2.6 DAM/LEVEE FAILURE

A dam failure is defined as an uncontrolled release of the reservoir. The causes of dam failures can be divided into three groups: dam overtopping, excessive seepage, and structural failure of a component. Despite efforts to provide sufficient structural integrity and to perform inspection and maintenance, problems can develop that can lead to failure. While most dams have storage volumes small enough that failures have little or no repercussions, dams with large storage amounts can cause significant flooding downstream.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, which cause most failures;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam and abutments, or maintain gates, valves, and other operational components;
- Improper design, including the use of improper construction materials and construction practices;
- Negligent operation, including the failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway;
- Landslides into reservoirs, which cause surges that result in overtopping;
- High winds, which can cause significant wave action and result in substantial erosion; and
- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, which can weaken entire structures.

Dams are complicated structures, and it can be difficult to predict how a structure will respond to distress. "… the modes and causes of failure are varied, multiple, and often complex and interrelated, i.e., often the triggering cause may not truly have resulted in failure had the dam not had a secondary weakness. These causes illustrate the need for careful, critical review of all facets of a dam" (*Safety of Existing Dams*, 1983).

The Ohio Department of Natural Resources, Division of Water - Dam Safety Program has the responsibility to ensure that human life, health and property are protected from dam failures. The program achieves its core purpose by performing six main functions:

- *Emergency response* – Assessing the conditions of dams during severe floods and emergency's, taking action to correct dams that pose an immediate threat to public safety, providing timely and best-available

information to other agencies and the public during disasters, and supporting mandate Ohio Revised Code (ORC) Section 1521.062;

- *Construction permits* – Ensuring that dams and levees are designed and constructed in accordance with proper engineering standards and OAC rules, reviews construction plans and specifications, performs calculations and investigations, issues permits, and monitors/approves construction;
- *Repairs and modifications* -- Ensuring that dams and levees are repaired in accordance with proper engineering standards and OAC rules, reviews construction plans and specifications, performs calculations and investigations, issues permits, and monitors/approves construction, and supports mandate ORC Section 1521.062;
- *Periodic safety inspections* – Identifying dam deficiencies and direct dame owners to correct said deficiencies, monitors the overall condition of Ohio's dams, provides data for NPDP, supports mandate ORC Section 1521.062, and inspects every jurisdictional dam once every five years;
- *Enforcement* – Requiring dam and levee owners to improve safety when efforts for voluntary compliance have been unsuccessful and focuses on highly deficient Class 1 dams with dense populations downstream; and
- Public information – Providing data security for Ohio EMA, USACE, the National Guard, OEPA, as well as state and federal legislature, provides dam and levee owners and engineers with technical information and access to division files, educates the public about dam safety and provides quality data, and gives presentations for EPA, WMAO, and OLCA.

The ORC provides the authority for the program to regulate dam safety and dictates the responsibilities of the program as well as the responsibilities of the dam owners. The program regulates approximately 1,656 dams in Ohio of which 498 are Class I (high hazard).

RISK ASSESSMENT

Location

In Ohio there are 1,656 known dams included in the USACE, national inventory of dams (NID). The volume of water impounded, and the density, type, and value of development downstream determine the potential severity and potential classification of dam failure.

The ODNR - Dam Safety Program classifies the hazard potential for dams as Class I, Class II, Class III, and Class IV dams (*see Table 2.6.a*). All Class I dams are required to have Emergency Action Plans (EAPs), including dam failure inundation mapping.

Table 2.6.a

Ohio and Federal Dam Classification Systems		
Ohio Hazard Classification	**Description**	**Corresponding Federal Classification**
Class I	Probable loss of life, serious hazard to health, structural damage to high value property (i.e., homes, industries, major public utilities)	High
Class II	Flood water damage to homes, businesses, industrial structures (no loss of life envisioned), damage to state and interstate highways, railroads, only access to residential areas	High
Class III	Damage to low value non- residential structures, local roads, agricultural crops and livestock	Significant
Class IV	Losses restricted mainly to the dam	Low

Source: www.dnr.stat.oh.us/water/dsafety/whatdam.htm

In Ohio, there are 498 high, 541 significant, and 639 low hazard potential dams. This assessment will primarily focus on the top ten dams in Ohio whose failure could have catastrophic consequences:

