3.2 Flood

Flooding is a common occurrence in Northwest Oregon. All jurisdictions in the Planning Area have rivers with high flood risk called Special Flood Hazard Areas (SFHA), except Wood Village. Portions of the unincorporated area are particularly exposed to high flood risk from riverine flooding.

Developed areas in Gresham and Troutdale have moderate levels of risk to riverine flooding. Preliminary Flood Insurance Rate Maps (FIRMs) for the Sandy River developed by the Federal Emergency Management Agency (FEMA) in 2016 show significant additional risk to residents in Troutdale. Channel migration along the Sandy River poses risk to hundreds of homes in Troutdale and unincorporated areas.

Some undeveloped areas of unincorporated Multnomah County are subject to urban flooding, but the impacts are low. Developed areas in the cities have a more moderate risk to urban flooding.

Levee systems protect low-lying areas along the Columbia River, including thousands of residents and billions of dollars in assessed property. Though the probability of levee failure is low, the impacts would be high for the Planning Area.

Dam failure, though rare, can causing flooding in downstream communities in the Planning Area. Depending on the size of the dam, flooding can be localized or extreme and far-reaching.

Level of Risk* to Flood Hazards

High
- Unicorporated Multnomah County

Moderate
- Gresham
- Troutdale

Low-Moderate
- Fairview
- Wood Village

Low
- None

Level of risk is based on the local OEM Hazard Analysis scores determined by each jurisdiction in the Planning Area. See **Appendix C for more information on the methodology and scoring.*

Seasonal shifts in precipitation patterns due to climate change, including more intense winter rain events, could increase the incidence of floods in the future.

3.2.1 Overview

The Planning Area is at risk of flooding between October and April from winter rains and between May and July from spring snowmelt in the Cascades. Typically, the area experiences flooding after more than three days of rain or when heavy rain falls on already saturated soil in a short period of time. Severe or prolonged storms can raise rivers and streams to flood stage and keep them there for several days. Historically, rain-on-snow events between December and February caused the majority of the most-severe flooding.

Types of Flooding

A flood is any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream. Floods occur for many reasons, such as long-lasting rainfall over a broad area, locally intense storm-generated rainfall, or rapid melting of a large snow pack with or without accompanying rainfall. Because floods result from many different circumstances, not all floods are equal in magnitude, duration or effect.

The Planning Area is subject to four types of flooding: riverine, urban, and levee or dam failure. **Table 3.2-1** provides a summary of the Planning Area's exposure to flooding, followed by descriptions of each type of hazard.

Table 3.2-1 Types of Flooding Hazards that Impact Each Jurisdiction

Jurisdiction	Riverine Flooding	Urban Flooding	Levee Failure Inundation Area	Dam Failure Inundation Area
Unincorporated Multnomah County	✓	✓	✓	✓
Fairview	✓	✓	✓	✓
Gresham	✓	✓	✓	✓
Troutdale	✓	✓	✓	✓
Wood Village		✓		

Source: Oregon Department of Land Conservation and Development (DLCD), 2015; Natural Hazards Mitigation Plan (NHMP) Steering Committee, 2016

Riverine Flooding

River flooding occurs when river or stream water levels rise and spill over the banks. This type of flooding often results from prolonged rainfall over a large geographic area and/or melting snowpack. River flooding is an important natural process that adds sediment and nutrients to fertile floodplain areas.

Rivers also can change course over time, called channel migration, which can change where rivers crest in their banks.

Because the Willamette and Columbia rivers are also influenced by tides, significant coastal storms can exacerbate flooding along these water bodies.

Urban Flooding

As land is converted from natural-scape to hardscape, the environment loses its ability to absorb rainfall. This transition from pervious surfaces to impervious surfaces results in more and faster runoff of water. During periods of urban flooding, streets can become swift-moving rivers and storm drains may back up, causing additional nuisance flooding (DLCD, 2015).

Levee/Dam Failures

A levee is a manmade structure, usually an earthen embankment, designed and constructed according to sound engineering practices to contain, control or divert water flow to provide protection from certain levels of temporary flooding. However, levees can and do decay over time. Levees also can be overtopped or breached during large floods.

A dam is a barrier constructed to hold back water and raise its level, the resulting reservoir being used in various ways. Dams are an important resource in the United States, providing many functions that include recreation, flood management, ecosystem-based functions, irrigation, water supply and hydroelectric power, but they also can be breached with little warning. Levee and dam breaches can result in catastrophic flooding (FEMA, 2015).

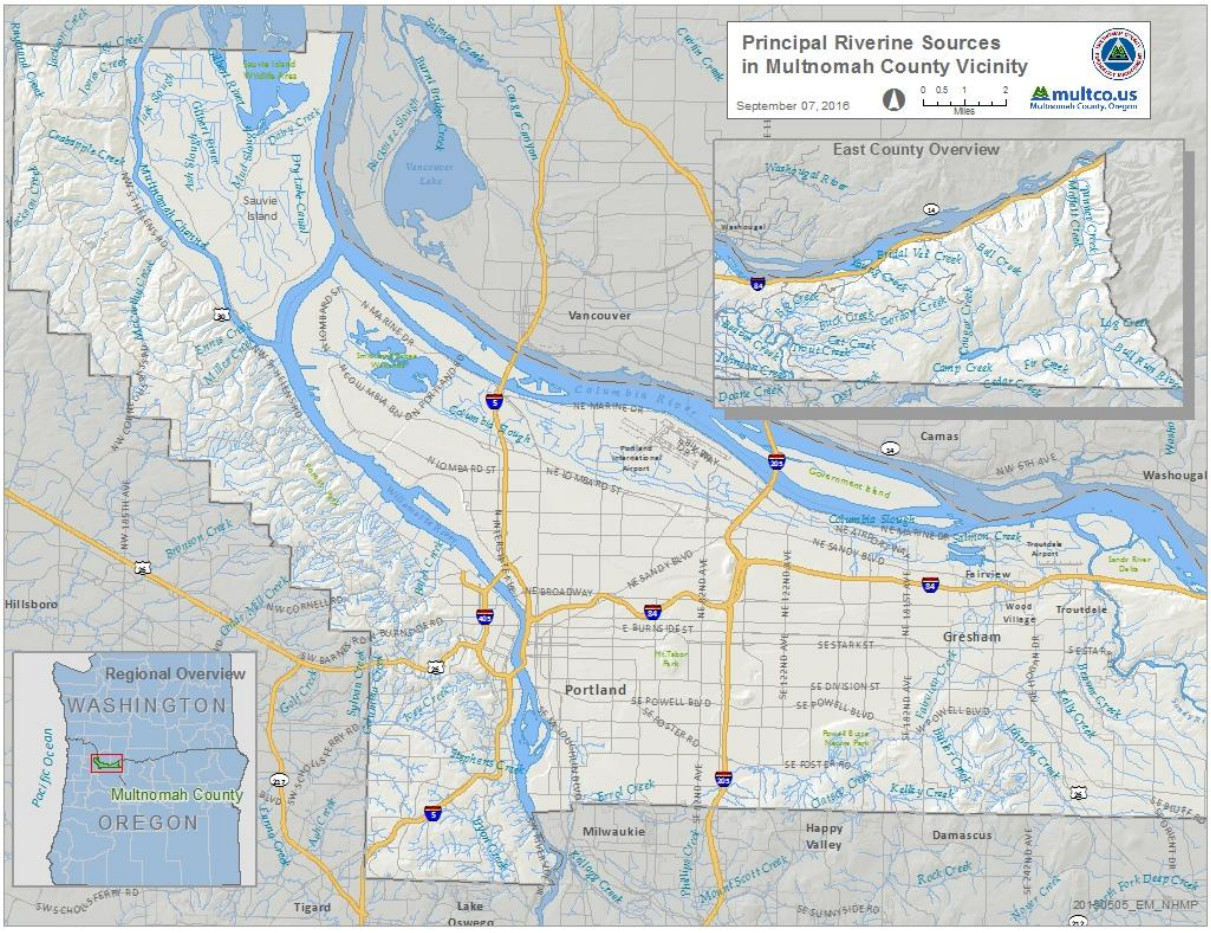
Location and Extent

Riverine Flooding

Principal riverine flood sources in the Planning Area are labeled in **Figure 3.2-1** and include:

- Columbia River and tributaries
- Willamette River and tributaries
- Sandy River
- Multnomah Channel
- Johnson Creek
- Fairview Creek
- Columbia Slough
- Beaver Creek
- Kelley Creek
- Mitchell Creek

