

Texas Dam Failures



Texas Dam Failures

- ▶ Since 1900, 171 dams have been reported to have either failed or have been damaged due to overtopping or structural issues.
- ▶ Some of these dam failures were significant due to size, use, or loss of life, which we will discuss.



Lake Austin Dam (Tom Miller Dam)



Lake Austin Dam

- ▶ Construction started in 1890.
- ▶ Constructed completed in 1893.
- ▶ Considered at that time to be the largest masonry dam in the world.

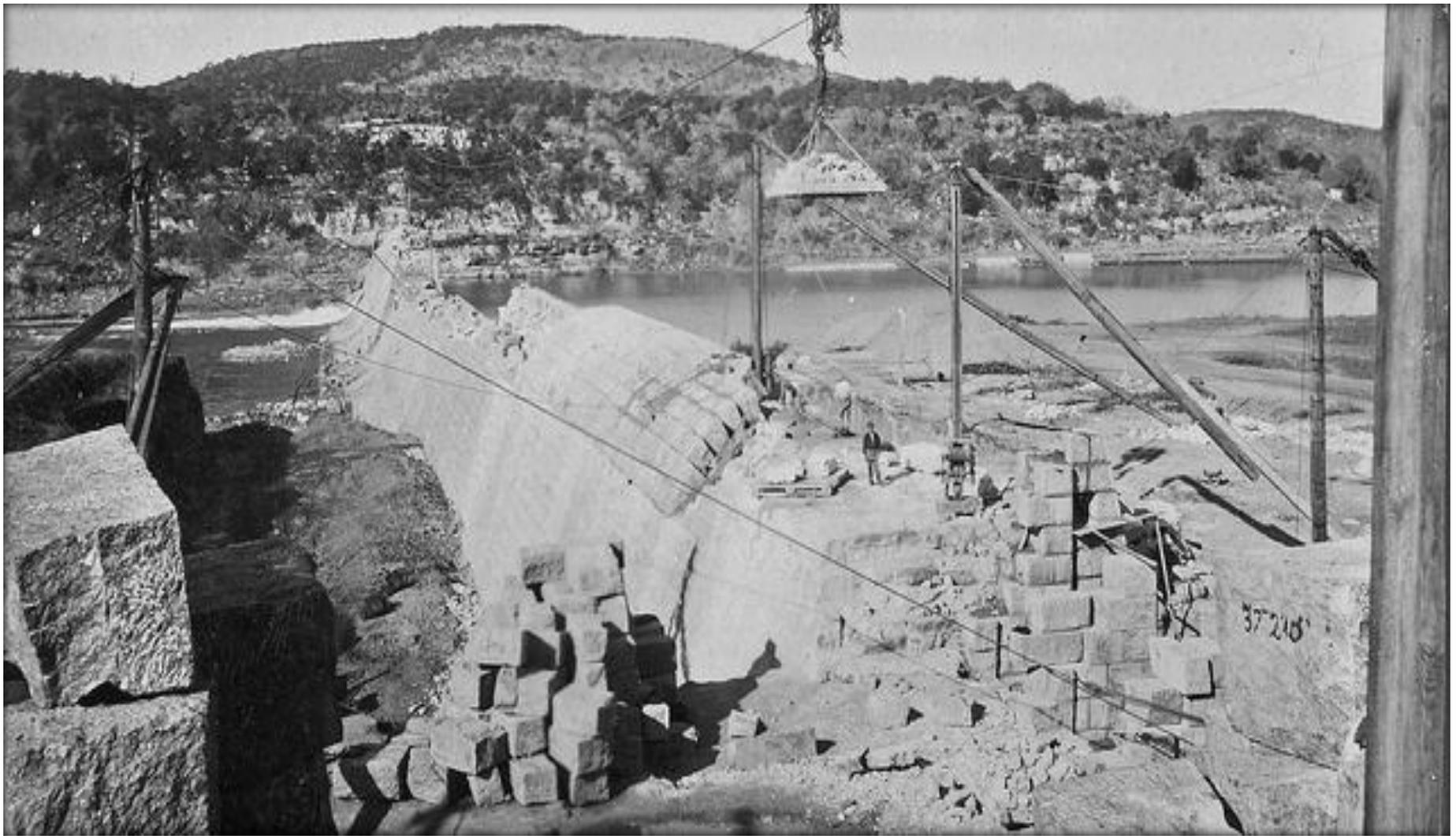


Lake Austin Dam

▶ Statistics

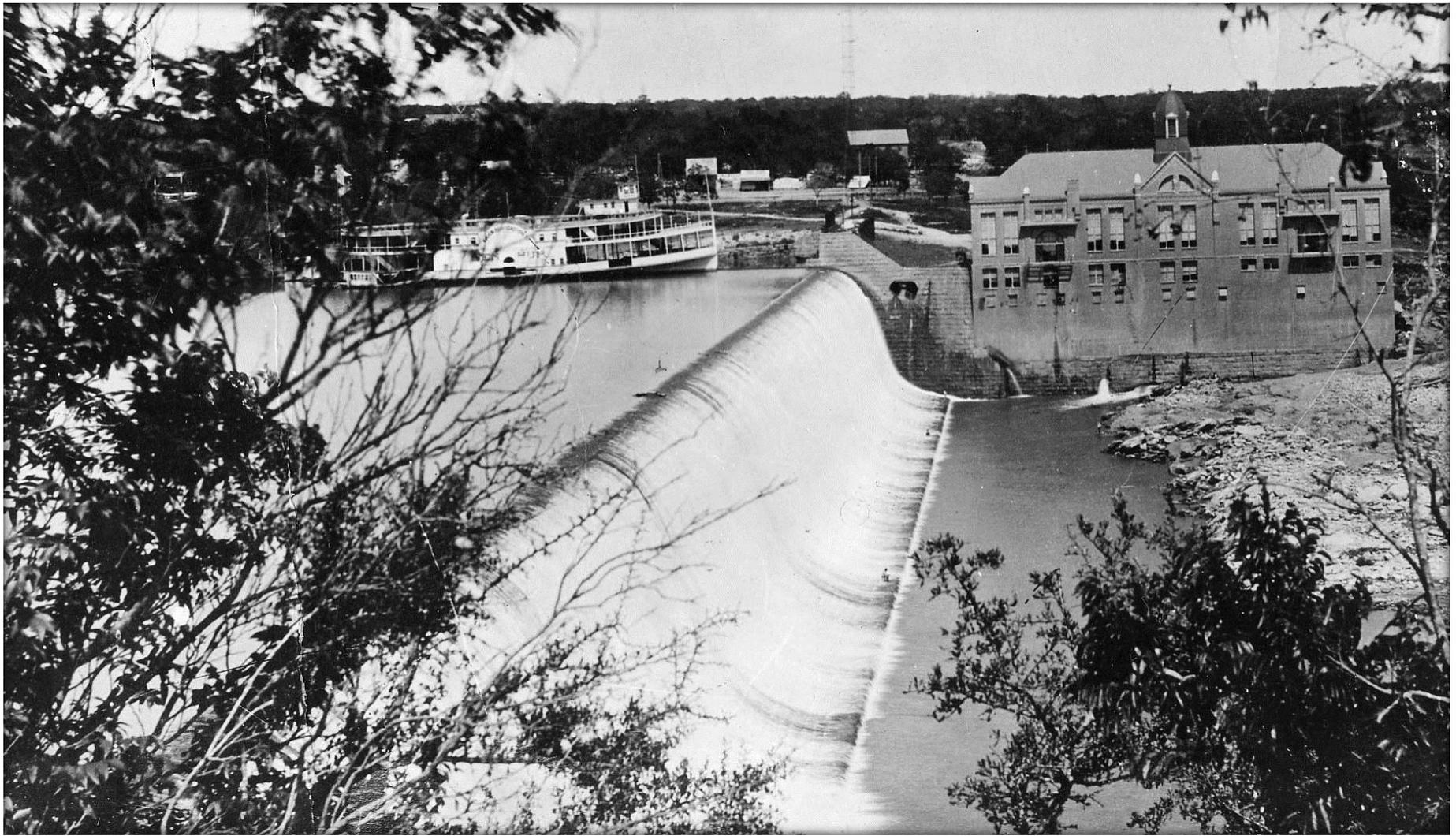
- 68 feet high.
- 1,275 feet long.
- 64,279 acre-feet impounded.
- Reportedly built of granite blocks.