- Salt Fork Dam – Guernsey County – Region 3
- Hoover Dam – Franklin County – Region 2
- O'Shaughnessy Reservoir Dam – Delaware County – Region 2
- Indian Lake Dam – Logan County – Region 1
- Grand Lake St. Mary's Dam – Auglaize County – Region 1
- Mineral Ridge Dam – Trumbull County – Region 2
- Lake Milton Dam – Mahoning County – Region 2
- Bridge Creek Dam – Geauga County – Region 2
- Rocky Fork Lake Dam – Highland County – Region 3
- Wolf Run Lake Dam – Noble County – Region 3

There are a total of 264 dams within Region 1, which is the least number of dams among the regions. Out of those there are 92 high hazards dams and 69 significant hazard dams. Within Region 1, Huron County has the largest number of dams for a total of 24, of which 17 are high hazard or significant hazard dams.

There are a total of 707 dams within Region 2 registered with NID. Out of those, there are 190 high hazard dams and 212 significant hazard dams. The largest concentration of dams within Region 2 is in Medina County. Medina County has the second highest number of high hazard and significant hazard dams in the county.

Region 3 has the second highest number of dams registered with NID for a total of 685 structures. Of these, 216 are high hazard and 238 are significant hazard dams which creates a higher vulnerability in the region than in region 2 where the total number of dams is higher, but the number of high hazard or significant hazard dams is lower. Within Region 3 Muskingum County has the largest total number of dams (66). Muskingum County, has the largest number of significant hazard dams (27) and the largest number of low hazard dams (30). However, Perry County has the largest number of high hazard dams (17).

Past Occurrences

The National Performance of Dams Partnership, a cooperative effort of engineers and dam safety professionals in the U.S., retrieve, archive, and disseminate information on dam performance, reports nine failures in regulated and unregulated dams in the State of Ohio between 1950 and 2003 (see Table 2.6.b). Of these events, only one failure was associated with one of the top 10 high hazard dams in Ohio (Wolf Creek Dam).

According to ODNR - Dam Safety Program, there has been little property damage that has resulted from a dam failure alone. However, there has been property damage that was a combination of downstream flooding due to excessive precipitation and dam failure. Unfortunately, it is difficult to assess which property damage was a direct result of the dam failure and which damage was a result of downstream flooding due to excessive precipitation. There has been some infrastructure loss in terms of roads washing away, but there has been no loss of critical facilities due to dam failure.

Table 2.6.b

Ohio Dam Failures/Near Failures From 1950 to 2003				
Dam Name	**County**	**State**	**Incident Date**	**Incident Description**
Morgan County Dam (Wolf Creek Dam)	Morgan	OH	1950	Heavy rainfall and flooding; downstream property damage.
Lake Logan Dam	Hocking	OH	1950	The dam was breached due to inadequate design and construction and the lake was forcibly drained.
Ashland Reservoir Dam	Ashland	OH	1969	Failed by overtopping. There were no details on the failure in the file.
Greenwich Reservoir Dam	Huron	OH	1969	There was a partial failure of the dam in 1969. There were no details of the failure in the file.
Houston Lake Dam	Holmes	OH	1969	The dam completely washed out in the 1969 flood. There are no specific details on the failure in the file.
Athens Fish and Game Club Lake Dam	Athens	OH	1975	The dam was breached in 1975 due to seepage seen in three areas and a slide approximately 15-feet wide and about 10-feet above the toe. There was no downstream property damage as a result of the breach.
Bloomingdale South Lake Dam	Jefferson	OH	1997	The spillway failed and the dam breached itself. There were no reported property damages down stream.
Brimfield Lake Dam	Portage	OH	1979	Storms from a hurricane caused the dam to overtop.

