3.15. Risk Assessment: Dam Failure

Description

Compared to other flood hazards in Idaho, dam failures are rare. However, because they release high flows into river channels with little or no advance warning, similar to flash flooding, they can cause significant damage and loss of life. The 1976 failure of the Teton Dam is an example of this hazard.

Three factors generally influence the potential severity of a dam failure: the height of the dam, the amount of water impounded, and the extent of development and infrastructure located downstream. If the river downstream of a dam has extensive development, then the dam's failure can lead to significant loss of life, property damage, and economic impact.

Definitions

A **dam** is an artificial barrier constructed across a watercourse to store, control, or divert water, mine tailings slurry, wastewater, or liquefied industrial or food processing byproducts. Dams can take many forms, and may not be immediately obvious. They typically are constructed of earth, rock, or concrete. Most have a section called a spillway or weir over or through which water flows, either intermittently or continuously. Some have hydroelectric power generation systems installed.

The storage area behind a dam commonly is referred to as the **reservoir** (such as the American Falls Reservoir behind the American Falls Dam on the Snake River, shown on Figure 3.1.A). The volume of storage in the reservoir is typically measured in acre-feet. An acre-foot is the volume of water that covers one acre of land to a depth of 1 foot (a little more than 325,000 gallons).

Figure 3.15.A. American Falls Dam and Reservoir on the Snake River

Source: U.S. Bureau of Reclamation

A **dam failure** is an uncontrolled release of impounded water or waste due to a catastrophic collapse, breach, or overtopping of the dam, resulting in downstream flooding.

Inundation zones are the areas that would be submerged by released water in the event of a dam failure. These zones can be estimated or modeled using known or assumed conditions, such as the storage capacity of the dam and the topography of the land downstream.

Dam Failure Causes

Dam failure occurs when structural or operational issues cause a dam to release dangerously high flows to downstream areas. Dam failures can result from any one or a combination of the following causes:

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures nationally, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures nationally.
- Failure due to piping and seepage accounts for 20 percent of all failures nationally. This includes internal erosion, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures nationally.
- The remaining 6 percent of dam failures nationally are due to miscellaneous causes that include but are not limited to:
    - Prolonged periods of rainfall or snowmelt that cause flow at the dam to exceed the design capacity of the emergency spillway
    - Poor design, including inadequate spillway capacity, resulting in overtopping of the dam
    - Lack of necessary maintenance and/or repair of deficient components
    - Improper construction, including the use of inadequate construction materials and practices
    - Negligent operation, including the failure of the dam owner to implement previously recommended safety features, practices, or standards of care
    - Failure of upstream dams on the same waterway
    - Earthquakes or landslides into reservoirs, which cause surges that result in overtopping
    - High winds, which can cause significant wave action and result in substantial erosion

Regulatory Oversight

Idaho Department of Water Resources Dam Safety Program

For regulatory purposes, the Idaho Department of Water Resources (IDWR) Dam Safety Program defines a dam as any artificial barrier or embankment constructed to store water that is at least 10 feet high and can store 50 acre-feet or more. For this definition, the dam height is measured from the natural bed of the stream on the downstream side of the barrier (or from the lowest elevation of the outside limit of the barrier, if it is not across a stream) to the maximum water storage elevation.

The Dam Safety Program establishes requirements for proper planning, design review, construction oversight, and inspection of regulated dams and reservoirs. Dam Safety Program personnel regularly inspect existing projects according to the potential consequences of the dam's failure on downstream life

and property. The frequency of individual dam inspections depends on the project's physical condition, method of construction, maintenance record, age, hazard rating, and size and storage capacity. All statutory-sized dams must be inspected by the Department at least every 5 years.

Regardless of size, any water storage embankment may be regulated for public safety if IDWR determines that its potential would result in significant damage to downstream life or property (IDWR 2020a). As of 2020, IDWR regulates more than 500 water storage dams and more than 20 mine tailings impoundment structures. Each has a size classification defined as follows:

- **Large**—40 feet high or more, or with a storage capacity of more than 4,000 acre-feet of water. *104 dams are currently listed as large*.
- **Intermediate**—Between 20 and 40 feet high or with a storage capacity of 100 to 4,000 acre-feet of water. *198 dams are currently listed as intermediate*.
- **Small**—20 feet high or less, with a storage capacity of less than 100 acre-feet of water. *244 dams are currently listed as small*.

The Idaho Dam Safety Program also classifies dams and reservoirs in a three-tier hazard rating system based on the potential consequences to downstream life and property that would result from a failure of the dam and sudden release of water (IDWR, 2020b):

- **High Hazard**—High-hazard dams are those whose failure likely would cause direct loss of human life and extensive property damage. IDWR defines extensive property damage as the inundation of residential structures with floodwater from a dam break to a depth greater than or equal to 2 feet. All high-hazard dams must be properly designed and at all times responsibly maintained and operated. An up-to-date emergency action plan is required.
- **Significant Hazard**—Significant-hazard dams are those whose failure would result in significant damage to developed downstream property and infrastructure or that may result in an indirect loss of human life. An example of indirect loss of life would be a scenario where a roadway is washed out and people are killed in an automobile crash caused by the damaged pavement.
- **Low Hazard**—Low-hazard dams typically are in sparsely populated areas that would be largely unaffected by a dam breach. Even if the dam were totally destroyed, damage to downstream property would be restricted to undeveloped land with minimal impact on infrastructure.

U.S. Army Corps of Engineers Dam Safety Program

The National Dam Safety Act (Public Law 92-367) requires a periodic engineering analysis of every major dam in the country. The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect the lives and property of the public.

The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety.

The USACE Dam Safety Program uses risk to inform how it manages the approximately 700 dams it operates and maintains, with life safety the highest priority. This approach is a best practice adopted to evaluate, prioritize and justify dam safety decisions. Using risk information allows USACE to repair its dams in the most effective manner within a constrained budget.

Table 3.15.A shows the USACE classification system for the hazard potential of dam failures.

Table 3.15.A. Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 1995

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. There are 3,036 dams that are part of regulated hydroelectric projects are in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC staff inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent consulting engineer, approved by FERC, must inspect and evaluate projects with dams higher than 32.8 feet, or with a total storage capacity of more than 2,000 acre-feet.

FERC staff monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC staff visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation's Dam Safety Program was implemented under the 1978 Reclamation Safety of Dams Act (Public Law 95-578 and subsequent amendments). It requires dams to be safely operated and maintained, as ensured through inspections for safety deficiencies, analyses utilizing current technologies and designs, and implementation of corrective actions as needed.

Reclamation's Safety Evaluation of Existing Dams program performs site evaluations and identifies potential safety deficiencies on U.S. Department of Interior dams. The program identifies dams that pose a threat to the public and completes analyses to expedite corrective action decisions.

Reclamation's Safety of Dams program evaluates and implements actions to resolve safety concerns at Reclamation dams. The selected course of action relies on assessments of risk and liability with environmental and public involvement input to the decision-making process.

Water Infrastructure Improvements for the Nation Act

The 2016 Water Infrastructure Improvements for the Nation (WIIN) Act created a new grant program under FEMA's National Dam Safety Program. The grants fund technical, planning, design, and construction assistance for rehabilitation of eligible high-hazard-potential dams (HHPDs). High hazard potential refers to any dam whose failure or mis-operation would cause loss of human life and significant property destruction. States with a dam safety program or an equivalent state agency can apply for HHPD grants. Dams eligible for funding under this program are non-federal dams that:

- Are located in a state or territory with its own dam safety program
- Are classified as "high-hazard-potential" by the dam safety agency in the state or territory where the dam is located

- Have emergency action plans approved by the state or territory dam safety agency
- Fail to meet minimum dam safety standards or pose an unacceptable risk to the public, as determined by the state or territory.

Licensed hydroelectric dams and dams built under the authority of the U.S. Secretary of Agriculture are not eligible.

The WIIN Act requires state hazard mitigation plans to include a risk assessment of eligible dams. The dam failure risk assessment presented in this chapter meets that requirement for the State of Idaho.

Location, Extent, and Magnitude

Dam Locations

The 2016 National Inventory of Dams lists 473 dams in Idaho. Federal agencies own 36; state agencies own 16; local agencies own 19; public utility companies own 25; private entities own 372; and ownership of 5 dams is not listed. The dams listed meet at least one of the following criteria (FEMA 2020):

- High hazard potential
- Significant hazard potential
- Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
- Equal or exceed 50 acre-feet storage and exceed 6 feet in height.

The IDWR maintains a listing of 1,165 dams across Idaho (IDWR 2017). These include regulated, non-regulated, pending, reclaimed, and breached dams, as well as dams with no identified status. Figure 3.15.B displays the location of these dams throughout the state.

Watersheds

The Idaho Office of Emergency Management's Multi-Hazard Risk Portfolio contains maps, statistics, and information pertaining to watersheds. It includes flood risk ranking for Hydrologic Unit Code 8 watersheds (sub-basins) across the state. These rankings are based on population, property, and professional judgment. The Idaho Silver Jackets core team provided professional judgment for the rankings. Participating agencies ranked their top 10 sub-basins of focus, from the point of view of each agency's vision statement. Figure 3.15.C shows the ranking results. The most significant dam risk in each of the top 10 sub-basins is described in the sections below.

Figure 3.15.B. Locations of Dams in Idaho

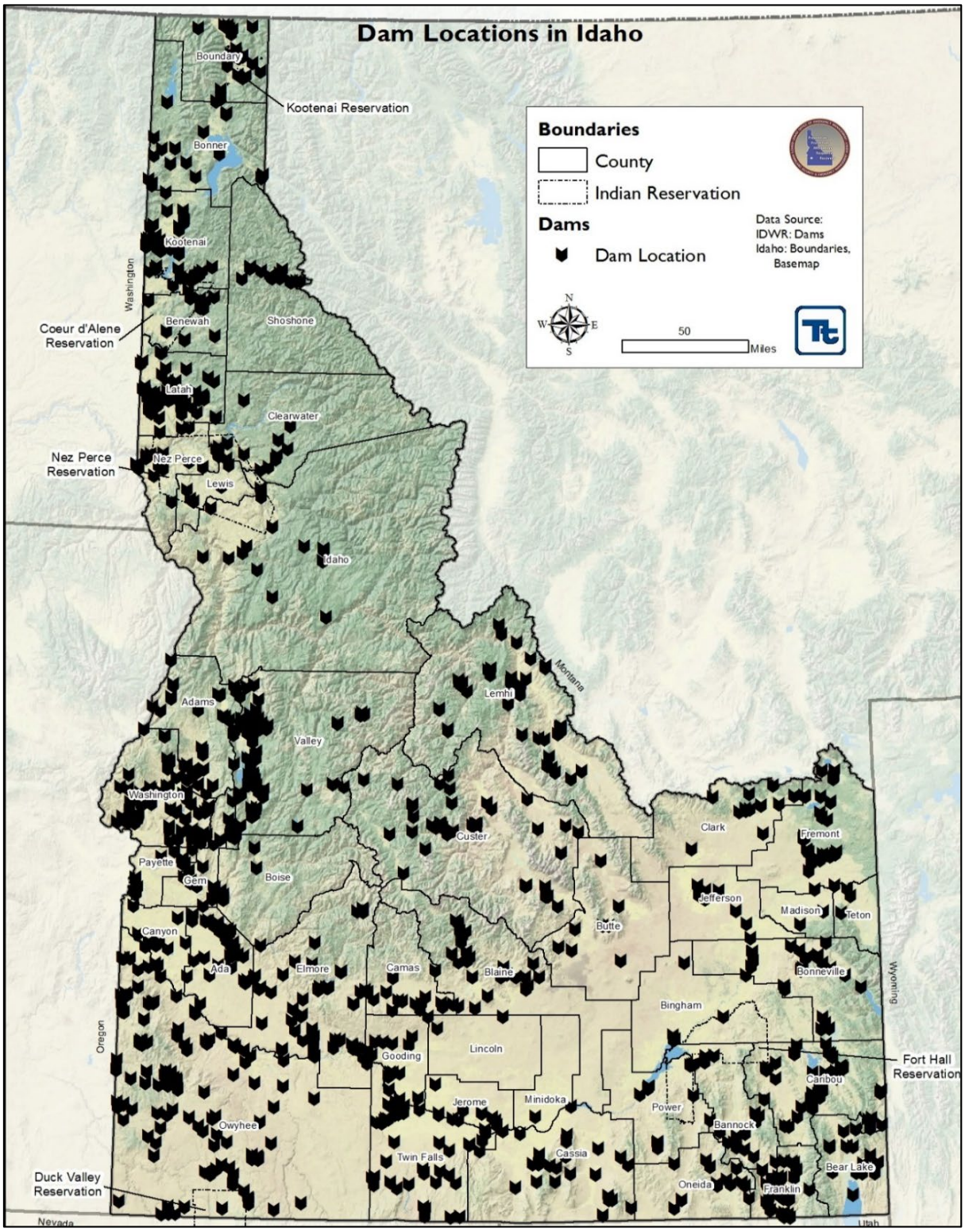
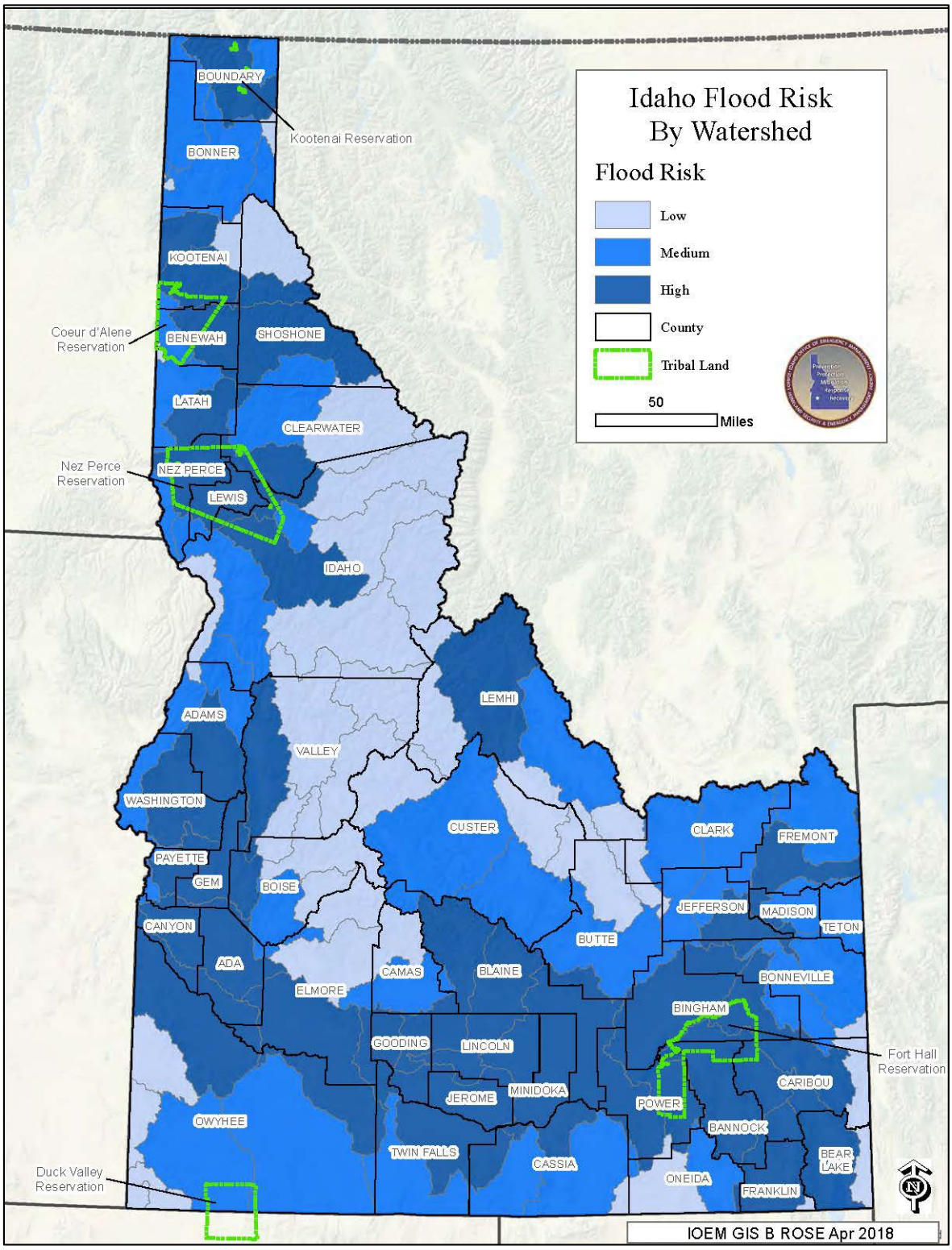


