Lake Oglethorpe Dam Failure Analysis

Introduction

Lake Oglethorpe Dam was originally designed by the Soil Conservation Service (now known as the Natural Resources Conservation Service) in 1970 for Oglethorpe Lake Development, Inc. The construction of the dam was completed in 1972. Although the dam was built primarily for recreation on Goulding Creek, it does provide significant flood control benefits for property and infrastructure located downstream. The following is a data summary of the dam, auxiliary spillway, and reservoir.

Height of Dam: 40 feet
Length of Dam: 543 feet
Normal Pool Surface Area: 63 acres
Flood Pool Surface Area: 90 acres
Normal Pool Storage: 992 acre-feet
Flood Pool Storage: 1436 acre-feet
Primary Spillway Conduit: 48 inch diameter reinforced concrete pipe
Auxiliary Spillway: 150 foot wide vegetated spillway
Drainage Area: 3.44 square miles

NRCS conducted a joint inspection of the dam on November 1, 2005 with the Lake Oglethorpe Homeowners Association (results are attached). Generally the dam is in good condition and well maintained. During the inspection the Homeowners Association requested an inundation map in order to create an Emergency Action Plan. The map would also be used to prevent development within the inundation zone in order to avoid a change in the hazard classification of the dam to “high hazard” by the Georgia Safe Dams Program.

Dam Breach Model Analysis

The scenario for the analysis is a “sunny day” breach utilized by the Georgia Safe Dams Program for classification of dams. This scenario is run with the water elevation at the top of dam and assumes that the auxiliary spillway is blocked. The dam failure analysis was modeled using the National Weather Service’s (NWS) BREACH Program and the U.S. Army Corps of Engineers Hydraulic Engineer Center’s River Analysis System program known as HEC-RAS.

The BREACH Model predicts the outflow hydrograph from a breached dam and the breach size, shape, and time of formation of a breach in earthen dams where the breach may be initiated by either piping or overtopping. This model utilizes the principle of soil mechanics, hydraulics, and sediment transport to simulate the erosion and bank collapse processes which form the breach.

The HEC-RAS utilizes a one-dimensional model based on the St. Venant Equations to model unsteady flow. The program utilizes a modified version of the UNET equation solver to provide the user with a water surface profile for the user input geometry and unsteady flow data.

For this analysis the geometry of the dam, stage-storage data for the reservoir, and soil mechanics properties of the dam were input into the BREACH model to produce an output hydrograph for an overtopping failure described above. This hydrograph was then input into HEC-RAS along with the downstream geometry. The results have been plotted on the attached maps.

The following is a list of assumptions and parameters used during the modeling:

- The downstream geometry was developed based on USGS topographic quadrangles and survey data collected by NRCS.
- Stage storage table for the model was developed using the original design drawings and the USGS topographic maps mentioned above.
- No outflow from the spillway was modeled to keep the lake at peak stage prior to breach formation.
- A constant inflow hydrograph of 1000 cubic feet per second (cfs) was input to initiate the dam breach at time equal to zero hours.
- The breach is initiated when the reservoir's water level is at maximum pool at the top of dam (approximately 639.5 feet mean sea level).
- Twenty-one cross-sections were input into the model over a distance 7.3 miles downstream from the dam.
- The creek joins with the Oconee River just below the extent of this study. It is assumed that the Oconee River Floodplain is large enough to absorb the attenuated flow levels at the end of this study.
- Inflows along the downstream reach were not modeled since the flows would be insignificant during a "sunny day" scenario. However, due to the large size of Moss Creek and Big Creek the backwater storage was simulated by using off channel storage areas.
- Manning 'n' values were assumed to vary by depth and location. The values selected for use were 0.04 for the channel and 0.10 for the floodplain. These values were chosen from looking at the imagery and a site visit by NRCS.
- Road crossings were modeled at Wolfskin Road and Double Bridge Road. The road crossing at Black Snake Road was not modeled since the flood wave would quickly wash out the culvert crossing at this location.

The HEC-RAS model predicted the dam breach floodplain inundation as shown on the attached map. Peak discharge from the dam failure decreases from 44,592 cfs at the breach to 10,138 cfs 7.3 miles downstream. The flood wave peak has a 1 hour 53 minute travel time to the end of the model after initiation of the dam failure. The flood wave crest has a maximum height of approximately

23 feet immediately downstream of the dam and minimum height of approximately 9 feet at the end of the model 7.3 miles downstream. Breach Data is summarized in the table below.

