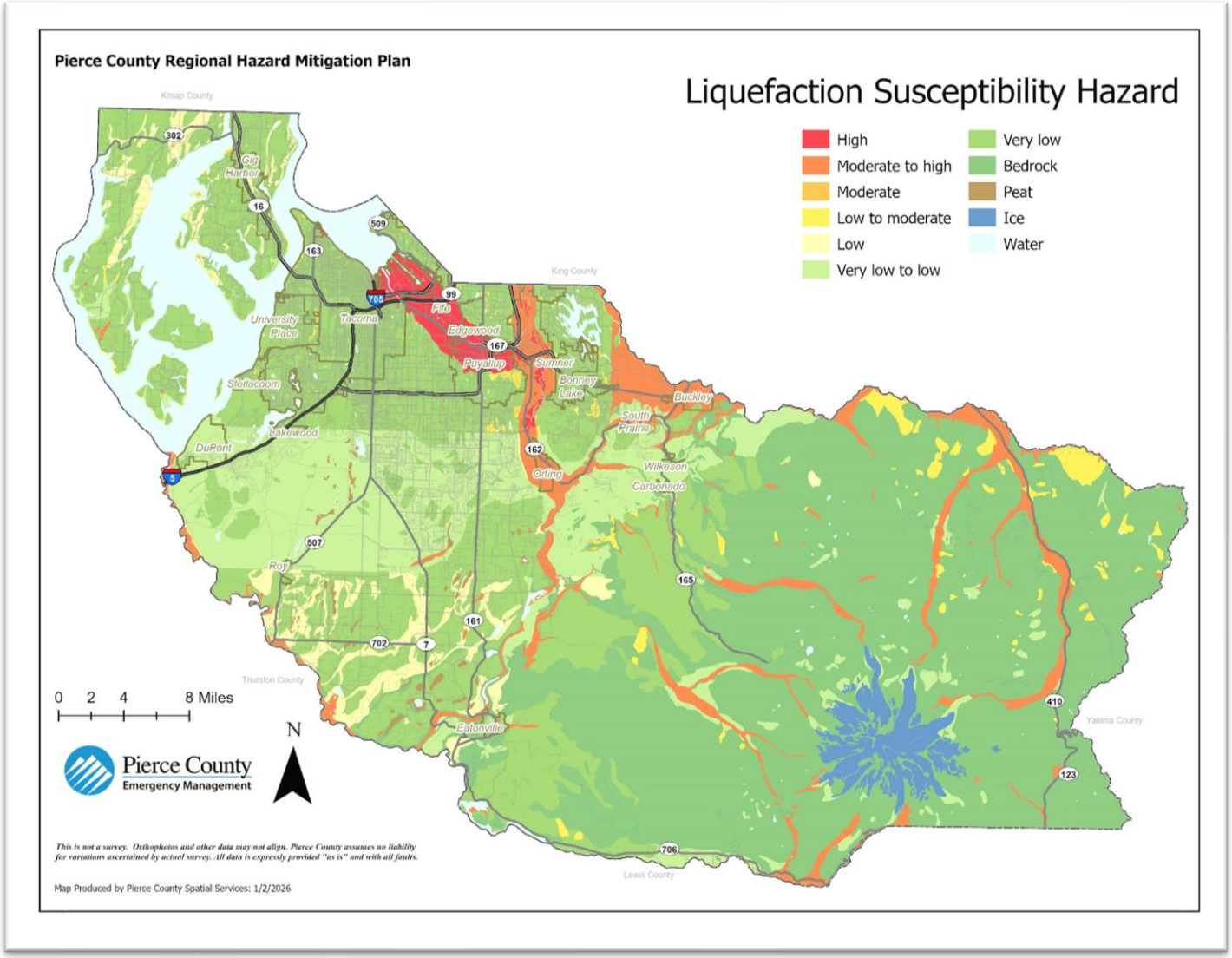
Earthquakes directly and indirectly affect all of Pierce County. To illustrate the earthquake risk in the County, Figure 4.2-2 shows the location of the various types of earthquakes that affect the Pacific Northwest, Figure 4.2-3 shows the major faults in the Puget Sound. Map 4.7-1 shows the seismic hazard areas throughout Pierce County as defined by areas of liquefiable soils.

The scientific studies that have been done that created these maps state that the entire region is at risk to the earthquake hazard. Continuing updated information on the Tacoma Fault is revealing it and the surrounding geologic structure in greater detail yearly. One of the methods has been through the use of Light Detection and Ranging (LIDAR) mapping. The documented examples of these land-level changes date to about 1,100 years ago, though much remains to be learned about its extent and shape. As can be seen from Map 4.2-1 the various segments of the fault appear to run westward and northwestward from Tacoma across the Kitsap Peninsula[9] Ongoing research will continue to change our understanding of the Tacoma Fault and other local faults and their potential for a damaging earthquake to affect Pierce County.

While the entire County experiences shaking during earthquakes, areas of liquefaction experience even greater shaking. Map 4.2-6 illustrates the location and extent of Pierce County's seismic hazard based on areas of liquefaction. As illustrated, the majority of liquefiable soils in Pierce County are located in the County's river valleys. The largest area of liquefiable soils is the areas. The areas with the highest liquefaction hazard are located in both incorporated and unincorporated areas of the County. Auburn, Buckley, Eatonville, Fife, Milton, Puyallup, Orting, South Prairie, Sumner, and Tacoma all have at least some of their land located in these areas.

The other area of earthquake risk is in the area of landslide potential. Earthquakes tend to create landslides as a secondary hazard. This can be especially true during periods when the soils are saturated. In Pierce County this can go from October through June depending on the fall and winter weather. The landslide potential can be seen in the Landslide section.

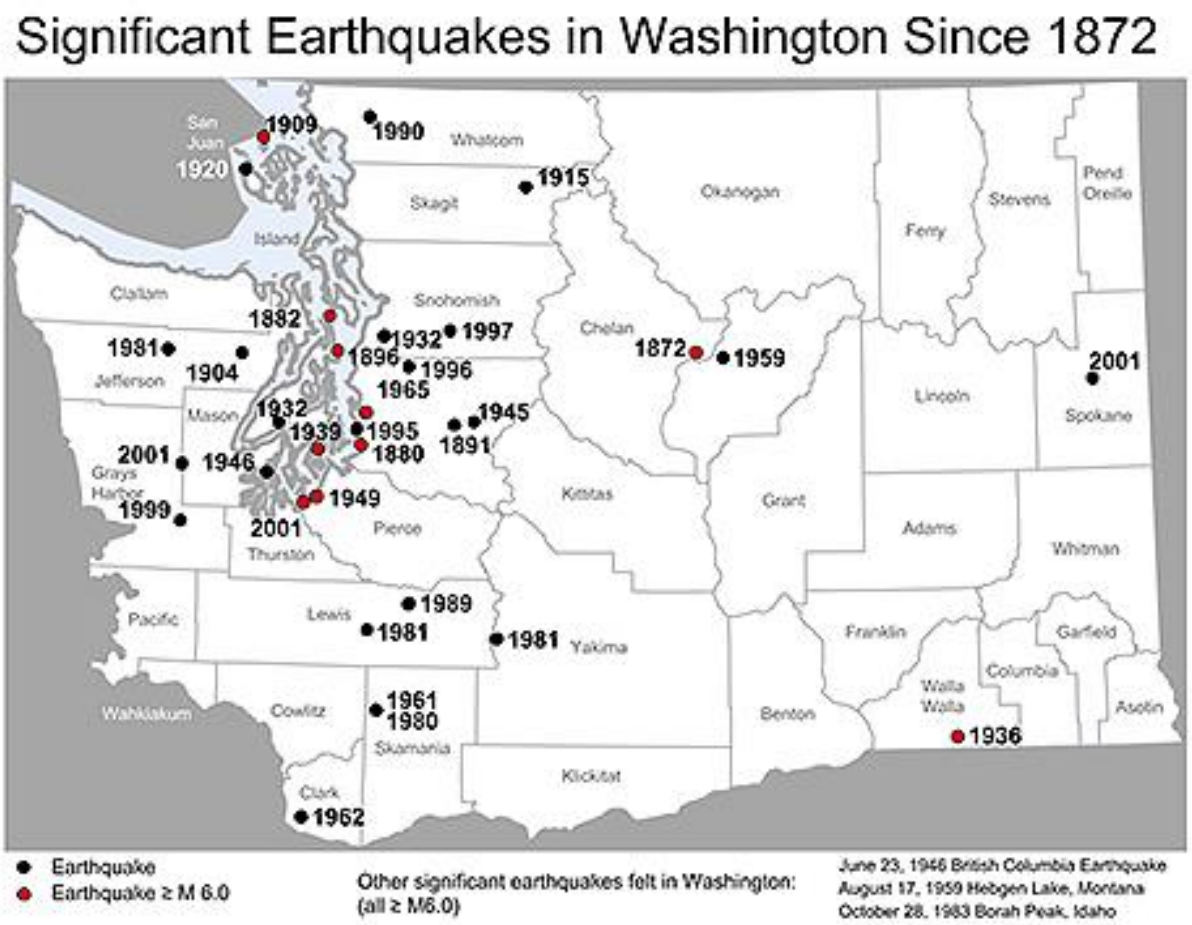
Map 4.2-1 Pierce County Earthquake Liquefaction Risk



Occurrences[10]

Over the last 100 years, a large area of the state has experienced earthquake damage. The majority of the largest earthquakes felt in Washington have occurred in the Puget Sound region between Olympia and the Canadian border, in the Cascade Mountains, and along the Washington-Oregon border. Medium to large magnitude earthquakes (greater than 5.0) have occurred repeatedly in the Puget Sound region. Figure 4.2-7 shows the location, date, and magnitude of major earthquakes since 1872 in the Pacific Northwest.

Figure 4.2-7 Major Pacific Northwest Earthquakes



In addition, Table 4.2-1 lists some of the notable earthquakes felt in Pierce County and is followed by a discussion of occurrences by type of earthquake.

Intraplate (Benioff Zone[11]) Earthquakes[12]

The magnitude 6.8 Nisqually earthquake on February 28, 2001 caused extensive non-structural damage throughout the region. Loss estimates from this event are greater than $350 million statewide. The large earthquakes of 1965 (magnitude 6.5), 1949 (magnitude 7.1), and 1946 (magnitude 6.3) killed 17 people and caused more than $340 million (2002 dollars) in property damage in several counties. Since 1870 there have been six significant intraplate earthquakes in the Puget Sound basin.[13]

Table 4.2-1 Notable Earthquakes, Magnitude 5.0 or Greater, Felt in Pierce County[14]

Date yy/mm/dd	(UTC)Time hh:mm:ss	Latitude (N)	Longitude (W)	Depth (km)	Magnitude
12/12/1880	20:40:00	47.50N	122.50W	0.0	6.0
12/15/1872	05:40:00	47.75N	119.87W	0.0	6.8
04/30/1882	10:40:00	47.40N	122.59W	0.0	5.7
03/07/1891	07:40:00	47.50N	121.75W	0.0	5.0
11/29/1891	23:21:00	48.00N	123.50W	0.0	5.6
03/17/1904	04:20:00	47.79N	123.00W	0.0	5.3
12/31/1931	15:25:00	47.50N	123.00W	0.0	5.0
07/18/1932	06:01:00	48.00N	121.80W	0.0	5.7
08/06/1932	22:16:00	47.70N	122.30W	0.0	5.0
11/13/1939	07:45:54	47.40N	122.59W	31.0	6.2
04/29/1945	20:16:17	47.40N	121.69W	0.0	5.7
04/30/1945	07:45:45	47.40N	121.69W	0.0	5.0
02/15/1946	03:17:47	47.29N	122.90W	25.0	5.8
02/15/1946	12:17:15	46.86N	122.26W	0.0	5.0
02/23/1946	08:54:53	47.04N	122.88W	0.0	5.0
06/23/1946	15:13:00	49.80N	125.30W	0.0	7.4
09/24/1948	22:35:00	47.85N	122.58W	0.0	5.0
04/13/1949	19:55:43	47.09N	122.75W	54.0	7.1
05/15/1954	13:02:32	47.40N	122.50W	0.0	5.0
04/29/1965	15:28:43	47.40N	122.40W	57.0	6.5
05/18/1980	15:32:11	46.20N	122.18W	2.8	5.7
02/14/1981	06:09:27	46.34N	122.23W	7.3	5.2
05/28/1981	09:10:45	46.52N	121.39W	3.2	5.0
04/14/1990	05:33:26	48.84N	122.16W	12.6	5.0

Date yy/mm/dd	(UTC)Time hh:mm:ss	Latitude (N)	Longitude (W)	Depth (km)	Magnitude
01/29/1995	03:11:22	47.38N	122.36W	15.8	5.0
05/03/1996	04:04:22	47.76N	121.87W	4.3	5.4
07/03/1999	01:43:54	47.07N	123.46W	40.7	5.8
02/28/2001	18:54:32	47.14N	122.72W	51.9	6.8
06/10/2001	13:19:11	47.16N	123.50W	40.7	5.0

Crustal Earthquakes[15]

Best available science indicates that on the Tacoma Fault uplift to the north and subsidence to the south occurred most recently in A.D. 800–1200, not necessarily in a single year. The age range of this uplift on the north side of the Tacoma Fault includes times of coseismal uplift and subsidence at many sites around Puget Sound.[16] It must be understood that damage could also come from earthquakes on other crustal faults from both within and outside Pierce County. Of particular concern are the Seattle Fault and the West Rainier Seismic Zone. Other small, localized faults like the Burnett, Wilkeson, Miller and Devereaux faults in the eastern portion of the County might cause some localized problems but are not expected to cause widespread damage.

Cascade Subduction Zone Earthquakes[17]

In addition to crustal and intraplate earthquakes, research indicates that the Cascadia Subduction Zone (CSZ) offshore Washington, Oregon, California, and British Columbia has generated great earthquakes in the past and will do so again the future. These earthquakes estimated to be in the range of magnitude 8 to 9 appear to have occurred at uneven intervals over the past several thousand years. At least 41 great subduction earthquakes may have occurred in the Pacific Northwest over the past 10,000 years. The most recent great subduction earthquake in Washington State occurred over 300 years ago on January 26, 1700. Currently, it appears that the mean recurrence rate for CSZ events is about 550 years. The actual recurrence rate is highly variable with the shortest time period between them being around 100 years, and the longest time span being around 1,100 years.[18]

Recurrence Rate

For each of these earthquake sources (crustal, deep, and subduction zone), the largest earthquakes recur at poorly known, probably irregular, intervals. On average, the intervals are on the order of decades for the intraplate (deep) earthquakes on the Juan de Fuca Plate, millennia for the best-known of the upper-plate faults (the Seattle Fault), and centuries for the subduction zone.

Although the earthquake record in Washington State is relatively short to form precise estimates of the recurrence rate for earthquakes, the record we do have allows at least an estimate of the overall rate. Realizing the fact that earthquakes happen daily in Washington, we are only interested in the ones that potentially cause damage. Taking into account the three different types of earthquakes listed above and the past occurrences we know of, we find that for the short historical record we have the intraplate earthquakes are the ones with by far the shortest recurrence rate. It must be realized that the 36-year period between the 1965 quake and the 2001 earthquake may be closer to the real average and that the 23-year average from the record may be a little short. So, until better scientific evidence allows an improved estimate of the actual recurrence rate, we will list the probability of recurrence for the earthquake hazard in Pierce County to be less than 40 years.

Impacts

All discussion of the impacts of an earthquake must take into account the magnitude, epicenter and focus of the earthquake. This includes whether it is a subduction quake on the junction of the Juan de Fuca and North American plates off the coast of Washington, a deep earthquake like the 2001 Nisqually quake or one on either the Seattle or Tacoma faults. Other variables outside the obvious impact of magnitude of the quake include aftershocks, weather both before and after the earthquake, the time of day, time of year, and the percentage of older buildings of construction techniques that are not up to current building code standards. For the purposes of this section, preliminary impacts will be from the Scenario for a Magnitude 7.2 Earthquake on the Seattle Fault.[19]

Health and Safety of Persons in the Affected Area at the Time of the Incident

Depending on the size and location of the earthquake, the effect on persons in the impacted area is expected to range from a repeat of the Nisqually quake of 2001 up to those from a hypothetical 6.7 or larger earthquake on one of the major faults in Puget Sound or a large subduction quake located off the coast of Washington.

The magnitude 6.8 Nisqually Earthquake of February 28, 2001 resulted in one death and approximately 400 recorded injuries, including a dozen that were serious, throughout the Puget Sound Basin (Figure 4.2-8).[20] The expectation is that a similar quake would produce similar results.

Figure 4.2-8 Salmon Beach, Tacoma – Following February 2001 Earthquake

The effects of a surface rupture on the Seattle or Tacoma faults could lead to a much greater loss of life and injuries due to stronger ground shaking, surface rupture, and potential tsunami impacts. Losses are estimated to be equivalent to those from the Northridge California quake of 1994. However, in Northridge, the time of day dramatically decreased the actual number of casualties. That earthquake, striking at 4:30 in the morning, did not cause the number of deaths and injuries that would have happened at a later hour. At that time the number of people on the roads and bridges that collapsed was very low as were the staff in the buildings that collapsed. In contrast, a model from 2005 estimated losses here in the Puget Sound Basin (based on 2000 Census data) following a magnitude 6.7 Seattle Fault earthquake with an expected 1,600+ fatalities and 24,000+ injuries.[21] A variation on this either up or down in the magnitude could have a significant effect on the outcome.

In discussing a subduction quake, it must be understood that while the State has experienced quakes of this type possibly as high as magnitude 9, all of them were prior to settlers with a written language entering the State of Washington. The violent shaking expected with a surface quake on the Tacoma or Seattle faults will be attenuated to a certain extent by the distance from the actual fracture zone. Located off the Washington coast, the earthquake waves will have to travel over 100 miles to reach Pierce County. On the other hand, “his particular type of

earthquake is especially hazardous to tall buildings, which could lead to significant fatalities in downtown areas."[22]

In previous large earthquakes, the potential for an outbreak of disease appears to increase. This can be caused by polluted water sources, the eating of spoiled food, and the inhalation of dust kicked up by the quake. In addition, here in Pierce County, there could be environmental injuries such as hypothermia if the earthquake happened during the winter months.

Health and Safety of Personnel Responding to the Incident

Responders are subject to a number of hazards in the response phase of the emergency. Damaged fire stations could prevent fire personnel from utilizing all the equipment with which they are used to responding. Already damaged structures could collapse during search and rescue operations, especially during aftershocks. Response personnel, by the very nature of their work are putting themselves in harm's way, not just from structural collapse during aftershocks but also from further landslide activity and respiratory problems due to the inhaling of quantities of dust and microbes stirred up by the earthquake. In addition, they can be exposed to bacteria and chemicals in the environment they are working in, sometimes without realizing what the particular dangers are. "Following the Loma Prieta earthquake, about 20% of post-earthquake injuries were caused by toxic materials."[23] For those who are caught in the dust cloud created by an earthquake the respiratory problems could be similar to those experienced by first responders to the World Trade Center collapse in 2001.[24] This can be shown to be a problem across many different emergency responses. It correlates with the amount of toxins and dust that are in the environment, for example approximately 80% of Red Cross responders who went to work on Hurricane Katrina response returned home with respiratory infections.[25]

First responders frequently have adverse psychological reactions to trauma and especially disasters. Long term psychological impacts were noticed years ago, such as after the collapse of the Hyatt Regency Hotel walkway in Kansas City, Missouri in 1981, and eventually led to the development of Critical Incident Stress Management. Divorce and suicide rates are higher than the normal population in the first responder community and even greater after a major event.[26] "(S)tress is not like a light switch—the images of such tragic events often haunt the responder into his or her home life, piling more pressure on other events. Ill health effects can include high blood pressure, sleep disorders, alcohol or sleeping aid abuse, anger, withdrawal from family members, over protectiveness for family members, and even paranoia."[27],[28]

Continuity of Operations and Delivery of Services

For a large earthquake impacting Pierce County, continuity of operations will be severely taxed for many, if not most, of the agencies and jurisdictions located therein. The impacts affecting continuity of operations include:

- Death or injury to staff limiting the number of staff able to fill normal operational duties;
- Inability of staff to respond to their work sites due to road closures from debris on the roads, liquefaction or lateral spreading damaging the roads, and bridges or overpasses damaged closing arterials in particular;
- Staff absenteeism while checking on or taking care of family, and handling damage to home or other personal property;
- Damage to communications systems will limit organizations' ability to coordinate their own resources, and it will also limit their ability to pull together a full picture of the damage suffered in their jurisdiction and to request assistance if needed
- Damage to facilities and equipment; and
- Damage to the water, energy and sewer systems connected to agency facilities will not allow operations to continue in their normal manner.

Due to the limitations mentioned above, delivery of services will be heavily impacted by a large earthquake. Infrastructure damage or destruction combined with lack of staff will obstruct the delivery of normal governmental services.

Law enforcement operations will be taxed to the maximum. Road closures, prevention of individuals entering hazardous areas, control of looting, responding to search and rescue operations, etc. combined with a decrease in available staff due to all the factors listed above will severely limit normal day-to-day operations. Most individual law enforcement officers operate independently of others in their jurisdiction. Since many of them have their equipment with them, including cars, they may be able to assist at least in the area they are at when the earthquake happens.

Fire response will be impacted in a similar vein, however for many of them they will have to report to a station where they can respond from. Between the inability to get to their station and the possibility that the stations and equipment may be damaged or destroyed the response will be compromised. Many fire stations, especially the older ones, even though they have survived previous moderate quakes may not survive a large one. Even if a station is not destroyed or collapsed, a racking of the walls could jam the bay doors closed.

Public works and utilities will not have the ability to have services back up and operational, in many cases, for days, weeks or even months. Repair of roads, bridges, water and sewer lines, the electric grid and telephone lines and towers will tax these utilities to the maximum. Even

with the importation of mutual aid and other assistance from other portions of the state and other states, the service delivery will be slow to develop and spotty at best for some time.

Schools will be unable to fulfill normal expectations. Damage to schools' infrastructure as well as the public infrastructure of roads and utilities will close down schools at least temporarily. Those that might be able to be operational will, in many cases, have to act as temporary shelters for those displaced by the earthquake. Immediately after the earthquake, if school is in session, they may have to house students for days until parents are able to retrieve them.

Property, Facilities, and Infrastructure

Any large earthquake on the Seattle or Tacoma Faults or from many other faults in Washington State will create damage to the property, facilities and infrastructure either owned by jurisdictions in Pierce County or needed to support their economy and communities. This includes damage to buildings, electrical grids, telephone service, including cellular phone operations, water and sewer utilities, port facilities, transportation systems, and both natural gas and liquid fuel pipelines.

Several factors will determine the effect of ground shaking on the building stock and infrastructure of any area. These include soil composition, age of the facilities, focus (depth of the quake), epicenter (point on the earth's surface directly over the focus), and weather previous to the event surface faulting subsidence and uplift.

First, is soil composition. Soft and liquefiable soils will both intensify ground shaking and in the case of liquefiable soils lose structural integrity. Earthquake waves moving along the surface of the ground have different characteristics depending on the soil composition they encounter. These surface waves, when they progress from one soil type to another change. They tend to travel slower through soft soils than they do through hard soils or bedrock. Yet the energy contained in the wave stays the same. The result is that as the wave changes speed the amplitude will change in relation to it, increasing in soft soils and decreasing in hard soils. This increase in wave amplitude in soft soils can damage structures, especially unreinforced masonry and pre-1970 tilt up structures.[29]

When the soil loses structural integrity, liquefaction or lateral spreading may be the result. This is especially prevalent in areas of artificial fill like on the Tacoma Tide Flats and the valley bottoms like the Puyallup and Nisqually where thousands of years of silt and sand washing down the river combined with lahar debris has created soils prone to it. In cases like this, buildings or portions of buildings built on it may sink (Figure 4.2-9)[30].

Figure 4.2-9 Liquefaction, Niigata Japan 1964

In the case of lateral spreading, it can move railroad tracks, bend or collapse roads, move cranes or do other damage associated with the soil under the facility moving (Figure 4.2-10)[31]. For emergency operations it limits the ability of emergency workers to respond to incidents throughout the community and it can prevent people from bringing the community back to normal and developing its economic base until this portion of the infrastructure has been repaired.

Figure 4.2-10 Lateral Spreading –March 2001

Secondly, much of the building stock that exists in Pierce County was built before current earthquake codes were put into place and before there was much of an understanding of the actual hazard that exists from earthquakes in Washington State. It was only towards the end of the 1980s that geologists began to understand some of the processes that cause earthquakes in the Pacific Northwest, and decades later when the earthquake hazards were incorporated into the building code. Since that time both geologic research into our local earthquake hazard as well as engineering studies of building response in earthquakes has shown that some of the older building stock could have major structural problems, possibly to the point of collapse.

The third and fourth factors that will have a major bearing on the damage done to a community and to its ability to recoup from its losses are the depth of the earthquake (focus) and the location of its epicenter in relation to the rest of the County.

An intraplate earthquake located inside the Juan de Fuca Plate as it dives under the North American Plate will be deep enough that the waves it generates will be attenuated or lose some energy as they propagate outwards from the focus. In such a situation, even if the earthquake's epicenter is located in Pierce County the damage will not be too catastrophic. This was the case

with the 2001, 1965 and 1949 earthquakes all of which had epicenters close to or in Pierce County, see Table 4.2-1 Notable Earthquakes, Magnitude 5.0 or Greater, Felt in Pierce County.

Taking the same size earthquakes, with magnitudes 6.8, 6.5, and 7.1 respectively, and moving them close to the surface could have caused damage similar to the Northridge, California (6.7), Loma Prieta, California, (7.1), or Kobe, Japan (6.8) earthquakes. In each of these cases with the epicenter of the quake, 2001 (Anderson Island), 1965 (Des Moines) and 1949 (Nisqually Delta), deaths and injuries would have been much more prevalent. Buildings would have collapsed, fires would have started, bridges and freeway overpasses would have been more heavily damaged and other lifelines would have been in disarray or out of commission for long periods of time.

This is the scenario that Pierce County is looking at if there was an earthquake of that size on the Tacoma Fault. In addition, any earthquake on a surface fault close to Pierce County like the Seattle or Olympia faults will cause damage in Pierce County although probably to a lesser degree, being some distance away.

A subduction zone earthquake will be located further away from Pierce County than the surface quakes mentioned above and so the waves will be attenuated somewhat by the time they get to Pierce County compared to their size on the coast. However, the shaking could run for multiple minutes. This shaking could continue for a much longer time than the intraplate earthquakes we have historically had. While all of Pierce County is vulnerable to this type of earthquake, the most vulnerable areas will be those containing soft soils; both natural and those created by artificial fill.

The next factor that can influence the outcome of an earthquake is the weather. The weather previous to the earthquake will have an effect on the eventual outcome. Rain saturating the ground can increase both the potential for earthquake generated landslides and the probability that liquefaction or lateral spreading will occur. This could increase the probability that pipes could break. Lateral spreading under roads, railroad tracks and port facilities would increase disrupting transportation and there could be an increase to building damage due to liquefaction.

The other area that could cause damage is actual surface disruption either from surface faulting, or subsidence and uplift. Fault ruptures breaking the surface can rip buildings apart, destroy bridges, offset roads, break pipelines, destroy sewer lines, and stretch or break transmission lines. The same can be said for subsidence and uplift. Having a building, road or any other piece of infrastructure where a portion of it either rises or falls in relation to the rest will break or destroy it. Any piece of infrastructure either in the ground or on its surface can be broken or destroyed by any of these three effects.

Changes in the ground can affect the water table. Wells may change their water levels or go dry. Stream flows may be altered and on a macro scale landslides or other ground deformation may change the course of streams or rivers.

The Environment

Impacts, or damage, to the environment may be thought of as two different processes. There is direct change to the environment caused by the earthquake. This incorporates all the natural damages such as landslides, coastal uplift, inundation of low-lying areas with coastal subsidence and tsunami damage. In contrast, the other process involves the pollution that becomes endemic in the aftermath of an earthquake that strikes an urban area or some part of the infrastructure today.

Traditional environmental changes due to earthquakes, while many times damaging in the short term, can sometimes be overcome with time as the local ecosystem absorbs them. These types of environmental effects have been happening for as long as the land that is now Pierce County has been around. These types of impacts include:

- Landslides – Landslides will sometimes block streams or rivers forcing them to reroute, occasionally causing lakes that swamp the local vegetation leaving a ghost forest standing in the water. Landslides can increase erosion affecting fish habitats. They can cause tsunamis that can damage coastlines.
- Coastal uplift – Can cause raised sections of the near shore marine environment above the tide line, killing all near shore tidal life in the area raised above the tide line.
- Coastal subsidence – Are responsible for dropping areas of beach and near beach land so that water now covers land that was recently dry. This can drown plants and animals in newly submerged areas and in some areas lead to saltwater intrusion into the local ground water supply.
- Tsunamis – Tsunamis cause local erosion of the beaches, direct damage to plants and animals living on the beach, and possible saltwater damage to non-salt tolerant species away from the beach.

Today, however, there is another type of environmental damage that is the result of human intervention. That is the damage caused by the release of hazardous chemicals and/or large quantities of sewage. These can be released from many different sources including but not limited to industrial plants, pipelines, overturned trucks, damaged ships or barges, railcars and even school chemistry labs. These impacts to the environment include:

- **Air pollution** - Some chemicals released as gasses can cause immediate damage to plants, animals and humans. Tanks filled with, for example, chlorine, ammonia or any other hazardous gas can harm or kill animals, birds, and plants, not just in the area of the spill but for some distance downwind depending on the chemical involved and the size of the release. The damage will usually be temporary and physical recovery to the environment will begin as soon as the gas dissipates.
- **Chemical Spills** - Chemicals that spill either directly into or that could drain into lakes, ponds, streams, rivers, or even drainage ditches could kill or create birth defects in fish and marine mammals. In some areas they would pollute drinking water. Depending on the chemicals involved and their ability to be either absorbed by the environment or break down quickly the environment may either recuperate quickly or be impacted for years or even decades. Damage to port facilities could create spills into the waterways that tidal currents could spread throughout the coastal areas of Puget Sound causing damage into Kitsap, King, Pierce, and Thurston Counties.
- **Damaged Wastewater Treatment Facilities** - The pollution of sewers, pump stations, etc. could lead to spills of sewage or the inability of the treatment plant to process waste allowing it to flow untreated into the local environment. This would have the same effect as many other hazardous chemicals, polluting the environment for possibly weeks, but also creating conditions that could with bacterial contamination lead to disease in both animals and humans.
- **Soil Absorption** - Spills onto land can, depending again on the type of chemical, either temporarily, as with the case with many caustics or acids or permanently, as with spills of heavy metals or many radioactive materials damage soils. Related to this is the absorption of material by the soil may allow it to pollute groundwater and be transferred for some distance causing damage. Depending on the ability of water and the chemical to leach through the underlying layers of soil, clay, rock, etc. it could eventually reach and pollute the aquifer.

Economic and Financial Condition

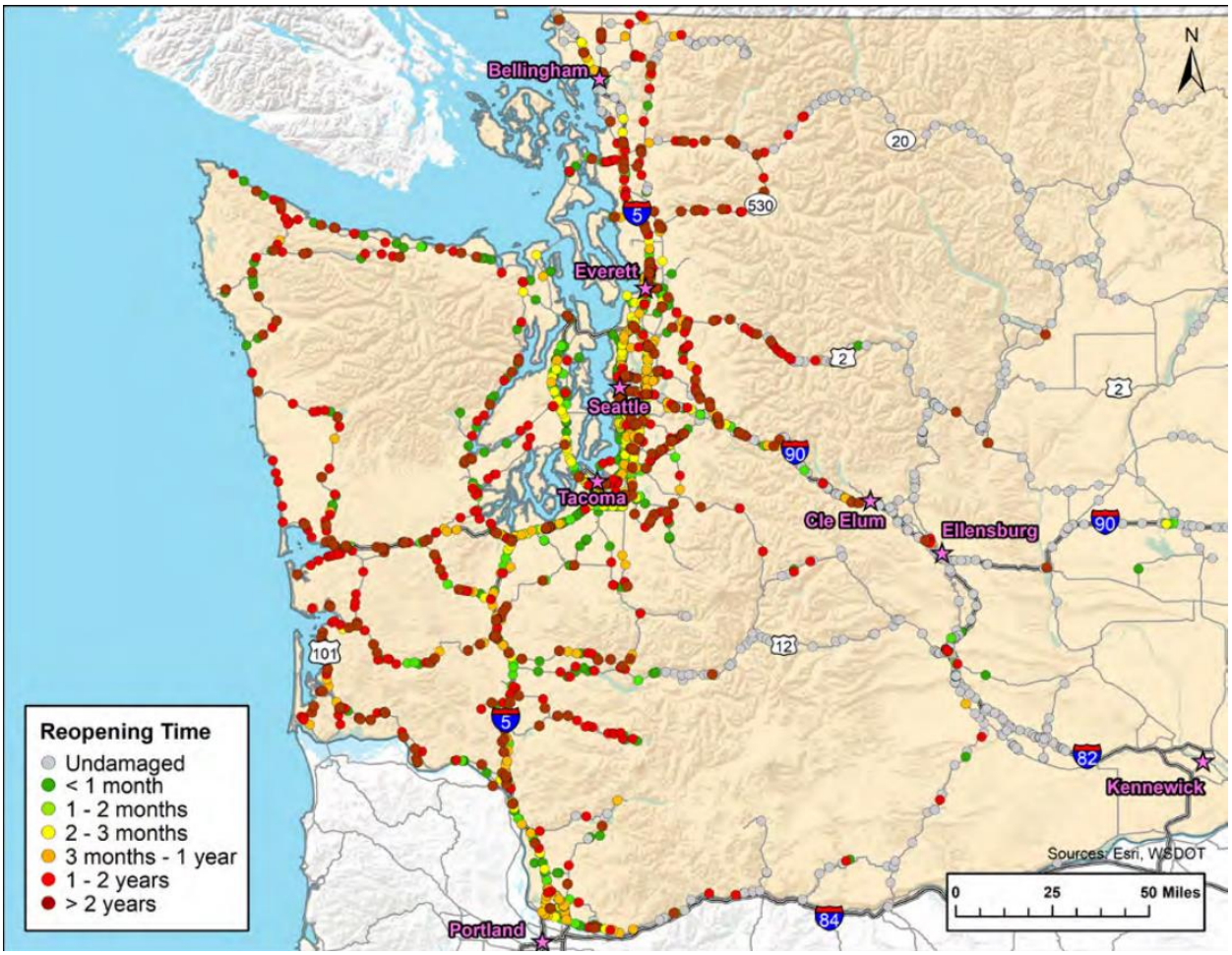
The economic effects from a large damaging earthquake will be extensive and the overall financial condition of most businesses, as well as local governments in Pierce County, will be compromised.

Economic factors will be impacted first by the direct damage to homes, businesses and the infrastructure. A number of factors come into play here. First, the housing stock will be affected, and while some people have earthquake insurance, the majority do not. Most home construction built to contemporary earthquake standards will probably not collapse, however damage could be extensive to older structures especially those not connected to their foundations. While assistance from FEMA and the Small Business Administration (SBA) will help with reconstruction, there will still be a large gap in what is needed to get families back into their homes.

Looking at the results of other earthquakes both in the Pacific Northwest and California, it can be seen that many businesses' buildings stock will be damaged. This will be especially prevalent in the areas of soft soils and older building stock. Combining this with the loss of water, electricity, and natural gas means that much of the local industry and businesses will not be able to continue operations in their normal manner. Most will be closed for at least a nominal portion of time. This will mean lost wages. In an escalating sequence of events the wage earner will not be able to buy necessities or pay bills that come due, including mortgages. This can lead to foreclosures and the further displacement of the population.

The loss of the transportation corridors including roads, rail transport and the damage to the Port of Tacoma will make it nearly impossible to both, import needed supplies and to ship goods to market in the near term. Some of these facilities may take years to recover. A detailed resiliency assessment on Washington State transportation systems (DHS, 2019) provides timeframes depending on what is broken. For instance, in 2017 the Port of Tacoma identified that if the port cranes collapse, not only could it block the waterway but could take up to six months to remove[32] (Figure 4.2-11).

Figure 4.2-11 Bridge Seismic Screening Tool (BSST) Projected Reopening Times of Highway Bridges in WA After the CSZ Scenario Earthquake



Other economic factors impacting businesses include loss of inventory, or for those businesses that operate on a "just in time" re-supply schedule and do not have an inventory, the loss of their ability to be re-supplied may denote the end of their business.

A contributing factor includes the inability of staff to report to their work. This will be due in some cases to injury, while for others they could be looking after their own homes and families. Another factor leading to staff absenteeism is the damage done to the transportation corridors.

The damage to homes, industry and other businesses will also have a direct impact on the long-term operation of government and the public infrastructure. With the loss of a percentage of the tax base due to damage, and the exorbitant cost of bringing the infrastructure back to normal, there will not be funds available for many of the services that communities have grown to expect. This will have a compounding effect of not attracting other business to the County which then continues to limit the tax base.

A Cascadia Subduction zone earthquake today is estimated to cause ~49 billion dollars in damage. In 1949 the magnitude 7 earthquake near Olympia killed eight people and 40% of households and businesses damaged. In 1965 the magnitude 6.5 earthquake killed 7 people and costed $12 million in property damage. The Nisqually 2001 magnitude 6.8 earthquake injured 400 people and cost billions in property damage.

Public Confidence in the Jurisdiction's Governance

How the aftereffects of the earthquake are handled will have a great deal to do with the public's confidence in the jurisdiction. For smaller size quakes there should be little or no decrease in the public's confidence about government's ability to act. However, as the size of the earthquake increases and as the parameters that could lead to major damage increase, such as depth, epicenter, rainy weather, etc., then the possibility of the public finding fault with local jurisdictions or agencies increases.

Local agencies and governments must be able to respond quickly to revive any portions of the infrastructure that have been impacted by the earthquake. The longer the delay in service restoration, the more the public loses confidence in an agency's or government's ability to handle the situation. Since many of the long-term effects of an earthquake have social and economic consequences, the more the public perceives that government is ignoring their plight or unable to respond to it, the more the public will lose confidence in it. Eventually, any perceived lack of ability, or slow response will result in finger pointing and acrimony.

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Epidemic and Pandemic

Human-Caused Hazard | 4.4

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Identification Description

Definition

An epidemic is a disease that spreads rapidly throughout a region or country's population. Pandemic refers to an epidemic that has spread throughout a larger geographic area impacting multiple countries or continents.[1]

Types

The best-known pandemic to date was the coronavirus disease 2019 (COVID-19) that spread worldwide in early 2020. Very little was known about the disease initially, including how it was transferred between individuals and what precautions were advisable or available to prevent the virus from spreading. In the United States as of March, 2023 there were 103,802,702 reported COVID-19 cases, and 1,123,836 reported deaths (Figure 4.4-1).[2] By December 2020, vaccines produced by Pfizer-BioNTech and Moderna were granted Emergency Use Authorization by the US Food and Drug Administration (FDA), although misinformation about the safety of vaccines caused delays and lack of public trust in the distribution and efficacy of the vaccines despite scientific evidence to the contrary. As of Mach 2023, 81.82% of the United States population had received at least 1 of the recommended 2 doses.

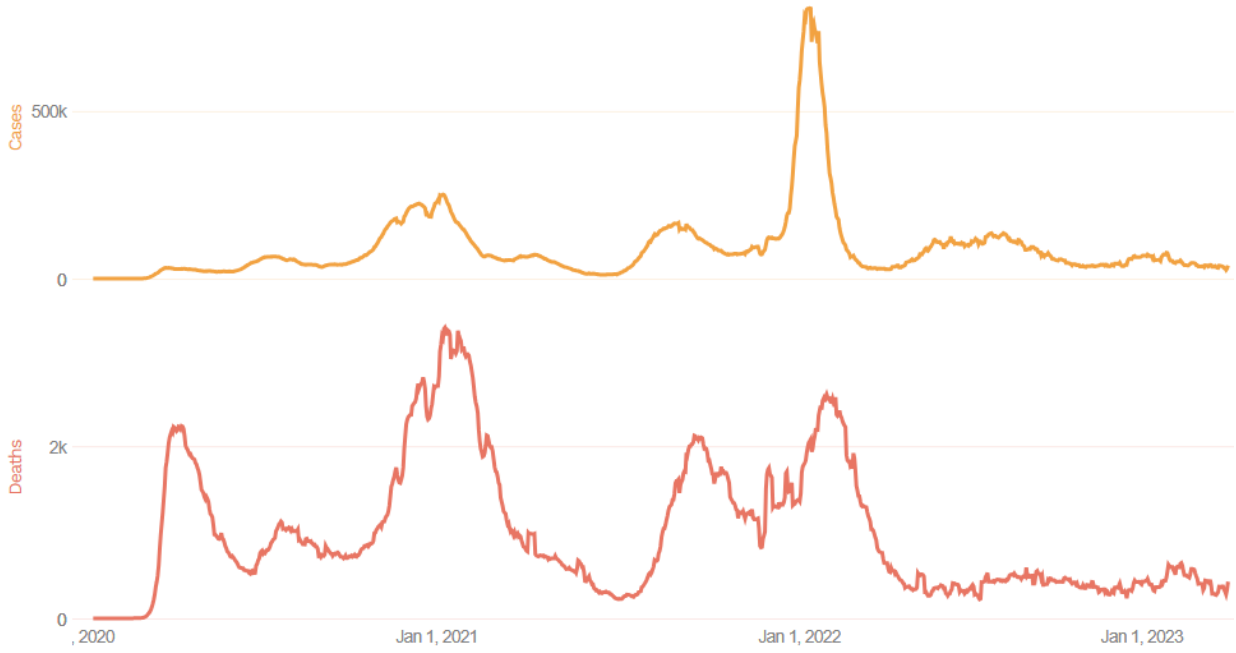

Figure 4.4-1 COVID-19 Cases and Deaths in the United States through March, 2023

The best-known types of pandemics are influenza pandemics. These have been some of the deadliest plagues in history. It is estimated that, worldwide, the 1918 flu pandemic killed over 50,000,000 people. The latest example of this is the H1N1 “Swine Flu”. This flu strain is a recombination of swine, human and bird flu genes. Initial cases appeared in Veracruz, Mexico in the spring of 2009. Spreading through the population, it next moved to the United States and then eventually worldwide. Symptoms were mild for a large percentage of the population; however, those with a compromised immune system, pregnant women, or very young children had a more intense reaction to diseases than many others in the general population.

Seasonal flu epidemics are a recurring phenomenon that migrates around the world. The flu virus tends to mutate allowing it to continuously re-infect the population. In the United States, annual flu respiratory infections range from 5 to 15 percent yearly.

Other diseases with pandemic pedigrees are cholera, AIDS, and now emerging, tuberculosis. Each of these has been around for many years, and for cholera, tuberculosis and Ebola may break out into a rapidly moving pandemic again. AIDS while currently in a pandemic stage is unlikely to recede into the background anytime soon.

Profile

Location and Extent

Epidemics and pandemics have in the past covered the entire County. They will continue to do so in the future. To what extent they infect the public depends on their ease of transmittal. How serious the disease is to the individual depends on a number of factors including age, general health, lifestyle, occupation, etc. If they follow the pattern of the annual flu infecting 5 to 15 percent of the population, that will mean anywhere from 44,415 to 133,245 people in Pierce County could become infected.

Occurrences

Pandemics and epidemics have plagued humans for thousands of years. As human populations began to congregate in cities, the potential for large scale epidemics grew. As this process continued and trade between the various population centers increased and so did the potential for the disease to spread. This eventually led to the potential for pandemics. Today with our mobile population, individuals can be in North America one day, in Europe the next and in Asia the next. This increases the ability for opportunistic diseases to migrate through the world’s population.

Recent Epidemics have included:

- 1976-2014 Ebola outbreaks.

Recent Pandemics[3] have included:

- 1918-1919: "Spanish Flu" Worldwide;
- 1957: "Asian influenza";
- 1961-1970s: "7th Cholera pandemic"[4];
- 1968: "Hong Kong influenza";
- 1981-Current: AIDS (Although pandemic in scale);
- 2009-2010: "Swine Flu"; and
- 2020 Coronavirus-19 (COVID-19).

In recent years, have been the of a number of different diseases some of which are on the verge of being, or are already, epidemics or pandemics. These have had an impact on the effect on the population's health in the County. A few of these diseases include the following.

- **Acquired immune deficiency syndrome (AIDS)** was only discovered nationally in 1981 and is currently considered an epidemic in the United States.
- **Measles** has been a major childhood disease ever since settlers with European heritage moved into Washington during the 1800s. Much of it has been controlled by vaccinations. However, in the 1990s, Washington experienced the largest measles epidemic since 1979.
- **Hepatitis B**, a serious, highly contagious liver disease is frequent in Washington, including outbreaks in Pierce County.
- **Tuberculosis (TB)** is another one of those diseases which has been around for many years. The belief, a few years ago, that it would soon be brought under control is no longer considered realistic. The development of strains that resist treatment, combined with lifestyles that allow the disease to be transferred easily, has allowed its resurgence during the past few years. Many people, once they become symptomatic, will continue to infect others until they themselves are located and given treatment. When left to themselves, many of those who initially resist treatment will also fail to complete treatment once the symptoms begin to disappear. This could lead to a later resurgence and contribute to the development of resistant strains. This is especially true in the denser urban cores. To counter this, the Tacoma/Pierce County Health Department has initiated a program of aggressive follow up to make sure that individuals complete a full course of their treatment. Without these preventative measures, the future could see a dramatic increase in the disease rate. It is estimated that between two and three new cases are

diagnosed in the County each month. This may not seem like many but considering that nationally only a few years ago we appeared to be on the verge of eliminating the disease, the numbers appear depressing.

- **The standard fall/winter flu season** creates its own epidemic on a yearly basis with some strains causing greater damage than others. In cases like this, the elderly are hit the hardest, resulting in several deaths attributable to flu each year.
- The highly publicized **e-Coli epidemic in January of 1993**, caused by tainted hamburger at fast food restaurants was an excellent example of how an epidemic we are not familiar with can suddenly enter our environment. In this case it infected a number of people and caused a great deal of suffering before anyone even realized it was happening. Pierce County's toll in that epidemic was 73 infected individuals. In 1998, another e-Coli outbreak occurred in the County from an unknown source at the Puyallup Fair.
- Another disease that has come to the foreground in Washington is **Lyme Disease**. While the first reported case in Washington was in 1987, cases have increased from year to year with the large number of people recreating in our wilderness areas, there is potential for the number of cases to expand rapidly.
- **Hantavirus Pulmonary Syndrome (HPS)** is another one of those emerging diseases. HPS was first reported in the United States in the spring of 1993. As of November 2001, 288 cases had been reported in the U.S. and about 38 percent of the people died as a result of the infection. There have been a few cases reported within Washington State, none contacted in Pierce County. Deer and mice shed the virus in their urine, saliva, and droppings. Exposure comes through breathing dust after cleaning rodent droppings or disturbing nests, or by living or working in rodent-infested settings. Testing shows that approximately 10% of the deer and mice tested are carriers of the disease.

Recurrence Rate

There have been four flu pandemics in the past 100 years with three of them being in the last 60 years. This produces a recurrence rate for pandemic flu of 25 years or less.

Other pandemics like the cholera pandemic, the AIDS pandemic, the possibly evolving tuberculosis pandemic, and Coronavirus pandemic reveal that taking all types of pandemics together will bring the recurrence rate down to 20 years or less.

Impacts

Health and Safety of Persons in the Affected Area at the Time of the Incident

With epidemics and pandemics there is no area unaffected by the spread of the disease. The impact on citizens is acute illness and depending on which disease they catch there could be respiratory problems, vomiting, diarrhea, sore muscles, joint pain, weakness, spitting up blood, coma or death. For some diseases, and this includes the 1918 "Spanish Flu," many people develop long term physical complications, or due to brain damage, there may be long term, residual, mental impairment.

Health and Safety of Personnel Responding to the Incident

Responders will be mostly from the medial services in fire departments, ambulance attendants and hospital personnel. Those diseases that are transmitted through human-to-human contact will put the rescuer in danger of coming down with the same disease.

Continuity of Operations and Delivery of Services

Depending on the severity of the epidemic or pandemic there could be problems with continuity of operations and the delivery of services. As staff members stay home because they themselves are ill, they are caring for others or because they fear contracting the disease, the ability of the County, or the other jurisdictions within it, to maintain delivery of services to their constituents could be severely limited. As the incidence of disease increases, there could be a loss of operational continuity within individual departments.

Property, Facilities, and Infrastructure

There should be no direct impact to property, facilities or the physical infrastructure. Indirect impacts could develop due to lack of maintenance on equipment, property or facilities. However, with an epidemic or pandemic, if the symptoms of the disease are severe, with many people requiring skilled nursing or hospital care, it would overwhelm the medical infrastructure.

The Environment

Epidemics and pandemics do not normally disrupt the environment. As a human disease they infect humans, and in some cases, certain animals. The avian flu H1N5 has attacked certain bird populations with a high rate of morbidity and mortality. This is also the case with West Nile Virus which is now moving through the bird population here in Washington State. It is possible that other diseases might make the jump between humans and animals, increasing animal illness and death.

Economic and Financial Condition

Seasonal flu by itself causes considerable economic hardship due to lost productivity[5], high medical costs and lost wages. In the United States these costs range from $71 to $167 billion dollars a year.[6] With a pandemic, if the symptoms of the disease are severe, including long periods of illness, or residual, debilitating effects, it could impact the economy of the County for years. The need to alter or prevent the normal social contacts, called "social distancing," will lead to a further temporary decrease in the financial condition of the community.

Public Confidence in the Jurisdiction's Governance

An epidemic or pandemic can shake the confidence of the public across all social groups. As an ever-larger portion of the population becomes ill, demands for limited and controlled medical supplies could cause questions to arise concerning the methods of distribution. Inadequate response to the public's concerns about the supplies or the method of distribution could lead to not only lack of confidence, but outright hostility towards both those in power and those who hold the reins of distribution.

If there is a decision to isolate those who are ill, restrict travel, cancel public events, close schools and businesses or take other, possibly controversial, actions or positions, there could be strong public resistance. Any action would have to be partnered with a strong public relations campaign to convince the public that it may be necessary. If the actions are truly perceived by the public to be in their best interest, the confidence in government may survive.

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Flood

Natural Hazard | 4.3

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Identification Description

There are 76,046 of acres of land within Pierce County within the 100-year floodplain, representing approximately 7.0 percent of the County's total area. Flooding is Pierce County's most common and most costly natural hazard. Flooding affects tens of thousands of families and properties owners in communities across the county, with life safety, economic, and workplace impacts on tens of thousands more. The Pierce County Flood Control Zone District was established in 2013 to regionally manage flood hazards and reduce risk, in partnership with the Pierce County Planning and Public Works – Surface Water Management division. The 2023 Pierce County Comprehensive Flood Hazard Management Plan drives much of the work that both the District and Pierce County do to reduce flood risks and manage flood-related hazards. The 2023 plan is a 10-year plan that builds off the 2018 update and expands beyond river flooding to include three other common flood types: urban, coastal, and groundwater.

Definition

Flooding is the inundation of normally dry areas by overflowing rivers, increased coastal waves, or other accumulation of surface waters. Several factors can contribute to flooding, from high intensity rainfall events driving rivers into their floodplains and coastal flooding due to high tides. Flooding can also be caused by events such as liquefaction of levees during an earthquake releasing water the levees are intended to hold back. Other causes of flooding include dam failure, landscape changes after wildfires that exacerbate flooding, rapid snowmelt, channel migration, and debris in streams or municipal stormwater systems causing water to backup.

Typically, Pierce County sees at least minor flooding every year in the fall and winter. Big events are often driven by atmospheric rivers where moisture is picked up from the Pacific Ocean and brought by the jet stream to fall as prolonged heavy precipitation.

Multiple factors affect where and how flooding occurs and its severity.

Figure 4.3-1 Floods in the Riverside Community from Clear Creek Backwatering Due to High Flows on the Lower Puyallup River in November 2009.

One main factor for riverine flooding is the hydrology, which includes how much rain falls, how fast it falls, how fast it reaches the stream, and the amount of water already in the stream. The second main factor for riverine flooding is the hydraulics of the watershed, which includes characteristics like the topography, stream channel dynamics, and the overall slope of areas of the watershed.

Flooding is a natural phenomenon. Many ecosystems thrive because of the natural floodplain functions that rivers and coastlines provide. Flooding is considered a problem when humans construct buildings and infrastructure in the path of floodwater creating a flood risk. The many aspects of natural floodplain functions help reduce impacts, slow floodwaters down, and preserve important habitat for endangered species.

Types

Riverine Floods

Riverine hazards are when flood waters overtop the channel bank and extend into the floodplain. This behavior occurs on major rivers to small streams. Our interest in this section will be to describe the major river reaches in the county that have the capacity to do the most harm. This is not to discount that smaller creeks can still cause significant damage to a property. Riverine flooding presents life safety challenges where deep and or fast flowing water can sweep away people and cars. Erosive forces and dynamic sediment loads can also cause the river to migrate to new locations that may have been high ground but are occupied by the river following a high-water event. For these reasons Pierce County regulates areas of deep and fast flowing water and areas at severe risk of channel migration as a floodway to limit future development. Areas behind a levee present a unique situation where residents may feel protected from a flood since their low-lying property doesn't flood as frequently as it did prior to levee construction. Levees can fail for many reasons (over-topping, breaching, sloughing, flanking, etc.) creating a situation where warning times are shorter, and evacuation routes become uncertain for the resident who is suddenly at risk.

Since 1906, there have been 16 Presidential Disaster Declarations and numerous flood events in Pierce County, in the following years: 1962, 1964, 1972, 1975, 1977, 1986, 1990 (x3), 1995, 1996, 1997, 2003, 2006, 2009, and 2012. Major river flooding has typically not caused fatalities, but rather significant property damage and emergency rescues. Flooding along multiple rivers in 2006 and 2009 were the most recent major floods to cause many millions of dollars in damage. Flooding in 1990 is considered the largest flood of record for most of the county.

Flooding impacts our community in many ways and affects our agriculture, residential, commercial, and industrial lands. Back-to-back atmospheric rivers can cause major floods on rivers. River flooding happens when rivers are filled above their capacity from excessive rainfall

and snowmelt, which causes rivers to overflow their banks. River flooding is exacerbated by sediment and debris loads transported down the river. Higher flows typically result in more sediment and debris being moved through the river system. When transported and deposited, sediment and debris reduce the carrying capacity of a river channel, thus resulting in an increased risk of flooding, which is a natural phenomenon. However, flood damage is a result of structures built in the floodplain.

Channel Migration Zones

Figure 4.3-2 House Destroyed Due to Erosion from Puyallup River Channel Migration

Rivers are dynamic systems that can shift significantly during high flow events or through erosion of streambanks even at normal flows. This risk is called "channel migration hazards," and is a common feature in large and steep rivers coming off mountains and through glacial outwash. The degree of channel migration depends on the severity of the high flow event, geology of the banks and streambed, and characteristics of the surrounding land. Pierce County maps and regulates eight such channel migration zones as 'CMZ floodway' with applicable development standards within these zones including: Puyallup, Carbon, lower White River, Nisqually, Greenwater, South Prairie Creek, Greenwater River, and Upper White River. While technically not a 'flood,' water causes erosion of land, and therefore it is also discussed in the Erosion Risk Assessment.

Coastal flooding most often occurs in winter months when winter storms bring low pressure, rain, and wind-driven waives that occur in conjunction with King Tides. The December 2022 and January 2023 events are examples of coastal flooding events influenced by weather. As Puget Sound experiences continued sea level rise the chance of more frequent and severe coastal flooding increases.

Coastal

Coastal flooding is defined as damaging impacts associated with marine waters. In Pierce County, this means Puget Sound shorelines. Coastal floods are caused by extreme sea levels, which arise as combinations of four main factors: waves, King Tides, storm surges, and relative mean sea level. Each of these four components of sea level exhibits considerable natural variability, which influences the frequency of flooding on inter-annual and multi-decadal time scales and makes isolating changes due to climate change difficult.

Pierce County has 223 miles of marine shoreline. The effects of coastal flooding can occur during high tide events and storm events. High tide events are predictable and occur over a 3-5 day period, usually twice a month. Each event can last from two to four hours. However, sea level rise predictions indicate that these events are expected to become more severe over time. Tidal events can aggravate stream, river, and upland flooding by backing up water into those channels and into nearshore drainage pipes and infrastructure. Likewise, wind events can increase the impacts from wave action and exacerbate damage from high tide events, which is often referred to as storm surge.

Pierce County has 123 miles of coastline that is predominantly high bank with a limited amount of low bank properties. The 2017 FEMA flood insurance rate map (FIRM) includes the first comprehensive coastal flood study of Puget Sound. 79 percent of the marine shoreline is mapped as a high hazard velocity zone where high waves can cause direct damage or erosion to structures. Chronic coastal flooding currently happens during high tide events that combine with wind events with Dash Point and Purdy seeing flooded structures, roads and parking lots. The latest NOAA guidance estimates sea level to be five feet higher in the next 80 years.

High coastal bank and bluffs can have coastal erosion lead to landslides and cause damage to properties both above and below the bank. This type of damage has been limited in the past but could increase with sea level rise

Groundwater

Pierce County was at the terminus of the last ice age and the glaciers left a mix of well-draining soils and nearly impervious hard till and clay. This geology results in pockets of groundwater flooding where underlying soils fill up after extended periods of rain and pool to the surface in low lying well-draining soils. Between Graham, Fredrickson and Spanaway, groundwater will move in a west-northwesterly direction until it reaches Puget Sound. Groundwater flooding generally occurs after above average rainfall from October to December and then surfaces from March to May in old glacier oxbows.

Since the long-term road closure of 192nd Street East due to groundwater flooding in 1997, there have been 10 groundwater flood events observed in Pierce County that have impacted

transportation and residentials properties. Groundwater flooding events occurred in the following years: 1997, 1999, 2011, 2012, 2014-17, 2019, and 2021.

Groundwater flooding, also known as clear water flooding, is defined as water emerging from the ground. This happens when the underground water table exceeds its limits, thus causing the water to emerge from the ground and flow onto the surface. Groundwater flooding is a phenomenon that occurs predominantly in the south-central portion of Pierce County in the Chambers-Clover Creek watershed. Groundwater flooding typically happens when rainfall totals are high over many months, and the flooding does not materialize until late winter and early spring. This area is geologically unique and has a high amount of glacial outwash soils as well as being an aquifer recharge area. The general boundary prone to groundwater flooding is primarily isolated to west-central Pierce County bounded by 267th Street East to the south, 118th Avenue East to the east, 154th Street East to the north, and 40th Avenue South to the west. The communities affected include Graham, Parkland, Spanaway, South Hill, and the southwest communities of Frederickson and Pioneer Valley.

Urban

Urban flooding has a large stormwater runoff component. Within the urban growth areas drainage and creek systems can experience flash flooding events intensified by land cover changes. Stormwater runoff also has water quality concerns for human and aquatic health.

Since 1996, there have been five major urban flooding events observed in Pierce County that impacted county infrastructure and residential properties, including 1996, 1998, 2001, 2004, and 2019. Urban flooding is defined as overwhelmed drainage systems (such as municipal separate storm sewer system also known as “MS4”) driven by localized rainfall events as seen in Figure 2.7. While these systems often discharge to a stream, they are considered a separate class of flooding because urban flooding can occur independently from stream flooding. All drainage networks around the county have not been mapped for this type of flooding due to the number of hydraulic controls that must be accurately surveyed to map a relatively small area. Flooding of this type can typically be seen throughout the county where the cities and county MS4 systems have replaced natural drainage systems.

Storm drainage systems in Pierce County are typically designed to accommodate the 25-year flood event. Urban flooding can be made worse when the effects of streams, rivers, coastal, or groundwater inundation limit the stormwater systems from efficiently draining. Some systems are built with those external factors in mind. However, as hydrology changes and climate change occur, existing systems may be found to be undersized. Unless adjustments are made to accommodate anticipated increased rainfall due to climate change, the risk of urban flooding will continue to rise as the rain events grow larger and more frequent. The 25-year flood event of the future will be less intense than in the past, so even that capacity is inadequate.

Flood Causes

Heavy Rain and Atmospheric Rivers

Most riverine and urban flooding is caused by heavy rain and atmospheric rivers that drive significant weather systems into the Pacific Northwest.

Intense rainfall can overwhelm a river's ability to carry flows within their banks and cause inundation of the adjacent floodplains. These factors not only drive riverine flooding, but also urban flooding issues that can overwhelm local stormwater infrastructure and cause flood damage.

Dam Failure and Overtopping

When dams fail, the water held back rushes out quickly, potentially causing catastrophic flooding downstream. Dams both large and small can pose significant impacts. Smaller structures that might be in a neighborhood can also lead to deaths and significant property damage. Dam failure can be caused by too much water for a structure to handle or by lack of maintenance that causes the dam to fail.

Severe Winter Storm, Storm Surge, and King Tides

Severe winter storms that have strong winds combined with King tides can cause significant coastal flooding, as seen in the December 2022 King Tide event that battered marine shorelines in Pierce County. Intense coastal storms and high tides can cause damage to low-laying coastal properties and damage infrastructure like roads, pump stations, stormwater infrastructure, and ferry docks.

Sea Level Rise

As sea level rises in Puget Sound, the stillwater elevation level, or the water level without effect of waves, rises and pushes more water inland during times of severe storms. While the actual increase in flood risk will differ based on the localized geography and wind patterns, sea level rise is certain to worsen flooding along the coastlines in Pierce County.

Channel Migration

Rivers naturally erode banks and soils due to the energy of moving water. This erosion causes rivers to migrate or move laterally across a floodplain. A channel can also move suddenly over a large distance in a single flood event. This can threaten development located in channel migration zones, which are mapped.

Levee Failure and Overtopping

Levees act as flood risk reduction facilities, but do not eliminate flood risks. All levees fail eventually. They also are earthen structures that require maintenance. Flooding can exceed a levee's capacity or flaws in the structure can cause it to fail, and both would cause rapid inundation behind the levee. Water can seep through levees and cause weaknesses that lead to collapse.

Landslide and Mudflow

Landslides can rapidly fill in river channels, causing a blockage in the river that leads to overflowing as the water finds a new path. This threat is particularly present where there are steep banks near river channels such as on the Carbon River upstream of Orting. Landslides can also add significant material to a river, causing a mudflow and rapid damage to property and loss of life, such as the Oso Landslide in 2014 in Snohomish County.

Lahar

Lahars can fill river valleys and drastically change the course of rivers, streams, and shorelines. The amount of materials brought downstream in a lahar affects the severity of impacts in future flooding. Lahars could occur during or after a volcanic eruption on Mt. Rainier, after rainfall on ash, because of an earthquake, or from heavy rainfall on loose soils after a wildfire. Lahar risks and evacuation routes are described further in the Mt. Rainier Volcanic Response Plan, 2024.

Earthquake

Earthen levee systems are prone to liquefaction in an earthquake, which can cause major failure of the levee structures. If floodwaters are being held back at the time of an earthquake, the levees can fail and flooding could occur very quickly.

Tsunami and Seiche

Tsunamis are powerful waves that are caused by an earthquake or displacement of water from an underwater land feature collapse. Specific scenarios are outlined in the Tsunami and Seiche Risk Assessment. A tsunami that affects Pierce County would cause significant wave action and likely major damage to low-laying properties on the coast, including the Port of Tacoma.

Humanmade Watershed Changes

One major factor in understanding flood risk is the underlying land that floodwaters flow over. Harder and more impervious surfaces such as those common in urban areas carry floodwater faster. As people continue to build buildings, roads, sidewalks, and other impervious features, floodwaters travel faster to streams, which can increase the severity of flooding.

Climate Varability

While climate variability influences many of the factors already identified, it is a specific scenario driver because of the potential to change flooding in Pierce County. The 2023 Flood Plan describes the climatic conditions we can expect in Pierce County, including higher intensity rainfall events, which will increase flood risks.

Secondary Hazards

Erosion

River erosion is the removal of material from the banks and beds of river streams. Erosion can occur when the hydraulic force of floodwater scours riverbanks, when large areas of sediment fall or topple from a bank due to undercutting, or subaerial erosion due to groundwater seepage. Erosion along rivers and during floods can cause damage to structures, infrastructure, utilities, and present a safety hazard to community members and responders.[1]

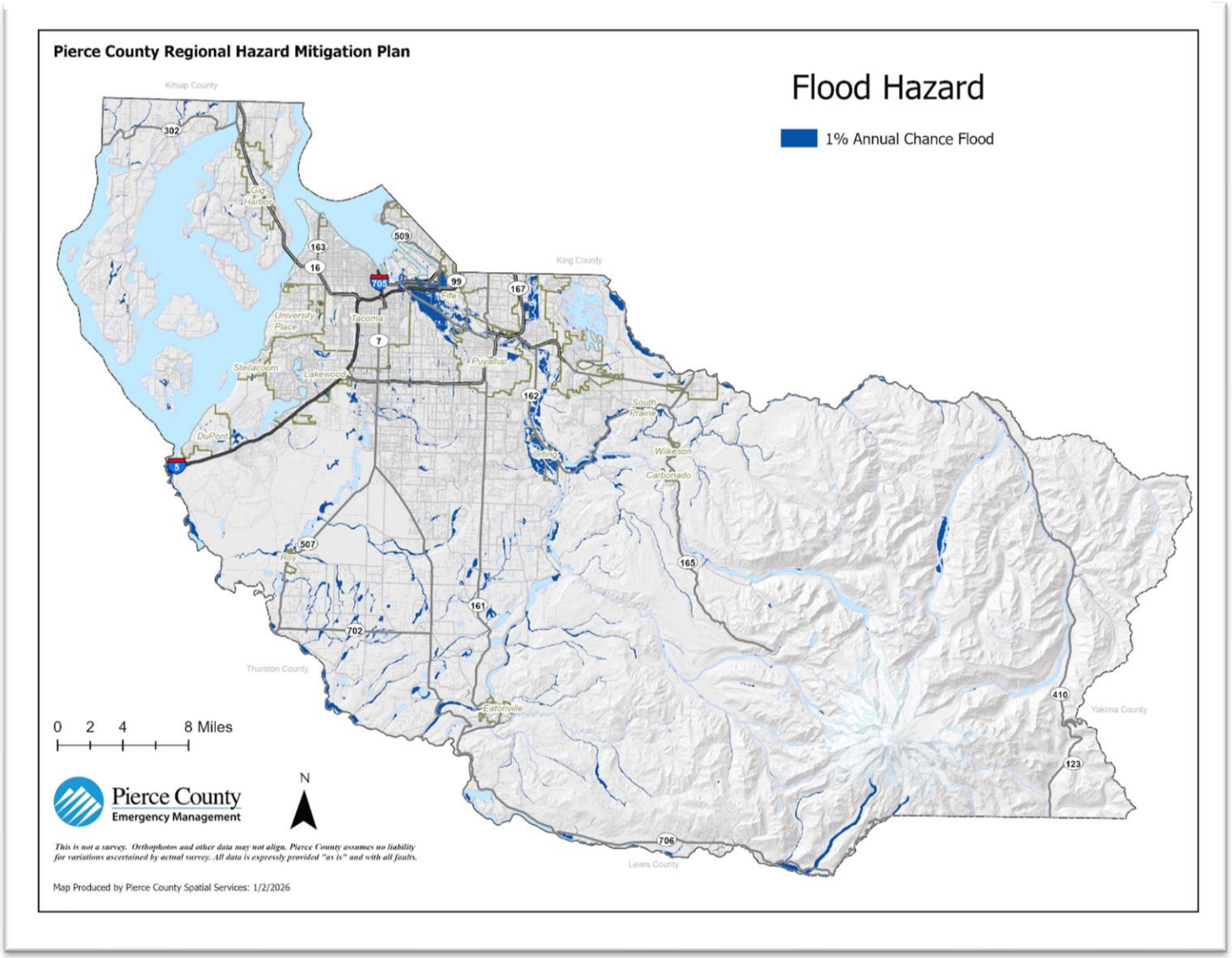
Profile

Pierce County

The geographic scope includes the floodplains of the two major river systems in Pierce County (Puyallup and Nisqually Rivers). The Puyallup River and Nisqually River watersheds include forests, national parks, and wilderness areas in the upper watersheds; rural and agricultural uses in the mid to lower basin areas; and urban areas dispersed throughout the lower Puyallup watershed near the river mouth. To capture the full impact of the Pierce County river systems, this section has been divided into 10 planning areas:

- Puyallup River
    - Lower Puyallup River
    - Middle Puyallup River
    - Upper Puyallup River
- White River
    - Lower White River
    - Upper White River
    - Greenwater River
- Carbon River
    - South Prairie Creek
- Middle Nisqually River
- Upper Nisqually River
- Mashel River

Map 4.3-1 Map Showing Mapped 1% Annual Chance Floodplains and Floodways in Unincorporated Pierce County.



Scenario Drivers

Most types of flooding caused by extreme weather are cyclical and are measured by their probability of occurrence in a given year based on the factors that drive flooding. The larger a flood event, the less likely it is to happen in a year. A flood with a 10% chance of occurring in a year is sometimes called a "10-year flood," and that flood event will have less river flow and likely fewer impacts than a 1% annual chance flood event, or a "100-year flood." These flood scenarios are modeled and maps created to show their extents by FEMA as Special Flood Hazard Areas.

The 1% annual chance flood, or 100-year flood, is the most important scenario because floodplain regulations and federal flood insurance are based on this flood event (see Map 4.3-1). This flood event represents the mapped floodplain on FEMA Flood Insurance Rate Maps and forms the basis for community regulations for participating communities in the National Flood Insurance Program. In unincorporated Pierce County, all new or substantially improved buildings in the regulated floodplain must be constructed with their lowest floor at least one foot higher than the expected elevation of the 1% annual chance flood.

While the 1% annual chance flood is the scenario most often discussed, the 10%, 2%, and 0.2% annual chance floods are often used for planning and certain regulatory purposes. The extents of the flood events are not consistently mapped throughout the county, but engineering data in flood models can be used in project planning or regulatory compliance.

The recurrence interval floods are driven by cyclical natural factors like atmospheric rivers bringing heavy rain or severe winter storms and King Tides. Other factors drive flooding scenarios in different ways. For example, levee or dam failures may happen due to problems caused by inadequate maintenance and be sudden, catastrophic, and without warning. Flooding damage from earthquakes will likely only be seen if an earthquake damages a levee during times of high water, but the damage and subsequent flood might not be immediate.

In Pierce County, the major rivers are measured by a "flood phase" system based on real-time flow information from both USGS and county gages. When a river reaches flood phase 1, the Rivers and Roads Operations Center may be activated, and if flooding exceeds capacity to monitor they coordinate with the Duty Officer at the Pierce County Department of Emergency Management to decide if the Emergency Operations Center will be activated, and the EOC coordinates with local, state, and federal agencies, and accepts calls from the public requesting information about flooding. When a river reaches flood phase 3, Rapid Damage Assessment teams are sent out to monitor flood protection facilities and any potential flooding impacts. When a river reaches flood phase 4, additional staff are brought into the Emergency Operations Center, sent on flood patrols, and begin to collect damage information in case of a disaster declaration.

Pierce County divides major rivers into ten reaches that list the flood phases and the corresponding gage level (ft) and volume (cfs), summarized in Table 4.3-1. There is a map and matrix for each river reach with further details about location, flooding hotspots and potential warnings to the community. These documents can be found in the PPW-SWM Emergency Response Plan and Rivers 101 Field Guide used by Rapid Damage Assessment teams.