Lake Austin Dam under construction

Courtesy of Lower Colorado River Authority



Lake Austin Dam circa 1900

Courtesy of Lower Colorado River Authority



Dam following construction circa 1900

Courtesy of Lower Colorado River Authority



Lake Austin Dam

- ▶ By 1897 glory days had faded.
- ▶ The lake was filling with silt. By 1900, it was estimated that the reservoir capacity had been reduced by 48%.



Lake Austin Dam

- ▶ The original engineer:
 - Warned that he had found a very friable foundation of rock 300 – 400 feet from the east (left) end when the dam was being built.
 - Warned that the entire eastern half of the dam had a poor foundation.
 - Advised that the City needed to sound the toe for erosion.
- ▶ No action was taken.



Lake Austin Dam

- ▶ April 7, 1900
 - Large rainfall event upstream over several days.
 - Lake was rising 2 to 4 feet per hour.
 - At 11:20 AM, with 11.07 feet over the dam, the dam broke at a point 300 feet from the east end.



Lake Austin Dam

- ▶ One observer saw a 50 foot high spout spring up over the crest.
- ▶ Another heard a dull, loud thud.
- ▶ Another heard an explosion.
- ▶ Witnesses described a roar that could be heard for several miles.
- ▶ A man on a horse rode downstream to warn people.



Lake Austin Dam

- ▶ 40 foot high wave pounded the powerhouse on the east shore. 8 people died, including 3 children, in the powerhouse.
- ▶ Two sections of dam, each about 200 feet long, were pushed downstream about 60 feet, but did not overturn.
- ▶ 23 people died, over 200 were injured, \$1.4 million in damages (1900 dollars).





One hour after failure, April 7, 1900

Courtesy of Lower Colorado River Authority





Dam after failure, April 1900

Courtesy of Lower Colorado River Authority





Lake Austin Dam during reconstruction circa 1913

Courtesy of Lower Colorado River Authority

Causes of failure

- ▶ Not built of solid granite. The interior was made up of fill and rubble, not granite blocks.
- ▶ Springs and leakage.
- ▶ Poor foundation.
- ▶ Uplift.
- ▶ Faults.
- ▶ Dam not built as designed.



Reconstruction

- ▶ Reconstruction started in 1911.
- ▶ Regarded as complete in 1915.
- ▶ Constructed with 54 automated gates on top, 28 large gates and 26 small gates.





Photo-
-ELLISON-
Austin,
Tex.

Completed dam in 1915

Courtesy of Lower Colorado River Authority

April, 1915 flood

- ▶ Reported rainfalls of 8 inches in 3 hours to 10 inches in 2 hours.
- ▶ Destroyed 4 of the 28 large gates.



September 17, 1915 flood

- ▶ Another large flood.
- ▶ “raft of drift” (estimated to be 20 feet thick) destroyed 20 of the 28 large gates and all 26 small gates.