River Station	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Top Width (ft)
38750	43066.00	598.00	621.22	25.74	334.91
36350	38408.11	580.00	606.22	18.75	454.31
32175	33099.80	566.00	590.90	21.82	395.54
30885	32855.99	561.00	578.83	32.37	244.02
29658	22684.04	558.00	574.11	10.09	508.20
29353	22641.73	557.50	574.07	5.31	515.77
28790	21974.71	553.00	573.92	6.62	602.33
25200	18248.58	543.00	565.73	22.85	254.43
24100	18449.28	536.75	565.52	5.04	480.93
23900	18256.61	536.25	550.30	12.61	323.01
23881	18255.92	536.00	550.55	10.45	408.29
23607	15744.88	535.50	550.54	5.06	390.24
23280	15735.34	535.00	550.43	5.02	495.26
23100	15672.92	534.50	549.27	14.74	365.59
19780	15197.37	518.00	534.25	23.94	110.19
17030	14895.65	505.00	518.91	15.95	422.86
16015	14449.34	500.00	514.55	12.24	533.38
15000	14140.00	495.00	511.58	12.61	373.77
12030	13610.07	484.00	501.52	14.43	315.39
7590	12438.15	475.00	487.08	8.61	541.87
4710	10625.91	470.00	482.82	5.73	772.20
2175	10229.96	464.00	478.20	10.73	423.23
0	10138.39	460.00	467.36	27.51	287.91

Dam Breach Inundation Mapping

The resulting water surface elevations from the HEC-RAS model were plotted at each cross-section on the USGS topographic map. The inundation zone was delineated by linear interpolation of the peak water surface elevations between each cross-section. Topographic contours were utilized as a guide for the linear interpolation between each cross-section. At bridges and culverts, engineering judgment was used to delineate the inundation zone. Finally the inundation zone was overlaid onto a digital orthophotoquad (DOQ).

Downstream Hazards

No residences were found within the inundation zone on the most recent imagery available from 1999. The closest residences are located along Elder road in the

vicinity of Big Creek. These residences are five to ten feet above the maximum water surface elevation at that location.

A number of roads would likely be overtopped and washed out due to a failure of Lake Oglethorpe Dam:

- The culvert crossing at Black Snake Road would be washed out almost immediately.
- The culvert crossing at Double Bridge Road would initially back water up. The water would eventually overtop the road by approximately three feet. This water would certainly sweep any vehicle off the road embankment and into the creek. It is likely that the water would also wash out the road and a portion of the embankment.
- The bridge on Wolfskin Road would not overtop; however, the flood wave and debris that it would be carrying would severely damage the framework beneath this aging steel bridge.
- The road crossing on Elder Road was not studied in this model. It should be assumed that this road crossing would also be overtopped.

Hazard Classification

This structure is currently categorized by the Georgia Safe Dams Program as "Category II" or "Low Hazard." The results of this study do not contradict with that finding; however, there is a potential for loss of life at bridges and culvert crossings that should be considered (Georgia Safe Dams Program does not use overtopped roads as a justification for classifying Dams as "Category I" or "High Hazard"). As little as one foot of water has been found to wash vehicles from overtopped roadways.

Recommendations for Emergency Action Plan

Based on the results of this study, the owners of the dam should work in coordination with Oglethorpe County to develop an emergency action plan (EAP). In the event of expected failure of Oglethorpe Lake Dam the road crossings at Black Snake Road, Double Bridge Road, Wolfskin Road, and Elder Road should all be closed. Additionally the residences located on Elder Road in the vicinity of Big Creek should also be temporarily evacuated. Although the water surface in the model did not reach the elevation of these homes, temporary evacuation of these homes would be a prudent safeguard in the event of an actual dam failure.

Accuracy and Limitations of Study Results

The results of this study are appropriate for planning for emergencies and hazard classification of the structure. The inundation map should be considered accurate to one half contour interval (10 feet of elevation) for the scenario that this study analyzed. This limitation is due to the accuracy of the topographic map produced by the USGS that this study utilized for source data.

It is unlikely that an actual dam failure would mirror the exact same conditions of the scenario modeled in this study. Piping or overtopping failures that resulted from defects in the dam or blockage of the principal spillway conduit would likely occur with the water surface elevation much lower than the top of the dam and consequently have a much smaller inundation zone. A storm in progress breach could have a larger inundation zone with contributing flows from Moss and Big Creeks.

For these reasons, NRCS recommends a conservative use of this map to determine road closures and evacuation areas in the event of an actual dam failure.