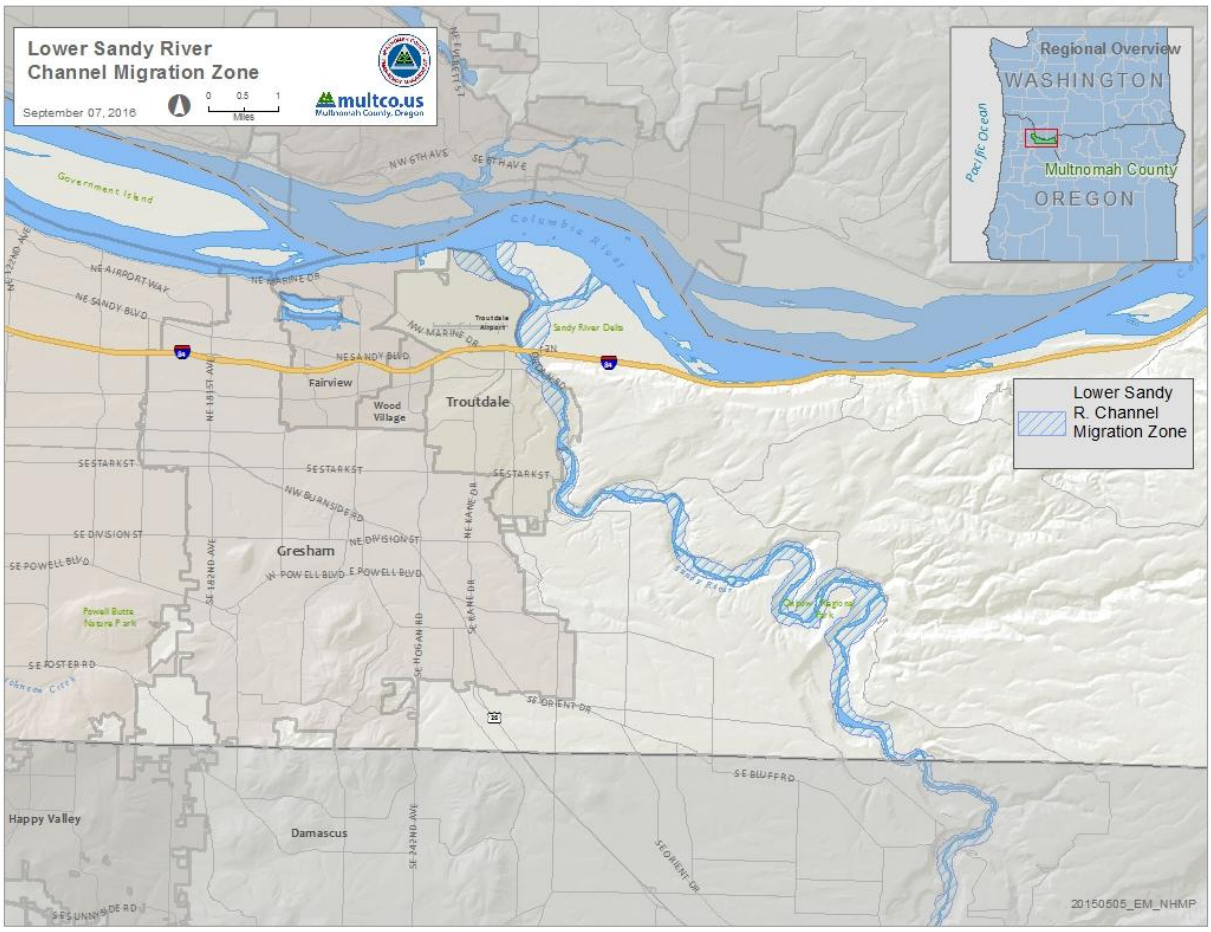
Figures 3.2-1 Principal Riverine Sources in Multnomah County Vicinity



Source: Multnomah County, 2016

The Sandy River has a history of channel migration, and the Oregon Department of Geology and Mineral Industries (DOGAMI) studied areas susceptible to future channel movement and erosion. This study is documented in DOGAMI's Open-File Report O-13-10**. Figure 3.2-3** shows channel migration zones along the lower Sandy River in east Multnomah County. Clackamas County also used Hazard Mitigation Grant Program funding following a 2011 flood event to do a more in-depth study of channel migration on the upper Sandy River.

Figure 3.2-3 Channel Migration along the Sandy River



Source: DOGAMI, 2011

Urban Flooding

In most locations, stormwater drainage systems are designed to handle only small to moderate rainfall events. Stormwater systems are sometimes designed to handle only 2-year or 5-year flood events, and are rarely designed to handle rainfall events greater than 10-year or 15-year events.

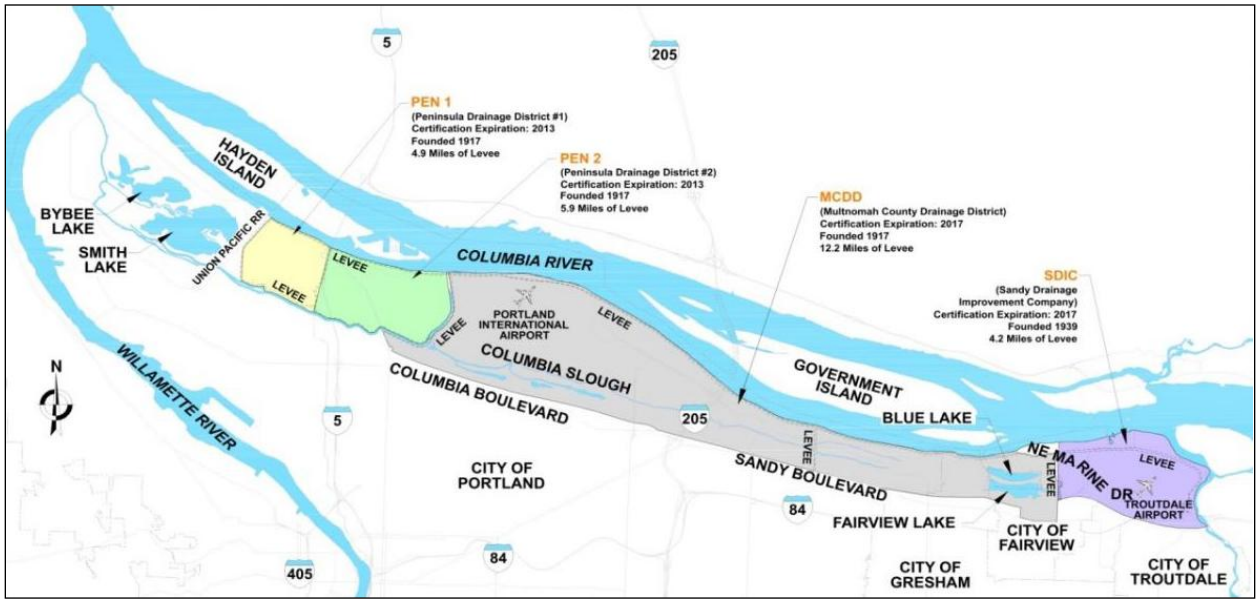
For local rainfall events that exceed the collection and conveyance capacities of stormwater drainage systems, some level of flooding inevitably occurs. In many cases, local stormwater drainage systems are designed to allow minor street flooding to carry off stormwater that exceeds the capacity of the stormwater drainage system. In larger rainfall events, flooding may extend beyond streets to include yards. In major rainfall events, local stormwater drainage flooding also can flood buildings. In extreme

cases, local stormwater drainage flooding can sometimes result in several feet of water in buildings, with correspondingly high damage levels.

Levee Failure

Low-lying areas along the Columbia River in Multnomah County are protected by five drainage districts. Four of the drainage districts make up a levee system stretching 27 miles from Smith Lake to the Sandy River (**Figure 3.2-4**) and are collectively referred to as the Columbia Corridor Drainage Districts. From west to east, these districts are the Peninsula Drainage District No. 1 (PEN 1), Peninsula Drainage District No. 2 (PEN 2), Multnomah County Drainage District No. 1 (MCDD), and Sandy Drainage Improvement Company (SDIC). The fifth district in the county, Sauvie Island Drainage Improvement Company (SIDIC), manages the 18-mile levee system and canal system on the southern half of Sauvie Island (**Figure 3.2-5**).

Figure 3.2-4 Columbia Corridor Drainage Districts



Source: MCDD

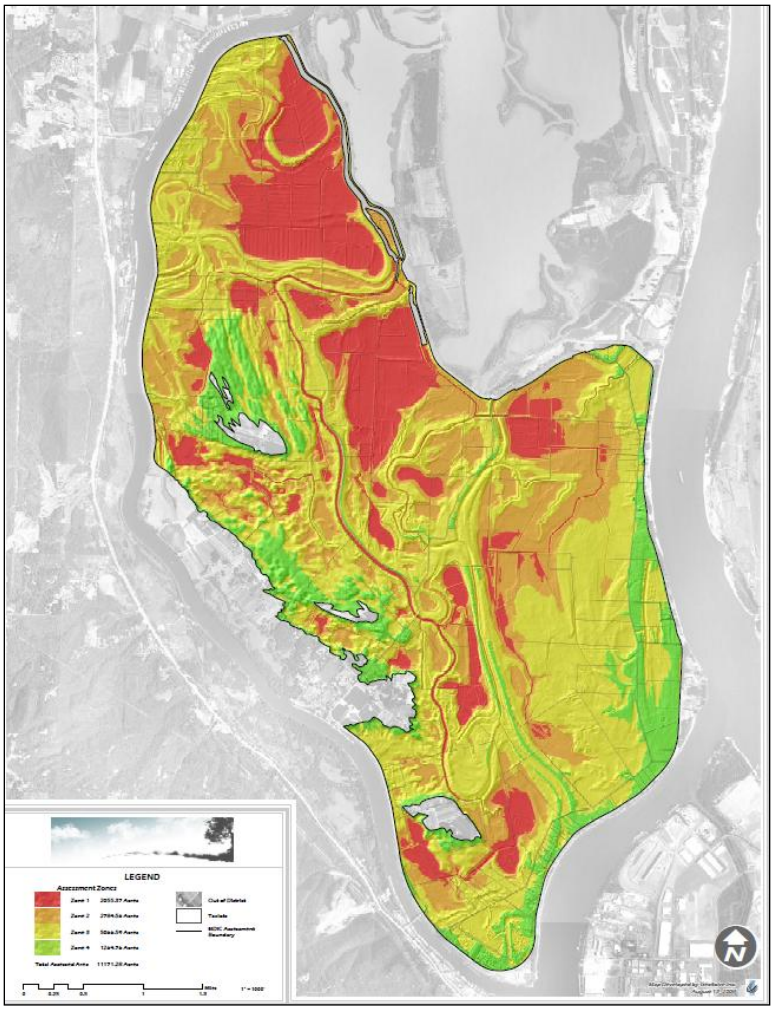
Columbia County Drainage Districts

PEN 1, PEN 2 and SDIC delegate administrative management for the levees in their districts, through annual contracts, to the staff of MCDD. To protect against external flooding, MCDD maintains approximately 27 miles of levees and floodwalls, 18 of which run directly alongside the southern bank of the Columbia River. The remaining levees border the Columbia Slough or the Sandy River, or create compartments within the leveed area by aligning perpendicularly to the Columbia River or Slough levees. The levees were originally built by local landowners starting in 1917. The U.S. Army Corps of Engineers (USACE) subsequently updated the levee system. All district levees have previously been accredited by FEMA. More about the Columbia Corridor Drainage Districts can be obtained from its website: www.mcdd.org.