Figure 3.15.C. Idaho Flood Risk by Watershed



Lower Boise

The Lower Boise Sub-Basin is home to hundreds of thousands of people who live in or near the Boise River floodplain. Lucky Peak, Arrowrock and Anderson Ranch dams upstream of this sub-basin provide flood control and storage capacity for the Boise River and its tributaries, though they cannot fully prevent flooding. With a combined reservoir volume of 949,700 acre-feet, these three upstream dams are all assigned the state's highest damage classification. There also are nine significant-risk and 10 high-risk dams within the Boise sub-basin. Hundreds of thousands of people living downstream of the reservoirs are at risk of annual flooding.

Upper Snake-Rock

The Upper Snake-Rock Sub-Basin is home to tens of thousands of people. Flooding within the Upper Snake-Rock Sub-Basin could affect life and property, especially along the highly incised Snake River canyon, but very few live in or near the Snake River floodplain. Effected properties can include residential, commercial, and agricultural lands along the river. A dam breach at Milner Dam, in an adjacent sub-basin, would flow into this sub-basin and flood the Snake River Canyon. The Milner storage volume is 36,300 acre-feet, and the dam has a high downstream damage classification.

Payette

The Payette Sub-Basin is home to hundreds of people who live in or near the Payette River floodplain. Flooding in this sub-basin could affect life and property, especially in the cities of Emmett, Horseshoe Bend, New Plymouth, and Payette, which have over 16,000 residents, combined. Affected properties can include residential, commercial, and agricultural lands along the river. Dam failure hazard includes a potential dam breach at Black Canyon Reservoir with a storage volume of 29,800 acre-feet. The dam has a high downstream damage classification.

South Fork Coeur d'Alene

Seven communities in the South Fork Coeur d'Alene Lake Sub-Basin are along the South Fork Coeur d'Alene River. This sub-basin has considerable risk to human life and property. There are three multiple loss communities (Pinehurst, Wallace, Kellogg) in this sub-basin. There are nine dams identified by IDWR.

Weiser

The Weiser Sub-Basin is largely privately owned with population and development concentrated along the Weiser River and the towns of Weiser, Midvale, Council, and Cambridge (combined population of around 7,000). The primary river system in this sub-basin is the Weiser River. There are several reservoirs in the sub-basin including Lost Valley Reservoir and Crane Creek Reservoir. The majority of the development in this sub-basin is agricultural, mostly along the Weiser River with some on Mann Creek and the Little Weiser. In this sub-basin, there are 19 dams considered by IDWR to be of high or significant risk. Most are a flooding risk to residential and farmland development downstream. Of 73 dams in the IDWR database listed in this sub-basin, none are on the Weiser River.

St. Joe

The St. Joe Sub-Basin is home to residents of St. Maries and spans much of Shoshone and Benewah County. The St. Joe and St. Maries Rivers make up the major water system within the basin. In this sub-basin, there are no flood control structures to regulate the strong waters of the St. Joe.

Big Wood

The Big Wood Sub-Basin is home to thousands of people who live in or near to the Big Wood River floodplain. The populated areas within the Big Wood boundaries include Sun Valley, Ketchum, Hailey, and Bellevue. Flooding within the Big Wood Sub-Basin could greatly disrupt life and property to Blaine County. Much of the population in the sub-basin lives along the Big Wood River. There are eight dams in the sub-basin categorized as posing a high to significant risk of flooding. The dams are along tributaries to the Big Wood and Malad Rivers. The largest dams are the Magic Reservoir Dam and the Trail Creek Dam, which is within the city limits of Sun Valley.

Lower Kootenai

The Lower Kootenai Sub-Basin is home to most of the residents of Boundary County, including the communities of Bonners Ferry and Moyie Springs (combined population of around 3,000). The Kootenai River is the major water system in the area. There is a high risk dam at McArthur Reservoir, south of Bonner's Ferry. Land along the banks of the river is used for agriculture and rural development.

Clearwater

The Clearwater Sub-Basin is home to thousands of people who live in or near the Clearwater River floodplain, as well as its tributaries, which include the Potlatch, Lapwai Creek, Orofino Creek, and Lawyers Creek. Most of the land and inhabited properties in this basin belong to the Nez Perce Tribe. The largest flood event would be a dam breach at the Dworshak reservoir upstream of this sub-basin. The volume of the reservoir is 3,453,000 acre-feet. A population of 164,208 lives in adjacent sub-basin, downstream of the reservoir that would be affected by a catastrophic dam breach, including the cities of Lewiston in Idaho, and Clarkston, Richland, Pasco, and Kennewick in Washington. The Dworshak dam is attributed with the highest damage classification.

American Falls

The American Falls Sub-Basin is home to thousands of people, with the majority living near the main flooding source: the Snake River. The cities of Blackfoot, American Falls, and Shelley are the largest cities. In this sub-basin, there are three dams considered by IDWR to be of High or Significant risk; Gem State Dam, Simplot Effluent Irrigation Dam, and American Falls Dam. The Gem State and Simplot dams are a flooding risk to residential development and farmland downstream. The City of Shelley is within 5 miles downstream of the Gem State Dam and the Simplot Dam is on the outskirts of the City of Chubbuck.

Severity

Two factors that influence the potential severity of a dam failure are the amount of water impounded and the density, type, and value of development and infrastructure located downstream. Dam failures can be swift and sudden and produce a very significant flash flood downstream. For this risk assessment, severity is indicated by the dam hazard classification. The number of high-hazard dams in the state is a suitable indication of the severity of the dam failure hazard. Figure 3.15.E shows the Identified high-hazard dams in Idaho.

"Hazard" is not synonymous with "risk," which accounts for the probability of failure. Risk is equal to some probability that a failure will occur, multiplied by the resulting consequences to downstream life and property. As described at the beginning of this chapter, the Idaho hazard ratings, as well as the USACE hazard ratings, are based only on the potential consequences of a dam failure on downstream lives and properties; but neither rating system takes into account the probability of such failures.

WIIN-Act Eligible Dams

The IDWR Dam Safety Program has identified nine high-hazard dams as meeting the eligibility requirements of the WIIN Act. These are listed in Table 3.15.B.

Other High-Hazard Dams of Interest

The *2018 Idaho State Hazard Mitigation Plan* included exposure and vulnerability analyses for 11 high-hazard dams other than the identified HHPDs. These are dams that qualify as high-hazard under Idaho's definitions but are not WIIN-eligible because they meet the State's minimum safety standards or are federal dams. The high-hazard dams analyzed in the 2018 plan are listed in Table 3.15.C.

Figure 3.1.D. Cascade Dam (a High-Hazard Dam of Interest)

Seasonal Variance

The severity of potential impacts from a dam failure can vary by season, based on population increases due to tourism and weather impacts with changing seasons. For example, Blaine County can see significant increases in population due to tourism in winter and summer. Several high-hazard dam inundation areas experience prolonged periods of extreme cold during winter, which can create the potential for ice jams and frozen ground impervious to infiltration that can increase flood flows. Risk models are unable to quantitatively assess these impacts, due to the number of variables. They can be qualitatively assessed only based on local knowledge and expertise.

Figure 3.15.E. Identified High-Hazard Dams in Idaho

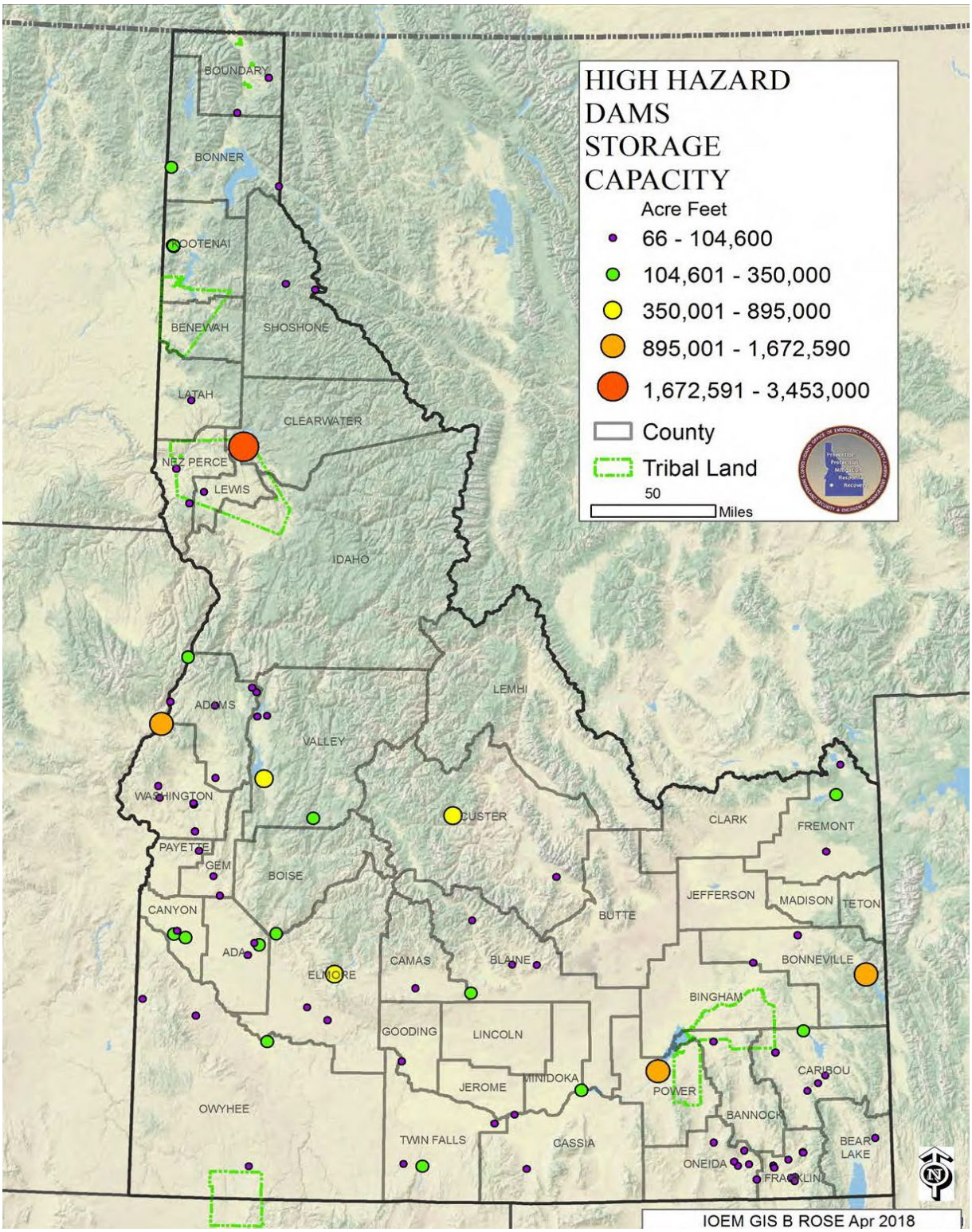


Table 3.15.B. Eligible WIIN Act High-Hazard-Potential Dams

Dam Name	Approximate Population at Risk	Hydraulic Height (feet)	Reservoir Volume (acre-feet)
Mountain Home Dam	3,500 + Interstate I-84	42.4	5,468
Winchester Dam	1,400 + US Hwy 95	36.3	1,425
Mackay Dam	3,000 + US Hwy 93	67	45,000
Crowther Dam	800	85.4	959
Oakley Dam	20,000	39	76,000
Blacks Creek Dam	14,000 + Idaho Corrections WWT Lagoons	45	3,640
Deep Creek Lower Dam	1,400 + Interstate-I15	81	5,537
Fish Creek Dam	300 + US Hwy 26	69	5,515
Strong Arm Dam #1	300	35.8	1,713

Table 3.15.C. Other High-Hazard Dams of Interest

Name	National ID #	County	Dam height (feet)	Hydraulic Height (feet)	Storage Capacity (acre-feet)	Hazard Potential
Albeni Falls	ID00319	Bonner	65	65	156,130	High
American Falls	ID00274	Power	87	78	1,672,590	High
Black Canyon	ID00282	Gem	128.5	111	29,882	High
Cascade Dam	ID00283	Valley	110	78	693,200	High
Deadwood	ID00284	Valley	154	144	162,000	High
Dworshak	ID00287	Clearwater	701	688	3,453,000	High
Little Wood	ID00041	Blaine	129	117	30,000	High
Lucky Peak	ID00288	Ada	258		307,000	High
Minidoka	ID00275	Minidoka	86	81	210,000	High
Palisades	ID00273	Bonneville	260	249	1,401,000	High
Ririe	ID00344	Bonneville	204	169	100,500	High

Extent

HHPD Failure Inundation Zone Mapping

Hazard mapping to support exposure and vulnerability analyses for the identified HHPDs was generated using the Decision Support System for Water Infrastructural Security (DSS-WISE) program administered by the University of Mississippi. Outputs from the DSS-WISE program include polygon shapefiles of dam failure inundation extents with depth grids suitable for import into FEMA's risk assessment platform, Hazus. For security purposes, DSS-WISE-generated inundation zone extent mapping is considered to be "for official use only" and is not presented in this plan.