September 1915 Flood

Courtesy City of Austin Library

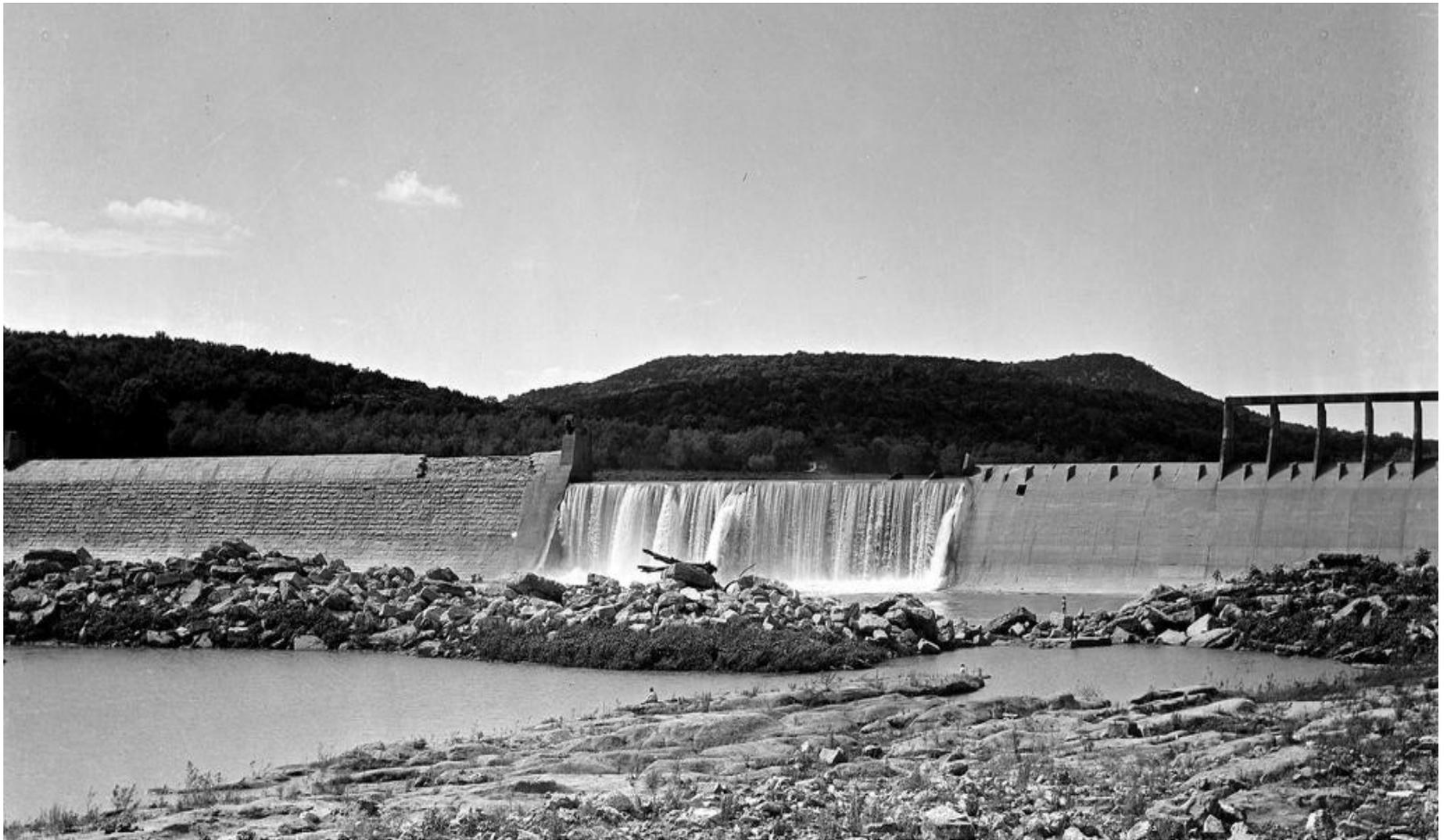




Raft of drift circa September 1915

Courtesy of Lower Colorado River Authority





Dam following 1915 failure

Courtesy of City of Austin Library



Subsequent events

- ▶ No reconstruction work for a number of years.
- ▶ Several floods occurred, damaging the dam even more; however, there was no failure.
- ▶ The 1935 flood caused considerable damage to the City, resulting in a move to construct other dams upstream of Austin.
- ▶ Mansfield Dam, Buchanan Dam, Tom Miller Dam, Inks Dam, Alvin Wirtz Dam, and Max Starcke Dam were built.