Sauvie Island Drainage Improvement Company

The Sauvie Island levee is approximately 18 miles in length and is divided into four segments (Figure 3**.2-5**). It is managed by the Sauvie Island Drainage Improvement Company (SIDIC). The levee protects 11,200 acres from flooding. Levee construction began in the late 1930s, and it was constructed of material dredged from the Columbia River and pits and canals dug on the island. The main Pump House was constructed in 1941 and houses four pumps capable of evacuating 125,000 gallons-per-minute of water at varying river levels. The interior of the drainage system consists of over 30 miles of canals and ditches to convey rain, seepage and spring water from the interior of the levee to the Multnomah Channel. This levee has been accredited by FEMA. More information on the SIDIC can be obtained from its website: www.sidrainage.org.

Figure 3.2-5 Area Protected by the Sauvie Island Drainage Company



Source: SIDIC

Federal Levee Infrastructure Programs

The Columbia Corridor Drainage Districts' levee system currently has two certified levee systems (MCDD and SDIC) and two systems that are pursuing certification (PEN 1 and PEN 2). USACE certification of the PEN 1 and PEN 2 levee systems expired in August 2013 after USACE policy changes were adopted in 2012. This situation puts these levee systems at risk of losing their accredited status when FEMA issues

new FIRMs for the area. The MCDD and SDIC levee systems have certifications that will expire in 2017. The full system is currently accredited by FEMA. The Sauvie Island levee is also certified until 2017. All systems are active in the USACE Rehabilitation and Inspection Program, PL 84-99. MCDD estimates the potential cost of repairs to meet current standards at between $100 million and $200 million. Levee Ready Columbia, a group of stakeholders from government, business, environmental and community organizations convened by Portland Mayor Charlie Hales and Multnomah County Commissioner Jules Bailey, has been formed to identify collaborative solutions to ensure the levee system meets the requirements for participation in federal programs and continues to reduce the risk of flooding for important regional assets in the area.

Dam Failure

Columbia River Watershed

There are about 75 large dams and numerous smaller dams on the Columbia River and its tributaries that provide hydroelectric power, recreation, ecosystem-based functions and flood management. The dams within the Columbia River drainage area are operated by federal agencies; state, provincial or local governments; public utilities; and private owners. The four large dams on the Columbia River within Oregon are: Bonneville Dam, The Dalles Dam, John Day Dam and McNary Dam. These dams are maintained and operated by USACE. In the case of very unlikely, but not impossible, failure of one or more of these dams, severe flooding would occur along the Columbia River.

Multnomah County Watersheds and Willamette River Watershed

Failure of any of the dams within Multnomah County would result in localized flooding within watersheds downstream of the dam.

Failure of the Bull Run Dam would result in major flooding along Bull Run and the Sandy River downstream of the confluence with Bull Run.

Failure of the Mt. Tabor Reservoirs would result in localized flooding within the City of Portland between Mt. Tabor and the Willamette River.

Failure of any one or more of the major dams upstream on the Willamette River could result in substantial flooding along the lower Willamette River. However, the extent of flooding would depend strongly on river levels at the time of dam failure, the amount of available storage in dams downstream of a dam that failed, and whether or not progressive failure of downstream dams were to occur.

3.2.2 History

A majority of flood events in and around the Planning Area have occurred in the winter due to rain accelerating snowmelt. **Table 3.2-2** lists significant flooding events that have impacted our communities.

Table 3.2-2 Significant Historic Floods

Date	Location	Type of Flood	Description
Multiple	Columbia River and Multnomah River	Flooding	Significant floods occurred in 1861, 1880, 1881, 1909, 1913, 1927, 1928, 1942, 1946, 1948, 1961, 1964/65, 1996, 2007. Details of some of these floods are provided below.
Dec. 1861	Willamette River	Rain on snow	Probably the most immense flood in the valley in recorded history, the “Great Flood” devastated the valley’s economy and resulted in the deaths of several people.
Dec. 1862	Willamette Basin	Rain on snow	Widespread flooding throughout western Oregon.

Date	Location	Type of Flood	Description
Feb. 1890	Willamette Basin	Rain on snow	Second largest flood of known magnitude; water levels in Portland: 22.3 ft.
June 1894	Columbia River	Snowmelt	Largest recorded flood on Columbia. Estimated to have covered everything below 36 feet along the Columbia River from the Sandy to the Willamette; only a few knolls were above water on Sauvie and Hayden islands.
Jan. 1923	Willamette & Columbia River	Rain on snow	Widespread damage to roads and railroads
Dec. 1937	Willamette Basin	Rain on snow	Considerable flooding; landslides
Dec. 1945	Willamette Basin/ NW Oregon	Rain on snow	Very warm temperatures; considerable flood damage
May–Jun. 1948	Columbia River	Rain, flooding, snowmelt	Memorial Day flood on the Columbia River. Levee breaches destroyed the City of Vanport (18,000 people); 15 fatalities recorded. Subsequent levee breaches followed, flooding Portland; flooding also occurred along Columbia River Highway and the Sandy River Delta. Snowmelt event in June and contributed impacts. Willamette River crested at 31.6 feet.
Dec. 1955	Statewide	Rain on snow	DR-49. Event occurred on December 29, 1955. Flooding and strong winds; five fatalities.
Jul. 1956	Statewide	Storms, flooding	DR-60. Event occurred on July 20, 1956. Storms and flooding.
Mar. 1957	Statewide	Flooding	DR-69. Event occurred on March 1, 1957.
Oct. 1962	Statewide	Storms	DR-136. Event occurred on October 16, 1962.
Feb. 1963	Statewide	Flooding	DR-144. Event occurred on February 25, 1963.Flooding.
Dec. 1964	Statewide	Heavy rains, flooding, rain on snow	DR-184.Event occurred on December 24, 1964. Record-breaking rainfall; damaged or destroyed about 750 homes along the Sandy River. In Multnomah County, the Columbia River Highway was washed out at the east end of the Beaver Creek Bridge. Statewide damage totaled $157 million and 17 deaths.
Jan. 1972	Willamette & Sandy Rivers	Storms, flooding, rain on snow	DR-319.Event occurred on January 21, 1972. Widespread damage; five fatalities.
1974	Western Oregon	Rain on snow, flooding	Flooding resulted from rain-on-snow events. Willamette River at Portland crested at 25.7 feet. Nine counties declared disasters.
Jan. 1978	Willamette River	Rain on snow	Intense rain/snowmelt; widespread flooding
Feb. 1986	Statewide	Snowmelt, flooding	Intense rain, a melting snow, and flooding. Some homes evacuated.
1990	Western Oregon	Rain on snow, flooding	Ten rivers in eight counties were flooding in a rain-on-snow weather event. Many bridges were washed away.
Feb. 1996	Statewide	Storms, flooding, rain on snow	DR-1099 Winter storms with rain, snow, ice, floods and landslides. Power outages, road closures and property damage. Warm temperatures, record breaking rains; extensive flooding in Multnomah County; widespread closures of major highways and secondary roads; eight fatalities. Multnomah County was one of 27 counties covered by the disaster declaration.
Dec. 1996-Jan. 1997	Statewide	Winter storm, flooding	DR-1160. Severe snow and ice. Up to four to five inches of ice in the Columbia Gorge. Interstate 84 closed for four days. Hundreds of downed trees and power lines. Widespread power outages in the greater Portland area, including Multnomah County.
Jan.-Feb. 1999	NW Oregon	Rain, flooding, landslides, mudslides	Widespread flooding on smaller rivers and streams;. numerous landslides and mudslides. Historic Columbia River Highway east of the Sandy River Bridge covered with slides coming from the cliffs above. Mudslide pushed a house into Sandy River, resulting in a fatality.

