SUBSECTION-SECTION 4M.8

PUYALLUP TRIBE ALL HAZARD MITIGATION PLAN
FLOOD HAZARD

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Identification Description

Definition[1]

A flood is a general and temporary condition of partial or complete inundation of normally dry land areas from:

- The overflow of inland or tidal waters,
- The unusual and rapid accumulation or runoff of surface waters from any source, or
- Mudflows or the sudden collapse of shoreline land, see the Volcanic Hazard and Landslide Sections or the Chapters of the Pierce County Hazard Identification and Risk Assessment 2015.

Pierce County's flood hazards are divided into two types: riverine and urban stream/groundwater.[2] These two types of flood hazards affect the Planning Area also.

Types[3]

Riverine Flood Hazard

Riverine flooding results from heavy and prolonged rainfall and may include substantial snowmelt if, there is rise in freezing levels after a measurable snowfall. Flooding of this type can last several days after the storm.

The most severe flooding on the Planning Area's rivers and major streams results from low- to moderate-elevation (1,000 to 3,800 feet) snowmelt runoff occurring in conjunction with a prolonged moderate- to high-intensity rainfall event. This is commonly referred to as a rain-on-snow event. Accumulating snowfall usually occurs for brief periods (one to three days) and can be followed by accelerated warming from warm Pacific frontal storm systems arriving from the tropics and containing a significant amount of precipitation. Rain-on-snow events typically result in sharp rise in river flow that can yield flood stages and can last for several days. The rise in peak flow can occur quickly, making consistent monitoring of river flow gauges essential during the flood season.

Urban Stream/Groundwater Flood Hazard

The second category of flood hazard in Pierce County occurs when runoff exceeds the conveyance capacity of natural and manmade drainage systems. Surface water runoff volumes in urban stream channels, closed depressions (potholes),[4] roadway ditches, culverts and conveyance pipe systems typically exceed the available conveyance and storage capacity of such systems during the fall, winter, and early spring wet seasons. This typically occurs with moderate- to high-intensity storms that can last for several days or occur in succession over a period of weeks. These events are characterized as rainfall of three inches or more in a 24-hour period. Urban area flooding generally occurs gradually and allows time for property owners to identify an impending flood situation and prepare for it. In the some areas, however, flooding can occur rapidly and may leave little time for preparation.

In some cases, debris can accumulate in stormwater collection systems and reduce the capacity of the system to convey flow. Such a reduction in capacity can lead to more frequent flooding events. Regular maintenance, however, can ensure that the stormwater systems function as designed.

Urban stream flooding is exacerbated by rain-on-snow events. During the winter months, these events usually result in widespread flooding along streets, streams, ditches, culvert pipe systems, and storm drains. Conditions in the basins can change rapidly and the onset of flooding can occur at an accelerated rate.

Groundwater flooding is associated with a large amount of cumulative rain over several storms or consecutive rainy seasons. High groundwater may occur weeks after the last significant rainfall and can also shift locations as groundwater levels change throughout the region. This type of flooding may last for several weeks or even months.

Profile

Location and Extent

Flooding directly affects less than 20% of the Pierce County and 21.3% of the Planning Area. The location of the flooding is categorized by the five major watersheds in Pierce County: the Puyallup/White River Watershed, the Nisqually River Watershed, the Chambers/Clover Creek Watershed, the Kitsap Watershed, and the Cowlitz Watershed, see Map 4.8-1.

Map 4.8-2 illustrates the location and extent of the flood hazard for the Planning Area. The map shows the extent of the 100-yr and 500-yr flooding areas based on the flood hazard areas from the Flood Insurance Rate Maps (FIRMs). Maps 4.8-7 to 4.8-9 further illustrates in greater detail the Tribal Trust Lands that would be affected during a flood. These maps will provide a more comprehensive opportunity to address those properties within the identified flood hazard area for possible future mitigation efforts as funding becomes available.

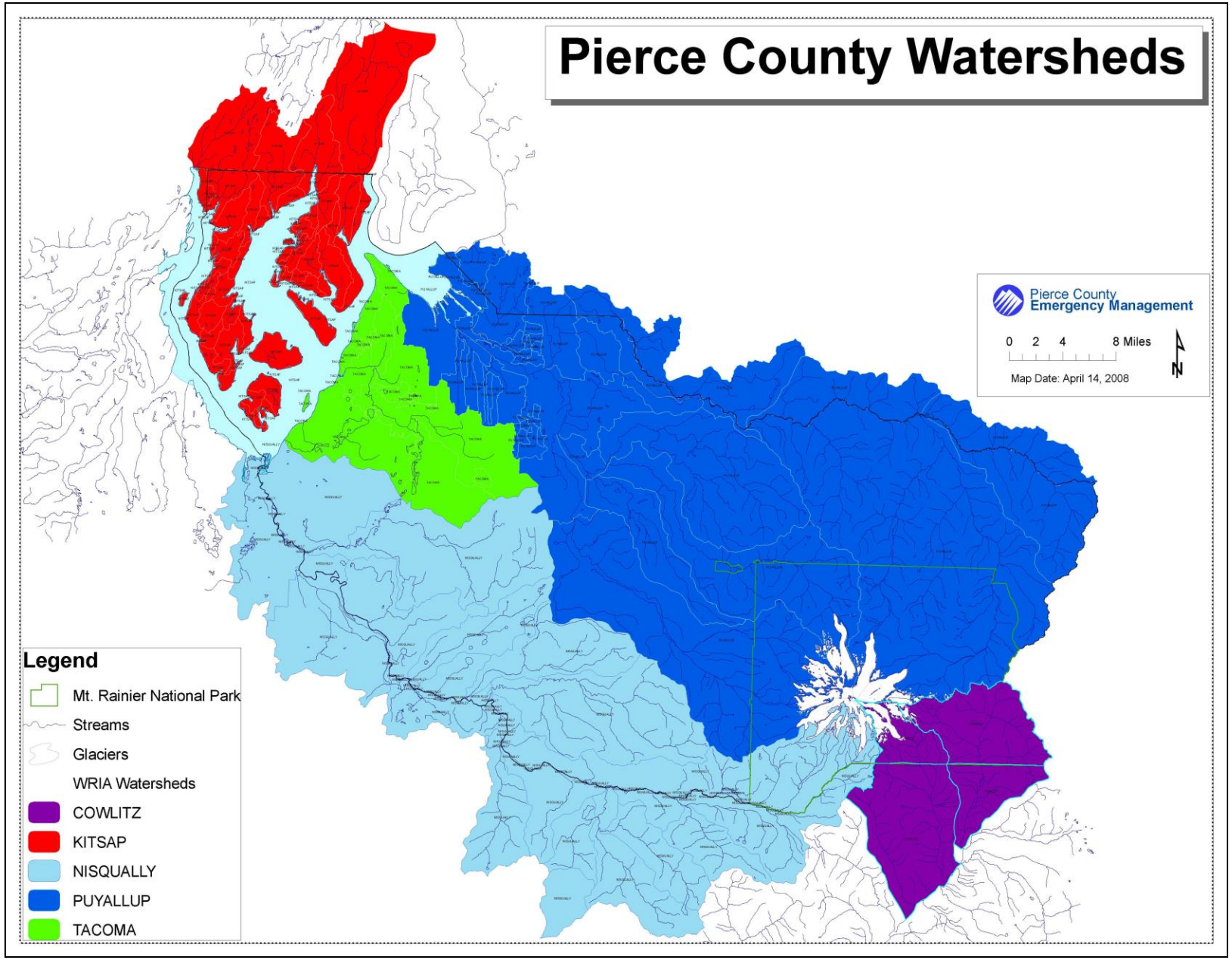
Areas of repetitive flood loss further illustrate the extent of the flood hazard, see Map 4.8-3. Some individual jurisdictions may also have repetitive loss properties that are not marked on this map. This analysis focuses primarily on those watersheds that contain these repetitive flood loss areas—the Puyallup/White River Watershed, the Nisqually Watershed, and the Chambers/Clover Creek Watershed—and more specifically, the basins in which the repetitive flood loss areas are located. Also included is a description of each type of flooding that occurs.

Pierce County's two categories of flood hazards are described in more detail below including their location and extent.