Table 4.3-1 Flood Phases by Reach

Reach/Phase	Phase 1	Phase 2	Phase 3	Phase 4
Lower Puyallup	< 35,000 cfs <26.2 ft	35,500 – 45,000 cfs 26.2 – 28.8 ft	45,000 – 50,000 cfs 28.8 – 30.1 ft	> 50,000 cfs > 30.1 ft
Middle Puyallup	<20,000 cfs 54.6 ft	20,000 - 30,000 cfs 54.6 – 57.0 ft	30,000 - 45,000 cfs 57.0 – 60.0 ft	> 45,000 cfs 60.0 ft
Upper Puyallup	<10,000 cfs 10.0 ft	10,000 – 13,500 cfs 10.0 – 10.8 ft	13,500 – 16,000 cfs 10.8 – 11.3 ft	> 16,000 cfs > 11.3 ft
South Prairie Creek	<4,000 cfs <29.4 ft	4,000 - 5,500 cfs 29.4 - 30.3 ft	5,500 - 8,000 cfs 30.3 - 31.6 ft	>8,000 cfs 31.6 ft
Carbon River	5,000 – 7,500 cfs 12.0 – 13.5 ft	7,500 – 9,500 cfs 13.5 – 14.5 ft	9,500 – 12,500 cfs 14.5 – 15.9 ft	> 12,500 cfs > 15.9 ft
Upper Carbon	5,000 – 7,500 cfs 12.0 – 13.5 ft	7,500 – 9,500 cfs 13.5 – 14.5 ft	9,500 – 12,500 cfs 14.5 – 15.9 ft	> 12,500 cfs > 15.9 ft
Lower White	5,000 cfs 114.1 ft	5,000 – 7,500 cfs 114.1 – 115.2 ft	7,500 – 12,000 cfs 115.2 – 116.8 ft	> 12,000 cfs 116.8 ft
Upper White	<10,000 cfs 52.9 ft	10,000 - 15,000 cfs 52.9 - 54.2 ft	15,000 - 20,000 cfs 54.2 - 55.3 ft	> 20,000 cfs 55.3 ft
Middle Nisqually	10,000 - 14,700 cfs 8.0 - 10.0 ft	14,700 - 23,200 cfs 10.0 – 12.99 ft	23,200 - 26,500 cfs 12.99 - 14.0 ft	>26,500 cfs >14.0 ft
Upper Nisqually	<10,000 cfs <10.2 ft	10,000 - 15,000 cfs 10.2 - 11.7 ft	15,000 - 20,000 cfs 11.7 - 13.1 ft	>20,000 cfs >13.1 ft

Extent and Occurrences

Since 1994, Pierce County has experienced an estimated 30 significant flooding events that were classified as riverine, urban, coastal, or groundwater flooding. Flooding impacts communities in many ways and affects agriculture, residential, commercial, and industrial lands. Flooding, no matter the source, causes widespread and long-lasting damage to the built environment. The force of moving floodwaters can dislodge homes from their foundations, sweep cars off the road, and destroy public infrastructure. Houses and businesses damaged by flooding can take many months to repair and are often unsafe to live in during the repairs. Certain types of flooding can leave buildings inundated for several days, which can further worsen property damage. Flood-damaged buildings can pose health risks including

electrocution, mold, contaminated food and drinking water, and mental health stresses from the traumatic experience.

The speed, depth, and volume of floodwaters impact how dangerous riverine flooding can be. A floodplain where the velocity is more than 3 feet per second and the depth is more than 3 feet is life-threatening. Pierce County code, for example, prohibits buildings in unincorporated areas to be built in fast-flowing and deep floodplains. Rivers in Pierce County also carry substantial debris, from fallen trees to boulders and sediment, and debris impacts can add to the severity and dangers of flooding.

Flooding is of greatest concern during the fall and winter months due to atmospheric rivers, heavy rain, and King Tides. Major floods occur on average every two to five years. There have been nine flooding events since 1990 that have resulted in federal disaster declarations. At least minor flooding occurs every winter. Climate change is already having a significant effect in changing the patterns of flooding in the river basins.

Flooding Hotspots

Some areas along rivers are more prone to flooding than others. Historical flooding tells shows which areas may require special attention to in case of potential flooding. Maps of these hotspots are in the PPW-SWM Emergency Response Plan (2025) and the Rivers 101 Field Guide used by the Rapid Damage Assessment Teams that PPW-M&O coordinates during forecasted floods.

River Reaches

- Lower Puyallup River - Tacoma to Sumner
- Lower Puyallup River - West of Puyallup to Tacoma including Clear Creek/Riverside area
- Lower Puyallup River - in Puyallup; Golden Rose mobile home park and Crossroads

Apartment Complexes

- Middle Puyallup River - Sumner to Orting; McCutcheon Rd; Haugsness at 115th St E, River Manor and River Grove Apartments, and the Mosby property (more detail in maps below)
- Middle Puyallup River - Sumner to McMillin; River Manor and River Grove Apartments
- Middle Puyallup River - McMillin to Orting; McCutcheon Road, Haugsness at 115th St E, and Mosby property
- Upper Puyallup River - City of Orting and Neadham Road (more detail in maps below)
- Upper Puyallup River - Orting area
- Upper Puyallup River - Neadham Road area
- White River - County-line/Pacific area; Butte Ave, Stewart Ave, and 16th St E

- Carbon River - 177th St E / Alward Road

Watersheds

Pierce County covers five large drainage basins and coastal flood hazard areas described below.

The Puyallup-White River Basin

The Puyallup-White River basin (WRIA 10) is the largest watershed and includes drainage from the White, Carbon, and Puyallup rivers and South Prairie Creek, and dozens of tributaries. These large rivers flow from glaciers on Mt. Rainier at 14,110 ft elevation in eastern Pierce County all the way through foothills of the Cascade range through valleys into Commencement Bay and Puget Sound at sea level. The Puyallup River is the largest, flowing approximately 46 miles from glacial headwaters on Mount Rainier before discharging to Commencement Bay. Commencement Bay is a 5,700-acre embayment with 25 miles of shoreline, 440 acres of intertidal and shallow subtidal habitat, and approximately 510 acres of open water habitat The basin drains 1,053 square miles of diverse terrain within Pierce County and includes major tributaries such as Swan Creek, Clarks Creek Clear Creek, Fennel Creek, Ball Creek, Diru Creek, and others. The cities of Orting, Pacific, Auburn, Sumner, South Prairie, Puyallup, Fife, and Tacoma, as well as many unincorporated area neighborhoods are located near or on the banks of the rivers and frequently experience impacts from flooding. The Muckleshoot Tribe Indian Reservation is near the White River, and the Puyallup Tribe of Indians Reservation is in the lower reaches of the Puyallup river. The population density is 404 persons per square mile, most of which is in the middle and lower reaches of the watershed. The basin features steep slopes in the upper portion, so significant runoff can cause major flooding relatively quickly. The rivers in the basin are also prone to channel migration and it is a significant hazard.

The White River, a large tributary to the Puyallup River, originates from the Emmons glacier on the northeast face of Mount Rainier. The White River drains an area of about 490 square miles, approximately one third of which lies within Pierce County, with the remainder in King County. Major tributaries join the White River along its path like the Greenwater River and Boise Creek. Over one hundred years ago, the White River (formerly the Stuck River) was diverted by farmers to flow south into the Puyallup River in Pierce County instead of its natural path north into King County and the Duwamish River watershed. Mud Mountain Dam is a major flood control dam that significantly reduces flooding in the basin. Additionally, water is diverted from the river for hydropower generation near Lake Tapps. Along the river are several small unincorporated communities in addition to the Muckleshoot Indian Tribe Reservation, City of Sumner, and portions of the cities of Auburn and Pacific.

The upper basin is primarily forested and includes a mix of national park, national forest, and private commercial timber lands. Although undeveloped, many of these forest lands contain

significant road networks and are subject to periodic disturbance from timber harvesting activities where late-seral (old growth) forest originally existed. Land use transitions to a mix of agriculture, commercial forestry, open space, and low-density residential in the middle basin. The lower basin is dominated by commercial, industrial, and high-density residential and urban uses. The White River flows about 68 miles from glacial headwaters on Mount Rainier to its confluence with the Puyallup River near Sumner. The Carbon River flows 33 miles from its glacial headwaters before discharging to the Puyallup River near Orting. The lower Puyallup, White, and Carbon Rivers are channelized and confined within a system of levees and revetments. The watershed supports several species of native salmonids, including Chinook (FERC [ESA] listed), chum, coho, pink salmon, steelhead (ESA-listed), bull trout (ESA-listed), and coastal cutthroat trout. The watershed is home to the only existing spring Chinook salmon population in south Puget Sound and is considered a core bull trout recovery area. Salmonids in various life history stages use habitat throughout the watershed during every month of the year, including nearshore habitats of Commencement Bay and associated small stream mouths.

Several Puyallup River tributaries, including Kapowsin, Fennel, Clarks, and Clear creeks, supply important spawning habitat for chum and pink salmon. South Prairie Creek, a major Carbon River tributary, is considered one of the most productive reaches for Chinook and steelhead spawning in the watershed. Upper White River tributaries such as the Clearwater, Greenwater, and West Fork White Rivers, along with major creeks such as Huckleberry, Silver, and Boise, supply important spawning habitat for White River Spring Chinook.

The White River Hatchery, operated by the Muckleshoot Indian Tribe, has brought the White River Spring Chinook back from merely a dozen fish in the early 1980s to several thousand today and continues to be important to the recovery of this stock. The Tribe relies upon Spring Chinook culturally and has ceremonial fisheries when there are sufficient adult salmon returns. The Puyallup-White River Watershed is one of the most populated and farmed basins in the Puget Sound region, and development pressure continues to increase throughout the watershed as area population grows and farms and forests are converted to residential and commercial uses. Much of the watershed lacks sufficient riparian shade due to development, levees and their maintenance, and infrastructure. Levees and revetments in the lower watershed isolate salmon from important off-channel and floodplain habitats needed and used for rearing and refuge. Water quality is impaired in portions of the watershed due to high bacteria levels, high water temperatures, and low dissolved oxygen. Shoreline and nearshore habitats have been degraded by armoring, dredging, and overwater construction.

Three major dams—Electron Dam on Upper Puyallup River and the Mud Mountain and Buckley Diversion dams on White River—impact salmonid migration and instream flow. Mud Mountain Dam also affects floodplain connectivity downstream. Overall priorities for restoration and protection are levee setback and floodplain reconnection projects; preservation of intact

floodplain and riparian habitats; restoration of natural stream features such as large woody material (LWM), natural banks, and deep pools; restoration and protection of highly productive tributary and mainstem river reaches; removal or alteration of passage barriers; restoration of hydrologic regimes; and restoration of nearshore and riparian habitats.

Nisqually River Basin

The Nisqually River (WRIA 11) basin drains much of the southeast and central part of Pierce County and is typically divided into two areas: the Upper and Lower Nisqually. From the Nisqually glacier in Mt. Rainier National Park to above Alder Lake Dam is the upper reach, and below the dam to the Nisqually estuary at Puget Sound is the lower reach. The basin also encompasses tributaries such as the Ohop Creek, Mashell River, and Muck Creek, among others. The Upper Nisqually River and some of the major tributaries are characterized by steep gradient headwater systems and some lower gradient floodplains near the Town of Eatonville, and unincorporated communities of Elbe and Ashford. The Lower Nisqually River features wide floodplains along the low gradient channel. The Nisqually Indian Reservation lie within the broad Lower Nisqually Valley. The Nisqually Watershed (WRIA 11) is a glacially fed watershed that drains approximately 761 square miles between Mount Rainier and the Nisqually Delta. Land use in the upper basin is primarily forested and includes a mix of national park, national and state forest, and private commercial timber lands. Land use in the lower basin is more varied and includes areas of public and private forest, prairie, agriculture, and some low- to moderate-density residential development. The watershed includes portions of Thurston and Lewis counties, Joint Base Lewis-McChord (JBLM), and the Nisqually Indian Reservation. There are over 300 streams in the Nisqually Watershed, for a total of 714 miles of stream channel, with only approximately 382 miles accessible to anadromous salmonids due to the presence of natural migration barriers and hydropower infrastructure. The Nisqually River is the largest drainage in the watershed, flowing approximately 78 miles from the Nisqually Glacier on Mount Rainier to a large delta in south Puget Sound. The lower 5.2 miles of the river mainstem is constrained by revetments and levees. At over 1,900 acres in size, the Nisqually Delta is one of the largest river deltas in Puget Sound and supplies diverse salmonid-rearing habitat, including mudflats, salt marsh, tidal channels, and eelgrass beds. Significant subbasins in Pierce County include Red Salmon Creek, Muck Creek, Ohop Creek, and Mashel River. Red Salmon Creek discharges to the Nisqually Delta from a small drainage at the northeast extent of the watershed. McAllister Creek is a spring-fed floodplain system in Thurston County that discharges to the southern part of the delta.

Muck Creek drains a 93-square-mile area and discharges to the Nisqually River north of Yelm. Ohop Creek flows 11.9 miles before discharging to the Nisqually River southwest of Eatonville. Mashel River flows over 32 miles from a small unnamed lake before discharging to the Nisqually River at Nisqually State Park. The watershed supports several species of native salmonids,

including Chinook (ESA-listed), chum, coho, pink salmon, steelhead (ESA-listed), and coastal cutthroat trout. The majority of Chinook, steelhead, and pink salmon spawn within the mainstem lower Nisqually River and the Mashel River. Steelhead are present in watershed streams year-round.

The watershed is a major producer of wild chum in south Puget Sound and is home to a uniquely timed late season run. The Nisqually Delta supplies regionally significant rearing habitat for non-natal salmonids, including bull trout and Chinook from south, central, and north Puget Sound watersheds. The Nisqually Watershed is one of the least developed watersheds in the south Puget Sound region. Much of the area is protected from development due to location within Mount Rainier National Park, Gifford Pinchot National Forest, Nisqually State Park, JBLM, and the Billy Frank Junior Nisqually River National Wildlife Refuge. The Nisqually River is also one of the least degraded major rivers in the state. However, stream water quality in portions of the watershed is impaired due to high bacteria levels and temperatures and low dissolved oxygen. Some lakes in the watershed are also affected by high phosphorous inputs and nearshore habitats have been degraded through placement of shoreline armoring and fill. Instream flow conditions and salmonid migration in the lower Nisqually River are affected by the LaGrande Dam, Alder Dam, and Centralia Diversion Dam. All of these dams are for hydropower, not flood control. Overall priorities for restoration and protection are preservation of intact floodplain and riparian habitats, restoration of hydrologic regime, projects that enhance instream habitat diversity and promote natural riverine processes, floodplain reconnection projects, and riparian restoration and enhancement projects.

The Chambers/Clover Basin

The Chambers/Clover basin (WRIA 12) is a rain and groundwater fed system that does not receive drainage from the Cascade mountain range. It drains a 149 square mile watershed, including several lakes (Spanaway, American, Gravelly), and smaller creeks besides Chambers Creek and Clover Creek, includes Spanaway Creek, Coffee Creek, Leach Creek, Flett Creek, Puget Creek, and Ponce de Leon Creek downstream of the mouth of the lake, which reduces frequency and severity of flooding. The system has been highly altered by white settlers originally to drain extensive wetlands for farming, now more recently as the dense urban core of Pierce County. It is the most densely populated area and the smallest basin with 2,751 residents per square mile including people living in Tacoma, Ruston, Steilacoom, Fircrest, Lakewood, DuPont, and University Place, as well as unincorporated communities of Spanaway and Parkland. The Chambers Clover-Creek Watershed (WRIA 12) is a small spring and groundwater-fed basin covering 144 square miles between the Nisqually and Puyallup watersheds. Chambers Creek is the largest creek in the Chambers Watershed with widths of up to 25 feet and depths ranging from 6 inches to 2 feet. Major tributaries to Chambers Creek include Clover, North Fork Clover, Spanaway, Morey, Flett, and Leach creeks. Sequalitchew

Creek is contained in a separate subbasin and discharges directly to Puget Sound. Some reaches go dry for months at a time as they are heavily influenced by the groundwater table.

Some areas of the watershed are natural with adequate instream and riparian habitat, forests, wetlands, and connected floodplains, especially on property owned by JBLM, but most of the watershed has been heavily urbanized and developed. Portions of the streams have been straightened, diverted, armored, and contained in pavement-lined channels and culverts. Nineteen miles of the shoreline are developed, and armored and natural processes are affected by railway infrastructure that disconnects nearshore areas and tidal flows from estuaries and salt marshes, as well as upland habitat.

The watershed once supported robust runs of coho, chum salmon, and steelhead trout Sockeye and Chinook salmon and coastal cutthroat trout were also found in the watershed. Today, the watershed primarily supports cutthroat trout and coho and chum salmon. Resident coastal cutthroat trout occur throughout Clover Creek and in all perennial reaches and have been documented spawning on the Naches Preserve. They also can be found in seasonal reaches, such as North Fork Clover Creek at Golden Given. However, these reaches go dry in the summer. Sea run coastal cutthroat is expected to forage in the nearshore areas, including the small estuaries. The nearshore areas also support foraging, rearing, and migrating wild and ESA-listed salmonids from other river systems throughout Puget Sound.

Along with development, threats to habitat include water quantity, particularly in summer months when instream flows are so low that large areas of the creeks go completely dry. Other water quality issues include increased siltation, low dissolved oxygen, fecal coliform, metals, and high-water temperatures. There is also the potential for contamination due to stormwater runoff past industrial discharges and tire dust due to the high-density road network. General restoration and protection strategies include protection and restoration of highly productive tributary and mainstem areas, especially the lower four miles of Chambers Creek; floodplain reconnection; removing fish barriers, especially Chambers Creek Dam; restoration of hydrologic regime; restoration of pocket estuaries and nearshore habitats; and water quality improvement.

The Key Peninsula – Gig Harbor – Island (KGI) Basin

The Key Peninsula – Gig Harbor – Islands (KGI) basin (WRIA 15) is on the western portion of Pierce County west of Puget Sound and drains 158 square miles. It consists of 10 islands, 179 miles of shoreline, and over 8,500 acres of shellfish growing areas. There are no major rivers, by numerous smaller ones that drain to Puget Sound. Communities in the basin include the City of Gig Harbor, Longbranch, Home, Rosedale, Key Peninsula, and Purdy. The population density is 569 residents per square mile. Extensive marine shoreline exists here. The landscape is largely forested and rural with large residential lots of upland and smaller lots on the shoreline. Small

scale agriculture and industrial aquaculture is also present. Several shellfish closure districts exist here, and flooding affects the toxicity and safety of eating shellfish. The Kitsap or Key Peninsula-Gig Harbor-Islands Watershed (KGI; WRIA 15 East Kitsap Peninsula) is a 158-square mile rain and groundwater fed watershed within the Kitsap Peninsula Watershed made up of two peninsulas and many islands between Case Inlet, the Tacoma Narrows, and Colvos Passage. The largest islands in the watershed include Fox Island, McNeil Island, and Anderson Island. Land use is primarily a mix of forest, pastureland, and moderate-density residential, with some high-density residential and commercial development associated with Gig Harbor. The watershed extends into portions of Mason and King counties.

There are no major rivers within the watershed, but there are many small, low-gradient salmon-bearing streams that drain into Puget Sound. Significant subbasins include Rocky, Minter (Huge), Purdy, Burley, Wollochet, Artondale, North (Donkey), and Crescent creeks. These subbasins represent small drainages, and most of the streams are less than 2 miles in length, with a few exceptions. Rocky Creek flows five miles from Wye Lake to Rocky Bay in Case Inlet. Minter Creek flows approximately 6.3 miles from headwaters in Kitsap County to Minter Bay in Case Inlet. Purdy Creek flows approximately 3.5 miles from headwaters in Kitsap County to Burley Lagoon. North (Donkey) Creek and Crescent Creek both flow approximately three miles before discharging into Gig Harbor Bay. The Watershed also includes approximately 179 miles of marine shoreline with diverse nearshore habitats, including salt marshes, tidal embayments, bluff-backed beaches, and submerged aquatic vegetation beds.

The watershed supports several species of native salmonids, including Chinook (ESA-listed and non-listed), chum, coho, steelhead (ESA-listed), and coastal cutthroat trout. Many streams in the watershed support productive spawning runs of chum and coho. The remaining steelhead are no longer productive and are at risk of extirpation. Watershed streams also supply significant rearing and foraging habitat for other juvenile and adult salmon. Chinook using watershed streams appear to be primarily hatchery stock. However, threatened Chinook from north, south, and central Puget Sound watersheds can be found year-round using the extensive nearshore marine habitats in the watershed for refuge, foraging, and migration. Bull trout are also believed to forage in nearshore marine waters of the watershed. Development pressure has been rapidly increasing in the watershed in recent years, as forest and agricultural land is being converted to residential and commercial uses. Partial and full fish passage barriers have been identified on many streams throughout the watershed that limits access to important spawning and rearing habitat. Nearshore areas have been significantly altered by shoreline armoring, construction of overwater structures, and dredging. Water quality in several streams, embayments, and nearshore areas within the watershed is impaired by low dissolved oxygen and high bacteria. Some streams are also known to be impaired by high temperatures and low pH levels.

Flood Impacts

Impact on Community

Flooding can affect anyone who travels, works or lives in or near floodplains. Most flood hazards are mapped and people living in the mapped 1% annual chance floodplains can expect at least a 26% chance of experiencing floodwaters over 30 years, the length of a typical mortgage. Flooding can threaten lives, particular in areas where flooding happens quickly and with little warning, in addition to those driving on flooded roads. Most deaths occur from people driving through floodwaters and being swept away in their cars.

Flooding also causes significant property damage and, on average, one foot of water in an average size home can cause over $50,000 in damage. Without flood insurance, this level of damage can overwhelm a family's finances. And those without many financial resources will be severely impacted by flood damage to their home and/or belongings.

Flooding also affects those who work in floodplains or commute through them. Many farmworkers are employed on farms in the Puyallup Valley and when flooding inundates or ruins crops, farmworkers can find themselves without jobs. Migrant farmers who are living in temporary housing on the farm are also at risk.

Businesses in floodplains will shut down during flooding, particularly if buildings and access roads are damaged. After the 1993 Midwest Flooding, FEMA found that over 40% of small businesses didn't reopen after being flooding.

Vulnerable Populations

Flooding is a complicated hazard to understand and accessing flood warning, flood insurance, and other information often requires command of English, understanding of government bureaucracy, and access to financial resources. Populations that don't speak English, don't have access to government resources, and those that cannot afford or don't have flood insurance are particularly vulnerable to the long-term impacts of flooding.

Renters can be particularly vulnerable to the impacts of flooding. Families that rent make up over 50% of the households in the floodplain, whereas they make up approximately 37% of households in the entire County. Renters are more often vulnerable because they're far less likely to have a flood insurance policy. Renters often have less wealth or savings to draw from to pay for uninsured losses.

Impacts to Property

Flooding particularly impacts property and often causes many millions of dollars in property damage in major flooding events. Even a small amount of water inside a building can cause significant property damage and leave building owners with large repair bills. For families,

damage to homes may mean difficult financial decisions, displacement for weeks, and lost belongings. For business owners, flood damage may mean lost economic output from shutdowns, destroyed inventory, and inability to pay employees.

Throughout Pierce County, there is at least $5 billion of building value in floodplains. Private flood insurance policies and the National Flood Insurance Program is the primary way building owners financially protect their property in flood prone areas. As of June 2024, insurance policies cover over $2 billion worth of property.

The Pierce County Planning and Public Works (PPW) Surface Water Management (SWM) Division is active in purchasing properties in repetitive flood loss areas and removing infrastructure from those sites. The Pierce County 2023 Comprehensive Flood Hazard Management Plan details recent repetitive flood loss properties in Pierce County from 2014 to 2018.[2] Table 4.3-2 summarizes these repetitive flood loss properties in unincorporated Pierce County.

Table 4.3-2 Estimated Repetitive Loss in Unincorporated Pierce County

Year	Estimated Repetitive Loss Priorities	Number of Properties Unmitigated	Number of Properties Mitigated	Properties in City Limits
2014	58	31	25	2
2018	63	45	18	2

Most of these repetitive flood-loss structures are residential. Overall, Pierce County has identified five distinct areas that have experienced recurring flooding and flood losses since 2014: Clover Creek near Parkland, coastal Dash Point, mid Puyallup River south of Sumner, South Prairie Creek, and Clear Creek behind the River Road levee.[3]

Impacts to Economy

There is a total of $2.8 billion of assessed value on properties that are within the 100-year floodplain extent. Based on estimates of buildings within the floodplain, approximately $947.3 million in property damage to buildings could occur from a one-foot flood inundation for the entire 100-year floodplain extent. There are approximately 1,958 business establishments and 15,416 employees located in the 100-year floodplain. A total of $4.3 million in labor income and $13.4 million in output could be lost if all businesses and employees are disrupted for a one-day period due to flooding. Total damages from a 100-year flood are estimated as $838.9 million for roads and bridges alone. In a large flood event, road closures could cause up to $3.0 million in costs due to transportation disruptions. If a catastrophic levee breech occurs, the costs from transportation delays alone would be $59.3 million.

Flooding will affect certain industries like agriculture, aerospace, manufacturing, and distribution more heavily because of their presence and reliance on floodplain locations. Approximately $49,232 in daily farmland gross revenue is located within the 100-year floodplain. In the lower Puyallup valley, there are an estimated 85 farms that produce a wide range of products from dairy to herbs and row crop vegetables. Flooding can negatively impact these operations, particularly if it occurs before harvest or late into the spring planting season. Farmers cannot sell food products from flood-damaged fields. Flooding, however, also provides nutrients to the soil that supports productive agriculture.

While some agricultural sectors are dependent on natural floodplain functions, other economic sectors have located in the floodplain over decades for other reasons. Large warehouses in the White River valley near Sumner, many in the floodplain, make the region one of the largest logistics hubs in the region. The square footage of warehouse and aerospace facilities means that billions of dollars are at risk of flooding every year as well as thousands of jobs.

Environmental Impacts

Flooding is a natural process and supports unique ecosystems and habitats. Many riparian and aquatic ecosystems depend upon some amount of regular flooding or high water events. Salmonid species use high water events to seek refuge as juveniles or access more favorable habitats, which makes flooding an important part of recovery for the endangered salmon species in Puget Sound.

Natural floodplain functions typically result in slower-moving floodwaters with less intense flood height peaks. When upland forest areas are logged or burned, rain and snowmelt reach streams faster, which can cause flooding to be more intense and push water through the floodplain more quickly.

Pierce County often incorporates natural functions into the design of projects, which helps reduce flood risk as well as protect and restore ecosystems. Reconnecting rivers and coastlines to their historic floodplains through levee setbacks, creating side channels, and removing obstructions help restore natural functions and bring flood risk reduction benefits as well.

Impacts to Health Systems

No medical facilities are located in the 0.2% annual chance floodplain (which includes the 1% annual chance floodplain). The risk from flooding to the overall healthcare and medical system is low, although access to/from them could still be a challenge if urban flooding occurs or if low-laying roads exist in floodplains that are used to access the medical facilities, but alternative routes should be available in most cases.

One area of concern is the ability of residents in certain areas of the county, in particular sole-access neighborhoods such as some of the neighborhoods in the Riverside/Clear Creek,

Greenwater, Ashford, Fairfax, Crocker, Orville Rd E, Needham Rd E, and to evacuate for medical reasons during times of flooding. Neighborhoods with roads that are inaccessible during flooding, such as those below base flood elevation, are particularly vulnerable.

Impacts to Continuity of Government/Continuity of Operations

Because few government facilities are located in flood prone areas, flooding does not pose a substantial risk to the continuity of government operations. The Parkland-Spanaway Sheriff Precinct and the Riverside Fire Station are two critical facilities that are in a floodplain.

Impacts to Responders

Police, firefighters, and paramedics play key roles in the response to flooding. Police officers often help shut roads down to prevent people from driving through floodwaters; firefighters often rescue people trapped by flooding; and paramedics transport people hurt by flooding, often from hypothermia or other causes. If any of these first responders' buildings are in the 0.2% annual chance floodplain, their ability to respond is threatened.

The Pierce County Parkland-Spanaway Sheriff's precinct station is in the 1% annual chance floodplain.

The Riverside Fire Station in the Clear Creek area is in the 1% annual chance floodplain. The fire station is seeking funding to relocate to higher ground. They have a plan to relocate staff and equipment during a flood.

Additionally, neighborhoods with roads that are inaccessible during flooding pose challenges to first responders. They may not be able to drive to homes and may require helicopters or boats to access, as in the Riverside/Clear Creek area where many roads are below the Base Flood Elevation.

Impacts to Infrastructure Systems

- **Energy systems**: most overhead powerlines are not susceptible to impacts from flooding unless the power poles are not resistant to flooding. Buried cables typically aren't affected by flooding very often.
- **Water/Wastewater**: flooding, particularly from King Tides and coastal storm systems can damage wastewater infrastructure.. Some city wastewater treatment plants are also located in flood prone riverine areas such as Sumner's wastewater treatment plant, which has been floodproofed. Where these linear systems cross rivers, flooding can pose issues. Tacoma Central Wastewater Treatment Plant, Puyallup Water Pollution Control Plant, and Sumner WWTP are protected by 100-year flood standards but could experience impacts in a 500-year flood or other flood high enough to breach the floodwalls. Orting WWTP is protected from a 500-year flood by levee standards, but it could impact from levee breach or overtopping.

- **Transportation**: roads through the South Prairie Creek valley, Crocker, and McCutcheon are particularly susceptible to flooding and close regularly during high water events. Valley residents are often isolated. Pierce County PPW -Maintenance and Operations closes county roads. Other roads such as State Routes 165 are managed by the WA Dept. of Transportation.
- **Communications**: most communications infrastructure is not vulnerable to flooding.

Public Confidence in Jurisdiction's Governance and Capabilities

Flooding occurs frequently enough in Pierce County that residents often turn to the Pierce County Dept. of Emergency Management for help and information during flooding events. Confidence is high in the government's ability to respond to flooding events. The multiple iterations of the county's Comprehensive Flood Hazard Management Plan have featured robust stakeholder involvement processes, which has inspired confidence in Pierce County's ability to manage floodplains with higher regulatory standards and other programs to keep people and property safe from flooding.

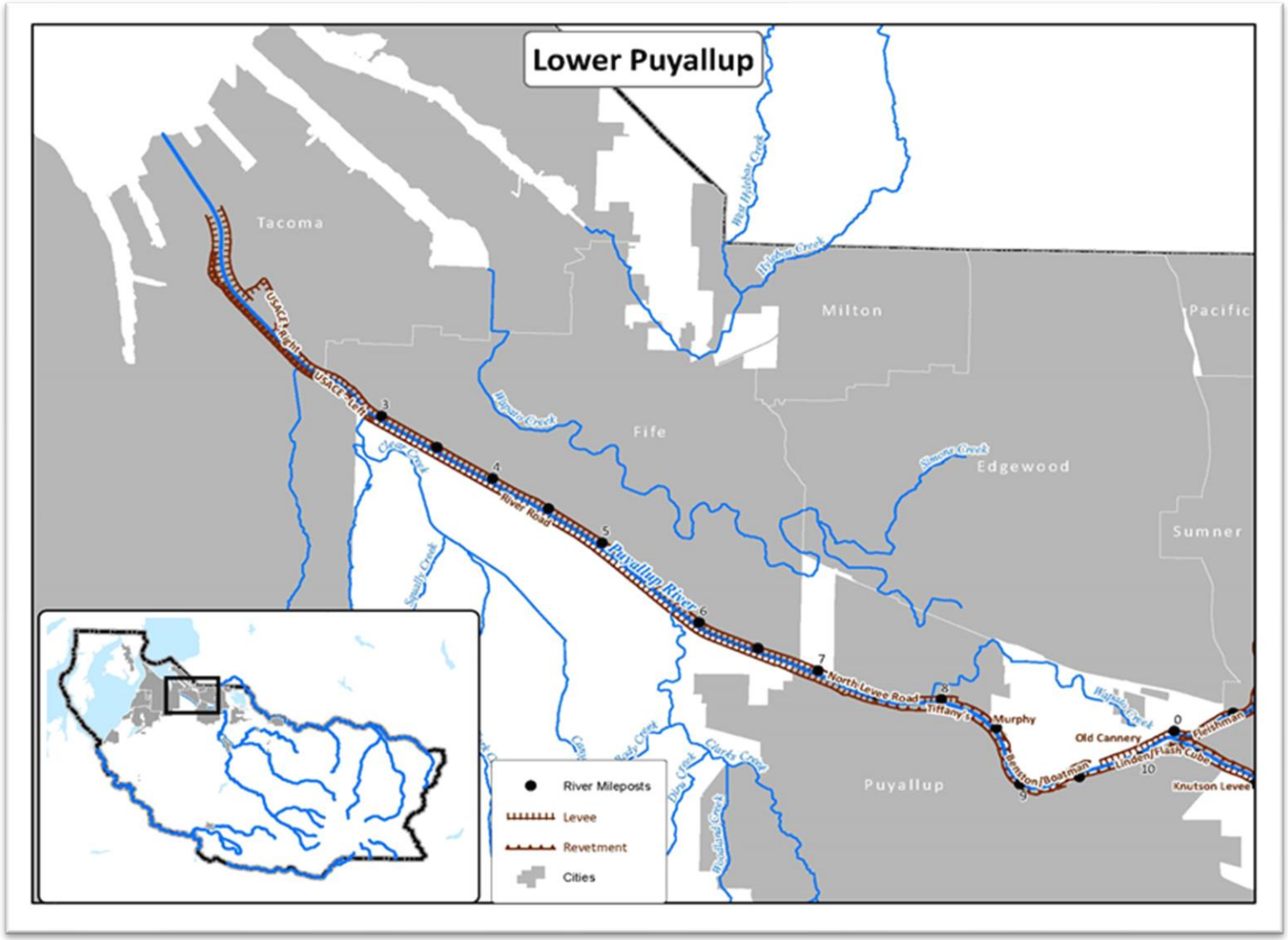
Puyallup River

The Puyallup River and its two main tributaries, the White River and Carbon River, drain a watershed of approximately 1,040 square miles and flow from the glaciers of Mount Rainier with an elevation of 14,410 feet to Commencement Bay and Puget Sound. The Puyallup River runs through the cities of Tacoma, Fife, Puyallup, Sumner, and Orting, and large areas of unincorporated Pierce County. The Puyallup Tribe of Indians owns the riverbed within the 1873 survey area from approximately River Mile (RM) 1.4 to RM 7.2. The lower reaches of the Puyallup River were historically straightened with levees and revetments for flood control purposes. Mud Mountain Dam (MMD) on the White River at RM 29.6 provides storage of up to 106,000 acre-feet of water to reduce flooding on the lower Puyallup River and to a lesser extent the lower White River. The dam was authorized by Congress after the 1933 flood of record and was completed in 1948 after an extended work stoppage for WWII.

Lower Puyallup River

The lower Puyallup River begins at its mouth in Commencement Bay at RM 0.00 and continues upstream to its confluence with the White River at RM 10.3. It flows through the cities of Sumner, Puyallup, Fife, and Tacoma and portions of unincorporated Pierce County (See Map 4.3-2). The Puyallup Tribe of Indians owns the riverbed, below the mean high-water line, within the 1873 survey area from approximately RM 1.4 to RM 7.2. The lower Puyallup River is primarily straight with levees on both the right bank, North Levee Road, and left bank, River Road. Surrounding land uses are mostly urban in the cities and a mixture of agricultural, rural, and urban in unincorporated Pierce County.

Map 4.3-2 Lower Puyallup River



Puyallup River Extent and Occurrences

Major flooding occurred in the lower Puyallup River in 1917, 1933, 1965, 1977, 1986, 1990, 1996, 2006, 2009, and 2025 (Figure 4.3-3). The largest flood on record since construction of MMD occurred in January 2009, with a flow of 48,200 cubic feet per second (cfs), approximately a 100-year event, in the lower Puyallup River based on current flood frequency flow estimates (FEMA/NHC 2003). Flows in excess of 45,000 cfs are considered severe with significant flooding expected. Moderate flooding occurred in the lower Puyallup in November 2014, and again in October, November, and December 2015.

Figure 4.3-3 Historical Flooding in Lower Puyallup River.

Historical Flooding in Lower Puyallup River USGS 12101500 Puyallup River at Puyallup, WA 103 Records from 1914 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
1934	December 10, 1933	57,000
2009	January 8, 2009	48,200*
1996	February 9. 1996	46,700*
1990	January 9, 1990	44,800*
1987	November 24, 1986	43,800*
1991	November 24, 1990	41,900*
1965	January 29, 1965	41,500*
1978	December 2, 1977	40,600*
1918	December 18, 1917	40,500
2016	December 9, 2015	39,800*
2007	November 7, 2006	39,700*
1935	October 25, 1934	39,500
1933	November 13, 1932	37,800
1956	December 12, 1955	37,600*
1984	January 25, 1984	37,100*
**Post Mud Mountain Dam*		

Probability of Future Hazards

In 2003 FEMA's study, contractor Northwest Hydraulic Consultants (NHC) calculated peak flows that would be utilized for updating the FEMA flood insurance study and flood insurance rate maps. For the Puyallup River at the U.S. Geological Survey (USGS) gauge at Puyallup (12101500), the calculations for the 10-year, 50-year, 100-year and 500-year recurrence intervals are shown to be respectively: 41,000, 46,000, 48,000 and 63,000 cfs. With the thresholds for moderate flooding (30,000-45,000 cfs) and severe flooding (greater than 45,000), the Lower Puyallup River valley can expect to experience moderate flooding every two to ten years and severe flooding every ten to 25 years over a long-term period (*Risk Assessment*, URS 2012). According to the *Pierce County Climate Resiliency Plan* , flood risks will increase with more extreme precipitation events and more of the precipitation falling as rain being captured in the upper watershed as snow. Sediment loading is expected to increase from rivers coming off Mount Rainier thereby decreasing flood carrying capacity and increasing the risk of channel migration.

Puyallup River Impacts

Impact on Community

Commercial and industrial properties comprise approximately 24 percent of the land use in the 100-year floodplain in the Lower Puyallup River Valley (URS 2012). A major flood event would result in the temporary loss of business for properties in this area. Short-term output, income, employment, and tax revenues may also decrease. If businesses were to close due to the financial effects of flooding, economic activity would be slow to recover, and long-term economic impacts would be experienced. Major businesses in this area include the Costco Wholesale warehouse, several large banks, and several large sporting goods warehouses. In addition, there are several storage facilities and a recycling distribution center in this area (URS 2012).

Land Purchases

Since 2013, eighteen properties have been purchased totaling 61 acres. This brings the number of acquired acres in the Clear Creek area to an estimated 117 acres. Prior to 2013, twenty-one parcels totaling 16.24 acres were purchased by Pierce County in the lower Puyallup area. Many of the properties experienced repetitive flooding as a result of the backwatering of Clear Creek. The backwatering is caused by the closing of the flood gate at the mouth of the creek preventing the creek from draining into the Puyallup River. The flood gates are necessary to prevent the further rise of flood waters in the creek from the elevated flows of the Puyallup River.

River Management

The lower Puyallup River is confined by nearly continuous levees and revetments from the river mouth at Commencement Bay to the Puyallup River's confluence with the White River at RM 10.3 (Figure 4.3-4). By restraining floodwaters from inundating the adjacent floodplain area, which includes residential, commercial, industrial, and port facilities within the cities of Tacoma, Fife, Puyallup, and Sumner, these flood risk reduction facilities collectively protect the highest land and improvement values in Pierce County. Substantial damage to these flood risk reduction facilities has the highest consequence and risk on the Puyallup River system. The taxable assessed value of property and improvements in the floodplain in the lower Puyallup is estimated at $1.8 billion (Entrix, Inc., 2010). The levees along the Puyallup River from RM 3.0 to 10.3 are owned and operated by Pierce County are summarized below.

Figure 4.3-4 Levees and Revetments in the Lower Puyallup River

Levees and Revetments in the Lower Puyallup River		
Name	**Location**	**Ownership**
Right Bank		
Port of Tacoma Revetment	RM 0.0 – RM 0.7	Port of Tacoma
COE Port of Tacoma Levee	RM 0.7 – RM 3.0	US Army Corps of Engineers
North Levee Road Levee	RM 3.0 – RM 8.1, PL 84-99	Pierce County
Murphy Levee	RM 8.1 – RM 8.6	Pierce County
Benston/Boatman Levee	RM 8.6 – RM 9.7	Pierce County
Old Cannery Levee	RM 9.7 – RM 10.3, PL 84-99	Pierce County
Left Bank		
Simpson Revetment	RM 0.0 – RM 0.7	Simpson Tacoma Kraft Company
COE Portland Ave Levee	RM 0.7 – RM 2.8	US Army Corps of Engineers
River Road Levee	RM 2.8 – RM 7.4, PL 84-99	Pierce County
Tiffany's Revetment	RM 7.4 – RM 8.6	Pierce County
Linden/Flashcube Revetment	RM 8.6 – 10.7	Pierce County

Damage to Facilities

Flood damage to Lower Puyallup River flood risk reduction facilities have generally been mild over the past three decades . However, two substantial repairs have been made to repair damages due to erosion and one repair to fix fractured concrete panels. Damages from major floods and high-water events between 1990 – 2017 have resulted in approximately 24 identified damage locations comprising 0.6 mile of levees and revetments. Damages have been estimated at nearly $2.15 million dollars (based on 2017 dollars). The following table summarizes recorded levee and revetment damages. No significant flood damage is currently apparent along the

lower Puyallup River reach. There are isolated locations along the reach where repairs have occurred. The system is approximately 100 years old and showing signs of its age. Pierce County maintenance crews annually inspect and monitor the reach and implement repairs when necessary.

Table 4.3-3 Summary of Damages to Lower Puyallup River Facilities

Summary of Damages to Lower Puyallup River Facilities (1996-2017)					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1996					
1996	Tiffany's	Left	9.2	100	Toe and slope failure.
2005					
2005	River Road	Left	7.2	540	Concrete panel repair.
2009					
2009	North Levee Road	Right	5.3	190	Silt bench repair – Dolos.
2010					
2010	Benston/Boatman	Right	9.35	100	Moderate slumping.
2010	Benston/Boatman	Right	9.35	200	Moderate slumping, major erosion; concrete panels collapsed.
2011					
2011	Benston/Boatman	Right	9.35	200	Four-foot-deep slump. Exposed concrete at toe.
2011	Murphy	Right	8.47 - 8.54	390	Scour and minor cracking in silt bench. Scour five feet in areas.
2011	North Levee Road	Right	4.27	105	Four-foot slump.
2011	North Levee Road	Right	4.45	106	Sha Dadx Seepage Control Buttress and drainage.
2011	Old Cannery	Right	10.3	60	Toe rock failure.
2011	River Road	Left	6.4	30	Six-foot deep scour.
2012					
2012	Murphy	Right	8.5	200	Toe and rock failure, some slump and erosion.
2012	Murphy	Right	8.55	30	Scour pocket out of face, downed tree.
2012	North Levee Road	Right	4.3	30	Four-foot slump.
2012	North Levee Road	Right	4.45	180	Sha Dadx: soil buttress - sand boils.

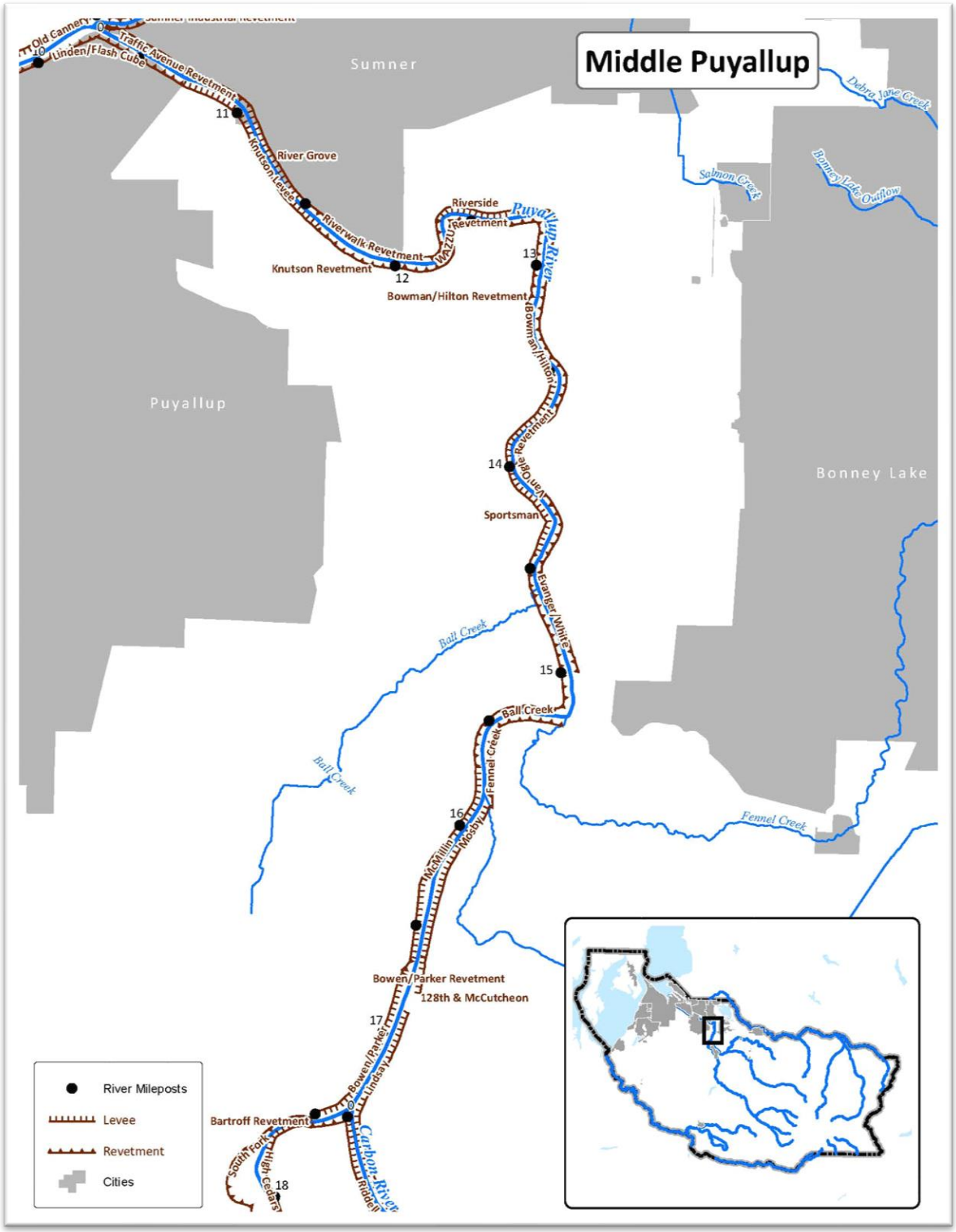
Summary of Damages to Lower Puyallup River Facilities (1996-2017)					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2012	North Levee Road	Right	5.8	100	Melroy Bridge partial scour/slumping.
2012	River Road	Left	3.05	40	Cave dug into silt on LB, 5' scour depth.
2012	River Road	Left	6.4	30	Six-foot deep scour in silt bench due to culvert outfall.
2014					
2014	River Road	Left	7.45	45	Toe and face rock failure.
2015					
2015	Benston/Boatman	Right	9.35	150	Slump in revetment. Concrete Panel missing.
2017					
2017	Benston/Boatman	Right	9.35	200	Storm drainage outlet onto revetment face has caused severe scour to occur and end segments of the outlet pipe have failed.
2017	Benston/Boatman	Right	9.3	140	Potential scour.
2017	Murphy	Right	8.4	120	Silt bench scour.
2017	Murphy	Right	8.41	25	Scour.

Middle Puyallup River

The middle Puyallup River reach begins at the confluence of the White River at RM 10.3 and continues upstream to the confluence with the Carbon River at RM 17.4, downstream of the City of Orting. Approximately 438 square miles drains to the middle Puyallup River. Throughout this reach, the river channel is a combination of large meander bends with segments which are straightened and confined by a combination of levees, revetments, and valley walls. The surrounding watershed and land use are mostly urban near the White River confluence in the cities of Sumner and Puyallup, while predominantly agricultural and rural residential through the Alderton-McMillan communities, and upstream to the Carbon River confluence (GeoEngineers 2003).

Several tributaries enter the middle Puyallup River in this reach including Alderton Creek, Van Ogles Creek, Fennel Creek, Ball Creek, and Canyon Falls Creek. The largest tributary, Fennel Creek, drains most of the eastern upland plateau, including much of the City of Bonney Lake. Fennel Creek flows into the Puyallup River near RM 15.2. Salmon and trout, including Chinook, coho, pink, chum, sockeye, steelhead salmon, and cutthroat and bull trout use the entire reach of the middle Puyallup River.

Map 4.3-3 Middle Puyallup River



Middle Puyallup River Extent and Occurrences

The middle Puyallup River experienced major flood events most recently in 1996, 2006, 2008, and 2009. The highest peak flow recorded at the Alderton Gauge occurred on January 7, 2009 with 53,600 cfs (based on the USGS calculation). However, this is thought to be an overestimate, because it is higher than the peak flow measured downstream at the Puyallup gauge in the lower Puyallup River. The Alderton gauge results historically have a lower confidence during high flood stage events. Since 2013, there has been no flooding in the Middle Puyallup.

Table 4.3-4 Historical Major Flooding on the Middle Puyallup River

Historical Major Flooding on the Middle Puyallup River USGS 12096500 Puyallup River at Alderton, WA 48 Records From 1915 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
2009	January 7, 2009	41,600
1996	February 9, 1996	41,500
2007	November 7, 2006	40,300
2016	December 9, 2015	35,800
2015	November 25, 2014	30,700
2000	November 25, 1999	24,800
1956	December 12, 1955	23,300
2005	January 19, 2005	23,300
1947	December 11, 1946	22,600
1954	December 9, 1953	21,900
2003	January 31, 2003	21,000
1922	December 12, 1921	20,000
2011	January 16, 2011	19,900

Probability of Future Hazards

In 2003, FEMA's study contractor NHC calculated peak flows that would be utilized for updating the FEMA flood insurance study and flood insurance rate maps. For the Middle Puyallup River at the USGS gauge at Alderton (12096500) the calculations for the 10-year, 50-year, 100-year and 500-year recurrence intervals are shown to be respectively: 27,500, 38,600, 43,500 and 55,100 cfs. Based on the NHC study and historical flow record, the Middle Puyallup River valley can expect to experience moderate flooding every two to five years, and severe flooding every ten to 25 years, over a long-term period (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February. The *Pierce County Climate Resiliency Plan* anticipates that flood risks will increase with more extreme precipitation events and more of the precipitation falling as rain being captured in the upper watershed as snow. Sediment loading is expected to increase from rivers coming off Mount Rainier, thereby decreasing flood carrying capacity and increasing the risk of channel migration.

Middle Puyallup River Impacts

Impact on Community

Commercial and industrial properties do not comprise a large portion of the Middle Puyallup (less than 1 percent) (URS 2012). Therefore, a large flood event would not result in a major impact to the economy and tax base in this area. Due to the large presence of vacant lands, open space, and resource land, temporary loss of business in this area is likely to be low. However, lands used for recreation or resource land may experience some economic loss if these areas are unable to be accessed or used during the flood or during the recovery period following a flood (URS 2012).

Land Purchases

The following land and home acquisitions have occurred since 1991, using a combination of federal and state grant funds and local match.

- Acquisition of home and property between 128th Street and the confluence with the Carbon River (48 acres).
- Acquisition of home and property between (RM 15.9 - RM 16.7) 116th Street and 128th Street (50 acres).
- Acquisition of homes and property near Fennel Creek confluence (44 acres).
- Acquisition of homes and property in the area of 96th Street and McCutcheon Road between RM 13.8 – RM 15.0 (78 acres).
- Acquisition of homes and property near Riverside Drive (1.8 acres).
- Acquisition of homes and property near/in the City of Sumner (11 acres).

In 2015, one additional property near Riverside Drive was purchased for flood damage mitigation. This parcel was an estimated .75 acre.

River Management

The middle Puyallup River levees and revetments form nearly continuous bank protection from the confluence with the White River at RM 10.3 to the confluence with the Carbon River at RM 17.4. Many levees within the middle Puyallup River system are included in the U.S. Army Corps of Engineers, Public Law (PL) 84-99 Levee Rehabilitation program. Revetment structures make up a significant number of the river management facilities that are ineligible for inclusion in the PL 84-99 program. The following table contains a list of river management facilities and their ownership.

Table 4.3-5 Levees and Revetments in the Middle Puyallup River

Levees and Revetments in the Middle Puyallup River		
Name	**Location**	**Ownership**
Right Bank		
Traffic Avenue Revetment	RM 10.3 – RM 11.0	Pierce County
River Grove Levee	RM 11.0 – RM 11.45, PL 84-99	Pierce County
Riverwalk Revetment	RM 11.45 – RM 12.0	Pierce County
Riverside Levee	RM 12.0 – RM 12.8, PL 84-99	Pierce County
Van Ogle Revetment	RM 12.8 – RM 14.2	Pierce County
Evanger/White Revetment	RM 14.2 – RM 15.0	Pierce County
Fennel Creek Revetment	RM 15.15 – RM 15.9	Pierce County
Mosby Revetment	RM 15.9 – RM 16.65	Private
Dollar Creek	RM 16.65 – RM 16.9	Pierce County
Lindsay Levee	RM 16.9 – Carbon RM 1.2	Pierce County
Left Bank		
Knutson Revetment	RM 10.7 – RM 12.0	Pierce County
WAZZU Revetment	RM 12.0 – RM 12.8	Pierce County
Bowman/Hilton Levee	RM 12.8 – RM 13.6, PL 84- 99	Pierce County
Sportsman Levee	RM 13.6 – RM 14.4, PL 84-99	Pierce County
Ball Creek Revetment	RM 14.4 – RM 15.7	Pierce County
McMillin Levee	RM 15.7 - RM 16.65, PL 84-99	Pierce County
Bowen/Parker Levee	RM 16.65 – RM 17.5, PL 84-99	Pierce County

Damage to Facilities

Flood damages to middle Puyallup River flood risk reduction facilities range from mild to moderate in the past three decades. Damages sustained generally range from partial washout of the flood risk reduction structure over a few hundred lineal feet to localized moderate scour and erosion. Damages from major floods and high-water events between 1995 – 2017 have resulted in approximately 91 identified damage locations comprising 3.6 mile of levees and revetments. Damages have been estimated at nearly $7.37 million (based on 2017 dollars). The middle portion of the Middle Puyallup River reach between RM 12.2 and RM 14.2 has historically been most vulnerable to repetitive damages requiring repair actions to restore the structures. Since 2013, levees and revetments that have experienced repetitive damages include WAZZU, Bowman-Hilton, Van Ogles, and Sportsman.

The following table summarizes recorded levee and revetment damages to middle Puyallup River facilitates (1995 – 2017).

Table 4.3-6 Summary of Damage to Facilities in the Middle Puyallup 1995 - 2017

Summary of Damage to Facilities in the Middle Puyallup 1995 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1995					
1995	Bowen/Parker	Left	16.8	50	Toe/slope failure.
1995	Bowman-Hilton	Left	13.2	150	Partial Washout. Toe and face rock.
1995	Bowman-Hilton	Left	13.2	600	Toe/slope failure.
1995	Mosby - Historic	Right	16.0	400	Toe/slope failure with spots of total failure.
1995	Mosby - Historic	Right	16.2	250	Partial Washout. Toe and face rock.
1995	Riverside Revetment	Right	12.8	600	Some Toe/slope failure.
1995	Van Ogle Revetment	Right	13.4	225	Partial washout. Toe and face rock.
1996					
1996	Bowen/Parker	Left	16.7	100	Total failure.
1996	Bowen/Parker	Left	16.8	200	Toe/slope failure.
1996	Bowen/Parker	Left	17.4	100	Toe/slope failure.
1996	Bowman-Hilton	Left	13.2	500	Toe/slope failure.
1996	Dollar Creek	Right	16.8	800	Toe/slope failure.
1996	McMillin	Left	16.0	600	Toe/slope failure with spots of total failure.
1996	McMillin	Left	16.2	250	Toe/slope failure with spots of total failure.
1996	Mosby - Historic	Right	16.0	400	Toe/slope failure.
1996	Riverside Revetment	Right	12.8	600	Toe/slope failure.
1996	Sportsman	Left	14.2	100	Slope failure.
1996	Wazzu Revetment	Left	12.2	600	Toe/slope failure.
2002					
2002	Van Ogle Revetment	Right	13.0	50	Toe and face repair.
2004					
2004	Riverside	Right	12.7	100	Partial washout of the toe and levee facing.
2005					
2005	Evanger/White	Right	14.2	450	Repair/replace toe and face rock.
2006					
2006	Bowen/Parker	Left	17.3	220	Face erosion.
2006	Bowman-Hilton	Left	13.2	500	Fracture: scour.
2006	Evanger/White	Right	15.0	300	Face erosion.
2006	River Grove	Right	11.0 - 11.5	0	Overtopping with minor levee damage.
2006	Sportsman	Left	13.6	40	Fracture.

Summary of Damage to Facilities in the Middle Puyallup 1995 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2006	Sportsman	Left	14.0	300	Washout.
2006	Wazzu Revetment	Left	12.2	300	Face erosion.
2007					
2007	Bowman-Hilton	Left	13.2	880	Repair scour from levee being overtopped.
2007	McMillin	Left	16.3	50	
2008					
2008	128th & McCutcheon	Right	16.7	12	Top of levee/access road scour.
2008	Bowen/Parker	Left	16.8	75	Toe rock failure.
2008	Bowen/Parker	Left	16.81	50	Toe rock failure and partial face rock failure.
2008	Bowman-Hilton	Left	13.2	60	Minor topcoat damage.
2008	McMillin	Left	15.7	30	Damaged toe and face rock.
2008	McMillin	Left	16.1 - 16.2	30	Toe and face rock failure.
2008	Riverside	Right	12.0	30	Damaged toe and face rock.
2008	Riverside	Right	12.4	236	Damaged toe and face rock.
2008	Riverside	Right	12.7	5	Minor topcoat damage.
2008	Sportsman	Left	13.75	0	Blocked culvert.
2008	Van Ogle Revetment	Right	13.5	30	Damaged face rock.
2008	Wazzu Revetment	Left	12.2	148	Wazzu partial washout.
2009					
2009	128th & McCutcheon	Right	16.75	20	Toe and face rock failure.
2009	Bowen/Parker	Left	16.7	12	Top of levee/access road scour. Tide gate damaged.
2009	Bowen/Parker	Left	16.7	300	Access road scour, face rock failure.
2009	Bowen/Parker	Left	16.8	75	Toe rock failure.
2009	Bowman-Hilton	Left	13.2	200	Scour 200 LF facing rock failure.
2009	Bowman-Hilton	Left	13.3	50	Scour 1/2 feet deep for 50 LF.
2009	Evanger/White	Right	15.0	200	Total levee failure/ end of levee.
2009	McMillin	Left	16.1 - 16.2	60	Toe and face rock failure.
2009	River Grove	Right	11.0 - 11.5	0	Overtopping with minor levee damage.
2009	Riverside	Right	12.6	15	Scour over top of revetment. 1-2 feet
2009	Sportsman	Left	13.75	200	Blocked culvert.
2009	Sportsman	Left	13.9	250	Damaged toe and face rock.

Summary of Damage to Facilities in the Middle Puyallup 1995 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2009	Sportsman	Left	14.00	300	Major scour.
2009	Sportsman	Left	14.10	150	Head cutting on back side of levee.
2009	Wazzu Revetment	Left	12.2	65	Partial washout.
2010					
2010	Riverside Revetment	Right	12.8	50	Minor face rock slippage and possible toe rock misplaced.
2010	Sportsman	Left	14.05 - 14.17	650	Slump and scour near Sportsman Club.
2010	Sportsman	Left	14.05 - 14.17	650	Slump and scour near Sportsman Club.
2010	Van Ogle Revetment	Right	13.65	100	Slump in front of Knobloch residence.
2010	Van Ogle Revetment	Right	14.14	120	Toe rock and face rock failure.
2011					
2011	128th & McCutcheon	Right	16.8	440	Major scallop scour missing levee.
2011	Evanger/White	Right	14.2	75	Toe rock failure.
2011	Evanger/White	Right	14.9	200	Toe and face rock failure.
2011	Fennel Creek	Right	15.4	45	6 ft deep scour.
2011	River Grove	Right	11.42	50	3 ft slump.
2011	River Walk Revetment	Right	11.9	60	Minor toe scour.
2011	Riverside	Right	12.3 - 12.4	425	Toe rock failure.
2011	Riverside Revetment	Right	12.8	70	Toe and face rock failure.
2011	Sportsman	Left	14.05 - 14.17	650	Slump and scour.
2011	Sportsman	Left	14.2	220	Toe rock failure.
2011	Van Ogle Revetment	Right	13.65- 13.66	100	Slump in front of Knobloch residence.
2011	Van Ogle Revetment	Right	14.14 - 14.16	120	Toe and face rock failure.
2012					
2012	Ball Creek	Left	15.3	100	Toe and face rock failure.
2012	Bowen/Parker	Left	16.7 - 16.8	300	Face rock failure.
2012	McMillin	Left	16.1	100	Toe and face rock failure.
2012	Riverside	Right	12.3 - 12.4	425	Toe rock failure.

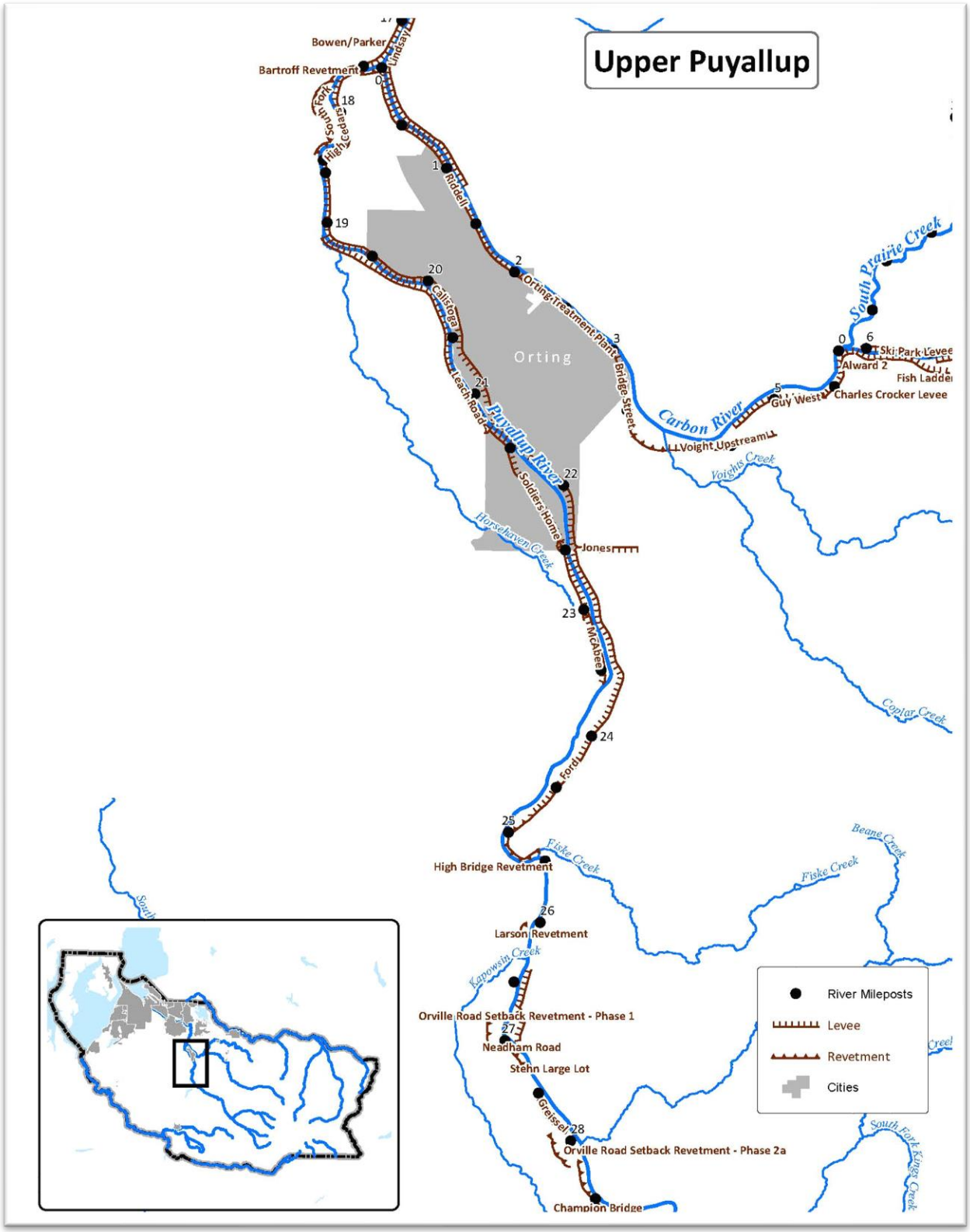
Summary of Damage to Facilities in the Middle Puyallup 1995 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2012	Riverside Revetment	Right	12.8	100	Missing face rock.
2012	Van Ogle Revetment	Right	14.1	120	Toe and face rock failure.
2012	Wazzu Revetment	Left	12.2	50	Over steepened, loss of face and toe rock.
2013					
2013	McMillin	Left	16.1	100	Toe & face rock failure.
2013	Riverside Revetment	Right	12.8	100	Missing face rock.
2013	Wazzu Revetment	Left	12.2	50	Toe & face rock failure.
2015					
2015	River Grove	Right	11.2	75	Tree root pulled out section of levee.
2015	Sportsman	Left	13.7	250	Partial erosion of revetment face rock.
2015	Wazzu Revetment	Left	12.2	150	Missing rock and over steepened.
2015	Wazzu Revetment	Left	12.2	150	Missing rock and over steepened.
2017					
2017	River Grove	Right	11.2	110	Overly steep. Sloughing. USACE repair.
2017	Wazzu Revetment	Left	12.1	60	Levee damage.

Upper Puyallup River

The upper Puyallup River begins at the confluence of the Carbon River at RM 17.4 and continues upstream to the Champion Bridge at RM 28.6, just downstream of Electron Road. The contributing drainage basin for this reach is approximately 188 square miles. In the lower portion of this reach, the river is confined by a combination of levees and revetments. In the middle portion there is less confinement due to the presence of two setback levees, the Soldiers Home setback levee at RM 21.5 to RM 22.5 and Ford setback levee at RM 23.4 to RM 25.0. Above RM 25.0, few levees and revetments remain on the right bank due to past flood damages and changes in flood management strategies. The surrounding watershed and land use is mostly urban on the right bank of the Puyallup near the City of Orting between RM 17.4 to RM 21.8, but predominantly agricultural, rural residential and forested upstream of RM 21.8. Like the middle Puyallup River, by the 1930s much of the valley and surrounding hills in the upper Puyallup River were harvested for timber and the valley cleared for agriculture (GeoEngineers 2003).

Several tributaries enter the upper Puyallup River including Horse Haven Creek, Fiske Creek, Kapowsin Creek, and Fox Creek. The largest tributary, Kapowsin Creek, originates in Ohop Lake and Lake Kapowsin located approximately 3.7 miles upstream from its confluence with the Puyallup River at RM 26.0. Salmon and trout, including Chinook, coho, pink, chum, and steelhead, use the entire reach of the upper Puyallup River.

Map 4.3-4 Upper Puyallup River



Upper Puyallup Extent and Occurrences

The upper Puyallup River experienced flooding most recently in 1990, 1996, 1999, 2000, 2006, 2008, and 2009 (see Historical Flooding in the Upper Puyallup River table). The largest flood event on record at the USGS gauge near Orting occurred on November 6, 2006, with a flow of 21,500 cfs, estimated to be approximately a 160-year event in the upper Puyallup River. Since 2013, there have been multiple high-water events that have not resulted in any significant damage to private property or public infrastructure other than flood facilities. The categorization of major flooding is based on a threshold of discharges in excess of approximately 16,000 cfs at the Orting gauge

Table 4.3-7 Historical Flooding in Upper Puyallup River

Historical Flooding in Upper Puyallup River USGS 12096500 Puyallup River Near Orting, WA 86 Records From 1932 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
2007	November 6, 2006	21,500
1996	February 8, 1996	18,300
2016	December 9, 2015	17,200
2009	January 7, 2009	16,900
2015	November 25, 2014	16,500
1963	November 20, 1962	15,300
1960	November 22, 1959	12,900
1934	December 10, 1933	12,800
1965	January 29, 1965	12,200
1956	December 11, 1955	12,100
1978	December 2, 1977	12,100
1933	November 13, 1932	11,800
1990	January 9, 1990	11,600
2000	November 25, 1999	11,600
2005	January 18, 2005	11,500

Probability of Future Hazards

In 2003 FEMA's study contractor NHC calculated peak flows that would be utilized for updating the FEMA flood insurance study and flood insurance rate maps. For the upper Puyallup River at the USGS gauge at Orting (12093500), the calculations for the 10-year, 50-year, 100-year and 500-year recurrence intervals are shown to be respectively: 12,200, 16,800, 18,600 and 22,600 cfs. The FEMA Levee Analysis and Mapping Plan (2019) used additional peak flow data through 2017 that includes significant flooding in November 2006, January 2009 and December 2015, and revised these estimates as follows for the 10-year, 50-year, 100-year and 500-year recurrence intervals, respectively: 12,890, 18,400, 20,800 and 26,520 cfs. This recent flow data shows a twelve percent increase in the one percent annual chance flow. Based on the NHC study, the historical flow record, and the thresholds for moderate flooding (13,500 cfs) and severe flooding (greater than 16,000), the Upper Puyallup River valley can expect to experience moderate flooding every two to four years, and severe flooding every three to five years, over a long-term period (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February.

Upper Puyallup River Impacts

Impact on Community

Although commercial and industrial properties do not comprise a large proportion of this area (less than 1 percent), a number of these properties are located within the 100-year floodplain (between the Puyallup River and state Route 162) (URS 2012). If a major flood event were to happen in the floodplain, it would impact the economy and tax base in Orting. Due to the large presence of vacant lands and resource land, temporary loss of business in this area is likely to be low outside the City of Orting (URS 2012). However, lands used for resource land, including agriculture, may experience some economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

Land Purchases

The following land and home acquisitions have occurred since 1991, using a combination of federal, state, and local funds.

- Acquisition of homes and property along Orville Road near Champion Bridge (53 acres);
- Acquisition of homes and property in the Neadham Road area (180 acres);
- Acquisition of homes and property near the High Bridge (8.5 acres);
- Acquisition of homes and property along Orville Road in Ford levee area (192 acres);
- Acquisition of property along Puyallup River left bank in Soldiers Home area (136 acres);
- Acquisition of homes and property near Leach Road (15 acres);

- Acquisition of homes and property near the confluence with Horsehaven Creek (29 acres);
- Acquisition of homes and property for the South Fork Setback levee (58 acres);
- Three properties were acquired in the Neadham Road area (17 acres);
- Six properties were acquired along Neadham Road, and one property was acquired near Orville Road Kapowsin Creek (40 acres);
- One property was acquired along Orville Road and one property was acquired near Neadham road (7 acres); and
- Three properties were acquired along Orville Road (73 acres).

River Management

Levees and revetments form nearly continuous bank protection in the lower segment of the upper Puyallup River system between RM 17.4 and RM 23.6. Near the City of Orting, flood risk reduction facilities help protect residential, commercial, agricultural areas, and public facilities. Above RM 23.6 the levee segments were heavily damaged by major flood events between 1996 and 2009. The following table contains a list of river management facilities, including ownership.

Table 4.3-8 Levees and Revetments in the Upper Puyallup River

Levees and Revetments in the Upper Puyallup River		
Name	**Location [a]**	**Ownership**
Right Bank		
High Cedars Revetment	RM 17.4 – RM 17.5	Pierce County
High Cedars Levee	RM 17.5 – RM 19.7, PL 84-99	Pierce County
Calistoga Levee	RM 19.7 – RM 21.25, PL 84-99	Pierce County
Jones Levee	RM 21.25 – RM 22.5, PL 84-99	Pierce County
Ford Levee	RM 22.5 – RM 24.9, PL 84-99	Pierce County
High Bridge Revetment	RM 24.9 – RM 25.45	Pierce County Roads
Neadham Road Levee	RM 26.4 – RM 26.9, PL 84-99	Pierce County
Left Bank		
South Fork Levee	RM 17.5 – RM 18.5	Pierce County
Leach Road Levee	RM 19.1 – RM 21.25, PL 84-99	Pierce County
Soldier's Home Levee	RM 21.25 –RM 23.1, PL 84-99	Pierce County
McAbee Levee	RM 23.1 – RM 23.6, PL 84-99	Pierce County
Orville Road Revetment	RM 25.6 – RM 28.1	Pierce County
Champion Bridge Levee/Revetment	RM 28.1 – RM 28.6	Pierce County

Damage to Facilities

Flood damages to upper Puyallup River flood risk reduction facilities have been extensive in the past three decades. Five significant flood events of more than 16,000 cubic feet per second (cfs) have occurred along the study reach since 1990. Damages sustained ranged from full washout of the flood risk reduction structure over several hundred lineal feet to localized moderate scour and erosion. Damages from the major floods and high-water events have resulted in approximately 243 identified damage locations along 16.3 miles of levees and revetments. Damages have been estimated at nearly $41.62 million (based on 2017 dollars).

