Section 15. Dam Failure

Contents

Why Dam Failure Is a Threat

Benefits provided by dams include water supplies for drinking, irrigation and industrial uses; flood control; hydroelectric power; recreation; and navigation. At the same time, dams also represent a risk to public safety. Dams require ongoing maintenance, monitoring, safety inspections, and sometimes even rehabilitation to continue safe service.

Dams are water storage, control, or diversion structures that impound water upstream in reservoirs. Dam failure can take several forms, including a collapse of, or breach in, the structure. While most dams have storage volumes small enough that failures have few or no repercussions, dams storing large 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 of the embankment;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, or maintain gates, valves, and other operational components;
- Improper design or use of improper construction materials;
- Failure of upstream dams in the same drainage basin;
- Landslides into reservoirs, which cause surges that result in overtopping;
- High winds, which can cause significant wave action and result in substantial erosion;
- Destructive acts of terrorists; and,
- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, leading to structural failure.

The nation's dams are aging. Old age and neglect can intensify dams' vulnerability to these influences. The terrorist attacks of September 11, 2001, generated increased focus on protecting the country's infrastructure, including ensuring the safety of dams.

Dam failures may result in the quick release of the water from the reservoir. In the event of a dam failure, the energy of the water stored behind the dam is capable of causing rapid and unexpected flooding downstream, resulting in loss of life and great property damage.

Hazard Profile

Failure of a major dam is an unlikely event. If it should occur, however, the severity of impact could be substantial. It could cause multiple deaths, completely shut down facilities for years, and cause the destruction of, or severe damage to, more than fifty percent of affected properties.

Flooding-related dam failure in the Guadalupe River Basin would most likely occur in months when floods are most likely -- during the late spring, early summer (May, June and July) and fall (September, October and December). Warning time for dam failure, or the potential speed of onset, varies with the causes but is estimated to be three to six hours.

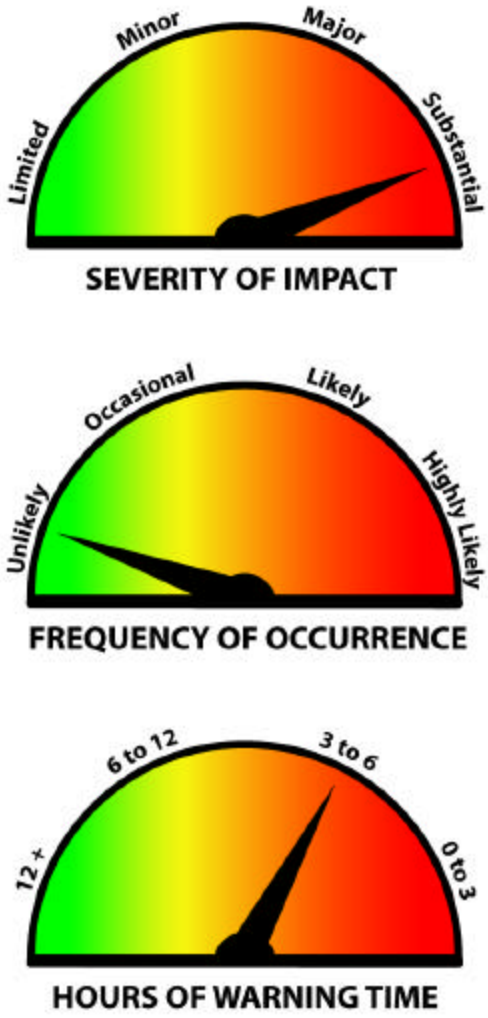

Figure 15-1. Dam Failure Hazard Profile Summary

History of Dam Failures

There are about 80,000 dams in the United States today.[1] Catastrophic dam failures have occurred frequently throughout the past century. Between 1918 and 1958, 33 major U.S. dam failures caused 1,680 deaths. From 1959 to 1965, nine major dams failed worldwide. Some of the largest disasters in the U.S. have resulted from dam failures. In 1889, 2,209 lives were lost when the South Fork Dam failed above Johnstown, Pennsylvania. The 1928 St. Francis Dam failure killed more than 500. During the 1970s the Buffalo Creek, Teton, and Toccoa Creek dam failures collectively cost 175 lives and more than $1 billion in losses.

The U.S. Congress enacted legislation mandating inspections and strict safety requirements for all governmentally and privately operated dams after a series of high-profile failures during the 1960s and early 1970s. The number of failures and deaths since then has dramatically decreased.