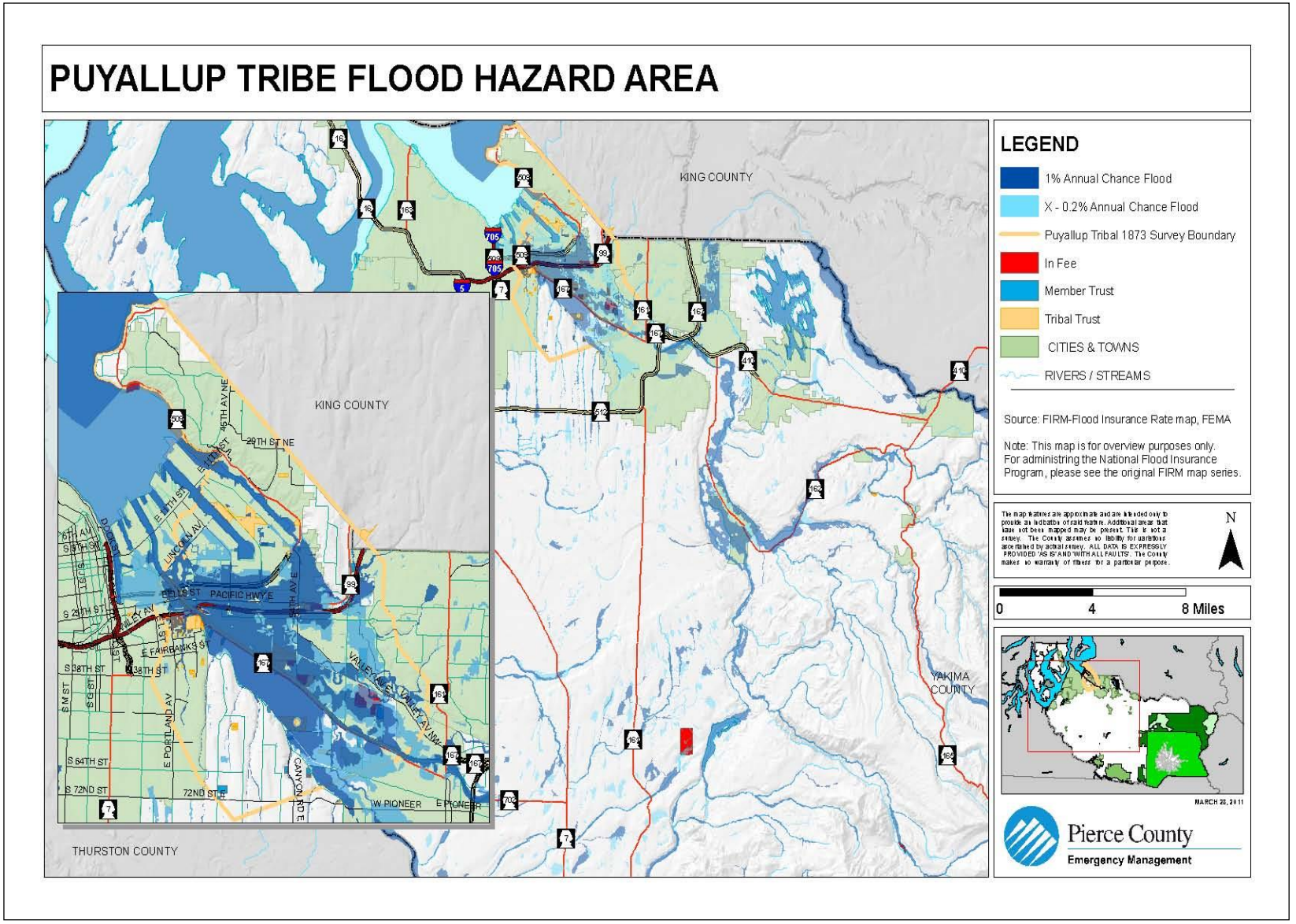
Riverine Flood Hazard

The riverine flood hazard typically arises from the Puyallup, White, Carbon, Nisqually, South Prairie Creek, Wilkeson Creek, and Mashel Rivers.

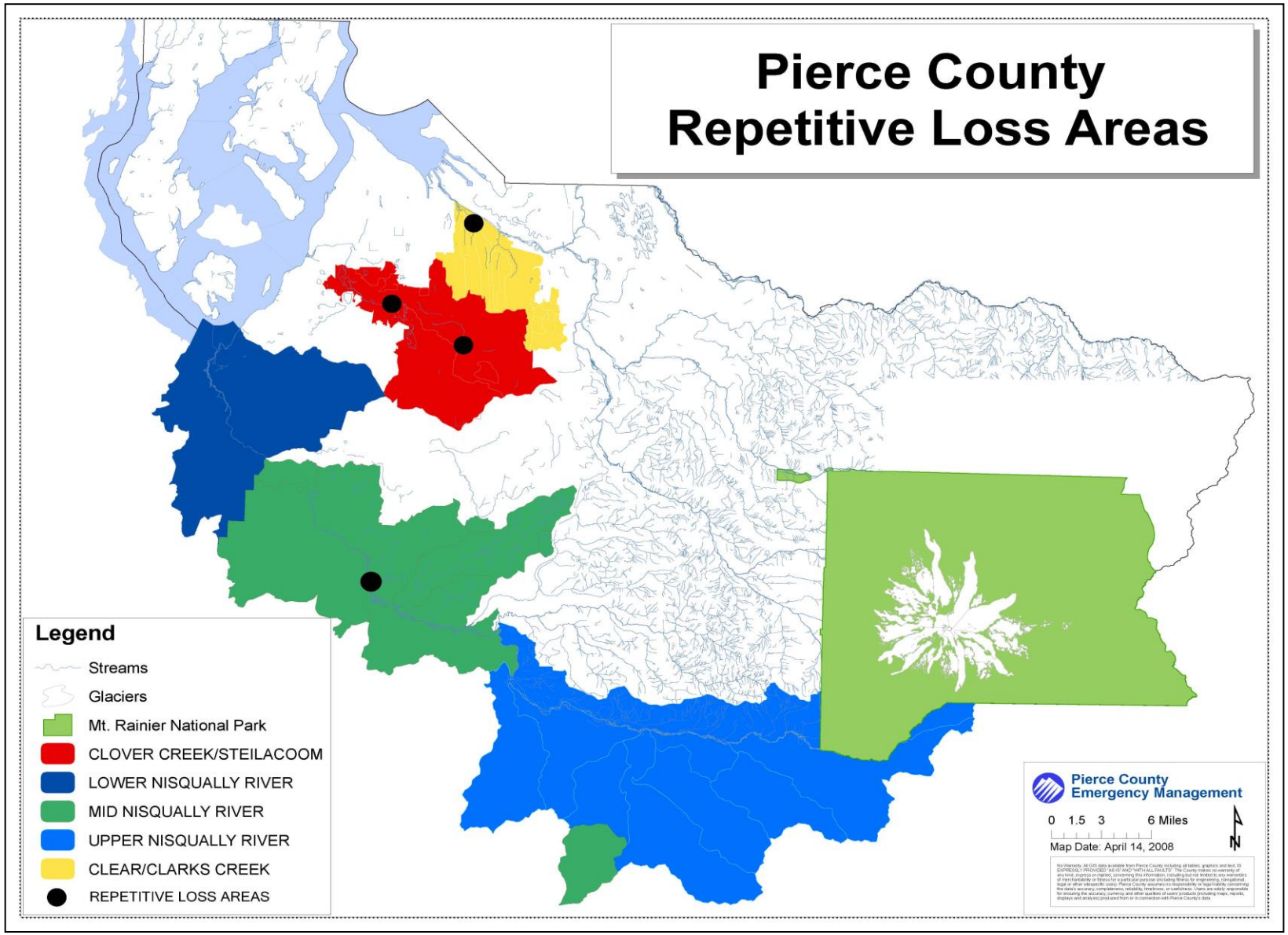
Map 4.8-1 Pierce County Watersheds



Map 4.8-2 Puyallup Tribe of Indians Flood Hazard



Map 4.8-3 Pierce County Repetitive Loss Areas



The White and Nisqually Rivers are regulated by dams that provide some flood control. However, during major events, neither of these has been able to prevent all flooding downstream from their facilities.

White River flows are regulated by the U.S. Army Corps of Engineers at Mud Mountain Dam. Mud Mountain Dam is operated solely as a flood control facility. The dam's primary goal is to provide flood control to the lower reaches of the Puyallup River, from River Mile 10.3 downstream through the Port of Tacoma to Commencement Bay. On the other hand, some flood control benefits can be seen within the entire reach of the White River downstream of the dam. As the water level behind the dam increases during major storms, and if there is no break in the amount of water entering the dam, the Army Corps of Engineers has at times had to increase releases to the point that some portions of the White/Stuck River have flooded. This was the situation in January 2009 when the Town of Pacific on the Pierce/King County border flooded. Much of this was due to deposited silt and gravel having raised the river bed. The increased flow then overtopped the levees flooding large portions of Pacific. While the Puyallup River has been impacted, the result has not been nearly as severe.

The middle and upper reaches of the Puyallup River and many of its tributaries constitute a largely unregulated and naturally flowing river system. Rapid changes in the quantity of water entering the system, either from heavy rain throughout the basin or rapid snow melt, usually from warm rain on snow, can change the downstream flood potential in a very short time. Because these rapid changes occur in remote areas within the basin, monitoring and forecasting, rain and rain-on-snow events are critical.

The lower Nisqually River is regulated by Tacoma City Light's Alder and La Grande Dams.[5] Neither dam is managed as a flood control facility. Their main purpose is as power generating facilities. As such they are managed to maximize power generation and therefore, flood control benefits from them are reduced. However, during periods when there is a threat of flooding Tacoma City Light does take into account the flood potential and will modify the flow of water released from the dams.

Despite the regulation from the dams, flooding from both the White and Nisqually Rivers downstream of the dams occurs when runoff exceeds their storage capacity and the dams must release more water than the downstream channels can convey.

The floodplain maps indicate that flooding occurs along either side of the Puyallup River, from Clear Creek (described below) to the South and along Wapato Creek to the north. Further north of Wapato Creek and still in the valley are mapped flood areas along Hylebos Creek. This includes two larger areas: 8th Street E to I-5 (north to south) and 62nd Ave E to 54th Ave E (east to west); and a portion just to the east of I-5 where the freeway bends northward and exits the Planning Area.

Urban Stream/Groundwater Flood Hazard

Urban stream/groundwater flooding occurs when runoff exceeds the conveyance capacity of natural and manmade drainage systems. It typically occurs with moderate- to high-intensity

storms that can last for several days or occur in succession over a period of weeks. Urban flooding in the Clear and Clover Creek basins is consistent with flooding areas shown on current FEMA Flood Insurance Rate Maps (FIRMs).

For some streams, flooding inundates broad areas for lengths of 1,000 to 3,500 feet, and longer in some cases. Floodwater can be high and flooding can last for several days until rainfall and saturated soil moisture conditions subside.

Repetitive Loss Areas

FEMA defines a repetitive loss property as being a National Flood Insurance Program (NFIP) insured property that since 1978, regardless of changes in ownership, has experienced any of the three following[6]:

- Four or more paid losses greater than $1,000;
- Two paid losses in excess of $1,000 within any 10 year rolling period since 1978;
- Three or more paid losses that equal or exceed the current value of the insured property.

To further illustrate the extent of the flooding hazard in the Planning Area and Pierce County, this analysis focuses on those areas within the County that have experienced repetitive flood losses (discussed further in the occurrences section). Based on FEMA records, the County has identified repetitive loss areas in three of the basins: Clear/Clarks Creek, Clover Creek, and the Middle Nisqually River, Map 4.8-4. These are discussed in further detail below, including a description of each basin and a description of the flooding that occurs.