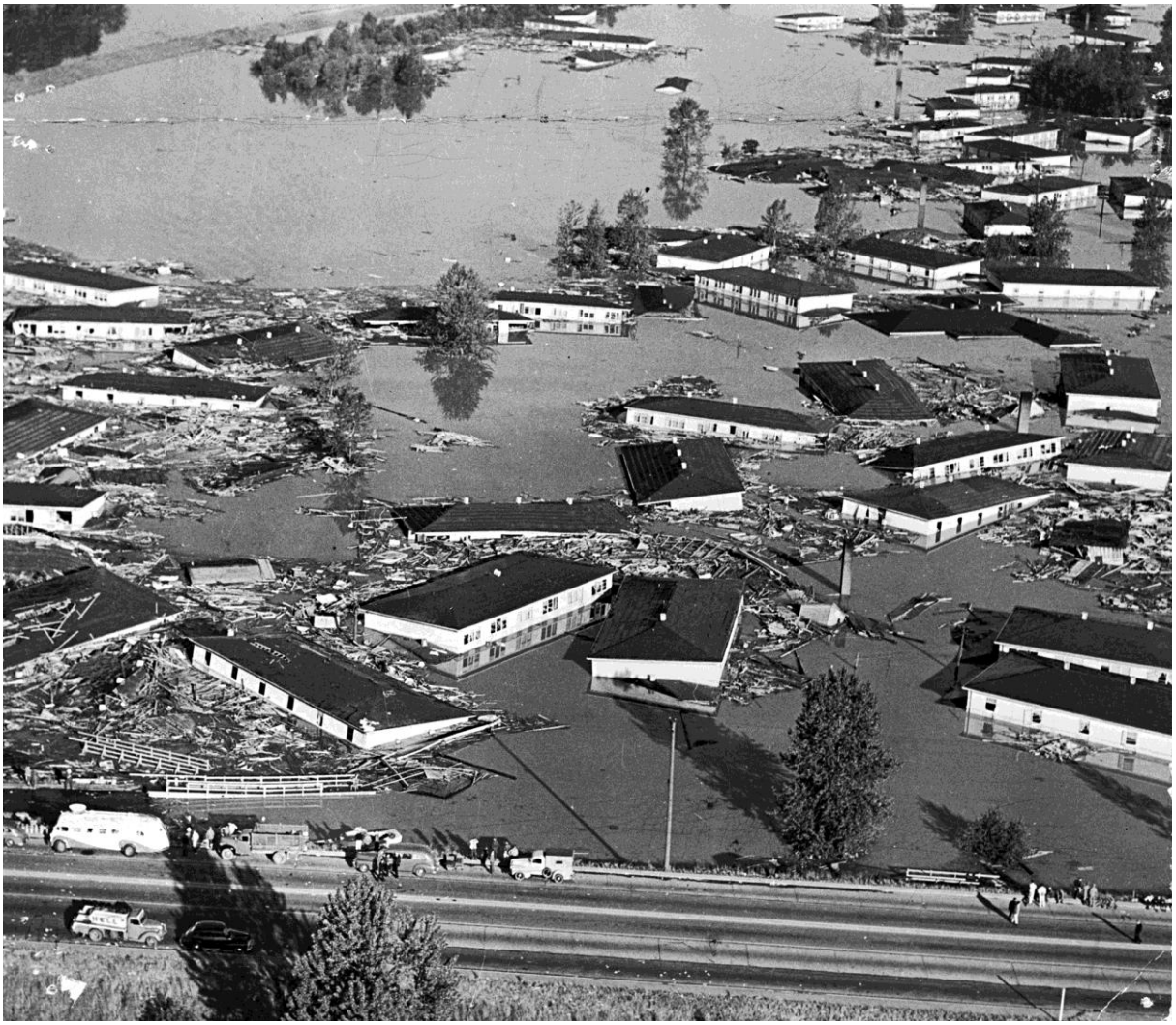
Date	Location	Type of Flood	Description
Winter 2001	Wood Village	Flooding	Arata Creek overflowed its banks at the point where it crosses NW 244th Avenue in the winter of 2001. One building east of that point was damaged.
Jan. 2003	Portland area	Heavy rain	Johnson Creek crested at two feet above flood stage, the highest Johnson Creek had risen in years. No damages were reported, but the rising river prompted the evacuation of approximately 25 nearby houses. Heavy rain resulted in standing water on many streets in the Portland metro area, resulting in some road closures. A small slide resulted in the temporary closure of a ramp leading to the St Johns Bridge.
Dec. 2007–Jan. 2008	NW Oregon	Winter storms, heavy rain, flooding	DR-1824. Severe winter storm, flooding, winds, record and near-record snow, landslides and mudslides. Gresham received, 26 inches of snow . Many roads closed. Significant damages to public infrastructure, homes and businesses.
Jan. 2009	Portland area	Rain, flooding, rain on snow	Portland area received 3.04 inches of rain from a warm tropical storm (“Pineapple Express”) which combined with extensive snowmelt from heavy snowfall in December. Flood elevations in Johnson Creek were the second highest recorded, and flooding also occurred on other streams in Multnomah County.
Jan. 2011	Statewide	Winter storm	DR-1956. Severe winter storm, flooding, mudslides, landslides and debris flows.
Jan. 2012	Multnomah County	Rain, rain on snow	Heavy rain combined with snowmelt runoff caused the Johnson Creek at Sycamore to overflow its banks and flood low-lying areas. Johnson Creek crested at 13.2 feet on January 19 at 4 pm PST, 2.2 feet above flood stage.
Sep. 2013	Portland Metro Area	Heavy rain, flooding	KPTV-KPDX Broadcasting reported that heavy rain resulted in flooding and damage to the Legacy Good Samaritan Medical Center and several businesses in Northwest Portland. Besides damage to the hospital's emergency and operating rooms, some elective surgeries were cancelled.
Dec. 2015	Western Oregon	Winter storm, heavy rain	DR-4258. Severe winter storms, straight-line winds, flooding, landslides and mudslides.

Sources: National Climatic Data Center; Oregon Historical Society; Multnomah County Flood Insurance Study, Oregon Office of Emergency Management; Taylor and Hatton (1999); National Climatic Data Center; KPTV-KPDX (2013); FEMA (2016).

The construction of flood control infrastructure on the Columbia River and Willamette River has reduced, but not eliminated, the potential for major flood events on these rivers. A devastating example occurred on May 30, 1948. The Columbia and Willamette rivers were cresting at eight feet above flood stage when a breach occurred in a railroad embankment that served as a levee separating the City of Vanport from Smith Lake. Subsequent breaches occurred along the Columbia Slough.

The breach became a 500-foot gap that allowed flood waters to inundate the city within 10 minutes (**Figure 3.2-7**). Vanport was the nation’s largest housing project and Oregon’s second largest city at the time. There were 15 fatalities recorded, and 18,500 residents were displaced; roughly 6,300 were black (Geiling, 2015). The Oregon Historical Society and the Smithsonian have in-depth articles that discuss the racial discrimination that caused this natural disaster to have even greater impacts to society in the Portland area.

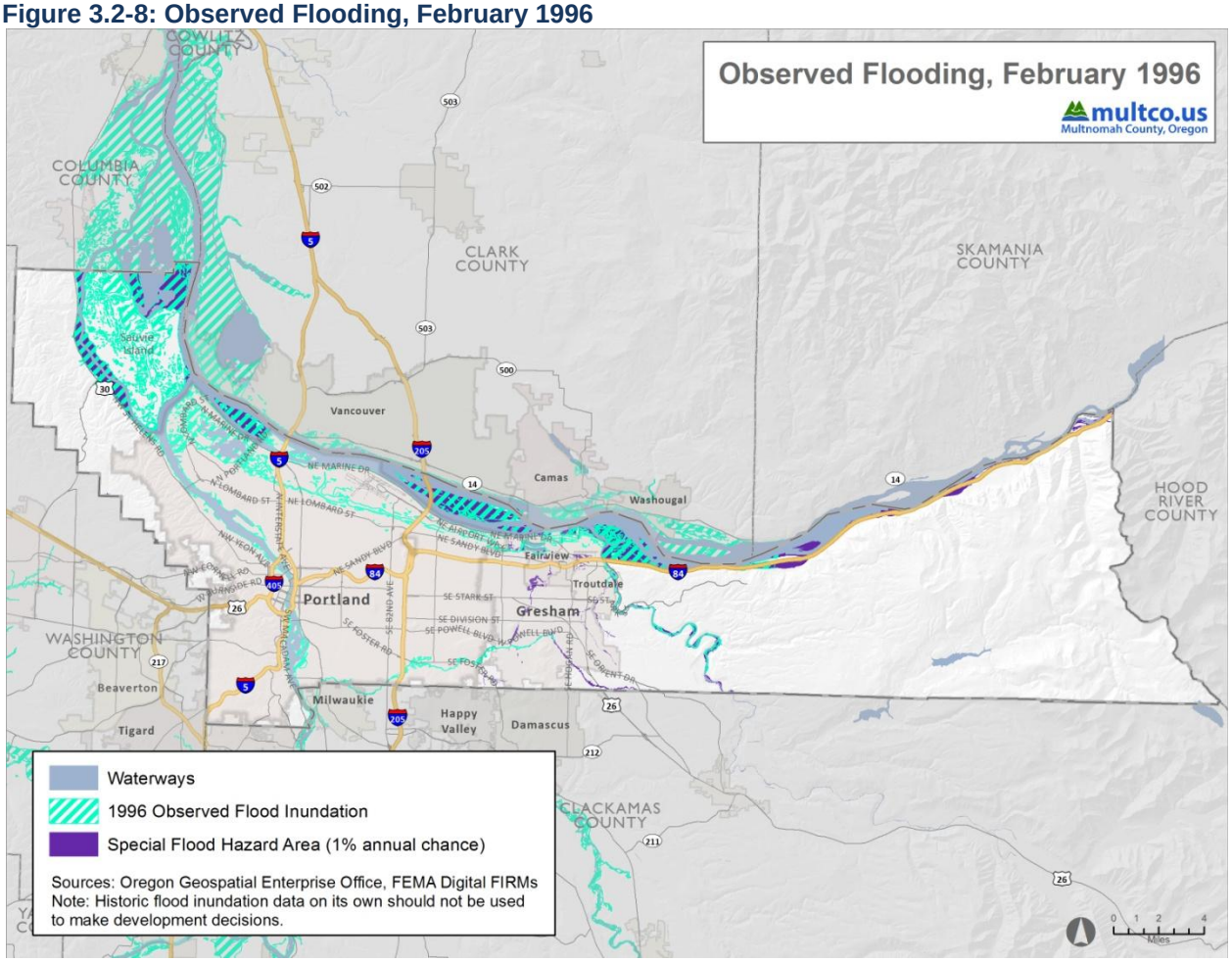
Figure 3.2-7 Vanport Flood, 1948



Source: Unknown

A more recent example of major flooding occurred in 1996 (**Figure 3.2-8**). The Willamette River crested at 28.6 feet in downtown Portland, nearly 11 feet above flood stage. Eight people died and damages were in the millions.

Figure 3.2-8: Observed Flooding, February 1996



Source: Oregon Geospatial Enterprise Office, FEMA Digital FIRMs

3.2.3 Probability

Flooding can happen anywhere, but certain areas are especially prone to serious flooding. To help communities understand their risk, FEMA has created flood maps, also known as FIRMs, to show locations with high-risk (SFHA), moderate-to-low risk, and undetermined-risk. The National Flood Insurance Program (NFIP) defines levels of risk as (NFIP, 2016):

- **Special Flood Hazard Area (SFHA):** In high-risk areas, referred to as SFHA, there is at least a 1 in 4 chance of flooding during a 30-year mortgage. All home and business owners in these areas with mortgages from federally regulated or insured lenders are required to buy flood insurance. The SFHA is shown in dark purple on the flood maps in **Figures 3.2-9** and **-10.**
- **Moderate-to-Low Risk Areas:** In moderate-to-low risk areas, the risk of being flooded is reduced but not completely removed. Moderate to low risk represents either 0.2% annual chance of flooding or 1% annual chance of flooding behind an accredited levee. These areas submit over 20% of National Flood Insurance Program (NFIP) claims and receive one-third of disaster assistance for flooding. Flood insurance is not federally required in moderate-to-low risk areas, but it is recommended for all property owners and renters. In **Figures 3.2-9** and **-10,** areas with moderate-to-low risk are medium purple.
- **Undetermined Risk Areas:** No flood-hazard analysis has been conducted in these areas, but a flood risk still exists. Flood insurance rates reflect the uncertainty of the flood risk. In **Figures 3.2-9** and -**10,** undetermined areas are not specifically identified.