The upper portion of this Puyallup River reach between RM 25.4 and RM 28.6 has historically been the most vulnerable to significant repetitive damages requiring repair and implementation of capital solutions to reduce flood risk. The following table shows Flood Damage to Levees in Upper Puyallup River to include current damages from 1990 to 2017

Table 4.3-9 Damage to Facilities along the Upper Puyallup River 1990 - 2017

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1990					
1990	McAbee	Left	P-68 23.6	100	Reshape and replace rip rap and toe rock.
1990	Ford - Historic	Right	P-70 24.0	100	Reshape and replace rip rap and toe rock.
1990	The Country - Remnant Iii	Left	P-74: 24.7	200	Partial washout.
1990	High Bridge Revet.	Right	P-76 25.1	600	Restore damaged rip rap.
1990	Fiske Creek Revetment	Right	P-78 25.5	800	Reconstruction.
1990	Neadham Road-Historic I	Right	P-80 25.9	280	Reconstruction
1990	Neadham Road-Historic I	Right	P-81: 26.0	900	Reconstruction.
1990	Orville-Kapowsin	Right	P-82: 26.2	800	Reconstruction.
1990	Orville-Kapowsin	Left	P-82: 26.2	150	Reconstruction.
1990	Orville-Kapowsin	Left	P-83 26.4	501	Reconstruction.
1990	Orville-Kapowsin	Right	P-83: 26.4	700	Reconstruction.
1990	Orville-Kapowsin	Left	P-84 26.6	600	Washout.
1990	Orville-Kapowsin	Left	P-84: 26.6	900	Reconstruction.
1990	Orville-Kapowsin	Left	P-85 26.8	350	Partial washout.
1990	Neadham Road	Right	P-85: 26.8	250	Reconstruction.
1990	Orville-Kapowsin	Left	P-86: 27.0	800	Reconstruction.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1990	Stehn Large Lot	Left	P-87 27.2	500	Washout.
1990	Stehn Large Lot	Left	P-88 27.4	632	Reconstruction.
1990	Griessel	Left	P-89: 27.6	1000	Reconstruction.
1990	Griessel	Left	P-90 27.7	200	Partial washout.
1990	Champion Bridge	Left	P-94 28.5	400	Washouts restore channel alignment.
1991					
1991	Neadham Road	Right	P-85: 26.8	250	Reconstruction.
1992					
1992	High Bridge Revet.	Right	P-78: 25.4	160	Reconstruction.
1992	Neadham Road-Historic Ii	Right	P-82: 26.2	150	Reconstruction.
1994					
1994	Jones	Right	21.8	20	Repair of levee damages.
1994	Ford - Historic	Right	23.6	20	Repair of levee damages.
1994	Ford - Historic	Right	23.8	20	Repair of levee damages.
1995					
1995	Calistoga	Right	19.8 - 20.2	500	Total levee failure.
1995	Calistoga	Right	20.0	375	Partial washout.
1995	Leach Road	Left	20.0	195	Reshape and replace riprap and toe rock.
1995	Leach Road	Left	20.2	300	Mostly toe failure with some slope failure.
1995	Calistoga	Right	20.7	100	Partial Washout.
1995	Leach Road	Left	20.7	200	Partial Washout.
1995	Calistoga	Right	20.9	200	Toe/slope failure.
1995	Jones	Right	22.3	250	Toe/slope failure.
1995	Jones	Right	22.4	200	Toe/slope failure.
1995	Soldiers Home - Historic	Left	22.5	200	Partial washout.
1995	Soldiers Home - Historic	Left	22.5	50	Total failure.
1995	Soldiers Home	Left	22.9	200	Partial washout.
1995	Ford - Historic	Right	23.6	900	Total failure.
1995	Ford - Historic	Right	23.7	200	Partial washout.
1995	The Country - Historic Ii	Left	24.0	200	Partial washout.
1995	The Country - Historic Ii	Left	24.0	800	Total failure.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1995	Mint Creek	Left	25.1	300	Partial washout.
1995	Neadham Road - Remnant I	Right	25.6	200	Partial washout.
1995	Orville-Kapowsin	Left	26.2	1500	Full levee washout.
1995	Orville-Kapowsin	Left	26.5	225	Partial washout.
1995	Orville-Kapowsin	Left	26.6	200	Partial washout.
1995	Neadham Road	Right	26.8	500	Partial washout.
1995	Orville-Kapowsin	Left	27.0	500	Full levee washout.
1995	Griessel	Left	27.6	400	Full levee washout.
1995	Griessel-Historic	Left	28.1	300	Cutoff levee, full washout.
1995	Griessel-Historic	Left	28.1	700	Full levee washout.
1996					
1996	High Cedars	Right	17.6	400	Toe failure.
1996	High Cedars	Right	18.0	500	Toe failure.
1996	High Cedars	Right	18.0	400	Total failure.
1996	South Fork	Left	18.2	200	Levee access road damage.
1996	High Cedars	Right	19.0	100	Toe/slope failure.
1996	Calistoga	Right	19.8 - 20.2	500	Total levee failure.
1996	Calistoga	Right	19.8 - 20.2	1200	Total levee failure.
1996	Calistoga	Right	20.0	375	Toe/slope failure.
1996	Calistoga	Right	20.2	200	Mostly toe with some slope failure.
1996	Leach Road	Left	20.5	300	Toe/slope failure.
1996	Calistoga	Right	20.7	300	Toe failure.
1996	Calistoga	Right	20.8	100	Toe failure.
1996	Calistoga	Right	20.9	300	Toe/slope failure.
1996	Calistoga	Right	21.2	200	Toe/slope failure.
1996	Soldiers Home - Historic	Left	21.9	400	Toe/slope failure.
1996	Jones	Right	22.3	250	Toe/slope failure.
1996	Jones	Right	22.4	200	Toe/slope failure.
1996	Jones	Right	22.5	200	Total failure.
1996	Ford	Right	22.9	300	Toe/slope failure.
1996	Ford	Right	23.1	200	Total failure.
1996	Ford - Historic	Right	23.6	900	Total failure.
1996	McAbee	Left	23.6	1200	Total failure.
1996	The Country - Historic Ii	Left	24.0	500	Total failure.
1996	The Country - Historic Ii	Left	24.1	300	Total failure.
1996	Ford - Historic	Right	24.6	1200	Total failure.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1996	High Bridge Revet.	Right	25.1	200	Total failure.
1996	Mint Creek	Left	25.15	250	Toe/slope failure.
1996	Neadham Road - Remnant I	Right	25.6	1300	Total failure.
1996	Neadham Road-Historic Ii	Right	26.2	2000	Total failure.
1996	Neadham Road	Right	26.4	600	Total failure.
1996	Neadham Road	Right	26.6	1000	Total failure.
1996	Orville-Kapowsin	Left	26.6	900	Toe/slope failure.
1996	Orville-Kapowsin	Left	26.7	1200	Toe/slope failure.
1996	Neadham Road	Right	26.8	1000	Total failure.
1996	Orville-Kapowsin	Left	26.8	2000	Total failure.
1996	Griessel	Left	27.6	2000	Toe/slope failure.
1996	Griessel-Historic	Left	28.0	2500	Toe/slope failure.
1996	Orville-Kapowsin	Left	26.7 - 27.6	3000	Total failure.
2003					
2003	Calistoga	Right	21.0	300	Partial washout of the toe and levee facing.
2003	Soldiers Home	Left	22.8	220	Partial washout of the toe and levee facing.
2003	Orville-Kapowsin	Left	26.2	360	Partial washout of the toe and levee facing.
2003	Champion Bridge	Left	28.2	40	Partial washout of the toe and levee facing.
2004					
2004	High Cedars	Right	17.8	1,300	Partial washout of the toe and levee facing.
2004	High Cedars	Right	19.6	250	Partial washout of the toe and levee facing.
2004	Leach Road	Left	20.7	10	Re-establish heavy riprap around outfall pipe.
2004	Soldiers Home - Historic	Left	22.3	250	Partial washout of the toe and levee facing.
2005					
2005	Soldiers Home - Historic	Left	22.3	100	Repair/replace toe and face rock.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2006					
2006	South Fork	Left	17.7	40	Washout.
2006	High Cedars	Right	18.0	50	Washout.
2006	South Fork	Left	18.0	350	Washout.
2006	High Cedars	Right	19.4	150	Washout.
2006	Leach Road	Left	19.4	50	Washout.
2006	Calistoga	Right	19.8	100	Washout.
2006	Leach Road	Left	19.8	200	Washout.
2006	Soldiers Home	Left	22.6	100	Face erosion.
2006	Ford	Right	22.8	350	Washout.
2006	McAbee	Left	23.6	600	Washout.
2006	Orville-Kapowsin	Left	26.3	415	Washout.
2006	Champion Bridge	Left	28.4	450	Washout.
2006	Champion Bridge	Left	28.6	150	Washout.
2006	Champion Bridge	Left	28.6	700	Washout.
2006	Neadham Road-Historic Iii	Right	26.7 - 27.0	1500	Washout.
2007					
2007	High Cedars	Right	18.0	70	Washout.
2007	Jones	Right	22.0	200	Repair.
2007	Orville-Kapowsin	Left	25.7	500	Washout.
2007	Orville-Kapowsin	Left	26.2	200	Washout.
2007	Neadham Road	Right	26.7	330	Cut-off construction.
2007	Neadham Road	Right	26.4 - 26.8	1,600	Washout - USACE Assistance.
2008					
2008	High Cedars	Right	18.2	75	Toe rock failure and partial face rock failure.
2008	High Cedars	Right	18.5	175	Toe rock and partial face failure.
2008	Leach Road	Left	19.3	250	Top of levee/access road scour.
2008	Leach Road	Left	19.75	350	Partial washout of the toe and levee facing.
2008	Jones	Right	21.7 - 22.4	600	Partial washout of the toe and levee facing.
2008	The Country - Historic I	Left	23.6 - 23.8	620	Washout.
2008	Calistoga	Right	19.82	200	Top surface access road scour.
2008	Calistoga	Right	20.78	130	Potential toe rock failure and face rock failure.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2008	Calistoga	Right	21.15	120	Potential toe rock failure and face rock failure.
2008	Jones	Right	21.3	450	Toe rock failure.
2008	Soldiers Home	Left	21.30	120	Toe rock failure.
2008	Jones	Right	22.0	300	Toe rock failure.
2008	Jones	Right	22.05	100	Toe rock failure.
2008	Ford	Right	22.8	150	Toe rock failure.
2008	Soldiers Home	Left	23.0	600	Toe rock failure.
2008	McAbee	Left	23.6	150	Partial levee core failure.
2008	Ford	Right	24.6	100	Toe rock failure.
2008	Neadham Road-Historic Ii	Right	26.3	738	Complete washout.
2008	Champion Bridge	Left	28.3	127	Toe and Face Rock Failure.
2008	Champion Bridge	Left	28.5	299	Partial washout.
2009					
2009	High Cedars	Right	18.2	75	Toe rock failure and partial face rock failure.
2009	High Cedars	Right	18.8	700	High cedars facing rock failure.
2009	Leach Road	Left	19.3	250	Top of levee/access road scour.
2009	High Cedars	Right	19.4	120	Face rock failure.
2009	Leach Road	Left	19.8	520	Revetment 30% of facing rock missing.
2009	Jones	Right	22.1	200	Primarily face scour loss of face rock.
2009	Jones	Right	22.35	60	Primarily face scour loss of face rock.
2009	Ford	Right	22.7	150	Primarily face scour loss of face rock.
2009	Soldiers Home	Left	22.7	141	Primarily scour along the lower portion of the face rock.
2009	McAbee	Left	23.3	200	Primarily face scour loss of face rock.
2009	McAbee	Left	23.6	150	Partial Levee Core failure.
2009	Neadham Road	Right	26.8	130	Cut-off extension.
2009	Champion Bridge	Left	28.15	150	Complete washout of levee.
2009	Champion Bridge	Left	28.2	168	Primarily face scour loss of face rock.
2009	Champion Bridge	Left	28.25	300	Primarily face scour loss of face rock.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2009	Champion Bridge	Left	28.3	135	Toe scour causing face rock to slough away.
2009	Champion Bridge	Left	28.5	435	Primarily face scour loss of face rock.
2010					
2010	High Cedars	Right	18.18	10	Small face scour pocket.
2010	Leach Road	Left	19.8	550	Toe and face scour - USACE assistance.
2010	Soldiers Home	Left	21.3	150	Slope and toe scour - USACE assistance.
2010	Jones	Right	21.4	500	Toe and partial embankment scour - USACE assistance.
2010	Soldiers Home	Left	22.5	140	Slope and toe scour - USACE assistance.
2010	Soldiers Home	Left	22.7	175	Slope and toe scour - USACE assistance.
2010	Neadham Road	Right	26.8 - 27.0	550	Levee extension.
2011					
2011	Leach Road	Left	19.9	60	Partial failure.
2011	Ford	Right	23.4	120	Face and toe rock failure.
2011	Ford	Right	24.7	300	Lower face scour.
2011	High Bridge Revet.	Right	25.3	90	Major face scour/scarp.
2011	Neadham Road	Right	26.45	120	Face and toe rock failure.
2011	Champion Bridge	Left	28.3	100	Face rock failure and sloughing.
2011	Champion Bridge	Left	28.15 - 28.3	700	Face and toe rock failure.
2012					
2012	High Cedars	Right	19.3	75	Toe scour.
2012	Leach Road	Left	19.9	60	Partial failure upstream end of Corp.
2012	Calistoga	Right	20.7	25	Knick point.
2012	Soldiers Home	Left	21.45	50	Lower face and possible toe scour.
2012	Soldiers Home	Left	22.6	50	Lower face erosion.
2012	Ford	Right	23.5	200	Toe scour.
2012	McAbee	Left	23.6	80	End of levee at rock point washed out to river mile post sign.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2012	Soldiers Home	Left	23.6	80	End of levee at rock point washed out to river mile post sign.
2012	Ford	Right	24.7	200	Toe scour and loss of lower face.
2012	High Bridge Revet.	Right	25.2	30	Knick points in revetment.
2012	High Bridge Revet.	Right	25.4	50	Over steepened w/ lots of rock missing.
2012	Neadham Road	Right	26.5	240	Face rock sloughing along entire length due to lost toe rock or toe being lost.
2012	Neadham Road	Right	26.65	210	Toe rock missing causing face to slough.
2012	Neadham Road	Right	26.7	75	Several upper-level toe rocks rolled out.
2012	Champion Bridge	Left	28.15	200	Continued damage from last year.
2012	Champion Bridge	Left	28.45	100	Sloughing moving upstream.
2012	Champion Bridge	Left	28.1- 28.2	700	Sloughing.
2013					
2013	High Cedars	Right	18.70	30	Toe rock and face rock missing with some core erosion.
2013	High Cedars	Right	19.4	75	Knick point. Toe rock loss and face sloughing.
2013	Ford	Right	23.50	200	Toe scour.
2013	Neadham Road	Right	26.65	210	Toe rock missing causing face to slough.
2013	Neadham Road	Right	26.70	60	Toe rock is being scoured and causing the face to slough.
2013	Champion Bridge	Left	28.3	100	Revetment repair.
2014					
2014	Soldiers Home	Left	21.45	100	Lower face scour.
2014	Neadham Road	Right	26.4	300	Thalweg against toe causing scour along the lower face and toe.
2014	Neadham Road	Right	26.6 & 26.7	285	Toe scour causing lower face to slough.
2014	Champion Bridge	Left	28.2 - 28.3	400	Toe rock rolling out and face sloughing.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2015					
2015	High Cedars	Right	18.15	100	Maintenance.
2015	High Cedars	Right	18.25	160	Missing face rock.
2015	High Cedars	Right	18.3	130	Missing face rock.
2015	High Cedars	Right	19.4	200	Maintenance.
2015	Leach Road	Left	19.4	200	Overtopping and scour over access road.
2015	Leach Road	Left	19.6	150	Overtopping and facing rock damaged.
2015	Leach Road	Left	20.3	10	Tree pulled in a chunk of levee.
2015	Leach Road	Left	21.0	75	Toe and face rock missing.
2015	Soldiers Home	Left	21.45	40	Levee rehabilitation.
2015	McAbee	Left	23.2	100	Core exposed.
2015	Ford	Right	23.60	100	Missing face and toe rock.
2015	McAbee	Left	23.6	100	Buttress end has started to erode.
2015	Ford	Right	24.70	300	Full washout over 200 LF. Orville road only 40 feet away.
2015	Ford	Right	24.70	400	Washout of levee. Emergency repair.
2015	High Bridge Revet.	Right	25.2	60	Face scour, sloughing, loss of toe rock.
2015	High Bridge Revet.	Right	25.35	350	Face scour and loss of toe rock.
2015	Neadham Road	Right	26.4	150	Missing face rock.
2015	Griessel	Left	27.7	30	Access road at culvert damaged.
2015	Champion Bridge	Left	28.15	40	Erosion at end of Champion Bridge Levee.
2015	Champion Bridge	Left	28.2	110	Missing toe and face rock.
2015	Champion Bridge	Left	28.2	220	Severe face scour.
2015	Champion Bridge	Left	28.2	450	Emergency - levee rehab.
2015	Champion Bridge	Left	28.25	150	Missing face rock and over steepened.
2015	Champion Bridge	Left	28.25	100	Project has grown from 150 to 250 from November Flood.
2015	Neadham Road	Right	26.6 & 26.7	80	Levee rehabilitation.

Damage to Facilities along the Upper Puyallup River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2017					
2017	High Cedars	Right	17.6	1	Over steepened.
2017	High Cedars	Right	18.6	100	Toe and face rock failure.
2017	High Cedars	Right	18.77	40	Toe and face rock failure.
2017	Leach Road	Right	19.3	800	Access Road damage.
2017	Soldiers Home	Left	22.8 - 22.9	900	Levee rehabilitation.
2017	Leach Road	Right	19.9	25	Scour at top of levee.
2017	Leach Road	Left	20.2	60	Localized scour. Missing toe and face rock.
2017	Leach Road	Left	20.7	50	Localized scour. Missing toe and face rock.
2017	Leach Road	Left	21.0	310	Face and toe rock failure.
2017	Jones	Right	22.2	500	Toe rock failure.
2017	McAbee	Left	23.6	160	Further erosion of buttress.
2017	Ford	Right	24.6	400	Levee washout.
2017	High Bridge Revet.	Right	25.4	50	Upstream end of past repair project is damaged.
2017	Neadham Road	Right	26.65	125	Thalweg against toe causing scour along the lower face and toe.
2017	Champion Bridge	Left	28.2	150	Emergency - levee rehabilitation.
2017	Champion Bridge	Left	28.2	175	Further damage at end of levee.
2017	Champion Bridge	Left	28.25	50	Project has grown from 150 to 250 from November Flood.
2017	Champion Bridge	Left	28.25	50	More toe and face rock missing.

White River

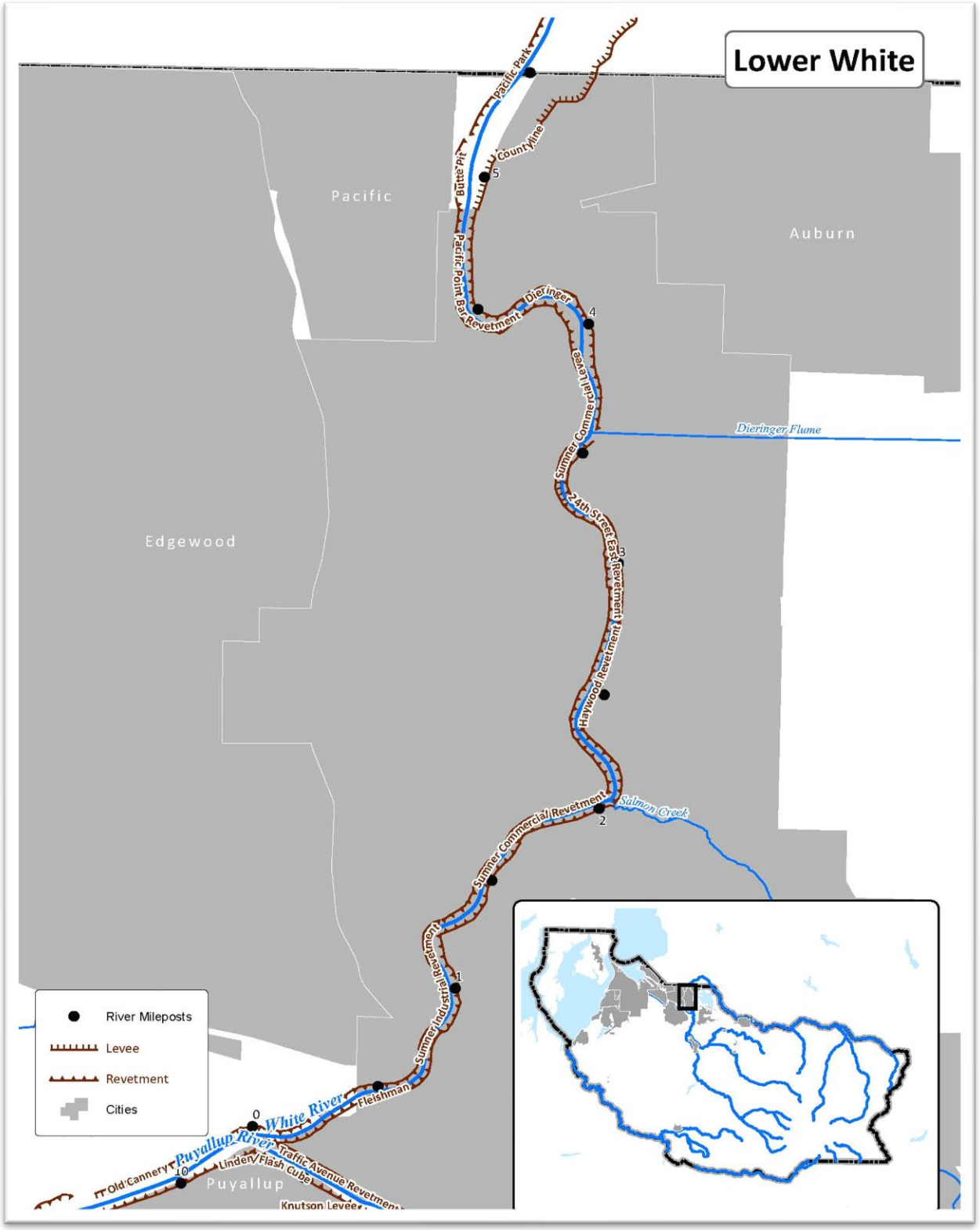
The White River drains an area of approximately 475 square miles. It flows about 75 miles from its source on the Emmons Glacier on the northeast side of Mount Rainier to its mouth at the City of Sumner. The river has several tributaries including Huckleberry Creek, Greenwater River and Clearwater River. It flows through the community of Greenwater, the Muckleshoot Indian Reservation, and the cities of Buckley, Auburn, Pacific, and Sumner before joining the Puyallup River at RM 10.3. Approximately 75 percent of the White River basin lies within Pierce County and the remaining 25 percent is within King County. The White River forms the county line

separating King and Pierce counties between the confluence of the Greenwater River and White River at RM 45.8 downstream to near the City of Auburn.

Lower White River

The lower White River reach begins at the confluence with the Puyallup River and extends upstream to River Mile 5.5 at the Pierce-King County-line. The lower White River flows through the cities of Auburn, Pacific, and Sumner before joining the Puyallup River at RM 10.3. Several tributaries enter the lower White River in this reach, including Bowman Creek, Government Ditch, Jovita Creek, and Salmon Creek. The drainage basin is approximately 496 square miles. Prior to 2004, the majority of flow in the White River was diverted by Puget Sound Energy's Buckley Diversion Dam located at RM 24.3. The Buckley Diversion Dam sent flow to Lake Tapps for power generation. Return flows from Lake Tapps enter the White River at RM 3.6. The dam is now owned by the Cascade Water Alliance and no longer produces energy. The White River is well known for its large sediment discharge and high turbidity levels. Today, substantial residential, industrial, and commercial development exists along the lower White River valley within the cities of Sumner, and Pacific. Salmon and trout, including bull trout, cutthroat spring and fall Chinook, coho, sockeye, pink, chum, and steelhead use the entire reach of the lower White River.

Map 4.3-5 Lower White River



Lower White River Extent and Occurrences

The 1906 avulsion of the White River into the Stuck River doubled the Puyallup River watershed and started a long partnership between King and Pierce counties to manage the change in flow. With a little over a hundred years of history, our understanding of the river's potential and balance of sediment and flow is still a work in progress. In the last 30 years major flooding in the lower White River occurred in 1990, 1996, 2006, and 2009. The largest flood on record in the lower reach occurred in December 1933, prior to the construction of Mud Mountain Dam (MMD). This would have been exceeded in the 2015 and 2011 floods if not for the dam. The USGS gauge upstream of the dam does not show record of the major floods of 1977, 1996 or 2006 as the gauge was flooded in the backwater of MMD. The largest recorded flow on the White River above MMD was in 2015. The peak flow of 31,900 cfs was attenuated by the dam so that the cities in the lower reach saw only 8,150 cfs at the USGS gauge at R Street. Increased flood risk in the lower White River has resulted from the reduction of channel capacity. Thresholds for flood warnings has decreased from 10,000 cfs to 6,500cfs. Since 2013, these events have occurred multiple times a year.

Table 4.3-10 Historical Flooding in Lower White River

Historical Flooding in Lower White River USGS 12100496 White River Near Auburn, WA - 20 Records from 1987– 2009 USGS 12100490 White River at R Street Near Auburn, WA - 8 Records from 2010-2017		
Water Year	**Date**	**Stream Flow (cfs)**
1996	February 10, 1996	15,000
2007	November 9, 2006	14,700
1990	January 9, 1990	14,500
1997	December 30, 1996	13,600
2006	January 11, 2006	12,400
2009	January 9, 2009	12,000
2009	January 9, 2009	12,000
1999	December 30, 1998	10,600
2008	December 5, 2007	9,830
2000	November 26, 1999	9,620
2016	December 9, 2015	8,150
2002	January 9, 2002	7,840
2011	January 17, 2011	7,750
2003	January 31, 2003	7,750
2015	November 25, 2014	7,380
2012	February 23, 2012	7,290
2017	March 15, 2017	6,970

Probability of Future Hazards

The Flood Insurance Mapping Study (NHC, 2005) identified the following peak flows for the Lower White River in Sumner from RM 0.06 to 5.5 for the 10-year, 50-year, 100-year and 500-year recurrence intervals, respectively: 14,000, 15,300, 15,500, and 19,000 cfs. Based on this study, the historical flow record (USGS gauge 12100490 at R Street near Auburn), and loss of channel capacity due to sediment transport, the thresholds have been significantly lowered for moderate flooding (8,000 cfs) and severe flooding (greater than 10,000 cfs). The White River valley can expect to experience moderate flooding every three to five years, and severe flooding every ten to 20 years, over a long-term period (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February.

Impacts

Impact on Community

Commercial and industrial properties comprise approximately 31 percent of the land use in the 100-year floodplain (URS 2012). A major flood event would result in the temporary loss of business for commercial and industrial properties in this area. Short-term output, income, employment, and tax revenues may decrease. Major industrial facilities in this area include Pacific Distribution Services, Norvanco International, Hudd Distribution Services, Roadrunner Transportation, and Cooper Tire and Rubber Company (URS 2012). Major businesses include Solo Cup Company and several coffee roaster businesses (URS 2012).

Land Purchases

There have been no land purchases or buyouts along the lower White River by Pierce County since 1991. However, 14-acres of property have been acquired by the City of Sumner between RM 3.8 and RM 4.9 for future use as a part of the Stewart to 16th street setback levee, Pacific Point Bar Setback Levee, and the White River Restoration. Additional floodplain property is anticipated to be purchased in the future.

River Management

The lower White River revetments and levees form nearly continuous bank protection from RM 0.0 at the Puyallup River to the Pierce-King County line at RM 5.5. The flood risk reduction facilities protect property and improvements in the floodplain, with an estimated assessed value of $535 million (Economic Analysis 2010). The facilities are owned and operated by Pierce County as summarized in the following table.

Table 4.3-11 Levees and Revetments in the Lower White River

Levees and Revetments in the Lower White River		
Name	**Location [a]**	**Ownership**
Right Bank		
Sumner Industrial Revetment	RM 0.0 – RM 5.1	Pierce County
Butte Revetment	RM 5.1 – RM 6.2	Pierce County
Left Bank		
Fleishman Revetment	RM 0.0 – RM 2.05	Pierce County
Dieringer Revetment	RM 2.05 – RM 4.9	Pierce County
Potelco	RM 4.9 – RM 6.2, PL 84-99	Pierce County

Damage to Facilities

Flood damages to lower White River flood risk reduction facilities in the past three decades have not been significant. Damages from major floods and high-water events between 1990 – 2017 have resulted in approximately 17 identified damage locations comprising 0.7 mile of levees and revetments. Damages have been estimated at nearly $1.54 million dollars (based on 2017 dollars). Since 1990, the levees and revetments along the lower White River have been stable requiring minimal repairs. However, in 2009, sediment accumulation became more apparent as there was a rapid diminishment of channel capacity resulting in increased flood risk. In 2017, King County constructed a new setback levee to improve channel capacity and habitat. The new County Line Setback levee was constructed on the left bank between RM 5.0 and 6.2. It was designed to provide capacity for the 1% chance storm event with sufficient freeboard. King County is scheduled to monitor and maintain the project into the future. Damage to the Sumner Commercial Revetment segment was identified in 2011 during an annual condition assessment. Over the course of the following storm season the damage rapidly increased in length and severity and is scheduled for repair. Due to the complexities associated with the site, developing a solution amicable to the stakeholders involved has delayed the repair of this revetment. The following table shows the Damage to Facilities in the Past 20 Years along the Lower White River from 1990 and 2017.

Table 4.3-12 Damage to Facilities the along the Lower White River

Damage to Facilities the along the Lower White River					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1990					
1990	Sumner Commercial Revetment	Right	W-49 2.0 and W-58 3.8	400	Partial washout.

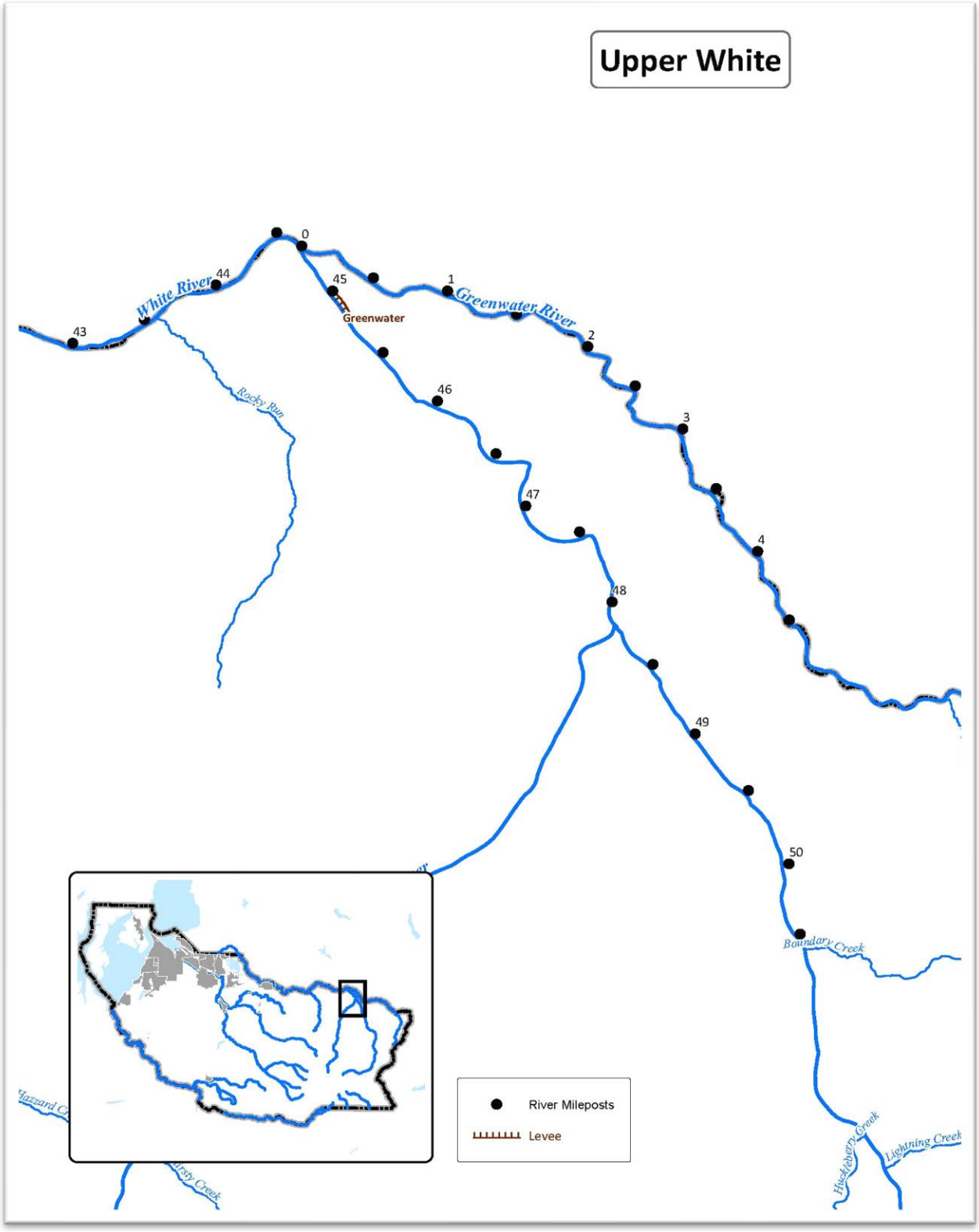
Damage to Facilities the along the Lower White River					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1993					
1993	Sumner Commercial Revetment	Right	3.4	100	Toe and face scour.
2008					
2008	Potelco	Left	5.4	20	Damaged face rock.
2009					
2009	Potelco	Left	5.25	20	Damaged face rock.
2011					
2011	Potelco	Left	5.05 - 5.15	650	Levee overtopping from wetland.
2011	Potelco	Left	5.35 - 5.5	570	Levee overtopping flowing to wetland.
2011	Sumner Commercial Revetment	Right	3.85	100	Levee core erosion, toe and face rock failure.
2011	Sumner Industrial Revetment	Right	0.03	30	Culvert replacement.
2012					
2012	Sumner Commercial Revetment	Right	3.85	400	Levee core erosion, toe and face rock failure.
2012	Sumner Industrial Revetment	Right	0.03	30	Culvert replacement.
2013					
2013	Dierenger	Left	4.0	135	Erosion and scour protection installed by the City of Sumner.
2014					
2014	Dierenger	Left	4.0	50	Erosion and scour of the City of Sumner's soft armoring.
2014	Potelco	Left	5.35 - 5.5	570	Levee overtopping flowing to wetland.
2015					
2015	Potelco	Left	5.3	50	Repairs spots where trees overtopped and damaged levee.

Damage to Facilities the along the Lower White River					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2017					
2017	Dierenger	Left	4.0	75	Old Sumner Levee repair site.
2017	Sumner Commercial Revetment	Right	3.8	530	Levee damage.

Upper White River

The upper White River reach in the study area extends from approximately RM 43.2 to RM 50.5, from downstream of the community of Greenwater to upstream of Crystal Village and Crystal River Ranch. State Route 410 parallels the river throughout this reach. Large tributaries include the Greenwater River, which enters the White River at RM 44.6 and the West Fork White River, which enters the White River at RM 48.2. Land uses in the reach include two residential communities, Greenwater Village and Crystal Village, which are supported by several commercial businesses located in Greenwater. Revetments have been constructed on the right bank of the river at Greenwater Village along 583rd Avenue East at RM 46.2 and in Crystal Village near RM 50.0. The upper White River has a large sediment discharge and high turbidity levels due to the proximity to its glacial headwaters. Salmon and trout, including spring Chinook, coho, pink, and steelhead, bull trout and cutthroat use this reach of the White River.

Map 4.3-6 Upper White River



Upper White River Extent and Occurrences

The White River gauge downstream of the Clearwater River confluence has operated intermittently from 1975 to the present, with several data gaps resulting from damage during large floods. In the last 40 years major flooding in the upper White River occurred in 1977, 1995, 1996, 2006, and 2008 (see the table below). Flow values in the table are shown as "less than" due to the larger drainage area for the Clearwater gauge.

Table 4.3-13 Historical Flooding in Upper White River

Historical Flooding in Upper White River USGS 12097850 White River Below Clearwater River Near Buckley, WA 25 Records From 1975 – 2017 No data for floods in 1997, 1996 or 2006 due to gauge damage		
Water Year	**Date**	**Stream Flow (cfs)**
2016	December 9, 2015	31,900
1996	*February 8, 1996*	*29,000 (estimated)*
2011	January 16, 2011	28,600
1976	December 2, 1975	22,800
2015	January 5, 2015	22,000
1996	November 28, 1995	20,500
2012	February 22, 2012	19,400
1991	November 25, 1990	18,400
2009	November 12, 2008	18,100
1990	January 9, 1990	17,200
1975	January 18, 1975	15,100
1987	November 24, 1986	14,900
1986	February 23, 1986	14,100
1984	January 25, 1984	13,300
2014	March 09, 2014	12,100

Probability of Future Hazards

The Upper White River above the confluence with the Greenwater River at RM 44.6 consists of flows primarily from the West Fork White River, White River and Huckleberry Creek. A USGS river gage originally existed on the Upper White River, but it experienced problems and was removed. Flows above Greenwater are monitored now by using the USGS gauge (12097850) White River below Clearwater and subtracting the flow from the USGS gauge (12097500) Greenwater River. The best available estimates of flood flow frequency on the Upper White River are from the 1987 Flood Insurance Study. This shows the 10-year, 50-year, 100-year and 500-year recurrence intervals, respectively: 13,500, 18,700, 20,900, 26,400 cfs.

Upper White River Impacts

Impact on Community

Commercial and industrial properties do not comprise a large portion of this area (less than five percent) (URS 2012). The only businesses in this area include small bed and breakfast inns and restaurants in the Town of Greenwater. Therefore, a large flood event would not result in a major impact to the economy and tax base. Due to the large presence of vacant lands, open space, and resource land, temporary loss of business in this area is unlikely to occur (URS 2012). However, lands used for recreation or resource land may experience economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

Land Purchases

There have been no land purchases or buyouts along the upper White River by Pierce County since 2013. However, 14-acres of property have been acquired by the City of Sumner between RM 3.8 and RM 4.9 for future use as a part of the Stewart to 16th Street Setback Levee, Pacific Point Bar Setback Levee, and the White River Restoration. Additional floodplain property is anticipated to be purchased in the future.

River Management

The upper White River has a single levee in the vicinity of 583rd Avenue East, just upstream of RM 45.0 on the right bank. The levee is owned and operated by Pierce County as summarized in the table below. The taxable assessed value of property and improvements in the floodplain in the upper White and Greenwater River areas is estimated at $36 million (Economic Analysis 2010).

Table 4.3-14 Levees in the Upper White River

Levees in the Upper White River		
Name	**Location [a]**	**Ownership**
Greenwater Village Levee	RM 46.0 – RM 46.2 RB, PL 84-99	Pierce County

Damage to Facilities

The Greenwater Village Levee continued to experience partial toe rock displacement. Since the last update, the residents of Crystal Village Ranch funded, permitted and installed a buried rock groin along the left bank of the White River. The groin was installed to address the residents' concern about the possibility of channel migration continuing to impact their development.

The damage to facilities table along the Upper White River (below) includes damages from 1996 to 2017.

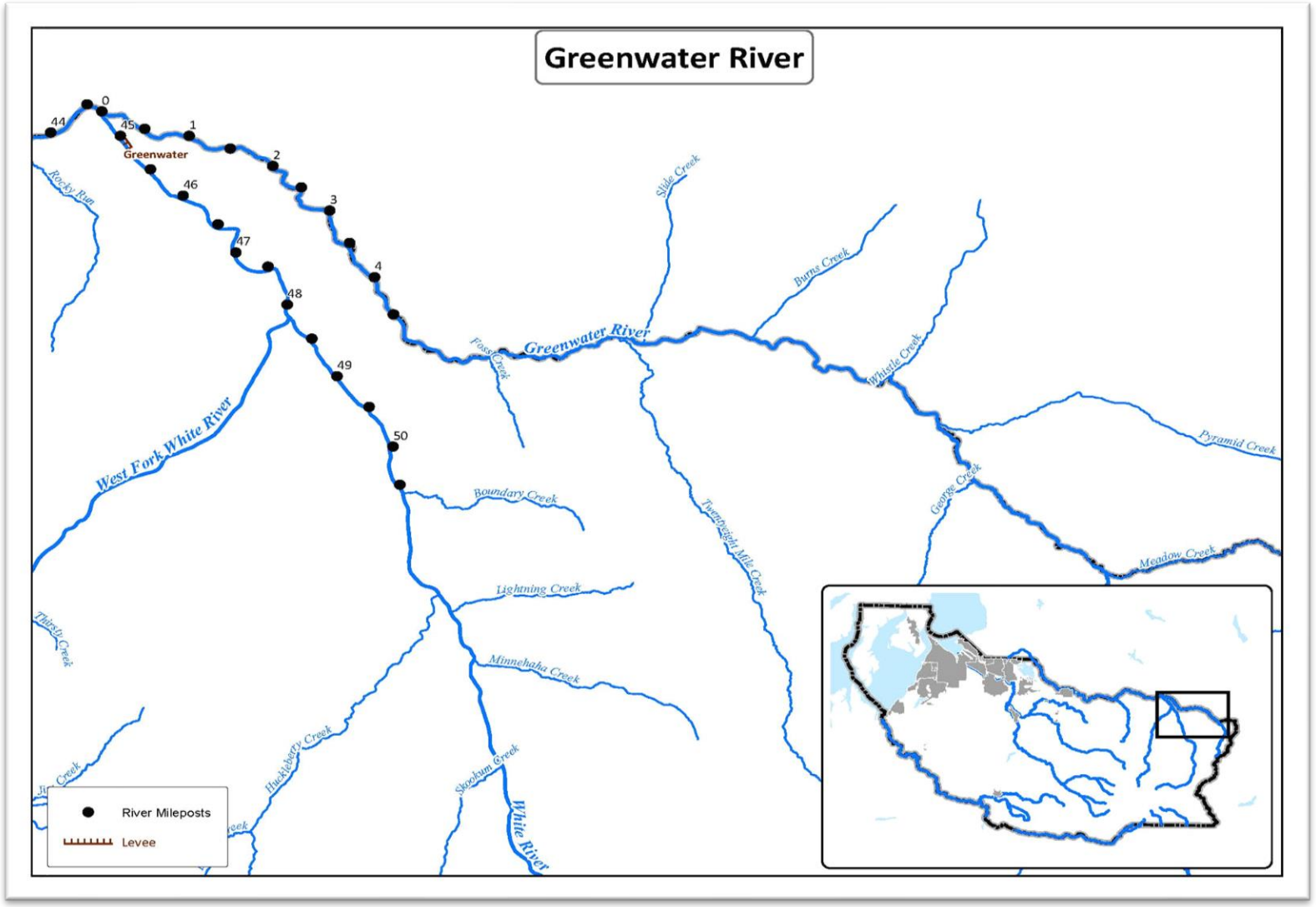
Table 4.3-15 Damage to Facilities along the Upper White River 1996-2017

Damage to Facilities along the Upper White River 1996-2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1996					
1996	Greenwater	Right	46.2	150	Toe/slope failure.
1996	Greenwater	Right	46.2	100	Toe failure.
2006					
2006	Greenwater	Right	46.2	300	Face erosion.
2007					
2007	Greenwater	Right	45.0- 45.2	750	Face erosion.
2015					
2015	Greenwater	Right	45.2	30	Partial toe rock displacement and missing face rock.
2015	Greenwater	Right	45.2	20	Missing toe rock.

Greenwater River

The Greenwater River lies in northeastern Pierce County and enters the White River at RM 44.6. The headwaters of the Greenwater River are in the Norse Peaks Wilderness area on Castle Mountain, elevation 6700 feet, and flows northwest for 21 miles to the community of Greenwater. The drainage basin is approximately 76 square miles. Primary tributaries include Maggie, Lost, Pyramid, and Twenty-Eight Mile creeks. Salmon and trout, including spring Chinook, coho, pink, and steelhead are present in the Greenwater River. The river forms part of the easterly boundary between King County and Pierce County. The planning area is from the mouth of the Greenwater River upstream to approximately RM 4.0. Land use consists of forested terrain, recreational and rural residential uses, and the community of Greenwater.

Map 4.3-7 Greenwater River



Greenwater River Extent and Occurrences

In December 1977, the Greenwater River experienced its most severe flooding with a peak flow of 10,500 cfs. Other large floods occurred in 1946, 1959, 1965, 1996, and 2009 (see the table below). The 1977 event caused the most extensive damage. A large log jam at the State Route 410 crossing of the river contributed to extensive flooding and damage in the community of Greenwater.

Table 4.3-16 Historical Flooding in Greenwater River from 1911-2017

Historical Flooding in Greenwater River USGS 12097500 Greenwater River at Greenwater, WA 75 Records from 1911 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
1978	December 2, 1977	10,500
1996	February 8, 1996	5,900
2011	January 16, 2011	5,590
1960	November 22, 1960	5,360
1965	January 29, 1965	5,090
1947	December 11, 1946	5,000
2016	December 9, 2015	4,620
2009	January 7, 2009	4,530
2012	February 22, 2012	4,440
1934	December 9, 1933	4,140
1976	December 2, 1975	4,140
2015	January 5, 2015	3,890

Probability of Future Hazards

The best available estimates of flood flow frequency on the Greenwater River are from the 1987 Flood Insurance Study. This shows the 10-year, 50-year, 100-year and 500-year recurrence intervals, respectively: 5,600, 8,080, 9,180, 11,900 cfs.

Greenwater River Impacts

Impact on Community

Most of the Greenwater watershed is forest land except for the lower 1.2 miles. There are small lot recreational cabins on both the Pierce and King County sides of the river. The left bank Pierce County side at Lumpy Lane is predominantly higher than the King County right bank community that accesses their property over a low bridge that spurs off Lumpy Lane in Pierce County. Lower areas along the east end of Lumpy Lane and Stubbs Road can be threatened during moderate to major flooding. There is a history of small revetments on both sides of the

river to limit erosion. The county purchased one home and three lots in the 1990s where channel migration threatened the home. Currently one more home has been identified by the Building Official as threatened by erosion. The state highway over the Greenwater has been the site of log jams in high water events that threatened the bridge abutments.

Land Purchases

In the early 1990's, three parcels were acquired that consisted of 0.47 acres along the left bank of the Greenwater River near RM 0.7. Two parcels were already vacant, and the other parcel contained a house that was at high risk of being destroyed by channel bank erosion. This house has been removed.

River Management

Pierce County has not actively maintained flood risk reduction facilities along the Greenwater River within the study area since 1982. There is a series of intermittent revetments along the left bank of the river between RM 0.1 and RM 1.27. King County maintains a series of intermittent revetments along the right bank of the river in the same area. A private revetment exists on the left bank between RM 0.6 to RM 0.7. There is also some armoring at the SR-410 crossing of the Greenwater River near RM 0.1.

Damage to Facilities

As noted above, there is currently no actively maintained Pierce County flood risk reduction facility on the Greenwater River. The most significant damage occurred during the 1977 peak flood event that affected the State Route 410 Bridge and approaches. Some toe and face rock protecting the bridge banks and approaches probably have been damaged by the peak flows since 1977. The condition and status of the private revetment is not known. There has been loss of private property. In 1990, the County purchased a home on Lumpy Lane that was falling in the river due to channel migration. The County is currently working with an adjacent property owner whose home is being threatened by channel migration.

Carbon River

Carbon River

The Carbon River drains an area of 230 square miles that originates on the north face of Mt. Rainier at the Carbon Glacier. It flows 33 miles downstream joining the Puyallup River below the City of Orting at RM 17.4. This plan concentrates on the lower 8.4 miles of the Carbon River. Most of this segment of the river is within unincorporated Pierce County, but the left bank of the lower 3.5 miles flows along the City of Orting. Above RM 11.0, the river is contained within steep canyon walls up to the community of Fairfax at RM 17.5. Between RM 0.0 and RM 8.3, the channel corridor lies in a relatively narrow trough-like valley.

The right bank is largely forested from RM 0.8 to RM 8.4. Below RM 0.8 the right bank is largely agricultural land. The left bank of the river from RM 0.75 to RM 3.54 is within the City of Orting and contains the Orting Wastewater Treatment Plant and single-family residential development. Between RM 3.4 and RM 8.3, the left bank land use consists mostly of agricultural and rural residential land. The left bank has a levee from RM 0.1 to RM 5.6 and RM 6.0 to RM 8.2. The right bank has a levee from RM 0.0 to RM 1.2 and RM 5.9 to RM 7.0.

Two major tributaries enter the Carbon River in this reach, Voight Creek at RM 4.0 and South Prairie Creek at RM 5.8. South Prairie Creek is described in Chapter 5.8. Voight Creek, a smaller tributary, collects runoff from the foothills to the south and west and flows across the valley floor before entering the Carbon River (GeoEngineers 2003). The Carbon River contains the most productive mainstem spawning habitat remaining in the Puyallup River watershed for all species of salmon. Chinook, steelhead, chum, and pink salmon are found in relative abundance.

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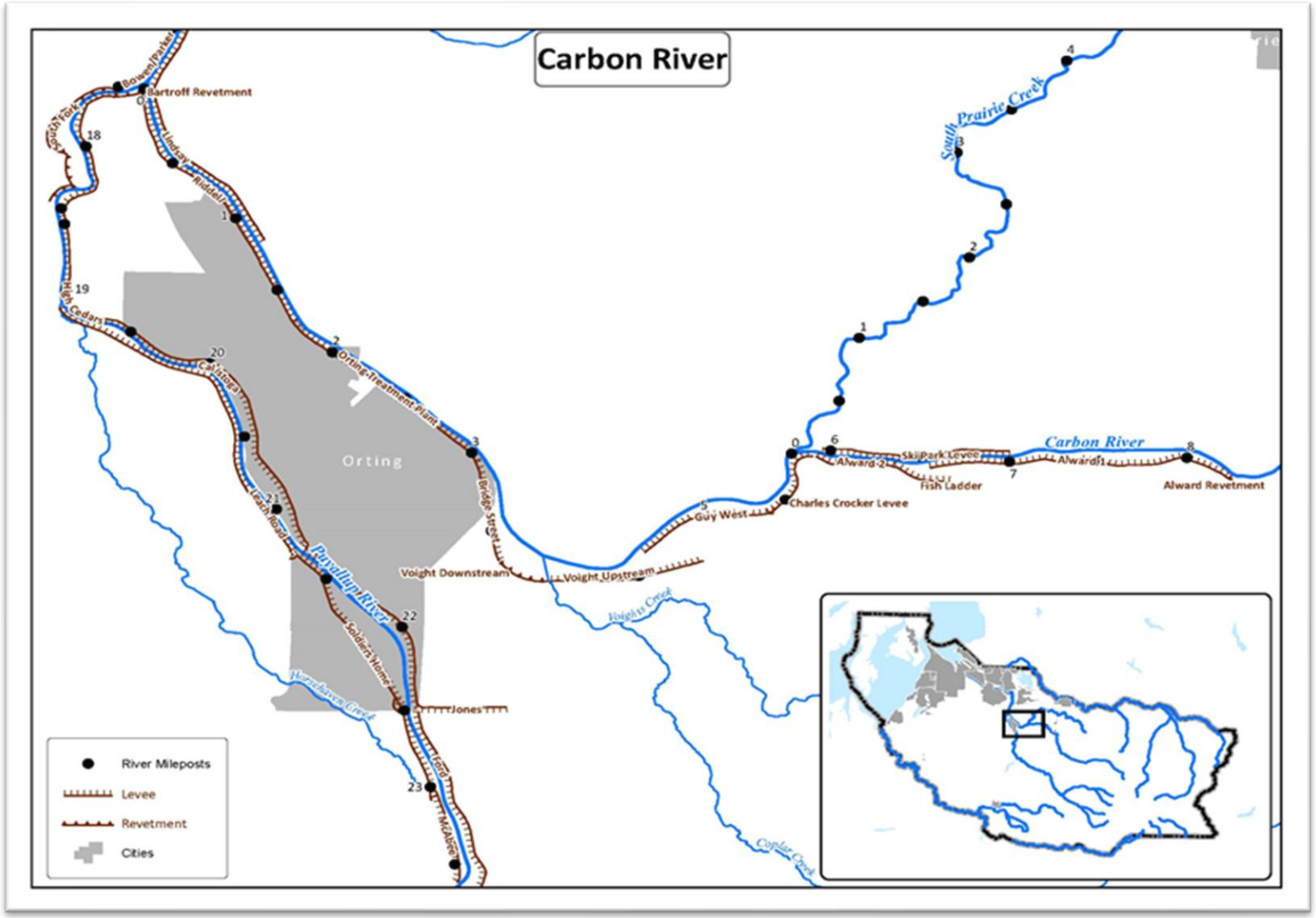
Map 4.3-8 Carbon River



Carbon River Extent and Occurrences

Major flooding of the Carbon River has been recorded occurred in 1933, 1959, 1977, 1990, 1996, 2006, 2008, and 2009 (see the table below). The November 2006 flood is the largest on record, with a measured flow of 14,500 cfs. The categorization of major flooding is based on a threshold of discharges in excess of approximately 10,000 cfs at the Fairfax gauge.

Table 4.3-17 Historical Major Flooding on Carbon River

Historical Major Flooding on Carbon River USGS 12094000 Carbon River Near Fairfax, WA 76 Records From 1930-2016		
Water Year	**Date**	**Stream Flow (cfs)**
2007	November 6, 2006	14,500
1991	November 24, 1990	13,000
1996	February 8, 1996	12,000
2009	November 12, 2008	11,700
1934	December 9, 1933	11,000
2016	December 9, 2015	10,200
1978	December 1, 1977	10,000
1960	November 23, 1959	9,970
2015	November 25, 2014	9,470
2005	January 18, 2005	7,650
1968	December 25, 1967	7,480
1976	December 1, 1975	7,460
1975	January 18, 1975	7,320
2003	January 31, 2003	7,310
1974	January 15, 1974	7,180

Probability of Future Hazards

In 2003, FEMA's study contractor NHC calculated peak flows that would be utilized for updating the FEMA flood insurance study and Flood Insurance Rate Maps. For the Carbon River at the USGS gauge near Fairfax (12094000) the calculations for the 10-year, 50-year, 100-year and 500-year recurrence intervals are shown to be respectively: 8,700, 12,700, 14,500, 19,100.

Based on the flow records for the past 20 years, the historical flow records, and the thresholds for moderate flooding (8,000-10,000 cfs) and severe flooding (greater than 10,000), the Carbon River can expect to experience moderate flooding every three to five years, and severe flooding every five to ten years, over a long-term period (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February. With 76

years of data at the gauge, eight of the ten peak flood events have occurred on the Carbon River since 2000.

Carbon River Impacts

Impact on Community

There are no commercial or industrial properties within this area; however, there are a substantial number of residential structures (URS 2012). Therefore, a large flood event would not result in a major impact to the economy and tax base. Due to the large presence of vacant lands, open space, and resource land, temporary loss of business in the area is unlikely to occur (URS 2012). However, lands used for recreation or resource land may experience some economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

Land Purchases

A significant number of parcels and flood damaged homes have been purchased along the Carbon River since the 1991 Flood Plan was adopted. Acquisitions have been focused on the Upper Carbon River between RM 6.4 & 8.3 in support of a future setback levee project planned along this reach. The objective of the project is to help resolve repetitive damages to the levee as well as reconnect historic floodplain that is currently cutoff by the existing levee.

River Management

On June 5, 1939, Pierce County approved Resolution No. 686, a plan for flood control of the middle Puyallup River, upper Puyallup River, and Carbon River. The plan was to establish a single channel on the Carbon River and Puyallup River (upstream of the White River confluence) by excavating gravel and river sediments and side casting them to form levees that were armored with rock riprap. This was the standard practice until the 1970s.

Current levees along the Carbon River were primarily built in the 1960s. The once meandering river channel was straightened and confined to an average width of 250 feet. The levee system was designed to prevent sediment sources from the banks and cliffs adjacent to the river from entering the channel contributing to increased sediment transport. It was believed that by constricting the channel width, there would be increased flow velocities to continue sediment transport downstream.

Pierce County currently owns and maintains approximately 10.5 miles of flood risk reduction facilities along the Carbon River in a combination of levees and revetments.

Table 3.4-18 Levees and Revetments along the Carbon River

Levees and Revetments along the Carbon River		
Name	**Location [a]**	**Ownership**
Right Bank		
Lindsay Levee	RM 16.9 (PR) – RM 1.7, PL 84-99	Pierce County
Ski Park Levee	RM 5.95 – RM 7.0, PL 84-99	Pierce County
Left Bank		
Riddell Levee	RM 0.0 – RM 1.7, PL 84-99	Pierce County
Orting Treatment Plant Levee	RM 1.7 – RM 3.05, PL 84-99	Pierce County
Bridge Street Levee	RM 3.05 – RM 3.7, PL 84-99	Pierce County
Voight Downstream Revetment	RM 3.7 – RM 4.0	Pierce County
Voight Upstream Revetment	RM 4.0 – RM 4.4	Pierce County
Guy West Levee	RM 4.6 – RM 5.6, PL 84-99	Pierce County
Guy West Revetment	RM 5.6 – RM 5.95	Pierce County
Alward Segment No 2 Levee	RM 5.95 - RM 6.4, PL 84-99	Pierce County
Fish Ladder Revetment	RM6.35- RM 6.65	Pierce County
Alward Segment No 1 Levee	RM 6.55 – RM 8.26, PL 84-99	Pierce County
Alward Revetment	RM 8.26- RM 8.33	Pierce County

Damage to Facilities

Flood damages to Carbon River flood risk reduction facilities have been extensive in the past two decades. Six significant flood events have occurred along the study reach since 1990. Damages sustained ranged from full washout of the flood control structure over several hundred lineal feet to localized moderate scour and erosion. Damages from the major flood events resulted in approximately 99 identified damage locations comprising 5.9 miles of levees and revetments. Damages have been estimated at nearly $15 million dollars (based on 2010 dollars). The following table summarizes levee and revetment segments subject to the most significant and repetitive damages. The upper portion of this Carbon River reach between RM 6.0 and RM 8.3 incurred the most damage.

Table 3.4-19 Damage to Facilities along the Carbon River 1990 - 2017

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1990					
1990	Alward 1	Left	C-36 6.8	750	Reconstruction.
1990	Alward 1	Left	C-37 and 38 7.2	1300	Reconstruction.
1990	Bridge Street	Left	C-17 3.2	175	Washout.
1990	Guy West	Left	C-31 5.9	400	Reconstruction.
1990	Lindsay	Right	C-2 0.4	250	Levee slope protection damage.
1990	Lindsay	Right	0.8	400	Reslope and replace levee washed out by flood.
1990	Riddell	Left	C-2 0.4	400	Reslope and replace levee washed out by flood.
1990	Riddell	Both	0.9	400	Reslope and replace levee washed out by flood.
1990	Riddell	Left	C-5 0.9	150	Levee slope protection damage.
1990	Ski Park	Right	6.0	770	Flood damage repair.
1990	Ski Park	Right	C-34 6.4	300	Washout.
1990	Ski Park	Right	C-34 6.4	500	Reconstruction.
1990	Ski Park	Right	6.5	300	Reshape and replace rip rap and toe rock.
1990	Ski Park	Right	6.8 and 7.6	1550	Flood damage repair.
1990	Ski Park	Right	C-32 6.1	900	Reconstruction.
1990	South Prairie Confluence	Right	C-31 5.9	100	Reconstruction.
1995					
1995	Alward 1	Left	6.7	350	Partial washout.
1995	Alward 1	Left	6.9	150	Full levee washout.
1995	Alward 1	Left	7.1	700	Full levee washout.
1995	Alward 1	Left	7.3	100	Partial washout.
1995	Alward 2	Left	6.2	255	Repair partially failed embankment.
1995	Alward 2	Left	6.3	250	Partial washout.
1995	Guy West	Left	4.6	100	Full levee washout.
1995	Guy West	Left	4.9	100	Partial washout.
1995	Lindsay	Right	0.8	379	Toe/slope failure.
1995	Ski Park	Right	6.9	200	Partial washout.
1995	Ski Park/Alward 1	Both	6.9, 7.3, & 7.4	730	Rebuild fully washed-out levee.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
1996					
1996	Alward 1	Left	6.6	400	Toe failure.
1996	Alward 1	Left	6.9	200	Toe failure.
1996	Alward 1	Left	7.2	400	Total levee failure.
1996	Alward 1	Left	7.2	850	Total levee failure.
1996	Alward 2	Left	6.05	250	Toe/slope failure.
1996	Alward 2	Left	6.25	250	Toe/slope failure.
1996	Alward 2	Left	6.3	100	Toe/slope failure.
1996	Bridge street	Left	3.2	50	Toe/slope failure.
1996	Bridge street	Left	3.6	350	Total levee failure.
1996	Fish Ladder	Left	6.4	50	Toe/slope failure.
1996	Guy West	Left	4.6	100	Total levee failure.
1996	Guy West	Left	4.9	100	Toe/slope failure.
1996	Lindsay	Right	0.2	450	Toe/slope failure.
1996	Lindsay	Right	0.5	50	Toe/slope failure.
1996	Lindsay	Right	0.6	80	Toe/slope failure.
1996	Lindsay	Right	0.95	50	Toe/slope failure.
1996	Lindsay	Right	1.0	30	Toe failure.
1996	Lindsay	Right	1.1	40	Toe failure.
1996	Lindsay	Right	1.2	125	Toe/slope failure.
1996	Orting Treatment Plant	Left	2.7	20	Toe/slope failure.
1996	Riddell	Left	0.4	100	Toe/slope failure.
1996	Riddell	Left	0.8	30	Toe/slope failure.
1996	Riddell	Left	1.05	20	Toe/slope failure.
1996	Ski Park	Right	7.1	800	Total levee failure.
1996	Ski park	Right	6.18	40	Toe/slope failure.
1996	Ski park	Right	6.9	320	Total levee failure.
1998					
1998	Alward 1	Left	6.9	150	Repair levee.
1998	Alward 1	Left	7.6	150	Repair levee.
1998	Alward 1	Left	8.0	200	Repair levee.
2003					
2003	Guy West	Left	5.4	260	Partial washout of the toe and levee facing.
2003	Ski Park	Right	6.6	450	Partial washout of the toe and levee facing.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2005					
2005	Alward 1	Left	6.6	450	Replace/ reconstruct/repair.
2005	Alward 1	Left	7.6	750	Replace/ reconstruct/repair.
2006					
2006	Alward	Left	8.3	100	Face erosion.
2006	Alward	Left	8.3	300	Face erosion.
2006	Alward 1	Left	7.2 - 7.4	750	Washout.
2006	Alward 1	Left	7.5	1200	Washout.
2006	Alward 1	Left	7.6	700	Washout.
2006	Alward 1	Left	8.2	150	Face erosion.
2006	Alward 2	Left	6.0 - 6.1	600	Face erosion.
2006	Alward 2	Left	6.3	600	Washout.
2006	Bridge street	Left	3.2	50	Washout.
2006	Bridge street	Left	3.6	120	Washout.
2006	Bridge street	Left	3.6	200	Face erosion.
2006	Guy west	Left	4.6 - 4.9	1700	Toe erosion/undercut bank.
2006	Guy west	Left	4.8	150	Washout.
2006	Guy west	Left	4.8	100	Washout.
2006	Guy west	Left	4.8	140	Washout.
2006	Guy west	Left	5.0	270	Face erosion.
2006	Guy west	Left	5.2	150	Face erosion.
2006	Guy west	Left	5.4	30	Washout.
2006	Lindsay	Right	0.8	60	Fracture.
2006	Lindsay	Right	1.2	150	Washout.
2006	Lindsay	Right	17.4	50	Face erosion.
2006	Riddell	Left	0.2	50	Slump.
2006	Riddell	Left	0.4	0	Overtopping.
2006	Riddell	Left	1.2	0	Overtopping.
2006	Ski park	Right	6.0	500	Washout.
2006	Ski park	Right	6.0	300	Washout.
2006	Ski park	Right	6.3	100	Face erosion.
2006	Ski park	Right	6.4	500	Washout.
2006	Ski park	Right	6.8	550	Washout.
2006	Voights d.s.	Left	3.8	180	Face erosion.
2006	Voights u.s.	Left	4.2	20	Fracture.
2006	Voights u.s.	Left	4.4	110	Restore levee face and toe.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2007					
2007	Alward 1	Left	6.6 - 6.7	810	Reconstruct new levee prism and set new face rock.
2007	Alward 1	Left	6.8 - 7.0	1250	Reconstruct levee prism, set new toe, and face.
2007	Alward 1	Left	7.2 - 7.4	850	Reconstruct new levee prism and set new face rock.
2007	Alward 1	Left	8.1	390	Replaced toe and re-slope and replaced face rock.
2007	Alward 1	Left	8.0	450	Re-establish toe and repair face.
2007	Bridge Street	Left	3.6 - 3.7	0	Overtopping.
2007	Guy West	Left	5.0	500	Set new toe and re-slope face.
2007	Lindsay	Right	0.8	600	Replace/ reconstruct/repair.
2007	Lindsay	Right	1.2	450	Re-establish toe and repair face.
2007	Ski Park	Right	6.0	540	Replace/ reconstruct/repair.
2007	Ski Park	Right	6.8	800	Re-establish toe and repair face.
2008					
2008	Alward 1	Left	7.0	100	Face scour and loss face rock.
2008	Alward 1	Left	7.2 - 7.3	796	Toe scour and loss of face rock. Lower face slumping.
2008	Alward 1	Left	8.0	100	Toe scour and loss of face rock. Lower face slumping.
2008	Alward 1	Left	8.1	100	Toe scour and loss of face rock. Lower face slumping.
2008	Alward 1	Left	8.25	150	Toe scour and loss of face rock. Lower face slumping.
2008	Alward 2	Left	6.0	824	Face rock thin due to scour.
2008	Alward 2	Left	6.25	302	Toe scour and loss face rock.
2008	Alward 2	Left	6.35	136	Toe scour and loss face rock.
2008	Bridge Street	Left	3.5	300	Toe scour and loss face rock
2008	Bridge Street	Left	3.55 - 3.7	325	Routine maintenance to the existing levee structure.
2008	Bridge Street	Left	3.6 - 3.7	380	Toe and face scour.
2008	Fish Ladder	Left	6.4	171	Toe scour and loss face rock.
2008	Guy West	Left	4.7	296	Scalloped washout.
2008	Guy West	Left	4.8	1,200	Re-establish levee core to inhibit lateral piping during high water.
2008	Guy West	Left	5.0	290	Replace undersized face rock.
2008	Guy West	Left	5.2	196	Replace undersized face rock.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2008	Guy West	Left	5.3	253	Toe scour and loss face rock.
2008	Lindsay	Right	1.0	50	Toe rock failure and partial face rock failure.
2008	Orting Treatment Plant	Left	2.0	25	Toe scour and loss face rock.
2008	Riddell	Left	0.4 - 0.5	634	Toe scour and loss face rock.
2008	Riddell	Left	0.9 - 1.10	500	Washout of the toe and levee face.
2008	Ski Park	Right	6.0	336	Toe scour and loss of face rock.
2008	Ski Park	Right	6.25	140	Toe scour and loss of face rock.
2008	Ski Park	Right	6.45 - 6.6	900	Face scour and loss face rock.
2008	Ski Park	Right	7.0	139	Washout.
2008	Voights u.s.	Left	4.2	324	Washout.
2008	Voights u.s.	Left	4.4	123	Toe and face scour.
2009					
2009	Alward 1	Left	7.5	118	Face scour with core exposure. Possibly some toe loss. Bank is undercutting.
2009	Alward 2	Left	6.35	140	Toe scour and loss face rock.
2009	Fish Ladder	Left	6.4	110	Lower face scour.
2009	Lindsay	Right	0.6	30	Facing rock failure.
2009	Lindsay	Right	0.9	75	Facing rock failure.
2009	Lindsay	Right	0.9	180	Re-establish toe and repair face.
2009	Lindsay	Right	16.9 - 16.95	100	Toe and facing rock failure.
2009	Riddell	Left	0.4	0	Overtopping.
2009	Ski Park	Right	5.95	50	armored spillway/notch.
2009	Ski Park	Right	6.2	255	Face scour with loss of most face rock.
2009	Ski Park	Right	6.25	144	Primary lower face scour causing upper face to slough.
2009	Ski Park	Right	6.4	310	Face scour with loss of most face rock.
2009	Ski Park	Right	6.75	200	Lower face scour.
2009	Ski Park	Right	6.45 - 6.6	400	Toe scour and loss of embankment.
2011					
2011	Alward 1	Left	7.1	75	Face and potential toe rock failure.
2011	Alward 1	Left	7.55	90	Toe and face rock failure.
2011	Alward 1	Left	8.05	130	Toe and face rock failure.
2011	Alward 1	Left	8.15	50	Face rock failure.
2011	Bridge Street	Left	3.35	30	Toe and face rock failure.
2011	Bridge Street	Left	3.45	120	Face rock failure.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2011	Guy West	Left	4.8	270	Undermining levee.
2011	Guy West	Left	5.3	70	Toe/face scour.
2011	Orting Treatment Plant	Left	2.0	129	Toe and rock failure.
2011	Riddell	Left	1.0	140	Toe is scoured out along with some face rock.
2011	Riddell	Left	1.1	400	Toe is scoured out along with some face rock.
2011	Riddell	Left	1.6	210	Undermined section with prism showing in sections.
2011	Voights d.s.	Left	3.75	90	Partial damage to facing rock.
2011	Voights d.s.	Left	3.8	130	Damage to toe and face rock.
2011	Voights u.s.	Left	4.2	700	Some toe rock failure.
2012					
2012	Alward 1	Left	7.1	250	Face and potential toe rock failure.
2012	Alward 1	Left	8.05 - 8.15	350	Toe and face rock failure.
2012	Bridge Street	Left	3.35	60	Face and toe scour.
2012	Bridge Street	Left	3.4	45	Facing and toe scour.
2012	Bridge Street	Left	3.45	120	Face rock is gone.
2012	Guy West	Left	4.8	270	Levee undermined along toe.
2012	Guy West	Left	5.3	170	Toe and face rock failing.
2012	Orting Treatment Plant	Left	2.0	129	Toe and face rock failure.
2012	Riddell	Left	0.4	634	Toe scour and loss of face rock.
2012	Riddell	Left	1.0	140	Toe is scoured out along with some face rock.
2012	Riddell	Left	1.6	210	Undermined trees are pulling apart face rock.
2012	Voights d.s.	Left	3.8	130	Some minor damage to face rock.
2012	Voights u.s.	Left	4.2	700	Some toe rock failure.
2013					
2013	Alward 1	Left	7.0 - 7.1	400	Toe and face rock failing.
2013	Alward 1	Left	7.2	150	Minor toe rock repair.
2013	Fish Ladder	Left	6.4	100	Toe and face rock failure.
2013	Guy West	Left	5.5	250	Toe and face rock failing.
2013	Orting Treatment Plant	Left	2.0	150	40 LF of prism core exposed.
2013	Riddell	Left	1.6	250	Missing face and toe rock.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2014					
2014	Guy West	Left	5.75	250	Face rock failure.
2014	Riddell	Left	0.5	500	Toe scour and loss of face rock.
2014	Riddell	Left	1.6	260	Toe and face rock failure.
2014	Ski Park	Right	6.0	100	Toe and face erosion.
2015					
2015	Alward 1	Left	6.55	200	Levee rehabilitation.
2015	Alward 1	Left	7.1	40	Missing toe rock.
2015	Alward 1	Left	7.2	390	Levee rehabilitation.
2015	Alward 1	Left	7.9	100	Large log jam diverting flows/jet scour into levee.
2015	Alward 1	Left	7.9	20	Log jam is gone that forced flows into levee.
2015	Alward 1	Left	7.9	120	Toe and face rock damaged from large log jam.
2015	Alward 1	Left	8.1	60	Toe rock missing.
2015	Alward 1	Left	8.2	40	Missing toe rock in three locations.
2015	Alward 1	Left	8.2	30	Missing toe rock in three locations.
2015	Alward 1	Left	8.2	150	Large scour has formed at the toe of the levee. Toe and face rock has fallen into scour hole.
2015	Alward 2	Left	6.35	100	Levee rehabilitation.
2015	Alward 2	Left	6.2 -6.3	490	Levee rehabilitation.
2015	Bridge Street	Left	3.35	200	Levee rehabilitation.
2015	Bridge Street	Left	3.4	130	Face rock missing.
2015	Fish Ladder	Left	6.35 - 6.4	200	Rock displaced
2015	Fish Ladder	Left	6.35	100	Levee rehabilitation.
2015	Fish Ladder	Left	6.4	34	Missing Toe rock.
2015	Fish Ladder	Left	6.4	16	An additional 16 feet of revetment damaged from flood event.
2015	Fish Ladder	Left	6.4	100	Emergency repair.
2015	Fish Ladder	Left	6.45	150	Face and Toe Rock missing.
2015	Guy West	Left	4.65	150	Levee rehabilitation.
2015	Guy West	Left	4.8	360	Levee rehabilitation.
2015	Guy West	Left	5.3 - 5.35	375	Levee rehabilitation.
2015	Guy West	Left	5.2	40	Missing toe and face rock.
2015	Guy West	Left	5.75	150	Missing toe rock.
2015	Lindsay	Right	1.2	150	Toe rock missing.

Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2015	Lindsay	Right	0.8	30	Missing toe rock and face rock slumping.
2015	Lindsay	Right	0.8	200	Trees were undermined and then pulled out a section of face rock in several locations.
2015	Lindsay	Right	0.8	125	Missing toe rock and face rock.
2015	Riddell	Left	0.55	60	Missing face rock
2015	Ski Park	Right	6.2 - 6.3	735	Levee rehabilitation.
2015	Ski Park	Right	6.20	40	Section of toe rock missing.
2015	Ski Park	Right	6.25	180	Missing toe and face rock.
2015	Ski Park	Right	6.80	200	Vertical face along inside radius of river bend.
2015	Ski Park	Right	6.80	200	Vertical face.
2015	Voights d.s.	Left	3.8	120	Missing toe and face rock.
2015	Voights d.s.	Left	3.8	140	Levee rehabilitation.
2015	Voights u.s.	Left	4.2	40	Partial undermining thru two repair sites in trees section.
2015	Voights u.s.	Left	4.2	80	Missing toe and face rock.
2015	Voights u.s.	Left	4.2	90	Missing toe and face rock.
2015	Voights u.s.	Left	4.3	20	Tree pulled out a chuck of face and toe rock.
2015	Voights u.s.	Left	4.3	50	Tree pulled out a chuck of face and toe rock
2015	Voights u.s.	Left	4.3	100	Large Cedar tree and Alder tree pulled a section of levee down.
2017					
2017	Alward 1	Left	7.9	120	Toe and face rock damaged from large log jam.
2017	Alward 1	Left	8.1	100	Toe rock missing. Scalloped along toe.
2017	Alward 2	Left	6.20	478	Reconstruction/preservation.
2017	Alward 2	Left	6.000	150	Unacceptable PL 84-99 tie in, proposing slightly setback levee alignment to tie into former railroad embankment.
2017	Bridge Street	Left	3.4	130	Face rock failure. Face rock missing.
2017	Bridge Street	Left	3.7	120	Toe and face rock.
2017	Bridge Street	Left	3.4	340	Loss of toe and face rock.
2017	Bridge Street	Left	3.1	200	Loss of toe rock.

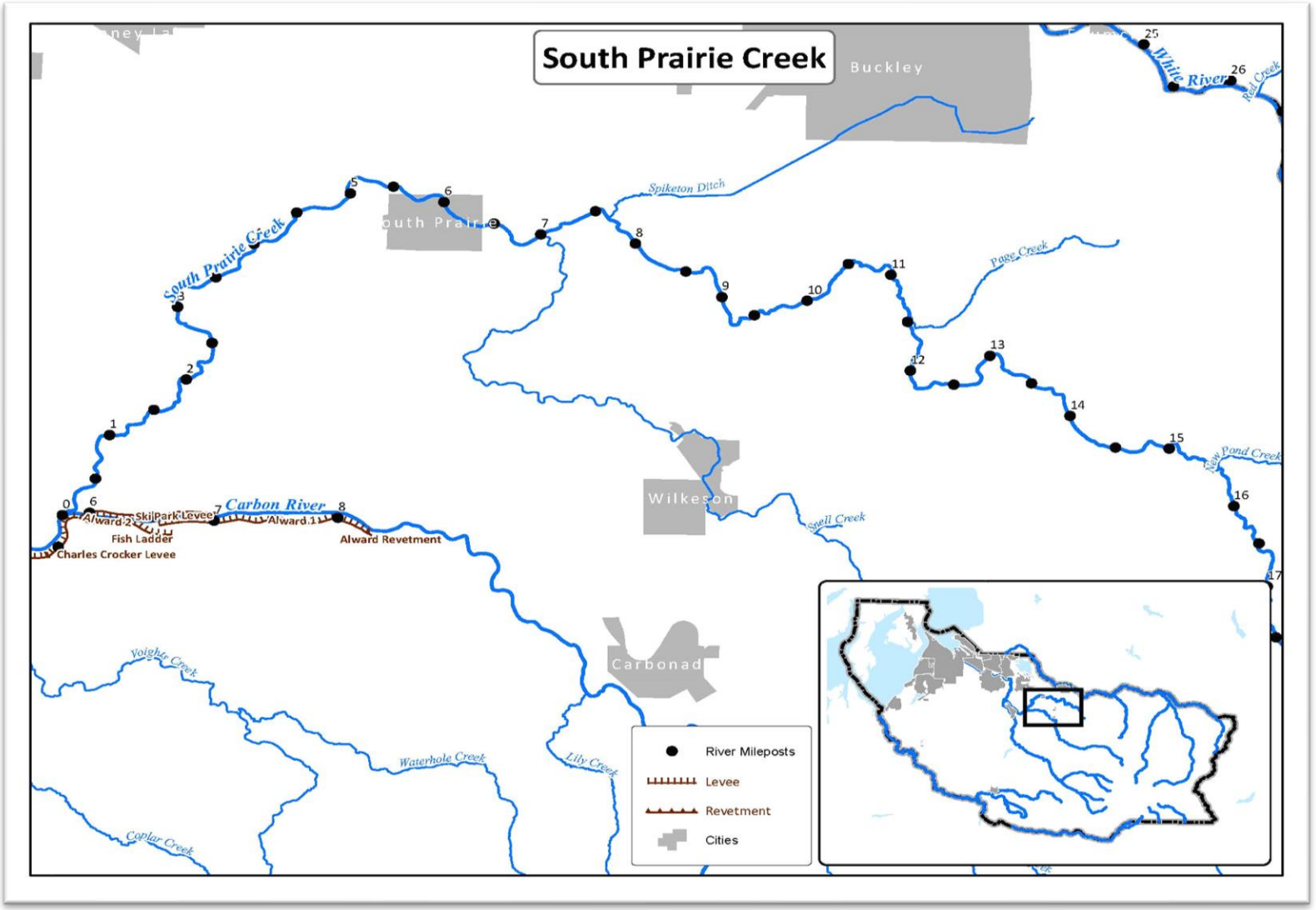
Damage to Facilities along the Carbon River 1990 - 2017					
Storm Season	**Segment Name**	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2017	Fish Ladder	Left	6.4	200	Loss of bank between 177th and the end of Alward 1 Levee.
2017	Guy West	Left	5.75	150	Toe and face rock failure.
2017	Orting Treatment Plant	Left	2.3	20	Portion of face rock missing.
2017	Orting Treatment Plant	Left	2.7	40	Toe rock failure.
2017	Orting Treatment Plant	Left	2.7	140	Partial of face rock missing.
2017	Orting Treatment Plant	Left	2.1	75	Levee face damage.
2017	Riddell	Left	1.2 - 1.3	500	Toe rock failure.

South Prairie Creek

South Prairie Creek lies in the center of the Puyallup River Basin, east of the City of Orting. South Prairie Creek has a drainage basin of 90 square miles and ranges in elevation from 285 feet above sea level to 5,933 feet at the summit of Pitcher Mountain. This plan concentrates on the lower floodplain area of South Prairie Creek (RM 0 - RM 6.4), extending from the Town of South Prairie to the confluence with the Carbon River at RM 5.9. There are no Pierce County levees along lower South Prairie Creek, but there are isolated rock riprap revetments and earthen berms that have been constructed by agricultural and residential landowners and transportation agencies, such as near SR-162 Bridge crossings of the creek.

Land use consists of agricultural and rural residential, and the Town of South Prairie. There are no Pierce County levees along lower South Prairie Creek, but there are isolated rock riprap revetments and earthen berms that have been constructed by agricultural and residential landowners, and near State Route 162 bridge crossings of the creek. Salmon and trout, including fall Chinook, coho, pink, chum and steelhead use South Prairie Creek. South Prairie Creek is one of the most productive salmon and steelhead tributaries in the entire Puyallup River Basin.

Map 4.3-9 South Prairie Creek



South Prairie Creek Extent and Occurrences

Major flood events since 1991 have damaged infrastructure, residential, agricultural, and recreational properties. Widespread flooding of roads, residential, and agricultural properties occurred in February 1996, November 2006, and January 2009. In most large floods, the Veteran of Foreign Wars campground sustains some damage. In January 2009, the Town of South Prairie Fire Station was flooded and sustained $36,000 in damage. State Route 162 and other local roads have been regularly closed during flooding due to water and debris over the roadway.

Major flooding occurred in the South Prairie Creek in 1955, 1965, 1990, 1996, 2006, and 2009 (see the table below). The January 2009 flood is the largest on record, with a measured flow of 9,480 cfs, exceeding the 100-year flood flow of 8,700 cfs estimated by FEMA (FEMA/ NHC 2006). Since 2013, there has been no major flooding in this reach.

Table 4.3-20 Historical Major Flooding on South Prairie Creek

Historical Major Flooding on South Prairie Creek USGS 12095000 South Prairie Creek at South Prairie, WA 60 Records From 1950 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
2009	January 7, 2009	9,480
1996	February 8, 1996	8,170
1956	December 11, 1955	6,850
2007	November 7, 2006	6,540
1965	January 29, 1965	6,400
1990	January 9, 1990	5,930
1954	December 9, 1953	5,470
1991	February 19, 1991	5,390
2016	October 31, 2015	5,060
1975	January 18, 1975	5,020
2000	November 25, 1999	4,650

Probability of Future Hazards

The thresholds for moderate and severe flooding for South Prairie Creek have not been established. During the past 20 years, peak flows over 6,000 cfs have occurred on three occasions. Based on the historical record, the November 2006 flood (6,540 cfs) was between a 10-year and 20-year event, the February 1996 flood was between a 25-year and 50-year event, and the January 2009 flood was greater than a 100-year event (URS 2012). Based on these flow records, South Prairie Creek can expect to experience moderate flooding every 5 to 10 years, and more severe flooding every 10 to 20 years, over a long-term period (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February.

South Prairie Creek Impacts

Impact on Community

There are no industrial properties and limited commercial properties within this area. Therefore, a large flood event would not result in a major impact to the county economy and tax base, although the Town of South Prairie could be severely impacted. However, lands used for residential and agricultural uses may experience some economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

The 2009 flood caused the South Prairie fire station to flood and several roads overtopped and/or washed-out causing residents to be stranded. There is a campground near river mile 2 that has to evacuate during minor flooding.

Land Purchases

There have been extensive land purchases in the South Prairie Creek basin by Pierce County and its partners since 1991 for both flood and habitat related purposes. Approximately 142 acres have been purchased. Between 2006 and 2009, six parcels totaling 55.6 acres and four flood prone homes were purchased and removed. Funding has been provided by the Salmon Recovery Funding Board, Pierce County SWM fees, and the Real Estate Excise Tax (REET) funds. In addition, some properties have also been purchased by the Pierce Conservation District.

River Management

No flood risk reduction facilities are owned and maintained by Pierce County Surface Water Management along South Prairie Creek. However, there are some rip rap revetments and armoring maintained by WSDOT along State Route 162 crossings and by Pierce County Roads along South Prairie Road East.

Damage to Facilities

WSDOT reported scour of bridge piers and large woody debris buildup on bridges as problems on several bridges. Water and debris on roadways are a common problem for Pierce County roads, but damage to roadways is not widespread. Typically, some repair and maintenance of toe and facing rock follows large flood events.

In 1996, South Prairie Creek jumped the right bank and washed-out South Prairie Road near 246th Avenue East and did the same further downstream at Spring Site Road. Road reconstruction, bank stabilization, and an armored overflow flood re-entry channel repaired the flood damage.

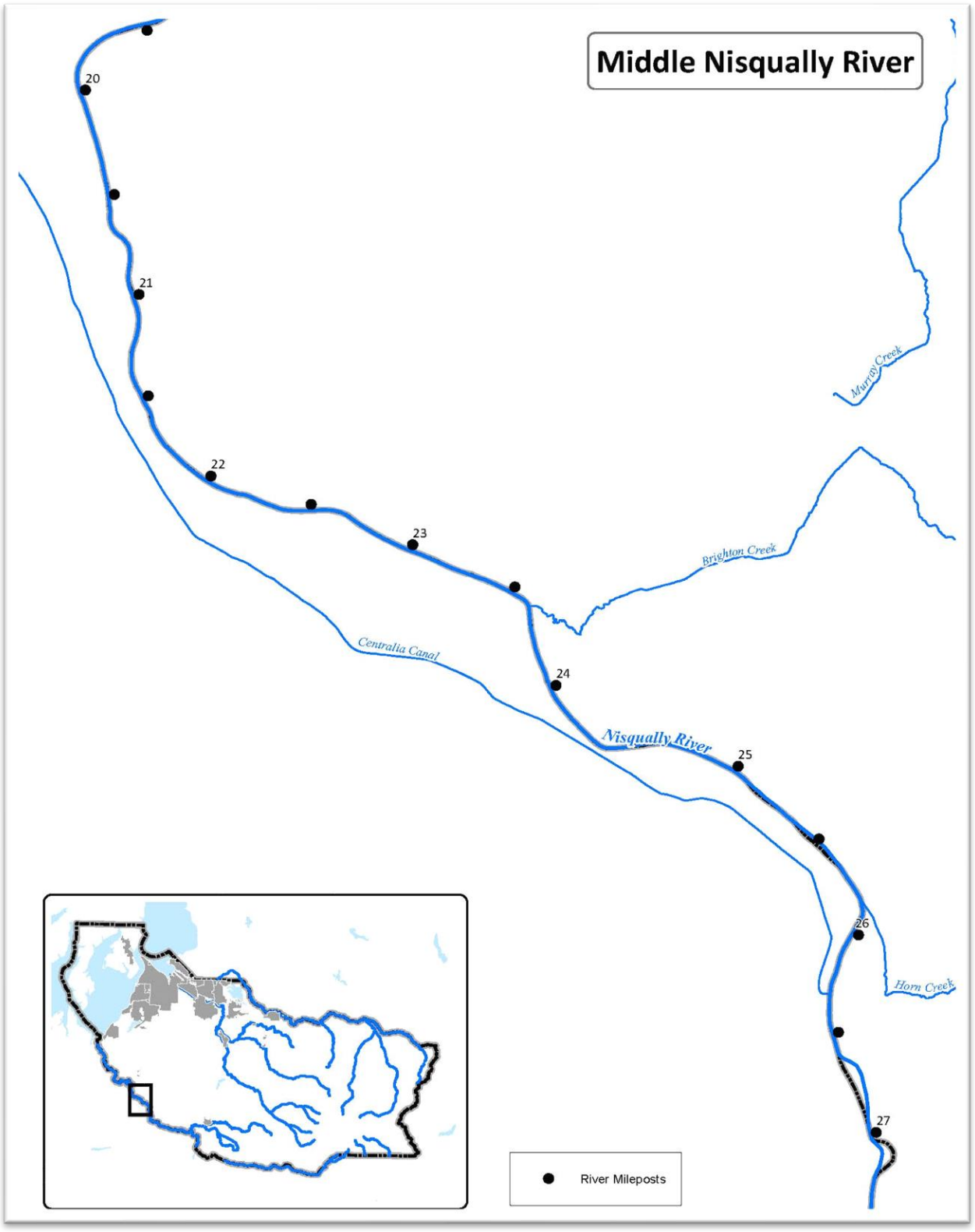
Nisqually River

The Nisqually River drains a watershed of approximately 760 square miles. The river originates from the Nisqually glacier on the south slope of Mount Rainier with an elevation of 14,411 and flows 78 miles to the estuary at the Nisqually National Wildlife Refuge before flowing into Puget Sound. There are two major tributaries to the Nisqually River, the Mashel River, and Muck Creek. Nearly 58 percent of the Nisqually River watershed lies in Pierce County, with the remainder in Thurston County (16 percent) and Lewis County (26 percent). There are two dams on the Nisqually River, the first at RM 42.4 (LaGrande Dam) and the second at RM 44.2 (Alder Dam). Alder Dam forms the 3000-acre Alder Lake. The two dams are part of the Nisqually Hydroelectric Project owned and operated by Tacoma Power. According to Tacoma Power, the dams provide incidental reduction of flood flows, but there are no flood control requirements noted in the operating agreement (Nisqually Watershed Characterization, 2008).

Middle Nisqually

The drainage area to the USGS gauge on the Nisqually River at McKenna is 517 square miles. The middle Nisqually River at McKenna forms the boundary between Pierce County and Thurston County. Flood risk on this reach is predominately in Thurston and Lewis County, as most of the Pierce County area is on high bank of the river. The focus of this reach is from approximately RM 21.3 to RM 26.0, where the 100-year floodplain is up to 2900 feet wide, and where substantial flooding occurred in the McKenna area during the February 1996 flood event. Land use in the McKenna vicinity consists of medium-density residential, rural residential and agriculture and pasture lands. There are also extensive lakes and wetlands in the surrounding area. Salmonid use in this reach of the Nisqually River includes fall Chinook, coho, chum and pink salmon and winter steelhead trout.

Map 4.3-10 Middle Nisqually River



Nisqually River Extent and Occurrences

One major flood in 1996, with flows estimated near 50,000 cfs, severely impacted the McKenna area (see the table below). Since construction of the Alder Dam in 1948, peak flow events exceeding 20,000 cfs have occurred five times. There have been no peak flows over 16,200 cfs since 1996. Records from the 1996 flood event indicate that 24 flooding problems were identified in the database for this area (Nisqually Basin Plan 2008).

Table 4.3-21 Historical Flooding on Middle Nisqually River

Historical Flooding on Middle Nisqually River USGS 12089500 Nisqually River at McKenna 61 Records from 1948 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
1996	February 8, 1996	50,000
1965	January 29, 1965	25,700
1981	December 26, 1980	21,100
1960	November 23, 1959	20,500
1956	December 12, 1955	20,200
1990	January 10, 1990	17,700
1991	April 5, 1991	17,200
1951	February 11, 1951	16,900
1954	December 10, 1953	16,200
1982	February 19, 1982	16,200
2003	January 31, 2003	16,200
2009	January 8, 2009	16,100
1997	January 1, 1997	15,900
2016	December 9, 2015	15,900

Probability of Future Hazards

The Flood Insurance Mapping Study for the Nisqually River (FEMA, 1987b) identified the 100-year peak flow at McKenna at 32,000 cfs only to have the 1996 flood exceed 50,000 cfs. Many residents outside of the mapped 500-year flood zone lost their homes. Flooding in the lower Nisqually generally happens in late winter and early spring as the Tacoma Public Utilities (TPU) dam complex will be filling the Alder Lake reservoir each fall. While the TPU dams are not licensed for flood control, the draw down to generate power during the summer has allowed for attenuation of fall flood events in the lower reaches of the river. FEMA is conducting a new Flood Insurance Study of the Nisqually River and the 2019 Hydrology Report (STARR II) using Bulletin 17C calculations for the 10-year, 25-year, 50-year, 100-year and 500-year recurrence intervals are shown to be respectively: 29,900, 38,300, 45,000, 52,100, 70,500 cfs.

Middle Nisqually River Impacts

Impact on Community

Commercial and industrial properties do not comprise a large portion of this area (less than two percent) (URS 2012). Therefore, a large flood event would not result in a major impact to the economy and tax base. However, lands used for recreation or resource land may experience some economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

Land Purchases

A significant number of parcels and flood damaged homes were purchased along the middle Nisqually River in the McKenna vicinity following the 1996 flood.

Acquisition of 25 parcels totaling 42.5 acres at a total cost of $2.04 million. Funding was a combination of Hazard Mitigation Grants (HMGP), with state and local match, including Real Estate Excise Tax (REET) funds.

River Management

There is no known flood risk reduction facility infrastructure, past or present, owned or maintained by the Pierce County Surface Water Management Division. WSDOT has limited armoring along the SR-507 bridge crossing. The extent of armoring along the Thurston County (left bank) side of the river is not well known.

Damage to Facilities

The 1996 flood eroded out the State Route 507 bridge approach on the Pierce County side (right bank), resulting in a two-day closure of the road and bridge. There is also ongoing scour and accumulation of large woody debris on the bridge piers during high flow events. The bridge is on WSDOT's Scour Critical List for shallow spread footings, and it is monitored during all high-water events.

Flooding in 1996 resulted in extensive flooding of homes and roads in the McKenna area, as well as the Nisqually Valley Care Center, a nursing home located on the right bank downstream of the State Route 507.

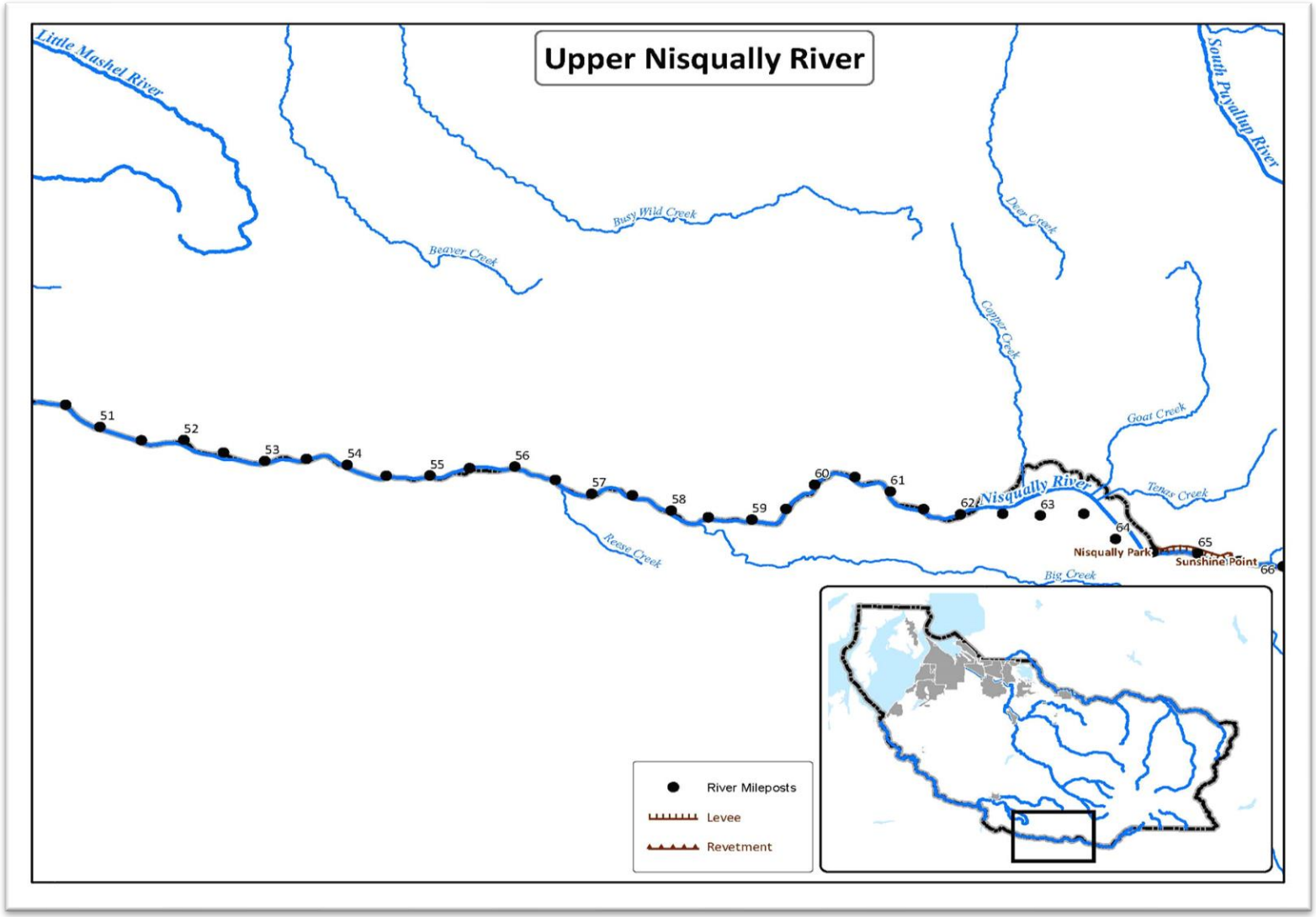
Upper Nisqually River

The upper Nisqually River begins on the slopes of Mount Rainier on the South Tahoma Glacier, Kautz Glacier, and Nisqually Glacier and flows generally east to west from the glaciers to Alder Lake, near the Town of Elbe. The upper Nisqually River forms the boundary between Pierce County and Lewis County. Glacial melt water and sediment flow down the mountain from three

major sources: Tahoma Creek, Kautz Creek, and the Nisqually River. From Alder Lake to the confluence of Tahoma Creek at about RM 65.8, the upper Nisqually River flows through a broad valley, occupied by terraces, glacial features such as moraines, and occasional bedrock outcrops (GeoEngineers 2007).

The focus of this reach is from RM 50.5, at the entrance to Alder Lake Park in Elbe, to the upstream end of the levee/revetment at RM 65.4, near the entrance to Mt. Rainier National Park. The drainage area to the USGS gauge on the Nisqually River near National is 133 square miles. The unincorporated towns of Elbe and Ashford provide residential and commercial land uses and are located adjacent to State Route 706. Recreational, forest and agricultural uses make up the balance of land uses within this sub area. There are no salmon in this reach of the river, due to natural barriers and the dams downstream; however, there are resident cutthroat trout.

Map 4.3-11 Upper Nisqually River



Upper Nisqually River Extent and Occurrences

Since the USGS gauge was installed in 1942, major flooding has been recorded occurring in the upper Nisqually River in 1974, 1977, 1996, and 2006 (see the table below). The February 1996 and November 2006 floods both exceeded 21,000 cfs and were similar in magnitude to the estimated 1.0 percent annual chance flood (100-year) of 21,950 cfs estimated by Pierce County SWM. The most significant channel migration event occurred near the park entrance in 1990 after a series of moderate floods. The categorization of major flooding is based on a discharge greater than 15,000 cfs for the Nisqually River gauge near National, Washington.

Table 4.3-22 Historical Major Flooding on Nisqually River

Historical Major Flooding on Nisqually River USGS 12082500 Nisqually River Near National, WA 75 Records From 1942 - 2017		
Water Year	**Date**	**Stream Flow (cfs)**
2007	November 6, 2006	21,800
1996	February 8, 1996	21,200
1978	December 2, 1977	17,100
2016	December 9, 2015	16,700
1974	January 15, 1974	15,000
1990	January 9, 1990	14,500
2009	November 12, 2008	13,900
1976	December 4, 1975	13,200
1981	December 26, 1980	11,600
2015	November 25, 2014	11,500
1965	January 29, 1965	11,000
1991	November 24, 1990	11,000
1960	November 23, 1959	10,900
2003	January 31, 2003	10,800
1963	November 20, 1962	10,400

Probability of Future Hazards

FEMA is updating the Nisqually River Flood Insurance Study at this time and released the hydrology report by their contractor STARR II in January 2019. The estimated peak flows for the Upper Nisqually reach for the 10-year, 50-year, 100-year and 500-year recurrence intervals of 12,900, 19,150, 22,500 and 30,000 cfs, respectively (STARR II 2019). Based on this estimate, the historical flow record, and the thresholds for moderate flooding (10,000-15,000 cfs) and severe flooding (greater than 15,000) (see section 3.9.3.1 below), the Upper Nisqually River can expect to experience moderate flooding every 10 to 25 years and severe flooding every 25-50 years, over a long-term period (URS 2012).

Upper Nisqually River Impacts

Impact on Community

There are no commercial or industrial properties in this area (URS 2012), therefore, a large flood event would not result in a major impact to the economy and tax base. However, the small percentage of resource lands may experience minimal economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012).

Land Purchases

There have been no known land purchases or home buyouts by Pierce County in the upper Nisqually area since 1991. In 2006, the Nisqually Land Trust purchased 404 acres of timberlands and wildlife habitat in the upper Nisqually Valley, near the town of Ashford and the main entrance to Mount Rainier National Park.

River Management

There is one levee/revetment in the upper Nisqually River owned and maintained by Pierce County Surface Water management. It is located near the entrance to Mt. Rainier National Park on the right bank, protecting both State Route 706 and Nisqually Park residences. There are also revetments and bank armoring at both road and rail crossings between Mt. Rainier National Park and Elbe, which are maintained by Pierce County Roads, WSDOT and Tacoma Rail. Additionally, there is armoring on the right bank at the entrance to Alder Lake, downstream of the State Route 7 Bridge.

Damage to Facilities

The only flood control structure Pierce County owns on this reach is the Nisqually Park Entrance levee that extends into Mount Rainier National Park which protects the highway. Due to the high energy of the Nisqually River, the levee is consistently being repaired for loss of face and toe rock that has eroded away. In November 2006, Mt. Rainier experienced a record-breaking rain event resulting in severe flood damages throughout the National Park. Eighteen inches of rain fell in 36 hours near Paradise. One of the hardest hit areas was near the Nisqually entrance at the Sunshine Point Campground. More than 1,000 linear feet of levee was washed away.

Table 3.4-23 Damage to Facilities in the Upper Nisqually River 1990-2017

Damage to Facilities in the Upper Nisqually River 1990-2017				
Storm Season	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
			1991	
1991	Right		0	Gravel removal and dike construction.
			2003	
2003	Right	64.7	219	Partial washout of the toe and levee facing.
2003	Right	64.8	137	Partial washout of the toe and levee facing.
2003	Right	65.0	547	Partial washout of the toe and levee facing.
			2004	
2004	Right	64.8	1200	Partial washout of the toe and levee facing.
			2005	
2005	Right	65.1	850	Partial washout of the toe and levee facing.
2005	Right	65.13	70	Partial washout of the toe and levee facing.
			2006	
2006	Right	64.6	200	Face erosion.
2006	Right	64.9	100	Washout.
2006	Right	65.1 - 65.4	1600	Washout.
			2008	
2008	Right	64.8	400	Toe scour and loss of face rock.
2008	Right	65.1 - 65.3	1150	Toe Scour and Loss of face rock.
2008	Right	65.3 - 65.4	600	Toe scour and loss of face rock.
			2010	
2010	Right	65.25 - 65.4	700	Severe toe scour.
			2011	
2011	Right	64.6	150	Toe and face scour.
2011	Right	65.05 - 65.25	1100	Severe toe scour.

Damage to Facilities in the Upper Nisqually River 1990-2017				
Storm Season	**Bank**	**River Mile (RM)**	**Damage Lineal Feet**	**Damage**
2012				
2012	Right	64.65	100	Active toe scour w/ face sloughing.
2012	Right	64.75	100	Active toe scour w/ face sloughing.
2012	Right	64.85 - 65.05	1000	Severe toe scour and loss of lower face.
2015				
2015	Right	64.8	320	Missing face rock near toe.
2015	Right	65.4	300	Major toe scour along the road.
2017				
2017	Right	65.4	300	Toe scour and loss of face rock.
2017	Right	64.77	90	Under cut toe, dislodged riprap, voids.
2017	Right	64.97	200	Toe rock failure.
2017	Right	65.02	30	Toe rock may be missing.
2017	Right	64.6	150	Toe rock has been scoured out.

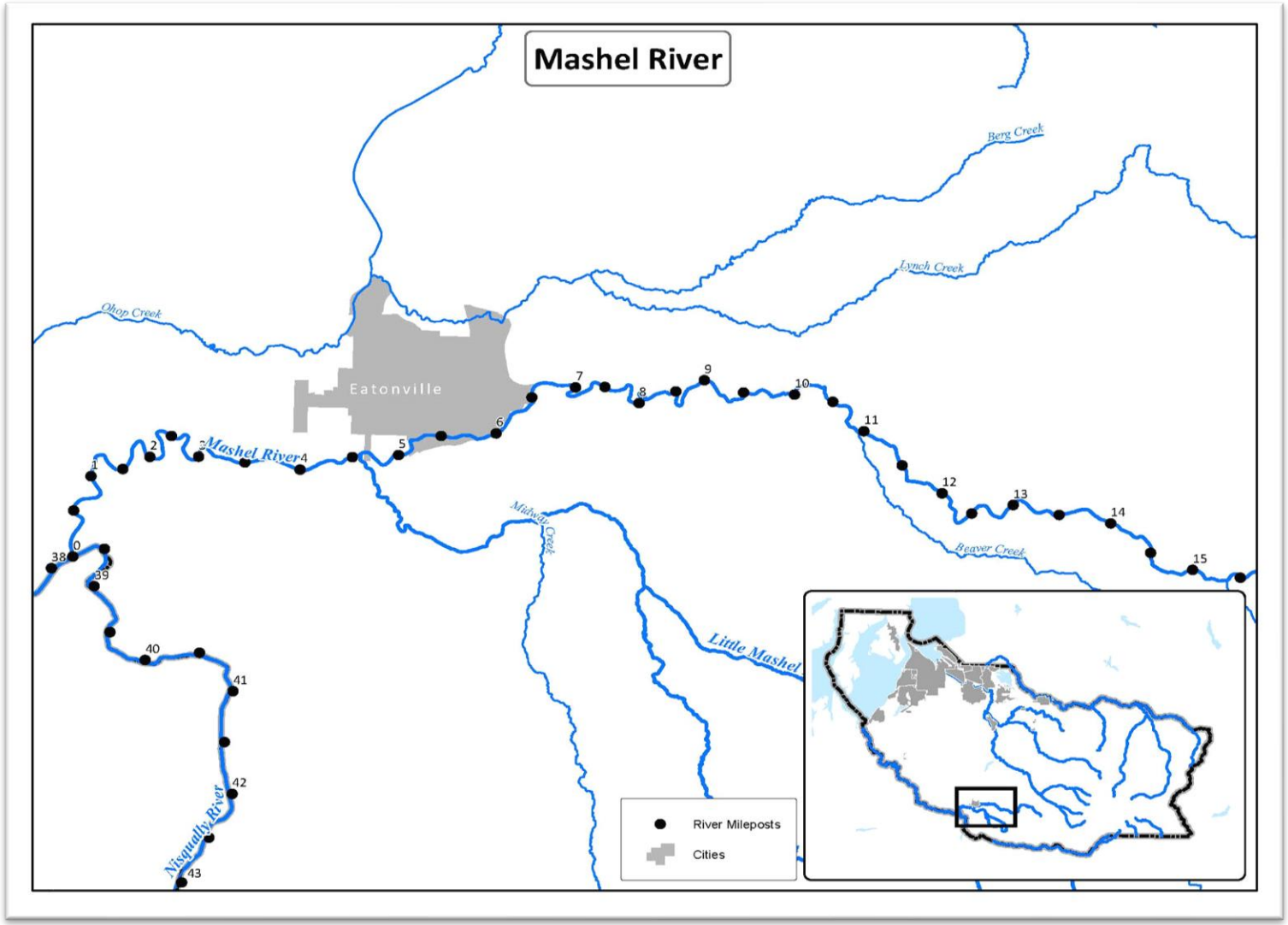
Mashel River

Mashel River

The Mashel River sub basin, covering about 85 square miles, is higher in elevation and steeper than most other tributaries to the Nisqually River. Over 40 percent of the basin has slopes greater than 30 percent (Nisqually Basin Plan 2014). Major tributaries of the Mashel River are the Little Mashel River, Beaver Creek, and Busy Wild Creek. Elevations range from 460 feet at the mouth to 4,845 feet on the flanks of Mount Rainier. The Mashel River winds through a steep, sinuous canyon as it approaches the Nisqually River, where it enters at approximately RM 39.6.

The Mashel River planning area is from the mouth of the Mashel River upstream to the Town of Eatonville (near RM 6.8). Land use consists of forested terrain, some agriculture (mostly livestock), rural residential development, and urban areas in the Town of Eatonville. Eatonville draws its drinking water from the Mashel River, and the secondary-treated wastewater is discharged to the river downstream of the town. The Mashel River is the farthest upriver tributary to the Nisqually River that has anadromous fish use, including fall Chinook, coho, and pink salmon and winter steelhead trout.

Map 4.3-12 Mashel River



Mashel River Extent and Occurrences

Major flood events since 1991 have adversely affected transportation facilities and some private properties. There was channel migration in January 2009 along State Route 161 at the bridge crossing at RM 5.5 and downstream on the left bank from RM 5.2 to RM 5.3. Past flooding of the Mashel River occurred in 1946, 1996, 2007, and 2009 (see the table below). The magnitude of flood flows is not known for the period of 1958 to 1991, due to a data gap in the USGS gauge record.

Table 4.3-24 Major Flooding on Mashel River

Major Flooding on Mashel River	
Date	**Mashel River Flows near La Grande Gauge (cfs) – USGS #12087000**
December 1946	6,859
February 1996	6,220
December 2007	5,790
January 2009	5,610

Probability of Future Hazards

The Flood Insurance Mapping Study for the Mashel River (NHC, 2002) identified the following peak flows for the Mashel River from the USGS gage at RM 3.3 for the 10-year, 50-year, 100-year and 500-year recurrence intervals, respectively: 4,995, 7,215, 8,250 and 10,900 cfs.

There are no established thresholds for moderate and severe flooding for the Mashel River. During the past 20 years, peak flows over 5,000 cfs have occurred on three occasions as noted above. Based on the historical record, the February 1996 peak flow was between a 25- year and 50-year event, and the December 2007 and January 2009 peak flows were between 10- year and 25-year event (URS 2012). Generally, flooding occurs during late fall into early spring, particularly between the months of November and February.

Mashel River Impacts

Impact on Community

Commercial and industrial properties do not comprise a large portion of this area (less than one percent) (URS 2012). Therefore, a large flood event would not result in a major impact to the economy and tax base (URS 2012). However, lands used for recreation or resource land may experience some economic loss if these areas are unable to be accessed or used during the flood and during the recovery period following the flood (URS 2012). The sewer treatment plant for the Town of Eatonville is adjacent to the river. While the structures and facilities are two to six feet above the base flood elevation, they are less than 100 feet from the active channel and could be compromised if channel migration occurs on the right bank.

Land Purchases

Pierce County has not purchased property in the Mashel River basin. However, the Town of Eatonville, the State of Washington, and the Nisqually Land Trust all own property along the Mashel River. The Land Trust owns 45 acres near Eatonville at Boxcar Canyon (purchased with Pierce County Conservation Future funds) and a 64-acre property that includes one mile of shoreline on the right bank of the Mashel River, downstream of the SR-7 crossing. The State of Washington and Washington State Parks and Recreation owns extensive property (over 1,000 acres) on the left and right banks of the lower Mashel River upstream of its mouth at the confluence.

River Management

No flood control facilities are owned or maintained by Pierce County Surface Water Management along the Mashel River. Pierce County historically placed rip rap along the Mashel River near State Route 161 between RM 5.12 and RM 5.24. In 1950, a groin was built by dredging and straightening the river channel. A timber bulkhead paralleling the highway had become badly decayed and the river was eroding the highway causing PCRI to take action. The groin was heavily blanketed with rock from the Orting quarry (PCRI Annual Report 1950). The last documented action of PCRI rip rapping the Mashel River was in 1962.

In the Town of Eatonville, riprap is present intermittently along both banks of the river from the wastewater treatment plant, located at RM 5.3, to the Alder Cutoff Road Bridge, located at RM 6.3. Rip rap protects the right bank from approximately 200 feet below the bridge to 50 feet above the bridge. The left bank has rip rap from approximately 50 feet below the bridge to 15 feet above the bridge. Much of the rip rap is old; however, WSDOT replaced rock on the right bank above the bridge and on the left bank upstream and downstream of the bridge in 2009. The town built a levee around the wastewater treatment plant following the 1996 flood. In 2004 log jams replaced rip rap on left bank in the vicinity of Smallwood Park, located at

approximately RM 5.6, and at a private residence, located at approximately RM 5.33 (Watershed Professionals Network, LLC, 2004).

Damage to Facilities

There is little historical information about damage to flood control facilities along the Mashel River. As noted above, Pierce County has no current river management facilities in the study area. WSDOT has several bridge crossings of State Route 161 and State Route 7, and revetments where the river flows adjacent to State Route 161.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Flooding kills citizens throughout the United States every year. While that has not been a major problem in Pierce County over the years, it very well could happen with any major flood we have. The fact that Pierce County has had to do swift water rescues in the past with floods in both 1996, 2006 and 2015 shows the potential for life threatening situations to evolve during a flood.

Pierce County streams and rivers run very fast and can quickly overwhelm individuals or vehicles caught in them. Persons caught in flood waters can be pinned under debris and drown. They can receive trauma from other debris being carried along by the river or by impacting rocks or other impediments in the river itself.

During the fall and winter flood season, rivers and streams are comprised largely of cold rain and snow, and for those originating on Mt. Rainier, some glacier melt. They are therefore very cold. In addition, air temperature in the winter during flood season can also be in the thirty-degree range, although not usually below that during floods. The result is that persons caught in flood waters can drown not just from direct action of the flood but also as a complication of hypothermia.

Figure 4.3-5 Nov. 2006 Flooding River Park Estates Along Puyallup River

Other problems that can compromise a person's health can develop after the flood waters have receded. Mold will grow in wet material, be it clothing, bedding, the walls of a house or the insulation under a floor. Sewage and hazardous chemicals may be present in homes, cars, or just as a layer coating peoples' property. Water and food may be contaminated. Heat and

electricity may be off for some time. All of these will contribute to a decrease in not just the quality of life for individuals, but also their current and long-term health. Health and Safety of Personnel Responding to the Incident

Response to flooding is response in hazardous conditions. Whether one is attempting swift water rescue, adding sandbags to dikes, or cleaning up debris after the waters have receded, an individual is working in a hazardous environment.

Impacts to responding personnel are similar to what can affect the citizens residing or working in the flood area. They include death from drowning and/or hypothermia, and either death or injury from trauma. Long-term, environmental hazards such as hazardous chemicals, sewage, etc. can cause illness, either acute or chronic.

Continuity of Operations and Delivery of Services

Continuity of operations for most jurisdictions within Pierce County will not be compromised due to flooding. However, those that have their main administration or critical components of their operations within the flood zone could find their operational continuity at risk. If files, paper or electronic, are damaged or destroyed, an organization may not be able to: contact clients; assign work; complete scheduled jobs; meet deadlines; access, track, and pay accounts; or pay staff. Without a Continuity of Operations Plan (COOP) that takes these issues into account, they may not be able to operate in their normal mode. This would be especially true for those jurisdictions like Orting, Sumner, Puyallup or Fife that lie directly on the river, or have a significant portion of their infrastructure located close to the river.

The delivery of services by the local jurisdictions and agencies within Pierce County is directly related to the degree of damage by the floods, to improved property, the infrastructure, and the areas in which the damage occurs. A flood that closes roads, either with water over the road or a washout, temporarily eliminates the ability of a local jurisdiction to repair other damaged infrastructure, respond to emergencies in the affected area, or deliver the other normal goods and services expected of it. Flooded electric substations, downed lines, contaminated wells, and broken pipelines all have the same impact. In all of these cases the delivery of services will be at least temporarily halted.

Damage to facilities, equipment, or files all could impact the delivery of services to citizens from individual jurisdictions or agencies.

Public Confidence in the Jurisdiction's Governance

The reputation of any individual jurisdiction within Pierce County or the public's confidence in the jurisdiction is highly dependent on the public's perception on how well the response and recovery were handled during and after the flood. A response that either shows or gives the impression that a jurisdiction is prepared and responsive to the public's needs and manages a recovery to gets services back and damage repaired in a timely manner will enhance a jurisdiction's reputation. If, however, the perception develops, rightly or wrongly, that the jurisdiction is incompetent, slow to react, or ignores the needs of its citizens, then the reputation of the jurisdiction and the confidence in its abilities will decline.

Economic Conditions

In 2010, Pierce County Surface Water Management had an Economic Analysis conducted by Entrix that supported the 2013 Pierce County Rivers Flood Hazard Management Plan. This analysis focused on the 100-year floodplains of two river systems, its tributaries, and the large streams within the Planning Area. The report examined (1) existing socioeconomic conditions, (2) flood impacts to regional economic activity, (3) property damage, (4) transportation impacts, (5) wastewater treatment plant impacts, and (6) recreation impacts related to closures of Mt. Rainier National Park and Crystal Mountain. Pierce County faces the threat of significant impacts from flooding with potential flood related losses in excess of $725 million from a 100-year or larger flood (Entrix 2010). Over 21,000 people live in the floodplain in 9,340 homes. Businesses located within the flood plain provide 11,800 jobs. There are three wastewater treatment plants serving 216,000 people located in the floodplain.

The study summarized a range of estimates of economic impacts that were quantified, with both a low and high estimate, as follows:

- Property damage is estimated to be between $199 and $520 million.
- Loss of business revenue from disruption or closure ranges from $13 to $46 million, depending on the number of days of closure.
- Delays in transportation network caused by road and rail closures are estimated to be between $12.6 and $19.3 million.
- The estimate of losses in agricultural output ranges between less than $1 to $20 million.
- Flood damage at wastewater treatment plants is estimated to be between $3 and $128 million.
- Lost revenue and income due to closures of Mt. Rainier National Park and Crystal Mountain Ski Resort is estimated to be between $1 and $14 million.

Surface Water Management will be updating the Pierce County Comprehensive Flood Hazard Management Plan in 2023. As a part of the update, a new economic analysis will be conducted.

Environmental Impacts

Minimizing Water Quality Impacts of Flooding

Three issues relate to flooding that affect aquatic life, ecosystem health and clean water. First, sources of pollution including chemicals, pesticides, fertilizers, metals, petroleum-based products, hazardous waste, and animal waste have the potential to contaminate flood waters when mobilized during flood events. This can be from improperly stored waste in the floodplain, or properly stored waste that is displaced due to flood flows. Locations of chemical or waste storage can include houses, garages, outbuildings, barns, and commercial and industrial businesses and a broad range of agricultural, residential, commercial, and industrial land uses. Second, septic systems and drain fields in floodplains are at risk of inundation and failure from floodwaters. Third, flood waters can erode and mobilize large amounts of sediment from watershed sources, instream and bank erosion that is later deposited downstream in rivers, floodplains, or Puget Sound. While some amount of sediment transport is natural and beneficial, excess sediment can degrade water quality and habitat.

Once chemicals, waste or other pollutants are mobilized by floodwaters the result can be degraded water quality conditions, toxic effects on fish and other aquatic biota, and habitat impacts. The proper storage, handling, and management of chemicals, waste and other pollutants is necessary to protect aquatic resources from adverse impacts. Components of a program to address these issues include education of citizens and businesses, technical assistance, best management practices, and regulation.

New development requirements prevent the construction of septic systems and drain fields in floodplains, but pre-existing systems remain a problem in some areas. Such systems need to be carefully managed to reduce risks to water quality.

Sources of excess sediment include watershed sources such as urban areas, agricultural activities, construction sites, and logging, as well as instream and bank erosion along rivers. Erosion control best management practices and stabilization of excessively eroding riverbanks can help reduce sediment sources.

Impacts on Water Quality, Fish and Wildlife, and Habitat

Water quality degradation can result from numerous pollutant types, including oxygen demanding materials (e.g., organic wastes), sediment, nutrients (phosphorus, nitrogen), metals (copper, zinc), trace organics (e.g., pesticides, fuels, oils and automobile products), and bacteria. Discharge of pollutants to receiving waters during flooding can cause violation of water quality standards, acute effects on fish and other aquatic biota, and impacts on habitat.

Impacts on aquatic species can lead to direct mortality from acute effects at toxic levels or chronic effects from sustained exposure to elevated levels of pollutants. For example, elevated levels of copper can impair olfaction (sense of smell) in salmon and impair the behavior of fish, in terms of their ability to migrate, feed, or detect predators. Water quality degradation can also reduce the diversity and abundance of aquatic insects and other stream biota, shifting to species that are more pollutant tolerant. Examples of habitat impacts include sedimentation of spawning areas, or reduction of dissolved oxygen levels in water or interstitial areas of gravel.

Repetitive Flooding

In the last twelve years, the county experienced three major floods with November 2006 and January 2009 events receiving a presidential disaster declaration and the November 2008 flood largely overshadowed by the flood two months later. 2014 and 2015 had moderate flooding that increased FEMA's listing of repetitive loss properties even though Pierce County has an active program removing flood prone structures. In the January 2018 publication from FEMA, there were 32 repetitive loss properties (two insurance claims of $1,000 or more in a ten-year period) with four of them meeting the severe repetitive loss (SRL) definition (four claims with the combined value at more than $20,000). The county has mitigated one property since this list was created and has recently purchased another home that will be removed from the FEMA list in the Clear Creek area. This brings the total of purchased homes to over 450 since SWM's buyout program began with just 31 being on the FEMA repetitive loss list.

The county has five primary repetitive loss areas where many properties have experienced flood losses in the last twenty years. These areas are Clover Creek near Parkland, Coastal Dash Point, Mid Puyallup River south of Sumner, South Prairie Creek and Clear Creek behind the River Road levee. While FEMA has a list of homes where property owners had purchased flood insurance to mitigate the cost of cleanup and repairs, there are many more homes where flood insurance may not have been purchased or was purchased after the "big" flood. This means that homes will continue to be added to FEMA's repetitive loss list until the area can be mitigated. The county intends to contact all flood prone properties, not just the ones on the FEMA repetitive loss list. This will be done through annual postcard notices that direct the recipient to learn more about their individual property by contacting the county. Once contacted, the county can discuss flood risk, mitigation and funding options. In the last four years this method has become more targeted to the flood risk (coastal, riverine, urban, and groundwater) which resulted in over 600 responses to last year's postcard campaign. SWM has received a written request to be bought out by 46 properties with one of these currently on the FEMA repetitive loss list.

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Endnotes

[1] United Nations Office for Disaster Risk Reduction (UNDRR), & International Science Council (ISC). (2025). UNDRR–ISC Hazard Information Profiles – 2025 Update: GH0404 River Erosion and Accretion United Nations Office for Disaster Risk Reduction; International Science Council. https://www.undrr.org/terms/hips/GH0404
[2] Pierce County Planning and Public Works (PPW) Surface Water Management (SWM) Division. (2023). https://www.piercecountywa.gov/DocumentCenter/View/130196/2023-Comprehensive-Flood-Plan
[3] Pierce County Planning and Public Works (PPW) Surface Water Management (SWM) Division. (2023). https://www.piercecountywa.gov/DocumentCenter/View/130196/2023-Comprehensive-Flood-Plan

Hazardous Materials and Transportation Accidents

Human-Caused Hazard | 4.5

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Hazardous materials incidents, pipeline incidents, and transportation incidents are all human-caused hazards that often involve difficult to predict and significant life and safety and environmental clean-up concerns. Furthermore, there is overlap in mitigation strategies to reduce risk to all three individual hazards as well. For these reasons, hazardous materials, pipelines, and transportation incidents are coupled into this greater "Hazardous Materials and Transportation Accidents" Subsection of the Pierce County Regional Hazard Mitigation Plan (RHMP) Base Plan and in each Jurisdictional Annex as well.

Hazardous Materials

Identification Description

Definitions

Hazardous materials are materials which, because of their chemical, physical or biological properties, pose a potential risk to life, health, the environment, or property when not properly contained. A hazardous material release then is the release of the material from its container into the local environment.

Types

Hazardous materials include materials that are explosive, flammable, combustible, corrosive, reactive, poisonous, biological or radioactive (see Figure 4.5-1). They can be in a solid, liquid or gaseous state. Of increasing interest is Bakken crude oil. This is due to a combination of the physical and chemical properties, and related hazards, combined with the fact that the very large quantities transported have the potential to create very large explosions, fires and environmental degradation of the environment. Prior to 2012, no trains carrying Bakken oil into or through Pierce County; this has since changed. There are on average an estimated 15 trains of around 100 cars each week carrying Bakken oil into or through Pierce County. Crude oil properties vary, as even wells within the same oilfield may produce different types.

Table 4.5-1 List of constituents or ingredients found in Bakken crude oil[1]

Chemical Name	CAS#	Percent		Chemical Name	CAS#	Percent
Crude Oil (Petroleum)	8002-05-9	100 by weight		N-Hexane	110-54-3	<5 by volume
Ethyl Benzene	100-41-4	<3 by weight		Xylenes	1330-20-7	<1 by weight
Benzene	71-43-2	<1 by weight		Hydrogen Sulfide	7783-06-4	<0.2 by volume
Naphthalene	91-20-3	0 - 0.9 by weight		Total Sulfur:		< 0.5 wt%
Crude oil, natural gas and natural gas condensate can contain minor amounts of sulfur, nitrogen and oxygen containing organic compounds as well as trace amounts of heavy metals like mercury, arsenic, nickel, and vanadium. Composition can vary depending on the source of crude.						

[2]

Profile

Location and Extent

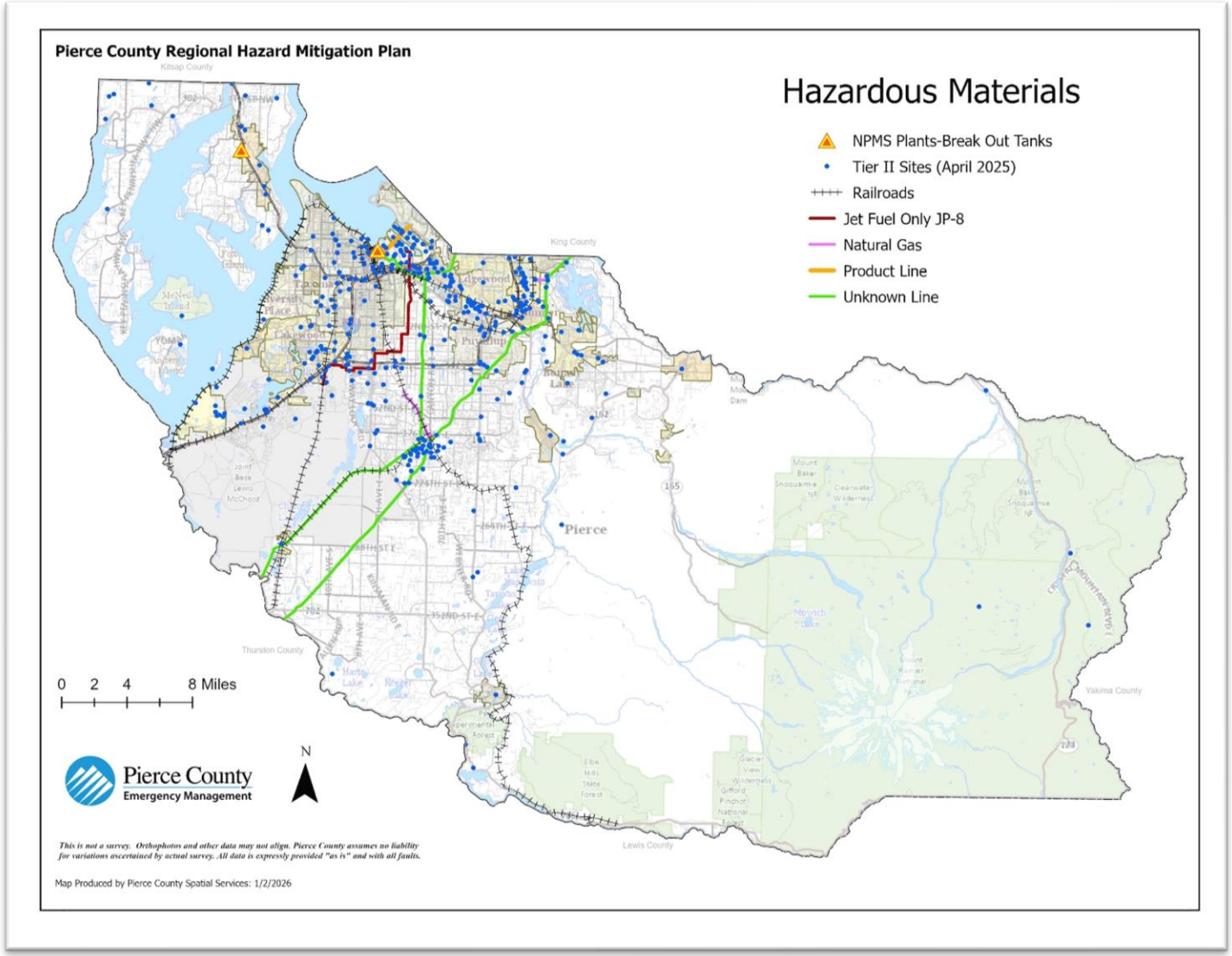
Hazardous materials incidents can be generated from a fixed site or the result of a transportation related accident or release. Not included here are terrorist incidents or radioactive releases from a fixed nuclear facility (FNF). Hazardous materials used in terrorism are covered in the "Terrorism and Extremism" Subsection of the Pierce County RHMP Base Plan "Section 4: Risk Assessment" As there are currently no local fixed nuclear facilities that would be an immediate threat through the release of material to Pierce County, they are not included in this subsection.

Hazardous materials are classified into four groups of chemicals under Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III). The following groups are:

- **Extremely Hazardous Substances –** These chemicals have acutely toxic properties. Includes approximately 366 chemicals;
- **Hazardous Substances** – Includes approximately 720 chemicals;
- **Hazardous Chemicals** – Inventories of these chemicals and material safety data sheets for each must be submitted if they are present at the chemical facility in certain amounts; and
- **Toxic Chemicals** – Chemicals or chemical categories that appear on the list because of their chronic or long-term toxicity. Includes 325 chemicals.

Chemicals within these categories have different reporting requirements as to quantities on site that need to be reported. The Tier II reporting forms go to the Washington State Department of Ecology, the Local Emergency Planning Committee (LEPC) of Pierce County, and the local fire department or district.[3] There are Tier II sites throughout the County, primarily along rail lines and major transportation corridors, particularly at the Port of Tacoma, and rail lines in the Frederickson, Puyallup, and Sumner areas.

Map 4.5-1 Unincorporated Pierce County – Pipelines as a Hazardous Material Hazard Risk



Occurrences

The defining moment in the control of hazardous materials was the December 1984 Union Carbide release of Methyl Isocyanate gas in Bhopal, India. This was the worst industrial accident in history, killing over 3,000 people initially and leaving others blinded or with other disabilities. Over one million claims were made for damages from the release, of which 574,366 claims were awarded damages.[4]

Hazardous material spills are a regular part of response organizations operations in Pierce County. While most reported spills are relatively minor, such as small amounts of hydraulic fluid or diesel, there are occasional spills that tax response organizations. Many small spills are initially reported to the County from the Washington Emergency Management Division (EMD), who may receive a notification from individuals, local jurisdictions, the Department of Ecology, or the National Response Center, an office within the U.S. Coast Guard.

Figure 4.5-1 Exxon Valdez Oil Spill, 1989

While there have been hazardous material releases in Pierce County, some of which have had fatal consequences, there has not been a large-scale incident that resulted in a number of deaths or injuries. This is also true when it comes to railroad accidents. Although there have not been any major hazardous materials derailments in Pierce County that have resulted in loss of life, there have been cases in Canada and other areas of the United States. With the rise of crude oil incidents, "crude oil emergency incidents have now become higher probability – high consequence events." The Pipeline and Hazardous Materials Safety Administration (PHMSA) further indicates that there is a higher risk as seen with recent derailments and the resulting fires. There are two major derailments of significance, the first is the Lac-Mégantic, Quebec, Canada 63 car derailment on July 5, 2013 which resulted in the death of 47 people due to fire and other effects of the accident.[5] The other derailment was on April 30, 2014 in Lynchburg, Virginia where 17 of 105 tank cars fell into the James River, spilling almost 30,000 gallons of oil.[6]

The last two largest spills that have caused major problems within Pierce County are the February 12, 2007 Chlorine Spill in the Port of Tacoma[7] and the Dalco Passage Oil Spill of October 13, 2004.[8,9] Both of these required a major response and, in the case of the Dalco Passage spill, took many days to clean up.

Recurrence Rate

Spills of small quantities of hazardous materials happen regularly. These can range from a meth lab being located and needing clean up to a diesel spill on the highway. Taking all these factors into account, a hazardous chemical spill occurs annually. However, the large spills that could impact a significant portion of the public and create major economic or environmental problems are a five year, or less, occurrence.

Impacts

Health and Safety of Persons in the Affected Area at the Time of the Incident

Depending on the hazardous material(s) involved, the quantity, proximity of exposures, and the current environmental factors during the time of the incident, the impact to persons in the affected area may range from negligible to fatal.[10] Initial reactions to inhaled hazardous gasses may include respiratory problems, burning sensation in the mouth, nose, and eyes, loss of consciousness, dizziness, suffocation, and death. Some substances in a solid or liquid state can be absorbed through the skin. Others, like caustics and acids, may cause burns on contact. For some chemicals there are residual problems that might not present themselves for years. Some of these leave lung lesions or impact other internal organs. These may result in later development of emphysema or various cancers.

Health and Safety of Personnel Responding to the Incident

Personnel responding to a hazardous chemical spill, if not properly protected, are subject to the same physical problems as the initial victims.[11]

Continuity of Operations and Delivery of Services

Most hazardous materials spills will impact a limited area. Government operations within the impacted area may have services disrupted. If the chemical is such that an area must be closed for an extended time or the method of service delivery is destroyed, it will be necessary for services to be maintained through new routing or delivery methods. If the spill impacts some portion of an agency or government directly, then there may be a loss in operational continuity.

Property, Facilities, and Infrastructure

Property, facilities, and the infrastructure may all be damaged by different individual spills. Hazardous material spills may contaminate a facility so that it must undergo extensive cleaning, or in the case of some radioactive materials, abandoned permanently. Hazardous material spills may also ignite, explode, destroy, and corrode objects or infrastructure in proximity, leaving it in need of replacement.

The Environment

Environmental impacts can range from relatively minor, short-term incidents, like many of the spills that occur annually in the county, to major events with long-lasting effects spanning multiple years. Two major national incidents, the Exxon Valdez oil spill and the Cantara/Dunsmuir spill show how a major spill can damage the environment, sometimes for decades.

The damage in the aftermath of the 1989 Exxon Valdez oil spill has continued to plague the environment. While the actual death of wildlife has declined other issues have continued. Studies have shown that “lingering oil deposits affect species over many years…” In many species “sublethal, chronic doses compromise health, growth and reproduction…” This can have a cascade impact as the various “impaired species interact negatively with one another…[12]"

In the case of the Cantara/Dunsmuir chemical spill of July 14, 1991, 19,000 gallons of metam sodium, a potent herbicide and pesticide that is usually used to sterilize soil, spilled from a train tank car into the Upper Sacramento River. It killed off all aquatic life in the river and damaged the riparian habitat for 41 miles to Lake Shasta. Its initial reaction with water created a toxic cloud that kept responders away until it had dissipated.

Vegetative damage from the spill resulted in a sudden and catastrophic reduction in canopy cover and foliage along the river, with a corresponding loss of many wildlife species dependent on the river’s riparian vegetation. Wildlife such as birds, bats, otters, and mink either starved or were forced to move because their food sources were no longer available.

Ultimately, over a million fish, and tens of thousands of amphibians and crayfish were killed. Millions of aquatic invertebrates, including insects and mollusks, which form the basis of the river’s ecosystem, were destroyed. Hundreds of thousands of willows, alders, and cottonwoods eventually died. Many more were severely injured. The chemical plume left a 41-mile wake of destruction, from the spill site to the entry point of the river into Shasta Lake.[13]

The damage caused by both of these spills to the environment has taken many years to overcome.

Economic and Financial Condition

The economic consequences of a large hazardous material spill can be wide ranging and can last for years. Financial problems are dependent on the chemical(s) released, the size of the spill, the number and size of the businesses impacted, the number of homes impacted or destroyed, which pieces of infrastructure have been impacted, and the complexity of and length of time to complete the cleanup. If the facilities have burned or the cleanup takes an extended time, the economic losses are compounded. If the chemical(s) released do not allow cleanup, as a radioactive substance might, the economic impact could be permanent.

Public Confidence in the Jurisdiction's Governance

Generally, there is no change in the public's confidence in a jurisdiction for the routine small spills. Public scrutiny of the role local government played in the handling of a large or dangerous spill will impact the way it is regarded in the future.

Pipelines

Identification Description

Definitions

Although there are many different substances transported through pipelines including sewage, water, and even beer, this subsection will focus on transportation arteries carrying hazardous liquids and gaseous substances.[14] According to the U.S. Code Title 49 Subtitle VIII chapter 601, "Pipeline transportation means transporting gas and transporting hazardous liquid."[15] Pipelines may be buried or above ground.

Types

This subsection is concerned with the two interstate pipelines that transport petroleum products and natural gas through Pierce County and the pipeline that delivers jet fuel to Joint Base Lewis/McChord. All three pipelines are capable of a catastrophic spill or leak that could devastate a large area in its proximity. While there are crude oil pipelines in Washington, there are none in Pierce County.

The small gas pipeline systems for local distribution, while not operated or controlled by the pipeline companies, can also pose a safety risk. Cities, towns and those portions of the county that have gas distribution systems need to be aware of the condition of any underground gas pipeline systems serving their facilities. For the purposes of this subsection, we will consider only those three companies transporting large quantities of product over distance, not the distribution and residential systems prevalent in many of our communities.

Profile

Location and Extent

Current Pierce County pipelines include Northwest Pipeline Corp, Olympic Pipeline Company, and Par Pacific. Between these they contain 80.93 miles of natural gas pipeline and 44.68 miles of liquid petroleum product pipeline.

Northwest Pipeline Corporation[16] is a primary conveyer of natural gas to the Pacific Northwest and the Intermountain Region. It transports natural gas at a pressure of up to 960 pounds per square inch (psi). A subsidiary of Williams Pipeline, it enters the County as a 30-inch line from the north on the Muckleshoot Indian Reservation. Crossing to the west of Lake Tapps, it skirts the eastern edge of Sumner and the southeastern portions of Puyallup. Here at 192nd it joins a 36-inch line that replaces an old 26-inch line[17]. It then crosses Meridian around 122nd and continues southwest until just east of McKenna where it crosses the Nisqually River.

Olympic Pipeline Company has a 14-inch gasoline pipeline that runs through Pierce County coming in from the north along the Interstate 5 corridor, passing through the west edge of Milton and the south section of Fife. In Fife, the main line turns south, crosses the Puyallup River and proceeds to Fredrickson. From there it changes direction going southwest. It crosses Joint Base Lewis/McChord, goes through Roy and crosses the Nisqually River downstream of McKenna. It carries gasoline, diesel and aviation fuel at pressures of up to 1,400 psi.

There are two transfer points for fuel in Pierce County. The first, the Tacoma Delivery Facility, delivers fuel through feeder lines to several points in the Tacoma port/industrial area. The second, the Spanaway Delivery Facility, delivers fuel to Puget Power.[18]

McChord Pipeline is a wholly owned subsidiary of Par Pacific Holdings Inc. At 14.25 miles in length, it is the shortest of the pipelines in Pierce County. It transports JP-8 jet fuel from the terminal in the Port of Tacoma, to Joint Base Lewis/McChord.[19]

Occurrences

One of the larger pipeline incidents, and one that could have caused even greater damage, was the rupture of the 16-inch gasoline line owned by Olympic Pipeline Company, on the afternoon of June 10, 1999, in Bellingham, Washington. That spill of 277,200 gallons of gasoline into Hanna and Whatcom creeks exploded killing three boys. The resulting fireball sent a plume of smoke 30,000 feet into the air.[20] (See Figure 4.5-2 Olympic Pipe Line Rupture 06/10/99.) That incident could have been much worse if the gasoline had not ignited before entering much of the downtown portions of Bellingham. Instead, by igniting when it did, most of the damage was confined to Whatcom Falls Park, a few residences and the water treatment plant located at the park.

Figure 4.5-2 Olympic Pipeline Rupture 06/10/99

The only significant occurrence of a spill, on any line, natural gas or petroleum product in Pierce County, was the Northwest Pipeline Corporation natural gas incident on May 1st, 2003, in Sumner[21]. This incident, caused by pipe corrosion, did not result in an explosion. However, the venting gas was heard for some distance and a small area nearby was evacuated. The line was shut down and repaired without further incident.

Recurrence Rate

The transportation of both natural gas and refined petroleum products is most safely done by pipelines. Due to the immense quantities of product that have to be delivered throughout the country, not only would it be nearly impossible to fill the need with trucks, it would also dramatically increase the potential for accidents and the resulting spills on the highways. While minor leaks happen in the local distribution systems, a major leak from either a natural gas or gasoline pipeline is a rare occurrence. With only one Pierce County incident recorded in the past ten years the recurrence rate is estimated to be ten years or more.

Impacts

The impacts from a natural gas pipeline incident compared to one from a petroleum product pipeline can be quite different. This section will therefore treat the two as separate incidents.

It must also be acknowledged that this section is based on a single break at any one time. In the advent of an earthquake there could be many breaks along one or more of the pipelines at the same time. This will increase the risk near the pipelines to individuals, businesses, the infrastructure, and the environment.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Natural Gas Pipeline

Natural gas is listed as a hazardous material due to its flammability. While it is non-toxic, it can replace the oxygen in the blood stream causing suffocation.[22] Natural gas is 40 percent lighter than air so a rupture can cause the gas to rapidly rise into the atmosphere. This limits the potential for suffocation unless a person is in an enclosed space directly within the area of the leak where the gas may be able to replace the oxygen.

While flammability and the explosive nature of the gas is the main threat, it takes a proper ratio of gas to air to create a combustible mixture. The approximate range of flammability is from 4.0 to 14.0 percent.[23] Unless there is the proper mixture of gas and air combined with a spark or fire, there will be no explosion. In most cases of natural gas pipeline ruptures, there are no fiery explosions, no injuries, and no deaths. Data from all-natural gas pipeline incidents in Washington State from 2000 to 2009 show a total of only seven incidents, none of which had a fatality or injury associated with it.[24]

Health and safety impacts in the affected area can range from minor burns, including frostbite from the cooling gas, and difficulty breathing, to death from aspiration or explosion.

Petroleum Product Pipeline

Petroleum product vapors coming from a liquid spill are the initial threat to persons in the impacted area. The vapors are heavier than air and will pool in low areas. Inhalation of the vapors can cause nose or lung irritation, produce dizziness or headaches, vomiting, and in large enough quantities can lead to coma and death.[25] Suffocation is a real possibility in low areas, gullies, creeks, or basins. Of the three people killed in the June 10, 1999 Olympic Pipeline rupture, one was overcome by the fumes while fishing and fell into the creek and drowned prior to the ignition[26].