Ohio Dam Failures/Near Failures From 1950 to 2003				
Dam Name	**County**	**State**	**Incident Date**	**Incident Description**
				There were no reported damages to downstream property.
Lexington Glen Dam	Delaware	OH	1987	The dam failed in 1987 due to erosion on the emergency spillway and four erosion rills on the downstream slope.
Chopper's Lake Dam	Washington	OH	1994	Heavy rainfall leading to dam overtopping and erosion of earth adjacent to spillway
Ivex of Ohio Upper Lake Dam	Cuyahoga	OH	1994	Heavy rain leading to dam breaching itself causing significant sediment to be released into the lake. There is no record of downstream property damage as a result of the breach.
Thomas Pond Dam	Adams	OH	1997	Heavy rain led to dam overtopping and breach; spillway clogged with debris; foundation poorly constructed; downstream damage included road underground power lines being destroyed and three homes receiving flood damage.
Cecil Hollow Lake Dam	Not recorded	OH	1997	Lack of spillway system lead to dam being overtopped and breached; downstream residents flooded.
Green Acres Levee	Not recorded	OH	1997	100-Year flood; levee overtopped; several homes flooded.
Bookhamer Lake Dam	Madison	OH	1998	Flooding affected spillway in poor condition spillway, leading to breach; no downstream damage.
Lower Hickory Hills Lake Dam	Meigs	OH	1998	There was a breach due to overtopping and severe erosion. The road downstream was washed out and overtopping contributed to trailers floating away.
Beldon Pond Lake Dam	Tuscarawas	OH	1999	Piping corroded leading to slow, continuous breach; no property damage.
Pischieri Pond Dam	Medina	OH	1999	The dam was breached when an inspection found a void in the dam. The downstream property owner was upset that the dam was breached across his property but suffered no structural damage to personal property.
Crown City Mining Pond No. 24 Dam	Lawrence	OH	1999	Dam breached; no downstream damage.
Polecat Lake Dam	Lawrence	OH	2001	The dam was found to have extreme seepage in 2001 and was breached in 2001. There was no reported property damage down stream.
Rustic Hills Lake Dam	Medina	OH	2003	The emergency spillway failed causing overtopping. This overtopping severely eroded the downstream slope.

Source: National Performance of Dams, Dam Incident Notification Database and ODNR – Dam Safety Program

Probability of Occurrence

For reasons previously mentioned and uncontrollable by humans, it is highly possible a dam can fail at any time, given the right circumstances. However, the probability of future occurrence is reduced due to proactive preventative action on the part of ODNR – Dam Safety Program. As previously discussed in this section,

the ODNR – Dam Safety Program provides oversight to dam/levee repairs, oversees and issues construction permits, enforces safety standards and mandates, conducts periodic safety inspections, and provides public information to levee owners, engineers, and the general public. This proactive approach to managing dam safety in Ohio reduces the number of losses to property and life as a result of dam failure or near failure. Table 2.6.c provides specific information on the events affecting the top ten high hazard dams in the state.

Table 2.6.c

Events for Top Ten High Hazard (Class 1) Dams in Ohio		
Dam	**Date**	**Event**
Salt Fork Lake Dam	1968	Dam Constructed
	1978	Phase I investigation completed
	1980	Phase II investigation completed
	1985	Outlet channel repaired and seepage control added
	1985	ODNR-DOW dam safety inspection
	2000	Last ODNR-DOW dam safety inspection
Hoover Dam	1956	Dam Constructed
	1974	First ODNR-DOW dam safety inspection
	1979	USACE Phase I inspection was performed by ODNR-DOW
	1986	Second ODNR-DOW dam safety inspection
	1992	Lake drains were rehabilitated
	1994	Concrete repair was made on spillway, sidewall and groin gutters
	1998	Bascule gates were rehabilitated
	2000	Third ODNR-DOW dam safety inspection
O'Shaughnessy Reservoir Dam	1925	Dam Constructed
	1980	USACE Phase I inspection
	1999	5-Year inspection of structure by private consultant
Indian Lake Dam	1852	Dam Constructed as a feeder lake to the Miami-Erie Canal
	1978	USACE Phase I inspection
	1986	First ODNR-DOW dam safety inspection
	1995	Replace lake drain
	1996	Widened the crest
	2000	Second ODNR-DOW dam safety inspection
Grand Lake St. Mary's Dam (West Embankment)	1837-1841	Dam was constructed as a feeder lake to the Miami-Erie Canal
	1978	USACE Phase I inspection
	1997	New Spillway and level crest to increase discharge/storage capacity
	2000	ODNR-DOW dam safety inspection
Mineral Ridge Dam	1932	Dam constructed
	1978	Phase I inspection
	1983	First ODNR-DOW dam safety inspection
	1994	Raised crest and normal pool, and added emergency spillways
	1997	Second ODNR-DOW dam safety inspection
	2003	Third ODNR-DOW dam safety inspection
Lake Milton Dam	1916	Dam constructed
	1930's	Significant repairs, upgrades, and maintenance on dam
	1969	Distress on upstream slope and crest of the west embankment is noticed
	1970	Seepage and evidence of instability on the downstream west abutment is noticed