Other High-Hazard Dams of Interest Failure Inundation Zone Mapping

The high-hazard dams of interest identified in the 2018 hazard mitigation plan had inundation mapping available that had been utilized by local hazard mitigation planning efforts in the state to assess risk to dam failure. Data for the Black Canyon and Lucky Peak dams came from local hazard mitigation plans for Ada and Gem Counties. For the other dams, the Idaho Office of Emergency Management geo-referenced paper inundation maps from USACE and the U.S. Bureau of Reclamation, digitized the results to create GIS data, and performed spatial analysis. For security purposes, inundation zone extent mapping for these other dams is considered to be "for official use only" and is not presented in this plan.

Warning Time

Dams can fail with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods can occur within 6 hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams, the accumulation of melting snow, buildup of water pressure on a dam with deficiencies after days of heavy rain, etc. Flooding can occur when a dam operator releases excess water downstream to relieve pressure from the dam.

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure because of earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (USACE 1997).

A structural failure can be sudden and perhaps with little to no warning despite warnings regarding the structural integrity of the system. If heavy rains are impacting a system, communities located in the immediate danger zone can be evacuated before a failure occurs. If the failure is caused by overtopping, the community may or may not be able to recognize the impending failure and evacuate. If a failure occurs suddenly, evacuation may not be possible.

Owners of high- and significant-hazard dams are required to maintain emergency action plans to use in the event of a potential dam failure or uncontrolled release of stored water. They are also required to have established protocols for flood warning and response to imminent dam failure in the flood warning portion of their emergency operations plans. These documents are customarily maintained as confidential information, although copies are required to be provided to the IDWR for response purposes.

Secondary Impacts

Flooding from dam failure may cause potential secondary hazards such as landslides, bank erosion, and destruction of habitat. Floodwaters carried to points downstream can cause damage in areas where it would

not otherwise be expected. Environmental incidents occur due to hazardous materials releases when floodwaters infiltrate facilities that store these types of materials. Utilities such as power, cable, and phone lines located in the inundation zones may also be susceptible to damage. Loss of these utilities could create additional problems for those impacted by flooding from dam failure.

Past Occurrence

Dam failure is infrequent but can have significant consequences. In addition to two major dam failures (Teton Dam in 1976 and Kirby Dam in 1991), Idaho has experienced a number of "near-miss" incidents, where disaster was averted. Table 3.15.D summarizes notable past events. Additional information on the Teton and Kirby dam failures is provided in the following sections.

Figure 3.15.F. Teton Dam Failure, June 1976

Source: http://www.damsafety.org.

Teton Dam Failure—1976

On June 5, 1976, Teton Dam in Fremont County failed (see Figure 3.15.F). An estimated 80 billion gallons of water was released from the reservoir into the Upper Snake River Valley. Devastating flooding occurred in Wilford, Sugar City, Rexburg, and Roberts; significant flooding occurred in Idaho Falls and Blackfoot. At the time of its failure, Teton Dam was brand new and stood 305 feet high, with a crest length of 3,100 feet and a base width of 1,700 feet. The dam was a zoned earth-fill structure with a volume of approximately 10 million cubic yards.

During the first filling of the reservoir, the dam burst when the water was 270 feet deep. It drained in less than 6 hours, setting off more than 200 landslides in the canyon below, taking 11 lives, and causing millions of dollars in property damage.

The floodwaters threatened American Falls Dam downstream on the Snake River. Dam managers opened the outlet works on American Falls Dam to empty the reservoir and save the American Falls Dam and a string of dams farther down the Snake River. On June 6, a federal disaster declaration was issued for Bingham, Bonneville, Fremont, Madison, and Jefferson Counties. This failure caused significant damage to the downstream Teton-Snake River Valley, with the inundation of an area as much as 9 miles wide and as far as 16 miles downstream of the dam (see Figure 3.15.G). Estimates of damage ranged as high as $2 billion; the federal government eventually paid over $300 million in claims. The U.S. Department of the Interior Bureau of Reclamation formed its dam safety program after this disaster. (U.S. Bureau of Reclamation 2019).

Table 3.15.D. Dam Failure Events in Idaho

Date	Event Type	Counties Affected	Losses / Impacts
June 5, 1976	Teton Dam Failure	Bingham, Bonneville, Fremont, Madison, and Jefferson	On June 5, 1976, Teton Dam failure resulted in 11 deaths and an estimated $2 billion in damage. The failure released 80 billion gallons of water, flooding Wilford, Sugar City, Rexburg, Roberts, Idaho Falls, and Blackfoot. On June 6, a federal disaster declaration was issued (DR-505) for Bingham, Bonneville, Fremont, Madison, and Jefferson Counties.
1984	Oakley Dam Failure	Cassia	Oakley Dam nearly overtopped. USACE completed Oakley Dam Advance Measures, which were a combination of emergency repairs to outlet controls and mitigation measures (emergency bypass canal, flashboards) by USACE.
1984	Twin Falls County Dam Failure	Twin Falls	Salmon Falls Creek release caused flooding.
1991	Kirby Dam Failure	Elmore	On May 26, 1991, Kirby Dam collapsed, cutting off electrical power and blocking the primary access bridge to Atlanta. Contaminated sediments (containing arsenic, mercury, and cadmium) were released into the Middle Fork of the Boise River.
2010	Brown's Pond Dam Failure	Valley	Browns Pond Dam was overtopped and breached during a June rain-on-snow event. A federal disaster declaration for Lewis, Idaho, Adams, Valley, Washington, Payette, and Gem Counties was issued July 27, 2010, for the storms that caused this event (DR-1927).
July 1-11, 2012	Flood, Planned Dam Release	Boundary	Due to a very wet June and early July, large quantities of water were released through Libby Dam in northwest Montana to accommodate rising water levels in Lake Koocanusa. Planned dam releases up until this event kept the river at Bonners Ferry just below flood stage. However, added releases from the dam pushed the river above its flood stage, resulting in widespread flooding along the Kootenai River in Boundary County at Bonners Ferry and downstream to the Canadian border. Damage occurred along the dikes in Bonners Ferry. Volunteers shored up 500 feet of levee behind the Kootenai River Inn to prevent water from spilling in. Water filled sub-surface storage areas of the General Feed and Grain located in Bonners Ferry. Sloughing of dikes downstream of Bonners Ferry was observed. Over 5,000 acres of farm land was damaged, resulting in $4 million in crop damage.
August 9, 2013	Heavy rain, Flash Flood	Lemhi	Slow moving thunderstorms produced heavy rain and flash flooding over the old 2012 Mustang burn scar in Lemhi County. Increased flow, up to 2 feet in Colson Creek, broke up a temporary earthen dam that emptied the pond.
August 13, 2014	Heavy Rain, Flash Flood	Lemhi	Thunderstorms brought heavy rainfall that triggered debris flows across the Mustang burn scar, west of Shoup. The debris flows occurred at Boulder Creek, Owl Creek, Colson Creek and at an unnamed gulch. A dam located near the delta of Colson Creek was damaged.

Sources: NOAA NCEI 2020; FEMA 2020; Idaho State HMP 2018

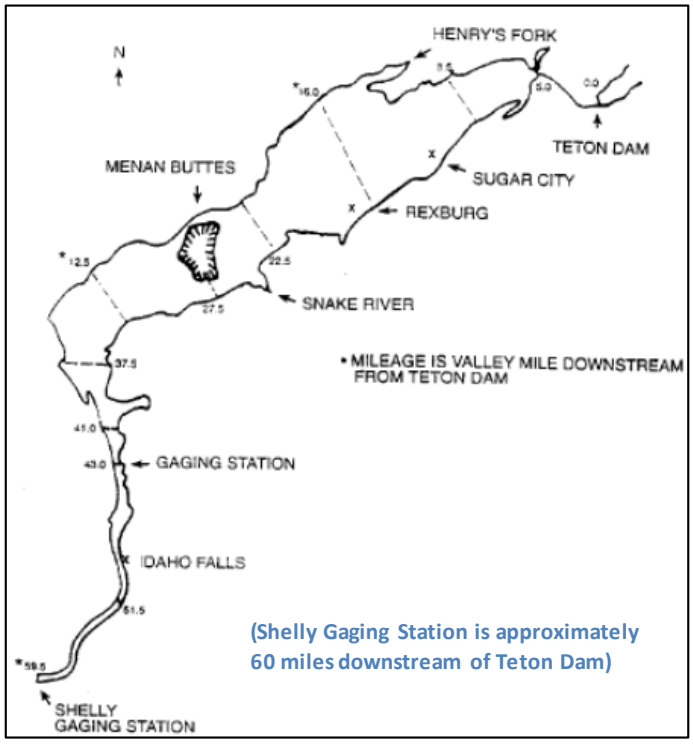
A study conducted by the National Weather Service concluded that the Teton Dam failure had an approximate instantaneous peak flow of 2.2 million cfs at the dam itself, a peak period of 1.43 hours, and a total duration of significant outflow of about 6 hours. This instantaneous peak discharge was about 30 times greater than the flood of record at Idaho Falls. The flood attenuated significantly as it moved downstream. The peak flow recorded at USGS Gage 13060000 (Snake River near Shelley, Idaho)

was 67,300 cfs on June 6, 1976. Nevertheless, the damage was significant and widespread, especially closer to the Teton Dam site.

Kirby Dam Failure—1991

During the summer of 1990, it became apparent that the old log crib structure of the Kirby Dam near Atlanta had become unsound and was in jeopardy of failing. The possibility of failure was of special concern due to the large quantity of mine runoff and tailings that had collected behind the dam over the years. IDWR and the U.S. Forest Service developed a strategy to stabilize the dam but the effort was unsuccessful. Kirby Dam collapsed on May 26, 1991, cutting off electrical power and blocking the primary access bridge to Atlanta. Contaminated sediments (containing arsenic, mercury, and cadmium) were released into the Middle Fork of the Boise River.

Figure 3.15.G. Teton Dam Inundation Area



Source: Idaho Office of Emergency Management

Future Occurrence

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. For example, a dam that is designed with spillway protection could cause significant downstream impacts when a spillway event is activated, but this would not be classified as a dam failure. This would be classified as a residual risk or "design" event. Overall, the probability of any type of dam failure is low in today's regulatory and dam safety oversight environment, although aging infrastructure and nature's continued ability to visit extreme events on local populations may increase a dam's overall risk.

The statewide occurrence of a HHPD failure should remain low if IDWR Dam Safety Program duties are adequately funded and implemented, and enforcement activities are continued that encourage dam owner responsibility for maintenance and repair, including regular update and testing of emergency action plans. Most causes of dam failure can be controlled through good design, proper construction, regular inspection by qualified personnel, and a commitment to strong enforcement to correct identified deficiencies. Likewise, the risk to downstream life and property can be reduced substantially

with efforts to limit some types of development adjacent to streams and rivers. Past efforts to proactively mitigate these risks have met with only limited success.

Relationships to Other Hazards

Dam failure events can influence other hazards, both natural and human-caused and are often the secondary impacts for other hazards such as earthquakes, flooding and landslides. Landslides can trigger landslides by destabilizing the toe of unstable slopes due to the erosion and scour caused by the high flows associated with a dam failure.

Impacts of a dam failure event on infrastructure and facilities could initiate a hazardous material or radiological release, a cyber disruption, or power outage. A dam failure event can overwhelm wastewater treatment facilities, leading to contaminated wells and other water supplies. Inundated agricultural land is out of production until the water drains away.

Wildfires, particularly large-scale fires, can alter ground conditions, making the watersheds that supply reservoirs impervious and resulting in increased runoff and sediment deposition in the reservoirs. Sediment deposition reduces reservoir storage capacity and can contaminate their water supply. Decreased storage capacity can impact the dam operation scenarios, which can result in increased flows downstream when the system is taxed by increased in flows.

Environmental Impacts

Dam failures can have a greater environmental impact than that associated with a normal flood event. The soil loss from erosion and scouring could be significantly greater, because of large amounts of fast-moving water affecting a small area. Great amounts of sediment from erosion can alter the landscape and change the ecosystem. In addition, hazardous materials can be carried away from flooded properties and distributed throughout the floodplain. Industrial or agricultural chemicals and wastes, solid wastes, raw sewage, and common household chemicals make up the majority of hazardous materials spread by floodwaters. They can pollute the environment and contaminate everything they come in contact with, including a community's water supply.

Climate Change Impacts

Resource managers have observed that climate change is already impacting water resources:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management, and ecosystem functions
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness, and emergency response.

Small changes in rainfall, runoff, and snowpack conditions may have significant impacts for water resource systems, including dams. Dams are designed partly based on assumptions about a river's flow

behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety. When this happens, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such releases can increase flood potential downstream.

Dams are constructed with safety features called spillways that serve as safety measures in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Climate change will not increase the probability of catastrophic dam failure, but it may increase the probability of design failures.

Development Trend Impacts

A good deal is known concerning the mechanisms that lead to dam failures. Consequently, dams are monitored by their owners, and breaches or failures rarely come without warnings. However, several factors contribute to ongoing risk associated with dam failure:

- Failure to recognize the extent of natural hydrologic forces in an area has led to development and occupation of areas that can be expected to be inundated by a dam failure event. While most dam failure inundation areas follow water courses that have flood mapping for regulatory purposes, the extent and location of dam failures areas tend to greatly exceed those of the mapped regulatory floodplain. This means that a large percentage of the development in these inundation areas includes no flood protection standards.
- Given how seldom dam failures occur, residents downstream of dams can become complacent.
- Sometimes, warnings are not heeded.