Like all built structures, dams deteriorate. Lack of maintenance causes dams to be more susceptible to failure. More than 520 dam incidents, including 21 dam failures, were reported in the past two years to the National Performance of Dams Program, which collects and archives information on dam performance from state and federal regulatory agencies and dam owners. Dam incidents are events such as large floods, earthquakes, or inspections that alert dam safety engineers to deficiencies that threaten the safety of a dam. Due to limited state staff, many incidents are not reported and, therefore, the actual number of incidents is likely to be greater.

As discussed in Section 6–Flooding, record rainfalls occurred from June 29 to July 10, 2002, resulting in a 0.4 percent annual chance of exceedance (250-year) hydrologic event over the Guadalupe River Basin upstream of Canyon Dam.[2] The emergency spillway of Canyon Dam was used for the first time in the Dam's 38-year history, resulting in significant spillway channel erosion and subsequent sediment deposition and loss of channel capacity in the Guadalupe River downstream from the outlet works and spillway discharge channels. The flood caused millions of dollars of damages below Canyon Dam even though, according to the U.S. Army Corps of Engineers, the dam reduced the peak flow in the Guadalupe River to about half of what it would have been otherwise. The U.S. Army Corps of Engineers estimates that Canyon Dam prevented an estimated $46.2 million in damages during this event.

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1 Federal Emergency Management Agency, Dam Safety Program, http://www.fema.gov/hazards/damsafety/.

2 "Canyon Lake Flood Emergency Operations During the Texas Hill Country Flood of 2002," by Robert Gergens, P.E., Hydraulic Engineer, Fort Worth District Reservoir Control Branch, U.S. Army Corps of Engineers.

Location of Hazardous Areas

The State of Texas has 7,413 dams, all regulated by the Texas Commission on Environmental Quality. Of these, 854 are considered "high-hazard," 779 are considered "significant-hazard," and 5,780 are considered "low-hazard." According to the American Society of Civil Engineers' "Report Card," the Association of State Dam Safety Officials reports that there are 403 unsafe dams in Texas.[3].

For purposes of this plan, high-hazard dams are those at which failure or misoperation would probably cause loss of human life. Significant-hazard dams are ones at which failure or misoperation probably would not result in loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or other significant damage. Significant-hazard dams often are located in predominantly rural or agricultural areas but could be located in populated areas having significant infrastructure. Low-hazard dams are those at which failure or misoperation probably would not result in loss of human life and would cause limited economic and/or environmental losses. Losses would principally be limited to the owner's property.

Table 15-1. Dam Failure Hazard-Potential Classifications Used in the National Inventory of Dams, Interagency Committee on Dam Safety

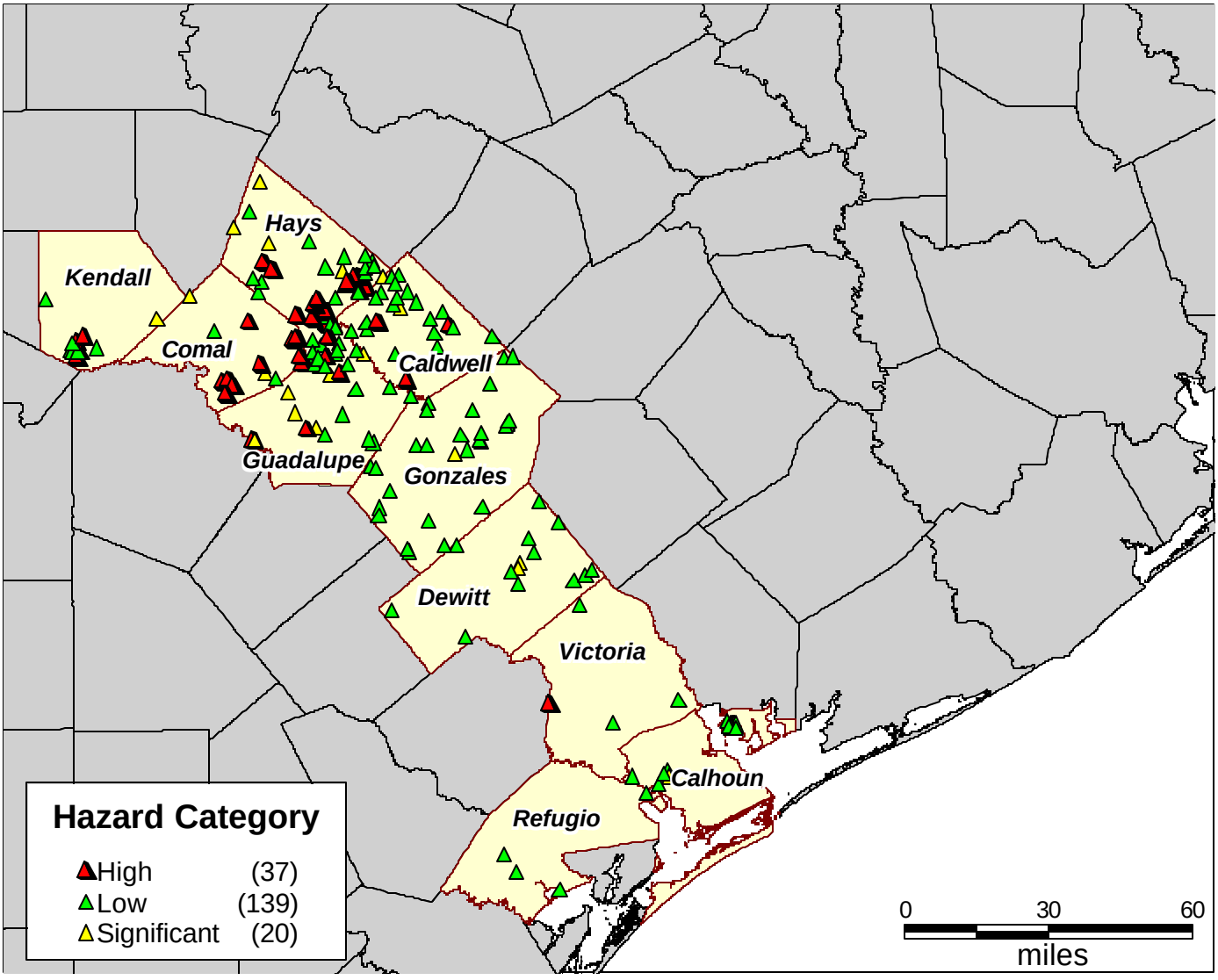
Hazard - Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