Except for Wood Village, all communities in the Planning Area have a SFHA. Portions of Fairview, Gresham, Sauvie Island and Troutdale have land along the Columbia River with a moderate-to-low risk.

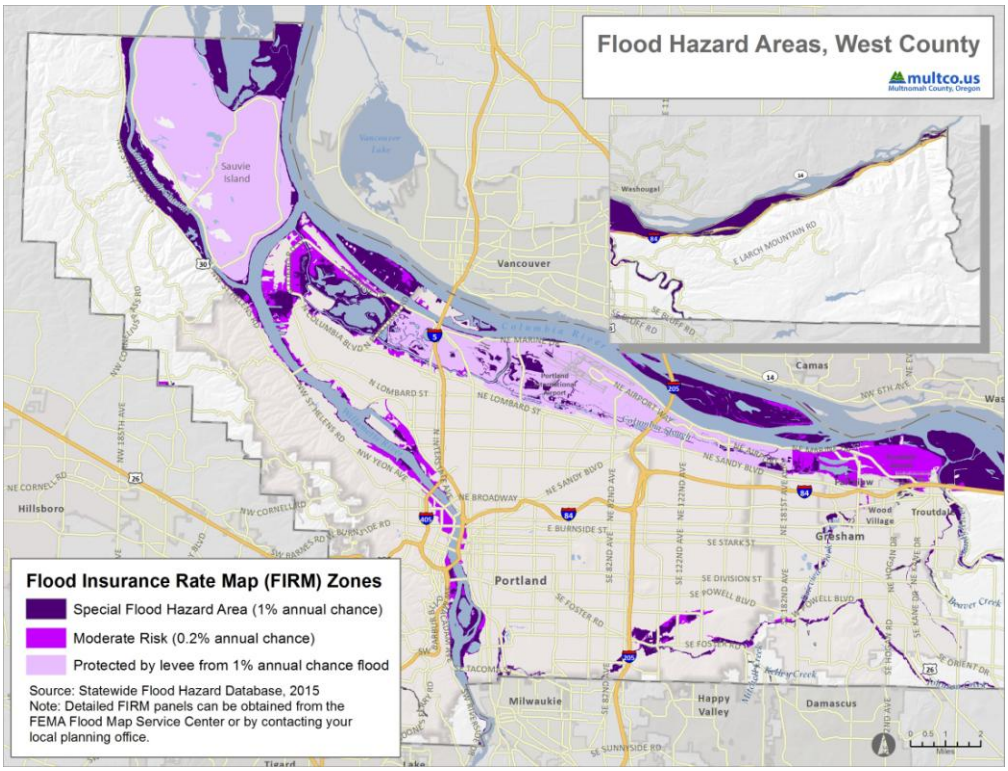
FIRMs were recently updated for all jurisdictions in Multnomah County (**Table 3.2-3**). Official FIRMs can be obtained online from the FEMA Flood Map Service Center (msc.fema.gov) or by contacting your jurisdiction's community development office.

Table 3.2-3 Effective FIRM Dates for the Planning Area

Jurisdiction	Initial FIRM	Current FIRM
Unincorporated Multnomah County	June 15, 1982	Dec. 18, 2009
Fairview	March 18, 1986	Dec. 18, 2009
Gresham	July 16, 1979	Dec. 18, 2009
Troutdale	Sept. 30, 1988	Dec. 18, 2009
Wood Village	Dec. 18, 2009	Dec. 18, 2009

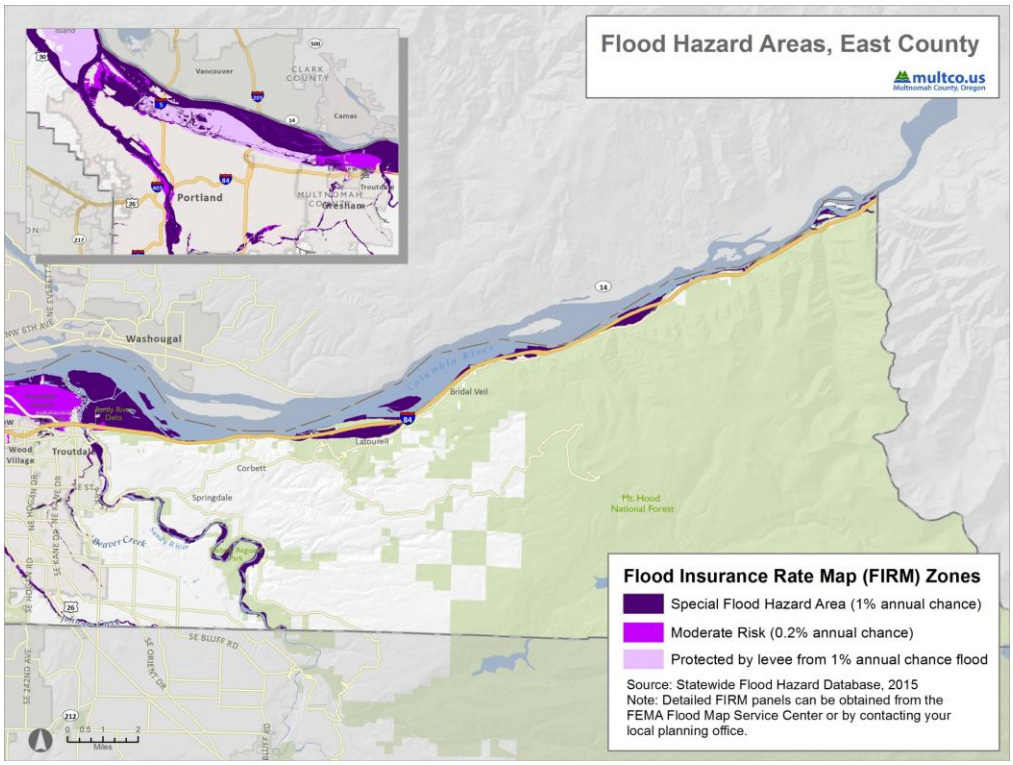
Source: DLCD, 2015

Figure 3.2-9 Flood Hazard Areas, West Multnomah County



Source: Statewide Flood Hazard Database, 2015

Figure 3.2-10 Flood Hazard Areas, East Multnomah County



Source: Statewide Flood Hazard Database, 2015

Conventional flood hazard maps examine only hazards posed by standing floodwaters on a given floodplain. However, damage from bank erosion as river channels naturally migrate may occur even in the absence of major flooding. Such channel migration can cause major damage.

Changing weather patterns, erosion and development can affect floodplain boundaries. FEMA has been working to update and modernize the nation's flood maps by identifying watersheds where additional study may be needed. Maps for the Lower Columbia–Sandy Watershed are in the process of being updated. Preliminary map reviews are currently taking place (in 2016). New maps are scheduled to become effective in 2017 (S. Lucker, personal communication, June 1, 2015). This risk assessment will be updated to reflect those changes during the next plan update.

Climate Change

According to the 2015 Oregon Natural Hazards Mitigation Plan, climate models project warmer drier summers for the Planning Area. Seasonal shifts in precipitation patterns means historical records may no longer provide a reliable guide to future flooding (Multnomah County, 2014).

An increase in extreme precipitation is projected for some areas, including an increased incidence of magnitude and return interval (DLCD, 2015). Increased urbanized flooding is likely with the potential for more intense rain events in mid-winter (Multnomah County, 2014).

Because landslides in Oregon are strongly correlated with rainfall, increased rainfall — particularly extreme events —likely will trigger increased landslides (DLCD, 2015). See **Section 3.3 Landslides** for more information on the relationship between rainfall and landslides.

In addition, the Willamette and Columbia rivers are tidally influenced, so sea level rise also could affect flooding. However, in the near-term, tectonic uplift of the coast may mitigate impacts of sea level rise (Multnomah County, 2014).

Warmer Winters and More Intense Rain Events

Climate models suggest that Multnomah County's total annual precipitation will not change dramatically and will continue to be dominated by natural variability and El Niño conditions. However, seasonal shifts in precipitation patterns are expected, leading to drier summers and the potential for more intense rain events in the other seasons. Some global and Pacific Northwest regional climate models suggest that extreme daily precipitation amounts could increase.

– Multnomah County Climate Change Preparation Strategy 2014

On the flip side, warmer, drier summers will have implications on water bodies and water supply systems. For more information on how climate change is projected to impact these systems, see **Climate Change** in section **3.4.3 Probability** under **3.4 Severe Weather.**

3.2.4 Vulnerability

Riverine Flooding

All jurisdictions in the Planning Area, with the exception the City of Wood Village, are subject to riverine flooding. To estimate the impact a major flood might have in the Planning Area, the HAZUS[1] flood model with national datasets was used. These datasets provide generalized outputs helpful in gaining awareness of the potential distribution of risk within the Planning Area (see www.fema.gov/HAZUS for details on datasets). More thorough analysis using local building data should be used before making policy decisions or designing specific flood mitigation projects.

Potential damages and expected losses were modeled for a 1% annual chance flood occurring on all rivers and streams within the county. It was estimated that 12 homes in the Planning Area would be substantially damaged during a 1% annual chance flood (**Table 3.2-5**). Substantial damage means that the cost of repairs is 50% or more of the structure's market value before the disaster occurred (FEMA). Many more homes, 203, are estimated to sustain minor to moderate damages. No commercial buildings or industrial buildings in the Planning Area were estimated to sustain damage. The model did not estimate any damages to structures with agriculture, education, government or religion uses. The model also assumes levees will not fail.

Table 3.2-5 Residential Structures with Estimated Damage from a 1% Annual Chance Flood Scenario

Community*	# of Homes Substantially Damaged (>50% of Value)	# of Homes with <50% damage	# of Undamaged Homes	Total Homes in Inundation Areas
Total for Planning Area	12	203	109	324
Total for Unincorporated Multnomah County	10	62	18	90
• East of Sandy River	2	10	0	12
• Interlachen	0	0	1	1
• Pleasant Valley	0	1	3	4
• Riverdale Area	3	2	0	5
• Sauvie Island Area	5	47	14	66
• West of Sandy River	0	2	0	2
Fairview	0	36	13	49
Gresham	0	78	71	149
Troutdale	2	27	7	36
Wood Village	0	0	0	0

*Only communities with modeled flood impacts are included.