Events for Top Ten High Hazard (Class 1) Dams in Ohio		
Dam	**Date**	**Event**
	1974	ODNR-DOW orders City of Youngstown to breach dam after a review of inspection findings
	1975	Ogee weir stabilized with rock anchors. Stabilizing berm and relief wells placed along tow of east embankment section.
	1980	USACE inspection to determine the adequacy of structural and hydraulic components
	1984	First ODNR-DOW dam safety inspection
	1987-1988	Significant repairs, upgrades, and maintenance on dam
	1998	Second ODNR-DOW dam safety inspection. Slide noted on downstream slope of the east embankment. Slide repaired.
	2000	Problem with gate #4 noted.
	2003	Third ODNR-DOW dam safety inspection
Bridge Creek Dam	1961	Dam constructed
	1978	Phase I inspection
	1983	First ODNR-DOW dam safety inspection
	1991	Second ODNR-DOW safety inspection
	2001	Third ODNR-DOW dam safety inspection
Rocky Fork Lake Dam	1952	Dam constructed
	1978	Phase I inspection
	1984	First ODNR-DOW dam safety inspection
	1995	Large boulders fell from left abutment
	1998	Second ODNR-DOW dam safety inspection
	2003	Third ODNR-DOW dam safety inspection
Wolf Run Lake Dam	1966	Dam constructed
	1980	USACE Phase I inspection
	1985	First ODNR-DOW dam safety inspection
	1994	Second ODNR-DOW dam safety inspection
	1998	Principal spillway pipe inspected after the 1998 flood
	2001	Third ODNR-DOW dam safety inspection
	2004	Widened emergency spillway, groin drains, developed draft EAP with inundation map

Source: ODNR, Division of Water – Dam Safety Program

Environmental Impacts

Dam or levee failures can have a greater environmental impact than that associated with a flood event. Large amounts of sediment from erosion would alter the landscape changing the ecosystem. Hazardous materials are carried away from flooded out properties and distributed throughout the floodplain. Industrial and agricultural chemicals and wastes, solid wastes, raw sewage, and common household chemicals comprise the majority of hazardous materials spread by flood waters along the flood zone, polluting the environment and contaminating everything they come in contact with, including the community's water supply.

The soil loss from erosion and scouring would be significantly greater because of a large amount of fast moving water affecting a small localized area, which would likely change the ecosystem.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

Assessing the hazard that a dam poses to downstream areas can be divided into three analyses: (1) analysis of an uncontrolled release of the reservoir, (2) analysis of the inundation from the uncontrolled release, and (3) analysis of the consequence of the release. In other words, a dam fails, the failure causes flooding downstream, and the flooding has negative impacts on people or property. Each of these analyses includes substantial uncertainty. Legitimate estimates of discharge from a breach can differ by over 200%. Discharge from a dam breach is usually several times the 1% chance flood, and, therefore, typical flood studies are of limited use in estimating the extent of flooding. Dam failure inundation studies require specialized hydraulic modeling software and experience. Determining the impact of flooding is also difficult to accomplish, especially for estimating loss of life. Loss of life is a function of the time of day, warning time, awareness of those affected, and particular failure scenario. Many dam safety agencies have used “population at risk”, a more quantifiable measurement of the impact to human life, rather than “loss of life”. Population at risk is the number of people in structures within the inundation area that would be subject to significant personal danger, if they took no action to evacuate.

