SUBSECTION-SECTION 4T.13

PUYALLUP TRIBE ALL HAZARD MITIGATION PLAN
DAM FAILURE HAZARD

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Identification Description

Definition

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

Types

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

Profile

Location and Extent

The Washington Department of Ecology's inventory of dams, lists 57 dams or retention facilities either totally in Pierce County or shared jointly with another county. Of these 46 have a peak storage capacity of 10 or more acre-feet. Of the 57dams 27 of them are listed as being of either high or significant hazard. (See Table 4.13-1Pierce County Dams that pose a high or significant risk to the public.) Many of these, even though they are located in portions of the county with a low population base are a hazard because of the quantity of water they impound. (See Map 4.13-1Pierce County High and Significant Risk Dams.) This is the case with Alder, La Grande, and Mud Mountain Dams. A catastrophic failure of any of these could impact community's miles downstream. Others are listed as hazardous not because of the quantity of water they could release, but rather because of their proximity to the public. There could be tens to hundreds of people or businesses located in a close proximity to the flow from a failure. It should be

Figure 4.13-1 Reasons for Dam Failures Nationally[3]

OVERTOPPING – 34% of all failures
- Inadequate Spillway Design
- Debris Blockage of Spillway
- Settlement of Dam Crest

FOUNDATION DEFECTS – 30% of all failures
- Differential Settlement
- Sliding and Slope Instability
- High Uplift Pressures
- Uncontrolled Foundation Seepage

PIPING AND SEEPAGE – 20% of all failures
- Internal Erosion Through Dam Caused by Seepage– "Piping"
- Seepage and Erosion Along Hydraulic Structures Such as Outlet
- Conduits or Spillways, or Leakage Through Animal Burrows
- Cracks in Dam

CONDUITS AND VALVES – 10% of all failures
- Piping of Embankment Material Into Conduit Through Joints or Cracks