Houseboat over the dam circa 1932

Courtesy of Lower Colorado River Authority



1935 Flood

Courtesy of Lower Colorado River Authority

Tom Miller Dam

- ▶ Tom Miller Dam was built in 1940.
- ▶ Portions of the original 1900 dam were left in place.
- ▶ In 2004 – 2005 the dam was anchored to prevent overturning or sliding during the probable maximum flood.





Tom Miller Dam

Courtesy of Lower Colorado River Authority



Bass Haven Lake Dam



Bass Haven Lake Dam

- ▶ **Statistics**
 - 30 feet high.
 - 520 acre-feet impounded.
- ▶ State inspection revealed seepage adjacent to the low flow pipe.
- ▶ Owner's representative later noted water percolating around the low flow pipe.
- ▶ Owner decided to breach the dam at the maximum section to repair seepage.
- ▶ Lake was 16 feet deep at that time.



Bass Haven Lake Dam

- ▶ Dam was cut and water allowed to flow through cut on August 17, 1984.
- ▶ Dam eroded quicker than planned due to sandy material in dam.
- ▶ Slightly over an hour after draining started, soil in the lake bottom started to move.
- ▶ Then the entire upstream slope and the crest at the right end moved toward the lake due to the rapid drawdown.



Bass Haven Lake Dam

- ▶ Several people were on the crest at that time.
- ▶ 3 people were trapped in the dam. One died before he could be dug out.
- ▶ Breach was 95 feet wide.
- ▶ Lake drained in 1.5 hours.
- ▶ A downstream lake had been lowered to catch the water. No damage occurred downstream. The downstream lake caught the entire amount, with no discharge.





After failure from upstream

Courtesy of TCEQ files





Failure from right side

Courtesy of TCEQ files





View of failure from left end of dam

Courtesy of TCEQ files



Side slope of failure

Courtesy of TCEQ files



Nix Lake Dam



Nix Lake Dam

▶ Statistics

- Dam built in 1941.
 - 25 feet high.
 - 837 acre-feet maximum capacity.
 - Approximately 100 acre lake.
 - Small spillway – 25' bottom width.
- ▶ Considered to be low hazard under the rules at that time
- ▶ Tall pine trees; sandy soils; 2 fish screens across spillway; no maintenance



Nix Lake Dam

- ▶ On March 28 and 29, 1989, a 12-inch rainfall occurred in 12 hours.
- ▶ Around 2:00 am on March 29 caretaker reported strong winds with a noise like a tornado.
- ▶ Dam failed shortly after that.
- ▶ Caretaker reported that the dam failed quickly and had a large breach area.





Failure March 1989

Courtesy of TCEQ files





Failure width

Courtesy of TCEQ files



Nix Lake Dam

- ▶ Flooded State Highway downstream.
- ▶ Came within ½ foot of a house downstream of the highway.
- ▶ 51 foot railroad embankment downstream of highway detained the water and backed it up over the highway, reportedly 29.5 feet deep.
- ▶ One man died after driving into the water over the highway.





Downstream highway and house

Courtesy of TCEQ files





Downstream railroad embankment

Courtesy of TCEQ files



Possible causes of failure

- ▶ Under-designed spillway with blocked fish screen across entrance.
- ▶ Questionable construction materials (mostly sands).
- ▶ Possible toppling of trees due to high winds with the root balls creating low areas on the crest.
- ▶ Sandy soils easily erodible.
- ▶ Overtopping of the dam.





Partially blocked fish screen

Courtesy of TCEQ files



Other issues

- ▶ Media coverage on site.
- ▶ Law suits.
 - Dam Safety Program staff provided depositions and copies of material.
 - Law suit reportedly settled outside the courts.
- ▶ Dam eventually rebuilt without knowledge of Dam Safety Program.