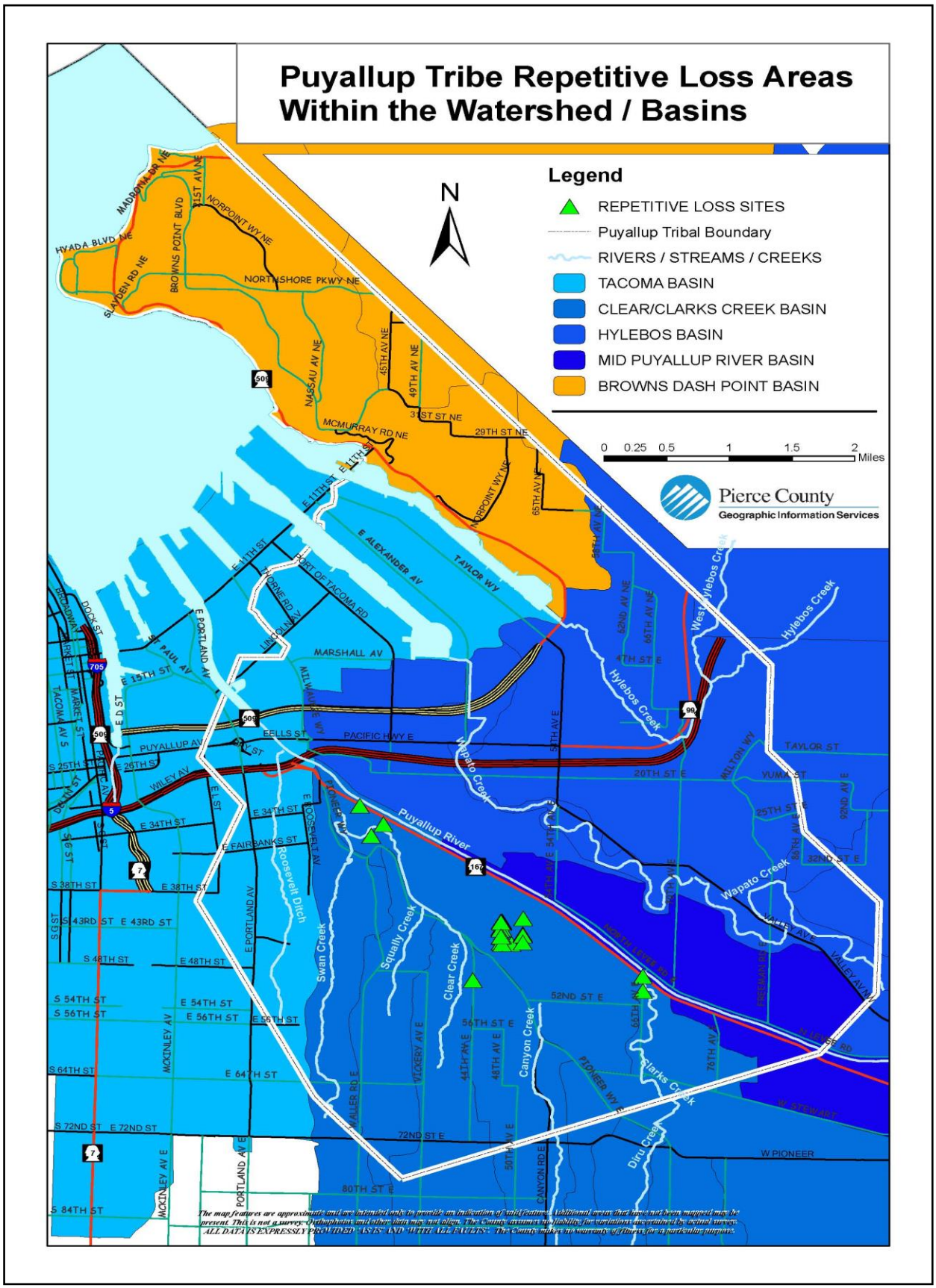
The Planning Area is located in the Puyallup Watershed, which the Clear/Clarks Creek Basin repetitive loss area, see Map 4.8-5 is a part of. These three repetitive loss areas are discussed in further detail below, including a description of each basin and a description of the flooding that occurs. Although the Planning Area is not located within two of the watershed basin boundaries, Clover Creek and the Middle Nisqually River they impact the Puyallup Tribe of Indians with their Usual and Accustomed fishing rights and this can impact the Planning Area indirectly.

Puyallup Watershed: Clear Creek Basin[7]

Description of Basin

Clear Creek, a tributary to the Puyallup River, is a major source of repetitive and destructive flooding in the Planning Area. The majority of repetitive loss properties within Pierce County exist within this basin. Clear Creek and its tributaries drains an area of approximately 12.7 square miles, see Map 4.8-5. Most of the Clear Creek basin is in unincorporated Pierce County and the Planning Area, but it also contains small portions of the Cities of Tacoma and Fife. Topography in the basin is composed of level river bottom in the lower portion of the basin along the Puyallup River and gently rolling hills and flatlands in the upper basin, with a steep transition in between.

Map 4.8-4 Puyallup Tribe of Indians Repetitive Loss Areas

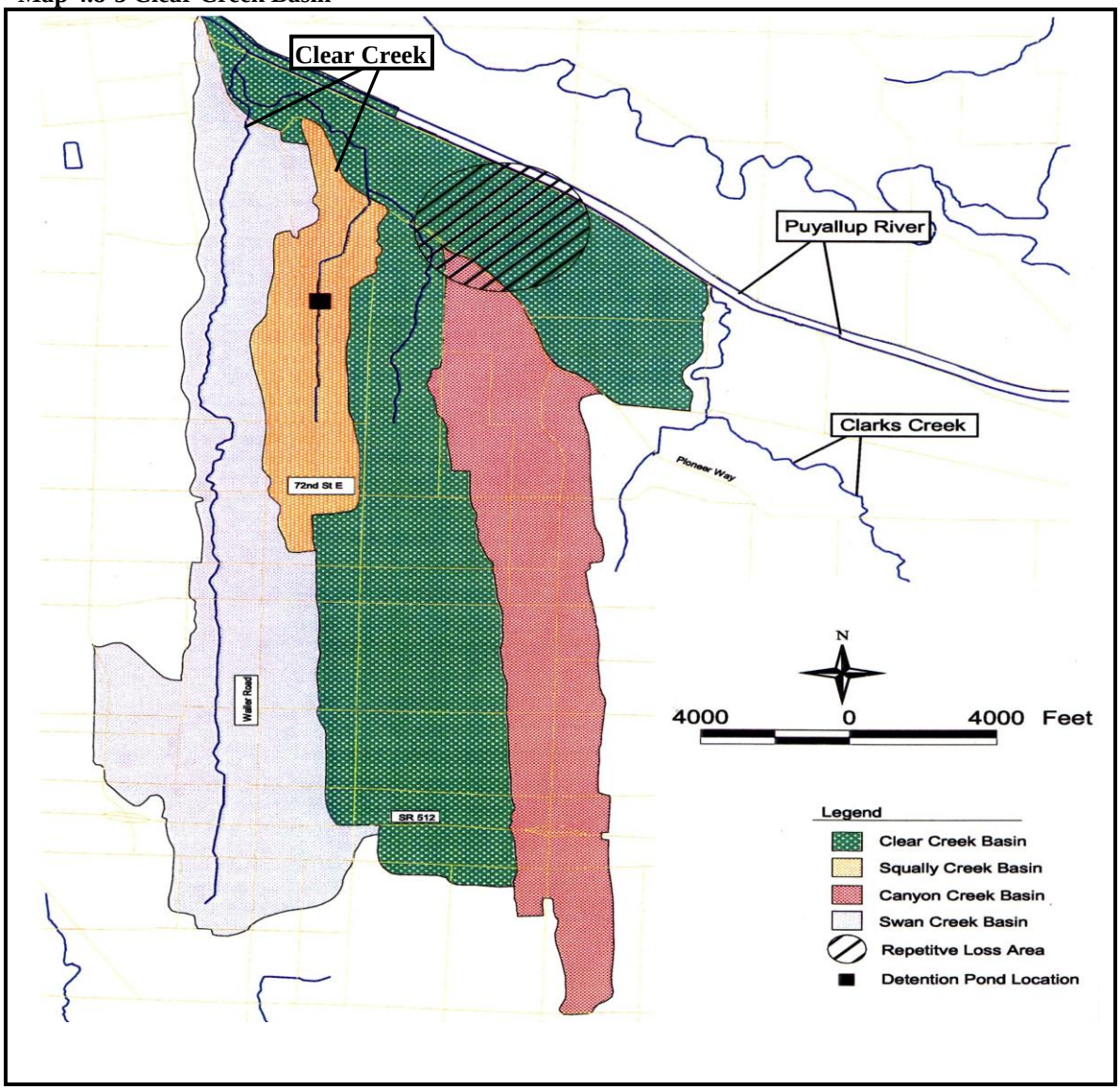


The Clear Creek Basin includes the East and West forks of Clear Creek (5.8 sq. mi.), Canyon Creek (2.2 sq. mi.), Squally Creek (0.9 sq. mi.), and Swan Creek (3.8 sq. mi.), all of which are narrow, relatively steep creeks, Squally Creek and Swan Creek both enter Clear Creek downstream of the repetitive loss area. Clear Creek also drains a portion of the flat agricultural floodplain south of the Puyallup River that contains the repetitive loss area. In addition to natural drainage courses, many storm drains carry water to the creeks from roads, low-lying farmlands north of Pioneer way and south of the Puyallup River[8], and developments.[9]

Description of Flooding

The repetitive loss area is in the flatlands of the lower portion of the basin. Map 4.8-5 shows the Clear Creek basin and repetitive loss study area.[10] In addition, Map 4.8-9 shows the Puyallup Tribe Trust Lands at risk for flooding in this area.