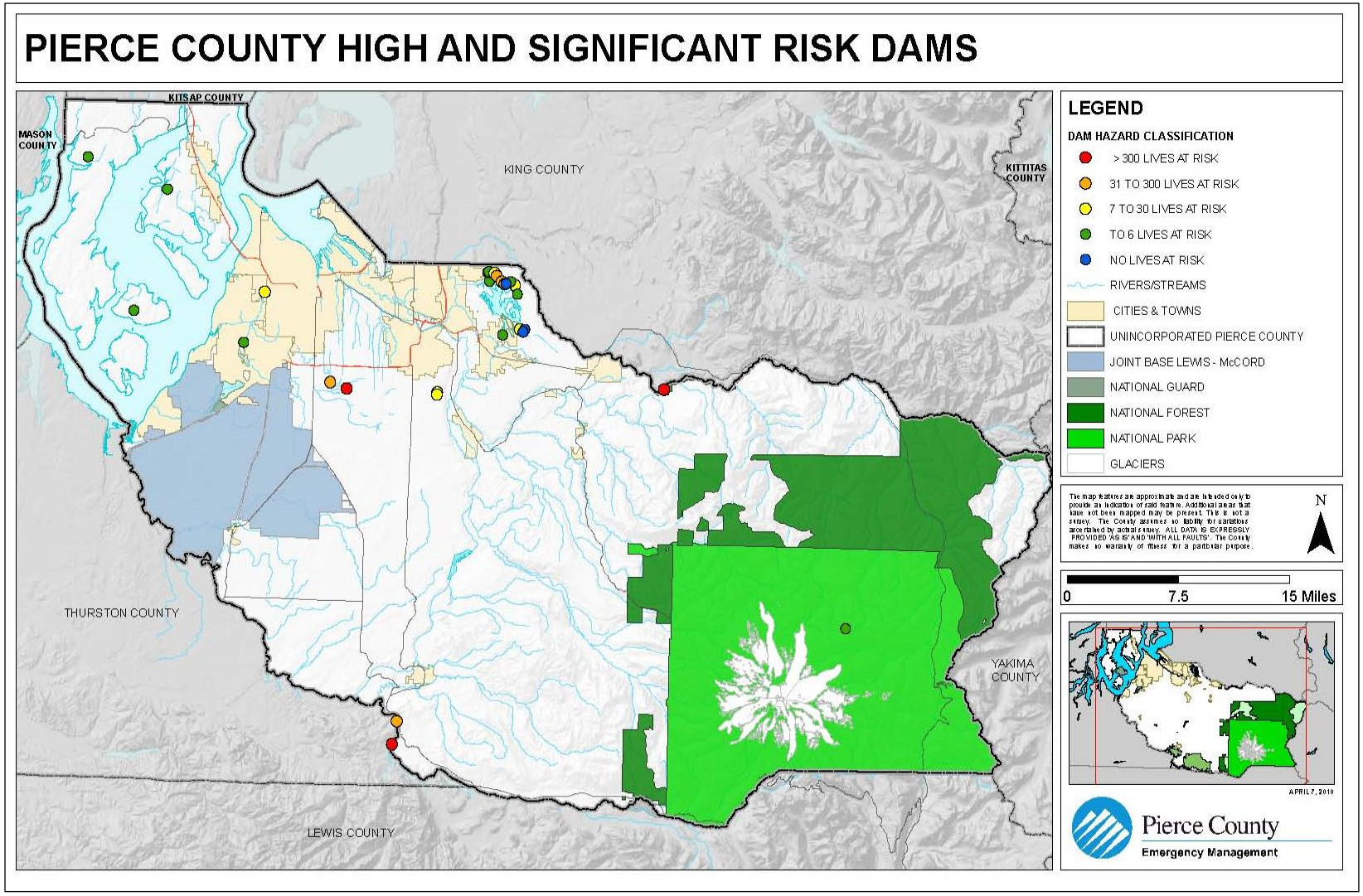
OTHER - 6% of all failures

Table 4.13-1 Pierce County Dams that Pose a High or Significant Risk to the Public.

Name	Hazard Class*	Owner	River or Stream	TWN RNGE SEC	Type**	Purpose†	Crest	Height	Normal Storage‡	Max Storage‡	Max Discharge
Alder Dam	1A	Tacoma. P. U.	Nisqually R.	T15N R04E S09	VA	H, R	1550 ft	330 ft	231,936	241,950	85,000 cfs
Butterworth Dam	2	WA DFW Eng.	Eden Creek	T15N R04E S20	RE	I, S	300 ft	61 ft	2050	2450	25 cfs
Frozen Lake Dam	2	US DOI NPS	Tributary – White R.	T17N R09E S33	RE	R, S	215 ft	19 ft	64	76	0 cfs
Leach Creek Stormwater Detention Dam	1C	Tacoma P. W.	Leach Creek	T20N R02E S14	RE	C	1000 ft	10 ft	1	110	280 cfs
McMillin Reservoir No.1 N. Dam	1C	Tacoma P. U.	Tributary - Puyallup R.- Offstream	T19N R04E S14	RE	S	2200 ft	30 ft	165	165	0 cfs
McMillin Reservoir No.1 S. Dam	1C	Tacoma P. U.	Tributary - Puyallup R.- Offstream	T19N R04E S14	RE	S	2200 ft	30 ft	166	166	0 cfs
North Fork Clover Creek E1 Detention Basin	1A	Pierce Co.	N Fork Clover Creek	T19N R03E S14	RE	C, Q	850 ft	10 ft	1	135	749 cfs
North Fork Clover Creek E1 Detention Facility	1B	Pierce Co.	N Fork Clover Creek, W Branch	T19N R03E S10	Unknown	C	1090 ft	10 ft	85	104	1260 cfs
Slavic Lake Dam	2	Slavic Christian Center	Offstream	T22N R01W S35	RE	R	40 ft	8 ft	8	10	30 cfs
Steilacoom Lake Dam	2	J & Z Dev	Chambers Creek	T20N R02E S34	PG	F, R	120 ft	28 ft	2640	6970	1980 cfs
Sylvia Lake Dam PC	2	Sylvia Lake. Country Club	Tributary - Puget Sound	T21N R01E S11	RE	R	387 ft	25 ft	67	124	160 cfs
Tapps Lake Backflow Prevention Structure	1C	PSE	N/A	T20N R05E S26	PG	R, S	73 ft	21.5 ft	0	46,655	1000 cfs
Tapps Lake Dike No. 1	2	PSE	Diversion from White R.	T20N R05E S09	RE	H, R	200 ft	18 ft	19,000	22,000	0 cfs
Tapps Lake Dike No.11	1C	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	1600 ft	23 ft	36,000	38,000	0 cfs
Tapps Lake Dike No.12	2	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	1250 ft	14 ft	23,000	25,000	0 cfs
Tapps Lake Dike No.2A	2	PSE	Diversion from White R.	T20N R05E S05	RE	H, R	350 ft	9 ft	18,000	20,000	0 cfs
Tapps Lake Dike No.2B	2	PSE	Diversion from White R.	T20N R05E S04	RE	H, R	300 ft	16 ft	26,000	28,000	0 cfs
Tapps Lake Dike No.3	1C	PSE	Diversion from White R.	T20N R05E S04	RE	H, R	600 ft	15 ft	26,000	28,000	0 cfs
Tapps Lake Dike No.4	1B	PSE	Diversion from White R.	T20N R05E S09	RE	H, R	4000 ft	45 ft	56,000	58,340	0 cfs
Tapps Lake Dike No.5	1B	PSE	Diversion from White R.	T20N R05E S09	RE	H, R	500 ft	24 ft	38,000	40,000	0 cfs
Tapps Lake Dike No.6	1B	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	600 ft	26 ft	41,000	43,000	0 cfs
Tapps Lake Dike No.8	2	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	350 ft	20 ft	32,000	34,000	0 cfs
Tapps Lake Dike No.9	2	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	250 ft	15 ft	24,000	26,000	0 cfs
Tapps Lake Dike No.10	2	PSE	Diversion from White R.	T20N R05E S10	RE	H, R	700 ft	19 ft	30,000	32,000	0 cfs
Tapps Lake Dike No.13	2	PSE	Diversion from White R.	T20N R05E S27	RE	H, R	350 ft	6 ft	8000	10,000	0 cfs
Mud Mountain Dam	1A	US ACE	White R.	T19N R07E S17	ER	C	700 ft	425 ft	106,000	156,000	245,000 cfs
La Grande Dam	1B	Tacoma P. U.	Nisqually R	T16N R04E S04	PG	H, R	710 ft	217 ft	2676	3015	88,000 cfs