Media coverage

Courtesy of TCEQ files





Nix Lake Dam 2012

Courtesy of TCEQ files



Tyler County Flood, 1996



Tyler County Flood, 1996

- ▶ Rainfall event September 27, 1996.
- ▶ 16 inches in 24 hours, 13 inches in 4 hours.
- ▶ Maximum between 1:30 am and 5:30 am.
- ▶ 10 dams confirmed that failed.
- ▶ Could not be determined if the failures were a domino process or if they failed randomly.
- ▶ No deaths, but some 800 people were stranded.
- ▶ Estimated to be at least 50% of the PMF.
- ▶ Most of the dams would not pass 100-year flood without overtopping.



Tyler County flood, 1996

- ▶ Dams confirmed to have failed, listed from top of watershed:
 - Urland Lake Dam
 - Electro Lake Dam
 - Boykin Lake Dam
 - Twin Lakes Dam
 - Sutton Lake Dam
 - West Lake Dam
 - East Lake Dam
 - Big Lake Dam
 - Lake Galahad Dam
 - Lake Charmaine Dam



Urland Lake Dam

- ▶ Statistics:
 - 17 feet high.
 - 28 acre-feet normal capacity.
 - 68 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt.



Electro Lake Dam

- ▶ Statistics:
 - 10 feet high.
 - 30 acre-feet normal capacity.
 - 50 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt



Boykin Lake Dam

- ▶ Statistics:
 - 12 feet high.
 - 23 acre-feet normal capacity.
 - 57 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached in two places from overtopping by 2 feet.
 - First breach: top width 130 feet; bottom width 100 feet.
 - Second breach: top width 60 feet; bottom width 40 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt





Boykin Lake Dam failure September 1996

Courtesy of TCEQ files



Twin Lakes Dam

- ▶ Statistics:
 - 10 feet high.
 - 75 acre-feet normal capacity.
 - 125 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt



Sutton Lake Dam

- ▶ Statistics:
 - 13 feet high.
 - 164 acre-feet normal capacity.
 - 210 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 2 to 3 feet.
- ▶ Top width of breach: 125 feet.
- ▶ Bottom width of breach: 75 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt





Sutton Lake Dam failure September 1996

Courtesy of TCEQ files



West Lake Dam

- ▶ Statistics:
 - 18 feet high.
 - 140 acre-feet normal capacity.
 - 257 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Top width of breach 150 feet.
- ▶ Bottom width of breach 75 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt





Aerial of West Lake Dam failure September 1996

Courtesy of TCEQ files



East Lake Dam

- ▶ Statistics:
 - 18 feet high.
 - 129 acre-feet normal capacity.
 - 327 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Top width of breach 100 feet.
- ▶ Bottom width of breach 40 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt





East Lake Dam failure September 1996

Courtesy of TCEQ files



Big Lake Dam

- ▶ Statistics:
 - 21 feet high.
 - 161 acre-feet normal capacity.
 - 357 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Top width of breach 225 feet.
- ▶ Bottom width of breach 125 feet.
- ▶ Sandy soils in embankment.
- ▶ Now exempt