The biggest threat to lives is through ignition of the product. Ignition of the various petroleum products, whether they are gasoline, diesel, or a kerosene product, can injure anyone in the vicinity. Burns ranging from minor to fatal would be the primary impact of those in the vicinity of an explosion.

Health and Safety of Personnel Responding to the Incident

Natural Gas Pipeline

With the natural tendency of the gas to escape into the atmosphere, there should be little threat to first responders. As soon as a leak or rupture is discovered the Northwest Pipeline will shut off the gas flow and allow the remaining gas in the line to dissipate. If the gas has ignited, shutting it off will allow the flame to burn itself out. Then a repair crew will go in and repair the line.

A threat to first responders is possible when a person is injured requiring aid in the vicinity of the leak or break. The possibility of an ignition source close to the break causing it to ignite, or medical or rescue personnel themselves, unwittingly causing it to explode, could cause injury or death to the responders.

Petroleum Product Pipeline

The threat to rescuers is the same as for the public. Petroleum product vapors coming from a liquid spill will be a threat to first responders attempting to rescue those in the impacted area. Entering the impacted area could open first responders to both the explosive potential of the product as well as the physical consequences of inhaling the vapors. As with the public, the biggest threat to lives is through ignition of the product.

Continuity of Operations and Delivery of Services

Natural Gas Pipeline

A rupture of a natural gas pipeline could cause a disruption in the delivery of services to the localized area impacted by the break. Due to natural gas being forty percent lighter than air there will be little, if any dispersion, into the surrounding community. If a break occurred near or under a major transportation route it could require rerouting of services around the area until the line is repaired. If in a community, it could require the evacuation of residents, businesses, or governmental offices for a period of time until the line is closed, the pressure is reduced, and the gas line is purged of any remaining product. If a rupture resulted in a fire, local buildings may be directly impacted and, if they belong to a local governmental body, could further delay some services. Due to the limited area impacted by a natural gas pipeline rupture,

there should be no loss of service delivery for any extended period of time and no disruption of governmental operations.

Petroleum Product Pipeline

Both petroleum pipelines are in areas that include high industrial, business, and infrastructure use. The 1999 Olympic Pipeline rupture and spill provides a perfect example of the kind and size of spill that is possible in Pierce County. Depending on its location, a break causing a significant release, with or without an explosion or fire, could require evacuation of many homes, businesses, schools, and government buildings. In the right place, it could require the closing of the Interstate 5 or State Route 512. While a release, even with an explosion and fire, will not shut down the County's operations, it will prevent the delivery of services to the impacted area. Depending on the size of the spill, its location, the population impacted, and whether it ignites, service delivery could be compromised for a period ranging from a couple of days to weeks.

Property, Facilities, and Infrastructure

Natural Gas Pipeline

During a rupture, the pressure in a natural gas pipeline can disrupt or blow the soil from above the break. Any facility or piece of infrastructure over or adjacent to the rupture could be damaged or destroyed. If the gas ignites it will set flammable objects above it or near it on fire. Depending on environmental factors such as wind, proximity of vegetation or other fuels, and dryness of the environment, the fire could spread to other nearby structures damaging or destroying them.

Petroleum Product Pipeline

A spill that does not ignite is treated as a very large hazardous chemical spill. It can contaminate buildings and destroy equipment and documents. As a liquid, its tendency to penetrate porous material can irreparably damage many items requiring their replacement.

The biggest threat from a petroleum product pipeline rupture is from the potential fire or explosion, if the spill ignites. It can destroy property, buildings, equipment, businesses and government records. The heat can melt and ignite road asphalt, destroy electric powerlines, and weaken the metal on transmission and cell towers. It can damage bridges and railroad lines forcing a rerouting of normal traffic possibly for months.

The Environment

Natural Gas Pipeline

Environmental damage from a natural gas pipeline should be very limited, even if a fire has started. The immediate disruption to the surface environment will take a while to re-vegetate, but without a fire, there should be no long-term effects. If a fire is initiated, the impact will be more apparent, but, like any other fire will eventually heal. With a natural gas line rupture there are few, if any, residual products in the soil that could cause environmental problems years later.

Petroleum Product Pipeline

Spills from a petroleum product pipeline can have a major long-term impact on the environment even if the product does not ignite. Petroleum products, in concentration, are hazardous to both plants and animals. Acute short-term exposure by animals can cause burns, eye irritation, neurological impacts and lung damage that can lead to coma and death.[27]

Liquid petroleum products will, like water, seek the lowest place. A large spill will therefore flow down gullies, entering streams and rivers damaging fish, fish habitat, waterfowl, and mammals that rely on that watercourse. A spill's long-term environmental impacts can include pollution of the soil, the groundwater, and even, depending on the underlying strata, the local aquifer.

A large petroleum pipeline rupture resulting in an explosion and fire will effectively destroy all vegetation and animal life in the burned area. Eventually this will begin to return to the pre-spill condition, although, depending on the scale of the damage, it might take years. There was a resurgence of vegetation in Bellingham's Whatcom Falls Park in 2003, four years after the spill and explosion that destroyed large portions of it. While the tall firs that were destroyed still stand, the understory has already largely reclaimed the damaged property.

Economic and Financial Condition

Natural Gas Pipeline

Due to the usually limited nature of the damage from a natural gas pipeline rupture and explosion, the economic impacts should be limited to any businesses in the immediate vicinity of the rupture and to the owner of the pipeline itself. Unless there is direct damage to roads or rail, rerouted traffic should be back to normal within a short period after the line has been purged and any fire put out.

Petroleum Product Pipeline

The economic and financial impact from a petroleum product pipeline rupture, spill, and explosion would vary considerably depending on where in the county the incident occurred. A rupture and resulting explosion in the Port of Tacoma could destroy many businesses,

temporarily closing some international shipping terminals, and impacting rail lines. If close to Interstate 5, it could close the freeway requiring a rerouting of north-south traffic until such time as the fire is put out and clean up around the freeway is complete.

In contrast, a rupture, with a resulting fire, in the southern portion of the county would impact a small, local population. While the economic impact to those communities would be high the overall impact to the county would not be significant.

Public Confidence in the Jurisdiction's Governance

Natural Gas Pipeline

Unless there is some circumstance that exacerbates the problems associated with the rupture, there should be little if any impact on the public's confidence in whichever jurisdiction the incident happens. Normal response should be similar to the 2003 natural gas line rupture in Sumner. In this case, there was a small evacuation, the fire department responded, Northwest Pipeline shut down the gas, bled out the line, and repaired it.

If there are exacerbating problems, for example a highway closure, fiery explosion damaging buildings or causing deaths, the public's confidence will depend entirely on how effective the response was perceived to be. If there are questions about the response, the public's confidence will decrease. If the response is perceived to be good, there will be no decrease in the public's perception of the incident.

Petroleum Product Pipeline

The public's confidence will be directly related first to the immediate impact on themselves. A spill and explosion in the southern, rural portion of the county that impacts very few people will not have people questioning the response nearly as much as one in the more populated, industrialized portions. This is especially true if there are many deaths, economic loss is great, or the infrastructure that impacts them personally is compromised. There will be comparisons with the 1999 Bellingham incident that will question whether the oversight that was implemented since then, was adequate and carried out.

Transportation Accidents

Identification Description

Definitions

Transportation accidents, as used in this assessment, include accidents involving a method of transportation on the road, rail, air, and maritime systems within Pierce County.

Types

Small accidents between a small number of motor vehicles, small watercraft, or an accident involving a small private plane are not included in this definition. Instead, accidents must involve a level of complexity that taxes first responder systems or triggers the activation of the mass casualty incident plan, mass fatality incident plan or response to violence plan. Since hazardous materials are covered in the "Hazardous Materials" Subsection, this subsection, while mentioning it as contributing factor, will not emphasize it.

Road Transportation

Pierce County is traversed by 11 state highways, one interstate with a short interstate feeder into downtown Tacoma, and numerous roads and streets.

Rail Transportation

Passenger, freight, and tourist rail lines exist in various places in Pierce County. This includes Burlington Northern Santa Fe (BNSF) Railroad, Fort Lewis Rail, Sound Transit, Tacoma Rail, Tacoma Rail Mountain Division, and Union Pacific Railroad.

Air Transportation

Pierce County is home to thirteen working airports. (See Table 4.5-2 Airports in Pierce County.) Air traffic consists of private fixed wing, sea planes, small commercial jets, helicopters, and a large contingent of military aircraft.

Maritime Transportation

The Port of Tacoma is a major terminus for commercial vessels. Ships also traverse the western portions of the county in route to and from Olympia. Ferry routes cross between Steilacoom and McNeil, Anderson, and Ketron Islands. Vashon Island has a Washington State Ferry route that runs between Point Defiance and Tahlequah on the Island's southern end. A small private

ferry runs between the Longbranch Peninsula and Herron Islands. Commercial tour boats spend time in Pierce County waters as do hundreds of private boats of all types and sizes.

Table 4.5-2 Airports in Pierce County Overview

Airports in Pierce County		
Airport	**Location**	**Owner, Use**
Gray Field	Joint Base Lewis/McChord	US Army - Military
McChord	Joint Base Lewis/McChord	US Air Force - Military
Thun Field	S. of Puyallup	Pierce County - Flight Training, Lt. Jet Traffic, Helicopter, Commercial, Charter
Tacoma Narrows	Gig Harbor	Pierce County - Flight Training, Charter, Lt. Jet Traffic, Helicopter, Commercial
Spanaway	Spanaway	Public
American Lake Seaplane Base	Lakewood	Seaplane
Swanson	Eatonville	Public
Kapowsin Field	Kapowsin	Private
Mt. Rainier, Kautz	Kautz Creek	Federal - Helicopter
Fitz Pad 2 Heliport	Graham	Private - Helicopters and single engine planes.
Shady Acres	Spanaway	Private
Cawleys South Prairie	South Prairie	Community
Burnett Landing Airport	Wilkeson	Private

Profile

Location and Extent

Hazardous Materials

The various forms of transportation throughout the county have considerable potential for accidents that could threaten Pierce County's infrastructure, communities, and livelihood.

Road Transportation

Privately owned vehicles and local bus services provide the primary means of transportation for individuals in Pierce County. Freeways, highways and roads serve the area. Important roadways include Interstate 5, State Highways 16, 123, 161, 162, 163, 167, 410, 509, and 512. All major highways carry high volumes of traffic, including large numbers of commercial vehicles carrying goods, and in some cases hazardous materials. Transit, school buses, and even bicyclists

(including marathons) also use these roads. A major road transportation emergency could be caused by an accident involving any one of these carriers. Many traffic accidents, even when a death occurs, are considered routine and not a major incident. The type of situations where an incident could be considered major might involve an Amtrak train landing on the I-5, a semi-truck losing brakes and running into businesses, or a semi-truck carrying hazardous materials exploding during rush hour traffic. If carrying hazardous materials, surrounding areas could require sheltering in place or evacuation.

Rail Transportation

The rail lines run through the county and through or near the edges of DuPont, Steilacoom, Lakewood, University Place, Tacoma, Fife, Puyallup, Sumner, and Bonney Lake. Passenger transportation exists in Pierce County in the form of Amtrak, the Sounder, and Tacoma Link. Amtrak follows the tracks along Puget Sound north of the Nisqually River to Point Defiance, then through Tacoma and Puyallup and up the Auburn Valley. Sound Transit provides weekday service and covers special events on the Sounder between Lakewood and Everett and the Tacoma Link between Tacoma Dome and the Hilltop District. Burlington Northern/Santa Fe and the Union Pacific have lines which run north and south through the county. The railroad owned by the City of Tacoma transports goods and materials around the Port of Tacoma. It also operates the 132 miles of line out to Fredrickson and south out of the county to Morton and Chehalis. The Mt. Rainier Scenic Railway, a small privately-owned tourist rail line, runs from Elbe up the Nisqually River valley and then south along Mineral Creek to Mineral Lake in Lewis County.

Air Transportation

The fourteen active airports or airstrips in Pierce County range tremendously in size and use. At one end of the scale there are McChord and Gray Fields, both major US military facilities. At the other end of the scale, there are small fields like Spanaway and Ranger Creek or the heliport at Kautz Creek in Mt. Rainier National Park. Aircraft come and go from some of these small runways daily, while others have more casual use. Many of the smaller airports in the county were built in rural areas with low population. Over the years, as the county's population base expanded, many of these have now become part of the suburban landscape, surrounded by neighborhoods and businesses.

Pierce County owns two small commercial airports, Thun Field and the Tacoma Narrows Airport. Pierce County has the added risk of being directly in the flight path for many planes either landing or taking off from Sea-Tac International Airport in King County.

Maritime Transportation

Marine transportation accidents can be classified into two types: those that directly involve large numbers of people in a potential mass casualty accident, such as a ferry sinking, or those that threaten the larger community or the environment, such as a fire on a ship carrying hazardous chemicals.

If a fully loaded ferry were to capsize or sink, the injuries and death tolls could be very high depending on weather and amount of notice before the vessel is submerged. In addition to passenger ferries, there are a number of tour boat operators who work the waters around Pierce County. Depending on the boat, they may have anywhere from ten to a couple hundred people on board.

Commercial shipping traffic in Pierce County follows well defined shipping lanes. The majority of all types of commercial traffic flows through the Port of Tacoma. A major fire, hazardous chemical spill, or explosion, either on board or at the Port, could affect not only the City of Tacoma, but depending on wind direction and size of the incident, also Browns Point, Federal Way, Fife or even Puyallup. A much smaller volume of material, usually on small ships or barges, passes through the Tacoma Narrows.

Because of the quantity of materials carried by some of these vessels, a spill, explosion, or onboard fire could affect a significant coastal population. Marina fires, although connected to the land, can damage or destroy surrounding vessels or spread onshore to facilities. There will be no further coverage of marina fires in this plan.

Table 4.5-3 Ferry Service in Pierce County

Name	# of Cars	# of Passengers
McNeil Barge and Tug	16	75
McNeil Foot Ferry	0	336
Pt. Defiance Ferry	65	546
Anderson Island Ferry	54	250
Herron Island Ferry	12	49

Occurrences

General occurrences are summarized below. For more notable incidents see Table 4.5-4 Transportation Accidents/Catastrophic Failures in Pierce County.

Road Transportation

Over the years, there have been several major accidents in Pierce County. While many of these have happened along the I-5 corridor, others have happened on other major roads, especially

on State Route 16 at the Narrows Bridge. The various causes include heavy fog, freezing rain, side winds (especially on the Narrows Bridge), or ice forming on bridges. These types of accidents happen every year. Occasionally tanker trucks, chemical trucks, busses, or other vehicles are involved in a major accident. Some of these accidents have closed the highways for portions of a day and some have required evacuation of neighboring buildings. However, none have caused a large, long-term evacuation or closure of a highway.

Rail Transportation

Of rising concern is the transportation of Bakken crude oil which brings 123,000 barrels/day or 5,160,839 gallons/day into Pierce County[28]. Although there have not been any major derailments of Bakken crude oil in Pierce County, there have been a considerable number in Canada and the US. Two major derailments of significance include the Lac-Mégantic, Quebec, Canada 63 car derailment on July 5, 2013 which resulted in the death of 47 people due to fire and other effects of the accident.[29] The other derailment was on April 30, 2014 in Lynchburg, Virginia where 17 of 105 tank cars fell into the James River, spilling almost 30,000 gallons of crude oil.

Air Transportation

Pierce County has been the scene of dozens of airplane crashes over the years. Most of these have been small aircraft with one or two people in them. Some examples include test pilots from Boeing crashing within the county, military planes flying into each other, and pilots crashing during 4th of July celebrations. Ultralights have crashed and there is even an incident of a plane attempting to take off without its pilot. Mount Rainier, sticking up above the rest of the county, has accounted for several accidents. In addition to these problems, pieces of planes have occasionally fallen off during flights such as when a jet tire fell on Brown's Point, when a jet canopy popped off and hit a home in 1954, when a piece of a C-141 Starlifter fell into a yard in 1979, and in 1984, when the tail cone of a Boeing 747 fell into a field north of Puyallup.

Maritime Transportation

The last two major vessel fires in the Port of Tacoma were in 1986 and 1989. There have been several small craft that have exploded and burned or sank, as well as fires at marinas. In addition, there are the occasional freighters, like the Ocean Steelhead in 1983 or the Ace Accord in 1986, which have listed and come near to sinking in the Port of Tacoma. Barge shipments containing thousands of gallons of petroleum products are regularly transported up Puget Sound from Tacoma.

Bridges

There were two major bridge closures in Pierce County due to failures in 2025. Advanced deterioration of the SR 165 bridge over the Carbon River near Fairfax was discovered in spring 2024 forcing additional weight restrictions on the already restricted bridge. Additional inspections in 2025 revealed significant structural deterioration resulting in the permanent closure of the bridge in April 2025. In August 2025, the SR 410 White River Bridge, a vital link between Enumclaw and Buckley, was closed after an over-height truck struck the bridge's support beams. The bridge was repaired and re-opened to traffic on in October 2025.

Table 4.5-4 Transportation Accidents and Catastrophic Failures in Pierce County

Date	Description
Air	
August 10, 2018	A Horizon Air employee stole a 76-person turbo prop plane around 8:00 p.m. from Seattle-Tacoma International Airport and about an hour later crashed it into the south end of Ketron Island (the north end has six cabins). The employee was killed in the crash and no one else was injured.
April 1956	Northwest Orient Airlines flight crashed into Puget Sound on the Pierce/King County border off Dash Point. Of the 37 people on board, all but three survived.
November 27, 1952, Thanksgiving night	A C-54 transport crashed in southern Pierce County killing 37 of the 38 people on board. The lone survivor was a young boy who lost his parents, two brothers and a sister in the crash.
December 10, 1942	Marine transport plane with 32 aboard lost their lives when it crashed into the side of Mt. Rainier.

Date	Description
Maritime	
August 4, 2019	On Sunday afternoon around 4:30 p.m. Pierce County Planning and Public Works ferry had a catastrophic mechanical failure of the ramp while docked at Anderson Island. This lasted for less than 24 hours but approximately 100 people were impacted as they couldn't get home or go to work the next day. Many people had to leave their vehicles either on the ferry or left them in the ferry lanes on both Anderson Island and Steilacoom.
August 31, 2005	Harborview Marina Fire in Gig Harbor damaged 55 boats and sank 48 of them.[30]
Air	
December 18, 2017	At 7:34 a.m. southbound Amtrak passenger train 501, consisting of ten passenger railcars, a power railcar, a baggage railcar, and a locomotive at either end, derailed from a bridge near DuPont, Washington. Several passenger railcars fell onto Interstate 5 and hit multiple highway vehicles. At the time of the accident, 77 passengers, five Amtrak employees, and a Talgo, Inc., technician were on the train. Of these individuals, three passengers were killed, and 57 passengers and crewmembers were injured. Additionally, eight individuals in highway vehicles were injured.
July 2, 2017	At approximately 2:30 p.m. an Amtrak passenger train carrying approximately 250 people derailed near Chamber Creek Rd in Steilacoom. Four rail cars went off the track and there were four injuries. One was from the train derailment and the other three fainted from heat exposure at 92 degrees.
February 26, 2011	A 103-car freight train derailed and side-swiped a 14-car train. The smaller train, carrying four cars of sodium hydroxide, had three cars land on the shoreline near the Chambers Bay Golf Course in University Place. In this incident an estimated 50 gallons of sodium hydroxide discharged into the beach.[31,32]
May 16, 2007	See Figure TA-1 Train Wreck on Mounts/Old Nisqually Road. Minor amounts of diesel were spilled, and three people were trapped and had to be rescued. This incident closed the Mounts/Old Nisqually Road for five days.[33]
February 1996	Freight train carrying chemicals derailed near DuPont during the winter storm and partially went into the Puget Sound. The tank cars were damaged but intact so very little spillage. Not many people were injured as a result.

Date	Description
1984	Amtrak derailment along shore of Puget Sound near DuPont. People only suffered minor injuries.

Recurrence Rate

Small transportation accidents happen in Pierce County on a daily basis and mostly occur on the roads and highways. The large-scale accidents that threaten the lives and livelihood of a large number of individuals are less frequent. Reviewing the information above would point to a ten year or less recurrence rate for all types combined.

Impacts

The impacts of a major transportation accident, although varying depending on the type of accident and the vehicles involved, will have similar factors. Differences between them are discussed as necessary.

Health and Safety of Persons in the Affected Area at the Time of the Incident

The potential for injury and death are the major impacts from all types of transportation accidents. Traumatic injuries and possible burns are the primary results. For the survivors of a major incident, with many dead and injured, posttraumatic stress disorder (PTSD) and posttraumatic stress (PTS) are psychological impacts that affect first responders, adults and children. With ferry or other marine transport accidents, the potential for drowning and/or hypothermia are additional threats. An out of service ferry to Anderson or Fox Islands can prevent individuals from delivering baby food, medications, and other essential items, such as fuel, which can be a dire need, especially in the winter.

Health and Safety of Personnel Responding to the Incident

The threats to the health and safety of personnel responding to the scene of transportation accidents depend on the environmental factors associated with each incident. Threats include inhalation or contact with hazardous chemicals, fire, explosion, and in water rescues, drowning and hypothermia. As mentioned above posttraumatic stress disorder (PTSD) and posttraumatic stress (PTS) are psychological impacts.

Continuity of Operations and Delivery of Services

Impact to the continuity of operations and the delivery of services to the public will depend on the type of transportation and the location.

Road Transportation

An incident on the highways while damaging, should not impact the delivery of services or the continuity of operations for any jurisdiction for more than a short period of time (a couple of days). Establishing detours for all major routes is a standard operating procedure that happens frequently.

Rail Transportation

Continuity of operations should not be compromised by a rail accident in most jurisdictions in the county unless there is something to compound the problem. This would most likely be a chemical spill, especially in the form of a toxic cloud. Delivery of services could be jeopardized by a train accident that damages or blocks access to critical infrastructure.

Air Transportation

The impact to continuity of operations and the delivery of services from an air transportation incident are directly connected to what is hit by the aircraft. Any object struck by an aircraft of any type will suffer damage. If government buildings are struck, the continuity of operations for that agency or even jurisdiction could be at risk. If a critical portion of the infrastructure is struck, it could impact the delivery of services that it normally carries out.

Maritime Transportation

A ferry accident that puts a ferry out of commission and/or destroys a ferry dock will heavily impact the delivery of services to the areas served. The ability to get a route back in service will depend on the time it takes to replace or repair the ferry or dock.

A ship sinking in Commencement Bay, especially at the entrance to the Blair Waterway, could restrict commercial traffic and impact the operations of the Port of Tacoma and have cascading impacts on the supply chain. Currently, 80 percent of Alaska's imports come from the Port of Tacoma providing food, medicines, and other essential supplies.

Other types of marine accidents, unless combined with an explosion or hazardous chemical spill, will probably not impact service delivery or the continuity of operations.

Property, Facilities, and Infrastructure

Road Transportation

Most road or highway transportation accidents will result in very little damage to facilities, infrastructure, or property due to the limited or localized nature of any highway accident.

Rail Transportation

Rail transportation events, localized in nature like road events, can cause considerably more damage to property, facilities, and infrastructure due to the size of trains and the quantity of materials carried. Any piece of property or facility near the tracks has the potential of being damaged or destroyed. This is compounded by any fire or chemical spill that is created by the accident.

Air Transportation

The crash of any aircraft can damage or destroy any property, facility, or piece of infrastructure that it hits.

Maritime Transportation

Any property along the Puget Sound shoreline is at risk from a maritime incident. This can come from the actual grounding of a vessel, complications from a fire, or the release of hazardous chemicals.

The Environment

Generally, given the localized nature of the accident, the environment will not be greatly impacted unless the accident involves some other complicating factor. While the normal spill from accidents on the roads and highways of the county can cause minor environmental damage, it seldom covers more than a few dozen square meters and, after some clean up, the environmental damage is not permanent and will resolve over time. Aircraft may contain a large quantity of fuel and, in many accidents, this will burn causing local fire damage. Those accidents might include a large chemical spill and/or fire from a train, aircraft, or a truck and may take months or years to be resolved.

Economic and Financial Condition

The economic impacts from any transportation accident are directly related to its impact on the ability for businesses and industries to move their goods into, through, or out of the county.

Road Transportation

With few exceptions, damage to roads or bridges from a single incident, while changing the transportation route that cargo travels on the highways, will have little impact on the economic environment. A repeat of the collapse of the Interstate 5 bridge over the Skagit River is an example of a road accident that impacted the local economic environment. Local businesses

had to deal with a change in traffic patterns creating excessive truck and other vehicle traffic clogging up roadways on the alternate routes.

Rail Transportation

A rail incident involving damage to tracks could force shippers to change the methods of commodity movement. Due to the large quantity of goods carried by a train, if they were destroyed, it has the potential to have a strong impact on the financial condition of individual companies. This would be especially true of the companies that operate on a "just-in-time" basis. In the larger economic scheme, while there might be some ripples, it is unlikely to create large changes in the economic climate of the county.

Air Transportation

Major airline companies have insurance that will get them through their financial hardships. Smaller companies or privately-owned aircraft may face real financial hardships, but this will not have a widespread impact on the economic climate in the county.

Maritime Transportation

The sheer quantity of goods loaded on ships and barges in Commencement Bay and docked at the Port of Tacoma means that a maritime accident, leading to one being damaged, sunk, or destroyed, could impact not only the local economic climate, but the financial wellbeing of companies that may ship material overseas or to some other part of the United States. If an accident were to block either the Blair or Sitcum Waterways, it would shut down a large portion of the commercial traffic through the Port with major economic repercussions.

Public Confidence in the Jurisdiction's Governance

Confidence in the jurisdiction will be limited considering many service providers are non-profits or the private sector. Questions that arise will include:

- Could the accident have been prevented?
- Who is at fault?
- Was the response well handled?
- How soon will things be back to normal or the issue resolved?
- What measures are going to be taken to prevent a repeat of the incident?

Depending on the answers to these questions the involvement of one or more jurisdictions could be applauded or criticized.

Endnotes

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[22] Incident Response: Natural Gas and Electric Incidents, booklet published by Puget Sound Energy, 411 108th Ave. N.E., Bellevue, EA 98004, p.4
[23] The range can vary due to differences in the chemical composition of the gas, "as well as temperature pressure and humidity", Incident Response: Natural Gas and Electric Incidents, booklet published by Puget Sound Energy, 411 108th Ave. N.E., Bellevue, EA 98004, p.5

[24] Washington Significant Incidents Listing, U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, http://primis.phmsa.dot.gov/comm/reports/safety/IncDetSt_st_WA_flt_sig.html?nocache=8206#_ngtrans
[25] Public Health Statement for Automotive Gasoline, Agency for Toxic Substances and Disease Registry, http://www.atsdr.cdc.gov/toxprofiles/phs72.html
[26] Olympic Pipe Line accident in Bellingham kills three youths on June 10, 1999, on historylink.org at http://www.historylink.org/index.cfm?DisplayPage=output.cfm&File_Id=5468
[27]The Oiled Wildlife Care Network, Wildlife Health Center, U. C. Davis, http://www.vetmed.ucdavis.edu/owcn/oiled_wildlife/index.cfm
[28] Bakken Crude Oil distributed by the NW Area Committee. February 2015. Data for calculation of statistics can be found on page 3.
[29] Ibid, page 7.
[30] Harborview Marina Fire at Gig Harbor, Washington Department of Ecology, report at http://www.ecy.wa.gov/programs/spills/accidents/harborviewmarina/HarborViewMarinaFirebase.htm
[31] Department of Ecology. (Dec. 1, 2011). *BNSF Train Derailment*. Retrieved February 23, 2015 from http://www.ecy.wa.gov/programs/spills/accidents/ChambersBayDerailment/ChambersBayDerailment.html
[32] Attachment distributed by the NW Area Committee in an email from Lori Gifford with the Washington Military Department lorri.giffore@mil.wa.gov dated 2/24/2015. Currently (dated Feb. 2015) around 19 trains/week in Washington State transport Bakken Crude Oil, of which 15 enter Pierce County. Bakken Oil is unloaded at (48,000 barrels/day) at U.S. Oil and (75,000 barrels/day) at Targa Sound in Tacoma.
[33] Information on this accident came from the incident logs, situation reports and other archived ICS documents from the incident.

Landslide

Natural Hazard 4.4

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Identification Description

Definition[1]

A landslide is the gravity-driven downslope movement of a sliding mass composed of rock, soil, and vegetation (see Figure 4.4-1 and Figure 4.4-2). Landslides can pick up and include anything else that might be in its path whether part of the natural or the developed environment. A landslide occurs when the downslope weight of the slide mass exceeds the strength of the soil along the slip surface. That is, when the driving force (downslope weight) exceeds the resisting force (soil strength).

Figure 4.4-1 December 2025 Flood, Landslide, and Severe Storm Event

Factors influencing the stability of a slope include the following:

- Steepness of slope;
- Composition of soil and rock;
- Groundwater conditions;
- Recent precipitation patterns;
- Slope aspect;
- Earthquake;
- Vegetation on slope; and
- Anthropogenic activities (land clearing, grading, etc.).

Figure 4.4-2 2007 Northeast Tacoma Landslide

Types[2]

There are five broad categories of landslides that commonly occur in Pierce County: Shallow Bluff Landslides, Dee-Seated Landslides, Shallow Landslides, Debris Flows, and Submarine Landslides.

Shallow Bluff

Shallow bluff failures occur on the steep Puget Sound marine bluffs. These landslides are limited in area (usually less than 1-2 acres). The removal of vegetation from the marine bluff, usually done to improve views, can lead to serious slope erosion and instability. These landslides are typically fast moving.

Deep-Seated Landslides

Deep landslides can be as large as tens to hundreds of acres and can occur on slopes with a gradient as low as 15%. Deep landslides are those that fail below the rooting depth of trees and vegetation and can be reactivations of older, pre-historic failures. They are often slow moving but can also move rapidly. Often associated with extended periods of precipitation (months to years) this is typically a structural/infrastructure hazard.

Shallow Landslides

Shallow landslides involve movement of a relatively thin layer of slope material and have a shallow failure plane (generally less than 10-15 feet deep). This type of landslide is Pierce County's most common and is often associated with land use or intense rain events. Shallow landslides can block roadways, damage homes, and threaten life and safety.

Debris Flows

Debris flows are water-saturated masses of soil, rock, and debris (tree trunks, limbs, etc.) that usually occur in steep gullies, move very rapidly, and can travel for many miles. Debris flows are typically triggered by intense rainfall and can run long distances when confined to a channel. Slopes where vegetation has been removed by fire or humans are at greater risk for debris flows and many other types of landslides. These landslides provide little or no warning and are more dangerous because of their speed. They can cause both property damage and loss of life. For a more detailed description of this type of landslide and vulnerabilities to it, see the Volcano and Lahar Subsection.

Submarine Landslides

Submarine landslides (landslides that occur primarily underwater) have also occurred in Pierce County on the delta of the Puyallup River. Triggering factors for submarine landslides include:

- Rapid sedimentation resulting in an over-steepened and unstable slope,
- Loss of soil strength due to static liquefaction caused by rapid drop in water level at high to low tide transition,
- Loss of slope support because of bottom current erosion of material at the base of the delta slope,
- Additional loading at top of the delta slope (e.g., artificial fill) increases the down-slope weight of the soil (driving force), and
- Earthquake shaking causing loss of soil strength (liquefaction) and increase in down-slope force on soil mass.

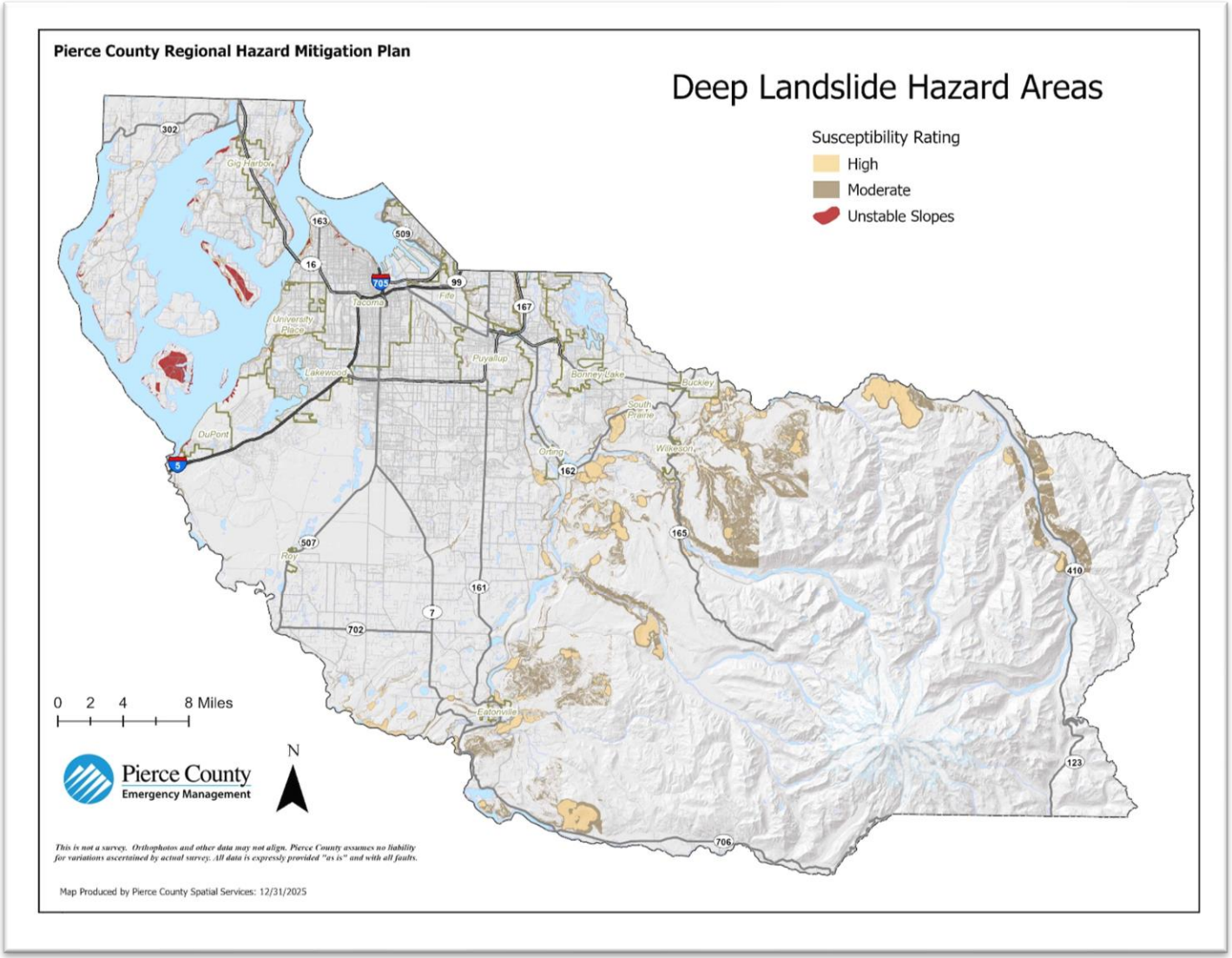
Large submarine landslides in the Pacific Northwest typically occur on the deltas of major rivers or streams, which can lead to tsunamis, see Tsunami and Seiche Subsection.

Profile

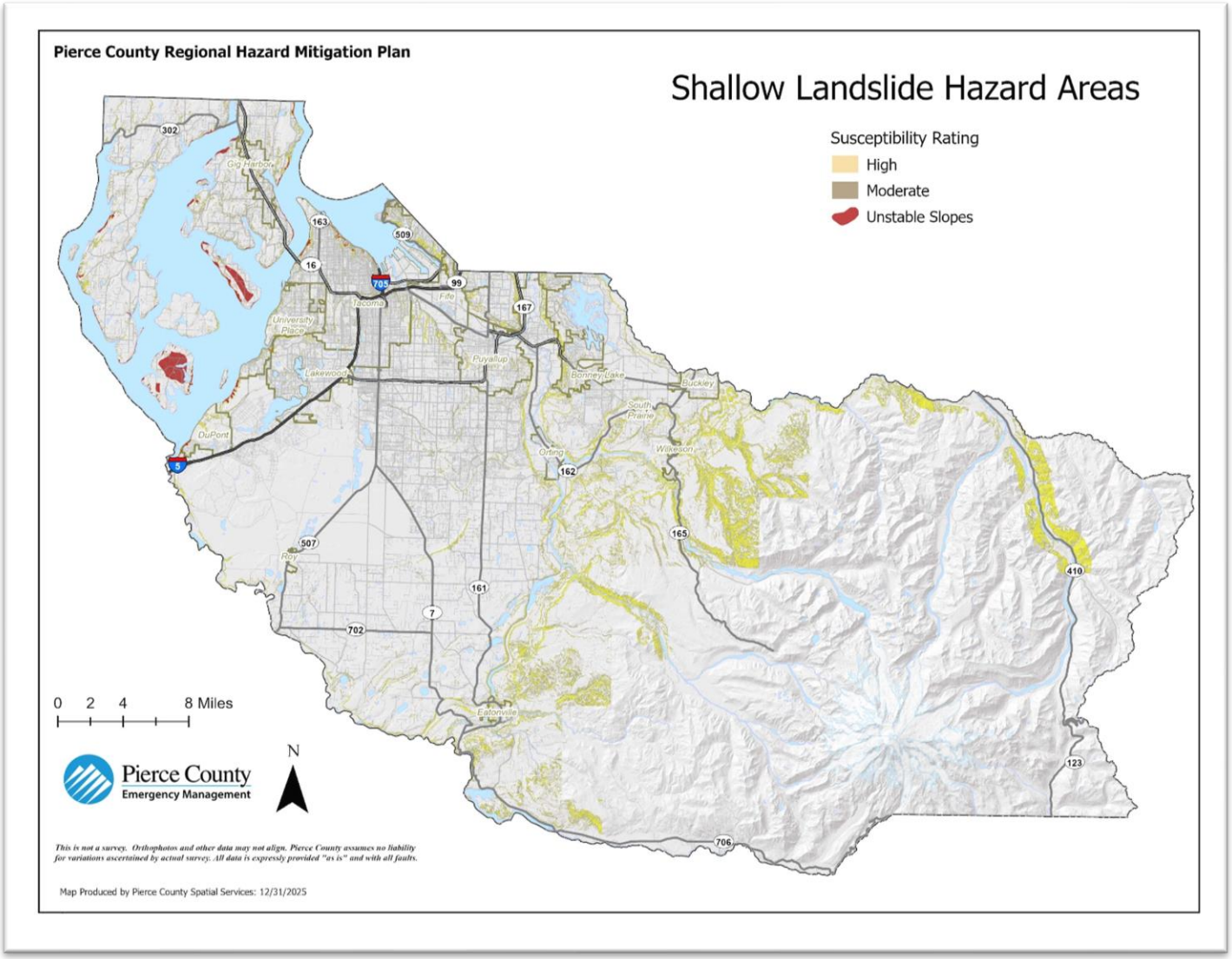
Location and Extent

Landslides directly and indirectly affect a small portion of the developed areas in the County. Map 4.4-1 shows the deep landslide hazard areas for Pierce County. Map 4.4-2 shows the shallow landslide hazard area for the County. The landslide hazard areas within the County include the walls of the major river valleys, the more mountainous regions, the coastal areas, and parts of the peninsula. Map 4.4-3 illustrates the steep slopes hazard areas of the coastal zones within the County. The most unstable coastal slopes are located on a small portion of the Kitsap peninsula, on the southwestern side of Fox Island, at Salmon Beach, and at various areas near DuPont.

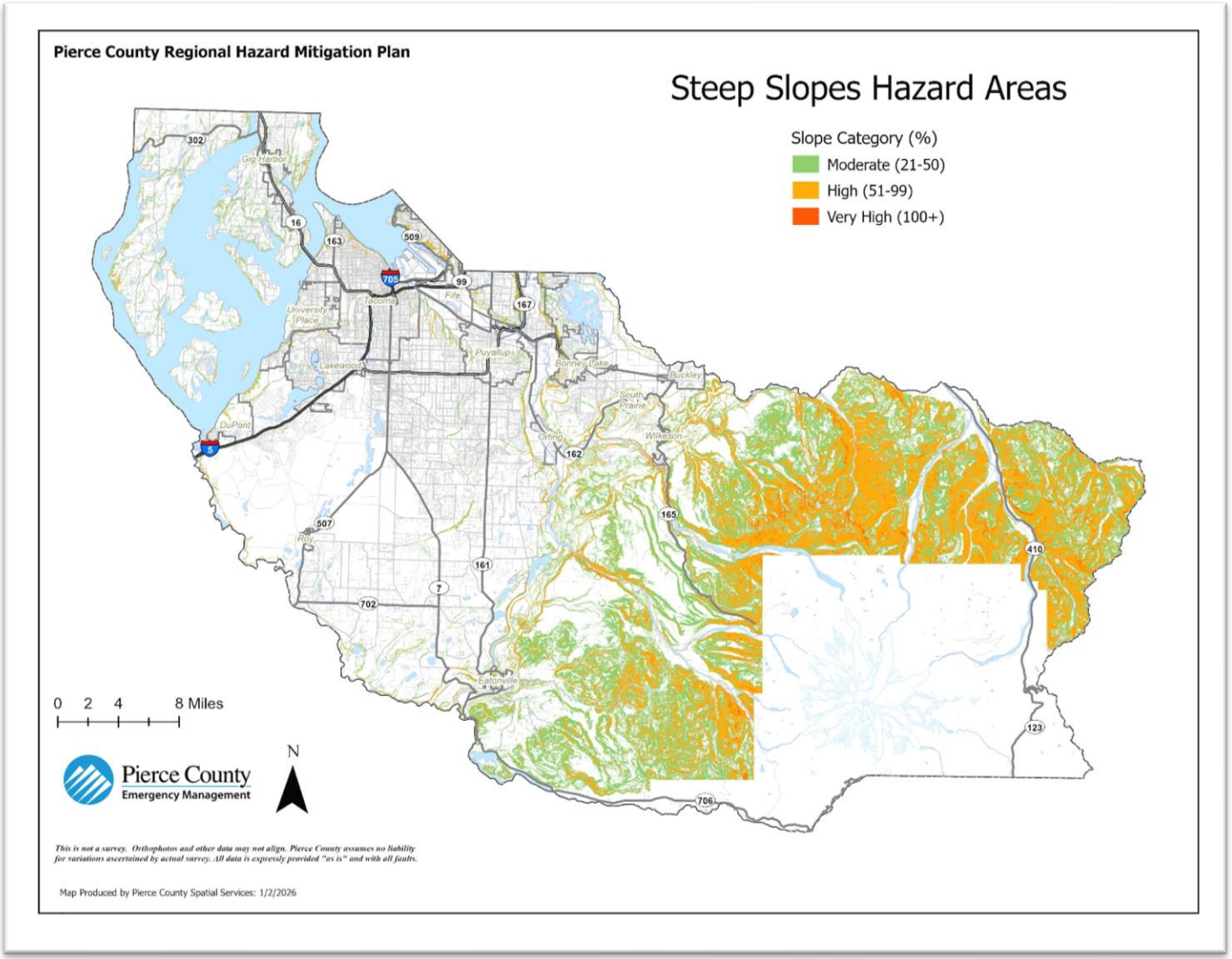
Map 4.4-1 Pierce County Deep Landslide Hazard Area



Map 4.4-2 Pierce County Shallow Landslide Hazard Area

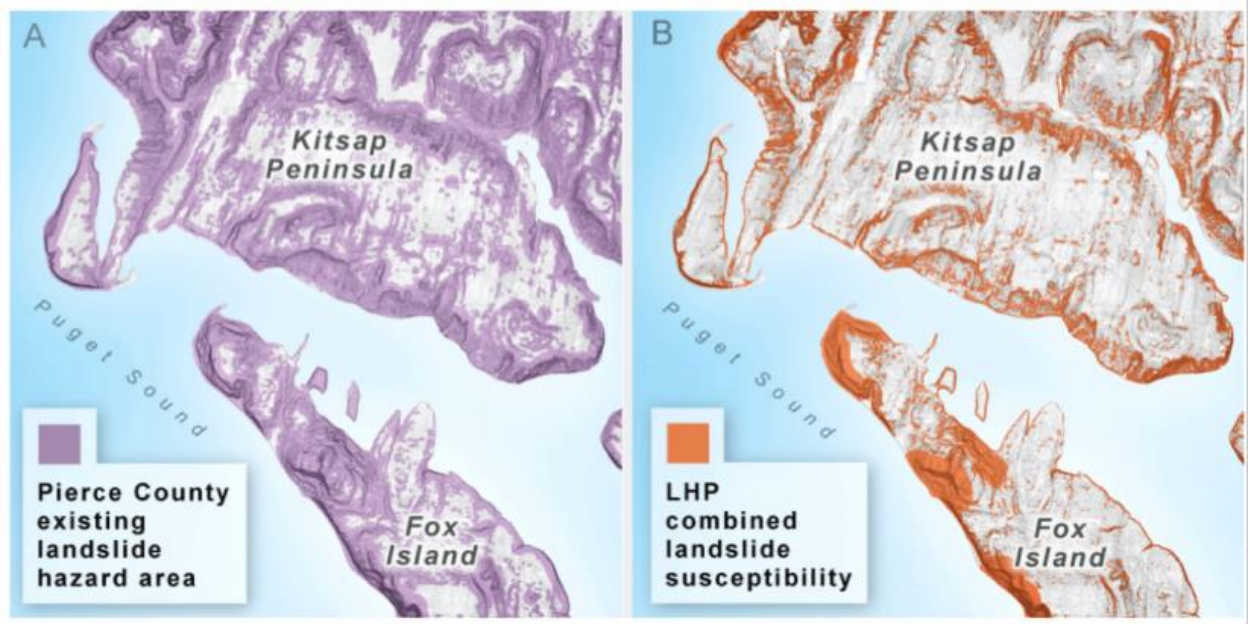


Map 4.4-3 Pierce County Steep Slopes Hazard Areas



The Washington Geologic Survey (WGS) landslide hazards program is in the process of updating their maps across the state. These include landslide inventory mapping (where landslides have occurred) and susceptibility mapping (where landslides may occur in the future). A comparison of the existing Pierce County unstable slopes map to the WGS landslide and susceptibility maps resulted in a 51% reduction in landslide susceptible areas (see figure 4.4-3 below). Pierce County had over 90% false positives (38,000 tax parcels were removed and 1,000 that were not previously identified were added).

Figure 4.4-3 Pierce County Comparison of Landslide Susceptible Areas



Occurrences[3]

Topographic and geologic factors cause certain areas of Pierce County to be highly susceptible to land sliding. Ground saturation and variability in rainfall patterns are also important factors affecting slope stability in areas susceptible to landslides. Strong earthquake shaking can cause landslides on slopes that are otherwise stable.

There is a history of landslides throughout Pierce County. In 1996, severe storms and flooding led to landslides occurring just west of Tacoma, and along Pioneer Avenue East, causing damage to homes and infrastructure. Examples of large, deep-seated landslides can be found in Pierce County on Fox Island, between Brown and Dash Points, along the Tacoma Narrows, and in the Dupont area. Table 4.4-1 lists some of notable and destructive landslides within Pierce County.

Figure 4.4-4 December 2023 Landslide on Johns Road East along Wilkeson Creek

Table 4.4-1 Notable Landslides in Pierce County

Date	Description
2025	In mid-December of 2025, an atmospheric river brought two weeks heavy rain to Pierce County and triggered several small landslides around the county. Landslides prompted closures at A.L. Card Road E south of 186th Ave. E, south of Orting; Johns Road E between AP Tubbs Road E and 156th Street Court E, near Wilkeson Creek; and Lower Burnett Road E west of Fettig Road E, east of South Prairie.[4]
2006 (Federal Disaster #1671)	Estimated ten plus inches of rain in the lowlands (4 – 5 day period) and 18 plus inches up on Mt. Rainier (36 hr period). The Carbon River experienced numerous slides in the vicinity- East of Orting and North of 177th. Major landslides also occurred in Mt. Rainier National Park closing the Park.
2006	After receiving rain for 31 of 33 days in January and February landslides occurred in various areas throughout the County.
2001 (Federal Disaster #1361)	During the February 28th earthquake, a portion of the hillside above Salmon Beach slid down the hill, damaging a number of homes and destroying electric service and physical access to the community.
1996 (Federal Disaster #1159)	Combined with heavy rain and flooding, about 20-30 landslides occurred in the region. The slides damaged or destroyed eight homes and damaged utility lines; a landslide south of DuPont pushed two locomotives and two rail cars into Puget Sound, spilling 3,000 gallons of fuel; damaged State Route 165 and undermined a bridge abutment at the Carbon River near Carbonado.
1991	A slide occurred along the lower portion of the Nisqually River near Fort Lewis, blocking the River with debris. The River backed up, temporarily changed course, and flowed through a forested section that abutted up against the opposing wall of the slide. The river-flow gradually eroded the remains of the slide. This gradual erosion prevented a sudden release of water, possibly preventing flooding down-river.
1984	Ground gave way below railroad tracks in the area south of DuPont resulting in a derailment of several cars of an Amtrak carrying passengers. The train engineer suffered a non-fatal heart attack soon after the event. Several people sustained minor injuries requiring transportation and treatment.
1949	This occurred three days after the 1949 Olympia earthquake. Water saturated ground broke immediately to the north of Salmon Beach below Fort Nisqually and slid into the Tacoma Narrows. The slide generated a tsunami in the Tacoma Narrows. The slide missed waterfront homes, but the tsunami damaged them.
1894	A submarine landslide in the Puyallup River delta caused a damaging tsunami that killed two people.

Figure 4.4-5 January 2003 Ski Park Road Landslide

Recurrence Rate

Small landslides happen in Pierce County every year. Since very few of them have any effect on the citizens they are irrelevant for determining the recurrence rate. Landslides with minor impact are defined as landslides impacting five or less developed properties or causing $1,000,000 or less damage. Significant landslides are those that begin to have a major impact on the fabric of a local community. For the purposes of this assessment they are defined as being six or more developed properties or damages greater than $1,000,000. The probability of recurrence for minor landslides in Pierce County could be ten years or less with the potential for significant slides being 100 years or less. This is based on information from past landslide occurrences and information from local hazard experts.

Impacts

Health and Safety of Persons in the Affected Area at the Time of the Incident

The impacts include the injury and possibly death to persons in the affected area. Death may result from suffocation from being buried by the landslide debris, traumatic injury from the impact of sliding material, or the collapse of structures by the landslide. In some areas there is the possibility that a structure could be pushed into a water feature like a lake, river or the Puget Sound. In these cases, it is possible that a person could be trapped inside the structure and actually drown as a result of the slide.

The other impact relating to landslides has to do with underwater landslides. In this case the possibility exists that an underwater landslide could initiate a tsunami that could affect the surrounding areas, in particular Commencement Bay. This issue is covered in the Tsunami Hazard Section of the Plan.

Health and Safety of Personnel Responding to the Incident

Personnel responding to the scene of a landslide must be aware of the potential for more land to collapse while they are attempting to respond or rescue persons from the slide impacted area. Other secondary hazards include ruptured gas lines and charged electrical wires. Also, hazardous chemicals associated with the damaged facility could have spilled and be in the environment.

Continuity of Operations and Delivery of Services

Due to the very limited terrain covered by any individual landside in Pierce County, unless the landslide has a major effect on some portion of the infrastructure, its impacts to the continuity of operations for any jurisdiction should be limited. The interruption in the delivery of services should be very localized, if at all, and in most circumstances, of short duration. Individual departments or organizations, especially ones with infrastructure tied to the landscape like sewer utilities, water purveyors, and others could have their delivery of services compromised on a very local level but seldom on a large scale. Even a major landslide knocking out the City of Tacoma's water pipeline from King County would have a work around from the City's well system that could cover the lack of water until the pipeline was repaired.

There is the potential for a limited number of areas to be temporarily cut off from the rest of the County by landslides. The majority of these are located in the more rural areas of Pierce County. For example, a landslide located under the north end of the Home Bridge on the Key Peninsula can cut off the entire lower end of the Longbranch Peninsula. The same can be said for Ski Park Road on the east side of Ohop Lake. In the latter case they are cut off from much of the rest of the County every few years by landslides. The overall effects would be limited, and the roads should be opened within a short period of time. Generally, during normal years, most landslides are taken care of quickly, however in the advent of an earthquake generating a number of landslides throughout the County, as well as other damage affecting the infrastructure; it could be weeks before some areas are accessible for emergency vehicles and crews.

Figure 4.4-6 February 1996 SR-165 Bridge along Carbon River Landslide

Property, Facilities, and Infrastructure

Due to their probable location in the less settled portions of Pierce County, many of the landslides will have no effect on the developed property. However, in the developed areas there is a danger of roads, railroad tracks, gas, water and sewer lines either being buried, broken, or in some cases swept away when undercut by a slide as in Figure 4.4-6[5]. Private property has the same problem. While many of the landslides will not be large enough to affect large numbers of homes or businesses many could affect individual parcels of private property. It is also possible that damage to water and gas lines will increase danger from fire.

The Environment

The impacts are generally local and would not include large scale damage to the environment. Generally, the slides will affect individual hillsides, possibly blocking rivers or streams. This can cause a backup of water that once it breaks through could cause a flashflood downstream. The possibilities exist that a major slide in a river could damage spawning beds or create an obstacle to fish migration. Any landslide that breaks pipelines, sewer lines, etc. or impacts the transportation or storage of hazardous chemicals could cause considerable environmental damage that could take decades to correct.

Economic and Financial Condition

Due to the very limited terrain covered by any individual landside in Pierce County, the impacts to the economy for any jurisdiction affected should be limited. The biggest potential problem economically could come from a major slide taking out a section of railroad track along the coast. This could impact the transportation of goods into and out of the Port of Tacoma for a short time until either the tracks are repaired or a work around is established.

Financially, while a landslide within the boundaries of any jurisdiction could cause some strain, the limited area covered should restrict the actual financial hardship to the local jurisdiction. There are areas that slide on a regular basis in both the unincorporated areas of the County and within the City of Tacoma. These are handled yearly with the local budgets and to date have not stressed those budgets. If any area of Pierce County were to experience a landslide of the proportions of the Aldercrest-Banyon landslide in Kelso and the subsequent Haussler Road Landslides on the opposite side of the ridge in 1999, it could cause financial difficulties due to the streets and other utilities affected or destroyed; see Figure 4.4-7**.**

All geologic hazards can be insured except landslide and earth movement. For those with landslide damage, property litigation is often the only recourse.[6]

Public Confidence in the Jurisdiction's Governance

Many landslides that occur each year in Pierce County do not affect homes, businesses or infrastructure to the extent that there is any lasting impact noticed by the public. That could take a turn in another direction if Pierce County has a landslide that destroys several homes or a major arterial that could take months to reopen. If several homes are destroyed and if people are killed or injured, there will be questions asked as to why people were allowed to build on unstable slopes.

Figure 4.4-7 January 1999 Aldercrest Drive Landslide

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Endnotes

[1] Modified from Pierce County HIVA (DRAFT), Landslide Section, September 5, 2002, p. 1. http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/HIVAWEB.pdf
[2] *Ibid*, p. 1, 2.
[3] *Op cit*, Pierce County HIVA C p. 2,-3.
[4] Flooding Eases in Pierce County and Some Evacuations Lifted as Damage Assessments Begin, December 12, 2025, Flooding eases in Pierce County and some evacuations lifted as damage assessments begin
[5] Landslides and Landslide Hazards in Washington State Due to February 5-9, 1996 Storm--U.S. Geological Survey Administrative Report-- Debris flow undermining abutment of bridge across the Carbon River on Washington SH-165 south of Carbonado, Washington.
[6] Stephen Slaughter, Washington Geologic Survey, Landslide Hazard Program Manager, May 1, 2019.

Severe Weather

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Identification Description

Definition[1]

Severe weather includes a variety of meteorological phenomena that are detrimental to communities and or infrastructure in Pierce County. These atmospheric disturbances are usually characterized by strong winds frequently combined with rain, snow, sleet, hail, ice, lightning, or heat. This definition includes unusual weather disturbances such as tornadoes or waterspouts, which appear infrequently in Pierce County. In addition, any heavy fall of snow or rain might be considered a severe storm in its own right. Secondary hazards or impacts that can result from severe weather include flooding (see Flood Hazard Subsection), landslides (see Landslide Hazard Subsection), and closed transportation routes limiting emergency response, pollution, and environmental damage (see Hazardous Materials and Transportation Accidents Subsection). This subsection will not cover rainstorms since the primary hazards that occur from heavy rain are flooding, landslides and erosion; the effects of rain will be covered in the subsections on flooding and landslides.

Types[2]

Hail

Hailstorms occur when freezing water in thunderstorm clouds accumulates in layers around an icy core. Hail can cause damage by battering crops, structures, automobiles and transportation systems. While Pierce County does get occasional hailstorms, they seldom include hail stones large enough to cause major damage. However, when hailstones are large,[3] especially when combined with high winds, damage can be extensive.

Heat

Average annual temperatures for the Pacific Northwest have risen 1.3°F since 1895.[4] More extreme heat incidents are likely to occur, although the increase may be moderated by other changes in weather patterns. Heat incidents are more likely to occur more frequently while extreme cold events will become less frequent.

Ice Storms

Ice storms occur when rain falls out of the warm, moist upper layer of atmosphere into a below-freezing, drier layer near the ground. The rain freezes on contact with the cold ground and other surfaces. It accumulates on exposed surfaces such as trees, roads, houses, power lines, etc. The accumulated weight of this ice, especially when accompanied by wind, can cause damage to trees and utility wires. Ice storms are usually of short duration from several minutes to a few hours. However, the danger left behind will last until a rising temperature allows for thawing.

Referencing the Vulnerability Analysis Tables in the Pierce County RHMP Jurisdictional Annexes, "Section 4: Risk Assessment," Ice Storm vulnerability and risk were analyzed with National Risk Index (NRI) Ice Storm data. Risk to Ice storms is assessed through looking at the annualized frequency period of record (1946 2014) and daily hazard occurrence.[5] According to the NRI's metadata, ice storm risk is analyzed in relation to a jurisdiction's population and infrastructure.

Snowstorms

Snowstorms or blizzards, which are snowstorms accompanied by high wind and/or poor visibility, occur occasionally in the County. A snowstorm including warmer moist air from the Pacific Ocean, overrunning existing cold, subfreezing air could continue to drop snow for several days.

Referencing the Vulnerability Analysis Tables in the Pierce County RHMP Jurisdictional Annexes, "Section 4: Risk Assessment," snowstorm vulnerability and risk were analyzed with National Risk Index (NRI) winter weather data. Risk to winter weather is assessed through looking at the annualized frequency period of record (2005 to 2024) and daily hazard occurrence. According to the NRI's metadata, winter weather risk is analyzed in relation to a jurisdiction's population, infrastructure, and agriculture.

Thunderstorms

Severe thunderstorms can produce a tornado, winds of at least 58 mph (50 knots), and/or hail at least 1" in diameter. Structural wind damage may imply the occurrence of a severe thunderstorm. A thunderstorm's wind equal to or greater than 40 mph (35 knots) and/or hail of at least 1" is defined as approaching severe. Lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud.

Tornadoes and Waterspouts

Tornadoes are the most violent weather phenomenon known. Their funnel shaped clouds rotate at speeds up to 300 miles per hour or more, and large ones may affect areas from one-quarter to a mile and a half in width (Table 4.5-1). They may travel for some distance although seldom more than 15 miles. Tornadoes are produced by strong thunderstorms. Such thunderstorms can also produce large hail, heavy rain and strong sustained winds over a larger geographic area. A waterspout is a tornado occurring over water. Specifically, it normally refers to a small, relatively weak rotating column of air over water beneath a towering cumulus cloud.

Table 4.5-1 The Enhanced Fujita Tornado Damage Scale

Scale	Wind Est. (MHP)	Typical Damage
F0	65-85	**Minor damage.** Peels surface off some roofs, some damage to gutters or siding, branches broken off trees; shallow- rooted trees pushed over.
EF1	86-110	**Moderate damage.** Roofs severely stripped, mobile homes overturned or badly damaged, loss of exterior doors; windows and other glass broken.
EF2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted, mobile homes completely destroyed, large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	**Extreme damage to near total destruction.** Well-constructed houses and whole frame houses completely leveled; cars thrown, and small missiles generated.
EF5	65-85	**Massive damage.** Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critically damaged; high rise buildings have severe structural deformation. Incredible phenomena will occur.

Windstorms

Figure 4.5-1 December 2024 Windstorm Damage

There are four main types of windstorm tracks that impact the Pacific Northwest and Pierce County. From these systems two basic windstorm patterns have emerged that impact Pierce County. These are the south-wind event and the east-wind event; see maps Map 4.5-1 and Map 4.5-2. South-wind events are generally large-scale events that affect large portions of not only Pierce County, but also most of Western Washington and possibly Western Oregon. The East Wind events and South Wind events outlined below are the typical windstorms in Pierce County that cause damage. Wind speeds vary and are noted on the maps and the following occurrences table. South-wind events are generally large-scale events that affect large portions of not only Pierce County, but also most of Western Washington and possibly Western Oregon.

In occasional cases, they may even affect areas as far south as Northern California. South-wind events, due to funneling effects, can reach up to 100 mph in confined areas such as the Tacoma Narrows. In contrast, east-wind events are more limited. High pressure on the east side of the Cascade Mountain Range creates airflow over the peaks and passes, and through the funneling effect of the valleys, the wind increases dramatically in speed. As it descends these valleys and then exits into the lowlands around Enumclaw and Buckley, the wind can pick up enough speed to damage buildings, rip down power lines, and destroy fences. Once it leaves the proximity of the foothills the wind tends to die down rapidly causing little damage to the rest of the County.

While these are the primary wind events to cause damage within the County, they are not the only problem. A strong north wind event combined with a higher than normal tide can cause coastal flooding along the County shorelines and can push extra water into the lower reaches of the Puyallup River.

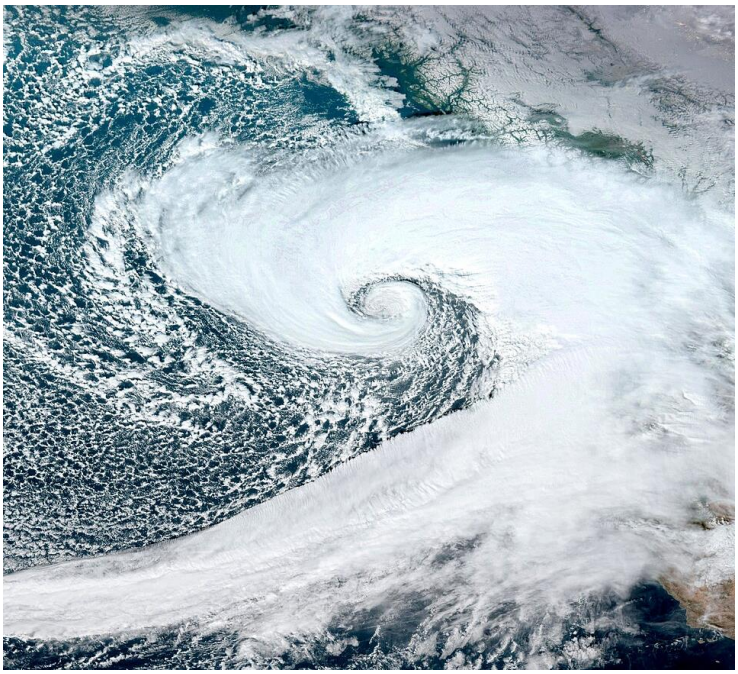
Localized geographic conditions can exacerbate the problem, causing an increase in wind intensity. Ridges, valleys, mountains, and even large buildings can redirect wind flow and cause local variations in damage.

Profile

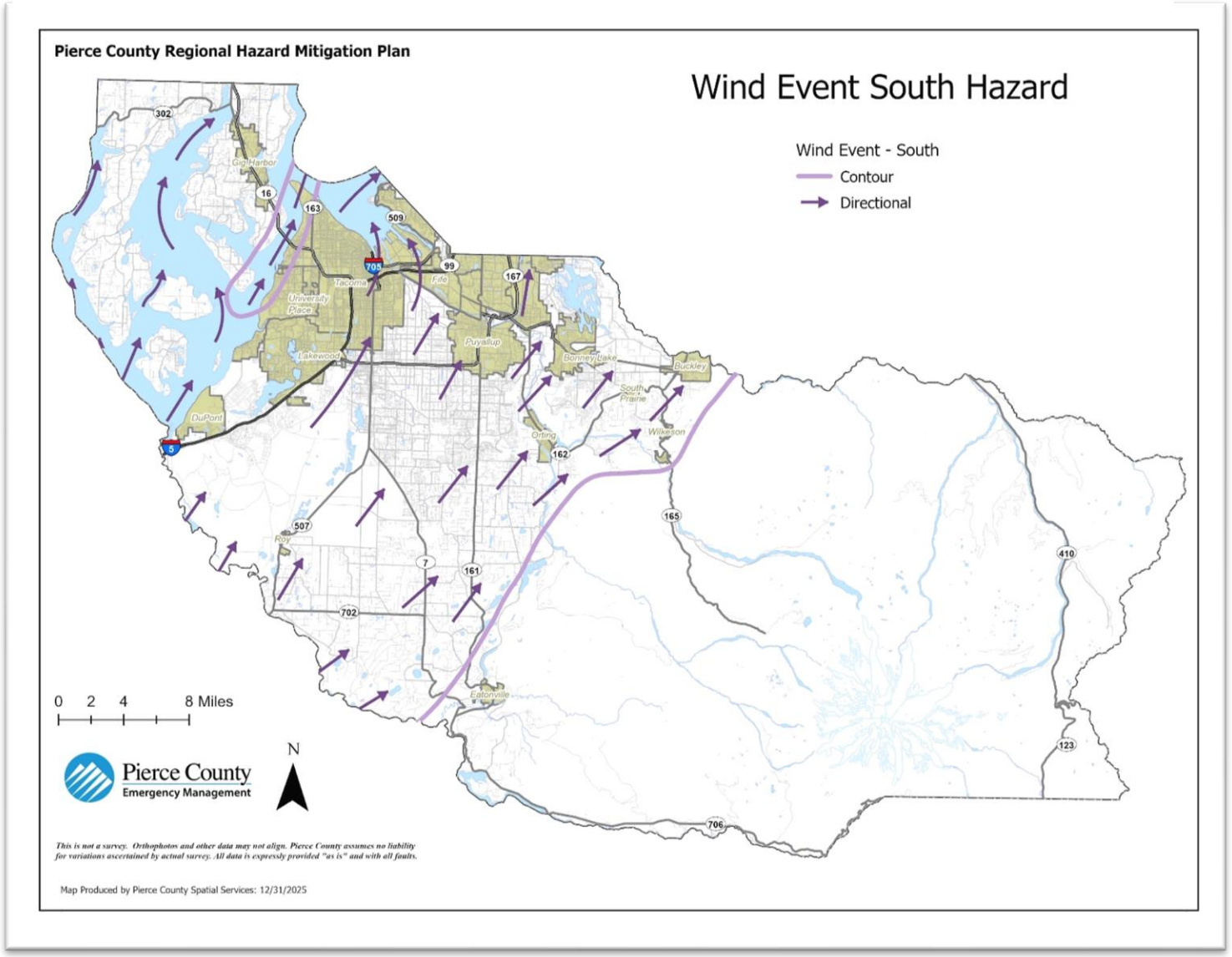
Location and Extent

Severe weather of all types directly and indirectly affects the County. Due to variations in geographic location and elevation, certain areas of the County are more vulnerable to certain types of severe weather, including: windstorm, snowstorm, and ice storm. Maps are currently available that depict wind events. Maps 4.5-1 and 4.5-2 show the severe windstorm hazard for Pierce County as depicted in South Wind Event and the East Wind Event. Windstorms directly and indirectly affect all of Pierce County. The maps show Pierce County and the extent of severe windstorms with predominant wind direction.

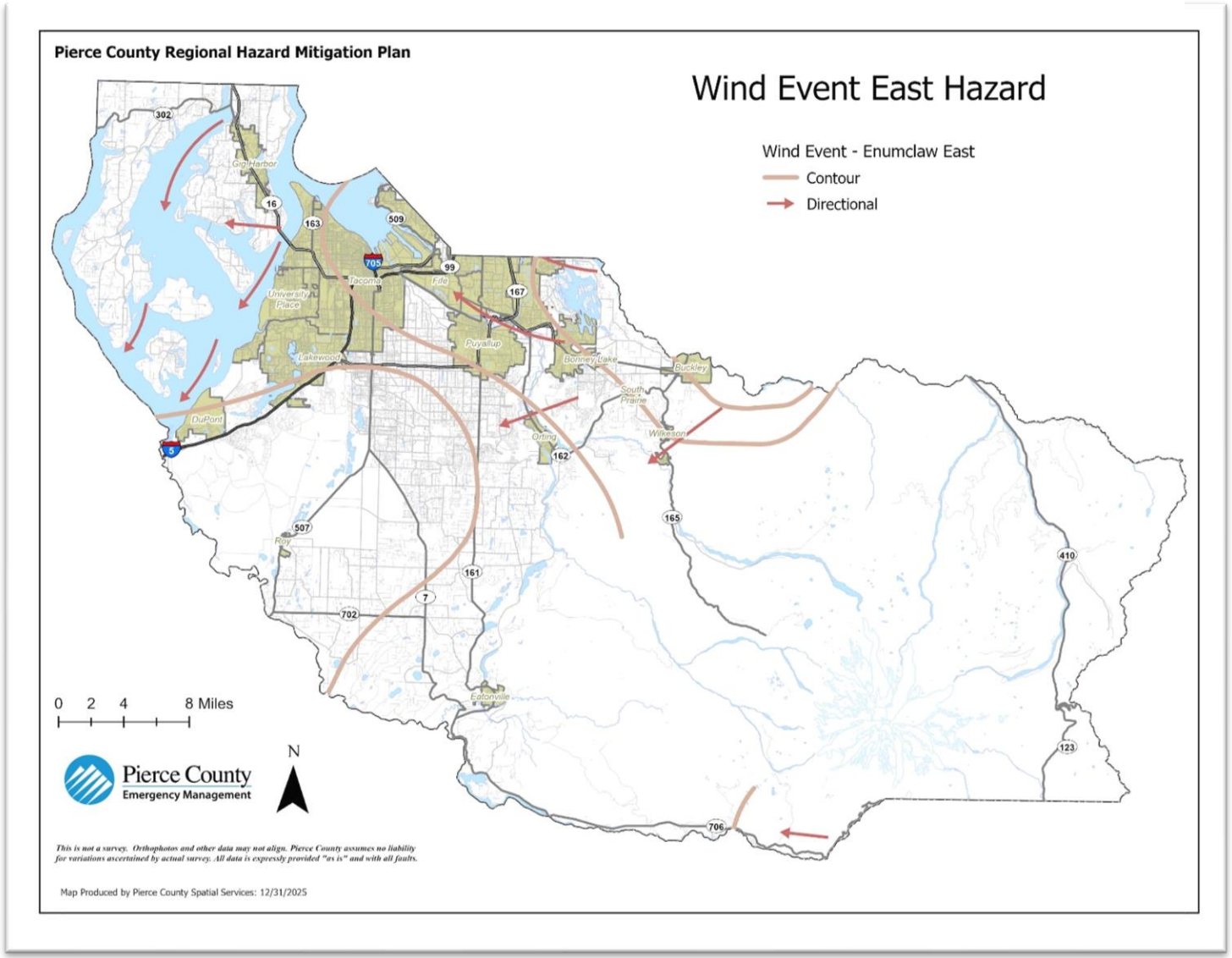
Figure 4.5-2 Satellite image of the November 2024 Northeast Pacific bomb cyclone, as seen on 19 November 2024.[6]



Map 4.5-1 Pierce County Severe Weather Wind Hazard – South-Wind Event



Map 4.5-2 Pierce County Severe Weather Wind Hazard – East-Wind Event



Occurrences

Historically, over the years Pierce County has had several instances of severe weather. While not all of these have caused major long-term problems, they all have disrupted people's day-to-day activities and posed a burden, especially on the poor and elderly. Table 4.5-2 lists some of the other notable severe storms (weather) in Pierce County.