***Hazard Classes: 1A – High Hazard, greater than 300 lives at risk, 1B – High Hazard, 31 to 300 lives at risk, 1C – High Hazard, 7 to 30 lives at risk, 2 – Significant Hazard, 1 to 6 lives at risk.**
****Type: ER – Rock Fill Dam, PG – Concrete Gravity Dam, RE – Earth Fill Dam, VA – Concrete Single Arch Dam.**
†Purpose: C – Flood Control & Storm Water Management, F – Fish & Wildlife, H – Hydroelectric, I – Irrigation, Q – Water Quality, R – Recreation, S – Water Supply
‡All dam storage numbers are in acre-feet. One acre-foot is the quantity needed to cover one acre to the depth of one foot or 43,560 cubic feet, or 325,851 gallons.

Map 4.13-1 Piece County High and Significant Risk Dams



noted that a dam failure can happen at any time and be caused by anything. The failure of the Seminary Hill Reservoir in Centralia occurred during the drought of 1991,[4] and the Upriver Dam failure in Spokane, was caused by a lightning strike. (See Table 4.13-2 Select Dam Failures in Washington State.)

Occurrences

There have been a number of dam failures in Washington State over the past 100 years, some of which are shown in Table 4.13-2, but a review of the literature has not turned up any in Pierce County.

Table 4.13-2 Select Dam Failures in Washington State[5,6]