Big Lake Dam failure September 1996

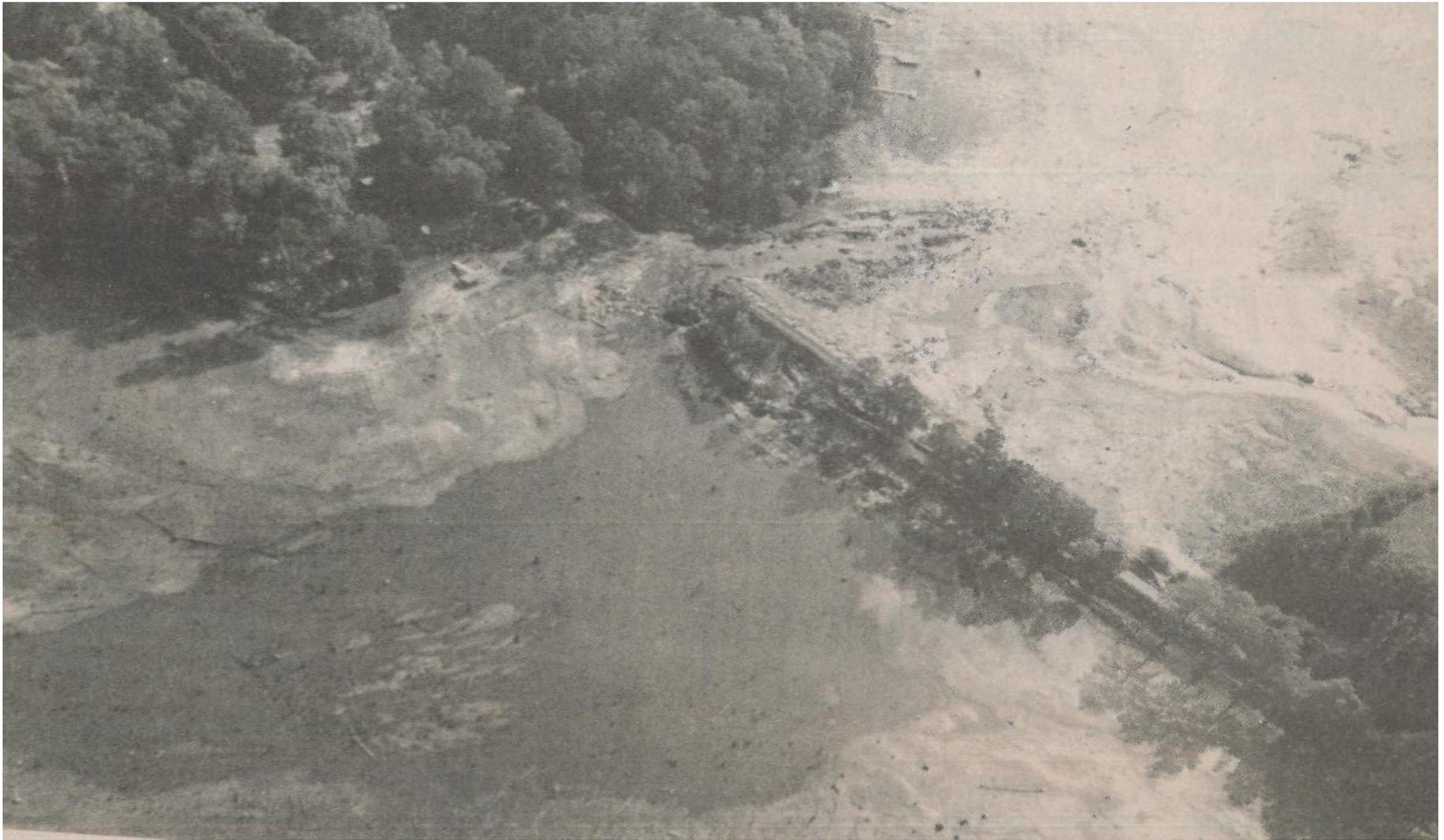
Courtesy of TCEQ files



Lake Galahad Dam

- ▶ Statistics:
 - 18 feet high.
 - 129 acre-feet normal capacity.
 - 327 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached from overtopping by 1.5 to 2 feet.
- ▶ Top width of breach 100 feet.
- ▶ Bottom width of breach 40 feet.
- ▶ Sandy soils in embankment.





Aerial of Lake Galahad Dam failure 1996

Courtesy of TCEQ files



Lake Charmaine Dam

- ▶ Statistics:
 - 18 feet high.
 - 129 acre-feet normal capacity.
 - 327 acre-feet maximum capacity.
 - Significant hazard.
- ▶ Breached in spillway due to erosion undercutting.
- ▶ Sandy soils under the spillway.





Aerial of Lake Charmaine Dam failure 1996

Courtesy of TCEQ files



Edgewood Old City Lake Dam



Edgewood Old City Lake Dam

- Statistics:
 - 14 feet high.
 - Normal capacity – 73 acre-feet.
 - Surface area – 25 acres.
 - 10-foot crest width.
 - Steep slopes.
- Lack of maintenance.



Edgewood Old City Lake Dam

- Reportedly built in 1927.
- Reportedly modified in 1956.
- Originally owned by the City of Edgewood for municipal water supply.
- Sold by City to an individual in 1971. Privately owned since.
- Partial failure in 1988, reportedly caused by animal burrows.