Table 4.5-2 Notable Severe Weather in Pierce County

Date	Description
Hail	
June 2007	National Weather Service reported hail between ¾" and 1" in the Cascades of Eastern Pierce County.
Heat	
June 2021	An unprecedented heatwave, known as the "Heat Dome," affected the Pacific Northwest in June of 2021.[6] This event had record-breaking temperatures reaching 108°F in Pierce County. Due to these temperatures, there were increased heat-related illnesses and fatalities. It also caused strain on power grids due to elevated air conditioning use. 138 people died in Washington State during this event – 29 of which were Pierce County residents.[7]
July 2022	An extreme heat wave from July 29th to July 31st in 2022 saw temperatures 95 degrees Fahrenheit and higher across parts of Pierce County.[8]
Ice Storms	
December 1996 – February 1997 *(Federal Disaster #1159)*	A series of winter storms delivered snow, freezing rain, warm rain and wind to the west coast producing floods, snow and ice damage, and landslides.
Snowstorms	
February 2019	Winter Storm Maya brought 8-24 inches of snow for nearly two weeks in WA. Governor Inslee signed an emergency proclamation that encompassed all counties on Feb. 8. The Pierce County EOC was activated to level two (virtually), the County Planning and Public Works Department plowed 24/7 until the storms end, and the search and rescue 4x4 team transported over 130 hospital staff, 911 dispatchers, and public works staff who were running the snowplows within seven days. From Feb. 8-9 six to twelve inches of snow fell in the County. In Puyallup there was twelve inches of reported snow and Lakewood and Tacoma reported eight inches of snow.
January 2012 *(Federal Disaster #4056)*	'Snowmageddon' resulted in heavy snow and local high winds, causing damage of more than $32 million.

Date	Description
December 2008 – January 2009 *(Federal Disaster/Emergency #1825)*	A cold snap with multiple days of snow closed roads and eventually a record snow event was declared with a snow emergency declared for the County.
November 2006	Up to six inches fell throughout the County, followed by two days of sub-freezing temperatures.
January 2006	Up to seven inches fell throughout the County, followed by two days of sub-freezing temperatures.
January 2004	Successive snowfalls and freezing causes EOC activation and closure of Pierce County government due to severe weather conditions. 5.5 inches recorded in Tacoma, up to 12 inches recorded in southern areas of County.
November 1996 *(Federal Disaster #1152)*	Up to 12 inches of snow, knocking out power, causing road, school, and business closures.
November 1985	A snowstorm combined with a cold spell lasted for over a week causing power outages, traffic congestion, broken pipes, and all-around havoc with the normal day-to-day business of the County.
February 1980	Significant snowfall.
January 1980	Up to 15 inches of snow fell throughout the County.
January 1972	Snowing in the County with drifts up to four feet. Winds with the snow were clocked at 25 mph.
November 1960	Up to seven inches of snow fell throughout the County, knocking out power.
March 1960	Up to seven inches of snow fell throughout the County.
January 1950	Tacoma had drifts up to twelve feet. Economic loss in the County ran into millions of dollars.
February 1916	From two to four feet of snow fell throughout Western Washington.
Thunderstorms	
September 2019	The National Weather Service counted more than 2,200 cloud-to-ground lightning strikes in the Puget Sound area between 6 p.m. and 11 p.m., a rate of 440 an hour. The Washington State Fair was evacuated, and no injuries were reported within the County.
May 2017	Lightning struck Good Samaritan Hospital Dally Tower in Puyallup. One of the 800 MHz phones was rendered inoperable leaving only two to communicate with EMS, other hospitals, and the Pierce County EOC.

Date	Description
Tornadoes and Waterspouts	
October 2014	Waterspout off Anderson Island in South Puget Sound never hit land and lasted for a couple of minutes.
April 2014	A tornado (EF0), maximum width of 25 yards, touched down in Eatonville for less than a minute. Estimated peak wind speed was 75 mph.
September 2009	A tornado (F1-high end) touched down at Lake Tapps and continued in a NE direction for 9.6 miles with winds from 100-110 mph.
February 2007	A funnel cloud was reported near Orting. It did not touch down.
June 2002	A funnel cloud was recorded in the Gig Harbor area. It did not touch down.
September 2001	This F1 tornado began as a funnel cloud over the Puyallup Valley and then moving to the NE touched down in the Bonney Lake area.
May 1997	A tornado (F1) touched down in south Tacoma near the Tacoma Mall, damaging a church, power lines, and few other buildings.
June 1996	A tornado (F0) touched down in north Tacoma running north into Ruston, damaging some homes, downing a number of trees and breaking power lines.
September 1981	A tornado touched down at Gray Field on Ft. Lewis.
June 1978	A tornado touched down in E. Tacoma and at Ft. Lewis.
October 1899[9]	A tornado devastated a tract of land from 300 to 600 yards wide from Mossy Rock and Osborne in Lewis County to Orting. The storm was strong enough to uproot old growth forest.
Windstorms	
January 2019	South windstorm with gusts more than 50 mph left 20,000 customers without power when a large tree knocked out the Tacoma Public Utilities substation in Graham. Temperature high was 52 degrees F and the low 36. The City of Orting was hit particularly hard and opened a charging center at their City Hall during the day.
January 2007	Windstorm came into Washington causing minor damage in Pierce County but major damage to isolated counties such as Chelan County.
December 2006 *(Federal Disaster #1682)* Hanukkah Eve Windstorm	South-wind event, serious damages throughout Western Washington. Over 1,500,000 people were without power, some as long as 10 days. Major tree and electrical damage.
November 2006	Damaging winds up to 86 mph on coast and 60 mph around western interior. Power was out to over 100,000.
February 2006	East-wind event, localized to Pierce County, produced sustained winds of 40-50mph for 18hrs, knocking down trees and power lines and causing over $4,000,000 in public damage alone in the County.

Date	Description
December 2005	Christmas Day Gale had winds of 40+ mph recorded at a number of weather stations in Pierce and other counties in W. Washington
December 2003	East-wind event causes downed trees, power outages, and damage to property in Buckley, Eatonville, Bonney Lake and surrounding areas. Sustained winds of 60 mph and gusts up to 80 mph.
December 1995	Windstorms starting in Northern California generated winds in excess of 100 mph and continued to the north into Canada causing three states, including Washington, to issue disaster proclamations.
March 1995	Windstorms created multiple power-outages and downed trees.
January 1993 *(Federal Disaster #981)*	Inauguration Day Storm.
November 1981	High winds in Western Washington.
October 1962 *(Federal Disaster #137)*	Columbus Day Storm recorded winds up to 88 mph in Pierce County. This was less than in some other areas. Maximum wind speed in other areas reached as high as 150 mph. Strongest recorded windstorm in Pierce County History causing extensive damage throughout the County.
November 1958	High winds in Western Washington.

Recurrence Rate

Based on the previous history of severe weather that has impacted Pierce County and information from the National Weather Service[10] it was determined the probability of recurrence for the severe storms hazard in Pierce County to be five years or less occurrence.

Hail

To date the various hailstorms in the County have caused limited damage to some of Pierce County's agricultural products. The only reported hailstorm with hail large enough to have caused extensive damage in the past was located in the Cascades. Minor hailstorms happen on almost a yearly basis somewhere in the County. Since large hail is such a rare occurrence it is listed as a 100 year or less occurrence.

Heat

Extreme heat continues to be a growing threat and concern for the County and the Pacific Northwest due to climate change. Washington's average temperatures have increased by almost 2°F since 1900 and continue to climb and destabilize the region's climate patterns. Since 1960, Seattle and Portland have experienced 4 to 6 additional heat waves annually compared to historic climate conditions, and this trend is similar in Pierce County. The 2021 heat dome event has been described by some scientists as a "1,000-year event made 150 times more likely by climate change. Instead of being a rare anomaly, events like the heat dome could occur every 5 to 10 years with just 2°C of global warming.[11]

Ice Storms

The record shows only a single significant ice storm in the past 100 years. It was therefore determined the probability of recurrence as 100 years or fewer occurrences.

Snowstorms

Table 4.5-2 lists 15 significant snowstorms in the past 100 years. Taking this as an average it was determined that snowstorms of consequence happen as a ten year or less occurrence.

Thunderstorms

Thunderstorms occur almost every year. The frequency in which there is an impact to people, property, or the environment has been a larger focus in recent years especially now that we are experiencing a drought and wildfires are a big concern. However, due to the lack of data collection on this hazard, it is an estimated five year or less reoccurrence.

Tornadoes

While not as frequent as windstorms, there have been seven recorded tornadoes in the past 120 years. Given this frequency, it was determined the probability of recurrence as 20 years or less.

Windstorms

Wind has played a prominent role in the history of emergencies and disasters impacting communities within Pierce County. Major events (Table 4.5-2), have occurred 13 times during the past 70 years and caused millions of dollars' worth of damage. Pierce County can expect some wind-related problems on an annual basis, although few of these cause extensive damage. Based on the historical frequency of large windstorms it was determined the probability of recurrence as 10 years or less.

Impacts

As can be seen above, the impacts from severe weather can be largely dependent on the type of incident. Since the severe weather can range from snowstorms to tornadoes each one is factored out in this section.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Hail

Over the years, hail has not been a major factor in Pierce County. While injury and even death to people and animals that are in the wrong spot at the wrong time can occur, the size of hail that impacts Pierce County is usually too small to cause injury or death. While the damage to crops, cars and other items out in the weather can be dramatic, direct impacts to people in the affected areas of Pierce County are usually limited to minor stings and bruises. However, should a hailstorm with large hail stones occur, individuals could be injured and in rare instances killed.

Heat

Exposure to extreme heat can cause stress to multiple organ systems and put individuals at risk for illness or death. Heat-related illness can include acute heat illness (e.g. heat exhaustion, heat stroke), chronic disease exacerbations (e.g. flares of cardiovascular, kidney, respiratory, and psychiatric disorders), injuries (e.g. occupational injuries, drowning), and adverse pregnancy outcomes (e.g. increased risk to the pregnant individual, premature delivery, low-birth weight).[12] Historically, residents of the west side of the state had not experienced as much extreme heat as the east side of the state or other parts of the country, leading to a lack of infrastructure and knowledge to support life-safety during extreme heat, such as a lack of air conditioning units in private residences, especially amongst more vulnerable segments of the population.

Elderly people, children, pregnant people, and people with pre-existing medical conditions, particularly heart, lung, kidney, and mental health concerns are more vulnerable to extreme heat. People who live unsheltered outside, in marginal housing, or in poverty are also more vulnerable. Individuals who do not speak English as their first language are also more vulnerable. People who live in more urban areas with lots of uncovered asphalt and concrete and few trees, known as heat islands, are also more vulnerable. [13] Other factors may influence exposure during extreme heat events and make certain people more vulnerable, including people who work outdoors or participate in athletic activities outside.

During the 2021 Heat Dome, more people died in Washington each day than the total number of heat-related deaths in a typical summer.

Ice Storms and Snowstorms

Direct impacts from ice storms and winter storms can include injuries such as hypothermia, frostbite, falls, blunt force trauma from falling debris or death. Accidents can occur when people walk on icy walkways or on the ground. Transportation accidents increase drastically with icy roads. In addition, the overload of ice on trees or utility wires can cause limbs or wires to break. These can fall on individuals, automobiles, or homes causing traumatic injuries or death. In the case of downed utility wires, fires can start or individuals could be electrocuted.

Direct impacts on the general public can be especially prevalent in the residentially challenged individuals (formally known as homeless), older adult populations and any persons who lose heat and power for extended periods of time. There is an increase in injuries and deaths from accidents and in some cases increases in heart attacks from individuals attempting to shovel snow from walkways and driveways. Individuals on home-based life support systems could be adversely impacted by the power outages if they do not have a backup power system.

Depending on the depth of the snow, the length of time it stays around, and the number of downed tree limbs, or trees in lines, road closures could isolate some individuals; possibly for days.

A combination of the cold and lack of power will force many people to find alternate ways of cooking and heating. Those who attempt to cook or heat with barbecue grills, hibachis or portable generators inside any building run the risk of carbon monoxide poisoning leading to brain damage and death.

Access to public transportation, shelters, stores and businesses, healthcare facilities, and government services can all be compromised due to snow (Figure 4.5-33). In many cases the hills and slopes of many of the roads and streets restricts individuals' movements. This remains the case until road crews can sand and plow roads.

Figure 4.5-3 Snowstorm 01/2004 Downtown Tacoma

Thunderstorms

Lightning is one of the leading causes of weather-related fatalities. But the odds of being struck by lightning in a given year are only around 1 in 500,000. However, some factors can put you at greater risk for being struck. Regional, seasonal, and occupational differences affect your risk of being injured by lightning. Lightning can occur during any time of the year, but lightning casualties are highest during summer. July is generally the month with the most lightning. Lightning strikes often occur in the afternoon. In fact, two-thirds of all lightning casualties occur between noon and 6pm. Lightning most often strikes people who work outside or engage in outdoor recreational activities. More than a third of lightning strike deaths occur on farms. Other common places are industrial locations and private residences. Construction and material handling such as loading and unloading are two of the most common work-related activities where lightning strikes occur.[14]

Tornadoes and Waterspouts

Most tornadoes that have historically impacted Pierce County have been rather small. The exception is the October 1899 tornado. The results of any tornado can be devastating to those caught in one. However, the number of people injured or killed and the number of houses, businesses, community facilities, etc. destroyed or damaged varies dramatically depending on the size of the tornado, where it touches down, and how long it is in contact with the ground or water.

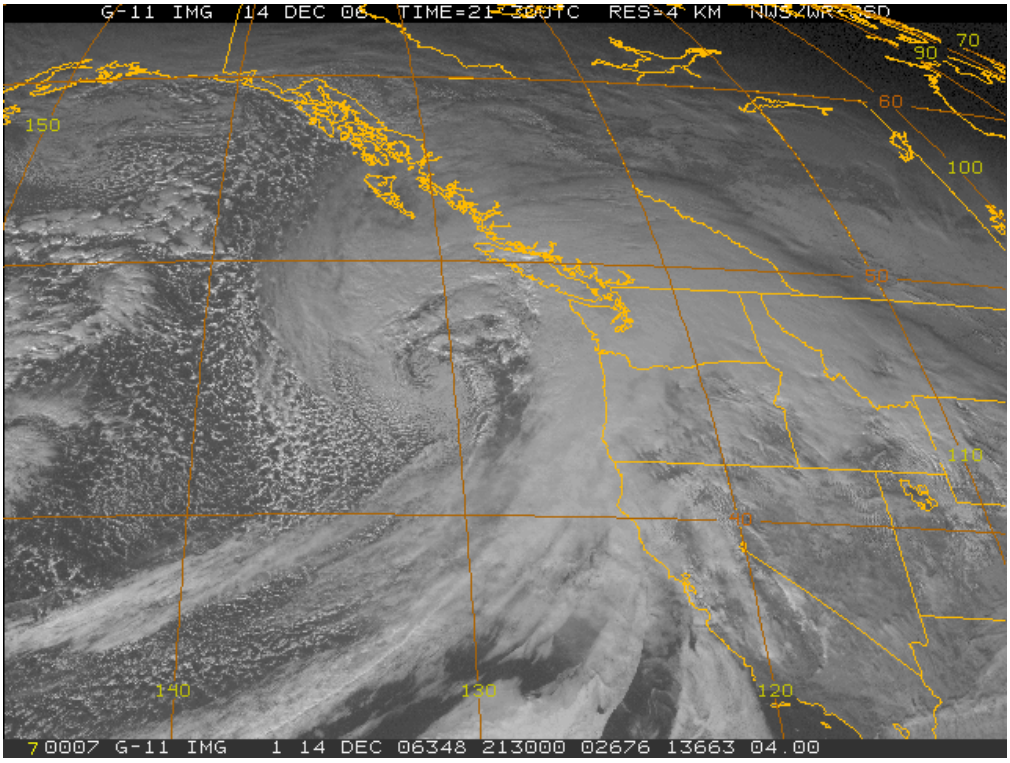
Windstorms

Windstorms are one of the emergencies that impact all of Pierce County on a regular basis. Some are much more damaging than others. For those like the Hanukkah Eve Windstorm of 2006, the impact on the public can be very severe (Figure 4.5-44).

Individuals can be hit by flying debris or falling limbs and trees. During past windstorms cars have been crushed and houses split by falling trees. Individuals can suffer injury or death. Downed wires have been known to electrocute individuals, as happened in Gig Harbor in the Hanukkah Eve Windstorm of 2006.

Large numbers of power lines down, combined with trees and limbs on roads can keep fire, medical and law enforcement personnel from responding to incidents. During heavy wind first responders may have to wait until the wind abates before being able to respond to calls.

Figure 4.5-4 Satellite Image Hanukkah Eve Windstorm[15]



Health and Safety of Personnel Responding to the Incident

Hail

First responders have very similar safety and health concerns to those of the general public regarding hail.

Heat

First responders may experience the same heat-related illnesses or injury as other impacted individuals in the area. A surge in heat-related illness and injury during heat events can strain the health system, increasing the amount of 911 calls, ambulance transports, emergency department visits, and hospital admissions. [16]

Ice Storms and Snowstorms

First responders can expect similar injuries as the general public. First responders operating in the hazardous environment of an ice or snowstorm have the potential to get cold related injuries if they are not adequately protected from the elements. Due to the amount of time spent on snow covered roads responding to storm related problems, they also have a potential for traffic accidents. Road crews will have to be careful of downed lines and work in conjunction with utility workers to open roads.

Thunderstorms

The potential impact to first responders is the same or lesser than persons affected at the time of the incident. First responders are very efficient in transporting affected persons to medical facilities and therefore would be spending a considerable amount of time in their vehicles which provides a layer of protection.

Tornadoes

During the actual tornado itself, responders are like any other citizen. They are as likely as anybody else to be injured or killed by the storm. Once the tornado has passed however, they will enter the area where the damage has occurred. With a large tornado this puts them in a hazardous area. They could be exposed to live electric wires, hazardous chemicals, and unstable debris.

Windstorms

First responders will be putting themselves in harm's way throughout windstorm incidents. They can be hit by flying or falling debris as well as coming in contact with downed power lines. Response vehicles have been crushed and over the years there are the occasional injuries. In the aftermath of the windstorm, first responders by the nature of their work are putting themselves in harm's way.

Continuity of Operations and Delivery of Services

Hail

Hail has not traditionally caused more than the most minor slowdown of any public services within the boundaries of Pierce County. Due to the shortness and small size of the normal hailstorm it is not expected to disrupt any organizations continuity of operations or the delivery of services to the public for more than a short period of time. Should there be an increase in size of the hail stones and an increase in the length of the storms then damage might begin to appear on equipment, facilities, vehicles and people.

Heat

Extreme heat may cause impacts to directly to staff or their ability to safely get to or be at work. Continuity of operations may also be impacted if people who normally work outside are not safely able to perform their routine duties during periods of extreme heat, even with mitigation measures in place like additional water breaks or provided shade. Heat may also cause damage to infrastructure, facilities, and/or utilities that disrupt routine operations, including power outages or malfunctioning building cooling systems which may necessitate the activation of continuity plans to relocate staff to a safer working location.

Ice Storms and Snowstorms

While ice storms themselves tend to last only a few hours at the most, the after affects can last for days or weeks. The actual problem with iced roads, falling branches, and other types of damage will continue until the temperature warms enough for the ice to melt. In a situation where the temperature remains below freezing for a long period of time there may be continuity of operations problems for local jurisdictions or agencies. Local jurisdictions and agencies with limited or small staffing following the event could cause their operations to lapse for short periods.

Both an ice storm and snowstorm can slow down and, in some cases, halt the delivery of services over the entire County and for any jurisdictions or agencies located within its borders. Ice or snow coated streets do not allow the normal movement of emergency vehicles of any type within their normal response times, so the delivery of all types of services will be slower than normal or even non-existent until such time as the streets are once again passable. Government offices, schools, businesses and services might be shut down for days.

A few days following Winter Storm Maya in February of 2019, the Pierce County Auditor's Office had a special election. Luckily many roads were passible and the snow was quickly melting but if the storm had lasted any longer or if temperatures were not high enough to melt the snow, the Auditor's Office would have been responsible to ensure voters had access to the election center or possibly postpone the election (this can only be done if certain conditions and thresholds are met). Keeping jurisdictions or agencies operations going is one aspect but making sure that the services you provide are accessible and doesn't infringe on person's rights is a complex issue and should be considered with all hazards.

Thunderstorms

Lightning strikes can cause short-term disruptions of services or close the State Fair early. Continuity of operations from a jurisdictional level will not be impacted as greatly as a small agency or business that doesn't have additional resources outside of their single location. Communications equipment and technology devices that we rely on to deliver services may be taken out but not to a scale where the impact will be long term. The main concern is lightning starting fires.

Tornadoes

A small tornado touching down in Pierce County should not impact the continuity of operations for any of its larger jurisdictions. It is possible that a small tornado could directly damage the only response capability or administrative office of a very small agency or jurisdiction. In that case, their continuity of operations would be impacted until they were able to get assistance from a neighboring jurisdiction. However; this is unlikely.

An EF one tornado could damage a large area to the extent that a large proportion of a jurisdiction's capability, either physically or administratively may limit its continuity of operations. Having the administrative offices destroyed, possibly along with the staff being injured or killed, would make the normal day-to-day operations difficult to maintain. Combining this with broken pipes in the destroyed buildings, phone and electric lines down, streets covered with debris and possible fires from broken gas lines would increase the difficulty of maintaining the continuity of operations.

Due to the localized nature of the tornado, the delivery of services to the rest of the County should be minimally impacted with the exception of energy. The damage to the power infrastructure could have a direct effect on surrounding neighborhoods, businesses, jurisdictions, and the State.

Windstorms

Operations for most if not all the agencies or jurisdictions in Pierce County should be able to continue, albeit at a reduced level in some cases. Damage to the administration, infrastructure and a reduction in response are very possible consequences of a major windstorm. Damage to administrative facilities, operational equipment, communications systems, or utilities would put various organizations in a bind as far as maintaining their normal support to the public but would not completely shut down their operations.

The impacts to the delivery of services could impact the entire County or in some cases, only a portion of it. This is largely dependent on the type of windstorm.

An east-wind event, see Map 4.5-2 Pierce County Severe Storm Wind Hazard – East-Wind Event, with very strong winds will usually only impact the eastern portions of the County. The force of the wind decreases rapidly over distance. Wind speeds that can hit 100 mph in Buckley will be 50 mph or less by the time it gets to the western portion of the County. In a case like this there could be some loss of ability by local jurisdictions in the eastern portions of the County to deliver adequate services to the community. With heavy winds there could be extensive debris on the roads, broken lines and if some buildings are damaged, there could be broken water or gas pipes.

With a south-wind event, see Map 4.5-1, essentially the entire populated area of the County will be impacted. This is equivalent to the Columbus Day windstorm of 1962 or the Hanukkah Eve Windstorm of 2006. In these two cases, there was major damage to the trees and powerlines. Many roads were totally closed, and some people were without power for over 10 days. In situations like this the local jurisdiction is not capable of maintaining an adequate delivery of services.

Property, Facilities, and Infrastructure

Hail

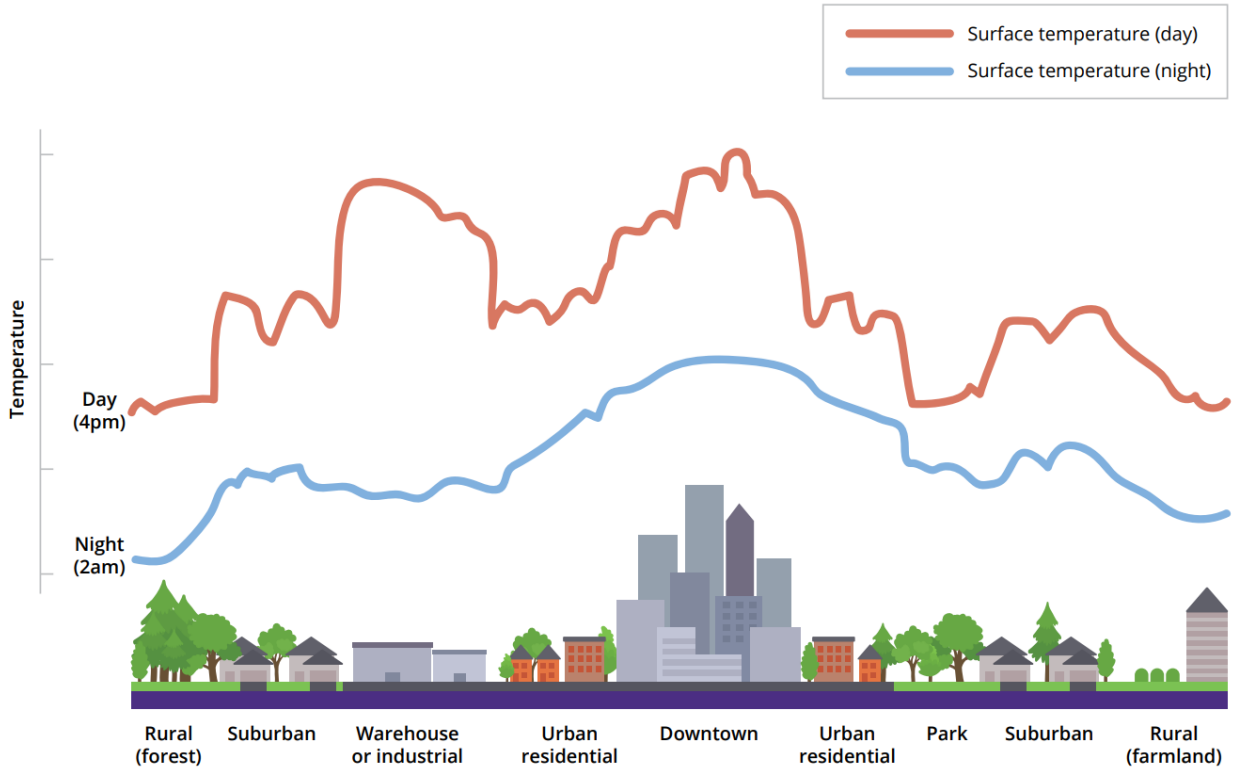
Large hailstones can damage property, facilities and some infrastructure like electrical transformers, etc. However, in Pierce County the size of hail that has fallen historically has caused minimal damage, if at all, to any of the jurisdictions' facilities or infrastructure in Pierce County.

Heat

Infrastructure, utilities, and manufacturing may be significantly impacted not only by individual heat events, but by overall increasing temperatures and the frequency and intensity of heat events that can push materials and equipment beyond their lifetime thresholds in conditions they weren't designed for.[17]

Urban areas with exposed buildings, asphalt, and concrete and a lack of tree coverage experience higher temperatures during heat events, as well as less of a temperature drop overnight which may provide needed relief for facilities and community members alike (Figure 4.5-55) [18] Excessive heat also places stress on the electric grid and causes damage to transportation infrastructure like roadways.[19]

Figure 4.5-5 Day and night surface temperatures in a hypothetical urban heat island event.



Ice Storms and Snowstorms

Ice and snowstorms can cause significant damage to public and private property, facilities, and local infrastructure. Overloaded tree limbs breaking off and landing on cars, buildings, and equipment can cause significant damage. Overloaded wires can break causing fires.

Ice and snow on roofs add extra weight and can cause damage, especially on lightly built structures. A 50-foot conifer can accumulate as much as 99,000 lbs of ice during a storm[20], and when combined with wind may topple causing much more damage than it would have otherwise.

Thunderstorms

Lightning strikes are associated with fires, electrical loss, and damage to equipment. The vulnerability to lightning cannot be understated as virtually every structure and system can be impacted by a lightning strike.

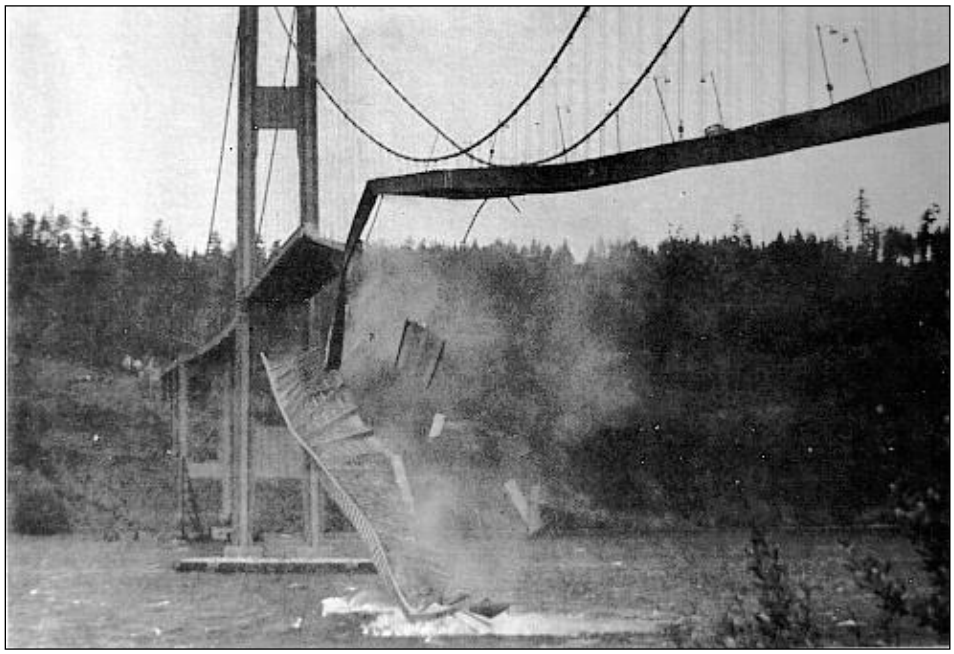
Tornadoes and Windstorms

Depending on the track and size of the tornado, it could devastate facilities and infrastructure. The last few tornadoes to strike Pierce County have been relatively small and have caused minor damage to the facilities or infrastructure of any jurisdiction in the County. If a tornado the size of the Greensburg Kansas tornado of May 4, 2007 were to strike one of the towns or other jurisdictions in the County they would have extensive damage to their property, facilities and the jurisdiction's infrastructure. Descriptions of the 1899 tornado to hit Pierce and Lewis counties appear to put it in the same category. That tornado destroyed old growth forest with trees up to four feet in diameter and left a path of destruction 300 to 600 yards wide and 50 miles long. A repeat of that event passing through the populated portions of the County could destroy or damage some major pieces of infrastructure in addition to family homes and businesses.

Windstorms can cause significant damage to public and private property, facilities, and local infrastructure. Power can be out to portions of the County for over a week after a major windstorm. This means that traffic lights will be out at crossings and emergency facilities without generator backup will not be able to function. Having many roads covered with debris would virtually shut the County down.

Strong wave action from windstorms can erode coastal areas with railroad tracks and roads built in some cases right up to the water's edge. Response vehicles and facilities may have trees or branches fall on them. Blowing debris, such as parts of roofs, fences, metal signs, and even sand can all cause damage to property and equipment.

Figure 4.5-6 Tacoma Narrows Bridge – November 7, 1940, Windstorm



The Environment

Hail

Hail can cause extensive damage to crop and other plants such as abrade or tear leaves; break stalks, stems or branches; destroy blossoms; and bruise fruit. This will be short term environmental damage, lasting about one year.

Heat

Increased heat events are a result of human-caused climate change. Heat events are a reflection of these negative environmental impacts, and will become more intense and more frequent as climate change continues to worsen. Periods of extreme heat can directly cause environmental harm by increasing risk for wildfires, droughts, and ecosystem stress which may lead to droughts and water shortages, crop failure or reduced yields, livestock loss, and harm to wildlife.[21] Air pollution levels also spike during periods of extreme heat due to increased particulate matter from drought and wildfires, harmful compounds and chemicals released during wildfires, and the acceleration of biological processes responsible for the degradation of organic waste and wastewater. Some pollutants can also feed on the heat, chemically reacting through exposure to sunlight and exacerbated by warmer temperatures leading to ground-level ozone that can reach dangerous levels, especially in urban areas.[22]

Ice Storms

Ice storms cause environmental damage by placing an excess amount of weight on plants that can break the limbs off large trees, crush small shrubs and injure or kill animals. Conifers are a little more resilient to the effects of the ice than are deciduous trees and can accumulate large quantities of ice. When combined with wind however they then can topple with considerable force.

Icing can further damage plants by sealing the leaves, stems and buds from the air, suffocating these parts. When the ice sheet covering the ground persists for a lengthy period it can also suffocate some plant species.

Animals that are used to snow cannot dig through the ice as they would snow to reach their normal food supply and so starve. Some could become encased in ice themselves and die.[23]

With enough time the environment will regain its normal vitality but depending on the amount of damage done it could take from a few months to several years.

Snowstorms

Light snowstorms have very little impact on the environment. The plants and animals that are endemic to Pierce County are used to this type of winter weather. With a heavy snowfall, broken limbs from trees will be one of the most visible signs of damage. If the snow remains deep for an extended period of time, some large animals being unable in deep snow to cover enough terrain to find food may starve to death. Regardless of the initial damage done by the storm, the scars on the environment will disappear; usually in a matter of months.

Thunderstorms

The only environmental impact is caused by fires and will not be further discussed in this chapter (see the Wildland Urban Interface Fires chapter).

Tornadoes

Tornadoes by their very nature can destroy everything in their path. The 1899 tornado, according to news reports, cut a 300 to 600-yard path through forest ripping up trees four feet in diameter. A repeat of a tornado of that size could cause even more environmental damage today. In 1899 it tore through forest and farms. While the environment suffered the loss of many trees it began to repair itself immediately and eventually the vegetation and forest recovered.

The environment that the tornado would travel through has changed considerably. Forests have been logged and are now in at least their second if not third re-growth. Instead of a few farms spread apart you have a modern metropolitan area. A tornado that touches down in the wrong area could destroy oil storage tanks and hundreds of other hazardous chemical storage sites. All the hazardous materials that are transported on the highway system or through the port by ship or rail would be at risk of being spilled. Many of these could cause drastic, long-term environmental damage possibly lasting for many decades. Spills into the rivers or Commencement Bay could decimate fish populations for years.

Windstorms

The impacts include downed trees and limbs. In some cases, entire stands of trees can blow down in a single windstorm (Figure 4.5-77).[24] A single tree falling at any one point is a very minor environmental problem that will have very little impact depending on the location. However, a full stand of trees all falling together leaves a scar that will take decades to re-grow. Loss of forest increases erosion and increased erosion leads to more silt in the rivers. Fallen trees can block streams or cause log jams on rivers that can cause the water to back up with possible flood consequences.

Along coastal areas strong winds, especially when combined with high tides can erode beaches. The wave action can undercut hillsides that extend down to the water increasing the possibility of landslides.

Figure 4.5-7 County Road December 2006 Windstorm

Wind damage to homes, businesses or industry can cause further environmental damage through the release of hazardous chemicals. Natural gas lines can be broken leading to fire. Very strong winds can tip over trucks or cause the driver to have an accident leading to a spill. Depending on the quantity and type of chemical the spills will be more or less damaging.

Economic and Financial Condition

Hail

Economic impacts from hail, even the relatively small hail that occasionally falls here in Pierce County can be dramatic. Portions of the Puyallup Valley are used for farming and have a high potential for damage to crops if there is a hailstorm at the right time of year. Other types of economic damage may come about if the hailstones are large enough to damage cars, equipment being used outside and building exteriors.

Heat

Economic impacts of extreme heat include illness and death that can result in healthcare costs, productivity loss, and more. The United States is projected to lose an average of $100 billion annually from productivity loss due to extreme heat, which is set to double by 2030 and quintuple by 2050 without meaningful mitigation. [25] Extreme heat can also increase costs of energy, cause shortages in staple grains and livestock, cause harm directly to workers, and produce other negative economic drivers. In Washington, an estimated 25% of workers are in a heat-exposed industry.[26]

Ice Storms and Snowstorms

The economic or financial impact of an ice storm or major snowstorm can be extensive. A major storm that knocks out electricity; closes roads, schools and businesses could have a major impact on the local economy. Damage to facilities due to the weight of the ice and/or snow can be in the millions of dollars. When employers close their business even for a few days the ripple effects include not just lost goods but lost wages for employees. With lost wages, the employee becomes unable to pay his/her bills. If this goes on for very long, the lost wages make it difficult for the worker to pay the normal day-to-day bills that arrive in the mail much less support the retail economy. Damage to homes and personal property can also be high, leading to increased debt for the individual or family.

Thunderstorms

Lightning strikes that directly hit infrastructure and destroy critical equipment will need to be replaced. For those who do not have insurance that covers this hazard in their policy, may not be able to replace damaged equipment.

Tornadoes

A small tornado hitting the unpopulated areas of Pierce County would have negligible economic or financial consequences for the jurisdictions in the County.

In contrast, a large tornado moving through an industrial area, a concentration of businesses, or a populated area could devastate the local economy. Homes and some businesses could be rebuilt and be up and running within a year or so. Larger scale projects like malls or the port industrial complex could take many years to rebuild and re-staff.

Windstorms

The economic and financial aspects of a windstorm can be extensive. Local damage to homes and businesses can run into the millions of dollars. When business or industry is damaged there can be extensive loss of employment. This leads to individuals and families not being able to make their bill payments, including rent or house payments. People unable to work will need assistance which puts a burden on the taxpayer. If the situation does not resolve itself the jurisdiction could eventually have some people leave the area.

Coastal erosion through wind damage can cause transportation problems. The under-cutting of roads along the coast, the damage to bridges from high-wind coastal flooding and the erosion leading to landslides are all problems that could affect the local economies throughout Pierce County's coastal areas.

Another area is agricultural damage. This includes the lumber industry. Lumber can react differently than the other agricultural products of Pierce County. Damage to most crops from a windstorm might take a year or more to recover. With the lumber industry a large timber blow-down might be salvageable. While this could keep the loggers employed and the company in a good financial condition initially, they will have to jump right into replanting the area to allow a harvest in a few decades.

Public Confidence in the Jurisdiction's Governance

Hail and Thunderstorms

Hailstorms and thunderstorms should not cause any loss of confidence in any of the jurisdictions in Pierce County.

Heat

As instances of extreme heat continue to increase in frequency, intensity, and duration, so to will associated loss of confidence in governance if no meaningful mitigation measures are taken. Drivers of heat impacts reflect any given jurisdiction's urban planning priorities (e.g., amounts of exposed asphalt or urban tree canopy coverage), availability of third-spaces and/or cooling centers to provide relief, and energy costs that skyrocket during heat events. In addition to public criticism of government response during heat incidents, the amount by which a jurisdiction's mitigation strategies and long-term planning reflects heat mitigation priorities will influence how community members perceive that jurisdiction's response to heat impacts.

Ice Storms, Snowstorms, and Windstorms

The reputation of local jurisdictions and agencies in the wake of an ice or snowstorm is partly dependent on the weather itself. A major storm that maintains below freezing temperatures for a long period of time will continue to tax local resources throughout that period. Two factors will affect peoples' perceptions on the competency of the local jurisdiction. The first is how fast the roads are brought back to being passable and the second is how quickly their electricity is returned. If these two things are brought back to normal quickly, confidence in the local entity will be high. If, on the other hand, things are slow and the perception develops that not enough is being done, then confidence in the local jurisdiction will falter and it will develop a reputation for either incompetence or not caring about the citizens it serves.

Tornadoes

In the wake of a tornado the confidence in any individual entity will be based on how quickly it responds to the needs of the affected community. People know that tornadoes are extremely damaging and there are not many of them that form in Pierce County.

A tornado by its very nature is more localized in its damage. Rather than being a County-wide phenomenon, the path of destruction will be well defined. Any jurisdiction directly impacted by the wind should be able to begin recovery operations immediately. If assistance is needed, and it hasn't been for the last few tornadoes, it would be available from nearby agencies and jurisdictions on short notice.

If the perception, real or not, is that any agency or jurisdiction is not responsive to the needs of the community affected by this incident, then there will be a decrease in confidence in that organization. If, on the other hand, the entities involved acts quickly to get the community back on its feet, its reputation should not be hurt.

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Terrorism and Extremism

Natural Hazard 4.6

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Terrorism

Identification Description

Definition

The United States defines terrorism under the United States Code (USC) and Code of Federal Regulations (CFR). Title 18 of the USC defines terrorism and lists the crimes associated with terrorism. Section 2331 of Chapter 113(B) defines terrorism as: "…activities that involve violent… or life-threatening acts… that are a violation of the criminal laws of the United States or of any State and… appear to be intended...

(i) to intimidate or coerce a civilian population;

(ii) to influence the policy of a government by intimidation or coercion; or

(iii) to affect the conduct of a government by mass destruction, assassination, or kidnapping; and…(C) occur primarily within the territorial jurisdiction of the United States…". [1]

Title 31 CFR Section 594.311 defines terrorism as: "(a) Involves a violent act or an act dangerous to human life, property, or infrastructure; and (b) Appears to be intended: (1) To intimidate or coerce a civilian population; (2) To influence the policy of a government by intimidation or coercion; or (3) To affect the conduct of a government by mass destruction, assassination, kidnapping, or hostage-taking." [2]

Relevant Terrorism Definitions

In using the term "domestic terrorism", the Department of Homeland Security (DHS) refers to the Homeland Security Act definition of terrorism contained within Title 6 USC 101 (18), which is substantially similar to the Title 18 definition.[3] However, the HSA definition specifically includes acts that are potentially destructive to critical infrastructure or key resources and sets it apart from the Federal Bureau of Investigation's (FBI) definition of domestic terrorism.[4] Within the United States, 32 states and the District of Columbia criminalize the act of domestic terrorism.[5]

In Washington State, domestic terrorism (DT) is an undefined term in the Revised Code of Washington. For the purposes of RCW 70.74.270 (Malicious Placement of an Explosive), 70.74.272 (Malicious Placement of an Imitation Device), and 70.74.280 (Malicious Explosion of a Substance), Washington State defines "terrorist act" under RCW 70.74.285 as an act that is intended to: (1) Intimidate or coerce a civilian population; (2) Influence the policy of a branch or level of government by intimidation or coercion; (3) Affect the conduct of a branch or level of government by intimidation or coercion; or (4) Retaliate against a branch or level of government for a policy or conduct of the government.

Consistent within the RCW, Washington State approaches potential legal options to respond to DVE incidents in existing civil and criminal codes such as: hate crimes (RCW 9A.36.078, 9A.36.080, 9A.36.083); threats against the governor, lieutenant governor, and their families (RCW 9A.36.090); criminal conspiracy and attempt (RCW 9A.28.040, 9A.28.020); obstructing governmental operation (RCW 9A.76); intimidating a public servant (RCW 9A.76.180); obstructing a law enforcement officer (RCW 9A.76.020); impersonating of law enforcement (RCW 9A.60.045); criminal mischief, failure to disperse, and disorderly conduct (RCW 9A.84.010-.030); harassment and stalking (RCW 9A.46); private paramilitary activity (RCW 9A.48.120, 38.40.120); and public nuisance (RCW 7.48.130).

The DHS Office of Intelligence and Analysis' Homeland Threat Assessment 2025 offers definitions and contextual notes that further elaborates the threats facing the country.[6]

- **Foreign Terrorist Organization (FTO)**: Any foreign organization that is designated by the Secretary of State in accordance with the criteria section 219 of the Immigration and Nationality Act (INA), which are 1) It must be a foreign organization; 2) The organization must engage in terrorist activity or retain the capability and intent to engage in terrorist activity or terrorism; and 3) The organization's terrorist activity or terrorism must threaten the security of U.S. nationals or the national security (national defense, foreign relations, or economic interest) of the United States.
- **Homegrown Violent Extremist (HVE)**: A person of any citizenship who has lived and/or operated primarily in the U.S. or its territories who advocates, is engaged in, or is preparing to engage in ideologically motivated terrorist activities (including providing support to terrorism) in furtherance of political or social objectives promoted by a foreign terrorist organization but is acting independently of direction by a foreign terrorist organization. HVEs are distinct from traditional domestic terrorists who engage in unlawful acts of violence to intimidate civilian populations or attempt to influence domestic policy without direction or influence from a foreign actor.

- **Domestic Violent Extremist (DVE)**: An individual based and operating primarily within the U.S. or its territories without direction or inspiration from a foreign terrorist group or other foreign power who seeks to further political or social goals wholly or in part through unlawful acts of force or violence. DVEs can fit within one or multiple categories of ideological motivation and can span a broad range of groups or movements. Of note, mere advocacy of ideological positions and/or the use of strong rhetoric does not constitute violent extremism. In some cases, direct or specific threats of violence must be present to constitute a violation of federal law.[7]

Targeted Violence

Targeted violence refers to violence that is premeditated and directed at specific individuals, groups, or locations. Perpetrators often select their targets as a result of grievances.

> *Targeted violence is distinct from violence that is spontaneous, random, or impulsive crime emanating from a person's immediate anger or fear and is often distinguished by pre-attack behaviors that suggest violence as a possible outcome.*[8]

Examples include school shootings, workplace violence, domestic violence and terrorism.

The factors that lead to targeted violence can be wide-ranging, complex, and occur over a period of time. In contrast to DVE and HVE attacks, most mass casualty attacks[9] in the homeland over 2024 were not motivated by an ideology but were rather associated with suspected or confirmed mental illness or driven by relationship grievances; however, these factors alone are not diagnostic indicators of likely violence. In 2024, at least eight mass casualty attacks primarily motivated by reasons other than an ideology have occurred in the U.S., killing at least 38 and injuring 68.[10] Individuals acting alone conducted most of these mass attacks while using firearms and targeting commercial and education facilities.

FTOs, like ISIS and al-Qa'ida, maintain the enduring intent to conduct or inspire attacks in the U.S. and have leveraged the conflict in the Middle East to reaffirm this intent. These organizations maintain worldwide networks of supporters that could target the U.S. FTO media outlets promote violent rhetoric intended to inspire U.S. persons to mobilize to violence, while foreign terrorists continue engaging online supporters to solicit funds; create and share media; and encourage followers to attack within the U.S., against U.S. interests, and what they perceive as Western interests.[11]

Active Shooter

The Department of Homeland Security defines an active shooter as "an individual or multiple individuals actively engaged in killing or attempting to kill people in a confined and/or populated area". These areas include where people shop, learn, work and exercise free speech. Attacks can be perpetrated by many different actors with different motivations, but all use violent and destructive tactics to cause harm to people and/or property. Some actors include terrorists (domestic and international), violent extremists, and targeted violent offenders.

Types

Domestic Terrorism

The U.S. Government, including the FBI and DHS, broadly divides the domestic terrorism threat among the following threat categories:[12]

Table 4.6-1 FBI and DHS Domestic Terrorism Categories

Domestic Terrorism Categories	
Animal Rights/Environmental Violent Extremism	This threat encompasses the potentially unlawful use or threat of force or violence in furtherance of ideological agendas by those seeking to end or mitigate perceived cruelty, harm, or exploitation of animals and/or the perceived exploitation or destruction of natural resources and the environment.
Abortion-Related Violent Extremism	This threat encompasses the potentially unlawful use or threat of force or violence in furtherance of ideological agendas relating to abortion, including individuals who advocate for violence in support of either pro-life or pro-choice beliefs.
Anti-Government or Anti-Authority Violent Extremism	This threat encompasses the potentially unlawful use or threat of force or violence in furtherance of ideological agendas, derived from anti-government or anti-authority sentiment, including opposition to perceived economic, social, or racial hierarchies, or perceived government overreach, negligence, or illegitimacy.
	The FBI and DHS further break down the Anti-Government/Anti-Authority Violent Extremism category into:[13] • Militia Violent Extremists: DVEs who take overt steps to violently resist or facilitate the overthrow of the U.S. Government in support of their belief that the U.S. Government is purposely exceeding its Constitutional authority and is trying to establish a totalitarian regime; oppose many federal and state laws and regulations, particularly those related to firearms ownership.

Domestic Terrorism Categories	
	• Anarchist Violent Extremists: DVEs who oppose all forms of capitalism, corporate globalization, and governing institutions, which are perceived as harmful to society • Sovereign Citizen Violent Extremists: DVEs who believe they are immune from government authority and laws.
Racially or Ethnically Motivated Violent Extremism	This threat encompasses the potentially unlawful use or threat of force or violence in furtherance of ideological agendas derived from bias, often related to race or ethnicity, held by the actor against others or a given population group. Racially or Ethnically Motivated Violent Extremists purport to use both political and religious justifications to support their racially or ethnically based ideological objectives and criminal activities.
All Other Domestic Terrorism Threats	This category encompasses threats involving the potentially unlawful use or threat of force or violence in furtherance of ideological agendas which are not otherwise defined under or primarily motivated by one of the Other Domestic Terrorism threat categories. Such agendas could flow from, but are not limited to, a combination of personal grievances and beliefs, including those described in the other Domestic Terrorism threat categories. Some actors in this category may also carry bias related to religion, gender, or sexual orientation.

Active Threats

Examples of tactics include mass shootings, bombings, arson, murder, kidnapping, hijacking, or skyjacking. Not all attacks are politically motivated, some are based on personal grievances. Most attacks happen in public gathering places or institutions, of which Tacoma has many. The threat of attacks has grown with the interconnectedness of the internet and social media. In today's security conscious, post-9/11 environment, the main threat appears to be attacks using small-scale tactics such as shootings or vehicle ramming.

No official sources were found that categorize active shooter events by type of incident or method. From a planning perspective in Pierce County, these events can be categorized into three general categories: workplace, school and public venue. In addition to location, the differentiating consideration is the potential triggering event or conditions leading up to the incident. These can be very personal in nature and specific to the individual and set of circumstances at the time.

Evolution of Terrorism: Domestic and International

Since the September 11, 2001, terror attacks, the threat landscape in the U.S. has expanded considerably, and international terrorism remains a serious threat. The threat of domestic terrorism also remains persistent overall.[14]

According to the FBI, the DT threat "expanded significantly" in 2021 and 2022. As it had in previous years, the FBI concluded that the increase is largely attributable to an escalating threat from DVEs and an increase in anti-government or anti-authority violent extremism. DHS has echoed this conclusion and states that DVEs present the "most persistent and lethal threat" to the country. [15] Further, the FBI and DHS expect the terrorism threat environment in the U.S. will remain high due to a confluence of factors. These factors include violent extremist responses to domestic sociopolitical developments and the 2024 election cycle, the enduring intent of FTOs to conduct or inspire attacks in the Homeland, and the galvanizing effect that successful terrorist attacks abroad and the ongoing conflict in the Middle East have had on a range of violent actors.[16]

In the Strategic Intelligence Assessment and Data on Domestic Terrorism[17], budget documents, and FBI testimony regarding the DT threat over the last several years, the FBI has stated that it is most concerned about lone actors and small groups of individuals, primarily using firearms and easily accessible weapons. According to the FBI, these individuals "act without a clear group affiliation or guidance, making them challenging to identify, investigate, and disrupt" and they often radicalize online.

Many factors have contributed to the evolution of the terrorism threat on both the international and domestic fronts:[18]

- **Lone offenders**: Terrorist threats have evolved from large-group conspiracies toward lone-offender attacks. These individuals, as lone actors or in small groups of individuals, commit acts of violence motivated by a range of ideological beliefs and/or personal grievances. Lone offenders often radicalize online, mobilize to violence quickly, and look to conduct attacks with easily accessible weapons. Without a clear group affiliation or guidance, lone offenders are challenging to identify, investigate, and disrupt.
- **The internet and social media**: International and domestic violent extremists have developed an extensive presence on the Internet through messaging platforms and online images, videos, and publications. These facilitate the groups' ability to radicalize[19] and recruit individuals who are receptive to extremist messaging.
  Social media has also allowed both international and domestic terrorists to gain unprecedented, virtual access to people living in the United States in an effort to enable homeland attacks.

Profile

Location and Extent

Terrorist Attacks

Terrorist attacks vary by type in terms of location, how many people or how much infrastructure is impacted. These attacks continue to take place at open-access events, mass gatherings, and outside the perimeter of secured events, possibly because of a perceived lack of security, the availability of publicized schedules, and largely unrestricted admittance. Examples of open-access events include marathons, parades, protests, rallies, festivals, fireworks displays, farmers markets, and high-profile funerals and vigils or memorials. Terrorists could also target gatherings located close to ticketed events, such as tailgating adjacent to major sporting events or concerts.[20]

Judging from the drivers of previous terrorist plots and attacks, DVEs and HVEs will likely remain interested in conducting opportunistic attacks against civilian targets, most notably mass gatherings. Techniques used in recent terror attacks have included the use of vehicles as weapons, edged weapons, small arms, and improvised explosive devices (IEDs).

The Department of Homeland Security has identified 16 critical infrastructure sectors that "compose the assets, systems, and networks, whether physical or virtual, so vital to the U.S. that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof."[21] Due to their criticality, these sectors are often viewed as attractive targets to acts of violence, intrusion, or destruction. Special events or venues that attract large gatherings tend to be the most lucrative targets due to the high volumes of potential victims and become even more appealing during visits by high profile personalities and dignitaries. Organized by the critical infrastructure sectors, **Error! Reference source not found.**features, in no specific order, examples of high impact targets:

Table 4.6-2 High Impact Civil Unrest Target Areas

High Impact Target Areas	
Commercial Buildings	Stadiums, concert venues, convention centers, theaters, parks, shopping malls, casinos, etc.
Cyber/Information Technology	Networks, power grids, communication industry, etc.
Special Events	Parades, festivals, concerts, sporting events, other planned celebrations, etc.
Government Buildings	Courthouses, federal buildings, schools, national laboratories, etc.
Law Enforcement and Emergency Services	First responders and all law enforcement facilities, equipment, personnel, etc.
Defense	Military bases, Department of Defense facilities, airfields, equipment, etc.
Transportation	Airports, bridges, ferries, interstate highways, passenger rail, tunnels, seaports, hazardous materials, pipelines, etc.
Dams, Water Reservoirs, and Power Distribution Networks	Operating systems, facilities, etc.
Financial Institutions	Banks and other financial institutions.
Food and Agriculture	Food products at point-of-sale, distribution, and storage, etc.
Healthcare and Public Health	Hospitals, public health facilities, etc.
Historic Places and Sites	Historical landmarks, monuments, museums, and other iconic sites.

Terrorism events can be distinguished from other types of man-made hazards by three important considerations:[22]

- In the case of chemical, biological, and radioactive agents, their presence may not be immediately obvious, making it difficult to determine when and where they were released, who was exposed, and what danger is present for first responders.
- Terrorist events evoke very strong emotional reactions, ranging from anxiety, to fear to anger, to despair to depression.
- Even failed attacks have long-term economic impacts for the targeted government and critical infrastructure sector disproportionate to the cost of the attack itself.

The form and locations of many natural hazards are identifiable and, even in some cases, predictable; however, there is no defined geographic boundary for terrorism. Based on previous historical events, it is presumed that critical facilities, services, and large gatherings of people are at higher risk.

Pierce County has areas of concentrated population and venues and events that draw large crowds. It also has significant infrastructure that is important locally as well as nationally. The county is a key component in the Pacific Northwest transportation network that supports extensive domestic and international commerce. There are key transportation nodes and routes that cannot be easily replaced or bypassed.

One of largest joint military bases in the Department of Defense resides in Pierce County. Joint Base Lewis-McChord (JBLM) is the jumping off point for the United States' military and strategic influence across the Pacific Rim. Additionally, there are multiple Reserve Component and military recruiting facilities throughout the county. There are significant populations of military personnel and their families residing in the communities surrounding JBLM as well as a significant number of county residents who are employed on the base. The rural areas of the county contain large swaths of private, state and national forests. Additionally, it contains the Mount Rainier National Park. These areas are sources of revenue and employment for Pierce County residents.

English-language terrorist media continues to identify similar gatherings as "soft targets" and promote them as potential attack sites. For example, Inspire #12 magazine published online by Al Qaeda, suggested targeting locations "flooded with individuals, e.g., sports events . . . election campaigns, festivals, and other gathering [sic]. The important thing is that you target people and not buildings."[23] Attacks targeting these types of events will continue to present security challenges to public safety personnel, because attendees are anonymous and generally unscreened for prohibited items.

Vulnerability

In terms of Pierce County's vulnerability to terrorism and extremism, Pierce County is the second most populous county within Washington State and is ranked 60th most-populous in the U.S. according to the U.S. Census Bureau.[24] Within Pierce County, the Washington State Fusion Center tracks over 500 annual large-gatherings that encompass public assembly and outdoor events. These events include a diverse range of locations that draw large crowds of people for shopping, business, entertainment, sports or lodging, as well as for fireworks, marathons, festivals, and parades.

DVEs and HVEs have increasingly targeted mass-gatherings in densely populated or high-profile areas. Consequently, any major urban area in Washington State could be considered at-risk as well as any crowded or high-profile critical infrastructure. The specific motivations of terrorists will largely dictate target selection. A number of evolved weapons, tactics, and targets have emerged through the sheer volume of attacks within the last decade. This normalization of targeted violence has been further exacerbated by extensive media coverage and the ease by which detailed instruction manuals, 'how-to' videos, and online forums dedicated to weapons, explosives, and tactics. It is "essentially shared community content, easily accessible for extremists of all stripes to consume and put into action" including those with no affiliation to foreign or domestic extremism ideologies.[25] Lessons learned from past attempts continue to shape the means by which attackers develop plots—the push for using small arms, edged-weapons and vehicle ramming against soft targets—instead of the often-failed large-scale attacks.[26]

Active Threat

The Federal Bureau of Investigation (FBI) has many resources on active shooter statistics. From 2000-2017 there were 250 active shooter incidents (Figure 4.6-1 and Figure 4.6-2). In 2013 when the FBI released their first study results there were only 160 active shooter incidents. A few images highlight the increase in frequency and casualty counts.[27]

Figure 4.6-1 250 Active Shooter Incidents in the U.S. from 2000-2017: Incidents Per Year

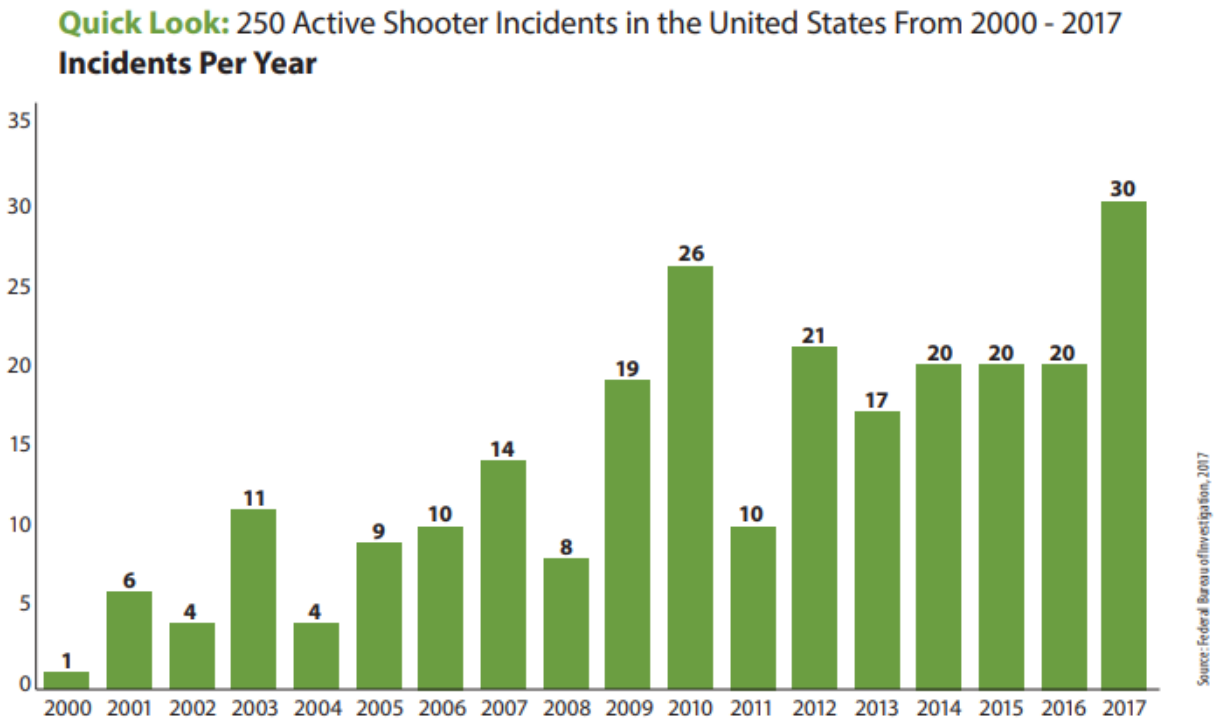
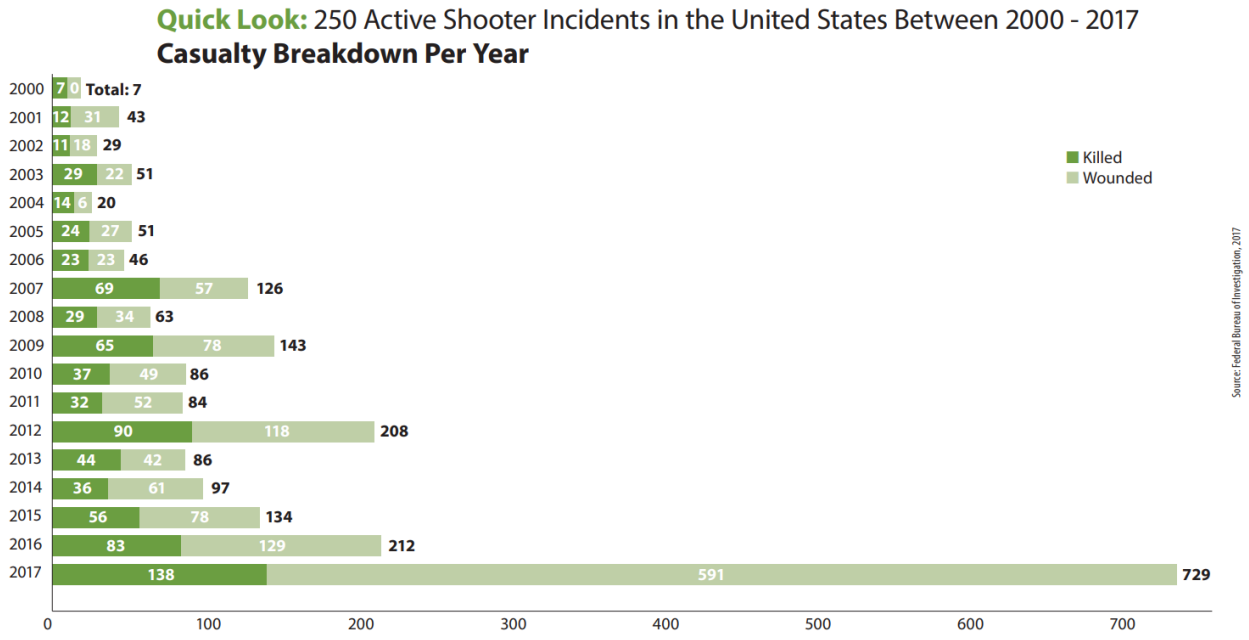
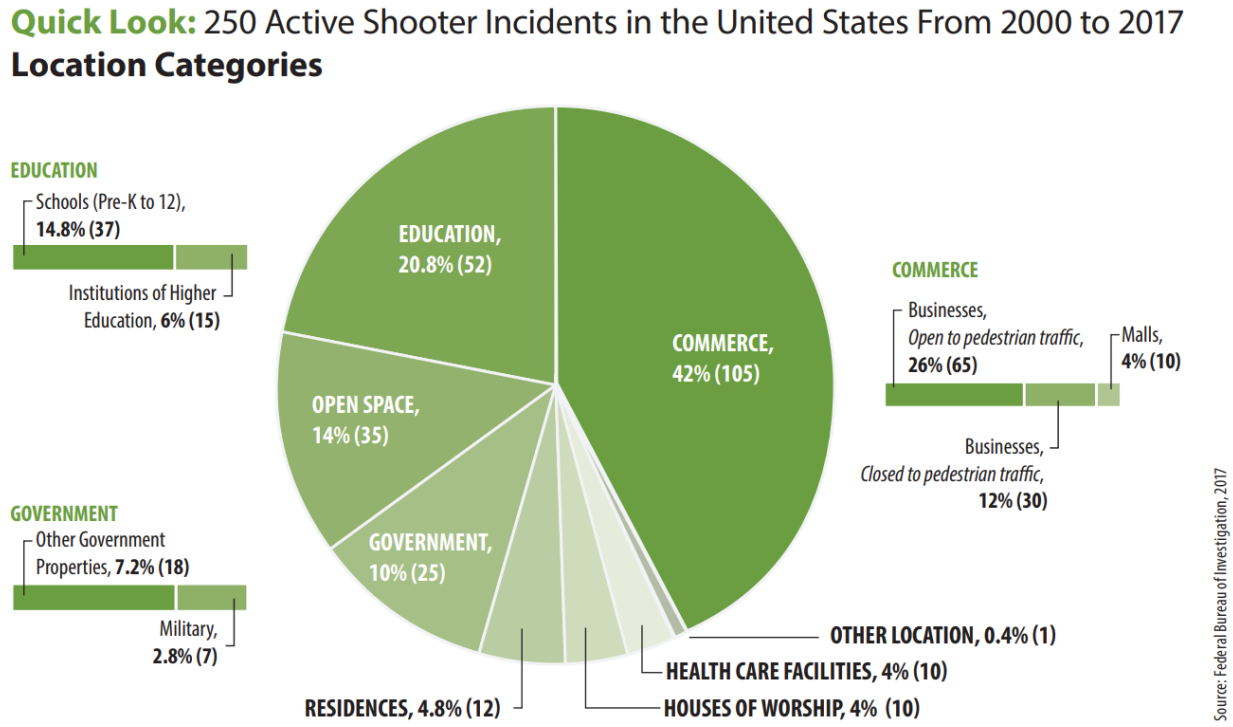


Figure 4.6-2 Active Shooter Incidents in the U.S. from 2000-2017: Casualty Breakdown Per Year



The FBI identified 11 separate incident location categories when seeking to identify the primary locations where the public was most at risk during an incident (Figure 4.6-3). These location categories include commercial areas (divided into malls, businesses open to pedestrian traffic, and businesses closed to pedestrian traffic), educational environments (divided into schools [pre-kindergarten through 12th grade] and IHEs), open spaces, government properties (divided into military and other government properties), residences, houses of worship, and health care facilities.

Figure 4.6-3 250 Active Shooter Incidents in the U.S. from 2000-2017: Location Categories



Since 2000, most active shooter events involved locations that could be considered "soft targets." These were venues where groups of people congregated, access was relatively easy and there was little to no security presence. Workplace or academic settings were common locations in which attacks occurred. Some attacks appear to have been spur of the moment or the product of a sudden emotional event. Others were methodically planned over a period of time, presumably for revenge, notoriety or to make a statement to society in general. In the latter cases, attackers appeared to be in full control of their emotions and made deliberate decisions about how to carry out their attacks. Target locations were specifically selected, method of attack was carefully calculated, the timing was selected based on the highest potential for casualties and there is even evidence that some of these attackers even planned how the event would end.[28]

Whether the attack is deliberately planned or an immediate reaction to an emotional event, potential indicators that the risk level has increased are difficult to spot and unreliable. Recent events have shown that they can occur at malls, concerts, department stores, schools, workplaces, public gatherings and any other location that can be easily accessed. Furthermore, there is typically no discernible pattern or set of criteria as to how the attacker selects their victims. The goal of the assailant is to kill as many people as quickly as possible before the attack ends. This puts the attacker in the position of advantage as they determine the time, location and method of the attack, forcing victims, bystanders and responders to react to their actions.

Due to the unpredictable and uncontrollable nature of these events, countermeasures characteristically involve the immediate actions of people at the attack site and quick deployment of law enforcement officers. Active threat events are frequently short lived and over before law enforcement can arrive on scene. Because of this, individuals must be mentally and physically prepared to deal with the situation as it is happening.[29] Survivor initiated actions are as important toward ending an active shooter event as law enforcement response. These actions span the full spectrum of the Run, Hide, Fight methodology.[30]

Analysis of known events indicates that few attackers had previous negative contact with law enforcement, however most had recently experienced something significant in their lives. Dramatic events, such as the loss of a job, severe financial hardship, loss of a relationship, a personal humiliating event, or other significant events have been known to act as a trigger. Some of these were tied to a one-time occurrence (i.e. an employee was unexpectedly fired or laid off) while others occurred over a period of time (i.e. bullying in school, struggling academic performance, history of negative interaction between a supervisor and employee etc.). These incidents frequently had a “last straw” event that was the tipping point for the attacker(s). It is important to understand that attacks do not necessarily happen immediately after a “last straw” event. This event may mark the beginning of the planning process. The duration of that process is individual to the potential attacker. Some further analysis indicates that mental illness may be a contributing factor in many of these cases, but no definitive causal relationship is specifically established at this time.[31] It is important to note that the fact that a person has suffered a hardship or has experienced a series of life impacting events is not, in and of itself, a reliable indicator of potential risk. A more comprehensive review of the individual is generally required. As this is realistically only possible in a narrow band of potential cases, the ability to truly predict an event like this is minimal.[32]

Guns were the most commonly used weapon and in many cases the attacker had multiple weapons.[33] Although rare, there were incidents in which the attacker brought an explosive

device of some kind, potentially in an effort to kill more people or as a means to engage first responders.

Occurrences

Terrorism

The form and locations of many natural hazards are identifiable and, even in some cases, predictable; however, there is no defined geographic boundary for terrorism. Based on previous historical occurrences of terrorism, it is presumed that critical facilities, services, and large gatherings of people are at higher risk.

A number of violent extremists embrace multiple, sometimes competing motivations, challenging the U.S. Government's ability to identify their potential targets in advance because their pre-attack statements online are often unrelated or only loosely related to the targets they ultimately choose.[34]

- Between September 2023 and July 2024, U.S. law enforcement disrupted at least eleven DVE plots. Two HVE attacks, partially motivated by the Israel-HAMAS conflict, also occurred during this timeframe, and law enforcement disrupted at least three other HVE plots.
- Throughout 2024, DVE efforts have focused on a range of targets, including ethnic and religious minorities, government officials, and ideological opponents, while HVEs have mostly targeted faith-based organizations.
- DVEs motivated by various ideologies have used online messaging to increasingly promote the swatting and doxxing of ideological opponents, including public and private officials at their residences. Other DVE-related violent threats have targeted court officers associated with divisive sociopolitical cases; migrants and government officials linked to immigration grievances; and Jewish, Muslim, and Arab communities, partly in response to the Israel-HAMAS conflict.
- DVEs and HVEs will continue to be influenced by sociopolitical drivers emphasized in popular discourse, particularly those related to current events, which are used to amplify existing narratives and justify violence. These events will likely be referenced in FTOs' official and unofficial messaging and contribute to the radicalization and mobilization of U.S.-based individuals to violence throughout and likely beyond 2025.