Dam	Location	Failure Date	Nature of the Failure and Damage
Masonry Dam (Boxley Burst)	Near North Bend	12/23/1918	Excessive seepage through the glacial moraine abutment caused mud flow about one mi. from reservoir. It destroyed a RR line and village of Eastwick.
Eastwick Railroad Fill Dam	Near North Bend	02/1932	A landslide blocking a culvert caused a RR fill dam to fail destroying a portion of the RR tracks, the village of Eastwick and killing seven residents.
Loup Loup Dam	Near Malott	April 1938	A 50 foot high hydraulic fill dam failed when emergency spillway was undercut during a flood. It destroyed ½ mile of state highway, 25 homes and left 75 people homeless.
Lake Dawn Dam	Port Angeles	February 1950	Heavy Rains caused overtopping and failure of the earthen dam. one home destroyed and $4000 damage
North Star Sand & Gravel Dams	Everett	December 1967	A 40 foot high dam washed out by overtopping due to lack of spillway. 25 foot high dam rebuilt, also failed, washed out Great Northern RR tracks and derailed a passing train
Pillar Rock Dam	Wahkiakum Co.	January 1970	A logging road fill culver was blocked by debris. It overtopped and failed. That caused a 25 foot high concrete gravity dam to fail. three homes and a fish cannery were destroyed.
Sid White Dam	Near Omak	May 1971	Earthen dam failed due to seepage through animal burrows. Caused a second dam to fail and dumped debris into the town of Riverside.
Alexander Lake Dam	Near Bremerton	December 1982	Spillway undermined and failed during heavy rains. Caused damage at fish hatchery and homes in Gorst
Upriver Dam	Spokane	May 20, 1986	Hydropower facility failed by overtopping. Lightening struck the system causing the turbines to shut down. Water rose behind the dam while they were trying to restart the turbines. Backup power systems failed and the spillway gated could not be raised in time. Caused $11 million in damage to the facility
Chinook Dam	Pacific County	Thanksgiving Weekend 1990	Heavy rains overtopped the embankment and undermined the spillway, leading to failure of the dam. Approximately $100,000 damage to the facility
Seminary Hill Reservoir	Centralia	October 05 1991	Failure along weak rock zone in a hillside caused a massive slide which breached the reservoir. three million gallons of water drained from the reservoir in three minutes. two homes were destroyed, many homes damaged, $3 million in damage.
Iowa Beef Processors Waste Pond Dam No. 1	Wallula near Richland	January 25, 1993	Failure of 15 foot high embankment released 300 acre-feet of waste water. Failure attributed to high reservoir levels due to snowmelt, entering animal burrows near the embankment crest, and eroding the dam. Washed out the Union Pacific RR tracks, derailed five locomotives and caused $5 million in damage.
Mill Creek Dam	Cosmopolis and Aberdeen	November 12, 2008	Pedestrian bridge washed out; residential areas flooded; ~12 homes received flood damages