The impacts of a dam failure are contingent on many factors and, therefore, cannot be concisely described. The assessments below are very rough estimates based on experience with flood modeling, other inundation studies, best available information, preliminary calculations, and flood insurance rate maps. Loss of water supply due to failure of the dam is not specifically addressed; refer to OEPA for this information. Unless otherwise noted, the assumed failure scenario is rapid breach of the dam during an elevated pool.

- All distances are approximated
- 1% flood = a flood that has a 1% chance of being equaled or exceeded in any given year = 100-year flood
- Comparisons to the 1% chance flood are made for perspective – flood waves diminish as they move downstream
- Vulnerable population and structures are estimated
- Dam failure discharge is estimated
- Multiples of discharge don’t necessarily correspond to multiples of depth

Results

For this particular vulnerability analysis and loss estimation, the top 10 high hazard dams discussed.

Salt Fork Lake Dam

Salt Fork Lake Dam is located on Salt Fork Creek near Cambridge. Salt Fork Creek joins Wills Creek 1 mile downstream of the dam. Wills Creek flows generally to the west and meets Wills Creek Dam 32 miles downstream of the Salt Fork Lake Dam. Wills Creek Dam is a flood-control structure regulated by the US Army Corps of Engineers and normally has about 37 feet of flood storage in its reservoir (flood pool). Flood pool at Wills Creek Dam would inundate a portion of the downstream side of Salt Fork Lake Dam. Communities and their distances downstream include Kimbolton at 8 miles and Plainfield at 23 miles. Discharge from failure of Salt Fork Lake Dam is estimated to be at least 9 times the 1% flood discharge. The 1% flood in Cambridge, 9 miles upstream of Salt Fork Lake Dam on Wills Creek, is about 35 feet deep. The impacts of failure of Salt Fork are relatively uncertain because of the complexity of flood elevations on Wills Creek due to storage behind Wills Creek Dam and natural flooding on Wills Creek. Inundation would damage several homes, local roads, and an interstate highway, and would cause a significant rise in the pool behind Wills Creek Dam. The impact on Wills Creek Dam is unknown but would be dependent on flooding conditions at the time of failure. It appears that during a dry period, Wills Creek Dam would safely pass the flood from Salt Fork. Floodwater from failure of Salt Fork Lake Dam would likely flow upstream to Cambridge. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Salt Fork Dam.

Salt Fork Lake Dam does not have a detailed emergency action plan or inundation mapping.

Hoover Dam

Hoover Dam is located on Big Walnut Creek on the northeast side of Columbus. Big Walnut Creek flows along the east side of Columbus, joins the Scioto River south of Columbus, and then flows to Circleville. Discharge from failure of the dam is estimated to be at least 10 times greater than the 1% flood discharge. Communities and their distances downstream include Gould Park at 4 miles, Gahanna at 7 miles, Whitehall at 10 miles, and Columbus at 12 miles. Inundation is expected to noticeable in Circleville 30 miles downstream. Damage is expected to be extensive and would include many residential structures, state routes, local roads, interstate highways, and businesses. Table 2.6.3.2.a displays the total vulnerable population, structures and estimate of potential loss for the inundation area of Hoover Dam.

Hoover Dam has a working emergency action plan (EAP), and inundation mapping is being developed. The Division of Water has not approved either document. The assessment provided above was partially based on inundation mapping for Alum Creek Reservoir Dam. Alum Creek Reservoir Dam and Hoover Dam are of similar size and construction, which allows for some comparison of the expected extent of inundation. Alum Creek Reservoir Dam is located north of Columbus and is regulated by the US Army Corps of Engineers.

O'Shaughnessy Reservoir Dam

O'Shaughnessy Reservoir Dam is located on the Scioto River on the northwest side of Columbus. The Scioto River flows south through urban areas of Columbus, meets the Olentangy River 15 miles downstream, and continues south. Julian Griggs Dam is located 11 miles downstream. Discharge from failure of the dam is estimated to be at least 5 times greater than the 1% flood discharge. Inundation would damage many residential structures, a state route, a local road, I-270, and the road across the dam. The population at risk is 85. Failure of O'Shaughnessy is not expected to cause failure of Julian Griggs Dam. Significant impact from failure of O'Shaughnessy Reservoir Dam, while at normal pool leve,l would likely terminate before the Olentangy River. Flooding downstream of Griggs may cause problems but it is not estimated to put any population at risk. Impact could extend farther downstream if the dam failed during a significant flood event. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of O'Shaughnessy Reservoir Dam.