Historical Cases

Prior to the attacks on September 11, 2001, there were less than a dozen major terrorist events in Washington State. Since then, violent extremism has become commonplace, on a global and national scale, and the number of local terrorism and violent extremism cases continue to rise.[35] Some of the most notorious terror cases in Washington State include the arrest of Ahmed Ressam, the "Millennium Bomber," in December 1999[36], the Earth Liberation Front (ELF) firebombing of University of Washington's (UW) horticulture center in May 2001[37], and the foiled Seattle Military Entrance Processing Station attack plot in 2011.[38]

March 26, 2018

On March 26, 2018, Thanh Cong Phan from Everett was arrested after mailing at least 11 suspicious packages to multiple military and government facilities in the Washington, D.C. metropolitan area, which contained potential destructive devices. He was charged with shipping of explosive materials, after the packages were found to contain small amounts of black explosive powder.[39]

March 31, 2017

Muna Osman Jama of Reston VA and Hinda Osman Dhirane of Kent WA were sentenced to 12 years and 11 years respectively, after being found guilty of conspiracy to provide material support to al-Shabaab. The two reportedly organized an all-female fundraising group, called the "Group of Fifteen," who provided monthly payments to al-Shabaab; facilitating and tracking money sent through conduits in Kenya and Somalia.[40]

August 25, 2017

Melvin Neifert from Selah was arrested and charged with receiving incendiary explosive device materials—specifically, potassium nitrate and other materials to make a potassium nitrate-sugar bomb—that were to be used in connection with the 2016 May Day events. Federal authorities seized evidence and questioned Neifert on May 1, the same day anti-capitalist demonstrations took place in Seattle.[41]

April 9, 2015

Blake Heger was arrested after attempting to place two shrapnel-laden pipe bombs near a high foot-traffic area outside a hardware store in Puyallup, WA. Police were called after a concerned citizen saw him sharpening large knifes in the parking lot. He was found with two additional pipe-bombs, four large knives, and a screwdriver that he had sharpened into a dagger.[42]

January 1, 2014

Musab Masmari attempted to set fire to a gay nightclub on Capitol Hill in Seattle, WA by spilling gasoline down a set of stairs and lighting it, while 750 people packed the club's New Year's Eve event. According to investigative documents, Masmari told a friend that "homosexuals should be exterminated." In July 2014, he was sentenced to ten years in federal prison for arson.[43]

July 18, 2014

Ali Muhammad Brown was arrested after killing four people in WA and a college student in NJ, as part of a personal vengeance against the U.S. government for its actions in the Middle East. In 2004, he was arrested and prosecuted for his role in a bank fraud scheme to finance fighters traveling abroad and had known links to a disrupted terror cell in Seattle, WA and Bly, OR in 1999.[44]

September 8, 2011

Michael McCright was arrested and charged with second-degree assault for a July 2011 incident where he intentionally swerved his vehicle at a government-plated vehicle occupied by two U.S. Marines in Seattle. Known on the Internet as "Mikhail Jihad," McCright had ties to Abu Khalid Abdul-Latif, a man convicted of plotting to kill federal employees and military recruits in Seattle, WA.[45]

June 22, 2011

Abu Khalid Abdul-Latif and Walli Mujahidh were arrested for planning to attack the Military Entrance Processing Station (MEPS) in Seattle with machine guns and grenades after previously planning, but discounting, an attack at Joint Base Lewis McChord (JBLM). According to FBI investigators, "Abdul-Latif said that 'jihad' in America should be a 'physical jihad,' and not just 'media jihad'."[46]

Active Threat

There have been five planned or conducted events in Pierce County since 2001 that were formally categorized as “active shooter”. Another five occurred within the state, mostly in Western Washington (Table 4.6-3 Occurrences in the Puget Sound).

It must be noted that this assessment does not account for potential reporting bias in how events were categorized and/or officially reported by law enforcement agencies.[47]

Table 4.6-3 Occurrences in the Puget Sound[48]

Date	Community	Location
11/1999	Seattle	Northlake Shipyard
5/2001	Tacoma	Pacific Lutheran University
11/2005	Tacoma	Tacoma Mall
4/2006	Puyallup	Rogers High School
7/2006	Seattle	Jewish Federation of Greater Seattle
11/2009	Lakewood	Forza Coffee Shop
2/2010	Tacoma	Birney Elementary School
7/2011	Auburn	Muckleshoot Casino
5/2012	Seattle	Café Racer Coffee Shop
4/2013	Federal Way	Pinewood Village Apartments
6/2014	Seattle	Seattle Pacific University
10/2014	Marysville	Marysville-Pilchuck High School
9/2016	Burlington	Cascade Mall
12/2017	Graham	Graham-Kapowsin High School
6/2018	Seattle	Highway 509 Near Seattle-Tacoma International Airport

There is no pattern as to frequency or recurrence of attacks in Pierce County or Washington State. The last known active threat event in Pierce County occurred in 2019. On a national scale, compared to all violent crimes committed, active shooter events are the most common.[49] That said, the unpredictable nature of these events, the mental and emotional triggers that can cause them and the current social and economic influences within the general society make it prudent to assume that there will be an occurrence in the future within Pierce County.

Impacts

Terrorist attacks continue to take place at open-access events, mass gatherings, and outside the perimeter of secured events, possibly because of a perceived lack of security, the availability of publicized schedules, and largely unrestricted admittance. Examples of open-access events include marathons, parades, protests, rallies, festivals, fireworks display, farmers markets, and high-profile funerals and vigils or memorials. Terrorists could also target gatherings located close to ticketed events, such as tailgating adjacent to major sporting events or concerts[50]. Judging from previous terrorist plots and attacks, terrorists will likely remain interested in conducting opportunistic attacks against civilian targets, most notably mass gatherings. Techniques used in recent terror attacks have included the use of vehicles as weapons, edged weapons, small arms, and improvised explosive devices (IEDs).

Health and Safety of Persons in the Affected Area at the Time of the Incident

The goal of most attackers is to kill and injure as many people as possible in as short a time as possible. Sometimes this begins by targeting a specific individual(s) and then escalates. In other events, there is no specific target in mind. Based on the analysis of previous events in Washington State, people in the workplace and school settings are most likely to experience an active shooter event. That does not rule out or reduce the potential that people in public places such as malls, churches or community events can find themselves in an active threat situation. Four of the ten events in Washington State occurred in public venues (see chart above).

Injured people have the potential of dying from their injuries before medical response can arrive. Until law enforcement has successfully secured the scene, medical personnel will not enter the affected area. Law enforcement's initial focus will be to stop the threat and secure the area. At least initially, injured people may be on their own to render aid and evacuate the area within their capabilities.

Those who are injured may face a long and painful recovery as well as significant medical expenses that can lead to financial hardship. In some cases, people will not fully recover from their physical injuries dramatically effecting their quality of life and potentially their ability to work.

There will likely be significant potential for psychological effects for people who witnessed the incident. Post-traumatic stress syndrome is a concern in the weeks, months and possibly years following the incident. This will significantly affect individual quality of life, ability to work and may add to the financial hardship as well.

Health and Safety of Personnel Responding to the Incident

Responding law enforcement should expect to be in the line of fire as soon as they arrive on scene. To date, most active threat events were resolved very quickly; either before or upon the arrival of law enforcement. [51] Delaying intervention by law enforcement may result in additional time for an attacker to carry out their attack, as seen during the Uvalde School Shooting in 2022.[52] The two biggest risks to responding personnel are a heavily armed attacker that is willing to stand and fight and/or an attacker that has introduced an explosive device to target responders. Secondary devices at likely staging areas or assembly areas should be a concern for responders. This tactic has significant potential to dramatically impact evacuees and responders and slow the response/recovery.

Responding medical personnel are further at risk if there is more than one attacker or if the attacker has not been contained. Multiple threat events may involve at least some planning on the part of the attackers, who may want to engage responding fire and medical personnel to increase casualties and delay aid to survivors. Depending on where the attack happens, securing the location can be a lengthy process, which increases the chances that seriously injured people can die from their wounds. This may place the burden of initial triage and medical care on law enforcement.

The psychological impact to responders cannot be overlooked. These are very intense events that can result in a high number of casualties. Being in the line of fire or responding to the carnage can have a significant emotional impact. Post-traumatic stress syndrome can affect responders' ability to perform their jobs in the future.

Continuity of Operations and Delivery of Services

Depending on where the attack occurs and how extensive it is, continuity of operations may be an issue. An attack that occurs in a workplace, will not only affect the available personnel to continue operating, but may prevent the facility from being operational for some time while recovery and investigations take place. The facilities with public access may find delivering normal services difficult as people are afraid to re-enter the facility. This may necessitate establishing an alternate location with potentially reduced staffing and capability until normal operations can be reestablished or improving virtual access to services.

If an attack occurs at a service delivery facility, there may be a temporary interruption of those services during the recovery and investigations. Personnel, facilities and equipment may not be available or capable of providing necessary services for some time, depending on how long it takes for the agency and its employees to recover from the incident. Agencies and their supported populations should plan for reduced or interrupted service capabilities following an active threat event.

Property, Facilities, and Infrastructure

Property, facility and infrastructure damage has not been a main concern for active shooters in the past. Overall damage was localized to the incident site and typically not extensive. In the event that the attacker introduces an explosive device, the amount of damage will likely increase, but should still remain generally localized to the event site.

The Environment

The environmental impact of an active shooter event will likely be negligible, unless an explosive device is introduced. The nature of the device, size, composition and what was damaged will determine the extent of environmental impact. In general terms, it is not likely that a single active threat event will result in significant environmental impact.

Economic and Financial Condition

The economic impact of an active threat event would likely be localized and tied directly to the nature of the attack. The event that occurred at the Tacoma Mall in 2005 may have had a short-term economic impact on the stores at that location, but its effect did not extend beyond that. The likelihood of a larger economic impact as a result of a single active threat event is remote.

The financial impact will likely be most significant to jurisdictions in which the event occurred. These will predominantly come in the form of personnel costs (i.e. overtime, loss of productivity, extended leaves of absence, medical costs, legal costs…) due to response and recovery requirements.

Public Confidence in the Jurisdiction's Governance

Public confidence will be most shaped by the effectiveness and efficiency of the initial response, then by how effectively local and county agencies transition through the recovery phase of the incident. Public information and how it is managed will be of paramount importance to shape public confidence. A single active threat incident is not likely to reduce overall public confidence in the jurisdiction's governance if the incident is managed effectively and efficiently.

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Tsunami and Seiche

Natural Hazard | 4.6

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Table 4.6-1 Notable Tsunamis in Pierce County 10

Identification Description

Definitions

Tsunami

The term tsunami is a Japanese word, meaning "large wave in harbor," and comes from the observation that such waves tend to be especially large and dangerous after they enter harbors. A tsunami consists of a series of high-energy waves that radiate outward like pond ripples from the area in which the generating event occurred. They also build in height as they move into shallow water, just before striking the open shore or reaching the heads of bays and then inundating the low-lying areas near the shore. Often, a quick recession of the water precedes the first wave crest.

It is unusual for tsunamis to resemble the icon used to depict them, a towering wave with a breaking crest. While they can have that form it is more usual for them to resemble a series of quickly rising tides, or a surge of water. When they withdraw, they do so with currents much like those of a river. Swift currents commonly cause much of the damage from tsunamis, either from impacting objects directly, or from the material picked up and transported along with the water, such as logs, cars, or parts of buildings. They also pick up pollutants like oil, gas, and sewage, that can cause further damage and long-term environmental problems.

Seiche

Seiches are water waves generated in enclosed or partly enclosed bodies of water such as reservoirs, lakes, bays, and rivers by the passage of seismic waves (ground shaking) caused by earthquakes. Sedimentary basins beneath the body of water can amplify a seismic seiche. Seismic waves can amplify water waves by exciting the natural sloshing action in a body of water or focusing water waves onto a section of shoreline.[1]

Types[2]

Tsunamis are a secondary hazard, the result of geological events. Typically, tsunami and seiches are triggered by earthquakes and landslides, see “Earthquake and Landslide Hazard” Subsections of this plan. These sources are discussed below.

Earthquake Source

Sudden raising or lowering of a portion of the Earth’s crust during earthquakes generally causes a tsunami, although landslides and underwater volcanic eruptions can generate them as well. Movements of the sea floor or lakebed, or rock falling into an enclosed body of water, displace the water column setting off a series of waves that radiate outward like pond ripples. The two main Washington earthquake scenarios that may generate a tsunami are a Cascadia subduction

zone event, around a magnitude 9, and a shallow crustal earthquake, such as the Tacoma or Seattle Faults around a magnitude 7.

Landslide Source

An earthquake is possible deep in the mantle in the Benioff Zone. These earthquakes are typically around a M7 and occur every 30-50 years. However, these earthquakes do not directly cause a tsunami as they do not displace the sea surface, but they can trigger landslides that do. The 2001 Nisqually earthquake is an example of a Benioff earthquake. Three distinct landslide situations could result in a significant tsunami or seiche affecting local communities bordering Puget Sound: submarine landslides on delta fronts, submarine slides elsewhere in the Puget Sound, and slides from adjacent uplands. For more information see the “Landslide” Subsection.

Local Source Tsunami

Usually generated by an earthquake, but can also be caused by a landslide, volcanic eruption, meteorological events, or meteor impact. Tsunami wave arrival within minutes. Shaking is a warning.

Distant Source Tsunami

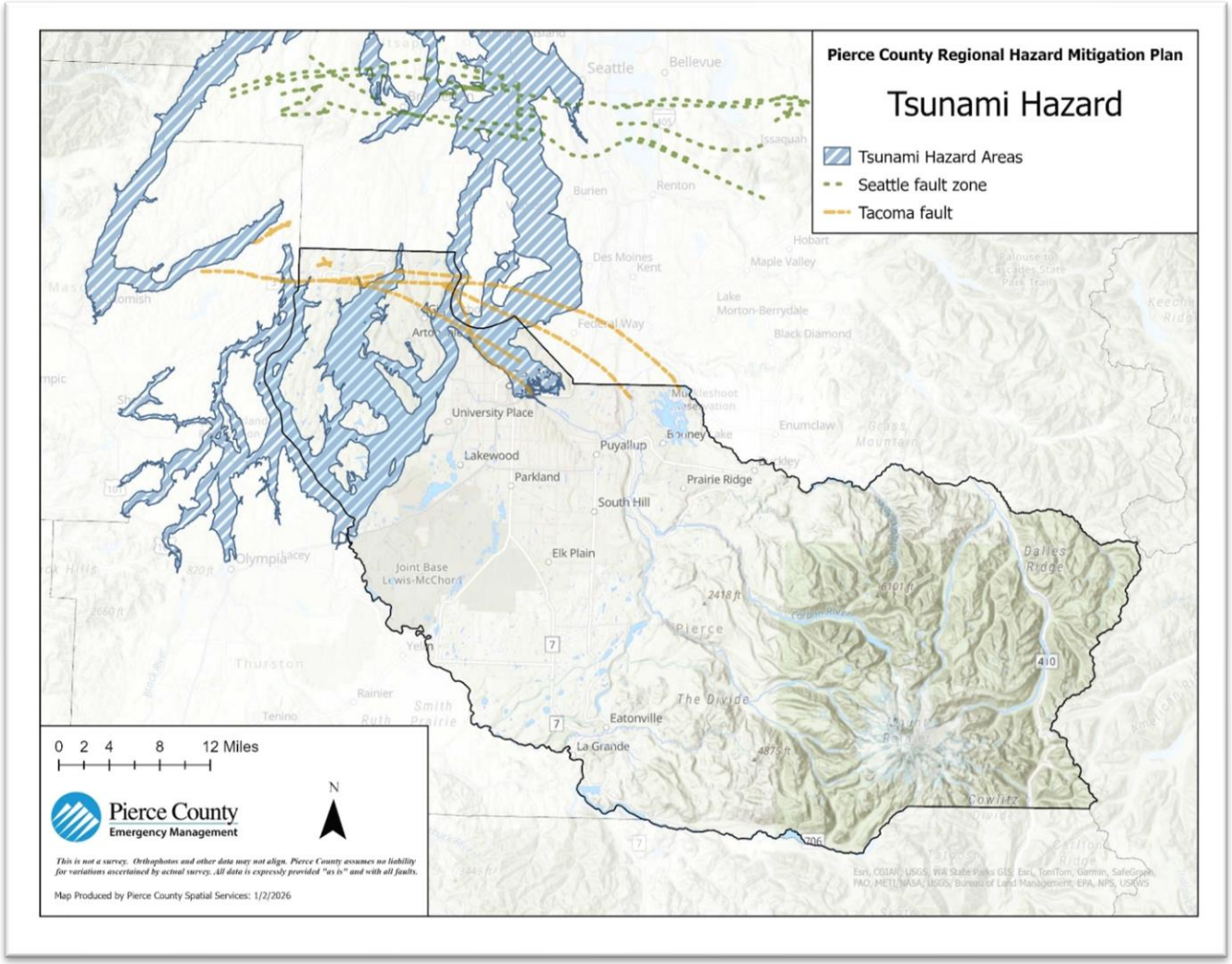
A tsunami originating from a faraway source, generally more than 600 miles or more than three hours of tsunami travel time from its source. Warning must be distributed.

Profile

Location and Extent

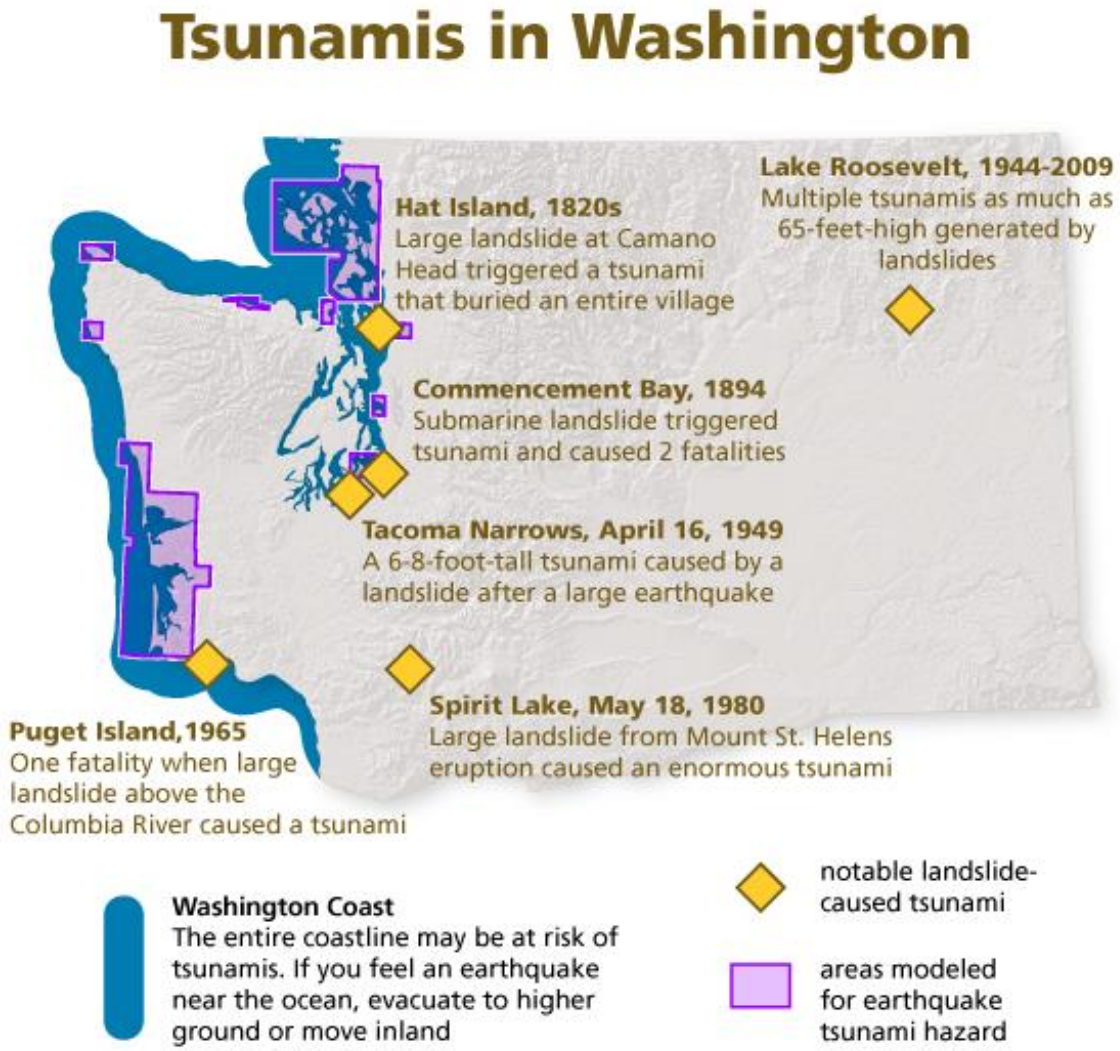
In Washington State, the Pacific Coast, Strait of Juan de Fuca, and the Puget Sound are all at risk from tsunamis. In addition, large lakes and other enclosed bodies of water, like the Puget Sound south of the Tacoma Narrows, could be affected by a seiche. Projected increases in sea level combined with subsidence in portions of Puget Sound will exacerbate these problems

Figure 4.6-1 Tsunami Map for Pierce County



Tsunami history in Washington State is shown in **Error! Reference source not found.** below.

Figure 4.6-2 Tsunamis in Washington State[3]



Earthquake Source

Geologic record in tidal marshes can extend the modern tsunami record prior to written records. What can be seen are distinct clean marine-derived sand layers preserved in the stratigraphy from previously unrecorded tsunami events. Researchers have been able to constrain ages of these sand layers based on radiocarbon dating of the soil above and below. The dates of these layers suggest that large tsunamigenic earthquakes have occurred for the last 3,500 years directly offshore of Washington. The tsunami record has been extended even

further when looking at additional geologic records on the seafloor. During an earthquake event, the shaking triggers turbidity currents, or submarine landslides.

Based on the both the tidal marsh and seafloor record, the Washington State Department of Natural Resources (DNR) has discovered that Cascadia has been actively rupturing for the past 10,000 years. There have been at least 40 events.

A more detailed rendition of the Tacoma and Seattle Faults is shown in Map 4.6-1. In addition, this shows those areas that have a history of uplift and subsidence in previous earthquake events, probably leading to tsunami generation. Displacement along both the Tacoma and Seattle faults happened approximately 1,100 years ago.[4]

Figure 4.6-33 Seattle and Tacoma Faults[5]

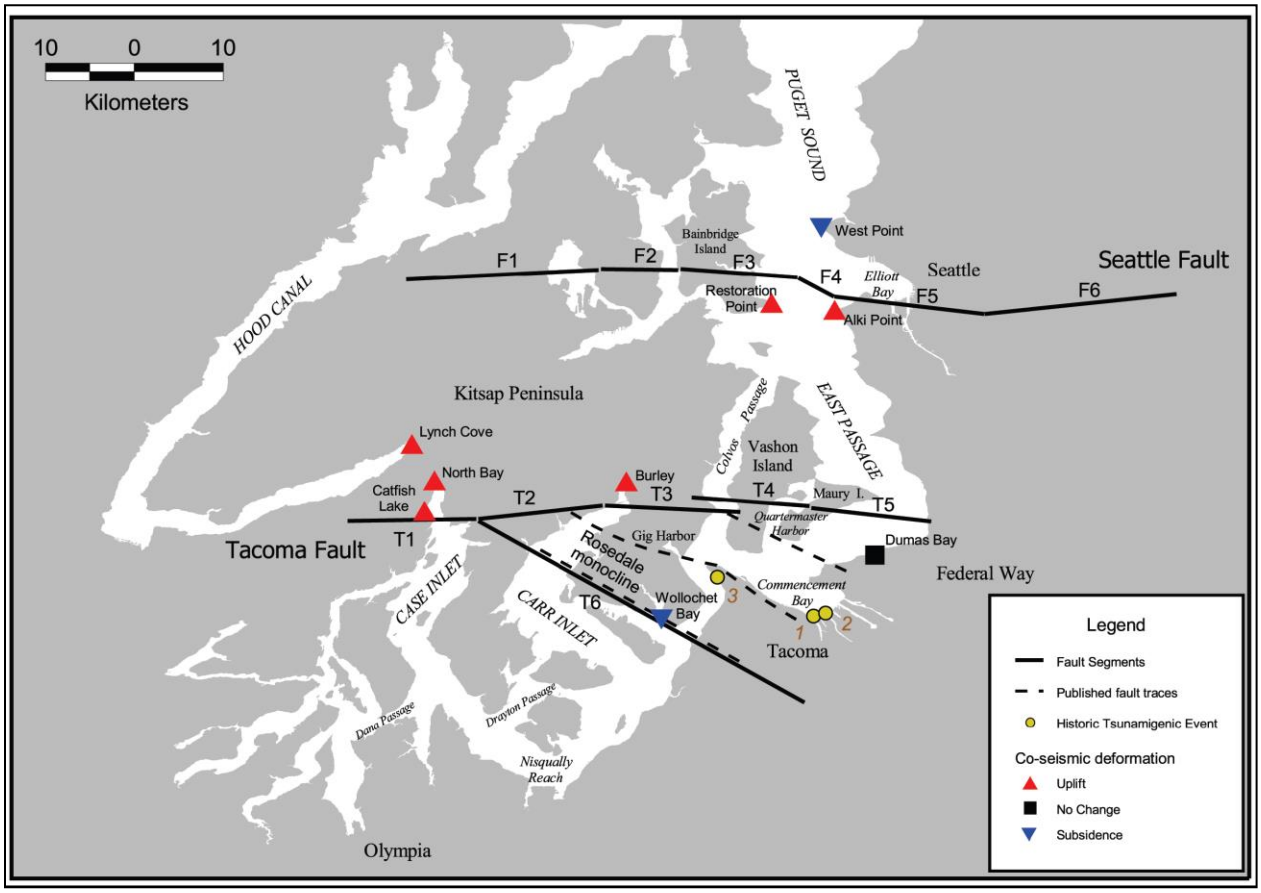
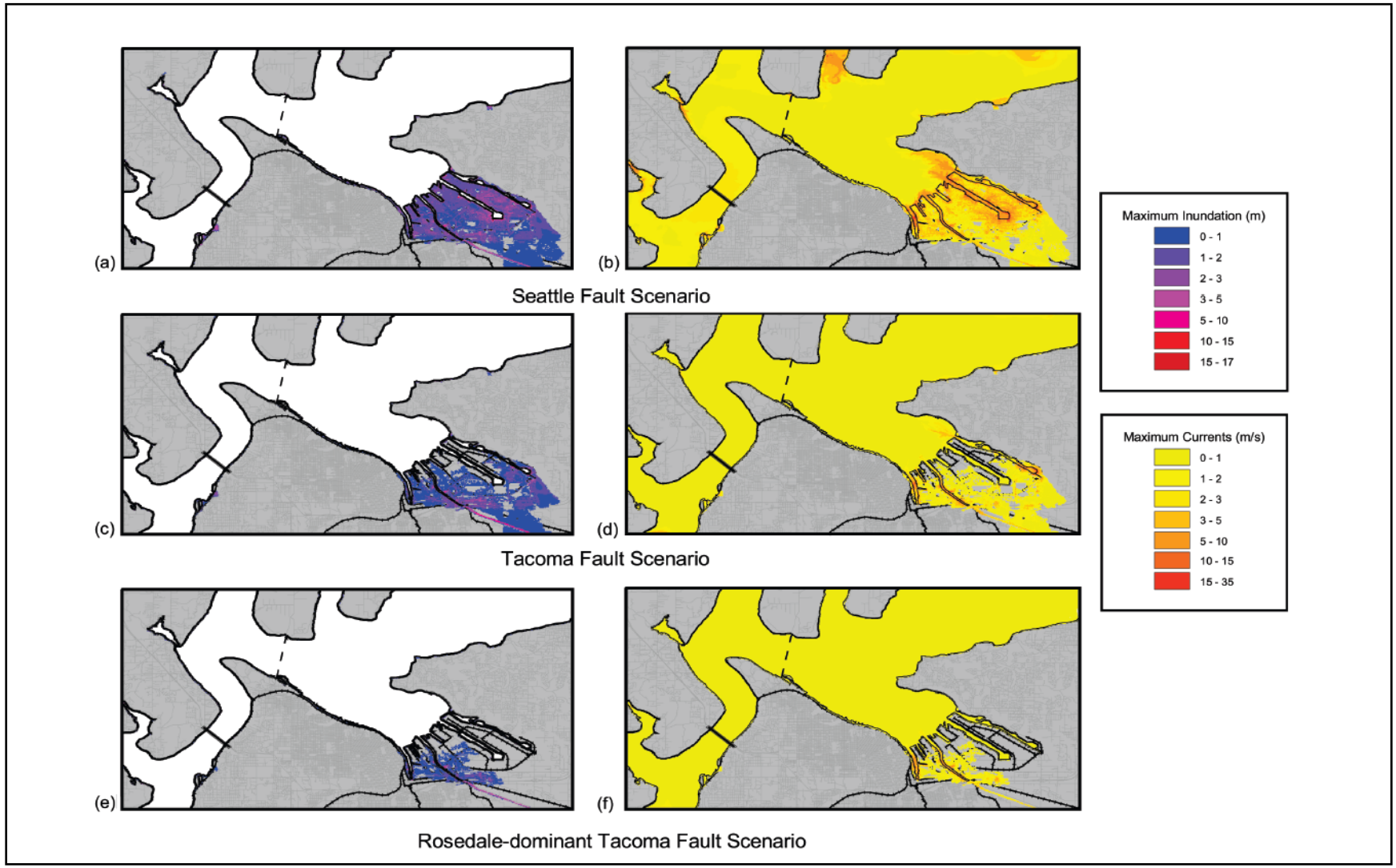


Figure 4.6-33 identifies the maximum inundation (a, c, e) and maximum wave speeds (b, d, f) for each earthquake source scenario. Most inundation occurs within low-lying, relatively flat regions of the study area such as the Port of Tacoma harbor in Commencement Bay. Minimal inundation occurs along steep topographical slopes. Consequently, the inundation is determined primarily by local topography rather than offshore wave dynamics.

The Seattle Fault scenario creates the most inundation and highest currents within the study area due to the large displacement of water in the deepest and widest region of the Puget Sound. The Tacoma Fault scenario has significant inundation in the Port of Tacoma region, but with smaller amplitudes. This scenario causes less inundation overall since much less water is displaced in the narrower and shallower regions of Carr Inlet, Colvos Passage, and East Passage. The Rosedale-dominant Tacoma Fault scenario causes the least inundation and lowest current speeds due to relatively small displacements in the regional channels.[6]

Figure 4.6-44 Tsunami Inundation and Current-Based on Earthquake Scenario[7]



Earthquakes could also lead to landslide-induced tsunamis, the location and extent of which are described below.

Landslide Source

Landslides can occur on most bluffs throughout the coastal regions of Pierce County, including the islands and the peninsula. Landslides can also originate on the delta slopes of major rivers flowing into the Sound. In Pierce County, this has happened primarily on the Puyallup River delta leading into Commencement Bay. Either of these instances can induce a tsunami. Earthquakes can also cause landslide-induced tsunami, as was the case in Tacoma in 1949.

Occurrences

In 2011, Japan experienced a triple disaster: a subduction zone earthquake with a magnitude of 9.0 that triggered the devastating tsunami, which in turn caused a cooling system failure at Fukushima's Nuclear plant.[8] There were 21,000 people left dead or missing and 202,000 buildings/homes were totally or partially damaged. Around 500,000 people were left homeless after this event.[9] Following the triple disaster, there was a shift in the job market, while many were left suspended or displaced from work, there was an increase in new jobs. Construction, engineering, and technical based jobs surfaced in an abundance relating to post disaster recovery. Though this sounds promising, there was a disbalance of the type of work available and the work citizens were seeking. There were not enough workers skilled in construction, engineering, and technical fields to fulfill the jobs. The largest field damaged by this event was manufacturing, specifically the fishery occupation. This was reported over a year after the event and predicted to have lasting effects. There was also a clear increase in emigration from 2010 to 2011 with an increase of 30,799 emigrants. This was directly linked to the triple disaster in Japan.[10]

In 2018 Indonesia was struck by multiple tsunamis, one in September triggered by an earthquake that with the combined effect of the earthquake and following landslides left more than 2000 people dead and around 200,000 displaced.[11] This is one such event where communities' resources were limited, and it kept many people trapped and without necessities. Many people were desperately seeking a way out, but fuel shortages and rations made it impossible. This event also brought some reports of communities' crime rates increasing.[12] In December of 2018 Indonesia experienced another tsunami, this one much more shocking. This tsunami was triggered by an underwater landslide believed to be a result of distant volcanic activity. Indonesian tsunami warning systems were based on tracking earthquakes and were not equipped to read underwater landslides.[13] This event left around 400 dead and around 40,000 displaced and damage brought to 1,300 homes.[14]

The recorded history of tsunamis is short, and research is currently being conducted to develop a chronicle of past occurrences of tsunamis in Puget Sound. Below is a descriptive narrative of each occurrence organized by the tsunami's source.[15]

Table 4.6-1 Notable Tsunamis in Pierce County

Date	Description	Source
900 A.D.	The earthquake on the Seattle fault caused uplift that triggered a tsunami in central Puget Sound that, because of the geography of the Sound waterways, may have reached Pierce County.	Earthquake
1894	A large submarine landslide occurred at night on the Puyallup River delta in Commencement Bay; triggering a tsunami. This resulted in two fatalities and the destruction of 300 feet of the Northern Pacific freight docks and other port facilities. It also created at least a ten-foot wave in the Old Town section of Tacoma, which washed over homes on the tide flats.	Landslide
April 16, 1949	A six to eight-foot-tall tsunami was caused by a landslide on the north end of Salmon Beach, Tacoma after a large earthquake in the Juan de Fuca plate. A 400 ft. high cliff gave way and slid into the Puget Sound. Water receded 20-25 feet from the normal tideline, and an eight foot wave rushed back against the beach, smashing boats, docks, a wooden boardwalk, and other waterfront installations in the Salmon Beach area.[16] It moved both directions within The Narrows causing damage at Salmon Beach, Gig Harbor, and as far south as Day Island. Shortly after the earthquake geologists had noticed that cracks had formed at the top of the slope and had notified residents that a slide was possible. Many people evacuated their property and while the slide itself did not damage the homes there was damage from the tsunami itself.	Landslide

Figure 4.6-55 Salmon Beach, Pierce County, 1949—Tsunamigenic Subaerial Landslide[17]

Recurrence Rate

Tsunamis have been a part of Pierce County long before there was a written record of their existence. Data from field studies shows that both the Seattle and Tacoma faults that run under Puget Sound had displacement around 1,100 years ago.[18] These would have resulted in tsunamis impacting the coastal areas of the County. Recent locally generated tsunamis from the various sources mentioned above have impacted Pierce County three times in the last 120 years. There has been earthquake generated tsunamis (1,100 years ago), as well as ones from landslides into Puget Sound (1949), and from an underwater landslide (1894). There is too short of a historic record to give a definitive answer for a recurrence rate. Taking these into consideration, until further research can provide a better estimate, a tentative recurrence rate of plus or minus 100 years will be used.

Impacts

With earthquakes and landslides as a source, see the respective subsections for impacts not directly related to tsunamis.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Warning signs of an approaching tsunami include feeling the ground shaking severely, seeing a rapid fall or rise in sea level, hearing a loud roar coming from the open water, or receiving alert from Channel 16, NOAA Weather Radio, Emergency Alert System (EAS), Wireless Emergency Alert (WEA), or sirens.[19]

Depending on the location, direction that the wave propagates, time of day and even time of year, fatalities and casualties from any tsunami could be high within the impacted area. Swift currents commonly cause much of the damage from tsunamis either from impacting objects directly or from carrying materials along with the water such as boats, logs, cars, parts of buildings, and pollutants like oil, gas and sewage.

This was the situation with the 1894 tsunami discussed above; see Figure TS-6 Damage in Tacoma from the 1894 Tsunami. One of the factors limiting fatalities and casualties in 1894 was the occurrence of the tsunami at night when the waterfront population was low. Today, a repeat of the 1894 tsunami could damage berthed ships and cause major damage to the restaurants and businesses located on pilings along Ruston Way.

Evacuation routes could be blocked as a result of the source of the tsunami such as landslides, power lines, or other debris. People could be trapped in damaged buildings along the waterfront and not be able to evacuate before a tsunami arrives.

Puget Sound tsunamis could damage both facilities located along the coast and rail cars traveling along the coastal tracks. Many of these contain hazardous materials that could be released in the water and surrounding environment. Depending on the chemicals released, this could pose a threat to citizen's health for weeks or even longer.

It is possible that bridges and ferry docks hit by the tsunami could be damaged; either partially or fully destroyed. This would limit the ability of citizens to evacuate the individual islands in Pierce County and in the case of the Purdy Bridge limit access to the Gig Harbor Key Peninsula communities.

In the 2004 Indonesian tsunami and the 2011 Japanese tsunami, crime rates were reported as lower.[20] Many sources report that disasters bring a stronger sense of community as seen in Japan.[21] There is acknowledgement of the possibility that crime is not being reported as much

in times of disaster recovery. Community destruction can lead to law enforcement groups to prioritize their efforts and it is possibly that some crime reports are pushed aside to handle greater more pressing matters.[22] After such events, communities can still face a lot of devastation and/or despair. While it may not be true that crime necessarily grows or increases long term for every event, it is apparent through reports that crime can change somewhat. When communities are struck by disaster that leaves them with shortages of food water and materials looting crimes become more popular. Following Japan's triple disaster there were also reports of scamming to receive money.[23]

Figure 4.6-66 Damage in Tacoma from the 1894 Landslide and Tsunami[24]

Health and Safety of Personnel Responding to the Incident

Response personnel located within the affected area will have the same threats as the general population during the actual period of time that the waves are active and dangerous.

Continuity of Operations and Delivery of Services

The adverse impact to jurisdictions within Pierce County for a non-earthquake generated tsunami, in maintaining normal day-to-day operations, will be limited. Damage and response will both be limited due to the small size and localized effect of the tsunami.

For tsunamis associated with a local earthquake on either the Tacoma or Seattle fault, computer modeling shows wave action and related currents moving deep into Gig Harbor, the Port of Tacoma, Fife, and reaching over five kilometers up the Puyallup River;[25] see Figure TS-4 Tsunami Inundation and Current-Based on Earthquake Scenario. It is probable that one of these

tsunamis would impact and damage the infrastructure and equipment in the Port of Tacoma and some other coastal jurisdiction; see Property, Facilities, and Infrastructure section below. Damage to cranes, docks, and even the Port Administration Building are all possible from a large locally generated tsunami. In this case the Port would not have the ability to maintain normal operations. For other jurisdictions the tsunami may have less direct effect on their ability to maintain operations. Instead, any operational continuity will be impacted more from the earthquake itself.

The impact to a jurisdiction's ability to deliver services is directly related to their proximity to Puget Sound. Damage throughout the coastline of Pierce County will not usually impact the delivery of services to citizens, residences, or businesses with a few exceptions. Damage to the ferries, ferry docks, or bridges to the islands will prevent normal County services, possibly for an extended period. There could be damage to the City of Tacoma's fire facilities including fire boats and the two stations located on Ruston Way and the Foss Waterway.

Loss of power due to damage to electric power stations is possible, especially to the Bonneville Power Administration substation located at the south end of the Hylebos Waterway. Rail lines in the Port and along Ruston Way and running south from Salmon Beach could sustain damage. Sewage treatment plants located at or near tidewater have a high probability of damage. In this case the City of Tacoma's treatment plant on the Tacoma tide flats could be damaged by a tsunami. In addition, the underside of bridges sometimes supports water, gas, and other lines that cross the Puyallup River and a high wave could damage these.

Within the City of Tacoma, Marine View Drive/Hwy 509, Ruston Way, Schuster Parkway, and Lincoln Avenue Bridge are all major routes that could sustain tsunami damage. Portland Avenue running along the Puyallup River and Dock Street on the Foss Waterway could be inundated. All these routes mentioned, if damaged, destroyed, or impassable would have a negative impact on the delivery of services to the community.

Due to local topography, University Place, Steilacoom and DuPont, while all located along the coast, only have a small portion of their populations within reach of a tsunami. Sunset Beach and Day Island in University Place are the two areas most likely to sustain damage. A tsunami inundating either area could damage or destroy most of the houses, and in the case of Day Island, the marina as well.

Gig Harbor is slightly different from the standpoint that much of the downtown or economic core of the city is located along the shore of the Harbor. The Harbor with its narrow entrance opening into a wider bay may in some cases dissipate some of the waves that enter it. However, recent research suggests that an earthquake along the Tacoma Fault could send a

5.5-foot wave into the Harbor.[26] An earthquake along the Seattle Fault can do even more damage to Gig Harbor. Computer modeling shows that an earthquake on the Seattle Fault could send a 11.5-foot wave into downtown Gig Harbor.[27] While a 5.5-foot wave would cause some damage within the Harbor, especially to boats and docks, it is doubtful that it would cause further damage within the City itself. A 11.5-foot wave on the other hand will not only wreak havoc among the boats moored within the Harbor itself, but also along the streets paralleling the shoreline blocking them with debris, disrupting power and making response very difficult. Due to the rapid increase in elevation by the landscape above the waterfront, services should not be impaired by the tsunami itself throughout most of the city. Newer preliminary data for a Cascadia Subduction Zone event shows an estimated 8-foot wave at the northern tip of Gig Harbor into Crescent Creek Park, an estimated 7-foot wave at the entrance of Gig Harbor overtops Lighthouse Beach, and an estimated 5-7-foot wave on shoreline of Gig Harbor.[28]

The other area that could have problems with the delivery of services is the City of Fife. While not a coastal community, its proximity to the coast, the Blair and Hylebos waterways extending almost to its borders, its position on the Puyallup River and its low elevation leaves it susceptible to damage from tsunamis.

Property, Facilities, and Infrastructure

Property, facility and infrastructure impacts from a tsunami could range from minor to extreme. For example, a small tsunami generated by a landslide off the steep hillsides in the southern portion of the Sound either in or south of the Tacoma Narrows would affect only a small population that live right along the waterfront and a few businesses like the Day Island Yacht Harbor. Even with a small tsunami there could be damage to the rail tracks. It would put a temporary stop to rail traffic, both cargo and passenger, between Seattle and Portland if not further.

In contrast, a large earthquake generated on the Tacoma or Seattle faults could send a tsunami throughout the entire Port of Tacoma area as well as up the Puyallup River, through Fife, overtopping the levees along sections of the Puyallup River causing further flooding along sections of the lower Puyallup. In addition, due to the volumes of water there would be extensive damage from currents along not just the waterways, but also inland as the water flowed back to the Sound carrying debris with it.

Damaged property and infrastructure in this case would not just be the private property and businesses, but roads, both local and major like Highways SR-509, SR-99 and possibly I-5. Damage to the levees along the Puyallup could cause further problems with flooding in future storms. Ships docked in the Port could be damaged as they are moved by the waves and currents. Chemical companies would be damaged, possibly including spills of large quantities of

hazardous chemicals that could spread pollution over a large area. Bonneville Power Administration has a major electric power substation located at the south end of the Hylebos Waterway that could have major damage if it was inundated by a high wave (5 foot or higher) of saltwater. Rail lines in the Port could be damaged. The City of Tacoma's sewer treatment plant is vulnerable as are water, gas, and other lines that cross the Puyallup River on the underside of bridges.

Roads along the waterways could be heavily damaged. These include Marine View Drive, Ruston Way and Schuster Parkway. Businesses along these roads could be destroyed or heavily damaged. This includes the restaurants and others along Ruston Way, the grain elevator and loading facilities on Schuster and the marinas currently home to hundreds of boats.

In these scenarios, Gig Harbor will also receive a wave causing damage to docks, boats, and businesses as will portions of the rest of the Sound south of the Narrows.

The Environment

The environmental impacts from a tsunami striking Pierce County could range from very minor to catastrophic. A small tsunami, like the 1949 wave, would cause very limited environmental damage unless it caused a significant chemical spill. This could happen if it derailed a train carrying hazardous chemicals traveling along the waterfront. In most cases the damage would be to the beach covering at the point of the landslide and the animals that reside there, erosion from the wave action, and damage to the vegetation directly in the path of the wave's run-up.

At the other extreme, a tsunami originating either in Commencement Bay, perhaps from a rupture of the Tacoma Fault, or a large one traveling down Puget Sound from a rupture on the Seattle Fault could damage ships in port. It could destroy the oil and gas tanks at the entrance to the Foss Waterway and damage several other properties throughout the port, many of which have quantities of hazardous chemicals. Tides could carry those chemicals throughout not just Commencement Bay, but into other portions of Puget Sound as well. In this case the damage could be catastrophic and depending on the type and quantity of chemical(s) released the environmental damage could last for years if not decades.

Water overtopping the levees will leave a residue of salt, and possibly other chemicals picked up by the water's passage through the Port could affect agriculture for years if not decades.

Economic and Financial Condition

An example of how a local tsunami and distant tsunami may differ in severity at ports is best shown from a recent subduction zone event off Japan: the 2011 Magnitude 9.0 Tohoku earthquake and tsunami. In Japan, the tsunami was locally sourced and destroyed 28,000 ships, 26 large freighters, 319 ports and created a significant economic loss of 3.9 billion per day. Also,

the same tsunami crossed the Pacific and struck the western US as well. In California this distant tsunami destroyed or severely damaged 24 harbors causing 100M in damages. These ports took up to a year to open causing significant impact to the local economy.

We can also break the potential for tsunami economic impacts into three groups by size. While there are no exact size parameters, we will use the 1949, 1894, and a tsunami generated by either the Tacoma or Seattle faults.

Small tsunamis similar to 1949 or smaller would have very limited or no impact on the economic or financial condition of the jurisdictions located in Pierce County. Their area of impact will be restricted because the volume of water displaced is very limited. There could be more damage from the actual landslide than from the tsunami itself depending on where the slide occurs.

A repeat of 1894 could cause greater damage with a wave damaging or destroying many of the businesses along both Ruston Way and Marine View Drive as well as some in the Port of Tacoma and the Foss Waterway. In this case, damage could run into the millions.

The third scenario would be a large tsunami from a quake on either the Tacoma or Seattle fault. The developing tsunami could devastate large portions of the Pierce County coastline. In a situation of this magnitude, actual losses from the tsunami itself could be many times that of the previous scenarios. The damage to businesses located in the Port of Tacoma, perhaps as far as Fife, combined with the losses along Ruston Way, Gig Harbor and other points along the coast could set back the economic base for years. Many businesses and a large portion of the industrial base of the County would be damaged. Thousands of jobs would be lost, and tax revenues would drop. It could take years to repair all the infrastructure and only then could the economy begin to rebuild to pre-earthquake/tsunami levels.

Public Confidence in the Jurisdiction's Governance

Depending on the amount of damage, from a locally generated tsunami, the public's confidence in the jurisdiction's governance could be sustained or adversely affected. A large tsunami generated by either the Tacoma or Seattle faults could cause extensive damage all along the Pierce County coastline, throughout the Port of Tacoma, and possibly some distance up the Puyallup River. Even with a case like this the public's confidence in a jurisdiction would be governed by people's perceptions of how well the response and recovery went. A well-coordinated, visible, response and recovery effort will increase citizen confidence in their local government. In contrast, a poorly coordinated one will decrease the public confidence in the local jurisdiction's competence.

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Endnotes

[1] Modified from Washington State Natural Hazard Mitigation Plan (DRAFT), Tsunami Section, Washington State Emergency Management Division. September 5, 2002.
[2] Gonzalez, Frank I., et al. "Puget Sound Tsunami Sources: 2002 Workshop Report." NOAA/Pacific Marine Environmental Laboratory, Contribution No. 2526, 2003. p. 9-14.
[3] Note that all of these tsunamis were triggered from landslides and all of Washington's waterways are at risk including those in eastern Washington. Alex Dolcimascolo, Tsunami Geologist, Washington Geological Survey, September 25, 2019 presentation.
[4] NOAA Technical Memorandum OAR PMEL-132, Tacoma, Washington Tsunami Hazard Mapping Project: Modeling Tsunami Inundation from Tacoma and Seattle Fault earthquakes. Venturato, Angie J., et al, NOAA, United States Department of Commerce January 2007, p 3.
[5] Ibid. p.3.
[6] Tacoma, Washington, Tsunami Hazard Mapping Project: Modeling Tsunami Inundation from Tacoma and Seattle Fault Earthquakes, NOPP Technical Memorandum OAR PMEL-132, Venturato, Angie J. et al., pps. 9-10.
[7] Tacoma, Washington, Tsunami Hazard Mapping Project: Modeling Tsunami Inundation from Tacoma and Seattle Fault Earthquakes, NOPP Technical Memorandum OAR PMEL-132, Venturato, Angie J. et al., pps. 9-10.
"Due to constraints of the inundation grid, the model does not cover the full extent of wave propagation in the upper Puyallup River; subsequently, the wave reflects off the edge of the grid boundary leading to potentially nonphysical inundation within the City of Fife and Puyallup Nation territory."
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[14] Indonesia: Tsunami – Dec 2018, ReliefWeb, https://reliefweb.int/disaster/ts-2018-000423-idn
[15] Gonzalez, p. 9-14.
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[17] *Ibid*. Cover.

[18] Tacoma, Washington, Tsunami Hazard Mapping Project: Modeling Tsuami inundation from Tacoma and Seattle fault Earthquakes, Venturato, et.al., United States Department of Commerce, National Oceanic and Atmospheric Administration, Office of Oceanic and Atmospheric Research, January 2007, p. 3.
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[24] Damage to the docks from the 1894 tsunami generated by an underwater landslide in Commencement Bay. Photo from Archives in the Tacoma Public Library, Photo G27.1-099.jpeg
[25] Venturato, et al,, p.12
[26] Tacoma, Washington, Tsunami Hazard Mapping Project: Modeling Tsunami Inundation from Tacoma and Seattle Fault Earthquakes, NOPP Technical Memorandum OAR PMEL-132, Venturato, Angie J. et al., p 14.
[27] Tacoma, Washington, Tsunami Hazard Mapping Project: Modeling Tsunami Inundation from Tacoma and Seattle Fault Earthquakes, NOPP Technical Memorandum OAR PMEL-132, Venturato, Angie J. et al., pps. 10-11.
[28] The Cascadia Subduction Zone data is preliminary and there are still data gaps that will be completed in the coming years.

Volcano and Lahar

Natural Hazard 4.7

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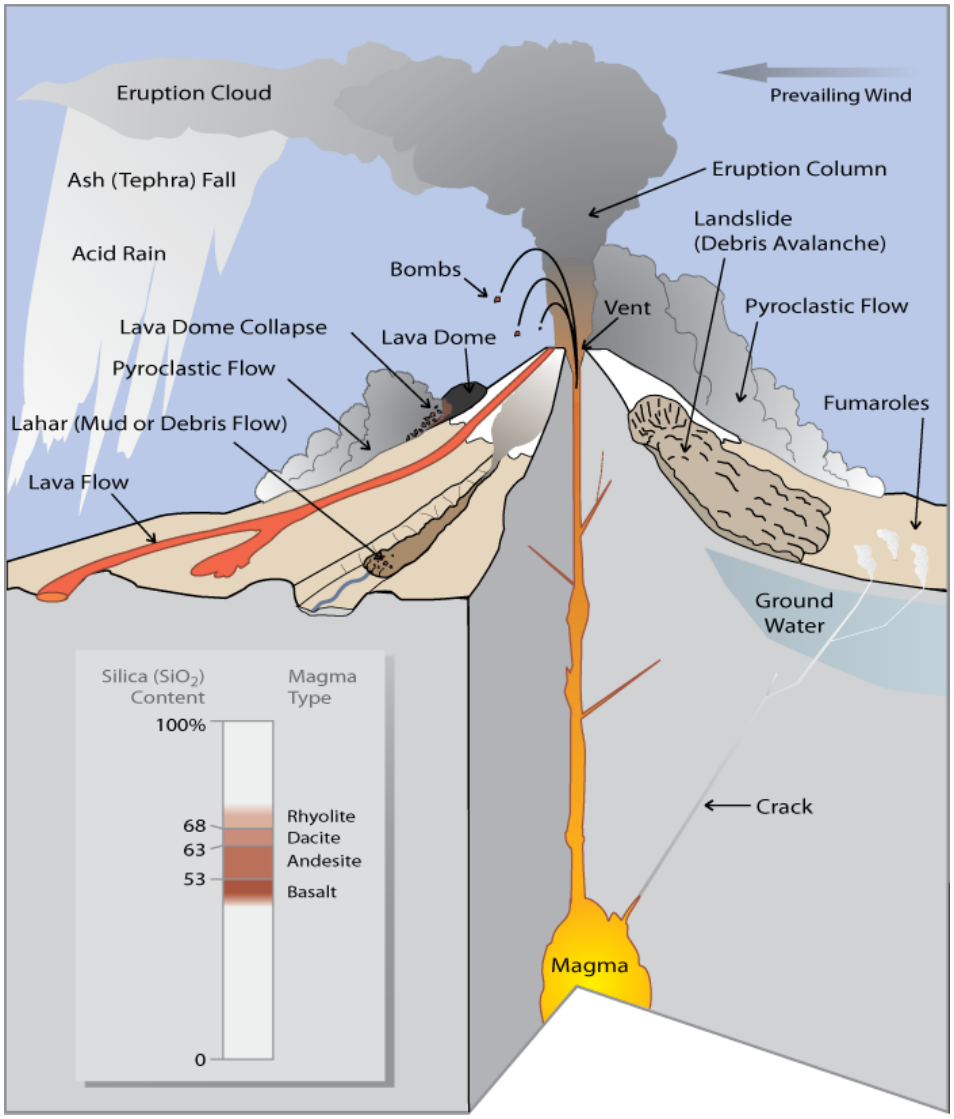
Identification Description

Definition

A volcano is a vent in the earth's crust through which molten rock (magma), rock fragments, gases, and/or ash can be ejected from the earth's interior. Volcanic hazards within Pierce County include all hazards associated with individual volcanoes in the Cascade Mountain Range. This includes tephra, landslides, lahars, pyroclastic flows, lava, and acid rain
(Figure 4.7-1).

Figure 4.7-1 Volcanic Hazards[1]



Types of Non-Magmatic Volcanic Hazards

Volcanic hazards can occur with or without an actual eruption. The U.S. Geological Survey (USGS) differentiates volcanic activity into two types. In the case of non-eruptive events (no lava), such as the generation of debris flows or lahars, there is generally no movement of magma and there may not be any detectable precursors to the event (minutes to tens of minutes of warning). Hazards associated with an eruption (magmatic activity) can usually be detected through volcano monitoring, so there is generally some warning prior to a magmatic event.

Debris Flows

Debris flows of glacial ice and rock debris may be set in motion by explosions, earthquakes, and heat-induced melting of ice and snow, or the sudden release of water held within a glacier called a glacial outburst flood. A debris flow is a type of landslide that moves at high speeds. Most debris flows at Mt. Rainier are confined to areas either within the park or, in a few instances, extending to areas just outside the park boundary.

Lahars

Lahars are volcanic mudflows consisting of dense mixtures of water-saturated debris that move down-valley, looking and behaving much like fast-flowing concrete. They involve much greater quantities of material than do the normal debris flows and can cover many square miles of the valley bottom with mud and other debris many meters deep. Over 60 lahars have been identified as coming from Mt. Rainier since the end of the last ice age, about 10,000 years ago.[2] Lahars not triggered by an eruption are called spontaneous lahars. Debris flows that extend beyond the limits of the Rainier National Park boundary are typically considered lahars.

Toxic Gases

Pockets or clouds of toxic gases may develop on or near both active and inactive volcanoes. Their chemical poisons can cause internal and external burns, or asphyxiation through oxygen starvation. Gases that may be present include carbon dioxide, sulfur compounds, carbon monoxide, chlorine, fluorine, boron, ammonia and various other compounds. Except for inside the summit caves, these generally are dissipated rapidly by wind.[3]

Landslide

Landslides from the sides of the volcano may be large or small, but all can have effects on valleys downstream. Small landslides are common on Mt. Rainier, whereas large landslides occur occasionally. Depending on the size of the slide and the consistency and temperature of the material, some of them may transform into lahars.

Types of Magmatic Volcanic Hazards

Volcanic Earthquakes

Earthquakes associated with volcanic activity at Mount Rainier will not directly cause major damage to areas surrounding the volcano, but they will give scientists important information about magma movement beneath the volcano. They could, however, potentially trigger landslides, which might result in debris flows or lahars that could cause widespread damage to population centers, like the City of Orting, in the valleys surrounding the volcano.

Lava Flows

Lava flows are masses of hot, partially molten to molten rock that flow downslope, generally following valley topography. Much of Mt. Rainier is composed of andesite lava flows. The term andesite refers to the amount of silica in the chemical composition of the magma. Andesitic lavas tend to be moderately viscous, or resistant to flow[4] and rather slow moving. Mt. Rainier lava flows have high silica content and tend to be thicker and stickier than those with low silica content, like volcanoes in Hawaii. As such, this lava tends to stay close to the volcano, rather than extending down valleys long distances, and are more likely to erupt or be ejected into the air before settling on the crust.

Tephra

Tephra is the general term for airborne volcanic ejecta of any size. Tephra can range from fine ash less than a millimeter in diameter to blocks and bombs greater than 2.5 inches.

Table 4.7-1 Tephra Types and Sizes

Tephra Types and Sizes	
Fine Ash	<1/16 mm
Coarse ash	1/16 mm – 2 mm
Lapilli	2 – 64 mm
Blocks and Bombs	>64 mm

Pyroclastic Flows and Surges

Pyroclastic flows and surges can occur during explosive eruptions. Pyroclastic flows are avalanches of hot ash, rock fragments, and gas that move at high speeds down the sides of a volcano during explosive eruptions or when the edge of a thick, viscous lava flow or dome breaks apart or collapses. Such flows can be as hot as 800 degrees Celsius and can burn and destroy everything in their paths. Pyroclastic flows are rare at Mt. Rainier. When they do occur, pyroclastic flows descend glaciers and are transformed into a lahar (a process that has happened many times at Mt. Rainier).

Profile

Location and Extent

Tephra

Mt. Rainier erupts explosively to produce small to moderate volumes of tephra. Future tephra and ash rich eruptions will distribute the products downwind, most often toward the east, away from Puget Sound's large population centers. Airborne plumes of volcanic ash can greatly endanger aircraft in flight and seriously disrupt aviation operations. Although seldom life threatening, volcanic ash falling on the ground can be a nuisance to residents, affect utility and transportation systems, and entail substantial clean-up costs.

Another possibility is that Pierce County could be affected by tephra from other volcanoes in the Cascade chain. This probability, while possible, is also very small. Besides Mt. Rainier, Mt. St. Helens has the highest probability of distributing ash across Pierce County.

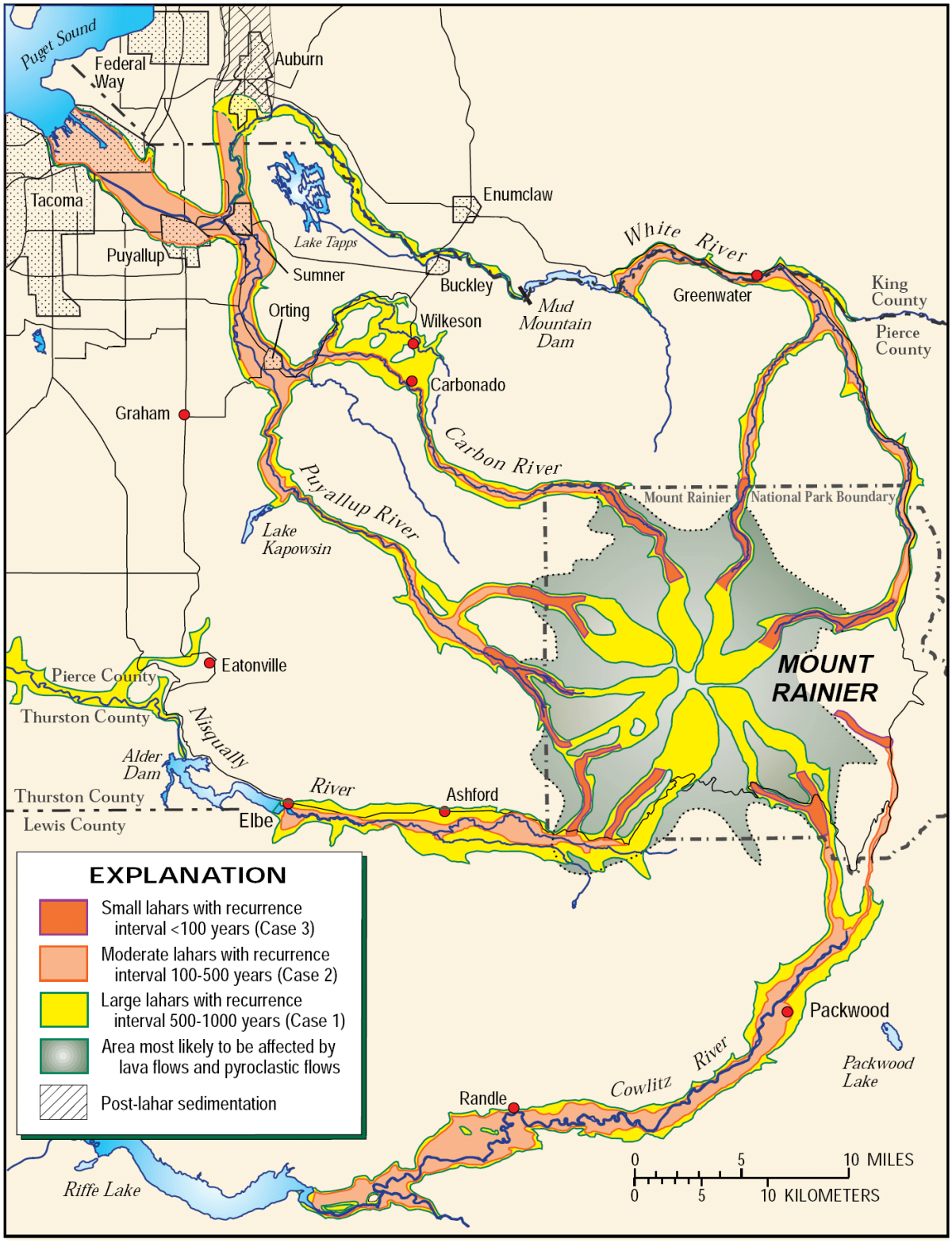
Eruptions

New eruptions of Mount Rainier will most likely start with steam and ash explosions at the summit, and progress to the effusion of a small lava flow or the disintegration of steeply sloping lava flows as avalanches of hot rock and gas called a pyroclastic flow. Either type of eruption will probably create lahars that can reach heavily populated areas.[5]

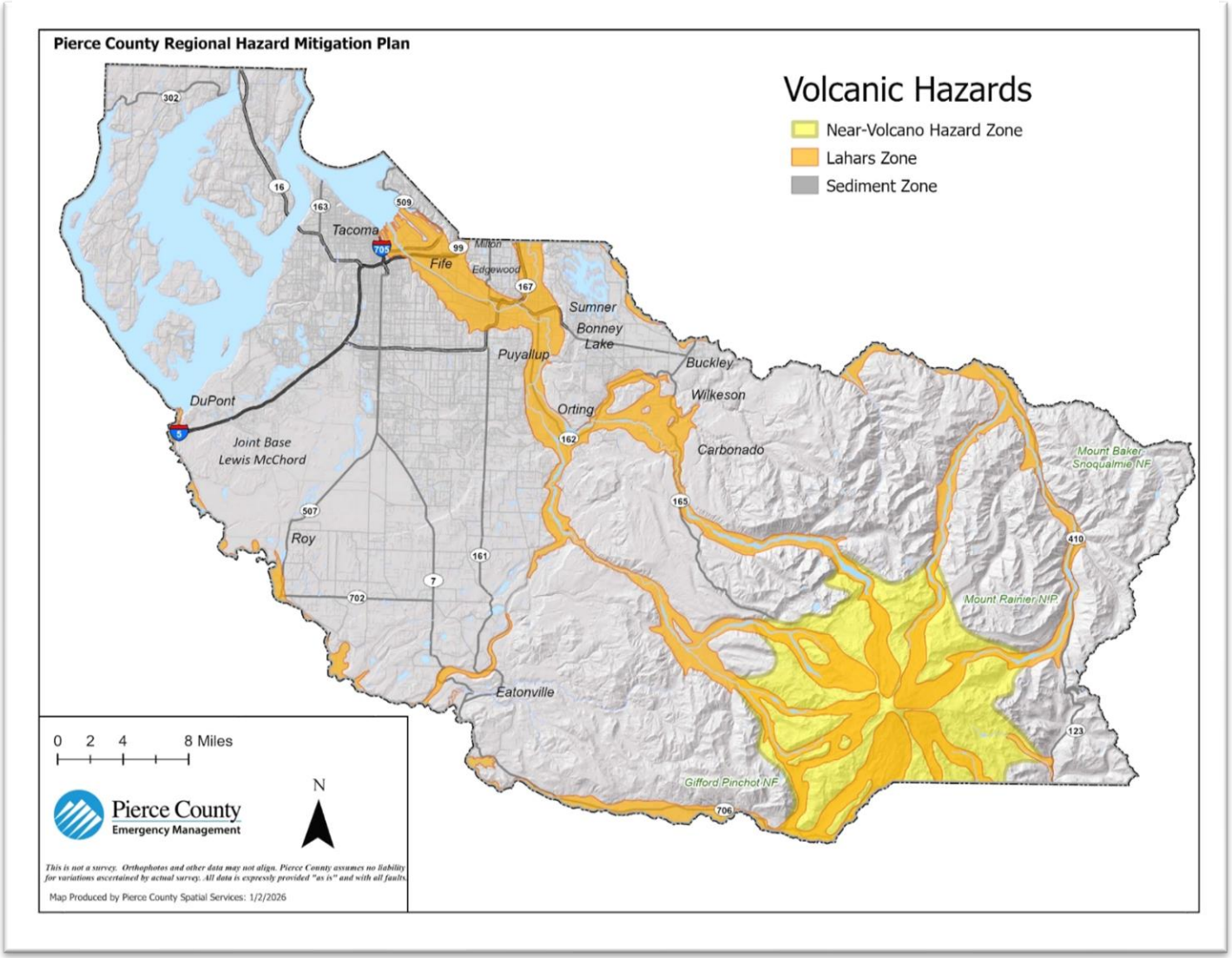
Lahar

As illustrated on Map 4.7-1 and Map 4.7-2, the lahar hazard covers a great deal of the County as each of the major river valleys comprises a portion of the lahar run out zone. Going by the magnitude of past events, the consequences of a lahar or debris flow down the populated river valleys will be catastrophic and could potentially result in a tremendous loss of life and property. Approximately 150,000 inhabitants of the river valleys work and reside on the deposits of prehistoric and historic debris flows.

Map 4.7-1 Lahars, Lava Flows, and Pyroclastic Hazards of Mt. Rainier[6]



Map 4.7-2 Volcano and Lahar Hazards



Lahars are categorized by both cohesiveness and size. Case M, I, II, and III lahars are outlined below by their recurrence intervals:[7]

- **Case M Lahars** – The largest lahar to occur in the past 10,000 years is the Osceola Mudflow. It formed about 5,600 years ago when a massive debris avalanche of weak, chemically altered rock transformed into a lahar. Osceola deposits cover an area of about 212 square miles in the Puget Sound lowland, extending at least as far as Kent and to Commencement Bay in Tacoma. The communities of Orting, Buckley, Sumner, Puyallup, Enumclaw, and Auburn are wholly or partly located on top of deposits of the Osceola Mudflow. This lahar is at least 10 times larger than any other known lahar from Mount Rainier. Geologists believe flows of this magnitude occur far less frequently than once every 1,000 years.

- **Case I Lahars** – Cohesive lahars originate as enormous avalanches of weak, chemically altered rock from the volcano. They can occur with or without eruptive activity. Most Case I flows have reached some part of the Puget Sound lowland. The Electron Mudflow reached the lowland about 600 years ago along the Puyallup River. Its deposits at Orting are as much as 18 feet thick and contain remnants of an old-growth forest. Average recurrence rate for Case I lahars on Mt. Rainier is about 500 to 1,000 years.

- **Case II Lahars** – Large non-cohesive lahars are most commonly caused by melting of snow and glacier ice by hot rock fragments during eruption but can also have a non-eruptive origin. More than a dozen lahars of this type have occurred in the past 6,000 years. A few have reached the Puget Sound lowland, including the National Lahar, which occurred about 2,000 years ago. It inundated the Nisqually River valley to depths of 30 to 120 feet and flowed all the way to Puget Sound. About 1,200 years ago, another lahar filled valleys of both forks of the White River to depths of 60 to 90 feet and flowed 60 miles to Auburn. The average time interval between Case II lahars from Mt. Rainier is near the lower end of the 100-to-500-year range.

- **Case III Lahars** – This class of flows includes small debris avalanches as well as debris flows triggered by sudden, unpredictable release of water stored by glaciers. These debris flows are largely restricted to the slopes of the volcano, rarely moving beyond the National Park boundary; since 1926, outburst floods destroyed or damaged bridges, roads, and national park visitor facilities on about 10 occasions. Glacial outburst floods are unrelated to volcanic activity and typically coincide with periods of unusually high temperatures or unusually heavy rain in summer or early autumn. About three dozen such flows occurred during the 20th century. Case III lahars occur at an average time interval at Mt. Rainier of about 1 to 100 years.

There were nine large lahars in the last 5,600 years, eight of which were associated with eruptions. The most likely scenario is a large lahar occurring during unrest/eruption. The approximate timeframe for a large lahar to reach the Nisqually entrance to the park is ~10 minutes, Ashford ~20 minutes, and Orting ~60 minutes.[8] These areas include many large population centers, transportation infrastructure such as highways (I-5) and rail (passenger and freight), and the Port of Tacoma (the County's economic and industrial base).

Table 4.7-2 Estimated Lahar Travel Times for Lahars 10^7 to 10^8 Cubic Meters in Volume (Approaching a Case I Lahar in Size)[9] is based on information from geologists at the Cascade Volcano Observatory (CVO). For the Puyallup and Carbon, they are based on the time it takes for the lahar to travel from the point where the lahars are recognized by the monitors that are part of the lahar warning system in those valleys. Because they have no lahar warning system, estimates on the White and Nisqually Rivers are from the actual release of material from the volcano's edifice.

Table 4.7-2 Estimated Lahar Travel Times for Lahars 107 to108 Cubic Meters in Volume

River Basin	Estimated Travel Time (Hours)
Carbon River	
Carbonado	0.2
Wilkeson	0.3
Orting	0.7
Puyallup River	
Orting	0.7
Sumner	1.1
Puyallup	1.3
Commencement Bay	1.8
Nisqually River*	
Alder Lake	1.0
La Grande	1.5
Haggedorn Road & 526th St	2.0
White River**	
Greenwater	< 1
Mud Mountain Dam Overtopping	ca. 2

Travel times on the Puyallup and Carbon Rivers are from Dr. Pierson and are based on the time it would take for the lahar to travel from the lahar recognition points. These are monitors that will pick up a seismic signal from the lahar and broadcast it to the State and County. Travel times on the Nisqually and White Rivers are from the Pierce County cartography work of Karen Truman.

**The Nisqually River lahar entering Alder and La Grande Lakes will displace the water column, pushing it over their tops, therefore travel times downstream from the dams will more closely follow the time patterns of a catastrophic flood.*

***The White River has the Mud Mountain Flood Control Dam on it that can work very well at containing a Case II lahar and most of a Case I lahar. This is why all times below the dam are assumed to be 2 hours or greater. It is dependent on the amount of water behind the dam. It is empty most of the year.*

New studies show that the process of hydrothermal alteration is unevenly weakening the inside of Mt. Rainier. This is a process whereby the interior portions of the mountain are being chemically altered by contact with hot, acidic water. This makes the slopes more susceptible for failure, increasing both the possibility and size of lahars. The slopes above the Puyallup River drainage are weaker than those above other river drainages originating from Mt. Rainier. The least-stable source of a collapse-driven lahar is St. Andrew's Rock located above the South Tahoma Glacier, Tahoma Glacier, and Puyallup Glaciers with an estimated size of 260 M m^3 debris avalanche.[10]

Occurrences

Tephra

The largest eruption in the last 10,000 years was 2,200 years ago. Map 4.7-3 Probability of Measurable Ashfall in Tacoma from Rainier modeling uses wind field data for 1,000 random days. It found that there was a 3% chance of 1 mm (0.25 inches) of ash in Puyallup if there is another large Mt. Rainier eruption.

Map 4.7-3 Probability of Measurable Ashfall in Tacoma from Rainier

During the past 10,000 years, there have been 11 identified tephra eruptions from Mt. Rainier, ranging in size from 0.001 to 0.3 km^3.[11] See Table 4.7-3, Mt. Rainier Identified Tephra from the last 10,000 years.[12] None come close to the magnitude of ash deposited from the Mt. Saint Helens eruption of 1980.[13] The St. Helens eruption of 1980 deposited approximately 1.01 cubic kilometers of material, or a little over three times the amount from the largest Rainier eruption shown on the table.