Source: HAZUS-MH Flood Model

The total losses for residential structures from a 1% annual chance flood affecting all rivers and streams in the county could be as much as $44 million, according to the HAZUS model (**Table 3.2-8**).

[1] HAZUS is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods and hurricanes. HAZUS uses Geographic Information Systems (GIS) technology to estimate physical, economic and social impacts of disasters.

Table 3.2-6 1% Annual Chance Flood Scenario Estimated Losses ($) for Residential Structures

Community*	Building Loss	Contents Loss	Relocation Cost
Total for Planning Area	44,247,000	28,351,000	32,000
Total for Unincorporated Multnomah County	19,462,000	12,887,000	11,000
• East of Sandy River	4,809,000	3,970,000	1,000
• Interlachen	109,000	69,000	0
• Pleasant Valley	292,000	182,000	0
• Riverdale Area	1,282,000	722,000	1,000
• Sauvie Island Area	10,910,000	6,622,000	9,000
• West of Sandy River	2,060,000	1,322,000	0
Fairview	4,882,000	3,013,000	5,000
Gresham	13,371,000	8,471,000	11,000
Troutdale	6,532,000	3,980,000	5,000
Wood Village	0	0	0

*Only communities with modeled flood impacts are included.

Source: HAZUS-MH Flood Model

National Flood Insurance Program (NFIP)

In response to the rising cost of taxpayer-funded disaster relief for flood victims and the increasing amount of damage caused by floods, Congress created the NFIP in 1968. The NFIP makes federally backed flood insurance available in communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage (Insurance Information Institute, no date). All jurisdictions in the Planning Area participate in the NFIP, with the exception of Wood Village, which does not experience riverine flooding.

Table 3.2-7 provides statistics on the policies for each jurisdiction. A total of 54% of the policies currently in force are for structures built before floodplain maps were available for that community, also known as Pre-Flood Insurance Rate Maps, or Pre-FIRMs. Of those properties, six have the lowest floor one foot or more below the base flood elevation. These are considered Minus Rated Properties.

Table 3.2-7 NFIP Policy Statistics in the Planning Area

Community	Policies In Force	Pre-FIRM Policies	Minus Rated Policies	Insurance Coverage ($)
Total for Planning Area	345	187	6	100,231,000
Unincorporated Multnomah County	177	112	2	49,917,000
Fairview	41	10	0	13,634,100
Gresham	83	45	1	23,214,600
Troutdale	44	20	3	13,465,300
Wood Village	NA	NA	NA	NA

Source: Oregon Department of Land Conservation and Development, 2016

Over the past 37 years, 105 NFIP claims have been made across the Planning Area. In that time period, $1.2 million in payments have been received by property owners with flood insurance policies to cover flood losses (**Table 3.2-8**).

Table 3.2-8 NFIP Loss Statistics, Jan. 1978 – June 2015

Community	Total Losses Submitted	Losses Paid	Closed without Payment	Total Payments ($)
Total for Planning Area	105	72	33	1,206,915.96
Unincorporated Multnomah County	86	61	25	1,148,575.44
Fairview	3	2	1	13,276.26
Gresham	6	2	4	7,862.87
Troutdale	10	7	3	37,201.39
Wood Village	0	0	0	0

Source: NFIP BureauNet

The NFIP defines a **repetitive loss structure** as an NFIP-insured structure that has had at least two paid flood losses of more than $1,000 each in any 10-year period. There have been four repetitive flood loss claims in the Planning Area, including:

- Unincorporated Multnomah County:
  - 2 single-family homes
  - 1 non-residential property
- Troutdale:
  - 1 single-family home

A **severe repetitive loss structure** is an NFIP-insured structure that has incurred flood damage for which:

a) Four (4) or more separate claim payments have been made under a Standard Flood Insurance Policy issued pursuant to this title, with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000; or
b) At least two (2) separate claims payments have been made under a Standard Flood Insurance Policy, with the cumulative amount of such claim payments exceeding the fair market value of the insured building on the day before each loss (FEMA, 2016).

There are zero severe repetitive loss claims in the Planning Area.

Community Rating System

The CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions (FEMA, 2016). Troutdale participates in the NFIP's Community Rating System (CRS), and has a rating of 7, providing a 15% discounted rate on flood insurance to properties within the SFHA and a 5% discount for properties outside the SFHA. Other jurisdictions in the Planning Area do not currently participate in the CRS program. However,

Channel Migration

According to a DOGAMI study, there are an estimated 479 people in the Planning Area at risk from channel migration along the Sandy River — 236 in Troutdale and 243 in unincorporated areas (DOGAMI, no date). The study found no critical facilities within this zone, such as hospitals, schools, police or fire buildings. There are, however, the following infrastructure within channel migration zones in Troutdale and the unincorporated areas, as shown in **Tables 3.2-9** and **3.2-10**:

- 186 structures, estimated at roughly $38 million
- 8.4 miles of transportation infrastructure
- 6.9 miles of electric transmission lines
- 6 bridges
- 8 electric transmission towers

In addition, Troutdale and Multnomah County have currently undeveloped parcels designated for residential or commercial use within the channel migration zone, which means there may be a potential for future development in these high-hazard areas. During Multnomah County's current Comprehensive Plan update process, planners are reviewing the need to restrict development in this zone and have proposed policies for inclusion in the plan.

Table 3.2-9 Structures Located within the Sandy River Channel Migration Zone

Community*	Residential		Commercial		Public		Total	
	#	Value ($)	#	Value	#	Value	#	Value
Total for Planning Area	144	$17,891,580	25	$10,960,030	17	$8,949,350	186	$37,800,960
Troutdale	53	$7,110,690	4	$3,895,980	10	$8,943,160	67	$19,949,830
Unincorporated Multnomah County	91	$10,780,890	21	$7,064,050	7	$6,190	119	$17,851,130

* Only communities with modeled channel migration impacts are included.

Source: DOGAMI, no date

Table 3.2-10 Infrastructure within the Sandy River Channel Migration Zone

Community*	Arterial Roads (miles)	Highway/ Interstate (miles)	Road Bridge (#)	Electric Transmission Lines (miles)	Electric Transmission Towers (#)	Railroad (miles)
Total for Planning Area	7.9	0.4	6.0	6.9	8.0	0.1
Troutdale	2.1	0.2	2.0	3.3	5.0	0.1
Unincorporated Multnomah County	5.8	0.2	4.0	3.6	3.0	0.0

* Only communities with modeled channel migration impacts are included.

Note: There were no electric substations, wastewater treatment plants, dams, airports or railroad bridges within the hazard zone.

Source: DOGAMI, no date

Urban Flooding

The risk of urban floods increases as development increases. During heavy rainstorms, runoff from buildings, streets and other impervious surfaces can exceed the capabilities of the existing stormwater drainage infrastructure and result in flooded streets, parking lots, yards and basements. Storm drains may back up with yard waste or other flood debris, leading to further localized flooding. The grading of developed property also can alter drainage direction of water from one property to another.

Some of the most problematic sites for urban flooding in the Planning Area include:

- **Unincorporated Multnomah County**
  - Stormwater drainage problems have been minor, with no locations known to have significant flooding problems. The county's current regulations for new stormwater drainage systems require control of the 10-year, 24-hour storm. However, many older drainage systems are built to lower standards.
- **Fairview**
  - NE Glisan Street at Fairview Creek
  - NE Halsey Street between 201st and 205th Streets
  - 223rd North of Halsey Street and south of Bridge Street
  - Sandy Boulevard at Fairview Creek
- **Gresham**
  - Areas along Burlingame Creek, particularly those near Hogan Road where Burlingame enters the Gresham Golf Course
  - Properties along Johnson Creek off Park Avenue

- **Troutdale**
  - Areas along the Sandy River
  - Areas along the lower reaches of Beaver Creek
- **Wood Village**
  - Historically, flooding has occurred where Arata Creek crosses NE 244th Avenue. In 2010, this problem was mitigated by the installation of a larger storm culvert and street drainage improvements on Halsey Street.
- **Sandy Drainage Improvement Company**
  - Increased influent stormwater may overload the system's current capacity.
  - Culvert at Troutdale Airport
  - Troutdale Reynolds Industrial Project Mitigation Site

Levee Failure

Columbia Corridor Levees

The Columbia Corridor Drainage Districts operate and maintain levees that were first built between 1917 and 1920, when farmers wanted local flood protection to support year-round farming. At that time, there were only 500 homes behind the levees, and most of the land was either unimproved or used for farming. Now, the levees protect the Portland International Airport, a regional Exposition Center, thousands of homes and three major interstates. The area also is home to hundreds of businesses and 10% of Multnomah County's employment base. The levee system is essential to the protection of the daily life of 7,500 residents and the nearly 13,000 acres of land amounting to more than $5 billion in assessed property (MCDD, 2014).

Despite the fact that the levees and pumping systems are aging infrastructure, current assessments show limited vulnerabilities. As part of Levee Ready Columbia, PEN 1 and PEN 2 have had recent engineering assessments to determine what work may be needed to be recertified, and identified vulnerabilities are presented in **Table 3.2-11**. Both systems continue to have targeted areas with deficiencies; however, the majority of the systems perform well even as water elevations near the 0.2% annual chance event (Oregon Solutions, 2015).

Table 3.2-11: Vulnerability Findings for PEN 1 and PEN 2 Levees

West Side of PEN 1: Railroad Embankment
The embankment was built by railroad companies for the purpose of rail transport and came to be included as part of the levee system after its construction.
The railroad embankment is one of the locations where there was a breach in 1948, resulting in the Vanport flood and subsequent flooding of PEN 2.
It was not possible to collect current soil samples or conduct analysis at this location due to access limitations associated with railroad ownership of the land.
Information gathered since the Vanport flood indicates that the embankment does not meet modern soil stability or water seepage standards.
PEN 1 Cross-Levee: Interstate 5 and North Marine Drive
There are two sections within the vicinity of the interchange that are not high enough to prevent flood waters from entering PEN 1 or PEN 2, in the event that one of the two districts floods.
Northeast Corner of PEN 2: Columbia River Levee
The height of the existing levee adjacent to Marine Drive (just west of the intersection of NE 33rd Drive) is 6 to 12 inches lower than the required height.