Long-term development in dam failure inundations areas is a factor that can be controlled. An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. To examine conditions that could affect hazard vulnerability, this assessment considered potential or projected development, projected changes in population, and other factors.

The U.S. EPA's Integrated Climate and Land-Use Scenarios project generated population and land use projections for the United States through 2100. The project examined multiple scenarios taking into account various population growth and economic development parameters that have been used as the baseline for the Intergovernmental Panel on Climate Change's *Special Report on Emissions Scenarios*. Population change projections that account for fertility, mortality, and immigration were used to drive the land use projections.

The *Special Report on Emissions Scenarios* estimated projections for each decade from 2010 to 2100 under multiple development scenarios (EPA, 2013):

- Economic development (A)—The A scenario will result in more sprawled development
- Environmentally driven development (B)—The B scenario will result in more compact developments close to existing urban centers.
- Combination of Scenarios A and B with two sets of parameters:
    - Global development (1)
    - Regional development (2)

Scenario A2 (economic development/regional development) was selected to examine if changes in land use and housing density estimates from 2010 to 2020 are projected in the dam failure inundation areas mapped for this assessment. The resulting housing density and land use categories are defined as follows:

- Urban, at 0.25 acres/unit
- Suburban, at 0.25 to 2 acres/unit
- Exurban, at 2 to 40 acres/unit
- Rural, at 40 acres/unit
- Commercial and Industrial.

The estimated change in land-use area in the identified dam failure inundation area between 2010 and 2020 is shown in Figure 3.15.H through Figure 3.15.L for Blacks Creek Dam, Crowther Dam, Deep Creek Dam, Mackay Dam, and Mountain Home Dam, respectively. There are no projected land use changes for the inundation areas for Fish Creek, Oakley, Strong Arm #1 and Winchester dams.

Figure 3.15.H. Change in Area of Land Use in the Blacks Creek Dam Inundation Area, 2010 – 2020

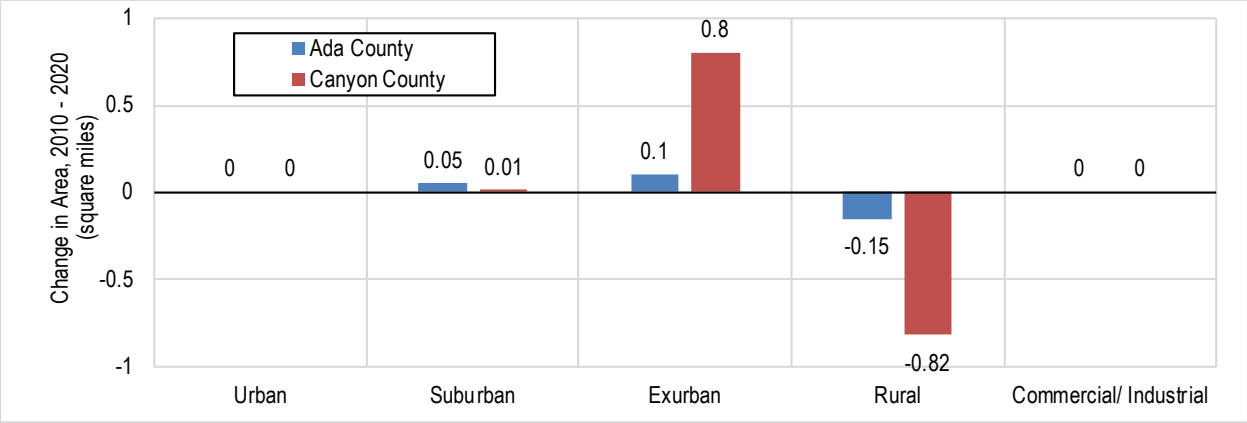


Figure 3.15.I. Change in Area of Land Use in the Crowther Dam Inundation Area, 2010 – 2020

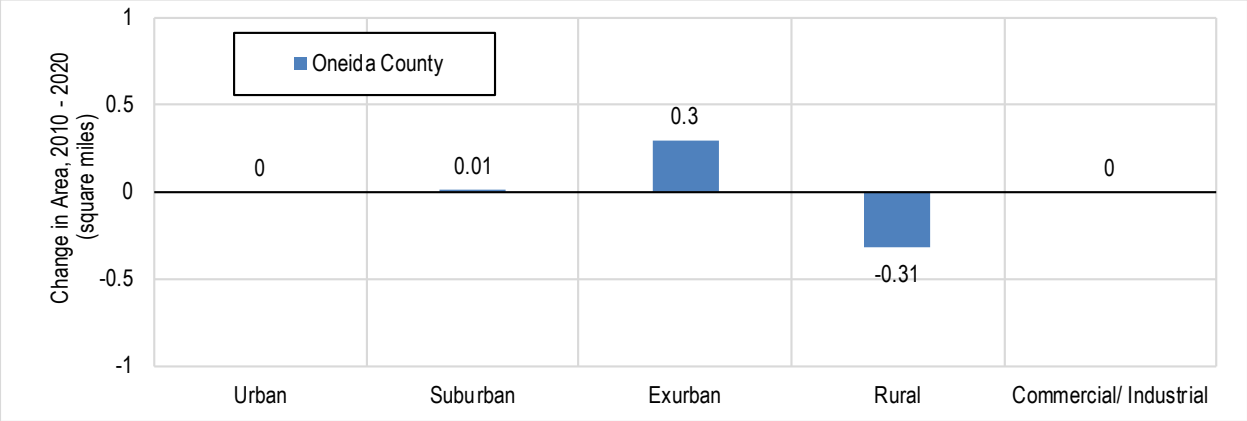


Figure 3.15.J. Change in Area of Land Use in the Deep Creek Dam Inundation Area, 2010 – 2020

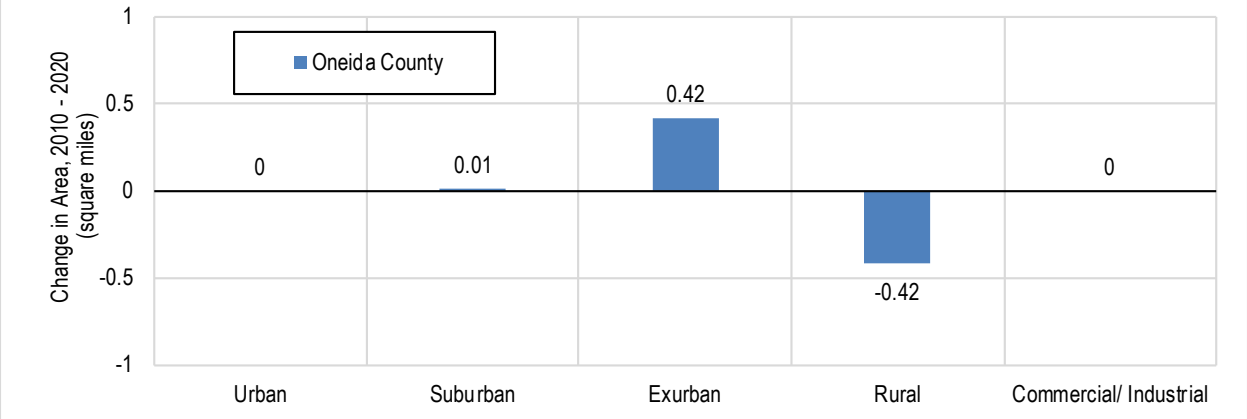


Figure 3.15.K. Change in Area of Land Use in the Mackay Dam Inundation Area, 2010 – 2020

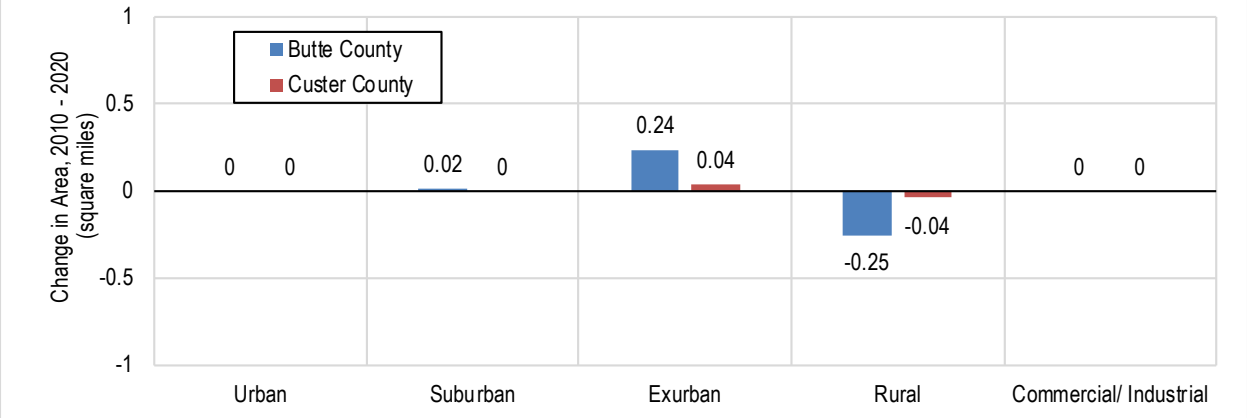
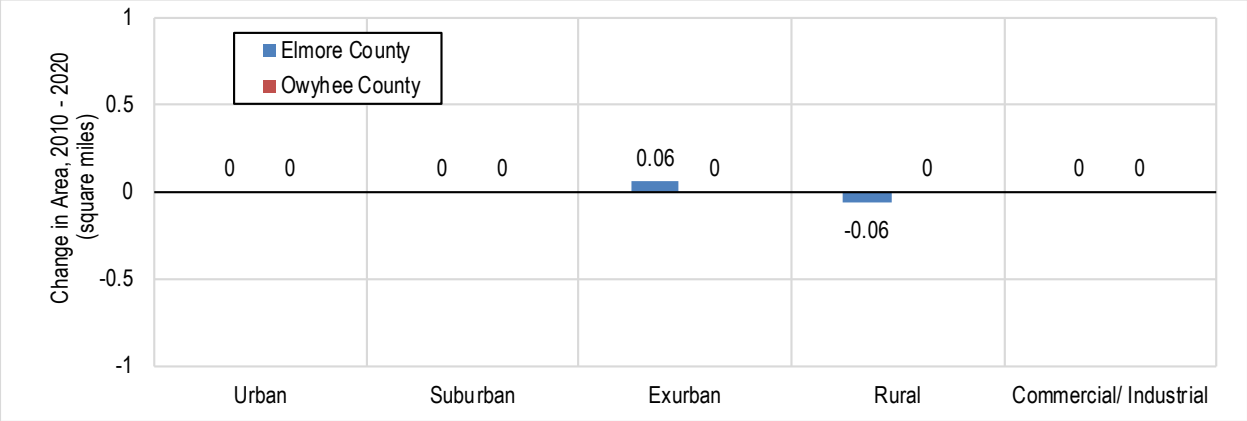


Figure 3.15.L. Change in Area of Land Use in the Mountain Home Dam Inundation Area, 2010 – 2020



The most significant changes in land-use are seen in the exurban and rural categories. Overall, 1.92 square miles of exurban area is projected to be developed in the dam failure inundation area of the targeted dams by 2020, with the greatest increase in Canyon County. There is a projected decline of 2.05 square miles of rural land in the five dam failure inundation areas. This decline is the greatest in Canyon County, where a reduction of 0.82 square miles of rural land is projected; this coincides with the increase in higher housing densities, which will place a greater number of people in the hazard area.

Vulnerability Assessment and Loss Estimation

A risk assessment of the dam failure hazard was conducted as follows for the nine HHPD dams:

- Dam inundation spatial datasets were developed for each of the analyzed dams using the DSS-WISE program described above.
- The dam failure inundation areas were used to estimate the land area exposed and the exposure of population, state buildings, and state critical facilities.
- To determine exposure, the hazard areas were overlaid with the assets to determine the total number and replacement cost value located in the hazard areas. All facilities located in the hazard area were deemed to be exposed to the hazard.
- FEMA's Hazus was used to estimate potential losses to structures from dam failure inundation by looking at depth of flooding and type of structure. A Level 2 Hazus study was conducted incorporating the state-owned and leased buildings and critical facilities as user-defined facilities. For more information on the data and tools used for this analysis, refer to Chapter 3.0.

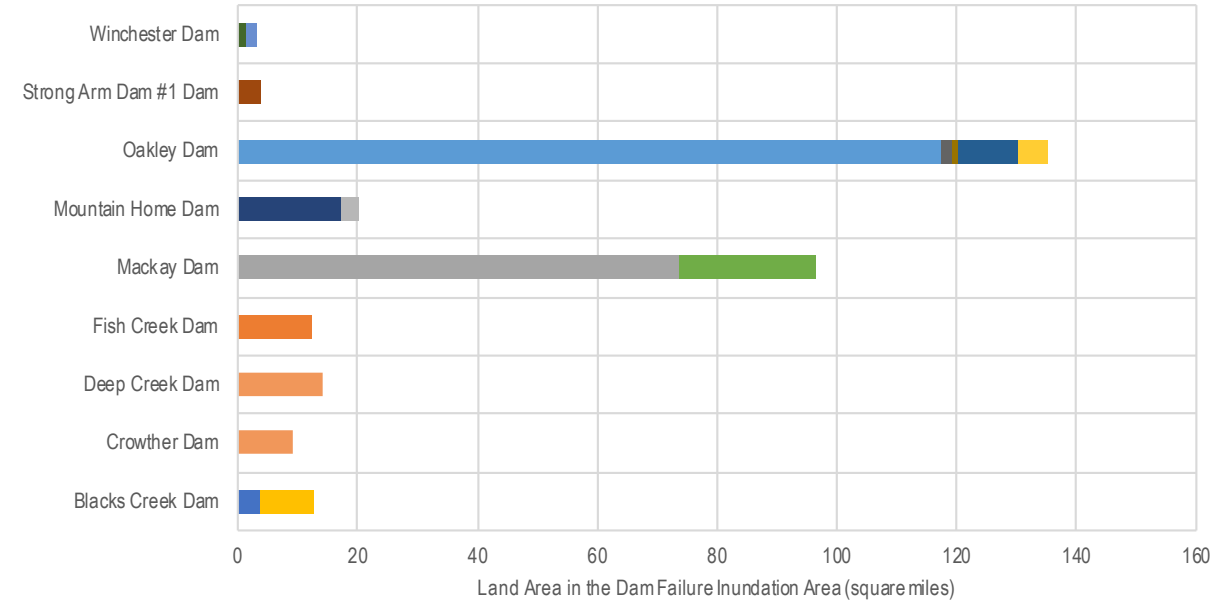
The 2018 State Hazard Mitigation Plan provided the assessment for the other (non-HHPD) high-hazard dams of interest. That assessment did not include an evaluation of general building stock in the dam failure inundation areas. Those dams were assessed for exposure of population, state-owned buildings, and critical facilities; with detailed results as provided in Appendix E. Future updates to this plan will expand that analysis to include the general building stock affected by these other dams.