Recurrence Rate

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

Vulnerability

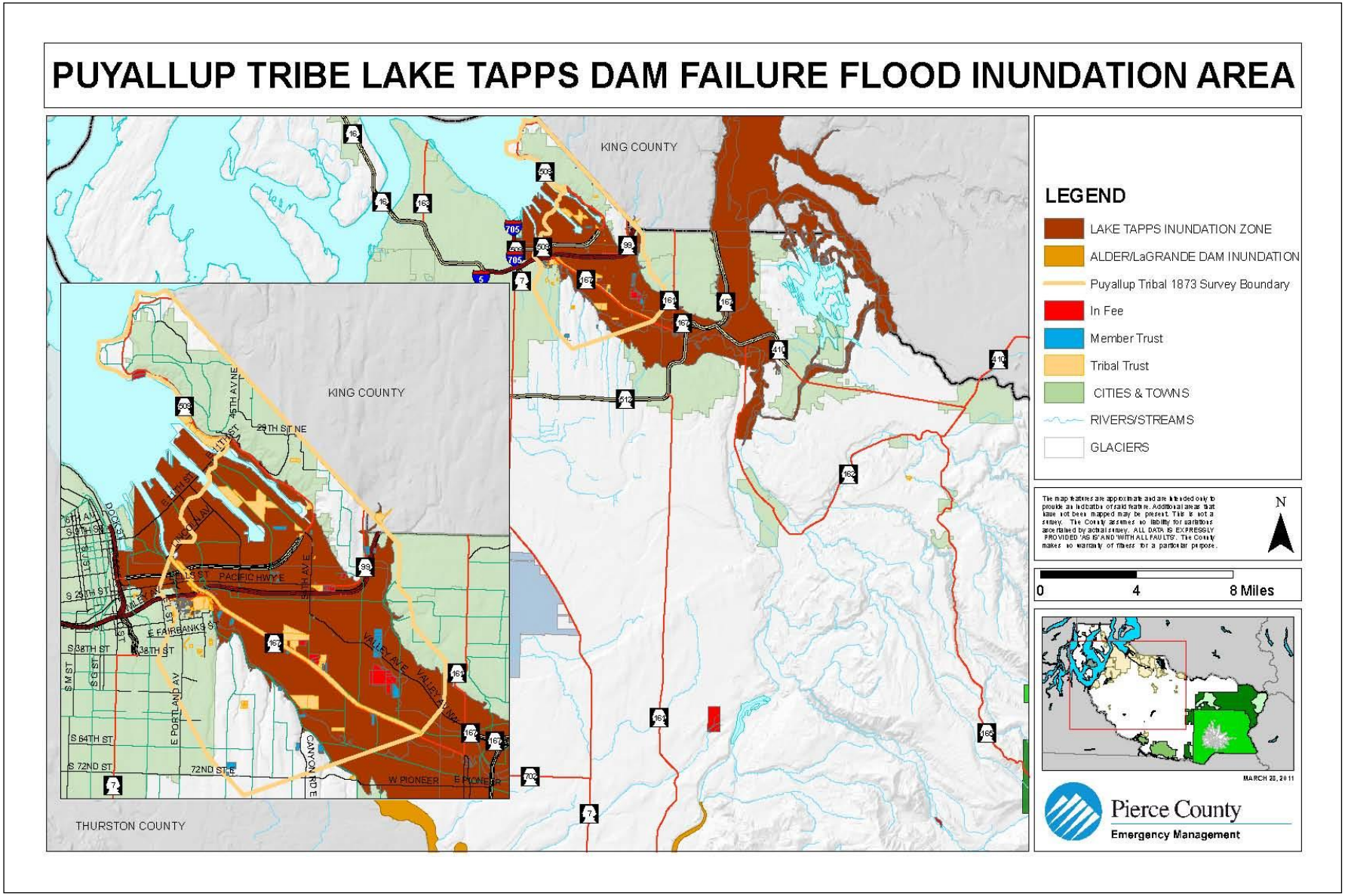
The Planning Team determined that the Planning Area has a low vulnerability to dam failure hazards because of the low recurrence rate across the state and specifically the Planning Area. In the entire Planning Area, over 16,000 acres are vulnerable to the two significant at risk dams, Mudd Mountain Dam and Lake Tapps.

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 7,935.44 acres (50.9% of the Planning Area) are located within the inundation zone (see Map 4.13-2 and Map 4.13-3). The total estimated losses to these parcels would equal a little over $4 billion (the assessed value of all parcels in the inundation hazard area, October 2016).