PEN 2 Cross-Levee: Peninsula Drainage Canal
The cross-levee is narrow in width and has steep walls. The level of existing water in the Peninsula Drainage Canal is lower than the 1% annual chance flood elevation. This inequality in water level causes instability in the levee and can result in a large amount of erosion, which can cause failure. This risk would be an issue in the event that PEN 2 or MCDD floods.
The Peninsula Drainage Canal is designated as a Special Habitat Area (SHA). It is home to sensitive species (including the Western painted turtle) and is also a migratory stopover habitat and a wildlife connectivity corridor. Any modification to the levee structure must evaluate the impacts to these species and existing habitat.

Source: Oregon Solutions, 2014

The minimum standard used by FEMA for accreditation (44 Code of Federal Regulation 65.10) is to reduce flood risk for a 1% annual chance flood elevation. Some cities in the United States have opted to protect to a higher 0.5% annual chance or 0.2% annual chance elevation. Because river systems vary widely, USACE selects a unique design standard for each levee's inclusion and rating in its Rehabilitation and Inspection Program. For the Columbia Corridor levee system, The PEN 1 levee system is authorized for the 1876 flood, meaning it was designed to withstand the magnitude of the 1876 flood. The PEN 2 is also authorized for the 1876 flood, but some modifications make certain portions of the system authorized for the Levee Design Flood, or the 1894 flood, accounting for floodwater storage since dam construction (a modeled flood). MCDD and SDIC levees are both authorized for the Levee Design Flood. The Levee Design Flood is a higher standard than the 1% annual chance flood used by FEMA.

Why should the levees meet federal standards?

Levees are maintained to modern standards for public safety and flood risk reduction.

Property owners are not required to buy flood insurance if levees are accredited.

Property owners can acquire low cost flood insurance through the National Flood Insurance Program.

Floodplain development code standards do not apply to developments protected by levees.

- Oregon Solutions, 2014

The engineering assessments did not include seismic assessment, climate change, or potential Columbia River Treaty scenarios (Oregon Solutions, 2014). The historical trends do not take into account future climate change projections (Multnomah County, 2014). As part of the current levee accreditation process, climate change modeling is being conducted in partnership with the U. S. Geological Survey (USGS) and USACE and should be completed in 2017 (Oregon Solutions, meeting notes, August 17, 2015).

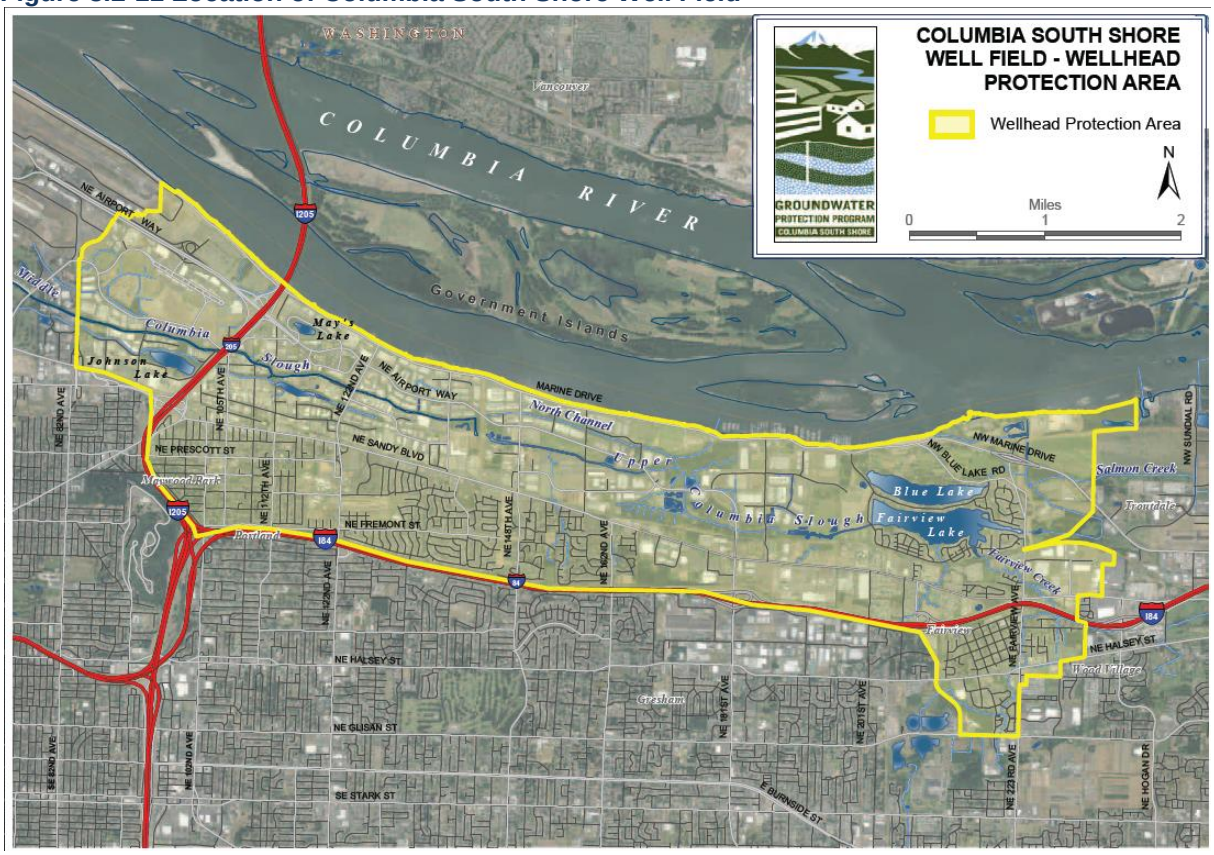
Analysis of the MCDD and SDIC levees began in 2016 and is overseen by Levee Ready Columbia. Preliminary discussions of potential vulnerabilities for these districts have included the following (Levee Ready Columbia Meeting Notes, Oct. 2, 2015):

- **MCDD:** Extensive beaver dens are located at the waterward toe of the levee near Blue Lake Park. MCDD is working on an animal management plan to find options for minimizing damage from beaver habitat.

- **SDIC:** There is one pump station from the 1950s with two pumps, one of which requires immediate repair and another that needs to be repaired or updated soon. Few encroachments on the levee are anticipated due to slow development growth in this area.

Another consideration for flood vulnerability in the levee districts is the presence of many industrial sites that contain hazardous materials. While proper management of these materials should minimize spills or leaks that could contaminate flood waters, the potential impact of contaminated flood waters is high due to the location of the Columbia South Shore Well Field Protection Area that covers a large portion of the Columbia Corridor Drainage Districts (**Figure 3.2-11**). The Portland Water Bureau's Groundwater Protection Program and the City of Gresham's Well Field Protection Program offer more information about reducing risk of groundwater contamination.

Figure 3.2-11 Location of Columbia South Shore Well Field



Source: Columbia South Shore Groundwater Protection Program

MCDD has been working on mapping potential inundation depths within the levee districts should a breach occur. Those maps are currently in progress and will be used at a later date to do a more thorough estimate of potential losses from different levee breach scenarios. MCDD also has been working on emergency response and evacuation planning with each jurisdiction, with land within the districts. Currently, the City of Portland has completed a draft evacuation plan for the area from Smith and Bybee Lakes on the west to the city limits at NE 185th Avenue on the east (City of Portland, 2014).

Levees on Sauvie Island

The land uses protected by the levee system in Sauvie Island are rural, low-density residential and agriculture. Community input during the recent update of the Sauvie Island/Multnomah Channel Plan (2015) emphasized the importance of preserving the rural character of the community. The population and property at risk therefore will not increase substantially due to the community's planning policies and implementing codes.

Recent discussions about the vulnerabilities of the system managed by the SIDIC included the following issues (Levee Ready Columbia Meeting Notes, Oct. 2, 2015):

- There is one main pumping station with four smaller interior pumps. The newest pump was installed in 1964.
- There are encroachments in the levees along the Willamette River and Columbia River that are primarily residences built within the levee. Some of the houses were built before the levee system.
- Most water on the island comes in through seepage from the river — the island was naturally a system of lakes.

The seasonal farm worker population on the island presents a special consideration for Sauvie Island levee failure risk is. Many of the farm workers are Hispanic and may have language barriers. The farm workers also may lack their own transportation if evacuation were necessary.