[3] http://www.asce.org/reportcard/pdf/tx.pdf

According to the National Inventory of Dams, there are 192 dams of all sizes in the 10-county Guadalupe River Basin. Figure 15-2 below shows the location of all 37 high-hazard dams in the basin listed on the inventory.

It should be noted that there are some significant disparities between the classifications of dams on the National Inventory of Dams and ratings by the Texas Commission on Environmental Quality (TCEQ). For example, the National Inventory of Dams classifies Lake Dunlap dam and Lake McQueeney as "significant-hazard," but they are considered "high-hazard" by TCEQ.

Figure 15-2. Location of High-, Significant-, and Low-Hazard Dams in Guadalupe River Basin, According to the National Inventory of Dams



Dams posing “high” and “significant” hazard according to the National Inventory of Dams are listed in table 15-2 below.

Table 15-2. High- and Significant-Hazard Dams in the Guadalupe River Basin, National Inventory of Dams, Federal Emergency Management Agency.

County	Dam Name	Significant Hazard	High Hazard
Caldwell	Barth Lake	X	
Caldwell	Langford Lake	X	
Caldwell	Lower Plum Creek WS SCS Site 23	X	
Caldwell	Lower Plum Creek WS SCS Site 24	X	
Caldwell	Lower Plum Creek WS SCS Site 26	X	
Caldwell	Lower Plum Creek WS SCS Site 28		X
Caldwell	Lower Plum Creek WS SCS Site 31	X	
Caldwell	Lower Plum Creek WS SCS Site 34		X
Caldwell	Lower Plum Creek WS SCS Site 37	X	
Caldwell	Lower Plum Creek WS SCS Site 38		X
Caldwell	Plum Creek WS SCS Site 14	X	
Caldwell	Plum Creek WS SCS Site 15	X	
Caldwell	Plum Creek WS SCS Site 20	X	
Caldwell	Plum Creek WS SCS Site 21	X	
Calhoun	Operating Basin No. 4 Levee	X	
Comal	Canyon Dam		X
Comal	Comal River WS SCS Site 1		X
Comal	Comal River WS SCS Site 2		X
Comal	Comal River WS SCS Site 3		X
Comal	Comal River WS SCS Site 4		X
Comal	Comal River WS SCS Site 5		X
Comal	Landa Park Lake	X	
Comal	Shaeferkoeter Dam No. 2	X	
Comal	York Creek WS SCS Site 1		X
Comal	York Creek WS SCS Site 2		X
Comal	York Creek WS SCS Site 3		X
DeWitt	North Cuero WS SCS Site 1	X	
DeWitt	North Cuero WS SCS Site 2	X	