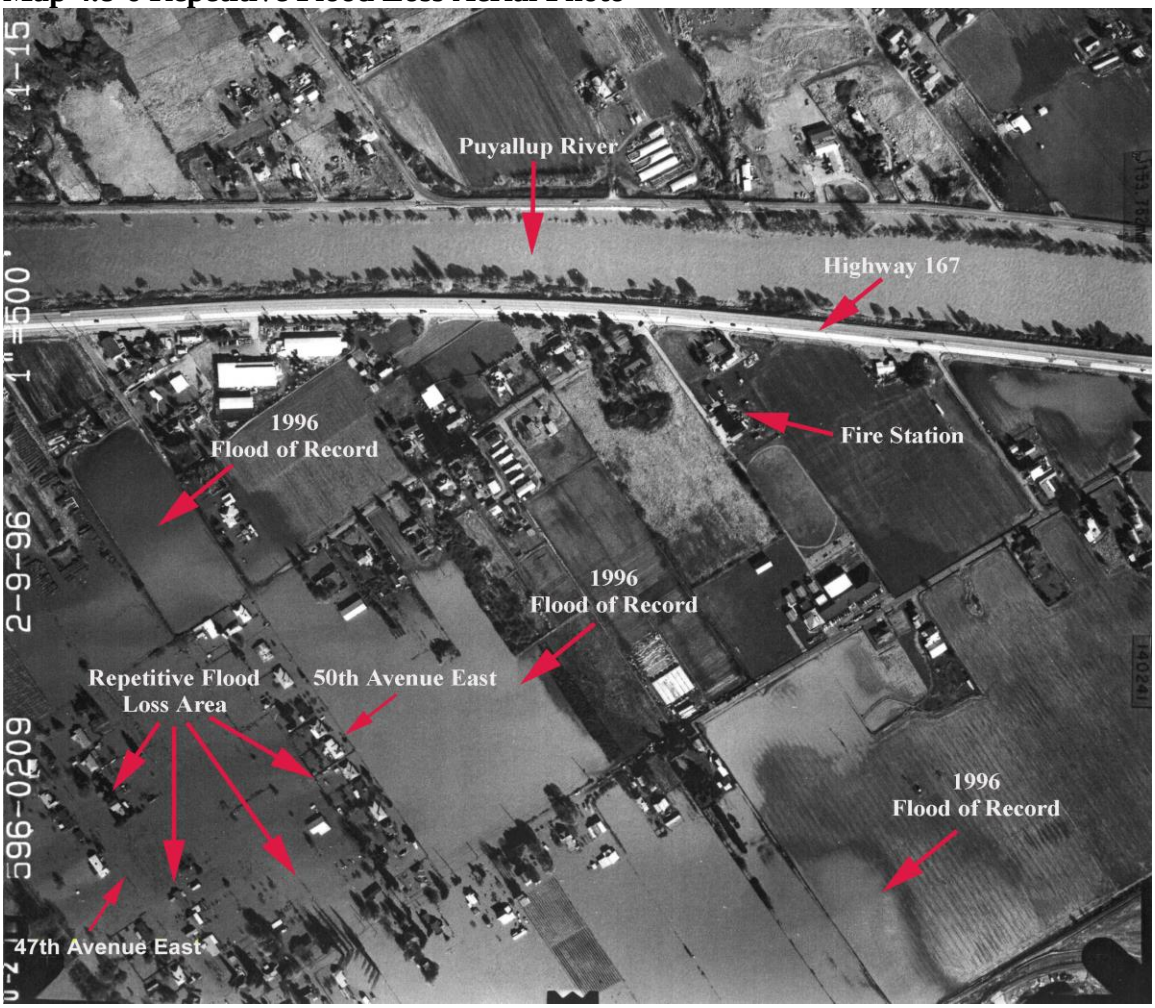
Map 4.8-5 Clear Creek Basin[11]



Puyallup River flood elevations (stages) at the Clear Creek confluence are influenced by a combination of tidal conditions and flow rates, which in turn influence Clear Creek stages. The outlet structure of Clear Creek into the Puyallup is designed to close at a river stage of 9 feet and reopen at a river stage of 8.5 feet. According to a September 26, 1995, Technical Information Report prepared by the Port of Tacoma, the operating elevations of the gate were chosen so that the gate would close or remain open as follows:

- The gate remains open for the 2-year, 3-day average flow (this is the flow that lasts three days at a magnitude that has a 50 percent chance of occurring in a given year).
- The gate closes for the 2-year instantaneous flow (this is the peak flow that has a 50 percent chance of occurring within a given year).
- The gate closes for the 10-year, 1-day average flow (this is the flow that lasts one day at a magnitude that has a 10 percent chance of occurring in a given year).
- The gate closes for the 10-year, 3-day average flow (this is the flow that lasts three days at a magnitude that has a 10 percent chance of occurring in a given year).

Map 4.8-6 Repetitive Flood Loss Aerial Photo[12]



The flooding in Clear Creek results predominately from backwater in the Creek and ponding within the drainage basin. If Puyallup River water surface elevations are greater than the Creek's, water from the Puyallup River can back into Clear Creek. The operation of the flood gate prevents major flooding. While closure of the floodgate prevents extreme flooding from the Puyallup River, it eliminates the gravity outlet for Clear Creek, causing water to accumulate behind the outlet structure. Since backwater from the creek and ponding within the basin is the primary cause of the Creek's flooding, the velocity of the water within the flooded area is low.

The aerial photo Map 4.8-6 displays the repetitive flood loss areas during the 1996 flood of record and illustrates the extent of the Creek's flooding.

The repetitive loss areas are concentrated along 47th Avenue East and 50th Avenue East, north of Pioneer Way and South of 40th Street East.[13]

Chambers-Clover Creek Watershed: Clover Creek Basin[14]

Description of Basin

The Chambers-Clover Creek watershed consists of level flatlands in the lower portion of the basin and gently rolling hills and flatlands in the uplands. Elevations within the watershed range from approximately 210 feet at Steilacoom Lake to 600 feet in the eastern uplands. Terrain was formed by glacial deposition or erosion. High-velocity glacial meltwater streams cut several distinct channels through the area, including the Clover Creek channel. Many of these channels have steep slopes or bluffs defining their boundaries. The Clover Creek channel starts near Puyallup's South Hill on the northeast boundary of the watershed and runs southwest to the Brookdale and Canyon Road area and into the current floodplain of Clover Creek. The repetitive loss areas are within the flatlands that floodplain in the lower portion of the basin.

The Clover Creek basin is part of the Chambers-Clover Creek watershed and contains portions of unincorporated Pierce County, including the Parkland and Spanaway communities, significant portions of the Lakewood incorporated area, a small portion of Tacoma, and portions of Joint Base Lewis-McChord. Urban development is concentrated toward the northern and western areas and near freeway and highway corridors. The basin's land cover is dominated by developed area, forest, and other natural cover, with water and non-vegetative cover over the remainder.

The Clover Creek basin covers approximately 47,400 acres, or 74 square miles. The main channel of Clover Creek is 12.8 miles long. Clover Creek has several tributaries and lakes including Morey and North Fork Clover Creeks, and Spanaway, Tule, and Steilacoom Lakes.

The natural drainage system is modified by collection, detention, discharge, and infiltration facilities. There are many piped systems in the Clover Creek basin. Due to the high propensity of porous surface soils from 50 to 60 percent of the basin's precipitation is absorbed becoming groundwater recharge.[15] Taking advantage of this porosity, the County operates numerous dry wells, excavated pits usually 3 to 12 feet deep filled with aggregate, to help control runoff. These are particularly prevalent in the western half of the basin.[16]

Description of Flooding

During high intensity or long duration rainfall, broad flooding occurs in two areas along Clover Creek. Broad flooding occurs in the vicinity of 38th Avenue East and 152nd Street East (Clover Creek South) and in the vicinity of A street/4th Avenue East and 133rd/138th Street East (Clover Creek North), downstream of the confluences of Clover Creek and the North Fork of Clover Creek. Residents in this loss area have filed flood insurance claims in 1996 and 1997. Five homes have been identified as repetitive loss properties. Surrounding homes are also within the flood hazard area.

Flooding in these areas typically results from overflow of the creek channel during or after large rainfall events, coupled with high flows in the North Fork of Clover Creek. The scale and occurrence of flooding depends on antecedent soil moisture conditions and the duration and depth of the rainfall. The creek overflows when the combination of backwater, flows from upstream, and runoff from surrounding areas exceeds the creek's conveyance capacity. The backwater often begins at constriction in the channel where the creek's capacity is lowest. Water begins to accumulate upstream of these constrictions, and propagates upstream as runoff into the creek increases. Flooding problems occur when the creek water elevation exceeds the channel banks and water overflows onto nearby improved property.[17]

Nisqually River Watershed: Mid Nisqually Basin[18]

Description of Basin

The Nisqually River flows northwest for approximately 80 miles from its origin at the southern base of Mount Rainier to Puget Sound just north-east of Olympia. The repetitive loss area is along a 14.5-mile reach of the river between the City of Centralia's diversion dam and the Nisqually Hydroelectric Project, which is owned by Tacoma Public Utilities. Four drainage basins contribute to this reach: the Upper Nisqually River Basin; the Mid Nisqually River Basin; the Mashel River Basin; and the Ohop Creek Basin. The repetitive loss area is in the Mid Nisqually Basin, in the vicinity of Harts Lake.[19] This basin and the flooding are described in the following paragraphs. For more information on the other basins, they are referenced herein.

The Mid Nisqually Basin consists of level to rolling terrain. Land use in the basin consists of medium development for agriculture purposes.

The Nisqually River flows northwest from the Upper Nisqually Basin for about 30 miles across the Mid Nisqually Basin. Tanwax Creek, a tributary to the Nisqually River in this basin, conveys flows that originate in several lakes in the eastern portion of the basin.