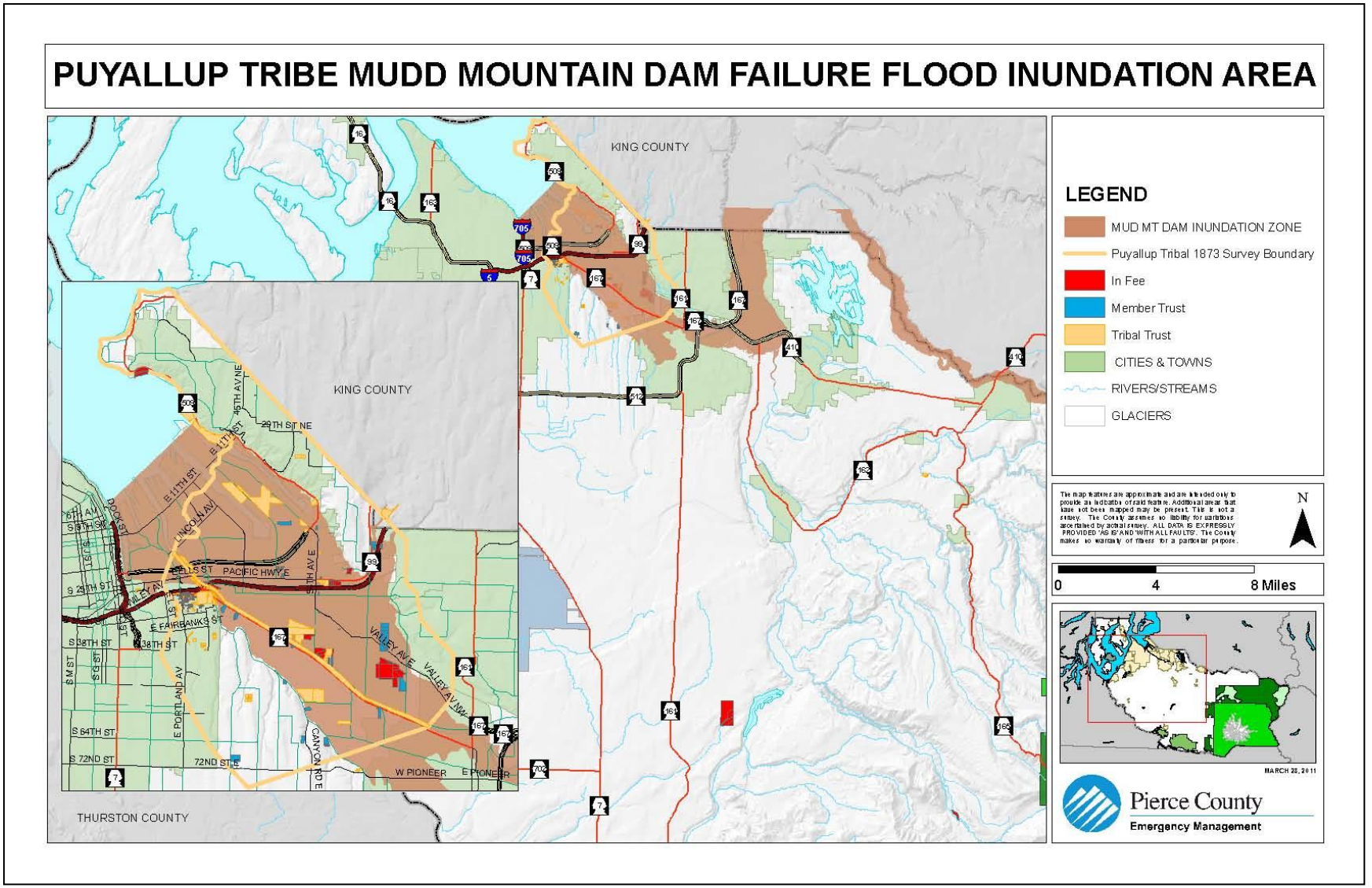
For Tribal Trust parcels located in the Planning Area, all 485 parcels are vulnerable to dam failure flooding. The total estimated losses to these parcels would equal $300 million (the assessed value of all Tribal Trust parcels, October 2016). Of the 485 Tribal Trust parcels in the Planning Area, 169 parcels (34.8%) are located in the dam failure inundation areas. The total estimated losses to these parcels would equal $234,276,900.

A further detailed description follows identifying the impacts on the Planning Area should either of these dams fail. There would be a catastrophic aftermath impacting not only the Planning Area but the region for months to come. Along with a major port, critical interstate highways and infrastructure would need to be rebuilt and thousands of lives would be lost.

Map 4.13-2 Puyallup Tribe of Indians Dam Failure Flood Inundation from Lake Tapps



Map 4.13-3 Puyallup Tribe of Indians Dam Failure Flood Inundation from Mudd Mountain Dam



Impacts

Figure 4.13-2 Mud Mt. Dam Intake[7]

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

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

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

Any individual dam has a very specific area that will be impacted by a catastrophic failure. Those dams listed above in Table 4.13-1 above are those that directly threaten the lives of individuals living or working in the inundation zone below the dam. The impact from any catastrophic failure would be similar to that of a flash flood. Lives could be lost. There could be injuries from impacts with debris being carried by the flood. With the cold water and cold air temperature for much of the year hypothermia could exacerbate many of the problems for those rescued and contribute to the number of drowning deaths.

Because of their small size, or their location in uninhabited areas, thirty dams in Pierce County are not shown on Table 4.13-1. While it cannot be precluded, these dams are not expected to cause death or injury to individuals. However, it is possible that an individual or group of individuals could be in the wrong place at the wrong time and become a casualty of one of them failing.