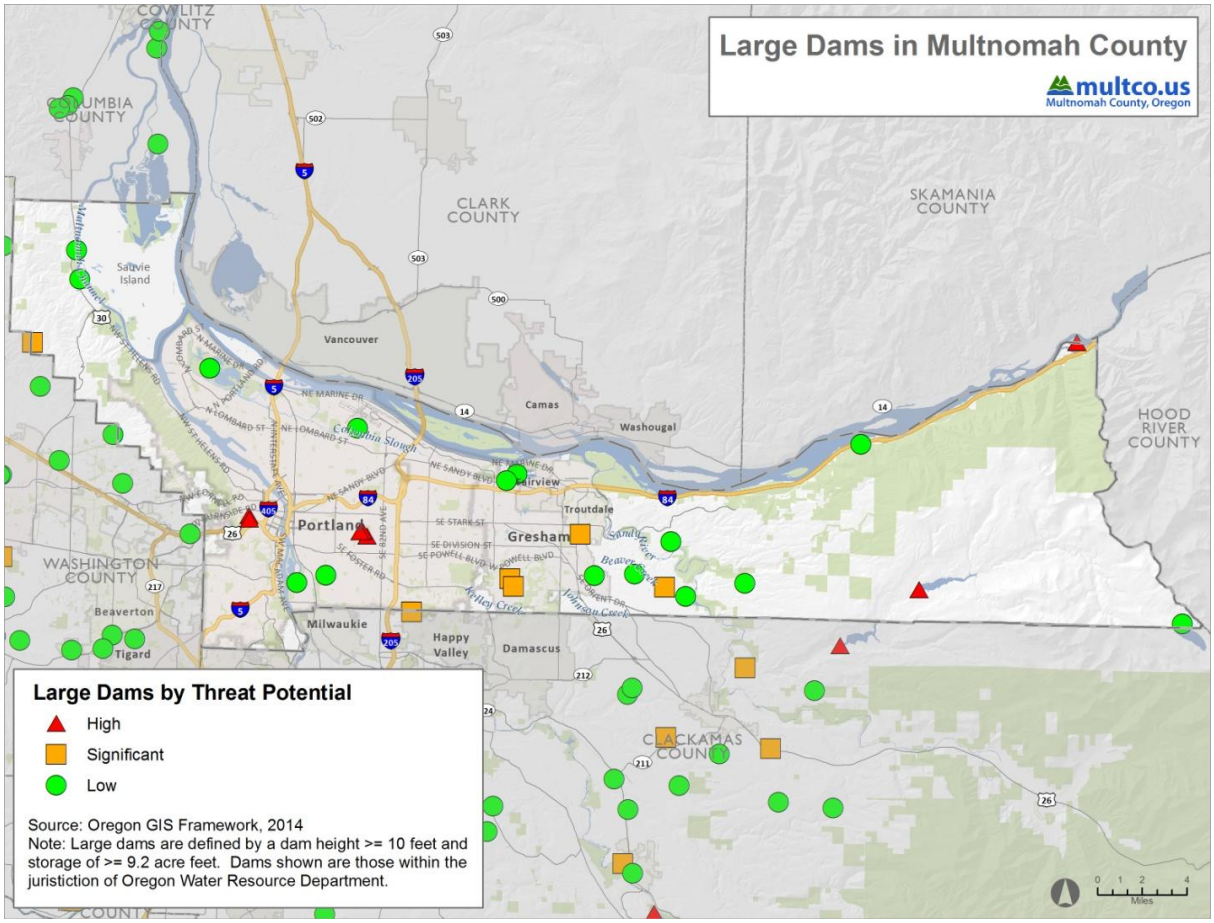
Dam Failure

If not maintained and operated correctly, dams can pose risks to people living downstream, who are often unaware they are in a potential inundation zone. When dams age, deteriorate or malfunction, they can release sudden, dangerous flood flows. Downstream development increases the potential consequences of a dam's failure. Many dams, should they fail, also can affect the delivery of essential utilities or flood control (FEMA, 2013).

The Oregon Water Resources Department uses the National Inventory of Dams (NID) threat potential methodology, and maintains an inventory of all large dams in Oregon. The inventory lists 26 dams in Multnomah County (**Figure 3.2-12** and **Table 3.2-12**) with the following threat potentials: 7 high, 5 significant, and 14 low. The downstream threat potential is defined by the Interagency Committee on Dam Safety as follows (USACE, 2008):

- **Low Potential:** Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- **Significant Potential:** Dams assigned the significant hazard potential classification are those where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impacts other concerns. Significant hazard potential classification dams often are located in predominantly rural or agricultural areas, but could be located in areas with population and significant infrastructure.
- **High Potential:** Dams assigned the high hazard potential classification are those where failure or mis-operation probably will cause loss of human life.

Figure 3.2-12 Dams in Multnomah County



Source: Oregon GIS Framework, 2014

Table 3.2-12 Multnomah County Dam Inventory

Dam	Height (ft.)	Storage (acre ft.)	River	Jurisdiction	Owner	Last Inspection	Threat Potential
BONNEVILLE DAM	110	277000	COLUMBIA RIVER	Multnomah	Corps of Engineers, Portland District	4/1/2008	HIGH
BULL RUN DAM 1 (UPPER)	194	33760	BULL RUN RIVER	Multnomah	City of Portland	7/6/2011	HIGH
PORTLAND #1 (MT.TABOR)	30	37	BULL RUN RIVER (OFFSTREAM)	Portland	City of Portland	6/28/2011	HIGH
PORTLAND #3 (WASHINGTON PARK)	53	50	BULL RUN RIVER (OFFSTREAM)	Portland	City of Portland	9/15/2014	HIGH
PORTLAND #4 (WASHINGTON PARK)	60	54	BULL RUN RIVER (OFFSTREAM)	Portland	City of Portland	9/15/2014	HIGH
PORTLAND #5 (MT.TABOR)	55	153	BULL RUN RIVER (OFFSTREAM)	Portland	City of Portland	6/28/2011	HIGH
PORTLAND #6 (MT.TABOR)	28	230	BULL RUN RIVER (OFFSTREAM)	Portland	City of Portland	6/28/2011	HIGH
BINFORD DAM	25	30	HIENY CREEK	Gresham	City of Gresham	7/25/2014	SIGNIFICANT
MT. HOOD COMMUNITY COLLEGE DAM	58	25	KELLY CREEK	Gresham	Mt. Hood Community College	1/13/2014	SIGNIFICANT
PEYRALANS RES.	23	12	BUTLER CREEK	Gresham	Marpol Ridge HOA	3/14/2013	SIGNIFICANT
SESTER, WILLIAM H. RES. 1	32	55	BEAVER CREEK, TRIB TO	Multnomah	William H. Sester	4/18/2013	SIGNIFICANT
VAN RADEN	27	115	ROCK CREEK	Multnomah	Fred & Kenneth Raden	5/28/2014	SIGNIFICANT
BELCHERS DAM	28	30	MIDDLE FORK BEAVER CREEK	Multnomah	Darrold Belcher/Dan Belcher	9/14/2010	LOW
BULL RUN LAKE DAM	55	14500	BULL RUN RIVER	Multnomah	City of Portland	4/28/1995	LOW
CRAMPTON, RAYMOND	18	16		Multnomah	Raymond Crampton	4/7/2009	LOW
DIACK RESERVOIR	26	20	SANDY RIVER, TRIB OF	Multnomah	Samuel L. Diack	4/8/2009	LOW
FAIRVIEW LAKE	18	411	COLUMBIA SLOUGH	Fairview	City of Fairview	3/12/2014	LOW
KELLY CREEK REGIONAL DETENTION POND	20	67		Gresham		3/15/2011	LOW
MULTNOMAH CHANNEL DAM #1	8.6	203	TRIB/COLUMBIA RIVER	Multnomah	Metro Parks & Greenspaces		LOW
MULTNOMANH CHANNEL DAM #2	11.5	240	TRIB/COLUMBIA RIVER	Multnomah	Metro Parks & Greenspaces	8/25/2010	LOW
OAKS BOTTOM (PTD PARKS)	9	451		Portland			LOW
OSBURN RESERVOIR	34	52	TROUT CREEK, TRIB TO	Multnomah	Tom Lehman	11/17/2011	LOW
PDX DE-ICING LAGOON	12	41		Portland	Portland International Airport	12/3/2010	LOW
REED LAKE	8	16.8	CRYSTAL SPRINGS CREEK	Portland	The Reed Institute		LOW
SMITH-BYBEE LAKES	14	4100	COLUMBIA SLOUGH	Portland	City of Portland	8/25/2010	LOW
WAHKEENA REARING RESERVOIR	19	180	WAHKEENA CREEK	Multnomah	ODFW	11/15/2011	LOW

Source: Oregon Water Resources Department, "Dam Inventory Query"

Currently, dam breach inundation zones are not shown on FIRMs as areas requiring flood insurance. Even though it is not required, buying flood insurance to protect a financial investment in homes and businesses located below dams may be wise. Dam breach inundation zones may far exceed the 1% annual chance flood zones mapped by FEMA. Dam failure floods are almost always more violent than normal stream or river floods (FEMA, 2013).

However, dam failures or partial failures are not usually caused by storm events. Most failures fall into one or more of the following categories (FEMA, 2013):

- **Structural Failures:** Foundation defects, including settlement and slope instability, or damage caused by earthquakes, have caused about 30% of all dam failures in the United States.
- **Mechanical Failures:** Malfunctioning gates, conduits or valves can cause dam failure or flooding both upstream and downstream, and account for about 36% of all dam failures in the United States.
- **Hydraulic Failures:** Overtopping of a dam often is a precursor to dam failure. National statistics show that overtopping due to inadequate spillway design, debris blockage of spillways or settlement of the dam crest accounts for approximately 34% of all dam failures in the United States.

In addition to the dams within Multnomah County, there are four dams on the Lewis River in Washington that could impact low-lying areas along the Columbia and Willamette rivers in Multnomah County. These dams are classified as having high downstream threat potential with more than 300 lives at risk (Department of Ecology, 2015).

The North Fork of the Lewis River flows from the slopes of Mt. Adams into the Columbia River about 19 miles east of Vancouver, Washington. PacifiCorp Energy operates four dams on this river. Computer modeling of hypothetical domino failures of the dams was conducted for the purposes of developing an Emergency Action Plan to notify the public and plan for evacuation. The worst case scenario dam failure included flood conditions that could impact low-lying areas along the Columbia and Willamette rivers in Multnomah County. This scenario included large portions of Sauvie Island. Because of the need to protect critical energy infrastructure information, these inundation scenario maps cannot be released. However, they did inform the development of procedures to provide early warning to people within the inundation zone who could be affected by the sudden release of water caused by natural disaster, accident, or failure of any component of the system of dams.

Other Hazards That Can Impact Flooding

Wildfires change the water conditions of a watershed, such as how fast water can move, and how vulnerable the land surface is to erosion. This can result in more severe flooding and mud or debris flows. These secondary impacts from a wildfire can damage property and infrastructure. For instance, if a dam is in an area impacted by a wildfire, this could increase the risk of dam failure by increased water flow or sedimentation and debris obstructing spillways (Department of Ecology, no date).

Both dams and levee systems are vulnerable to seismic activity. However, based on the 2001 USACE study of the seismic performance of the Columbia River Levee, a seismic event by itself would not result in interior flooding, unless a major flood event was in progress. The study also highlights that there is no known correlation between high-water periods and earthquakes. Though the study considered only a small section of the levee in front of the airport, and not all levees perform the same, the fact remains that there is no known correlation between high-water periods and earthquakes. Therefore, the likelihood of a major flooding event on the Columbia River and an earthquake occurring at the same time is very low.

3.2.5 References

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