The Mid Nisqually basin contains the City of Centralia's Yelm Project, which is west of Harts Lake at the downstream end of the Mid Nisqually Basin. The Yelm Project is a "run-of-the-river" project and diverts water from the river to generate power. Because it is a "run-of-the-river" project, there is no capability to store flood water at the diversion structure. A diversion dam directs water into two intake structures leading to an earthen power canal. The diverted water can generate 12 megawatts of power, and reenters the river 13.6 miles downstream.

Description of Flooding

Flooding in the Nisqually floodplain is extremely variable in terms of frequency, severity, and extent. The river's banks provide inadequate capacity to contain moderate to high flows. The repetitive loss property is within the 100-year floodplain. Flow in the Nisqually River is regulated by the Nisqually Hydroelectric Project. Using Alder Lake's storage capacity to regulate discharge, the project allows continuous power production while maintaining downstream flows and provides incidental flood control and recreation benefits. Although one of the dam's stated objectives is to provide flood control, the dam has also been identified as a possible cause of flooding downstream by holding back floodwaters as long as possible and then passing more water than the river has capacity to contain.[20]

Occurrences[21]

Throughout the settled history of Pierce County there have been floods that impact the population. Tribes living along the rivers learned to live with them. It was not until settlers with a European agricultural background began to move into the area in the 1850s, cleared the land, built homes and planted crops that the flooding became more than just a nuisance. Fort Maloney, a blockhouse erected to protect a ford on the Puyallup River was washed away in 1867.[22]

Since the early 1960's, Pierce County has experienced 21 federally declared disasters. Of these, 13 were either caused or exacerbated by flooding, see Table 4.8-1.

Table 4.8-1 Flood Hazard Declared Disasters

Federal Disaster	Notes
DR-4056-WA – 01/14-24/2012	Severe Winter Storm, Flooding, Landslides and Mudslides. 11 counties declared.
DR-1817-WA—01/06-16/09	Flooding from a severe storm throughout much of Washington. 23 counties declared.
DR-1734-WA—12/1-17/2007	Flooding throughout most of W. Washington. Pierce County was not declared.
DR-1671-WA--11/5-6/2006	Major flooding on the Puyallup, Carbon, White, Stuck and Nisqually rivers.
DR-1499-WA--10/2003	Surface flooding
DR-1159-WA--12/96-2/1997	Ice storm, snow and flood. Stafford Act assistance - $83 million, SBA $31.7 million.
DR-1100-WA--1-2/1996	Three deaths in Washington. Stafford Act disaster assistance provided – $113 million. SBA disaster loans approved - $61.2 million
DR-1079-WA--11-12/1995	100-year flood at Alderton on the Puyallup and 50-year flood at La Grande
DR-896-WA--12/1990	Stafford Act assistance provided $5.1 million
DR-883-WA--11/1990	Stafford Act assistance provided $57 million
DR-852-WA--1/1990	Stafford Act assistance provided $17.8 million

DR-784-WA--11/1986	Two deaths. $11 million in private property damage and $6 million in public damage
Federal Disaster	**Notes**
DR-545-WA--12/1977	16 counties were declared. Very heavy rain in the upper Nisqually caused significant damage.
DR-545-WA--12/1977	16 counties were declared. Very heavy rain in the upper Nisqually caused significant damage.
DR-492-WA--12/1975	13 counties flooded
DR-328-WA--2/1972	King, Pierce and Thurston counties flooding
DR-185-WA--12/1964	Wide ranging flooding affected 19 counties in both eastern and western Washington

The idea of channeling the Puyallup River began to take hold towards the end of the 19th century and in 1906 local citizens began the process of putting in small levees. Various work continued with both Pierce and King Counties joining forces, and later, the addition of the Army Corps of Engineers became involved, allowing the levee work to be completed in 1950.

Between 2002 and 1989, more than $22.8 million in Stafford Act disaster assistance was provided to Region 5 for repairs to public facilities following flood events.[23]

The floods of 2006, 1997, and 1996 will remain in memory as three of the worst in the County. All of Pierce County's major rivers reached flood stage or above. These included the largest floods on record for the Puyallup and Carbon Rivers. Levees were destroyed or overtopped, revetments eroded, homes damaged or destroyed and some migration of the river channels. During the February 1996 flooding, the Nisqually River had an unprecedented recorded event. The amount of water released from the Alder/LaGrande dams located on the Nisqually River exceeded the capacity of the river channel. Throughout the County, surface water flooding occurred and sandbagging continued for weeks.

The flooding of 1996-1997 will remain in memory as one of the worst in the region. All of major rivers in the County reached flood stage or above. It was the largest flood on record for the Puyallup River. There were 10,000 feet of levee partially damaged and 20,000 feet completely destroyed. The Nisqually River also had an unprecedented recorded event. The amount of water released from the Alder/LaGrande dams located on the Nisqually River exceeded the capacity of the river channel. Throughout the County, surface water flooding occurred and sandbagging continued for weeks.

In early January of 2009, a severe winter storm resulted in significant flooding, mudslides, landslides, avalanches, high winds and freezing rain throughout western Washington. Snow levels rose between 6,000 to 8,000 feet while there was heavy precipitation falling between 3 to 6 inches over the course of two days. This was a 100 year flooding event for the Puyallup River Basin. Pierce County was declared a federal flood disaster area.[24]

Repetitive Flood Loss Areas

Clear Creek Basin

Flooding has affected Pierce County and the Planning Area many times in the past. Map 4.8-4 illustrates the specific occurrences of repetitive flooding within the Clear Creek Basin. Clear Creek is the source of most of this flooding. The flood of record produced by the creek in February 1996 is illustrated from the aerial photo of the basin taken on February 8, 1996 (see Figure 4.8-1). The other major flooding occurred in November, 1995, and largely affected 47th Avenue East. The Creek produced widespread and destructive flooding in February 1996 and the extent of this flood of record is shown.

Figure 4.8-1 Feb 8, 1996 Flooding - Del Rio Mobile Homes Along Puyallup River

The repetitive loss areas are concentrated along 47th Avenue East and 50th Avenue East, north of Pioneer Way and South of 40th Street East. About 20 homes in this area have been identified as repetitive loss properties. Residents in the Clear Creek Repetitive loss area filed flood insurance claims in 1997, 1996, 1995, 1991, 1990, 1986, and 1984. The frequency of these claims indicates that each year there is approximately a 33 percent chance of flooding from Clear Creek. The February, 1996 flood was one of the worst in recent history, producing the highest stage of the Puyallup River since 1942. In this flood, the area of inundation greatly exceeded the previously delineated floodplain, emphasizing the need for updated flood mapping.[25]

Clover Creek Basin

Map 4.8-5 illustrates the repetitive loss property and flood hazard area. Broad flooding occurs in the vicinity of 38th Avenue East and 152nd Street East (Clover Creek South) and the vicinity of A street/4th Avenue East and 133rd/138th Street East (Clover Creek North). Residents in this loss area have filed flood insurance claims in 1997 and 1996.[26]

Mid-Nisqually River Basin

Map 4.8-3 illustrates the repetitive loss property and flood hazard area. The owner of the repetitive loss property has filed flood insurance claims in 1996, 1995, 1994, 1991, 1990, 1982, and 1980 and has indicated that his property also flooded in 1976, 1974, and 1972, although no flood insurance claims were made. The flood history for this property indicates approximately a 33 percent chance of flood damage in any given year. According to the property owner, the February 1996 flood was the most severe, with flood elevations as high as eight feet and rapidly flowing water.

A second area recently identified is in the Ohop Creek Basin. One property has been identified and there is the potential for another five that lie in the same area.

Recurrence Rate

Table 4.8-1 Flood Hazard Declared Disasters lists 17 disasters that were either flood disasters or were exacerbated by flooding that have impacted Pierce County over the past 44 years, or one every 3.1 years. In between these individual federally declared disasters were other flood issues that did not make it to the federal declaration level. It was then decided, based on the number of incidents, that the probability of recurrence for the flood hazard in the Planning Area is five years or less.

Vulnerability

The temperate marine climate of western Washington adds to the frequency and magnitude of floods. Annual rainfall ranges from 40 inches in the Puget Sound lowland to 80 inches or more in the Cascade foothills, with a large portion occurring during the winter months. Winter storms usually bring several days of low intensity rainfall, rather than short, intense thunderstorms. Average snowfall at Paradise on Mount Rainier is 680 inches. A warm, wet period with mid to low level snowpack accumulation in the mountains can cause swollen rivers to pour over their banks into the surrounding floodplains. Combined with a longer duration rainfall, saturated soils, and an elevated water table, the potential for severe flooding is significant.

Human alteration of the landscape—including clearing, grading, paving, building construction, and landscaping—has an impact on hydrologic processes. Soil compaction and paving reduce the infiltration and storage capacity of the soils. This leads to a runoff process called Horton Overland Flow, in which rainfall exceeds the infiltration rate and the excess precipitation flows downhill over the soil surface. This type of flow rapidly transmits rainfall to a stream or conveyance system, causing higher peak flow rates than would occur in the unaltered landscape. Unmitigated land development increases not only peak flow rates, but also annual and seasonal runoff volumes. The larger the percentage of an area covered with impervious surface such as buildings and pavement, the greater the runoff generated for a given rainfall event.[27] The following is a description of the specific factors affecting vulnerability in the repetitive loss area.

Clear Creek Basin

Most of the land use within the Clear Creek basin is single-family residential, with smaller areas of agricultural and resource lands, as well as some more heavily urbanized pockets. Urban development is concentrated toward the southern and western areas and near freeway and highway corridors; much of the flatland in the lower portion of the basin has a higher proportion of agricultural use.[28] The vulnerability in the Clear Creek Basin is influenced by the operation of the flood control measures identified in the Location and Extent Section—namely the operation of the flood gate.

The effects of these factors are noted as follows. Past flooding in the repetitive loss areas described above has impacted buildings, infrastructure, and public health and safety in a number of ways.