O'Shaughnessy Reservoir Dam has a detailed EAP and inundation mapping. The inundation mapping provided the basis for much of the information above. The Division of Water has approved both documents.

Indian Lake Dam

Indian Lake Dam is located on the Great Miami River near Logan. The Great Miami River flows south and west toward Sidney. Dam failure inundation would be relatively long in duration, shallow in depth, and far in extent because of the low height and high storage of the dam. DeGraff is 12 miles downstream and is the only community located along the Great Miami River that would likely be affected. Inundation would damage several habitable structures, local roads, and state routes. The population at risk is estimated to be 20 and mostly located near the dam. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Indian Lake Dam.

Indian Lake Dam does not have a detailed emergency action plan or inundation mapping. A brief EAP has been established.

Grand Lake St. Mary's Dam

Grand Lake St. Mary's Dam is located near St Mary's and has an east and west embankment to impound the reservoir. Discharge from the east embankment would flow east to the St. Mary's River, north into St. Mary's, and then west-northwest toward Indiana (36 miles downstream). Communities along the St. Mary's River and their distances downstream include St. Mary's at 3 miles, Mendon at 18 miles, and Rockford at 26 miles. Dam failure inundation would be relatively long in duration, shallow in depth, and far in extent because of the low height and high storage of the dam. Dam failure inundation would damage habitable structures, local roads, state routes, and a railroad.

Discharge from the west embankment would flow into Beaver Creek and then into the Wabash River. The Wabash River enters Indiana 10 miles downstream. No

communities are located in Ohio along Beaver Creek or Wabash River downstream of the dam. The discharge from failure of the dam is estimated to be at least 6 times greater than the 1% flood discharge. Several local roads and state routes would be damaged. The inundation would be relatively long in duration and shallow in depth and far in extent because of the low height and high storage of the dam. Dam failure inundation would damage habitable structures, local roads, and state routes. The west embankment is about 1 mile long and has several habitable structures located along it. There is potentially population at risk in this area depending upon the location of a dam breach. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Grand Lake St. Mary's Dam.

Grand Lake St. Mary's Dam does not have a detailed emergency action plan or inundation mapping.

Mineral Ridge Dam

Mineral Ridge Dam is located on Meander Creek near Niles. Meander Creek joins the Mahoning River 2 miles downstream, which flows toward Youngstown and eventually into Pennsylvania. Discharge from failure of the dam is estimated to be at least 10 times greater than the 1% flood discharge. Communities located along Meander Creek and the Mahoning River and their distances downstream include Niles at 1 mile, Girard at 3 miles, Youngstown at 10 miles, Campbell at 14 miles, Struthers at 15 miles, and Lowellville at 17 miles. The farthest extent of flooding downstream is not known but would likely be noticeable in Pennsylvania. Flooding would extend upstream along the Mahoning River toward Warren. Dam failure inundation would damage habitable structures, local roads, state routes, industrial properties, and railroads. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Mineral Ridge Dam.

Mineral Ridge Dam has an extensive EAP but does not have detailed inundation mapping. The Division of Water has not approved either document.

Lake Milton Dam

Lake Milton Dam is located on Mahoning River near Newton Falls. The Mahoning River flows north and northeast toward Newton Falls and then southeast toward Pennsylvania. Berlin Lake Dam is located directly upstream and regulates flow into Lake Milton. The US Army Corps of Engineers regulates Berlin Lake Dam. Discharge from failure of the dam is estimated to be at least 20 times greater than the 1% flood discharge. The communities and their distances downstream include Pricetown at 1 mile, Newton Falls at 6 miles, Leavitsburg at 17miles, and Warren at 21.5 miles downstream. The extent of dam failure inundation is not known but would be expected to extend beyond Warren. Dam failure losses would be devastating. Dam failure inundation would damage habitable structures, local roads, state routes, industrial properties, and railroads. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Lake Milton Dam.

Lake Milton Dam does not have a detailed emergency action plan or inundation mapping.