Crest of Edgewood Old City Lake Dam 2009

Courtesy of TCEQ files



Edgewood Old City Lake Dam Failure

- Local resident reported water flow from downstream side of dam around 11:00 AM, March 12, 2009.
- Failure occurred around 1:00 PM, March 12, 2009.
- Rainfall event – 3 day event with over 3-inches reported in that time frame.
- Breach at maximum section, 20 feet wide at base and 30 feet wide at crest.





Failure of Edgewood Old City Lake Dam 2009

Courtesy of TCEQ files





Edgewood Old City Lake Dam failure

Courtesy of TCEQ files





Upstream view of failure

Courtesy of TCEQ files



Edgewood Old City Lake Dam Failure

- When contacted, owner indicated:
 - He had noted a 4-inch stream of water flowing from downstream slope when the spillway was engaged in the past. The flow had always decreased as the water level dropped. Spillway was engaged at time of failure.
 - He had been filling in sinkholes in the crest.
 - The caretaker had killed 20 to 30 beavers in the lake in the last few years.



Edgewood Old City Lake Dam Failure

- Failure was attributed to piping, possibly along beaver tunnels through the dam.
- Breach zone was also area of old City water supply line.
- Numerous trees on the dam.
- Traffic ruts with standing water on crest.
- Sinkholes in crest reported by owner.





Animal burrow

Courtesy of TCEQ files



Edgewood Old City Lake Dam Failure Damage

- 2/3 of county road undermined.
- Farm-to-Market road overtopped by at least 18 inches. School bus route.
- Several wastewater manholes submerged for a short period of time.
- Wastewater lift station just above water.
- Water within 1 foot of two houses. Fences and septic systems affected. Dead fish everywhere.





Downstream damage

Courtesy of TCEQ files





Downstream hazards

Courtesy of TCEQ files



Edgewood Old City Lake Dam

- Now rebuilt by owner.
- One of the dams exempted by the Legislature.





Courtesy of TCEQ files





Courtesy of TCEQ files



Fatalities from Dam Failures

- ▶ Wayne Graham, Bureau of Reclamation
- 400 dam failures occurred from 1985 to 1998
- 300 fatalities from dam failures from 1960 to 1998



Dam Failures Resulting in Fatalities

- 86% of the fatalities resulted from dams between 20 and 49 feet in height.
- 47% of the fatalities resulted from dams with drainage area less than 2 sq. mi.
- 75% of the fatalities resulted from dams with drainage area less than 10 sq. mi. (90% of Texas watershed dams and 80% of all dams)
- 7 dams had less than 300 ac-ft of water released during the failure.



Rainfall events

- Hearne 1899 30 inches in 24 hours 66% of PMF
- Thrall 1921 38 inches in 24 hours 86% of PMF
- Alvin 1979 43 inches in 24 hours
- Medina 1978 31 inches in 24 hours 73% of PMF
and 48 inches in 52 hours 98% of PMF
- Albany 1978 29 inches in 24 hours with 23 inches
in 8 hours 73% of PMF



Rainfall events

- Odem 1984 26 inches in 4 hours 81% of PMF
- Woodville 1996 13 inches in 4 hours (10 dam failures) 50% of the PMF
- Marble Falls 2008 18 Inches in 9 hours, 9 inches in 1 hour



Probable Maximum Precipitation (PMP) study

- ▶ A study will be undertaken to determine updated PMP values for the state
- ▶ An 18-month study



Legislation (2013)

- Exemption of dams
 - Privately owned;
 - Maximum capacity (top of dam capacity) of less than 500 acre-feet;
 - Low or significant hazard dam;
 - Located in a county with a population of less than **350,000**; and
 - Not located inside the corporate limits of a municipality



Legislation (2013)

- The exemption is permanent. It does not mean that the dam is permanently exempt
- Nearly 3,200 dams exempt
- 216 significant hazard dams exempt



Questions