- Health Risks: Residents have indicated that floodwaters have, at times, flooded their drinking water wells and supply pumps.
- Public Health and Safety Risks: Resident accounts, public work documents, and aerial photos indicate that local access roads and arterials can be rendered impassible during flood events. Road flooding can limit emergency response access and poses potential risks for public health and safety.
- Property Damage: Buildings within the area suffer water damage. Since many residents do not have flood insurance, and since flood insurance does not cover all losses, damage can go unrepaired, resulting in lower property values.[29]

Flooding also results in a significant number of claims paid to property owners. Because flood insurance does not cover all losses, and because many property owners have no flood insurance, the actual financial impact of flooding is greater than the losses summarized in the tables above. The actual impact that this financial drain has on the economy has not been quantified. Likely impacts, however, include the following:

- The local economy suffers as savings are depleted to make necessary home repairs.
- The tax base is weakened as property values decrease in areas impacted by flooding.
- Conflicts in the community can arise as new developments create or exacerbate flooding problems.[30]

New construction to accommodate a growing population can lead to increased runoff if no mitigating measures are implemented. As more homes are built, larger areas of impervious surface are created. Impervious surfaces prevent rainfall from infiltrating into the ground. The rainfall instead is concentrated and flows directly into local creeks and rivers, increasing their flows. If currently proposed mitigation is not adequate, the number of repetitive loss properties is expected to increase in the coming years as floodplains expand with the increased flows.[31]

The most recent flood event (disaster declaration 1499) illustrated the region's increasing vulnerability to the flood hazard. Most of the damage occurred in areas not identified on the FIRMs. The majority of flooding was due to the urban flood hazard indicating an increasing vulnerability to this category of flooding.

Planning Area

The Planning Team determined that the Planning Area has a medium vulnerability to the flood hazard because of the following factors: high probability of recurrence, portion of the Reservation located in the 100-yr and 500-yr floodplain, the number of repetitive loss claims, and the potential for urban flooding.[32]

The entire Planning Area, over 16,000 acres is vulnerable to the two types of flood hazards (riverine and urban stream/groundwater) identified by the Planning Team. The total damage to

the Planning Area could equal approximately $8 billion (the assessed value of all parcels in the Planning Area, October 2016).

A more detailed vulnerability assessment by the Planning Team showed that approximately 5,588,000 acres (36% of the Planning Area) are located in FEMA mapped floodplain areas making those acres even more vulnerable to the flood hazard. The total estimated losses to these parcels would equal $2.7 billion (the assessed value of all parcels in the flood hazard area, October 2016). The repetitive flood loss properties property owners in the floodplain have filed 65 claims to FEMA estimated at over $1,600,000 in damage since 1978.

Of the 485 Tribal Trust parcels in the Planning Area, 150 parcels (30.9%) are located in FEMA mapped floodplain areas. The total estimated losses to these parcels would equal $167,822,500. Maps 4.8-7 through 4.8-9 show a detailed vulnerability to flooding on a parcel level. Three maps were scaled into to show the parcels at risk due to flooding in the Port of Tacoma area, the downtown area and the Fife/Puyallup area. Most of the Tribal critical infrastructure is located within these areas and scaling the map down to the parcel level will allow for critical mitigation strategies to be potentially applied to the facilities at greatest risk or re-location of the buildings as funding becomes available.

Impacts

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

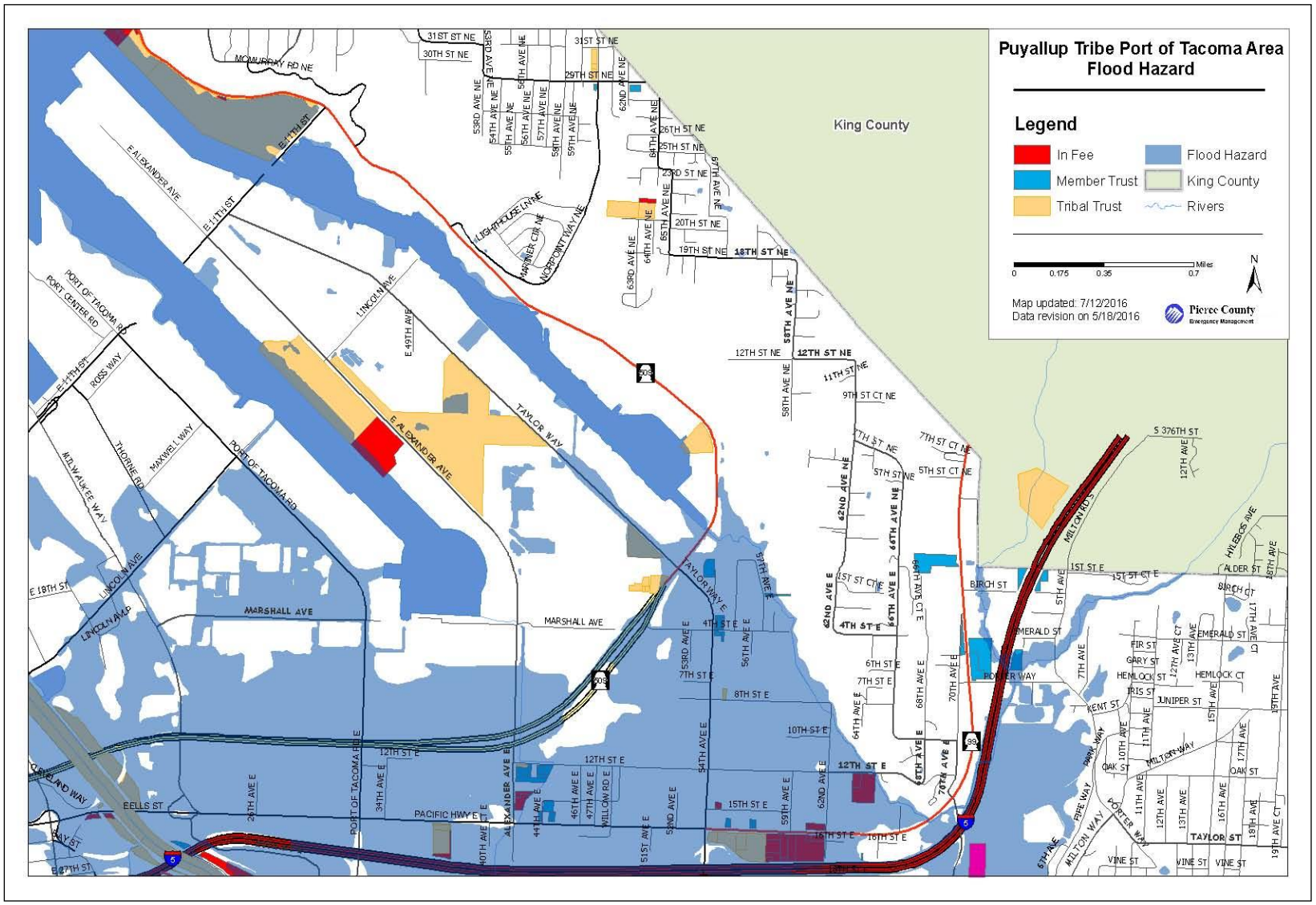
Flooding kills citizens throughout the United States every year. While that has not been a major problem in Pierce County over the years, it very well could happen with any major flood we have. The fact that Pierce County has had to do swift water rescues in the past with floods in both 1996 and 2006 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.

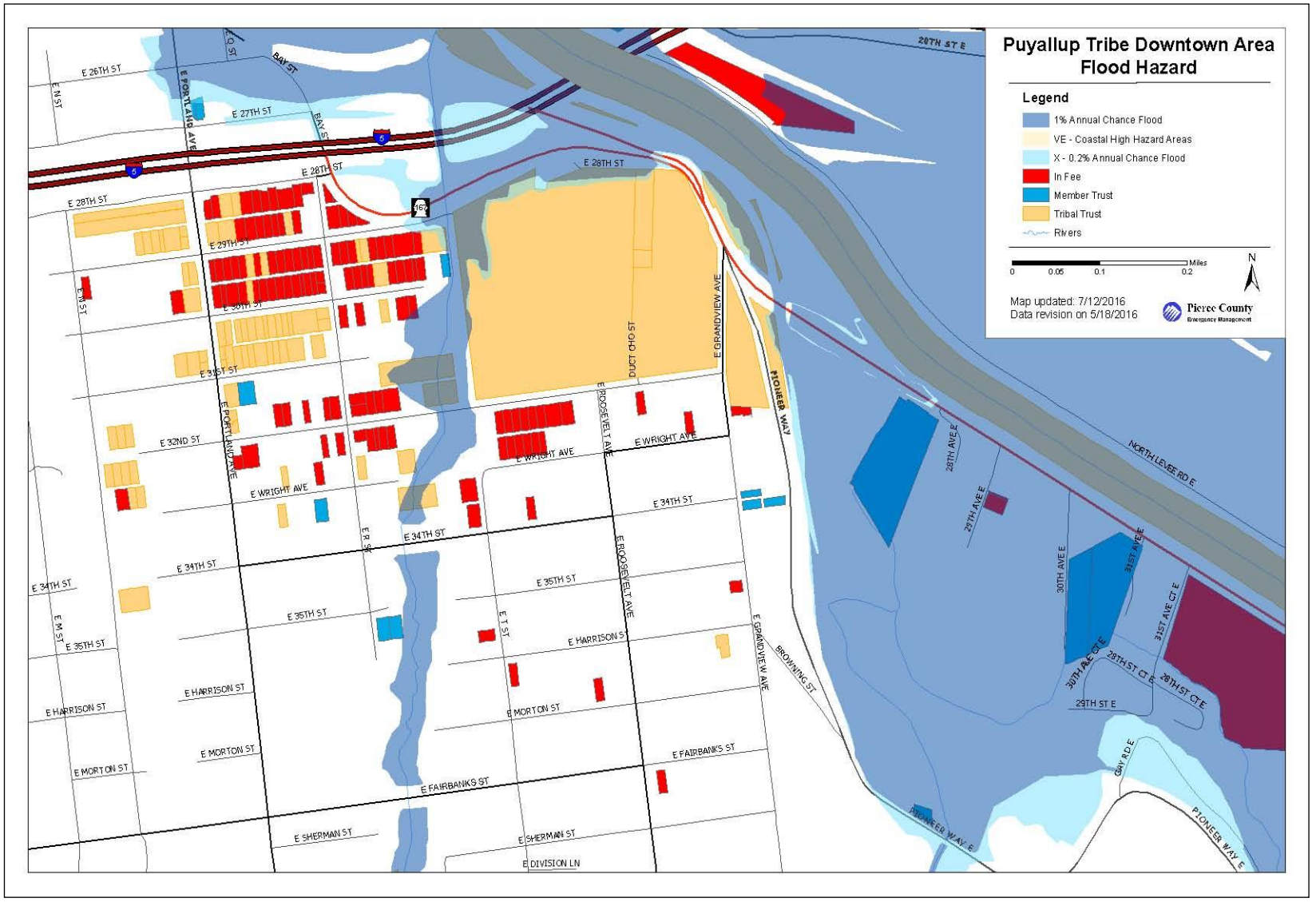
Figure 4.8-2 Nov. 2006 Flooding River Park Estates – Along Puyallup River