Bridge Creek Dam

Bridge Creek Dam is located on Bridge Creek near Burton. Bridge Creek flows northeast and joins the Cuyahoga River 2 miles downstream. The Cuyahoga River flows south and southwest toward Akron. Discharge from failure of the dam is estimated to be at least 16 times greater than the 1% flood discharge. Communities and their distances downstream include Hiram Rapids at 8 miles and Mantua at 12 miles, and Kent at 23 miles. Lake Rockwell Dam is located on the Cuyahoga River 21 miles downstream. Dam failure inundation would damage habitable structures, local roads, state routes, an interstate highway, industrial properties, and railroads. The population at risk between Bridge Creek Dam and Lake Rockwell is estimated to be 187. Failure of Bridge Creek Dam could cause failure of Lake Rockwell Dam. Kent, Munroe Falls, and Akron are located downstream of Lake Rockwell Dam and would likely be affected by failure of Lake Rockwell Dam. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Bridge Creek Dam.

Bridge Creek Dam does not have a detailed emergency action plan or inundation mapping. The owner does routinely inspect and maintain the dam.

Rocky Fork Lake Dam

Rocky Fork Lake Dam is located on Rocky Fork near Bainbridge. Rocky Fork joins Paint Creek 6 miles downstream, which flows toward Chillicothe and then into the Scioto River. Discharge from failure of the dam is estimated to at least 5 times greater than the 1% flood discharge. Communities and their distances downstream include Bainbridge at12 miles and Chillicothe at 35 miles. The extent of dam failure inundation is expected to extend beyond Chillicothe. Dam failure inundation would damage habitable structures, local roads, state routes, industrial properties, and railroads. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Rocky Fork Lake Dam.

Rocky Fork Lake Dam does not have a detailed emergency action plan or inundation mapping. The assessment provided above was partially based on inundation mapping for Paint Creek Dam, located on the near Rocky Fork Lake Dam and regulated by the US Army Corps of Engineers.

The assessment provided above was partially based on inundation mapping for Paint Creek Dam. Rocky Fork Lake Dam and Paint Creek Dam are of similar size and construction, which allows for some comparison of the expected extent of inundation. Paint Creek Dam is regulated by the US Army Corps of Engineers.

Wolf Run Lake Dam

Wolf Run Lake Dam is located on West Fork Duck Creek near Belle Valley. West Fork Duck Creek flows south along Caldwell and into Duck Creek 26 miles downstream of the dam. Discharge from failure of the dam is estimated to be at least 11 times greater than the 1% flood discharge. Communities and their distances downstream include Belle Valley at 1 mile, Caldwell at 6 miles, and Macksburg at 25 miles. The extent of dam failure inundation is expected to extend beyond Macksburg

and to be approximately the 1% flood at that location. Dam failure inundation would damage habitable structures, local roads, state routes, and interstates. Table 2.6.3.2.a displays the total vulnerable population, structures and EPL for the estimated inundation area of Wolf Run Lake Dam.

A detailed EAP and inundation mapping are in the process of being developed for Wolf Run Lake Dam. The inundation mapping is nearly complete and was used for this assessment.

STATE OWNED / CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

Comparing the state-owned and critical facility structure inventory identified and discussed in Section 2.1 of this plan with the inundation information discussed in Section 2.6 of this plan, an assessment of vulnerable state-owned structures and critical facilities was completed for the top ten dams in Ohio. This assessment provided an approximation of the state-owned structures and critical facilities at risk for each dam inundation area.

For the dams located in the counties that were not inventoried and listed in Section 2.1, field visits to the downstream dam site determined if state-owned structures or critical facilities over $1M were in the potential inundation area if the dam were to fail.

The estimate of potential loss for all state-owned structures and critical facilities, except for that of state-owned dams, was determined using the methodology identified in Section 2.1 of this plan. The estimate of potential loss of state-owned dams includes costs associated with dam construction after construction plans were finalized. That estimate is then increased using a 2 percent interest to bring the EPL to present day value. The estimate of potential loss of these structures are lower-end estimates of replacement costs with the assumption of complete dam failure through its maximum section and loosing its principal spillway.

Results

To date there are no state-owned structures or critical facilities located in the potential inundation areas of the top ten dams discussed in this section.