County	Dam Name	Significant Hazard	High Hazard
Gonzales	Lake Wood (H-5)	X	
Guadalupe	Lake Dunlap*		X
Guadalupe	Lake McQueeney*		X
Guadalupe	Lake Placid (TP-4)		X
Guadalupe	Max Starcke	X	
Guadalupe	Process Water Cooling Pond		X
Guadalupe	Stormwater Evaporation Pond	X	
Guadalupe	York Creek WS SCS Site 10		X
Guadalupe	York Creek WS SCS Site 11	X	
Guadalupe	York Creek WS SCS Site 12	X	
Guadalupe	York Creek WS SCS Site 13		X
Guadalupe	York Creek WS SCS Site 4		X
Guadalupe	York Creek WS SCS Site 6	X	
Guadalupe	York Creek WS SCS Site 8	X	
Hays	Aquarena	X	
Hays	Big Dam		X
Hays	Hog Creek		X
Hays	McAlister Ranch Dam No. 5	X	
Hays	Plum Creek WS SCS Site 1	X	
Hays	Plum Creek WS SCS Site 2		X
Hays	Plum Creek WS SCS Site 3		X
Hays	Plum Creek WS SCS Site 4		X
Hays	Plum Creek WS SCS Site 5		X
Hays	Plum Creek WS SCS Site 6		X
Hays	Plum Creek WS SCS Site 7		X
Hays	Purola Lake	X	
Hays	San Marcos State Fish Hatchery		X
Hays	Seven Ranch Lake	X	
Hays	South Ridge Estates Lake	X	
Hays	Upper San Marcos River Site No. 1		X
Hays	Upper San Marcos River Site No. 2		X
Hays	Upper San Marcos River Site No. 4		X
Kendall	KWW Ranch Lake No. 1	X	
Kendall	Upper Cibolo Creek WS SCS Site 1		X
Kendall	Upper Cibolo Creek WS SCS Site 2		X

County	Dam Name	Significant Hazard	High Hazard
Kendall	Upper Cibolo Creek WS SCS Site 3		X
Kendall	Upper Cibolo Creek WS SCS Site 4		X
Victoria	Coleto Creek		X

* Although classified on the National Inventory of Dams as "significant-hazard" dams, Lake Dunlap and Lake McQueeney dams in Guadalupe County are classified by the Texas Commission on Environmental Quality as "high-hazard."

People and Property at Risk

In the 7-county planning area in the Guadalupe River Basin, an estimated 537 people live within 10 miles downstream of high-hazard dams listed on the National Inventory of Dams.[4] Table 15-3 shows the estimated number of people and structures in the 7-county planning area exposed to the risk of dam failure from high-hazard dams on the National Inventory of Dams. Exposure is determined by the number of people and property within a 10-mile geographic boundary downstream of a high hazard dam. The 10-mile boundary downstream is used to obtain a rough approximation of risk for failure of small and medium size dams. For more precise estimates of risk, inundation maps are needed.

It should be noted the largest reservoir within the Guadalupe River Basin, Canyon Lake, is not included in this analysis. A dam failure analysis for this reservoir would be complex and is beyond the scope of work for this report.

Table 15-3. Estimated Exposure of People and Buildings, by County, to Risk of Dam Failure from High Hazard Dams on the National Inventory of Dams

Jurisdiction	Residential Buildings Potentially at Risk		Commercial Buildings Potentially at Risk		People Potentially at Risk
	Number	Value ($)	Number	Value ($)	
Caldwell	22	3,953,250	1	2,007	53
Calhoun	54	13,056,209	1	127,457	79
DeWitt	1	102,338	1	61,813	2
Gonzales	4	813,482	0	0	6
Kendall	36	9,057,398	1	64,964	64
Refugio	1	61,919	0	0	1
Victoria	155	40,788,195	1	529,195	432
TOTALS	**163**	**$57,822,791**	**5**	**785,436**	**537**

[4] PBS&J Risk Assessment for the Guadalupe River Basin.

Potential Damages and Losses

The potential impact on residential and commercial structures from dam failure at high-hazard dams is addressed in Table 15-3 above. Approximately 163 residential structures and 5 commercial structures are located within 10 miles downstream of high-hazard dams in the 7-County planning area. The value of the at-risk residential structures is over $57.8 million and the value of at-risk commercial structures is about $785,436, for a total of $58.8 million in property at risk. Annualized loss-estimates for dam failure are not available, nor is a breakdown of potential dollar losses of critical and hazardous-materials facilities, infrastructure and lifelines. No estimate is currently available for the replacement costs of GBRA dams.