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

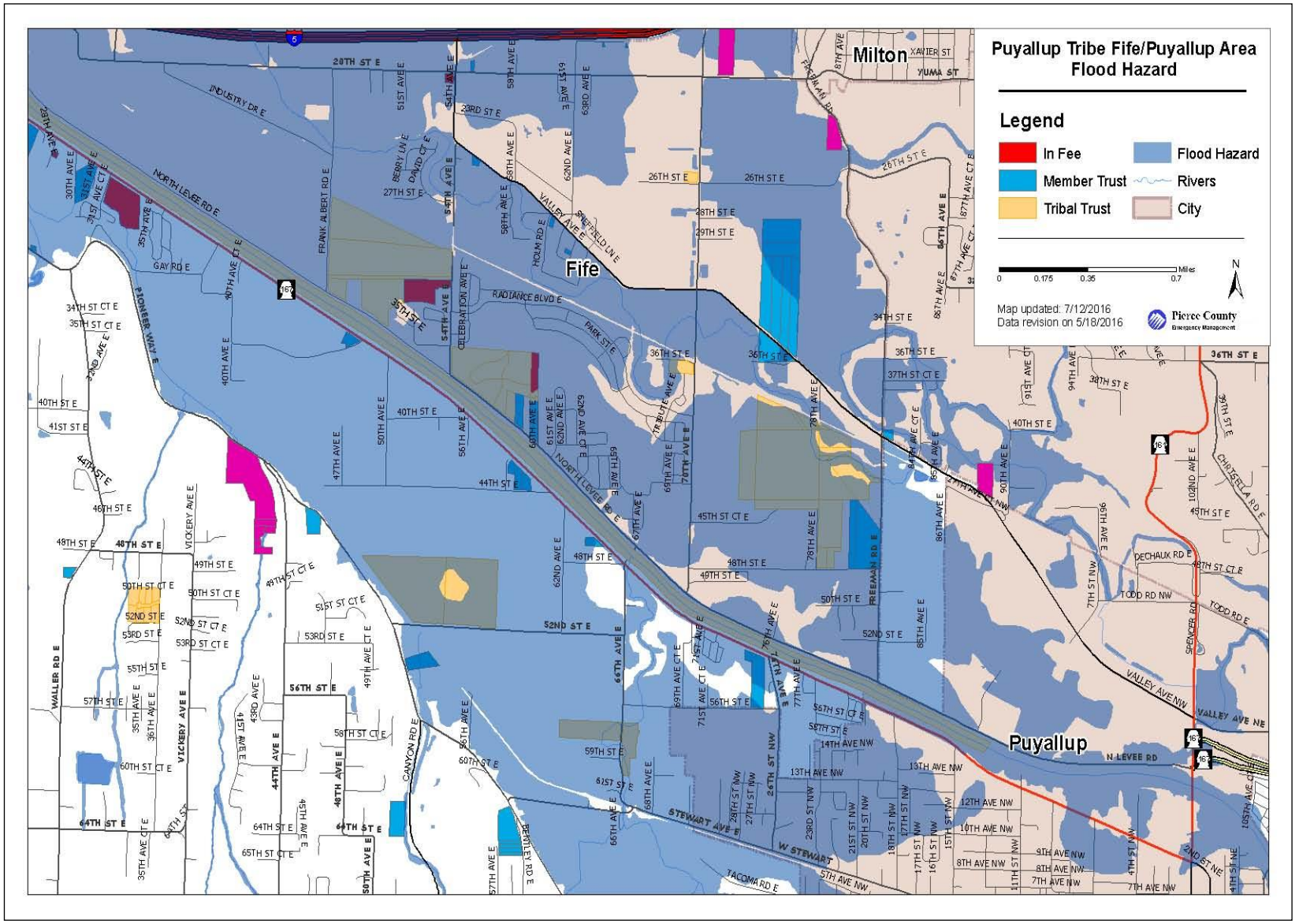
Map 4.8-7 Puyallup Tribe of Indians Port of Tacoma Flood Hazard Area



Map 4.8-8 Puyallup Tribe of Indians Downtown Flood Hazard Area



Map 4.8-9 Puyallup Tribe of Indians Fife/Puyallup Flood Hazard Area



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.

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.

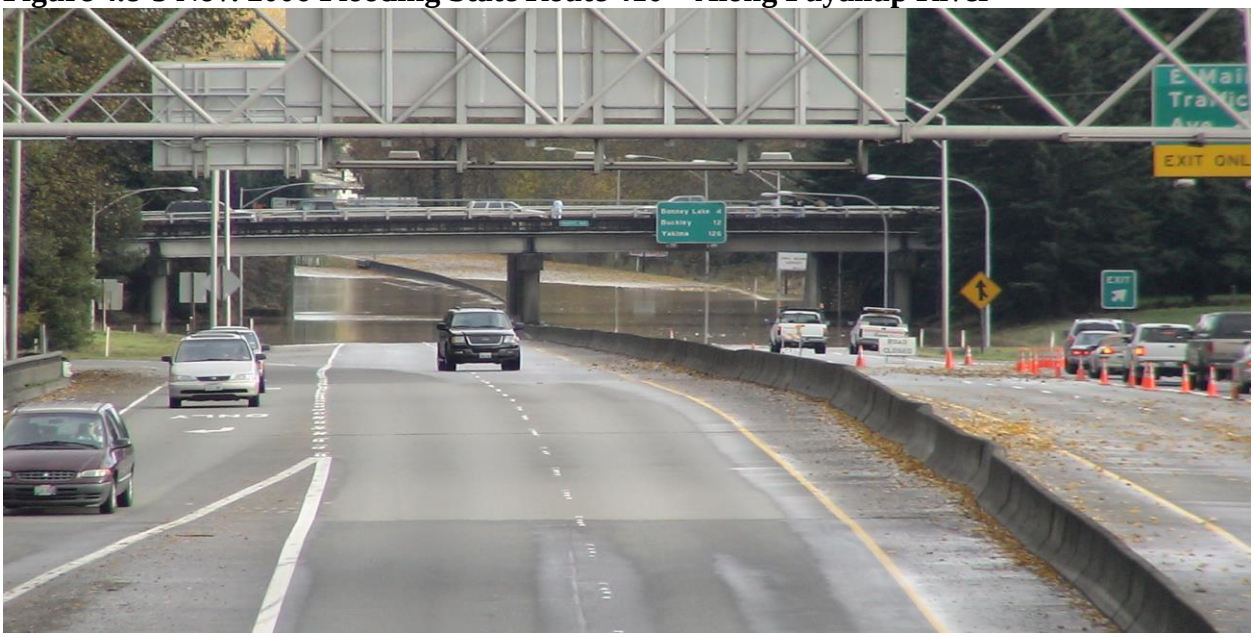
Property, Facilities, and Infrastructure

Flooding is one of the major causes of damage to and destruction of property, facilities and infrastructure throughout the country and it is no different in Pierce County. Individual property has been destroyed in every major flood to hit the County. Over the years this has included homes, barns, equipment, livestock, and transportation vehicles of various types.

Flood waters can damage or destroy a jurisdiction's facilities. Buildings can be flooded. Equipment, electronic or mechanical, ruined or in some cases made inaccessible due to flood waters. Files, electronic or paper, can be destroyed. Both water and the contaminants it carries can either damage or permanently ruin equipment.

Flood waters can erode land containing infrastructure such as roads, power lines, natural gas, fuel, water pipelines, and sewage control facilities. It can breach levees, erode revetments and destroy bridges. Water overtopping dams can cause damage to the dam's structure. Material carried by the flood waters, if not screened out or removed can cause damage to the hydroelectric generating components of a dam.

Figure 4.8-3 Nov. 2006 Flooding State Route 410 – Along Puyallup River



The Environment

The impacts to the environment from a major flood could include: erosion and scouring of stream or river banks; loss of plants and animals; and contamination from chemicals, sewage, and other noxious materials picked up, transported and deposited by the flood. The contamination of both the river and the flooded landscape from the various chemicals and debris picked up from farms, homes, and businesses along the river is a serious problem. Industrial chemicals, oil and gas, sewage, old tires, etc. can all pollute the landscape where they come to rest as the water recedes. Some of these materials may take years, decades or even longer to

break down and become harmless. Until that happens they can continue to degrade the environment where they have come to rest, in some cases leaching back into the water course or into ground water spreading contamination away from the site. Without clean-up this may continue for years.

However, from an environmental standpoint, not all flooding of rivers is bad. Floods are endemic in these valleys and the low areas of the County. They have changed the course of rivers, flooded low areas, uprooted or drowned vegetation, all as part of the natural environment. Areas where the river has changed course, frequently during floods, and moved away from, form oxbow lakes that attract water fowl and other animals. Where the river once ran the river gravels gradually develop a layer of topsoil forming meadows and allowing willows, alders and other open area bushes and trees to thrive. These species attract a growing diversity of animal life which continues to change, as the forest itself changes, progressing from open area species to taller trees like Douglas fir and eventually to shade resistant types like Western Hemlock.