Exposure

Land Area

The spatial analysis estimated the amount of land area exposed to each dam's inundation area. Figure 3.15.M shows the results of this analysis. The largest area of inundation is from Oakley Dam, covering 135.1 square miles over five Counties (Cassia, Gooding, Jerome, Minidoka and Twin Falls Counties). The smallest area of inundation is from Winchester Dam, covering 1.4 square miles over Nez Perce County and the Nez Perce Tribe.

Figure 3.15.M. Land Area in the Dam Failure Inundation Areas by Jurisdiction



	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	3.9								
Blaine County				12.3					
Butte County					73.6				
Canyon County	8.9								
Cassia County							117.3		
Custer County					22.7				
Elmore County						17.4			
Franklin County								3.9	
Gooding County							1.9		
Jerome County							1.1		
Minidoka County							10		
Nez Perce County									1.2
Nez Perce Tribe									2
Oneida County		9.3	14						
Owyhee County						2.8			
Twin Falls County							4.8		

Population

Populations exposed to the HHPD inundation areas are shown in Figure 3.15.N through Figure 3.15.P, broken down by total population, population 65 and older, and economically disadvantaged populations. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make evacuation decisions based on the net economic impact on their family. Those over 65 are more vulnerable because they are more likely to need medical attention which may not be available during a dam failure event, and they may have more difficulty evacuating.

The Oakley dam has the highest population exposure, at 19,690 persons over five counties (Cassia, Gooding, Jerome, Minidoka and Twin Falls Counties). Fish Creek Dam has the smallest population exposed, with 283 persons in Blane County. Oakley Dam also has the highest over-65 population (2,739) and economically disadvantaged population (1,698 households).

Appendix E provides population exposure results for the other high-hazard dams of interest. Bonneville County has the largest total population exposed to dam failure, with over 92 percent of its population exposed to dam failure from Palisades and Ririe Dams. Ada County has the largest over-65 population and economically disadvantaged population exposed to dam failure inundation, from Lucky Peak Dam.

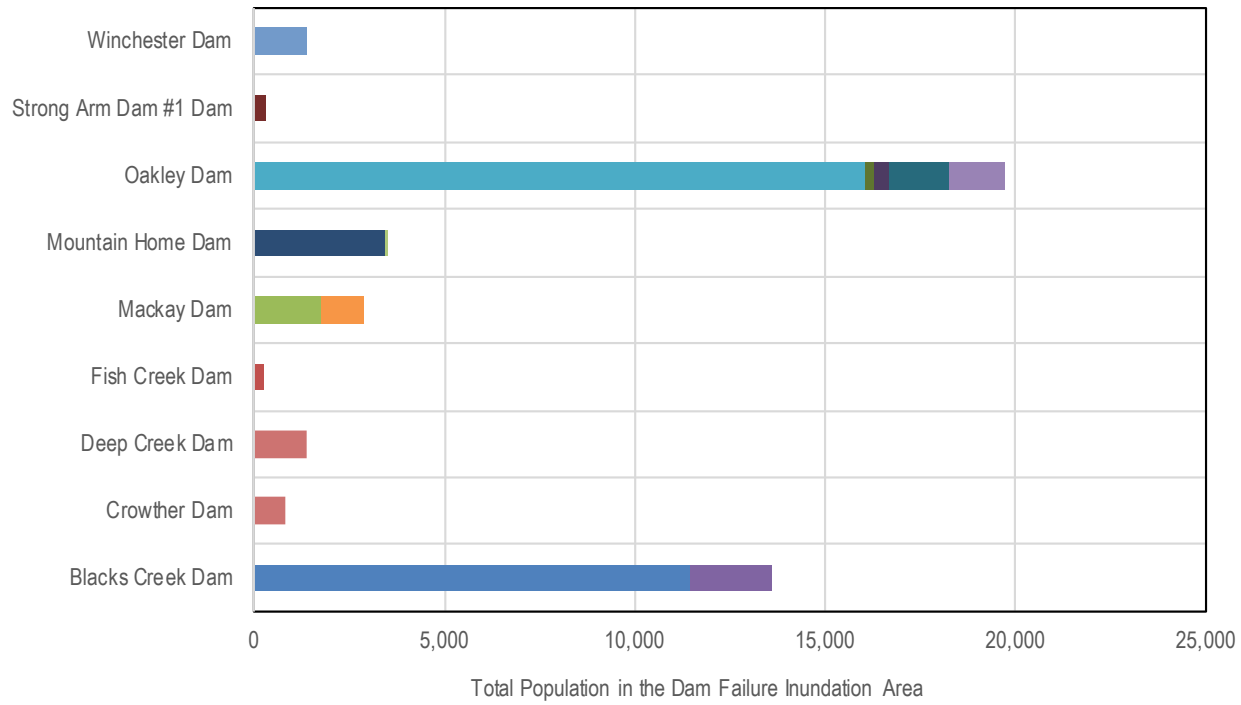
General Building Stock

General building stock exposure was examined in the dam failure inundation areas for HHPD dams and other dams of interest. Damage to buildings can displace people from their homes, threaten life safety and impact a community's economy and tax base. To provide a general estimate of general building stock exposure, the dam failure inundation areas were overlaid on Hazus's default general building stock inventory at the Census block level for each county and Tribal Nation. Where the Census block centroid was located within the flood boundary, the total building stock values for structure and contents replacement value in that Census block were considered to be exposed. This methodology was conducted for all jurisdictions with available dam failure inundation data. Figure 3.15.Q shows the general building stock exposure for the HHPD dams.

The total building replacement cost value for buildings within the HHPD dam failure inundation areas is $6.96 billion. Cassia County accounts for 34 percent of that total ($2.4 billion). The following counties have the greatest percentage of total county replacement cost value exposed to the dam failure hazard (in descending order): Cassia (75.5 percent), Butte (58.8 percent), Oneida (37.3 percent), Custer (20.1 percent), Elmore (13.1 percent), and the Nez Perce Tribe (6.1 percent).

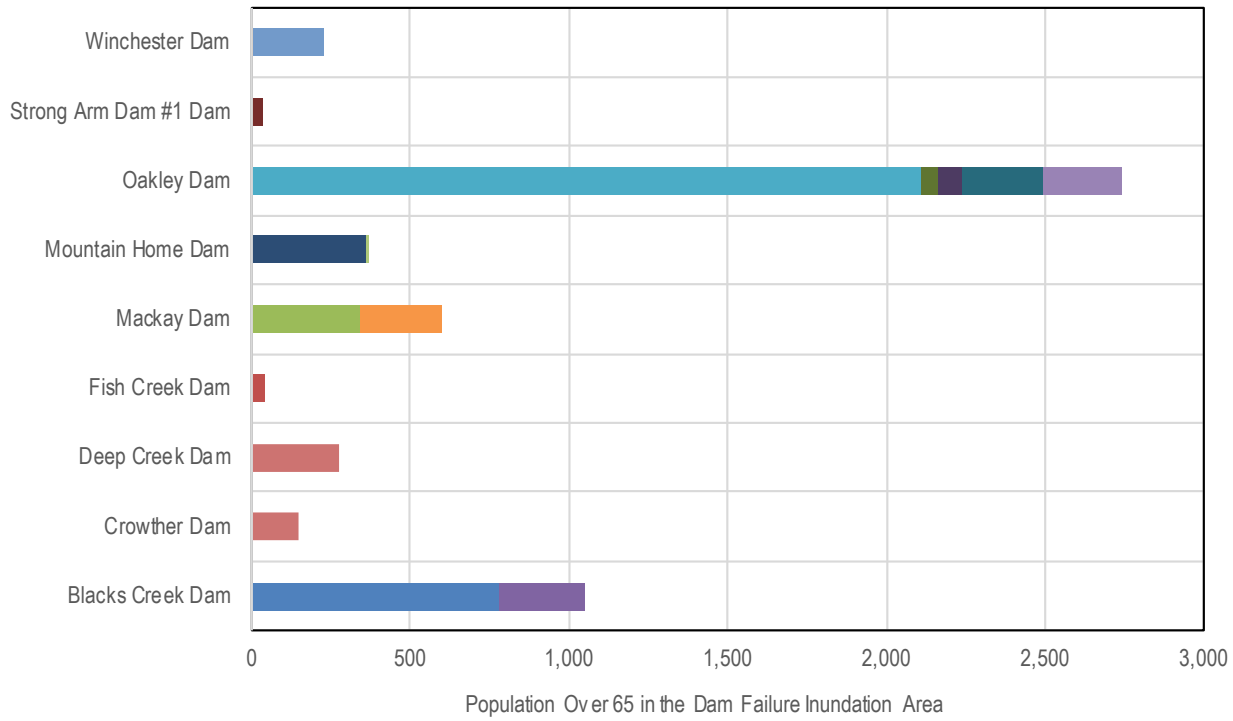
The 2018 Idaho State Hazard Mitigation Plan did not do a general building stock exposure analysis for the dam failure inundation areas, so this data is not presented for the other high-hazard dams of interest at this time. The next comprehensive update to the State Hazard Mitigation Plan will include this additional analysis.

Figure 3.15.N. Total Population in the HHPD Dam Failure Inundation Areas, by Jurisdiction



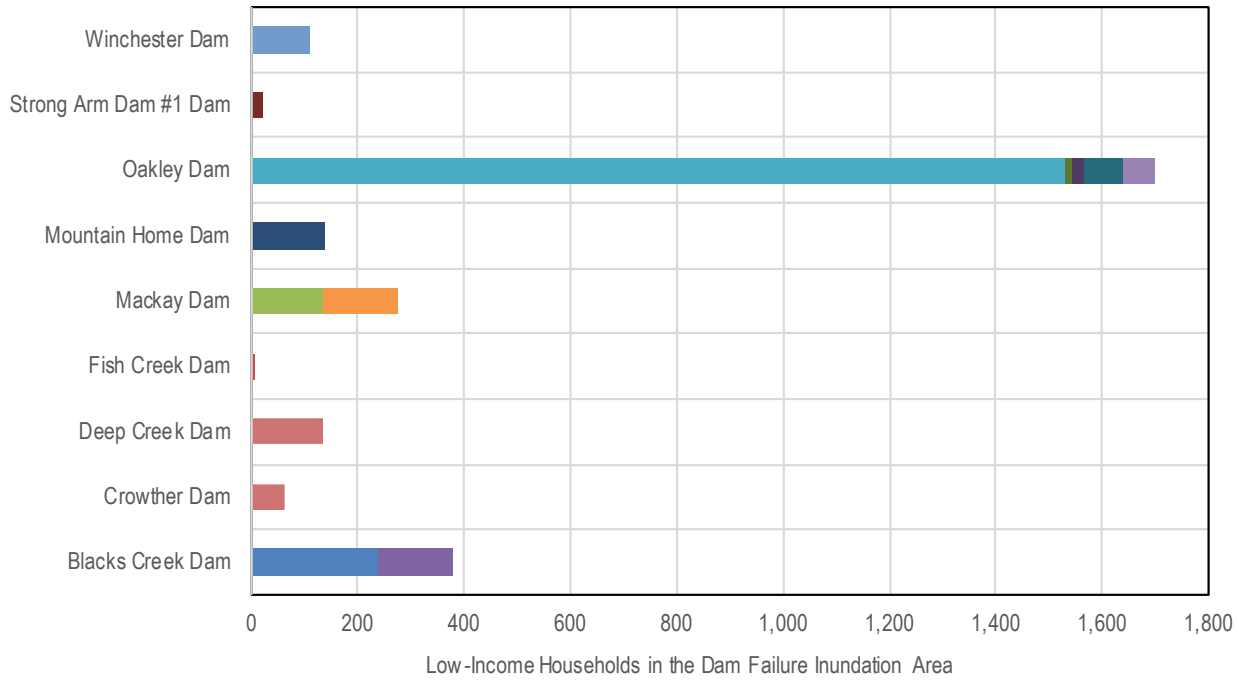
	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	11,464								
Blaine County				283					
Butte County					1,790				
Canyon County	2,144								
Cassia County							16,065		
Custer County					1,128				
Elmore County						3,446			
Franklin County								349	
Gooding County							241		
Jerome County							347		
Minidoka County							1,596		
Nez Perce County									11
Nez Perce Tribe									1,385
Oneida County		818	1,388						
Owyhee County						47			
Twin Falls County							1,441		

Figure 3.15.O. Population Over 65 in the HHPD Dam Failure Inundation Areas, by Jurisdiction