Table 4.7-3 Mt. Rainier Identified Tephra

Holocene Tephras from Mount Rainier

Layer	Age (radiocarbon years B.P.	Predominant Materials	Volume (in millions of cubic meters)
X	+/- 150 (from tree rings)	Pumice	1
C	2200	Pumice, scoria, lithic fragments	300
B	>4000	Scoria, lithic fragments	5
H	>5000	Pumice, lithic fragments	1
F	5000	Lithic fragments, pumice, crystals, clay	25
S	5200	Lithic fragments	20
N	5500	Lithic fragments, pumice	2
D	6000	Scoria, lithic fragments	75
L	6400	Pumice	50
A	6500	Pumice, lithic fragments	5
R	>8750	Pumice, lithic fragments	25

USGS *Topinka, USGS/CVO, 1997, Modified from: Swanson, et.al., 1989, AGU FieldTrip Guidebook T106, taken from Mullineaux, 1974*

Table 4.7-4 provides a list of past occurrences of debris flows on the various river valleys in Pierce County.

Table 4.7-4 Pierce County River Valley Debris Flow History

Puyallup River Debris Flow History		
Type of Flow	**Age or Date**	**Area Reached**
Electron Mudflow	530-550 BP*	Puget Sound Lowland, possibly to Puget Sound
Lahar	~ 1000 BP*	Puget Sound Lowland
Round Pass Mudflow	~2,600 BP*	Probably to the Puget Sound Lowland
Lahar runout	< 3400 BP*	Puget Sound Lowland
"Pre-Y" Lahar	< 3500 BP*	Puget Sound Lowland
Lahar runout	>3500 BP*	Puget Sound Lowland
Nisqually River Debris Flow History		
Type of Flow	**Age or Date**	**Area Reached**
Kautz Glacier/Van Trump Creek Debris Flows	August 2001	Near the Park boundary
Outburst flow on Kautz Creek	1947 AD	Below confluence with Nisqually River
Tahoma Lahar	Post 1480 AD	Below the confluence of Tahoma Creek & the Nisqually River
Lahar runout	< 2500 BP*	At least to Elbe
Lahar runout	< 2500 BP*	At least to Elbe
National Lahar	~ 2200 BP*	Puget Sound
Round Pass Mudflow	~ 2,600 BP*	At least to National
Lahar runout	< 3400 BP*	At least to Ashford
Large lahar runout	< 3400 BP*	Probably to Puget Sound Lowland
Paradise Lahar	4,500-5,000 BP*	At least to Elbe
White River (including West Fork) Debris Flow History		
Type of Flow	**Age or Date**	**Area Reached**
Debris Avalanche	1963	Within 1 km of the White River Campground
Gravel-rich flow	~ 1550 AD	At least to Mud Mountain Reservoir
At least one lahar	> 1480 AD	At least 5-10 miles outside of Park boundary
Lahar in West Fork	< 2200 BP*	At least to confluence of forks
Lahar (TBD)	< 2200 BP*	Probably to Puget Sound
Many lahars	< 2200 BP*	Probably to Puget Sound
At least 5 lahars	< 4500 BP*	Probably to edge of Puget Sound Lowland
Osceola Mudflow	~ 5000 BP*	Puget Sound Lowland
Greenwater Lahar	~ 5000 BP*	Puget Sound Lowland
Carbon River Debris Flow History		
Type of Flow	**Age or Date**	**Area Reached**
Lahar runout	Post 1480 AD	At least 5 km below end of glacier
Lahar runout	Pre 1480 AD	8-10 km beyond end of glacier
**Carbon 14 years before present, working from a base line of 1950*		

Recurrence Rate

While Mt. Rainier had a few small steam or very small tephra eruptions during the 1800s, these were not eruptions to cause concern. The same can be said about the small mudflows down Tahoma Creek over the past 40 years, or even the larger Kautz mudflow of 1947. The geologic history of the volcano, as shown in the above tables, shows 11 volcanic tephra eruptions over the past 9,000 years. In addition, the history of lahars in the valleys shows their time frames to be variable with some long periods, occasionally over 1,000 years, between them. Research from USGS scientists and others points to an annual probability of 1 in 500 to 1,000 for a significant landslide driven lahar. In addition, the "annual probability of eruption-triggered lahars is basically the same as the eruption probability because most eruptions will create lahars of some magnitude 1 in 100 to 500, but probably more toward the 500 end."[14] Taking all this into consideration, it is estimated the recurrence rate for damaging volcanic activity, be it a damaging tephra eruption or a lahar coming down a valley, to be a 500 to 1,000 year occurrence.

Impacts

Impacts discussed here will cover tephra and lahars, both eruptions triggered and spontaneous. Unless stated otherwise, lahar damage will be based on the potential for a Case I lahar traveling down the various valleys from Mt. Rainier. It will be assumed that general impacts are the same across the four main valleys (Carbon, Puyallup, Nisqually, and White) unless stated otherwise. Impacts from a lahar descending the Cowlitz River, the other river with its headwaters on Mt. Rainier and located partially in Pierce County, will have no direct effect on the County once it has exited the Park into Lewis County. There will be no further discussion of it.

Most of the impacts from a lahar will be determined by the volume of the lahar and which valley or valleys it descends. Next is whether there is a recognizable sequence of volcanic events leading up to its initiation. Whether it is a spontaneous lahar or the result of other developing volcanic convulsions leading to, or part of, an eruption will have a major impact on the response and the recovery.

For the purposes of this Section, we will assume an Electron size and type flow and for most impacts look at the difference between the two basic scenarios of an eruption or magmatic triggered lahar and a spontaneous lahar.

Health and Safety of Persons in the Affected Area at the Time of the Incident

Tephra

As mentioned above, most of the tephra or ash from a volcanic eruption of Mt. Rainier should leave western Washington and be deposited east of the Cascades. However, the wind patterns may not always blow in that direction. If not, then ash could be deposited over portions of Pierce County. If so, several problems will arise.

Thick deposits of ash can collapse buildings. This is especially true if it is raining. A one-inch layer of ash weighs between five and ten pounds per square foot. This weight can increase dramatically with rain, because ash will hold the water. The weight can increase to 10 to 15lbs per square foot, leading to collapse in some cases.[15] Persons inside those buildings have a significant chance of being killed or injured by the collapsing structure.

Persons located in areas with falling ash can experience eye, nose and throat problems. Patients with bronchitis, emphysema, and asthma are at even greater risk. Breathing similar material in mines and quarries by workers can lead to silicosis over many years. Short term breathing of small quantities of ash particles is not known to cause long-term problems. The decrease in visibility and increase in darkness in those areas heavily impacted by the tephra will disrupt outdoor activities and, in some cases, cause psychological distress.

Thin ash layers can make roads slick leading to an increase in accidents. It can also clog up air intake systems for automobiles and destroy the engine rendering the car useless for evacuation if necessary.

General Lahar

A lahar coming down one or more valleys from Mt. Rainier has the potential to cause the highest number of fatalities and casualties of any hazard treated in this risk assessment. The difference in the impact on the population will be highly dependent on whether the lahar was a result of increasing volcanic activity or is due to the spontaneous collapse of a portion of the mountain.

Lahars can be devastating in their consequences. The lahar that inundated the town of Armero in Columbia on November 13, 1985 was relatively small compared to some of the ones that have descended Mt. Rainier. That lahar, from the volcano Nevado del Ruiz, killed over 23,000 people and injured about 5,000 people.[16] In this case, the main wave of mud that demolished the town ranged in depth from 6.5 to 16 feet. There could be a similar percentage of injured and killed in a lahar from Mt. Rainier. The method of destruction, burying entire communities in a flow of dense mud, does not allow most people caught in it a chance of survival.

Magmatic or Eruption-Triggered Lahar

With a lahar that begins when the volcano enters an eruptive stage, there will usually be many hours, if not days or weeks of increasing volcanic unrest. During this time, the citizens that live in the valley areas surrounding the mountain will be put on a high alert that a lahar is possible. Memories of Mt. St. Helens and the lahar from it should inspire people in the valleys close to the volcano to prepare to evacuate or even self-evacuate early in the eruption process. The more distance from the volcano they live or work, the less preparation there will be overall, even for those who are directly in the path.

As the situation deteriorates, monitoring of the volcano will increase. Any needed warnings from the State, the County, or the Cascades Volcano Observatory will be broadcast to inform and warn residents in the potential paths to prepare for and evacuate, if able, well before any lahar is created. Having a percentage of the people leave the valleys early allows for a quicker evacuation when it becomes necessary.

Much of the response for an early evacuation will depend on the perceived security of property left behind. If local government does not provide adequate security, many people will not leave their property behind and will gamble that they can get out in time if necessary. For those who did leave early, the perception that there is a lack of security for their property will bring them back. The other factor that will bring people back is if the volcano does not erupt or send down a lahar over time. People's patience will rapidly wear thin and they will want to move back home.

Overall, having knowledge ahead of time that the volcano is active and that a lahar could happen at any time will allow many people to get themselves and their belongings out of harm's way before the mud arrives. This could save many lives and a great deal of personal belongings and property.

Spontaneous Lahar

A spontaneous lahar is most likely to happen due to the collapse of a portion of the headwall above the Tahoma Glacier on the west flank of Mt. Rainier. The Mt. Rainier Lahar Warning System, composed of sensors to detect the lahar and radio transmitters to send that information back to Pierce County and Washington State warning points, is in place to help prevent a lahar from coming down the Puyallup or Carbon Rivers and taking the communities by surprise. Once it is known that a lahar is descending either of the valleys, additional notifications will be pushed out through the Emergency Alert System (EAS), the Wireless Emergency Alert (WEA), NOAA weather radios, and other notification systems operated by locals.

Having a warning system in place does not mean that everyone will be able to evacuate the valley bottoms in time. The short time between the warning and the inundation of homes, schools, roads and businesses will not allow the entire population to escape. In the upper valley south of the confluence of the Puyallup and Carbon Rivers there could be many fatalities.

Health and Safety of Personnel Responding to the Incident

Tephra

As pointed out above, thick depositions of tephra can collapse buildings, especially if it is raining. Persons inside those buildings have a significant chance of being killed or at least injured by the collapsing structure.

Responders may wind up working for long periods of time in areas with ash. The problems of eye, nose, and throat irritation could impact their ability to work in those conditions. It is not known if this has long-term, negative health consequences.

Personnel responding to incidents will find that thin ash layers can make roads slick leading to an increase in accidents. Emergency equipment will break and ash can clog up air intake systems and destroy engines for rescue vehicles like helicopters, fixed wing aircraft and automobiles. This is not just a maintenance problem. It could lead to crashes of response vehicles.

General Lahar

Because of the enormity of the event, initial response to a lahar will be limited to saving response resources and assisting citizens to get to high ground, all while attempting to keep themselves safe. What will be a problem for the safety and health of responders is that the lahar will leave citizens stranded at various places throughout the valley. They could be on buildings that did not collapse or in trees that were not knocked down or highway overpasses. Essentially, people could be on any structure, tall enough to be above the mud and strong enough to survive being inundated by it. Since the mud will in many cases be too deep to drive or walk through directly, helicopter rescues might be necessary. This has all the dangers inherent in that type of operation. In addition, hazardous chemicals and sewage will contaminate some areas rendering them hazardous to anyone working there. There is also the possibility of more mud flows inundating the valley floor. A contributing factor is rain. Rain could pick up more of the material left in the higher parts of the valley and transport it down to the lower valley and deposit it as a new layer on the earlier flow.

During the initial build up to an eruption, when the Cascade Volcanoes Observatory warns about an upcoming event and warns citizens that they might want to evacuate, all local police

forces will be put in the position of controlling access to those areas deemed hazardous. This could include both the Nisqually and Puyallup Valleys. Irate citizens, demanding access to their properties could create hazardous situations for these forces. There could be attempts to push through barricades, threats to officers or others staffing those barricades, or even if the area is shut down for a long period of time, riots.

After a major lahar, responders from public works and utilities will not be able to do any initial work in the lahar zone to restore the damaged area. The lahar will totally block access to the area and will have taken out the utilities and roads, in effect, the entire surface infrastructure. Utilities that were underground to begin with, like pipelines, may be buried under the mud but may still be operational. As the mud solidifies over time, public works and utility providers may be able to work back out into the devastated areas. As they do so, they will have to be aware of any hazards that might still be in the environment.

Magmatic or Eruption-Triggered Lahar

With the knowledge that the volcano is threatening to erupt, first responders will be able to move critical equipment to high ground well ahead of time. Since the public will know what is happening as the volcano awakens and, in some cases, self-evacuate ahead of time, the problems relating to a spontaneous mass evacuation will diminish. Barricades and police services will be in position ahead of time to conduct evacuees rapidly out of the valleys should a lahar start. Close monitoring of the mountain should give the warning points quicker notification when a lahar does begin. The number of people needing assistance should decrease. This should decrease the number of technical rescues that will need to be done once the lahar has finished moving through the valleys. Problems could be compounded if there is a lot of tephra due to the eruption at the same time.

Spontaneous Lahar

With a spontaneous lahar, any responders in the affected valleys will be in the same position as other citizens. They will have to get themselves and any vital equipment to high ground as quickly as possible. In those areas some distance away from the volcano, like Fife and Puyallup, there should be enough time for a few first responders to assist with the evacuations of some citizens. In those areas closer to the volcano like Orting, that will be out of the question. It is possible that when a spontaneous lahar sets off the volcanic warning system or one is heard coming down either the White or Nisqually rivers that the ensuing panic could by itself injure, kill or trap in the lahar zone, those who would normally respond.

Continuity of Operations

Tephra

Small tephra explosions should not have an effect on the continuity of operations for jurisdictions or agencies in the County unless the wind patterns are perfect for dropping it directly on their service area.

Large tephra eruptions are different. Due to the amount of material dropped on an area, operations can be strained. Damage to communications equipment, roofs of buildings collapsing, roads closed, etc. can all limit the ability of an agency to maintain day-to-day operations. If the volcano has a large tephra eruption and conditions are right to deposit the ash across portions of Pierce County, there could be difficulty finding alternate facilities, getting staff to work and having necessary equipment in operational shape.

However, the probability that this will be the case is relatively low. As mentioned above, Mt. Rainier's eruptions tend to have low quantities of tephra and when an eruption does occur the normal wind directions over Pierce County should distribute it to eastern Washington. While possible, it is unlikely that tephra, by itself, will dramatically alter or limit the continuity of operations for agencies within Pierce County.

General Lahar

Any major lahar coming down one or more of the valleys radiating from Mt. Rainier will dramatically alter the continuity of operations for local jurisdictions. However, depending on the level of preparedness and whether a lahar is the result of the buildup of volcanic activity or of a spontaneous sector collapse the continuity of operations for a jurisdiction or agency could be very different.

Magmatic or Eruption-Triggered Lahar

Lahars triggered by a buildup and release of volcanic energy will have a lead in time, ranging from hours to weeks, for jurisdictions and agencies to prepare for the likelihood that a lahar may be forthcoming. Those entities with infrastructure in the path of the flow will be able to find alternate work sites and move at least some equipment to high ground out of the path. For those entities that are only partially within the lahar path this should work well. Even if the lahar does take out some of their infrastructure and property, they should still be able to maintain an operational posture, albeit reduced, for the rest of their jurisdiction or clients.

For those entities entirely, or nearly entirely, within confines of the flow, things will probably be different. Even if they were able to initially remove equipment from the valley floor and protect

all staff, normal day-to-day operations will be non-existent. With no citizens, no tax base, no offices, no infrastructure and no community, there is no continuity of operations.

Spontaneous Lahar

For spontaneous lahars the impacts to the valleys, while identical, could have a different impact on the agencies and jurisdictions located there. Those that have operations located in the valley that are unable to get an alternate site from which to operate will have all the problems of those jurisdictions and agencies who have a warning but also many others. In addition, they may lose records, staff and equipment when the lahar overwhelms the valley. The possibility of maintaining operational continuity in this scenario is impossible.

Those that have their operations run from outside the lahar inundation zone should be able to maintain operational continuity, albeit in a possibility reduced capacity.

Delivery of Services

Delivery of services will be nonexistent in those areas of the County that are deeply buried by a lahar. With no homes, no businesses, and no infrastructure, there will not even be a reason to attempt delivery of services into the impacted area. Delivery of services into other areas will depend directly on the infrastructure that is left after the lahar has inundated the valley, combined with how much of the jurisdiction's or agency's resources have been salvaged. If the lahar has destroyed one or more of the exits from Pierce County across the Puyallup and or Nisqually Rivers, then the ability to receive outside assistance will be delayed possibility for days. Re-supply of equipment, equipment parts, food or any of the necessities of life will be difficult.

A lahar inundating the Puyallup Valley will cut the eastern part of the County from the rest. Bonney Lake, Buckley, Cascadia, the East Hill of Sumner and others would have to go through King County for assistance. Delivery of services to those areas from local agencies within these areas would go on, although some might be reduced. There can however be some differences between the delivery of services after a magmatic generated lahar and a spontaneous lahar.

Magmatic or Eruption-Triggered Lahar

Just as with the continuity of operations, the disruption to the delivery of services would be reduced with an eruption generated lahar. The ability to get supplies stockpiled ahead of time, get equipment out of the lahar zone, set up sheltering system for thousands of people and develop immediate contingency plans will all assist with the delivery of services to those areas not destroyed by the lahar.

Spontaneous Lahar

A worst-case scenario would include a lahar that begins with a sector collapse on the west side of the mountain above the headwaters of the Puyallup River. Such a lahar could partially overtop the ridge separating the Puyallup River and Tahoma Creek that empties into the Nisqually River. This could cause delivery of services to be compromised in both watersheds.

All the problems that exist with an eruption triggered lahar are also inherent with a spontaneous lahar. In addition, delivery of services to citizens will be even more compromised in the case of a spontaneous lahar because local agencies and jurisdictions will not have the lead up time to evacuate equipment, records, and supplies from the valley bottom. Those that normally have their equipment, supplies and records or backup copies, out of the impacted area will be able to respond with at least some service delivery to those areas not directly impacted by the lahar.

Property, Facilities, and Infrastructure

Any Mt. Rainier major event, whether eruptive related or from a spontaneous lahar, will have a major impact on the property, facilities and infrastructure of jurisdictions and agencies within the confines of Pierce County as well as surrounding counties.

Tephra[17]

Tephra can collapse roofs, destroy engines, make roads slippery, clog both water and air filtration systems, kill crops, clog drains, and short out electrical systems. All these can and will affect jurisdictions and their ability to operate on a day-to-day basis. Depending on the depth and distribution pattern of the ash, individual agencies or jurisdictions will be impacted by it. With more than 1 cm of ash having the ability to disrupt traffic by closing down roads combined with the other damage listed above, it could take weeks for the local agencies and jurisdictions to get their individual infrastructures back to normal.

General Lahar

Lahars are the primary force that will damage the infrastructure, property, and facilities. They will flatten buildings, destroy equipment, bury roads, take out power lines and destroy sewer pumping systems. A major lahar coming down any of the river systems from Mount Rainier will damage, destroy or bury all facilities, property and infrastructure that are above ground in the impacted area. Only those areas on the periphery or where the flow weakens, thins out and reduces in speed and volume will have any chance of survival.

Current buried pipes, power lines, etc. should not be damaged directly; although where they rise to the surface, they can be damaged. However, having a sewer line buried under an extra 15 feet of mud in a community that no longer exists is essentially worthless. In areas where the lahar is shallow, many of these underground utilities may be able to be rehabilitated.

The extent of damage will be directly correlated with the quantity of debris the volcano coughs up. Smaller lahars will not cover as much territory as the larger lahar would and will cause less damage to those areas they do cover. This can be seen graphically on Map 4.5-1. Here the Case 1 lahars are inclusive of all the territory also contained in Case 2 lahars and in addition all the area highlighted in yellow.

Magmatic or Eruption-Triggered Lahar

With a magmatic triggered lahar there will be time to evacuate records, supplies, and equipment from the lahar's path. How much of the material will be evacuated depends on the length of time between when the volcano awakens and finally sends a lahar down the valley. This could be from a few hours to many days or weeks. The more time allowed the more that can be saved.

Spontaneous Lahar

With a spontaneous lahar, there will be very little that jurisdictions can do to protect their facilities, property or infrastructure located in its path. Those with resources further away from the volcano will have a little time once the warning has been disseminated, but it may be too little to make a major difference. Those agencies and jurisdictions will essentially have little or no time to evacuate anything of value. That which was not protected prior to the initiation of the lahar may be damaged or gone.

The Environment

Environmental impacts will be dramatic and, in some cases, long lasting.

Tephra

Small tephra eruptions will have limited environmental impacts. Large tephra eruptions could have dramatic impacts on the environment or ecology of large areas around Mt. Rainier. Because under normal circumstances the prevailing wind patterns will blow much of the tephra to the east impacting the upper White River and much of eastern Washington. In this scenario, plants and animals in the White River valley could suffocate under the ashfall.

Tephra damage[18] will partly depend on the size of the particles. Large pieces, one to two inches or greater in diameter, can be very damaging. However, lethal impact from falling tephra is

likely only in the immediate vicinity of the volcano, generally within about six miles of the vent. Animals not protected in this area could be severely injured or killed by the large particles. Further away, the finer grains begin to fall and can cause respiratory and eye irritation to animals, burying plants and robbing the animals of their natural food supply. Ash washed down by the rain will tend to add to the rest of the silt in the rivers and some of it will settle out downstream possibly affecting the fish resources, including salmon that return up the various rivers.

A large tephra eruption that blows in other than an easterly direction could cause extensive, long-term environmental damage to much of the County. Having the same types of damage mentioned above but spread over much of the County could cause environmental impacts that may take years to recover from.

Lahar

Lahars are the primary damaging factor associated with Mt. Rainier. Lahars descending the valley will destroy and bury all plants and animals in their path. They can destroy forested areas and silt up rivers, changing their channels. They will add pollutants or hazardous chemicals to the environment by the damage they do to manmade structures, vehicles, sewage treatment facilities, etc. The addition of mud to the valley bottom by winter rains bringing down more debris from upstream will continue to cause problems for the environment possibly for a few years after the initial mudflow. They may destroy salmon habitat, and the valley ecology in the areas they cover.

Those that reach Puget Sound could cover the near shore environment with silt and possibility partially fill in Commencement Bay, and/or cover the shallow Nisqually delta and mud flats creating a new surface and killing the creatures that currently make it home.

A new environmental balance will eventually be formed as plants and animals re-inhabit the area covered by the mud. While it may take years for nature to repair the damage, it will eventually reclaim those areas damaged by the lahar.

Economic and Financial Condition

Economic and financial affects will be of two parts. First is the damage to property, buildings, inventories and equipment. Second is the loss of revenue due to the inability to get supplies through the damaged area, the loss of markets, the decrease in population and, in some cases, the loss of infrastructure to support the area economically.

Tephra

The damage to individual businesses, homes, and equipment could cause major financial losses for individuals and businesses throughout Pierce County, but only if the wind does not blow the ash to the east. If the wind does blow to the east as expected, then areas in the White River Valley will be the ones affected. In this case, the Crystal Mountain ski area, and the homes between it and the Greenwater area could be heavily damaged. The Greenwater businesses and the Fire Department could all have structural building damage and the damage to vehicle engines may prevent owners from evacuating to a safer area.

Lahar

Lahars have the potential to be the major destroyer of economic viability within Pierce County. Any major lahar coming down one of the valleys from Mt. Rainier will destroy the homes, businesses and much of the infrastructure within whichever valley it descends. Closer to the mountain, like in Ashford or Elbe, some of it will be related to the tourist trade, or other wilderness operations. Citizens there maintain their restaurants and shops along the mountain highway, work in the National Park, or in many cases work for logging corporations, any or all of which may be out of business because of a lahar.

In other cases, like the cities of Puyallup, Sumner, and Orting, there are thriving communities that have been located on the valley floor for over 100 years, that have flourishing downtowns and whose citizens are involved in the full range of occupations that any city or bedroom community has in Washington. Many of them work in Pierce County or the City of Tacoma. Many of them have their own businesses in town. There are schools, medical clinics, libraries, fire stations and the Puyallup Fair Grounds. Any lahar that inundates these areas will be destroying vibrant communities that have taken over a century to grow to their current size.

Those portions of these communities on the valley floor, which includes most of Puyallup, almost all of Sumner and all of Orting could be destroyed totally with no viable way to regain their economic base. It is not a question of rebuilding a few destroyed buildings as it would be after an earthquake. With a lahar there may be no houses, no businesses and no infrastructure to begin the rebuilding process. The result will be that there will be no population base for an economic revival. People will have left the area. There will be no tax base for the cities to begin their rebuilding process. With many feet of mud in the valley, and the threat of further flooding and lahars, it will be a while until people begin the rebuilding process.

Magmatic or Eruption-Triggered Lahar

As the developing threat from the volcano is recognized by the scientists and they begin to warn the public there will be some time for some people and business to move some of their belongings, records and goods to higher ground. However, no matter how much they are able to save this way, the economic recovery will be long and hard. With the destruction of homes and the physical structures of the businesses in the valley, people will have no option except to leave the area and find homes and work elsewhere.

Spontaneous Lahar

With a spontaneous lahar almost no community in the pathway of the lahar will have the ability to adequately protect its assets. This is the worst-case scenario. There could be a total loss of homes and businesses in the impacted area. With buildings, equipment, records, inventories, and community infrastructure gone, no business in the lahar zone will be able to restart immediately. Even attempting to reestablish their business at a different location, outside the inundation zone, will, in many cases, fall short. With the exodus by many members of the community, numerous businesses will have little incentive to even attempt rebuilding in the valley.

Public Confidence in the Jurisdiction's Governance

The reputation of an agency or jurisdiction as well as the public's confidence in it will depend largely on the amount of planning and preparation that was done in anticipation of the eventual event. This, combined with the open distribution of information to the public regarding what is happening, could happen, and will happen during a volcanic event will greatly boost the public's confidence in the agencies and jurisdictions effected by it.

False alarms, alarmist pontificating, or confusion on what needs to be done will only lower the public's perception of the entity. Premature warnings of impending danger, especially if leading to what is seen as unnecessary evacuation, will only weaken any entity's authority.

Mt. Rainier is a big enough problem that good faith efforts put forth by the agencies and jurisdictions will reap a good response from the public. Incompetence, however, will show through and will destroy any reputation that the entity had before.

General Lahar

Good information provided prior to a lahar regarding what needs to be done to prepare, how to evacuate upon receiving a credible lahar warning, and limiting false alarms will maintain the public's confidence in a jurisdiction's ability. If, on the other hand, false alarms become the

norm, sirens do not work, and there is confusion as to what people are supposed to do, the entity's reputation will suffer. Any confidence the public has in that entity will be lost.

Another factor affecting the eventual reputation is the ability to get infrastructure back up and running as soon as possible. The fact that some areas will be unavailable, perhaps for years, will take a while for the public to accept. Even the visual clue of square miles of mud will not prevent some people from complaining that local, state and federal agencies are not doing enough to help them return to their pre-lahar state.

Magmatic or Eruption-Triggered Lahar

A lahar triggered by an eruption will allow the local agencies more time to prepare for the eventual destruction associated with it. They will have time to move resources, set up assistance centers, evacuate people if necessary and be seen as leading the response, not just being reactive to the circumstances. In this case, those agencies and jurisdictions seen as preparing for the potential lahar will maintain credibility with the public. Where this could break down is if an evacuation is ordered based on the best geological evidence the scientists can provide, and the mountain does not produce a lahar. In this case, there could be citizen unrest as they want to get back to their homes with the resulting loss of support for the actions of the local entity.

Spontaneous Lahar

In the case of a spontaneous lahar, the timely warning of an approaching lahar in the Puyallup Valley should help in the maintenance of the local entity's reputation. Even with some loss of life, if the warning system operates as it is designed and all jurisdictions follow the Mt. Rainier Volcanic Hazards Response Plan, confidence in the jurisdictions will remain intact.

This will not be the case if, without a warning, a spontaneous lahar descends upon either the Nisqually or the White River Valleys and impacts homes and businesses. In this situation, there would be many questions about why no warning system was regarded as necessary on the Nisqually or White River sides of the mountain and the reputation of government would be adversely affected. The short time frame from when a spontaneous lahar is initiated to when it begins to impact citizens in the Nisqually or White River Valleys does not allow enough time to put out an EAS or telephone ringdown message to citizens in those valleys close to the mountain. Those further downstream may be able to be reached in time to allow evacuation.

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Wildfire

Natural Hazard | 4.8

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Identification Description

Definition

A wildfire is an unplanned, unwanted fire burning in a natural area, such as a forest, grassland, or prairie. As building development expands into these areas, homes and businesses may be situated in or near areas susceptible to wildfires. Wildfires can damage natural resources, destroy homes, and threaten the safety of the public and the firefighters who protect forests and communities.[1]

Types of Wildfires[2]

During a wildfire incident, it is common to encounter all three types of fires outlined below, although the proportions can vary based on conditions such as weather (wind, humidity, precipitation), fuel types, moisture content, and topography. These factors play a critical role in shaping wildfire behavior and influence the types of fires that occur.

Ground Fires

Ground fires burn below the surface, primarily in decayed roots and the duff layer, which consists of compacted dead plant materials like leaves, bark, needles, and twigs. Sustained by glowing combustion without visible flames, ground fires can persist undetected for extended periods due to minimal smoke and slow spread.

Surface Fires

Surface fires consume vegetation near the ground, such as loose needles, moss, lichen, shrubs, and small trees. These fires primarily propagate through flaming combustion and dictate much of a wildfire's expansion. Surface fires can intensify to scorch or consume the forest canopy under specific conditions: high fuel loads, low fuel moisture, steep slopes, or strong winds. Flame length, tree crown base height, and crown density are critical factors in determining the transition of surface fires into crown fires.

Crown Fires

Crown fires burn through the forest canopy, consuming live and dead foliage, branches, and tall shrubs. Often ignited by surface fires, crown fires can be passive (torching individual trees or small groups) or active (spreading as a continuous wall of flames through the canopy). Active crown fires are particularly challenging to control due to spotting, where wind and topography carry large embers ahead of the fire line, igniting new areas and complicating suppression efforts.

Secondary Hazards

Wildfire Smoke

Wildfire smoke poses risk to communities in Pierce County in addition to the wildfires themselves. Wildfire smoke is a mixture of gases and fine particles. Individuals with underlying health conditions such as asthma or other chronic respiratory conditions and cardiovascular disease, younger populations, elderly populations, individuals spending a significant amount of time outdoors regularly, and individuals experiencing homelessness are particularly vulnerable to wildfire smoke impacts.[3]

Several factors can influence how harmful inhaling wildfire smoke is. Wildfire smoke particles larger than 10 micrometers usually irritate only the eyes, nose, and throat. Particles that are even smaller – PM2.5 or particles smaller than 2.5 micrometers – can be inhaled deeply into the lungs, which increases the risk of cardiovascular and respiratory problems.[4]

Table 4.8-1 Potential Wildfire Smoke Inhalation Impact List[5]

Potential Wildfire Smoke Inhalation Impacts	
Coughing	Runny Nose
Trouble Breathing	Irritates Sinuses
Wheezing	Headaches
Asthma Attacks	Tiredness
Stinging Eyes	Chest Pain
Scratchy throat	Fast Heartbeat

Wildfire Sources

Wildfires can occur naturally or as a result of human activity, with secondary effects such as erosion, landslides, and flash floods often compounding their impact (see Figure 4.8-1).

Natural Occurring Fires

These fires, often caused by lightning, are relatively rare in western Washington. King, Pierce, and Snohomish Counties report an average of 2,500 natural vegetation fires annually.

Human Caused Fires

In Washington, 85% of wildfires result from human activities, such as arson, debris burning, recreational fires, target shooting, illegal fireworks, smoking, and children playing with fire.[6]

Prescribed Burns

Prescribed burns are intentionally set to manage ecosystems and reduce fuel loads. When properly managed, these burns are not considered hazardous but do still cause smoke impacts to surrounding communities.

Figure 4.8-1 2024 Fire Near State Route 507

Profile

Pierce County's geographic diversity, from densely populated urban areas to remote forested regions, creates a complex wildfire risk profile. Map 4.8-1 details areas of potential wildfire hazard across the county. It highlights regions where vegetation, topography, development patterns, and historical fire activity intersect to elevate wildfire risk.

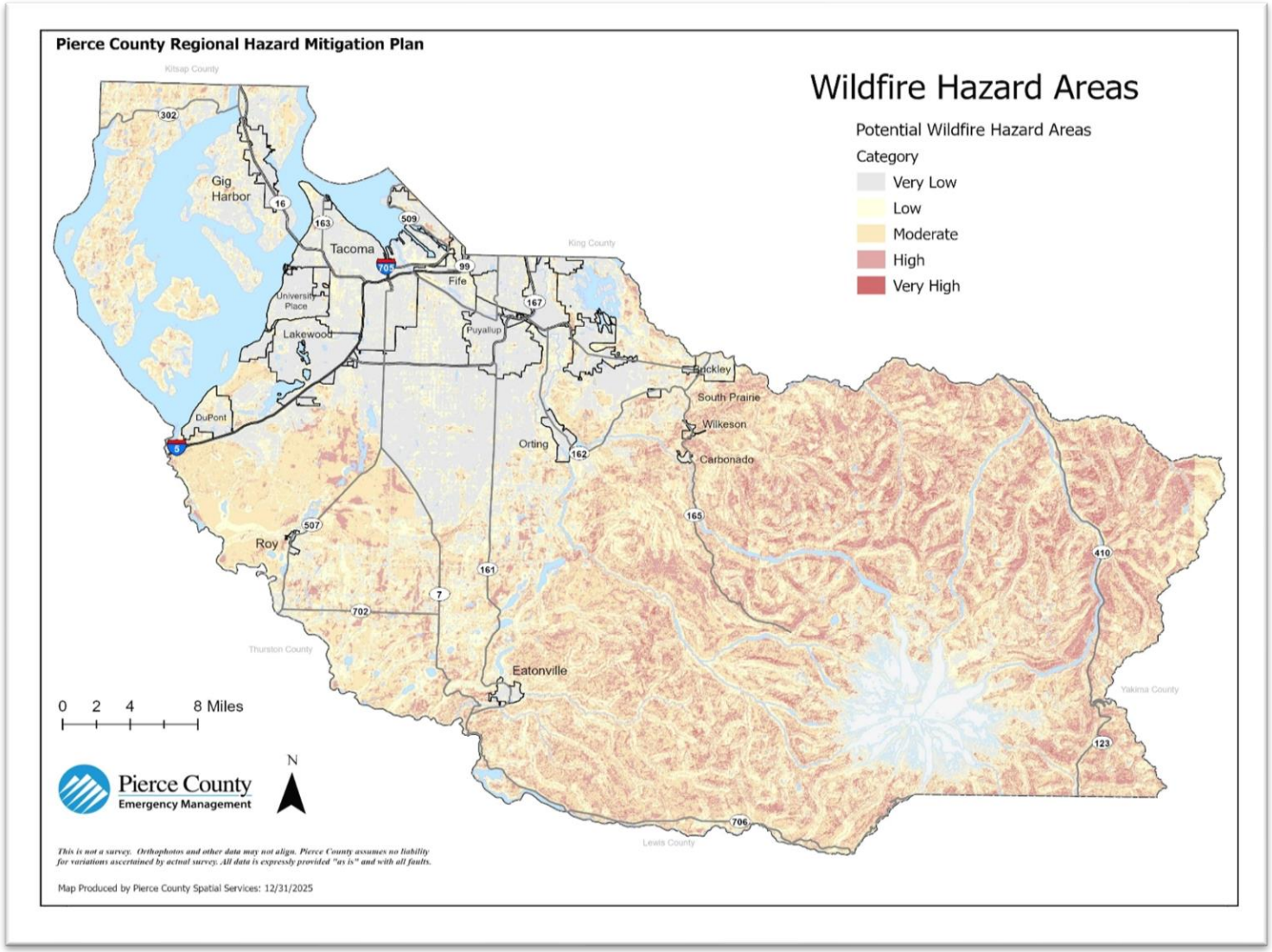
Due to variables affecting wildfire threat caused by topography, weather, and the amount of fuel, the Washington State Department of Natural Resources (DNR) has created different fire danger rating areas, or zones, based on recommended actions by the National Fire Danger Rating System (NFDRS). These zones are Industrial Fire Precaution Level (IFPL) Zones, and Pierce County falls within the zones detailed in Map 4.8-2.

By law, the Washington DNR uses two closure systems to reduce wildfire risk on 12.7 million acres of private and state forestland protected by the agency. These closure systems are activated when needed during fire season. One closure system applies to the general public, and the other applies to woods workers.[7] As of January 2026, there are four IFPL levels: Level I, Level II, Level III, and Level IV (see Table 4.8-2 for additional detail).

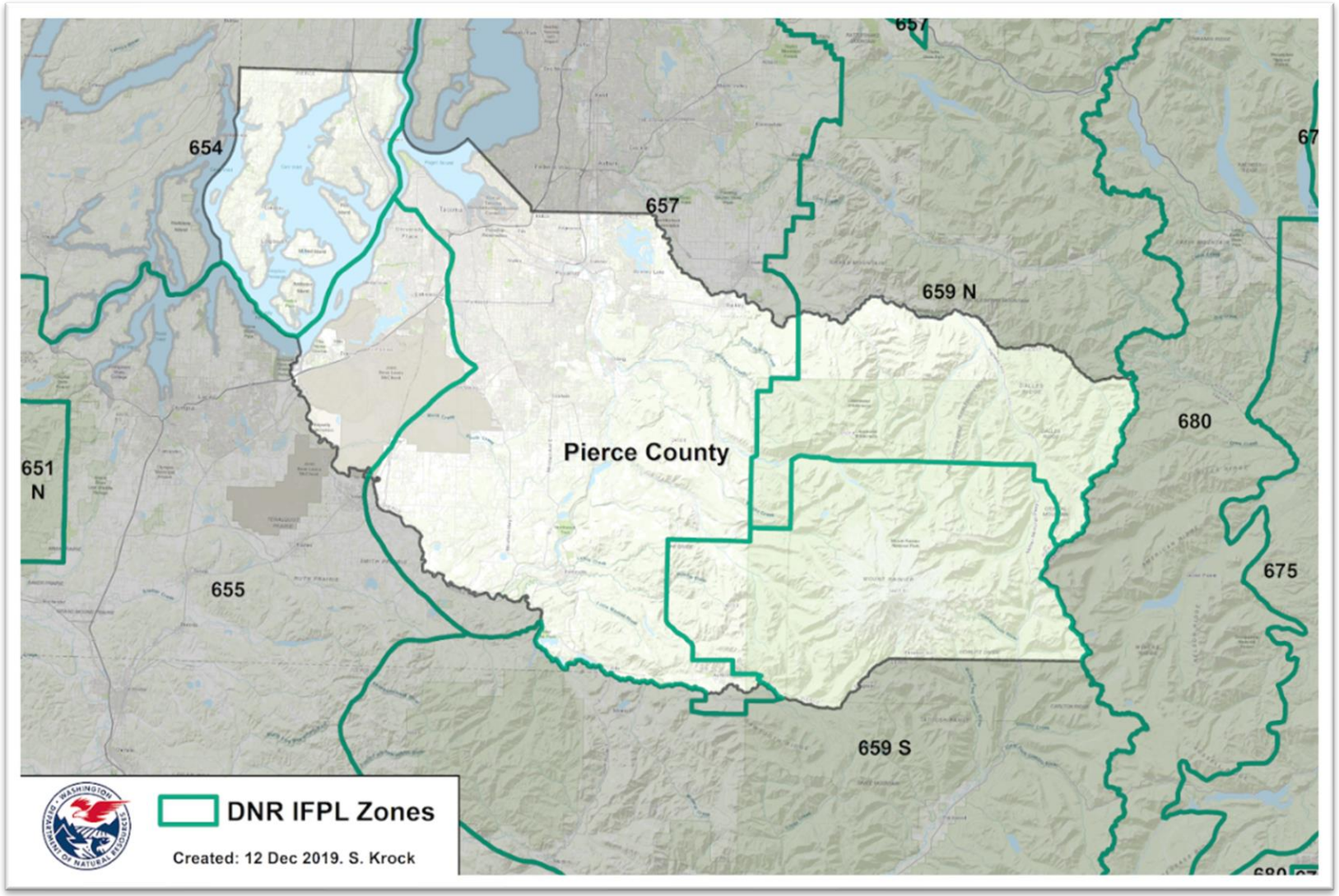
Table 4.8-2 Washington State DNR Industrial Fire Precaution Levels[8]

Industrial Fire Precaution Levels	
Level I: Closed Fire Season	Fire equipment and fire watch service is required
Level II: Partial Hootowl	Limits certain activities to between the hours of 8:00pm and 1:00pm
Level III: Partial Shutdown	Prohibits some activities altogether and limits other activities between the hours of 8:00pm and 1:00pm.
Level IV: General Shutdown	All operations prohibited.

Map 4.8-1 Wildfire Hazard Areas



Map 4.8-2 Industrial Fire Precaution Level Shutdown Zones and Pierce County



Location and Extent

Pierce County is the second-most populous county in Washington, with more than 959,900 residents living across twenty-three incorporated cities and towns, multiple Tribal Nations, and Joint Base Lewis-McChord (JBLM).[9] The county includes a mix of dense urban centers, rapidly growing suburban areas, rural communities, and extensive forested landscapes, all of which influence wildfire exposure and response needs.

More than 800,000 acres of forested land, managed by federal, state, tribal, and private partners, cover large portions of Pierce County.[10] Continued development along wildfire areas, combined with agricultural activity and changing land-use patterns, has increased wildfire risk and created new challenges for community protection and emergency response.

Occurrences

Fire is a normal part of most forest and range ecosystems in temperate regions of the world. Fires traditionally burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affect the species (including humans) within the ecosystem. Pierce County encompassed several different fire regimes historically, with fires occurring in some locations as frequently as every seven years on average, to as many as every 200 years on average.[11]

The expansion of communities into wildfire zones has increased the potential for ignition and for fire spread.[12] This risk is compounded by changing land use patterns, prolonged dry seasons, and the accumulation of fuels in forested areas. Prevention, preparedness, and resilience planning remain essential to lessening the impact of wildfires.

Wildfires occurring along Pierce County's borders with neighboring jurisdictions, such as King, Thurston, and Lewis Counties, can strain local response resources and infrastructure. Shared critical systems, such as transportation corridors and utility networks, are susceptible to disruption from smoke, fire damage, and emergency closures. These cross-boundary challenges highlight the importance of regional coordination in wildfire mitigation and response.

According to the Washington State Patrol Office of the State Fire Marshal's Fire in Washington Annual Reports, King, Pierce, and Snohomish Counties collectively report an average of 2,500 natural vegetation fires annually. Furthermore, from January 1st of 2025 to October 31st of 2025, there were 13 reported fire-related fatalities in Pierce County.[13] While many of these fires are small in scale, they reflect a persistent hazard that demands ongoing attention.

Recurrence Rate

Today many factors affect the overall recurrence rate of fires. A relatively new factor in wildfire recurrent is development encroachment into what has traditionally been forested area. Whether it is through logging, recreation, or the pressure of a growing population creating an expansion of homes and businesses into the traditionally rural areas of the County, the potential for fires to impact the human community has escalated over the past century and a half. Based on information from past fire occurrences and information from the DNR, the probability of recurrence for wildfire hazards in Pierce County is five years or fewer occurrences.

Wildfires in Pierce County are forecasted to occur more frequently and be more severe. The 2023 Washington State Enhanced Hazard Mitgiaton Plan identified the September 2020 Pierce County wildfire incidents as being an example of heightened wildfire frequency and severity.[14] Coupled with population growth in Pierce County and other communities in western Washington's greater Seattle metropolitan areas, more people, property, and critical infrastructure will be exposed to wildfire hazards.

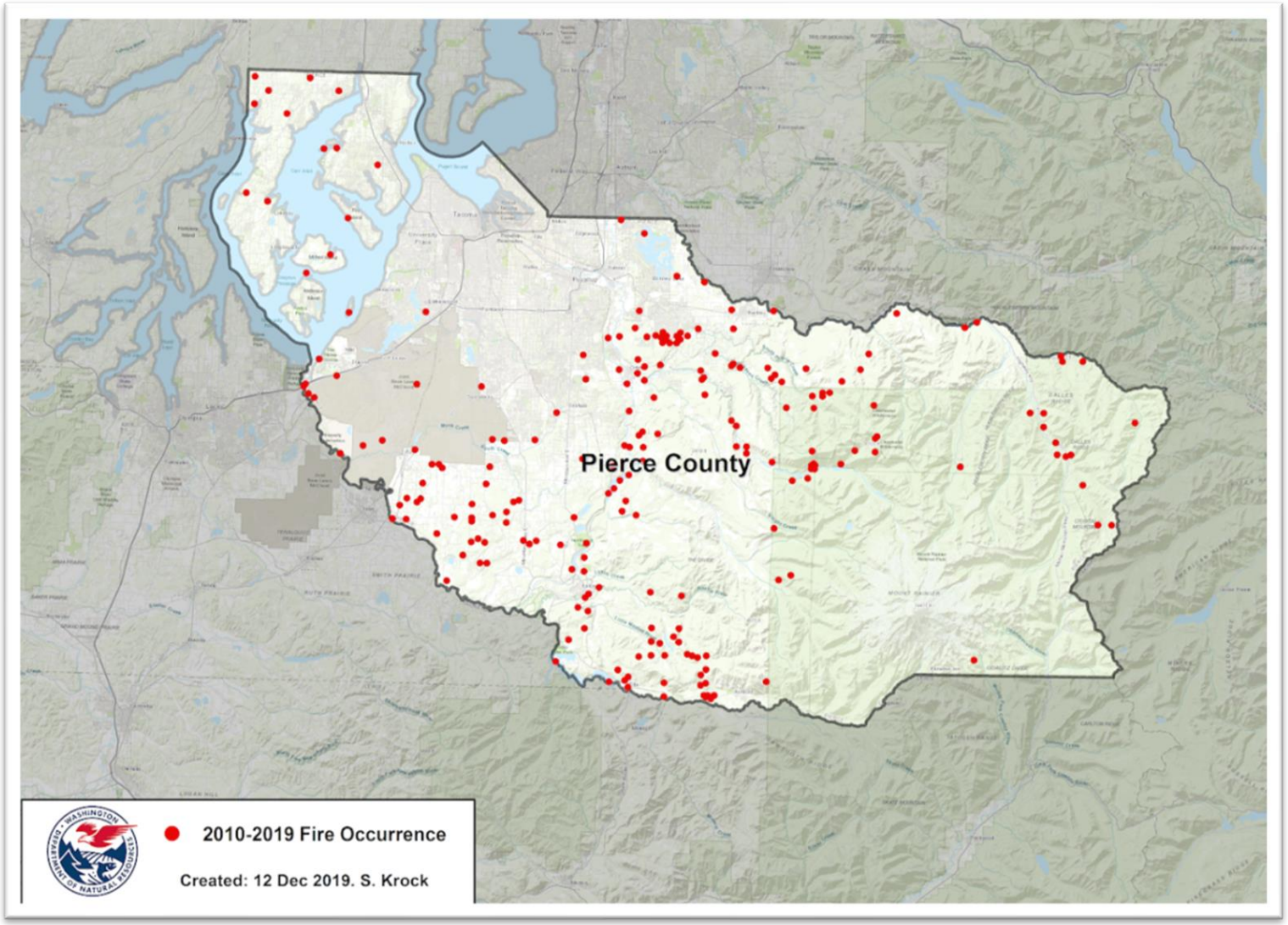
Table 4.8-3 A Record of Notable Wildfires in Pierce County[15]

Fire Name	Acres Burned	Wildfire Date	Wildfire Cause
Alder Lake	359	2015	Lightning
Carbon Copy	280	Aug 2006	Unknown (Human Suspected)
Greenwater 7440	220	Sept 2006	Unknown (Human Suspected)
Norse Peak	52,062	Aug 2017	Lightning
Sawmill Creek	1,099	Sept 2017	Unknown (Human Suspected)
Wrong Creek	424	Sept 2018	Lightning
Sumner Grade	347	Sept 2020	Powerline
Fish	132	Sept 2020	Powerline
244th	275	Sept 2020	Powerline
8 Road	157	Oct 2022	Human
Ft Steilacoom	40	Aug 2023	Unknown (Human Suspected)
Jamestown	(2 deaths)[16]	Aug 2024	Unknown (Human Suspected)

Occurrences Trends

While not all the fires recorded in Table 4.8-3 are technically wildfires, their relatively frequent occurrence indicates a risk to the wildfire hazard near populated areas of Pierce County. Map 4.8-3 shows the number of fire occurrences captured by Department of Natural Resources 2010-2019. None of the maps or figures in this hazard subsection represent a comprehensive count of all fires in Pierce County that have occurred, however, they do show trends in fire occurrence and location.

Map 4.8-3 Pierce County Fire Occurrences from 2010 to 2019



Impacts

Health and Safety of Persons in the Affected Area at the Time of the Incident

The health and safety of persons in the affected area at the time of the fire could be deeply compromised. Burns, smoke inhalation, psychological trauma, and death are among the impacts on the population living, working, recreating, or visiting within the impacted area. The California wildfires of 2003, 2018, and 2025 are perfect examples of major wildfires that not only caused damage, but death as well. The 2003 Southern California Wildfires killed 22[17], the 2018 Camp Fire killed 84[18], and the 2025 Palisades and Eaton fires killed 29.[19] The Maui Wildfires in 2023 resulted in the highest death toll to date with 102 killed and 2 fire personnel injured[20]. These numbers do not include the civilians who were injured in each fire.

In some ways, the psychological damage can be as traumatic as some of the physical injury. Both adults and children can present long-term psychological changes due to the incident.

Children may manifest these through regression or other actions including:

- Fear of injury or death;
- Fear of separation;
- Inability to sleep;
- Fear of the dark;
- Fear of closed spaces;
- Fear of outdoor spaces;
- Regression of toilet training/bed wetting or other outgrown childish behavior;;
- Withdrawal from normal activities;
- Fear of sudden noises;
- Refusing to eat, nightmares, hyperactivity and irritability; and
- Aggressive episodes with other children. [21]

“Adult stress symptoms include: anxiety, depression, insomnia, irritability, impairment in concentration, loss of productivity, feelings of sadness and gloom, and the tendency to link the fire to other traumatic events in their life.”[22]

Health and Safety of Personnel Responding to the Incident

The impacts to personnel responding to wildfires include burns, trauma, smoke inhalation, psychological trauma and death. Injury and death can occur from equipment failure or not wearing the proper equipment. They can occur from falling snags, burnover, or even a bulldozer rolling over on steep terrain.

Due to mutual aid, these deaths can affect communities nationwide, not just those where the wildfire takes place. Pierce County lost Fire Chief Dan Packer in a blaze in Yreka, California on July 26, 2008, when he was doing reconnaissance and was overrun by the fire front.[23] [24] Long-term effects for wildland firefighters can include heart disease, emphysema, and environmental-caused diseases.

Continuity of Operations and Delivery of Services

Depending on the area impacted by wildfires, the continuity of operations for multiple jurisdictions or agencies might all be affected at the same time. Many of the smaller jurisdictions or agencies, especially those located in the more rural areas of the County, with a limited staff and facilities, could have their entire infrastructure destroyed, their community gone, and staff may have evacuated because of the danger posed by a large wildfire.

Another problem is the isolation of certain areas. Many areas exist with their only access being the narrow two-lane roads that connect them to the more populated portions of the County. Pierce County also contains seven inhabited islands and one near island.[25] Four of these are only accessible by ferry and three by a two-lane road and bridge. This is exacerbated in some areas, like Ketron Island, which has no fire response located on the island, and is only accessible by ferry.

In contrast, larger entities with their infrastructure, equipment, and staff spread over a broad geographical area, will be less likely to experience the inability to continue operations. Long-term operational recovery may not be feasible for some of the smaller jurisdictions if the wildfire was large enough affect their entire jurisdiction. Losing both the resident population due to the fire and the resulting tax base, in addition to loss of their infrastructure, could make operational recovery impossible for smaller communities.

Second, delivery of regular, day-to-day services to the impacted area could be compromised for many months, if not years. In some cases, it is possible that the effects on service delivery will be not just to the area with direct fire damage, but also to areas around the periphery of the fire. Fire damage will include not just the building stock, but also much of the other infrastructure. Power poles and lines will be down, blacktop roads will have melted and in some cases, burned. The damage within the burned area could be so severe that few services will actually be required within it. Rather, it could be difficult providing services across the burned area to homes and businesses outside the actual area of damage. With power lines down, well houses burned, roads damaged, etc., not all services will be immediately available to neighboring communities outside the burned area. Within the burned area, infrastructure will need to be repaired prior to rebuilding being accomplished.

Property, Facilities, and Infrastructure

Within the geographic area covered by a wildfire there will be considerable damage to the facilities and infrastructure. The fires that burn throughout the western states present year-to-year images of the destruction possible. Pierce County, like any of these other communities, can expect private property, public facilities, equipment and infrastructure in some communities to have major damage or in some cases total loss.

The Environment

Environmental impacts from a major wilderness fire can be extreme and may be exacerbated even further if the fire becomes a wilderness/urban interface fire.

Normal environmental damage includes deforestation, death of animals, burnt material becoming polluting effluent in streams and rivers, increased erosion and a higher potential for landslides. This damage may take decades to reverse. If the fire happens in an area of old-growth forest, which may have been in existence for hundreds of years, it could take centuries for the environment to regain its original form and biodiversity. However, even with the damage done, not everything about the damage is detrimental. The damage done to the environment and the destruction of the forest opens up areas for colonization by new plants and animals. These burned areas allow sunlight to reach the ground. In doing so, plants that have not been able to survive in the heavily shaded understory, that normally exist in old growth forests, will thrive. As they do so, they will attract animals that thrive on them. Over time, the remnants of the original forest will encroach on the open area and it will once again return to forest.

With a fire that affects the interface between the forest and the developed areas of the County, there is the problem of further pollution. The burning of materials used in construction, the rupturing of oil, gas or other hazardous materials tanks, the melting and burning of tires, and the distribution of firefighting chemicals across the landscape.

Over the past few years, an increase in the knowledge of the effects from fire-fighting chemicals has shown that there can be long-term detrimental impacts on the environment, especially on water features and areas where the groundwater may become contaminated.[26;27] This is particularly relevant when there are repeat uses of the chemicals to control fires.

Economic and Financial Condition

The economic and financial condition of any individual jurisdiction will depend on the size of the wildfire and which parts of the community are directly affected. A fire that burns a couple of thousand acres of previously logged but not re-grown terrain and destroys a dozen homes

will have a relatively benign long-term economic impact for the larger community. In comparison, one that destroys an area the same size, but burns an entire small community, will have long-term lasting effects, if the community is able to rebuild at all. The Camp Fire that destroyed more than 13,000 homes in Butte County (including the Town of Paradise) was awarded nearly $500 Million in Small Business Administration (SBA) loans and FEMA grants.[28] The long-term effects include: a loss of economic vitality because of the destroyed businesses and wilderness jobs associated with recreation and logging; a loss of tax revenue; and, possibly the permanent loss to the community of the people that lived in the homes either due to death from the fire or moving away in the aftermath of the disaster.

Public Confidence in the Jurisdiction's Governance

The reputation of the entity will be directly related to the perception of competence in handling the fire threat and how well it was handled. The more damage caused by the fire that is shown to have been preventable by some action of the agency or jurisdiction, the lower the resulting reputation will be and the greater the decrease in confidence in the entity's ability to handle future situations.

A rapidly handled fire with little damage to homes or businesses will enhance the jurisdiction's reputation while a fire that burns many homes or businesses, even if it was well handled, may allow a lack of confidence to develop. Visuals of teams working to protect the homes and property of individuals will help to shore up this image. It's important for homeowners and residents to understand the large part they play here, too. Emergency personnel cannot require homeowners to clean gutters, roofs, and remove combustible directly next to their house. This needs to be an all-hands effort.[29]

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Section 5: Mitigation Strategy

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Mitigation Strategy Requirements

Code of Federal Regulations 44

Plan Content – Requirement §201.6(c)(3)(i), §201.6(c)(3)(ii), §201.6(c)(3)(iii), and §201.6(c)(3)(iv). This plan must include:

(3) A *mitigation strategy* that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools. This section must include:

(i) A description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

(ii) A section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure. All plans approved by FEMA after October 1, 2008, must also address the jurisdiction's participation in the NFIP, and continued compliance with NFIP requirements, as appropriate.

(iii) An action plan describing how the actions identified in paragraph (c)(3)(ii) of this section will be prioritized, implemented, and administered by the local jurisdiction. Prioritization will include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

(iv) For multi-jurisdictional plans, there must be identifiable action items specific to the jurisdiction requesting FEMA approval or credit of the plan.

Section 5: Mitigation Strategy

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Mitigation Strategy Overview

Mitigation actions are short and long-term actions to reduce hazard-related risk. The process of developing and implementing mitigation actions relies on community risks and vulnerabilities, planning team expertise, public participation, community needs and capabilities, a cost/benefit review, and input from governing elected officials. Each Jurisdictional Annex's "Section 5: Mitigation Strategy" details actionable ways for jurisdictions to reduce loss of life and property following a disaster and build lasting community resilience to natural and human-caused hazards.

Definitions

Figure 5-1 Mitigation Strategy Formula

Mitigation Strategy = Pierce County Mitigation Goals +
Pierce County Mitigation Objectives +
Local Mitigation Goals +
Mitigation Actions

The Pierce County RHMP defines each Jurisdictional Annex's Mitigation Strategy (Figure 5-1) as being the combination of Pierce County Mitigation Goals, Pierce County Mitigation Objectives, Local Mitigation Goals, and Mitigation Actions. These terms are further defined in the Critical Mitigation Strategy Definitions Table (See Table 5-1).

Jurisdictional Annex Organization

Each Jurisdictional Annex's "Section 5: Mitigation Strategy" is organized into a "Mitigation Strategy Overview" Subsection and "Mitigation Strategy: Narrative Description" Subsection. A comprehensive list of mitigation actions is listed in the Mitigation Strategy Matrix Table of each Jurisdictional Annex and further described in the "Mitigation Strategy: Narrative Description" Subsection.

Table 5-1 Mitigation Strategy Section Core Elements

Jurisdictional Annex: Mitigation Strategy Organization Overview		
	"Mitigation Strategy Overview" Subsection	**"Mitigation Strategy: Narrative Description" Subsection**
Core Element	**"The Mitigation Strategy Matrix" Table** *A comprehensive list of all of a jurisdiction's mitigation actions*	**A more detailed description of each mitigation action** *A narrative mitigation action description, relevant status updates, and a mitigation strategy feasibility evaluation*

Mitigation Strategy Table Development

The Mitigation Strategy Matrix Table provides a high-level overview of all mitigation actions for each jurisdiction and collectively forms the jurisdiction's overall mitigation strategy. The jurisdiction's overall mitigation strategy describes a cohesive approach to reducing short-term and long-term risk to natural and human-caused hazards. The Mitigation Strategy Matrix Table in each Jurisdictional Annex also describes the following elements:

- **Implementation Mechanism Category:** Groups of similar mitigation strategies that describe how each mitigation action will be implemented on the local level;
- **Mitigation Action and Hazard Type:** Identifies the natural or human-caused hazards each mitigation action addresses;
- **Lead Jurisdiction/Department:** Identifies the entity responsible for completing the mitigation action and tracking progress;
- **Timeline:** Indicates the estimated duration to complete the action; and
- **Plan Goals Addressed:** Specifies how many of the Pierce County RHMP Planning Team goals are addressed by the mitigation action.

Mitigation Strategy Narrative Development

Building upon the Mitigation Strategy Matrix Table, each jurisdiction's mitigation actions are described in greater detail in the "Mitigation Strategy: Narrative Description" Subsection. Each narrative description addresses four components of the mitigation action:

- **Mitigation Action Description:** What are all the hazards that this action mitigates, and how does this mitigation action accomplish mitigating these hazards?
- **Mitigation Action Status Update:** What is the general status update of this action?
- **Eight-Point Feasibility Evaluation**: How feasible is this mitigation action to implement with each jurisdiction's existing resources?
- **Mitigation Action Prioritization**: What priority is this action in comparison to other actions in the same implementation mechanism category?

Section 6: Infrastructure

Pierce County Regional Hazard Mitigation Plan | 2025 - 2030 Update

Infrastructure Requirements

Code of Federal Regulations 44

Plan Content – Requirement §201.6(c)(2)(ii)(A) and §201.6(c)(2)(ii)(B). This plan must include the following:

(2) A *risk assessment* that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards. The risk assessment must include:

(ii) A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description must include an overall summary of each hazard and its impact on the community. All plans approved after October 1, 2008, must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:

(A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B) An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate.

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Infrastructure Overview

“Section 6: Infrastructure” is an optional component of the Pierce County Regional Hazard Mitigatoin Plan (RHMP). The Pierce County RHMP Planning Team determined that including a survey of infrastructure and an evaluation of hazard risk provides valuable context for understanding local hazard risks and supports the development of mitigation strategies across Pierce County.

Infrastructure Section Format

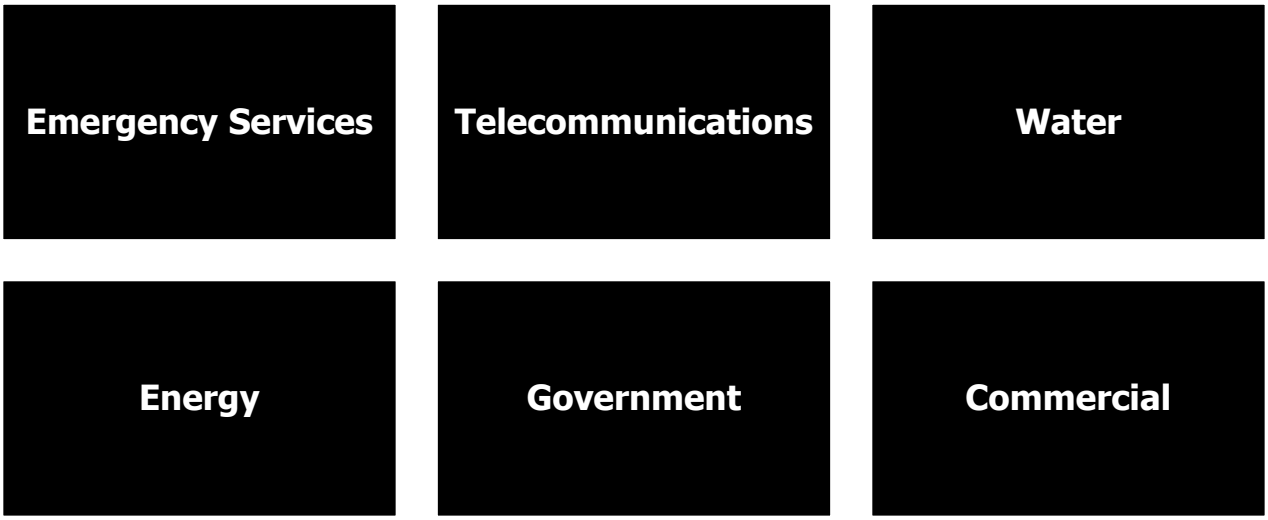
Each Jurisdictional Annex’s “Section 6: Infrastructure” includes a series of summary tables showing the relationship between infrastructure and each jurisdiction. These tables include:

- **Infrastructure Summary:** Details the number of pieces of infrastructure and their value;
- **Infrastructure Category Summary:** Summarizes the Homeland Security Sectors that the pieces of infrastructure belong to;
- **Infrastructure Vulnerability Dependency Summary:** Shows how many pieces of infrastructure rely on the six core Homeland Security Sectors;
- **Infrastructure Vulnerability Hazard Summary**: Assesses the extent that infrastructure may be impacted by hazards;
- **Infrastructure Dependency Matrix**: Displays the individual jurisdictions or agencies that support the jurisdiction; and
- **Infrastructure Matrix:** Lists individual pieces of infrastructure, key attributes, and their vulnerability to the natural hazards addressed in the Pierce County RHMP.

Homeland Security Sectors for Infrastructure

Each Jurisdictional Annex "Section 6: Infrastructure" analyzes six core Homeland Security Sectors for infrastructure (see Figure 6-1).

Figure 6-1 Department of Homeland Security Infrastructure Sectors



Public Disclosure

For each Jurisdictional Annex, the Pierce County RHMP "Section 6: Infrastructure" is exempt from public disclosure pursuant to RCW 42.56.420. Requests for public disclosure of this document, or any part thereof, should be referred to the Pierce County Executive. Distribution or modification of this document without the express written consent of the Pierce County Executive is prohibited.

Section 7: Plan Maintenance Procedures

Pierce County Regional Hazard Mitigation Plan | 2025 – 2030 Update

Plan Maintenance Procedures Requirement

Code of Federal Regulations 44

Plan Content – Requirement §201.6(c)(4)(i), §201.6(c)(4)(ii), and §201.6(c)(4) (iii). This plan must include the following:

(4) A *plan maintenance process* that includes:

(i) A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

(ii) A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.

(iii) Discussion on how the community will continue public participation in the plan maintenance process.

Section 7: Plan Maintenance

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Plan Maintenance Procedures Overview

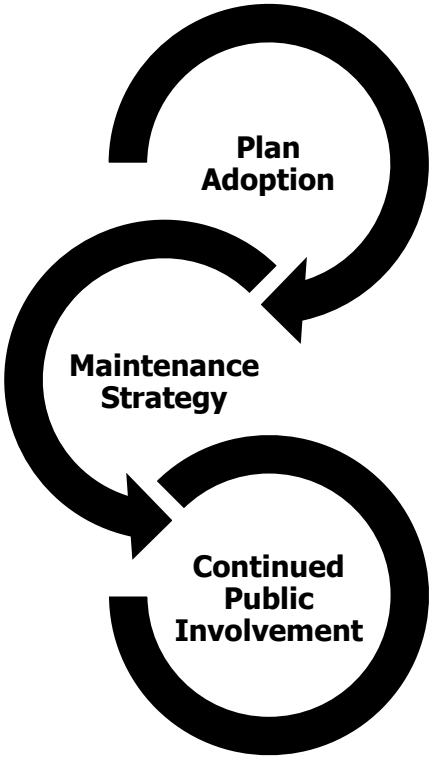
The planning update process for the 2025 Pierce County RHMP began in September 2024 and builds on the foundation of breaking the disaster cycle by planning for disaster-resistant communities. This section describes the formal plan maintenance processes used by jurisdictions to ensure the Jurisdictional Annexes remain active, relevant, and effective.

Each Jurisdictional Annex's "Plan Maintenance" Subsection includes documentation of the jurisdiction's formal adoption of the plan. This subsection also describes:

- The method and schedule of monitoring, evaluating, and updating the plan within the required five-year cycle;
- The process for incorporating the mitigation strategy into existing mechanisms; and
- The process for integrating public participation throughout plan maintenance activities.

The plan maintenance process also serves as a guide for implementing the hazard mitigation strategy. The Plan Maintenance Section is divided into three elements: Plan Adoption, Maintenance Strategy, and Continued Public Involvement (Figure 7-1).

Figure 7-1 Plan Adoption, Maintenance Strategy, and Continued Public Involvement



Plan Adoption

The initial review of the Pierce County Regional Hazard Mitigation Plan (RHMP), including the Jurisdictional Annexes, is conducted through a "Pre-Adoption Review" allowed by Washington State Emergency Management Division (EMD) and the Federal Emergency Management Agency (FEMA) Region X. Washington State EMD and FEMA will concurrently review the Pierce County RHMP and either approve it subject to adoption or require some changes along with adoption prior to final approval. If revisions are required for final approval, Pierce County Department of Emergency Management (PCDEM) will initiate a meeting with the Jurisdictional Annex planning partners to address these changes. Once the review is complete, the plan can be resubmitted for final approval.

Each jurisdiction's governing board is responsible for adopting the respective plan. Following adoption, the jurisdiction is responsible for submitting the plan and a copy of the signed resolution to PCDEM. PCDEM records the signed copy in "Appendix A" of each Jurisdictional Annex and forwards the copy to the State Hazard Mitigation Officer at Washington State EMD. Washington State EMD forwards the signed copy of the jurisdiction's plan to FEMA Region X for final approval. Once approved by FEMA, the jurisdiction is eligible for relevant grant and disaster funding opportunities. The Pierce County RHMP must be re-adopted and re-approved with the five-year update cycle coinciding with FEMA's approval.

"Appendix A" of each Jurisdictional Annex contains the final approval date, a copy of the signed resolution from the jurisdiction, and a copy of the FEMA letter approving the jurisdiction's plan.

"Appendix C" of each Jurisdictional Annex contains a log for changes and updates that occur within the five-year planning cycle.

Maintenance Strategy

The maintenance strategy for the Jurisdictional Annexes establishes methods to implement, monitor, and evaluate the plans. This strategy promotes collaboration, information sharing, and innovation. Through a multi-tiered approach, jurisdictions provide a localized strategy for loss reduction while advancing coordinated policies and programs that address their community needs.

The strategy emphasizes participation at all levels, supporting public involvement and adaptability to evolving risks and vulnerabilities. It also strengthens the connection between citizens and all levels of government, from community initiatives to the Department of Homeland Security. Through this strategy, each jurisdiction advances toward a more disaster-resilient community.

Implementation

To support efficient and effective implementation, each jurisdiction will use the identified capabilities, infrastructure, and community resources. Mitigation strategies will be implemented over the next five years based on jurisdiction-specific capabilities and a three-tiered implementation framework. This approach addresses local vulnerabilities, supports coordination across levels of government, promotes innovation, and provides a structured system to monitor progress.

The first tier focuses on implementation at the individual and community level through existing public education efforts, such as distributing information through utility bills. The second tier consists of jurisdiction-wide implementation through administrative processes, coordinated in conjunction with PCDEM. The third tier involves regional and multi-jurisdictional coordination through the Hazard Mitigation Forum (HMF). Each jurisdiction has designated an individual or group to oversee implementation activities. For planning and implementation purposes, jurisdictions are organized into discipline and regional groups according to their function and geography.

Hazard Mitigation Forum

The Pierce County HMF serves as the coordinating body for multi-jurisdictional mitigation initiatives and provides a mechanism to share best practices, strengthen coordination, and advance efforts to build a more disaster-resilient Pierce County. The HMF is comprised of representatives from unincorporated Pierce County and jurisdictions partially or wholly within its boundaries that have undertaken hazard mitigation planning efforts. Participation in the HMF supports implementation of hazard mitigation actions that address shared risks and promote consistency with the hazard mitigation planning requirements described in CFR §201.6 and in the Pierce County RHMP Base Plan, "Section 1: Plan Process."

Coordinated by PCDEM, the Pierce County HMF meets annually. Each jurisdiction participating in the Pierce County RHMP will be an active participant in the Pierce County HMF and will be represented by the designated planning partner or their representative.

Plan Evaluation and Update

Each jurisdiction must re-evaluate and update the hazard mitigation plan at least every five years. Some jurisdictions conduct annual reviews, while others follow a two or three-year review cycle. All jurisdictions conduct a comprehensive review and update every five years.

During the annual HMF meeting, participating jurisdictions collectively review disasters, emergencies, and incidents from the previous year and discuss implications for maintaining and updating Jurisdictional Annexes. This process helps identify potential mitigation actions from recent events to include in future updates.

At the end of each five-year cycle, jurisdictions are required to submit their updated plans to the State and FEMA for review and approval. This process is coordinated by PCDEM through the HMF. Beginning in 2026, and every five years following, jurisdictions will submit updated plans to PCDEM. PCDEM will compile the jurisdiction updates and submit them to Washington State EMD and FEMA for review and approval.

Continued Public Involvement

Figure 7-2 PCDEM Team Members Taught Kids About Hazard Mitigation Planning at the 2025 Scarecrow Festival

Continued public involvement is essential to the review and update process. The three-tiered implementation approach supports ongoing public participation throughout the planning cycle. Prior to submitting the Pierce County RHMP to Washington State EMD and FEMA for review, participating jurisdictions will hold public information and comment meetings.

Public comment meetings will provide an opportunity for community members to share concerns, perspectives, and ideas related to their jurisdictions hazard mitigation planning efforts. Meetings will be advertised through communication methods appropriate to each community. Following the 2025 update of the Pierce County RHMP, PCDEM will provide ongoing plan updates through an online dashboard to support continued engagement.