Health and Safety of Personnel Responding to the Incident

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

Continuity of Operations and Delivery of Services

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

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

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

Property, Facilities, and Infrastructure

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

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

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

Environment

Any dam that fails has a detrimental impact on the environment. This will vary depending on the size of the failure. Small dams will probably only impact a very small portion of the environment downstream. In the other extreme, the scouring action of a large quantity of water will destroy all vegetation in its path, for a very large dam even taking out forested areas. Like any flash flood, this will destroy any wildlife caught in the flow. Fish habitat including spawning beds could be destroyed. Unlike most floods the force of the water from a large dam failure will have a major scouring impact on portions of the valley. In some areas it will take off most if not all topsoil

limiting the ability of the environment to return to normal. It could take years for the natural restorative processes to bring back an ecosystem similar to what was there beforehand.

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

Economic and Financial Condition

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

As the size of the dam increases and the proximity to the public and/or critical infrastructure increases, the probability of damage to economy increases. Any of the dams listed in Table 4.13-1 could have an impact on the either the overall economy or on the financial condition of many of the businesses or homeowners located in the inundation zones from those dams.

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

Public Confidence in the Jurisdiction's Governance

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

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

When a dam fails that directly impacts the public, especially if there are deaths associated with it, there will be considerable scrutiny of why it happened. The next point will be to ask the date of the last inspection and what were its results. If an inspection was conducted multiple years ago questions will arise concerning why it was not done more recently. This will be especially critical if it is shown that the dam in question was not inspected at the rate recommended by FEMA.[8] This is summarized by the State of Washington:

> Guidelines for dam safety prepared by the Federal Emergency Management Agency recommend annual inspections of high hazard dams (3 or more homes at risk), a 2-year interval for significant hazard dams (1 or 2 homes at risk), and a 5-year interval for low hazard dams (no homes at risk).[9]

Current inspection requirements as listed in the Washington Administrative Code [10] are:

> (1) As authorized by RCW 43.21A.064, the department has the authority to conduct routine periodic inspections of all existing dams with high and significant downstream hazard classifications to reasonably secure safety to life and property.
>
> • Dams with high downstream hazard classifications will be inspected every five years.
>
> • Dams with significant downstream hazard classifications will be inspected every five years, or ten years if workload or staffing necessitates a longer cycle between inspections.
>
> • Dams classified as low hazard are not included in the periodic inspection program.

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

Resource Directory

Regional

- **Pierce County Department of Emergency Management**
  http://www.co.pierce.wa.us/PC/Abtus/ourorg/dem/abtusdem.htm
- **Washington State Department of Ecology, Dam Safety Office**
  http://www.ecy.wa.gov/programs/wr/dams/dss.html

National

- **FEMA National Dam Safety Program**
  http://www.fema.gov/plan/prevent/damfailure/ndsp.shtm

Endnotes

[1] Dam, Washington Department of Ecology, Glossary at http://www.ecy.wa.gov/programs/wr/cwp/images/pdf/legsrpt/chptr7_glossry_111506.pdf

[2] Dam Failure, NOAA, National Weather Service, Glossary at http://www.nws.noaa.gov/glossary/index.php?letter=d

[3] Notable Dam Failures, Washington State Department of Ecology, http://www.ecy.wa.gov/PROGRAMS/wr/dams/failure.html

[4] Seminary Hill Reservoir, Department of Ecology http://www.ecy.wa.gov/programs/wr/dams/seminary.html

[5] Notable Dam Failures and Incidents in Washington State, Department of Ecology http://www.ecy.wa.gov/programs/wr/dams/Reports/damfailure_ws.pdf

[6] Information on the Mill Creek Dam failure came from Dam Failures, Dam Incidents (Near Failures), Association of State Dam Safety Officials, http://www.damsafety.org/media/Documents/PRESS/US_FailuresIncidents.pdf

[7] Mud Mountain Dam and intake structure showing the dam in its normal empty state. Photo from the Army Corps of Engineers – Seattle District.

[8] Federal Guidelines for Dam Safety, prepared by the Interagency Committee on Dam Safety, Federal Emergency Management Agency, June 1979, reprinted April 2004, pp. 39-42.

[9] Water Resources Program Policy 5404, Washington State Department of Ecology, Dam Safety Office as shown at http://www.ecy.wa.gov/programs/wr/rules/images/pdf/pol5404.pdf

[10] WAC 173-175-705 Periodic inspection by the department, as shown at http://apps.leg.wa.gov/wac/default.aspx?cite=173-175-705