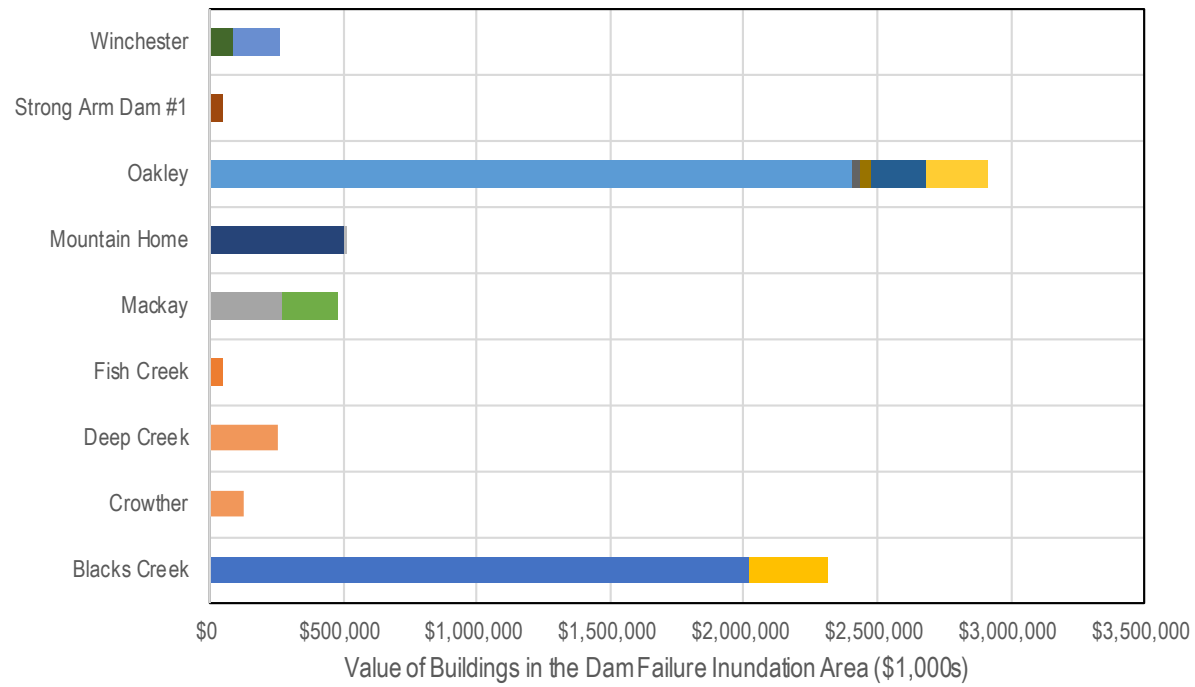
	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	778								
Blaine County				40					
Butte County					342				
Canyon County	271								
Cassia County							2,109		
Custer County					257				
Elmore County						363			
Franklin County								32	
Gooding County							57		
Jerome County							74		
Minidoka County							251		
Nez Perce County									3
Nez Perce Tribe									227
Oneida County		147	273						
Owyhee County						9			
Twin Falls County							248		

Figure 3.15.P. Low-Income Households in the HHPD Dam Failure Inundation Areas, by Jurisdiction



	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	237								
Blaine County				7					
Butte County					133				
Canyon County	142								
Cassia County							1,531		
Custer County					140				
Elmore County						140			
Franklin County								21	
Gooding County							12		
Jerome County							22		
Minidoka County							74		
Nez Perce County									2
Nez Perce Tribe									107
Oneida County		62	135						
Owyhee County									
Twin Falls County							59		

Figure 3.15.Q. General Building Stock Structure and Contents Replacement Value in the HHPD Dam Failure Inundation Areas, by Jurisdiction



	Value of Buildings in the Dam Failure Inundation Area								
	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	$2.02 B								
Blaine County				$50.8 M					
Butte County					$273.5 M				
Canyon County	$300.0 M								
Cassia County							$2.41 B		
Custer County					$201.4 M				
Elmore County						$499.0 M			
Franklin County								$49.8 M	
Gooding County							$25.1 M		
Jerome County							$44.0 M		
Minidoka County							$208.0 M		
Nez Perce County									$89.1 M
Nez Perce Tribe									$171.7 M
Oneida County		$128.8 M	$256.0 M						
Owyhee County						$4.0 M			
Twin Falls County							$231.0 M		

State Owned Facilities

The exposure analysis identified three state-owned facilities in the HHPD dam failure inundation areas:

- One Department of Fish and Game facility in the Blacks Creek Dam failure inundation area (Ada County) with a total estimated structure + content replacement value of $25,831
- Two Department of Fish and Game facilities in the Mackay Dam failure inundation area (Custer County) with a total estimated structure + content replacement value of $542,197

See Appendix E for detailed results of the exposure analysis for state-owned facilities in the inundation areas for the other high-hazard dams of interest. Key findings are as follows:

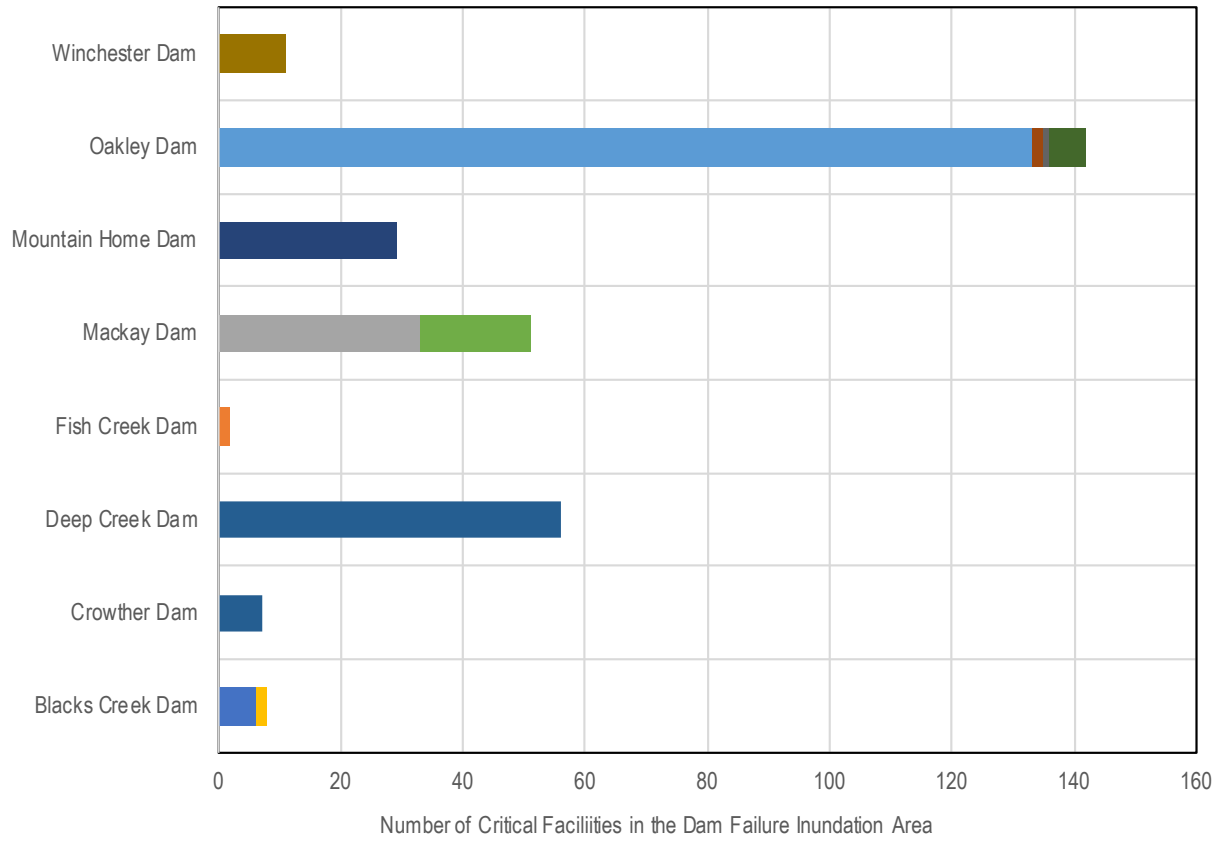
- Lucky Peak Dam is located in Ada County, which is the most populous county in the state and home to the state capitol. There are an estimated 417 state-owned buildings in the Lucky Peak dam failure inundation, of which 393 are in Ada County. Of the state entities, Boise State University has the greatest number of buildings (214) exposed and greatest replacement cost value ($1.5 billion) exposed.
- Gem County is the only jurisdiction with state buildings located in the Black Canyon dam failure hazard area. The County has eight state buildings with a total replacement value of $1.8 million located in the dam failure inundation area. The Department of Transportation owns the greatest number of state buildings in the Black Canyon dam failure inundation area (four). The Idaho Military Division owns the buildings with the greatest replacement value located in the inundation area ($769,000).

Critical Facilities and Infrastructure

An exposure analysis of identified critical facilities/infrastructure inventoried for each county was performed for both the HHPD inundation zones and those of the other high-hazard dams of interest. Figure 3.1.R shows the results for the HHPD dams. Cassia County has the highest level of exposure, with over 48 percent of its identified critical facilities/infrastructure exposed to HHPD dam failure inundation zones, followed by Butte County (41.2 percent) and Elmore County (7.7 percent).

See Appendix E for the results of the critical facility/infrastructure exposure analysis for the other dams of interest.

Figure 3.15.R. Number of Critical Facilities Located in the HHPD Dam Failure Inundation Areas, by Jurisdiction



	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Winchester Dam
Ada County	6							
Blaine County				2				
Butte County					33			
Canyon County	2							
Cassia County							133	
Custer County					18			
Elmore County						29		
Gooding County							2	
Jerome County							1	
Nez Perce Tribe								11
Oneida County		7	56					
Twin Falls County							6	

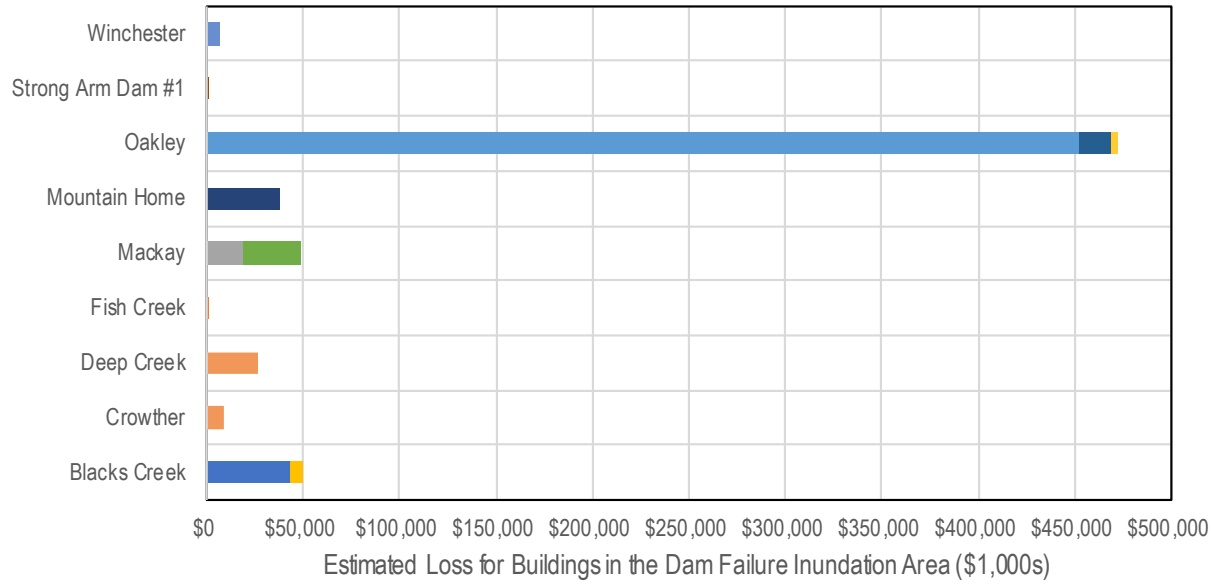
Note: No critical facilities identified in the inundation zone for Strong Arm Dam #1.

Vulnerability

General Building Stock

Hazus was used to estimate potential loss values to the general building stock from HHPD failure. Figure 3.15.S summarizes the results. General building stock loss results for the other high-hazard dams of interest was not performed, but will be provided during the next update to that plan.

Figure 3.15.S. Loss Estimate for General Building Stock in the HHPD Dam Failure Inundation Areas by Jurisdiction



	Estimated Loss for Buildings in the Dam Failure Inundation Area								
	Blacks Creek Dam	Crowther Dam	Deep Creek Dam	Fish Creek Dam	Mackay Dam	Mountain Home Dam	Oakley Dam	Strong Arm Dam #1 Dam	Winchester Dam
Ada County	$43.5 M								
Blaine County				$221,000					
Butte County					$18.8 M				
Canyon County	$5.7 M								
Cassia County							$452.2 M		
Custer County					$30.2 M				
Elmore County						$38.0 M			
Franklin County								$762,000	
Gooding County							$92,000		
Jerome County							$9,000		
Minidoka County							$16.8 M		
Nez Perce Tribe									$6.2 M
Oneida County		$8.6 M	$27.1 M						
Twin Falls County							$3.5 M		

State Owned Facilities

The Hazus flood model, updated with the statewide Risk Management Technical Records database of state-owned and state-leased buildings, was used to estimate potential loss to state facilities. Direct building losses represent the estimated cost to repair or replace buildings damaged by a dam failure. For the HHPD dam inundation areas, the estimated losses for state-owned facilities are as follows:

- Estimated loss of $2,402 to one Department of Fish and Game facility in the Blacks Creek Dam failure inundation area (Ada County) equal to 9.3 percent of the facility's total estimated structure + content replacement value of $25,831
- Estimated loss of $523,054 to two Department of Fish and Game facility in the Mackay Dam failure inundation area (Custer County) equal to 96.5 percent of the facilities' total estimated structure + content replacement value of $542,197

State facility loss results for the other high-hazard dams of interest was not performed but will be provided during the next update to this plan.

Consequence Analysis Evaluation

The 2018 Idaho State Hazard Mitigation Plan included a consequence analysis evaluation for each assessed hazard of concern, which did not include dam failure as a stand-alone hazard. Since this current plan update is being completed by the State of Idaho specifically to meet planning requirements of the HHPD program under the WIIN Act of 2016, and those requirements do not include the need for a consequence analysis, the State will defer this evaluation to the next comprehensive update of the State Hazard Mitigation Plan, scheduled to be completed before 2023.

Mitigation Rationale

The primary rationale for mitigating risks associated with dam failure is the potential for loss of life and economic loss. Risk mitigation is strongly dependent on reducing the probability that failure will occur, and reducing the potential damage to life and property if a failure does occur. Certain dams have been constructed to reduce downstream flooding, but they must still release water to prevent being overtopped. This release of water mitigates catastrophic flooding, but some downstream flooding may still occur. Other factors that contribute to damage to infrastructure systems are lack of maintenance on systems, and development of areas downstream of dams, creating issues with flooding and management of water release.

General Mitigation Approaches

The mitigation of risk associated with dam failure can depend in large part on whether the dam is new or old. New dams can be designed to meet stringent safety criteria, including the passage of extreme flood discharges and resistivity to earthquakes, thereby lowering the probability for failure. Land downstream of new dams can be zoned or otherwise regulated to limit new construction and exposure,

and thus reduce the hazard potential. The key to this mitigation approach is good hazard mapping and the availability of that mapping to local governments.