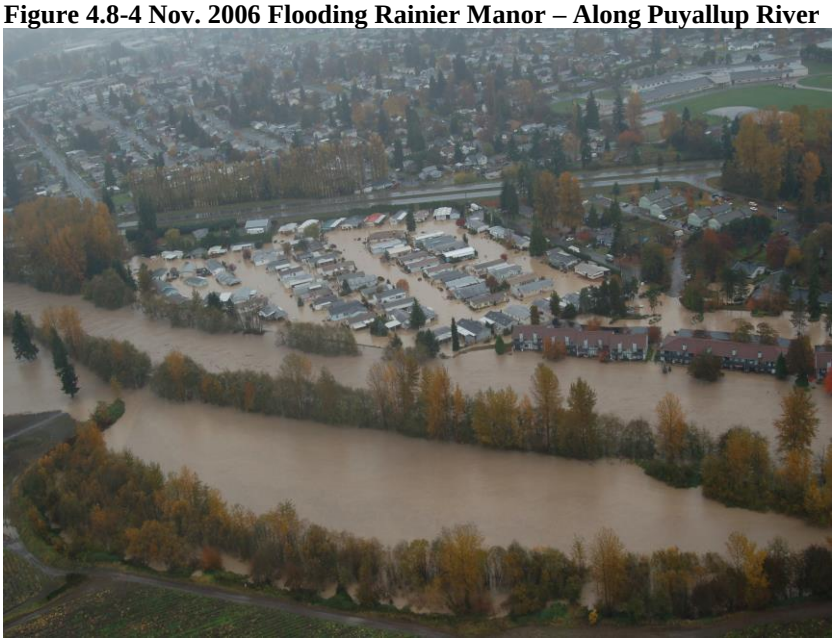
Flood waters traditionally have replenished the soil. In bringing down silt from higher elevations and depositing it across the landscape in the flat areas of the County, it adds a new quantity of nutrients to the soil that is already there. This contributes to the fertility of the valley floors aiding the growth of both natural vegetation and agricultural products.

Another development that occurs with flooding is the creation of snags within the river channel itself. As the river erodes the banks, trees become uprooted, fall into the river and either create coverage for fish at that spot or in many cases are transported by the flood down river and later are snagged creating more fish habitat.

Economic and Financial Condition

Economically, the after effects will depend directly on how much damage was done to local businesses, the local tax base, and the local infrastructure. While an individual home damaged by a flood can be devastating to an individual or family, it has very little effect on the overall economic condition of the community. However when a large number of homes, and businesses, are damaged or destroyed it can negatively alter the tax base decreasing the ability of the local jurisdiction to pay, not just for infrastructure repair and community restoration, but also for the normal day to day programs that make the community a viable area in which to live, work and play. Related to this is the possibility that many people may need temporary relocation assistance.

Figure 4.8-4 Nov. 2006 Flooding Rainier Manor – Along Puyallup River



If homes are not salvageable families may have to look for alternate housing. Depending on what is available, it could lead some to leave the County or Planning Area, moving to other areas. Depending on the size of the flood and the resulting exodus, there could be a small loss of population and tax revenue.

Damage to the business and industry sector does not only affect the tax base, but also removes jobs from the local economy. The loss of jobs can escalate into other problems. The unemployed may either move away, go on unemployment, or be forced to take a lower paying job all of which further decreases the financial stability of the community. If the loss of financial stability is not corrected there are other social problems that arise. Those out of work can develop a loss of self esteem that can lead to an increase in crime, alcohol and drug abuse, spouse abuse, and an increase in medical problems.

Flooding may damage the infrastructure by undercutting and washing out transportation corridors such as roads, bridges and train tracks, downing power poles, damaging pipelines, filling sewer lines with silt, and damaging levees and revetments. The time to repair these can take from weeks to years depending on the amount of damage and the available resources to repair them. This damage to the infrastructure will slow down the economic recovery for the jurisdiction. Even further, damages can limit the reopening of businesses or it can force those that may have had no damage, but operate on a just-in-time supply system, to close at least temporarily. For some of these, the lack of commerce and therefore loss of income can prove critical. With creditors needing payment and no revenue stream, some may not be able to recover and could close permanently.

Flooding may have a significant impact on the fisheries due to the scouring of river beds, back flooding of creeks and tributaries affecting salmon spawning and rearing habitats. The loss of this critical habitat hinders the restoration recovery efforts for salmon species. The continued loss of fish habitat not only affects recovery efforts but impacts the Puyallup Tribe who are culturally connected the salmon.

Grocery stores, restaurants and food delivery systems may lose product because of the lack of power. Large chains can recover, but small independent businesses may not. Those that have a system of backup power should do much better than those that do not.

In summary, the economic viability of the community will depend on not just how much damage is done, but also on how quickly the infrastructure can be repaired; how prepared businesses are to operate in the post disaster environment; how prepared citizens are for the flood and its after effects; and how well local governments and organizations can respond to the needs of the public for support, cleanup, and if necessary relocation.

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 get 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.

Resource Directory

Regional

- **Pierce County Department of Emergency Management**
  http://www.co.pierce.wa.us/pc/abtus/ourorg/dem/abtusdem.htm

- **Pierce County Department of Water Programs**
  http://www.co.pierce.wa.us/pc/services/home/environ/index.htm

- **Washington State Department of Ecology**
  http://www.ecy.wa.gov/

- **Western Regional Climate Center**
  http://www.wrcc.dri.edu

- **Corps of Engineers Northwest Division**
  http://www.nwd-wc.usace.army.mil

National

- **Association of State Dam Safety Officials**
  http://crunch.tec.army.mil/nid/webpages/nid.cfm

- **Copies of FIRMs, FISs, DFIRMs, Digital Q3 Flood Data, and FHBMs**
  http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1

- **Flash-Flood Safety Rules**
  http://www.nws.noaa.gov/om/brochures/flashfld.shtml

- **Flood Risk and Map Information**
  http://www.fema.gov/hazard/flood/index.shtm

- **Flood Safety Rules**
  http://www.nws.noaa.gov/floodsafety/

- **Floodplain Management Association**
  http://www.floodplain.org

- **General Flood Information**
  http://www.fema.gov/hazard/flood/index.shtm

- **Guide to National Flood Insurance Program on the web**
  http://www.fema.gov/business/nfip/qanda.shtm

- **Latest hydrological information (flooding, droughts, snow conditions, etc.)** http://www.nws.noaa.gov/oh/hic/current/

- **FEMA Map Service Center**
  800.358.9616
  www.msc.fema.gov/

Endnotes

[1] Modified from PC HIVA, Flood Section, September 5, 2002, p.29.
http://www.co.pierce.wa.us/xml/abuts/ourorg/dem/HIVAWEB.pdf
[2] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001. p.6.
[3] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001. p.1.
[4] Closed Depression flooding occurs where water collects in low-lying areas with little to no drainage capacity. Once flooding occurs, it can last for
the remainder of the wet season until evaporation or slow infiltration lowers the water level. (PC HIVA).
[5] Tacoma Public Utilities Nisqually River Project.
http://www.tacomapower.com/parksandpower/hydro_power/nisqually_river_project.htm
[6] Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public Works & Utilities Water Programs, TETRA TECH/KCM, p. 1-6.
[7] Most information on the Clear/Clarks Creek Basin is taken from Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public
Works & Utilities Water Programs, Tetra Tech/KCM, pp.4-1 to 4-15.
[8] Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public Works & Utilities Water Programs, Tetra Tech/KCM, p. 4-2
[9] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001, p. 7.
[10] Ibid. p. 7
[11] Pierce County Repetitive Loss Plan, Pierce County Water Programs, Prepared by Tetra Tech/KMC, Inc., Seattle, WA. July, 2001. Figure 4-1.
[12] Pierce County Water Programs, aerial photos for Clear Creek area, February 9, 1996.
[13] Ibid, p. 1, 9, 10.
[14] Most information on the Clover Creek Basin is taken from Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public
Works & Utilities Water Programs, Tetra Tech/KCM, pp.5-1 to 5-9.
[15] Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public Works & Utilities Water Programs, Tetra Tech/KCM, p. 5-1.
[16] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001. p. 10-11
[17] Ibid. p.11-12
[18] Some information on the Mid Nisqually Basin is taken from Pierce County Flood Risk Assessment – Draft, June 2007, Pierce County Public
Works & Utilities Water Programs, TETRA TECH/KCM, pp.11-19 to 11-21.
[19] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001, p.11-12
[20] Ibid. p. 14
[21] Modified from PC HIVA, Flood Section, September 5, 2002, p.29.
http://www.co.pierce.wa.us/xml/abtus/ourorg/dem/HIVAWEB.pdf
[22] City of Puyallup Natural Hazard Mitigation Plan, March 2005, p. 4.5-8.
[23] Washington State Hazard Mitigation Plan. Washington State Emergency Management Division, April, 2004. Tab 7.2.5 p. 16.
[24] Ordinance No. 2011-95s. Pierce County Code 11.06. Effective April 10, 2012.
http://www.co.pierce.wa.us/DocumentCenter/View/3334
[25] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001. p. 9, 10.
[26] Ibid. p.12

[27] *Ibid.* p. 8. For more information on percent-impervious analysis of the flood hazard areas, see the *Pierce County Repetitive Flood Loss Plan*

and the *Guidance for Basin Planning*.

[28] Pierce County Repetitive Loss Plan, Pierce County Water Programs. Prepared by Tetra Tech/KMC, Inc., Seattle, WA: July, 2001. p. 8

[29] *Ibid*. p. 15.

[30] *Ibid*, p. 15.

[31] *Ibid*. p. 17

[32] Pierce County Emergency Management. Spatial analysis using ArcGIS/CVPro to determine the vulnerability for flood hazard.

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