An important aspect to help reduce risk from the impacts of a dam failure is the development of an emergency action plan that is focused on the proper operation of the dam, advanced warning, and evacuation instructions. In extreme or unique cases, property acquisition or removing a dam may be the most efficient and cost-effective approach to mitigating imminent risk to life and property by removing the hazard.

Public awareness measures, such as notices on final plats and public education on dam safety, are proactive mitigation measures that should be implemented by local communities. Emergency action plans that establish potential dam failure inundation limits, notification procedures, and thresholds are prepared for response to potential dam-related disaster events.

HHPD Planning Process

The SHMP Dam/Levee/Canal Technical Working Group met virtually through webinars to discuss HHPD requirements, review drafts and assessments. Webinars were effective but had limitations on participation and were necessitated by the pandemic COVID-19 social distancing requirements. Invitations were extended to sectors responsible for emergency management, economic development, land use and development, housing, health and social services, infrastructure, and natural and cultural resources. The group participants included representatives from USACE, Flood Control District #10, Idaho Department of Lands, NOAA, FEMA, Idaho Department of Water Resources (IDWR), and Idaho Office of Emergency Management (IOEM). Tetra Tech was contracted by IOEM to update the dam risk assessment and SHMP chapter for the groups review. Meeting minutes capture discussions and are located in Appendix G.

The State Dam Safety Program is administered by IDWR, which coordinated with individual HHPD dam owners to understand risks or issues and obtain HHPD participation by-in. The Dam Safety Officer provided HHPD data on each dam for the risk analysis collected from the University of Mississippi DSS-WISE Program and the IDWR GIS section. Data included inundation extents, Digital Elevation Models, National Land Cover data, National Levee data, observation lines, raster files, reservoir volumes, shape files, and flood simulation reports.

The location and size of the Population At Risk as well as potential impacts to institutions and critical infrastructure/facilities/community lifelines are included in the risk assessment in this chapter. A Level 2 Hazus study was conducted incorporating the state-owned and leased buildings and critical facilities as user-defined facilities (page 3.15-22 and Appendix E).

Mitigation goals to reduce long-term vulnerabilities from HHPD

The SHMP Dam/Levee/Canal Technical Working Group reviewed the existing goals and concurred that the goals as stated in Chapter 1 were overarching and well thought out to include High Hazard Potential Dam concerns.

Mitigation actions and prioritization

The current mitigation actions were reviewed, specifically actions that address HHPD. A survey was created to capture new mitigation ideas and a Staplee form (Appendix D) scored and prioritized actions. The SHMP Dam/Levee/Canal Technical Working Group chose four new actions regarding land use regulations, working with dam owners on emergency action plans (EAP), rehabilitating HHPD, and ensuring downstream entities are aware of HHPD risk. Working with eligible dam owner on EAPs ranked first. The new actions identify the supported goals in the mitigation strategy and were added to the mitigation action table in Chapter 1.

Current and potential funding sources

Chapter 4 describes funding sources from multiple agencies and their programs. Idaho Department of Water Resources programs were updated to include HHPD (Chapter 4 Table 4.A page 4-18, and page 4-79). Each HHPD mitigation action lists a potential funding source shown in Chapter 1.

Local mitigation policies, programs, and capabilities

Hazard mitigation plans were analyzed for counties impacted by inundation areas of the nine selected dams for HHPD. Table 3.15.E summarizes the information regarding policies, programs, and capabilities along with challenges and opportunities for implementing mitigation actions to reduce risk.

Prioritizing HHPD funding

Risk Analysis is a term that is broadly defined as the method(s) used to assign a probability of occurrence for consequential events; the implication being that the consequence will be negative in terms of life safety or property damage. However, the term may be further defined very precisely by different groups; for example, the insurance industry, government regulators, and the legal profession. Any action that would serve to reduce the probability of occurrence can be considered "mitigation", but some actions are vastly superior to others in terms of effectiveness and efficiency (i.e. time, cost, and degree of risk reduction). Given the fact that financial resources to affect an outcome are universally limited, the dilemma becomes how one can best allocate funds to achieve the greatest benefit. One accepted method that is used by various state and federal dam safety programs to identify relative risk is a procedure known as Probable Failure Mode Analysis (PFMA). This procedure lists all known components, assemblies, and operating mechanisms associated with any particular dam, and the resulting effect that a failure of each could have the rest of the system. This method considers the importance that each one can have to the greater system, and how its failure to operate as designed could contribute to an uncontrolled release of water or breach of the dam. Once these have been

identified and arranged in order of severity (consequence), then it becomes possible to sort them relative to the likelihood the event can be detected prior to it occurring. Of course, early detection and the ability to intervene reduces the probability of a failure outcome, thus allowing those events so identified to be further sorted into groups of greater versus lesser benefit per a given budget.

The limitation of the PFMA is that not all the failure mechanisms can be identified. In addition, there exists the presumption that, once identified, future detection and intervention will occur in time to prevent the failure from occurring. Despite this limitation, the PFMA has been shown to be an effective way to identify 1) potential failure modes, 2) assign relative severity to the failure consequence, and 3) prioritize the event(s) to realize the greatest reduction in risk. This is especially helpful for individuals or organizations who have an inventory of high hazard dams, the failure of any one would result in loss of life.

Mitigation actions for HHPD were ranked and prioritized with the Staplee Method as were previous mitigation actions in the state plan. These prioritizations differ from the PFMA which will determine HHPD funding priority.

Table 3.15.E. Policies, Programs, and Capabilities of HHPD

Dam	County/Tribe	Policies, Programs & Capabilities	Mitigation Challenges	Mitigation Action Opportunities
Winchester Dam	Lewis County	Lewis County Emergency Operations & Response Plan (2009), City of Craigmont Capital Improvement Plan FY-17 through FY-21 (2016), City of Kamiah PWS: #ID231003 Source Water Protection Plan (2016), Drinking Water Protection Plan, City of Craigmont (2006), Teasdale, G.N. (2015). Reconnaissance Hydrologic Analysis of the Big Canyon Watershed and the Fisher Fire Burn Area in Nez Perce County, Lewis County, and the Nez Perce Reservation, Idaho, -Ida-Lew Economic Development Council Strategic Plan (2017), Wildland Fire & Flood Risk Assessment – Final Report, Lewis County, Idaho (2010), Bureau of Engineering, State of Idaho Department of Fish & Game (2017). Operation Plan – Winchester Reservoir, State of Idaho -Building Code (2016) IBC Building Code (2004); Zoning (1997 w/ amend. in 2002 Subdivision (1991 w/ amend. in 2002) Lewis County, Flood Damage Prevention Ordinance- 1995 - Building and construction standards for the flood prone areas in all unincorporated areas of Lewis County, Idaho. Winchester Reservoir Operation Plan11 – This document describes the dam, its uses, as well as normal and emergency operating procedures. (11 Bureau of Engineering, State of Idaho Department of Fish & Game (2017). Operation Plan – Winchester Reservoir.) The City of Winchester has a stormwater drainage plan from 2005 and a Transportation plan from	Lewis, Nez Perce, Nez Perce Tribe: Lack of resources small towns must allocate and prioritize and the need for doing the best with what is available. Lack of funding for projects is always a challenge. Challenges in maintaining parity with technology; and political challenges as well. Spring and Summer brings an influx of population increases due to recreation and fishing. The IDWR classifies potential losses and damages anticipated to downstream areas during a dam failure. Dworshak Dam, Soldiers Meadow Dam, and Winchester Dam are all classified as high risk. There are three major dams located in the vicinity of the Nez Perce Reservation: Dworshak Dam, Winchester Dam, and Soldiers Meadow Dam. None	No actions specific to Winchester Dam. Related Lewis County actions: 3. Develop improved hazard warning systems. 5. Develop a mass casualty annex and evacuation plan annex as part of the Lewis County Emergency Operations and Response Plan. 7. Continue to improve and update the County GIS system including development of E911 capability. 16. Encourage participation in the National Flood Insurance Program and continue to work with IDWR on an update floodplain ordinance. City of Kamiah 8. Implement land use and development policy to reduce exposure to hazards. 12. Educate the public on mass casualty and emergency evacuation protocols. 17. Repair and/or relocate the city's alert siren in order to alert populations in the city and surrounding areas with limited cellular service of large-scale emergencies City of Winchester: 2. Work with local partners to improve sheltering capacity during emergency evacuation events.

		2011. The City of Nezperce adopted a transportation plan in 2017, which helped to strengthen their capabilities. Nez Perce is also planning to update its floodplain ordinance.	of these structures have failed or been subject to significant damage. However, a threat of potential dam failure occurred for Winchester Dam following a severe flood/winter storm event in February 1996.	
Winchester Dam	Nez Perce County	Nez Perce County - Comprehensive/Master Plan, Capital Improvements Plan, Economic Development Plan, Emergency Operations Plan, Transportation Plan, City of Lewiston Waste Water and Stormwater Plans, zoning ordinances, subdivision ordinances, City of Lewiston Acquisition Policy, public works maintenance programs.		Nez Perce County related actions: NPC needs to be re-mapped with current lidar elevation data and current stream flow data, including a detailed flood study in areas of significant population density such as incorporated cities and unincorporated communities. Potlatch River Corridor Floodplain Analysis, Phased project - I hydrology analysis, establish flood zones, identify flood depths, quantify flow volumes; II - Identify protection measures; III – Install protection measures. Emergency Communications Center, build a robust, hardened communications capable of housing and providing Emergency Communications infrastructure for the County of Nez Perce, the City of Lewiston and other stakeholders. The current facility is in the area of impact from our largest HazMat Threat, as wellas in the inundation zone for two major dams.
Winchester Dam	Nez Perce Tribe	Nez Perce Tribe- Legal and Regulatory Resources Available Hazard Mitigation Administration Plan, Geographic Response Plan - Engages the region's partnerships and regulatory agencies of the Clearwater, Snake		Nez Perce Tribe related actions: 1.C Explore the need for hazard zoning and high-risk hazard land use ordinances. 1.D Incorporate hazard prone areas into land use planning.

		river, and Columbia River Basin Corridors to collaborate on emergency responses to toxic releases into the waterways, FOG - Field Operations Guide for frequencies to first responders, Forest Protection Fire Ordinance, Water and Waste Management Ordinance- Brownfields assessment and underground storage tanks are identified and tracked throughout the Tribe's Environmental Protection Agency compliance of identifying and potential removal of toxic releases. Forest Department Fuel Management Program, Student Conservation Association Program- Student Conservation Association conducts wildland urban-interface outreach and fuel management programs. Nez Perce Tribal Commercial Building Code - Enforces the Uniform Building Code for commercial buildings only, Mutual Aid Agreements - Lapwai Fire Department. Mutual Aid for firefighting includes fire responders and their equipment.		2.D Develop emergency evacuation programs for neighborhoods in hazard prone areas. 3.A Join the National Flood Insurance Program. 3.B Implement best management practices for floodplain areas. Provide community flood preparedness drills. Incorporate flood levels for community notifications.
Crowther and Deep Creek Dams	Oneida County	Oneida County Comprehensive Plan, Oneida County Land Use Ordinances, Oneida County EOP, Oneida County Multi-Jurisdiction All Hazard Plan, NFIP- Oneida County and the City of Malad	Deep Creek – Considered a high-hazard Dam -HAZUS estimates that about 51 buildings will be at least moderately damaged with 2 destroyed. Possible economic loss due to Dam failure is 13.73 Million. Crowther is considered a high-risk dam but nothing is really addressed in the current plan, so the vulnerabilities will need to be addressed in the next update. Right now, it does not show as high-risk. There have been no significant, recorded dam failure events in Oneida County Spring and Summer population increases due to recreation and fishing	No mitigation actions are specific to dams. Related actions: Request FIRM Maps Develop a listing of roads, bridges, cattle guards, culverts, and other limiting conditions and incorporate improvements into the County Transportation Plan Comprehensive Mass Shelter and Care Plan for the Entire County Enforce Building Codes Map Floodplain and Flood Prone Areas in the City of Malad

Fish Creek Dam	Blaine County	Blaine County and cities have Comprehensive Plans. All of the communities in Blaine County have Floodplain Ordinances, and all communities within the 100-year flood plain hazard area participate in NFIP. There are 2 repetitive loss properties in the City of Hailey. Multiple flood reports and Risk Map products exist for Blaine County.	Fish Creek Dam is a historical site and dam failure is ranked as one of the lowest risk hazards. Fish Creek Dam is shown in the mitigation plan as a high-risk dam but vulnerabilities are not addressed. Blaine County has big population influxes throughout the year. Skiing, fishing, camping, boating just to name a few, draw tourist to the area.	No mitigation actions are specific to Fish Creek Dam. The strategic goals include developing actions that will reduce damage to flooding. Related actions: Conduct a study for recharge in flood prone areas. Stockpile Temporary Flood Fight Material at W. Glendale BCRB Shop. Install Road Signs as prescribed by NFPA Standards. City of Carey – Seek CRS Status for the City
Blacks Creek Dam	Ada	Ada County and cities have existing programs: Ada County Comprehensive Plan (2007), The comprehensive plans for each of the incorporated city planning partners, Ada County and the cities of Boise, Eagle, Garden City and Meridian all participate in the NFIP. The Ada County Hazard Inventory and Vulnerability Analysis (2010), Ada County Threat/Hazard Identification and Risk Assessment (2015), The Ada County Emergency Operations Plan (2014), Ada County Flood Response Plan (April 2014), Ada County Wildfire Response Plan (May 2014), Ada County Dam Response Plan (April 2007) and the Boise River Enhancement Plan. Cities floodplain or watershed plans.	6 percent of dam failures are due to miscellaneous causes. Many are secondary results of other disasters, such as earthquakes, landslides, storms, snowmelt, equipment malfunction, structural damage, and sabotage. The most likely disaster-related causes of dam failure in Ada County are earthquakes, excessive rainfall and landslides. Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable through regular inspections. Terrorism and vandalism are concerns that all operators of public facilities plan for; these threats are under continuous review by public safety agencies. All statutory sized dams must be inspected by the IDWR no less than every five years. The frequency between individual dam inspections depends on such items as the project's physical	There are no reported mitigation action opportunities for Black Creeks Dam. Related mitigation actions: CW-1 Sponsor and maintain a natural-hazard informational website including hazard-specific information such as warning, private property mitigation alternatives, important facts on risk and vulnerability AC004- Keep first responder facilities out of flood areas where possible. AC005- Examine and determine the most cost-effective method to harden irrigation canals (i.e. tiling) in areas of high urban interface to prevent the flooding of residences and businesses. AC022- Where appropriate, support retrofitting, purchase, or relocation of structures located in hazard-prone areas to protect structures from future damage, with properties with exposure to repetitive losses as a priority. K3- Open space preservation in identified high risk hazard area. M-4 – Meridian apply for CRS and maintain standing

			condition, method of construction, maintenance record, age, hazard rating, and size and storage capacity. Inspection reports prepared by the IDWR for non-federal dams are available through the state office in Boise (Idaho Dam Safety Web Site, 2011). Blacks Creek is rated high for downstream hazard potential. The Boise and Snake River meander through the counties. These rivers, their impoundments, and their tributaries provide boating, fishing, bird watching and other water recreation activities that attract tourism to the most populated area in the state.	M-10 - Perform an assessment to determine housing areas that would benefit from foundation elevation projects. M-12 - Consider appropriate higher regulatory standards that prevent or reduce risk to the built environment from the known hazards of concern. KFD10- Evacuation routes, map and mark evacuation options from southern portion of District. Provide public education in regards to evacuations. Identify Ustick, Homedale, Notus, and Allendale Roads as critical evacuation routes
Blacks Creek Dam	Canyon County	Canyon County and cities have existing programs: The Canyon County 2020 Comprehensive Plan, Canyon County and the cities of Caldwell, Middleton, Nampa, Notus and Parma all participate in the NFIP. Community Planning - US Forest Service, Forest Stewardship Program – US Forest Service, Rural Fire Assistance – BLM, State Fire Assistance – US Forest Service, State Fire Assistance Hazard Mitigation Program – National Fire Plan, Idaho Forestry Assistance Program – IDL, HMGP and FMA – FEMA		8.3.e "Emergency Evacuation Route" signs along the identified primary, secondary and escape access routes in the County Change the policy to give local officials the authority to open irrigation canal head gates during flood events City of Caldwell: Construct diversion gates to direct floodwaters from the Boise River to the Dixie Slough Place Engineered dikes along the River channel through Caldwell Raise the banks on the larger canals that run through Caldwell Develop Policies that all local irrigation districts to open headgates or irrigation canals and ditches to divert floodwaters on to fields. Protect the Waste Water System Clarifier #2 from Flooding City of Notus:

				Protect the Sewer System Treatment Ponds located in the Floodplain
Mackay Dam	Butte and Custer County	Butte County Comprehensive Plan, County Land Use Ordinance 7-31-06, City of Arco Comprehensive Plan and Codified Land Use Ordinances, Butte County and the City of Arco participate in the NFIP Custer County Comprehensive Plan, City of Stanley Comprehensive Plan, City of Challis Comprehensive Plan, Custer County Emergency Operations Plan, Custer Road and Bridge Department Transportation Plan, City of Mackay Emergency Operations Plan (2019), 2016 Custer County Community Wildfire Protection Plan Custer County, as well as the cities of Challis and Mackay, participate in the NFIP. Custer County has two communities within the 100-year flood plain hazard areas that are not participating in the NFIP, including Clayton and Stanley.	Dam Failure causes - Overtopping caused by floods that exceed the capacity of the dam Deliberate acts of sabotage Structural failure of materials used in the dam construction Poor design and/or construction methods. Movement and/or failure of the foundation supporting the dam. Settlement of concrete or embankment dams Piping and internal erosion of soil in the embankment, and/or Inadequate maintenance and upkeep. The Mackay Dam, which is 67 feet high and has a storage capacity of 45,000 acre-feet of water, is located in the southeastern portion of the county. The purpose of the dam is to control flooding and provide irrigation water. The Mackay Dam is classified as a high risk because of potential flooding to residential and agriculture development downstream. If the dam failed catastrophically, flood waters would reach Mackay in 6 minutes. Because the dam is not manned 24 hours a day, it is anticipated that there would be no time to evacuate the town of Mackay should a breach occur. The inundation area would experience impacts greater than a normal flood event	Mackay Dam Report (2017), The Idaho Department of Water Resources Inspection Report of the Mackay Dam was used to assess the condition of the dam following the heavy flooding in 2017. The IDWR Dam Safety Program oversees the regulation and safety of dams and reservoirs throughout Idaho in order to protect the health, safety, and welfare of citizens and their property. Program personnel regularly inspect existing projects according to the potential consequences that the dam's failure would present to downstream life and property. The frequency of individual dam inspections depends on the project's physical condition, method of construction, maintenance record, age, hazard rating, and size and storage capacity. All statutory-sized dams must be inspected by IDWR at least once every 5 years Install a warning system on the Mackay Dam. Project deferred to Custer County. Butte County will assist Custer County upon request. City of Arco – Develop an Evacuation Plan and Notification System for a Mackay Dam Failure

Mountain Home Dam	Elmore County	2014 Elmore County Comprehensive Growth and Development Plan, Elmore County Zoning and Development Ordinance (2018), Mountain Home Flood Hazard Protection and Floodplain Ordinances, February 2019. "Amended Zoning and Development Ordinance." Elmore County, Mountain Home, and Glenn's Ferry all participate in NFIP.	Elmore county has stated that an additional Dam Failure annex would be created if funding was approved to allow them to expand their plan beyond what is currently FEMA funded. They have guidelines from USGS about the location of expanding buildings to prevent potential water pollution. This puts more people downstream and in danger of flooding. Mt Home Dam has overflowed in the past due to an upstream dam failure. This caused $2.7 million of damage in Mountain Home. The Snake River provides over half of the water for irrigation in the county and is a source of power generated at Bliss Dam and C.J. Strike Dam. It provides boating, fishing, and hunting as well as being a scenic attraction. middle portion of the Snake River is a working river and it is the prime source of water for irrigated agriculture in the county. The county has a few hot water artesian wells and springs. Several geothermal wells are being used for irrigation in the Snake River Plains area. Hot water springs can be found along the Front Range and on the Boise River.	There are no reported mitigation action opportunities as it relates specifically to Mt. Home Dam, however there are mitigation actions in place that will be helpful in the event of dam failure. Update Flood insurance Rate Maps. Evaluate culverts, roads and access points identified in floodplains. Add to the stormwater/ overflow collection systems in Mountain Home.
Mountain Home Dam	Owyhee County	Owyhee County Comprehensive Plan-2012, Owyhee County Wildland-Urban Interface Wildfire Mitigation Plan-2004, Owyhee County Energy Plan-2007, Owyhee County Ground Water Quality Improvement & Drinking Water Source Protection Plan-2009, 2010, Owyhee County Natural Resources Plan-2009, Owyhee	A challenge to mitigation actions is that because there haven't been any dam failures in Owyhee county to date there are increases in development and land use in potentially hazard prone areas. - AHMP 5.18	Identifying locations for needed retention ponds. Check and maintain or improve roads and waterways near and around Bruneau to mitigate flash flood problems.

		County Sage-Grouse Management Plan-2000, 2004, 2013. The City of Homedale does participate in NFIP. The City of Grandview, which could be affected by Mt Home dam, but does not participate in NFIP. They do have an ordinance that regulates construction in the 100-year flood zone within Grandview.	The county has mapped a majority of its waterways however they do not have Digital Flood Insurance Rate Maps (DFIRMS). Non-regulatory depth grids that were provided by FEMA where used to map the extent and magnitude of flood risk. These maps are also technically incomplete as they do not cover all possible waterways. Limited funds keep the county from updating their Flood Insurance Rate maps. The federally and state managed lands within the county allow for a wide variety of recreational activities ranging from jet boating to remote area camping to off-highway vehicle activities. Hunting and fishing are also popular on the lands and waters of the county. whitewater water sports are popular for tourists but no numerical data is provided. Rafting and kayaking are popular activities on the Bruneau River and Owyhee River drainages. Jet boating is also enjoyed, particularly on the Snake River. There are several boat ramps or put-in areas along both waterways; however, some of these sites present difficult or hazardous conditions.	

Strongarm #1	Franklin County	Franklin County and its incorporated communities employ other measures that regulate development and certain activities in hazardous areas. These include, but are not limited to, comprehensive plans, overlay districts, subdivision ordinances, building codes, and fireworks ordinances. Unincorporated Franklin County and the cities of Preston and Weston participate in the NFIP.	Strongarm Number One Dam, also known as Treasureton Reservoir, is a private earthen dam completed in 1887. It is 480 feet in length and 39 feet in height, with a hydraulic height of 36 feet. The impoundment covers a surface area of 131 acres and a drainage area of 4,456 square miles, with a 1,713 acre-feet storage capacity. The spillway is capable of 360 cfs and its potential hazard for downstream areas as a result from failure or mis-operation of the dam or facilities is recognized as high. An emergency action plan is in place for this dam. The dam has a controlled spillway type, with 20 feet of spillway available for discharge when the reservoir is at its maximum designed water surface elevation. The dam is inspected every two years and is state regulated by the Idaho Department of Water Resources. The most recent condition assessment rated Strongarm Number One Dam as satisfactory. Besides providing recreational opportunities and watershed provisions, Strongarm #1 reservoir can provide a water source for fire engines and helicopters during wildfire suppression operations	Related actions: 2, 39. Seek CRS Status for the County and City of Preston 3, 41. Request Updates of the FIRM Maps 45. Use the Risk Assessment in this HMP to develop land use policies 56. Maintain cooperation and communication with IDWR on monitoring and inspecting dams 66. Continue participation in the NFIP Program through the enforcement of Floodplain ordinances and building codes
Oakley Dam	Cassia	Community capabilities include comprehensive plans, overlay districts, subdivision and zoning ordinances, building codes, and fireworks ordinances. The City of Burley has a Master Water Plan and Municipal Airport Site Selection Study. Cassia County established an Outdoor Recreation Land Use Zone. The County and	The most recent condition assessment rated Oakley Dam as unsatisfactory. Given changes in climate conditions and development, the planning team and local officials are concerned with sheet flooding, localized flooding, and impoundment structure failure.	Mitigation Actions 59. Update dam operations plan for Oakley Dam 60. Install gate on the spillway to control flows on Oakley Dam and complete other engineering recommendations for Oakley Dam study

		Cities participate in NFIP. Evacuation plan for Oakley Reservoir from Oakley to Snake River.	Dispatch is in the flood zone. Skiing and fishing draw tourists to the area.	61. Improve West Canal capacity for Oakley Dam 62. Watershed Model/SNOTEL Data needed specifically for the Oakley Reservoir Drainage 64. Install injection sites for Oakley Dam
Oakley Dam	Gooding	Gooding County Community Wildfire Protection Plan, Floodplain Management, Stream Channel Protection Program, Emergency Operations Plan, Cities Ordinances and State Codes, Site Master Plans (wastewater treatment, landfill, airport, business incubators, etc.), Personnel Training Programs, NFIP, and Storm Drain Management.	Mountainous areas are especially susceptible to the damaging effects of flash floods, as steep topography may stall thunderstorms in a limited area and may also funnel runoff into narrow canyons, intensifying flow. Winter weather, Ice jams or debris contribute to flooding hazards. Recreational properties exist along the Snake River Canyon. Hagerman experiences a large seasonal population.	No actions are specific to Oakley Dam. Mitigation action 6.1.b. Develop county and city policies to restrict development in flood zone to help prevent losses. 6.1.p. Evaluate the structures located in the flood zone to determine measures needed to protect the structure from flood waters (elevation of structure, barrier, wet protection, etc.). Multiple jurisdictions: County and cities' continued participation in National Flood Insurance Program. Develop county and city policies to restrict development in flood zone to help prevent losses. Mitigate flooding in flood prone roads throughout County. Request FEMA update of Flood Insurance Rate maps. Placement of information and warning signs in open spaces.
Oakley Dam	Jerome	Emergency Operations Plan, Jerome County and cities' Comprehensive Plans, Fire Fighting, Emergency Medical Services, Transportation Planning, Public Utilities, Road and Bridge Maintenance, Law Enforcement, County and City of Jerome's participation in NFIP.	There is no indication that any part of Jerome County is at risk to inundation from a catastrophic dam failure event, except residents and structures residing in the Snake River Canyon. There are 387 parcels that lie in the Snake River Canyon that may be affected by a failure of any of the upstream dams. The total value of structures in the canyon is $59,083,383 and the total property value is $92,739,521.	No specific actions for Oakley Dam. Related actions: Request Updates of FIRM Maps to include Canal System Drainage.

			Jerome County offers many recreational opportunities including hunting, fishing, water and winter sports, hiking, camping, sightseeing, and wildlife and nature photography. The Snake River, Wilson Lake Reservoir, BLM Snake River Rim Special Recreation Management Area, and Scott's access south of Jerome offer many recreational access sites for tourists.	
Oakley Dam	Minidoka	Comprehensive Plans, subdivisions and Planned Unit Developments ordinances, building codes, city and county ordinances, zoning and land use ordinances, building codes, floodplain ordinances, NFIP, County Wildfire Protection Plan, and Local Emergency Planning Committee.	There are no impoundment failures currently to date in Minidoka County. Future land use and more intensive land use may increase the possibility of structural damage and loss of life and property. The County and cities ranked tourism low < 5% to medium low 6-10%. However, Craters of the Moon, the Snake River, Minidoka National Wildlife Refuge, Lake Walcott, Milner Reservoir, and small streams and springs provide many recreational opportunities.	No specific actions for Oakley Dam. Related actions: 9. Request Updates of FIRM Maps to include Canal System Drainage 39. Adopt the NFIP Program – City of Paul 46. Assess feasibility of Reopening injection wells near Camp Hawley
Oakley Dam	Twin Falls	Comprehensive Plan, local capital improvement plans which include infrastructure projects such as stormwater systems, water supplies, warning sirens, and communications equipment. Regulations, agreements, and related procedures and existing emergency operating or response plans and land use ordinances. NFIP Continuity Strategy	There is no history of damage from Oakley Dam. Twin Falls County is the most populous county in central Idaho. It is home to the College of Southern Idaho and the famous Shoshone Falls, sometimes called the Niagara of the West, with an impressive 212-foot drop. The county is not only a retail hub for most of central Idaho, but is also a recreational hot spot for travelers.	No specific actions for Oakley Dam, but Twin Falls County will continue to participate in the NFIP and develop actions that will reduce possible damage to county infrastructure due to flash and stream flooding.