Dam Hazard Assessment

Peppermill Lake Dam
Adams County, Wisconsin

Prepared for:
Adams County, Wisconsin

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Dam Hazard Assessment
Peppermill Lake Dam

Summary

Adams County retained Ayres Associates to perform a dam failure analysis for the Peppermill Lake Dam (also known as Coddington Dam). The purposes of the dam failure analysis were to delineate the areas that would be inundated by a dam failure during the 100-year flood and to determine the dam's hazard rating. This report presents the findings of the hydrologic analysis, the dam failure analysis, and the dam hazard rating for the Peppermill Lake Dam.

The hydrologic analysis consisted of a flood frequency analysis and development of an inflow hydrograph for the 100-year flood. The inflow hydrograph was required for the dam failure analysis and was determined using the HydroCAD version 8.50. The 100-year peak inflow to Peppermill Lake is 208 cfs. The spillway is capable of passing the 100-year inflow hydrograph with a reservoir surcharge of 0.41 feet. The corresponding 100-year outflow is 70 cfs.

The dam failure analysis involved modeling three conditions: 1) dam nonexistent, 2) dam in place with no failure, and 3) dam in place with failure. The hydraulic shadow was determined by comparing the "dam nonexistent" 100-year flood levels with the "dam in place with failure" 100-year flood levels.

To determine the dam hazard rating, the elevations of potentially affected development in the hydraulic shadow were compared with the 100-year flood elevations. The results of the dam failure analysis indicate that no development downstream of the dam would be flooded during a breach of the dam during the 100-year flood. According to NR 333, the dam would be classified as a high hazard dam because there are no land use controls in place to restrict future development in the hydraulic shadow. As a high hazard dam, the Peppermill Lake Dam will be required to pass the 1000-year flood outflow through its principal and emergency spillways without overtopping. As it is currently configured, the dam is capable of doing this.

The high hazard rating depends upon land use controls that prevent new development in the hydraulic shadow of the dam. There is currently no floodplain zoning in place downstream of the dam. For the dam to have its hazard rating changed from "high" to "low", the zoning should be amended to include the hydraulic shadow. The affected stream reach is approximately 5490 feet or 1.04 miles long, and the increase in the elevation profile ranges from 0.09 foot at Station 94510 to 4.53 feet downstream of the dam at Station 99650.

Introduction

Adams County retained Ayres Associates to perform a dam failure analysis for the Peppermill Lake Dam. The purpose of the dam failure analysis was to delineate the areas that would be inundated by a dam failure during the 100-year flood and to determine the dam's hazard rating. This report presents the findings of the hydrologic analysis, the dam failure analysis, and the dam hazard rating for the Peppermill Lake Dam.

The Peppermill Lake Dam is owned and operated by Adams County. The dam serves as a control structure for the 54-acre Peppermill Lake and is located in Sections 10 and 15, T15N, R7E. Exhibit 1 shows the location of the dam. Peppermill Lake is used for recreation.

The drainage area at the dam is approximately 2.5 square miles. Downstream of the dam, water travels in Peppermill Creek through a culvert under CTH G, into a wetland and McDougall Lake, over the weir that creates McDougall Lake, through a culvert under CTH A, into Neenah Creek, and eventually into the Wisconsin River.

All report elevations are referenced to the NAVD88 datum. Survey data for the dam structures and some cross sections entered in the model were obtained by Ayres Associates.

The main components of the dam include the following:

- An earthen embankment approximately 300 feet long with a crest elevation of approximately 915.0 feet.
- A conduit and riser structure that controls Peppermill Lake:
  - A 36-inch corrugated metal pipe (CMP) inlet.
  - A 54-inch CMP riser with stoplogs that have a top elevation of 910.81 feet. The stoplogs can be removed down to a concrete sill with an unknown elevation.
  - A 30-inch CMP outlet.
- An emergency spillway approximately 30 feet wide with an elevation of 912.3 feet, located at the east end of the main embankment.

A plan and profile of the dam is included as Exhibit 2.

Hydrologic Analysis

The hydrologic analysis consisted of a flood frequency analysis and development of an inflow hydrograph for the 100-year and 1000-year floods. The inflow hydrograph was required for the dam failure analysis and was developed using HydroCAD version 8.50. HydroCAD is a computer-aided design program used for modeling the hydrology and hydraulics of storm water runoff. The drainage area contributing to the Peppermill Lake Dam was determined by digitizing the drainage area on a USGS quad map. Existing land uses within the drainage area were determined using a watershed delineation Web site created by Purdue University. The fraction of each land use compared to the total land area was applied to the total land area determined using the USGS quad map. Curve numbers were chosen based on the existing land uses as reported by Purdue's Web site. The weighted curve number for the Peppermill Lake watershed is 52. The NRCS method was used for determining the time of concentration in the watershed. The time of concentration is 316 minutes or 5.3 hours.

Table 1 lists the flood frequency peak inflows for a variety of recurrence intervals at the Peppermill Lake Dam. The 500-year and 1,000-year peak inflows were determined by plotting the 2-year through 100-year, 24-hour precipitation values (from Bulletin 71), extrapolating the 500-year and 1,000 year, 24-hour precipitation values, and entering this information into the HydroCAD model. The HydroCAD model output is included in Appendix A.

Table 1
Flood Frequency Peak Discharges

Recurrence Interval (years)	Peak Inflow Into Peppermill Lake (cfs)
10	53
50	147
100	208
500	325 (precipitation extrapolated)
1,000	377 (precipitation extrapolated)

As an alternative method, USGS regression equations (Walker and Krug, 2003) were also used to determine flood frequency peak inflows at the Peppermill Lake Dam. The 100-year peak inflow determined using the USGS equation was 75% less than the 100-year peak inflow determined using HydroCAD. The HydroCAD peak inflows were used in the hazard assessment because they are more conservative.

The 100-year peak inflow into Peppermill Lake is 208 cfs. The spillway is capable of passing the 100-year inflow hydrograph with a reservoir surcharge of 0.4 foot, assuming the necessary stoplogs are removed near the beginning of the event. The corresponding 100-year outflow is 70 cfs.

Hazard Rating Assessment

The hazard rating assessment depends on the impacts of downstream flooding if the dam were to fail during the 100-year flood. Hazard ratings are divided into three classifications: high hazard, significant hazard, and low hazard.

The hazard rating assigned to a dam is dependent on the risk for loss of life during the 100-year flood with a dam failure and whether future development in the hydraulic shadow is restricted. A dam failure analysis is used to analyze the flood impacts. The downstream impacts are compared to two other cases: the 100-year flood with the dam nonexistent and the 100-year flood routed through the dam with no failure.

Dam Failure Analysis

The U.S. Army Corps of Engineers' River Analysis System (HEC-RAS) was used to model the following three conditions in accordance with Wisconsin Administrative Code NR 333 criteria:

- Dam nonexistent
- Dam in place with no failure
- Dam in place with failure

The 100-year flood levels were determined using the "dam nonexistent" model, and the hydraulic shadow was defined by comparing the "dam nonexistent" model with the "dam failure" model.

The channel cross-sections used in the modeling are from survey data collected by Ayres Associates and also from USGS quad maps.

HEC-RAS is not capable of modeling a riser structure, so only the controlling part of the structure was modeled. The 30" outlet pipe is the controlling part of the structure, assuming stoplogs are removed as needed to maintain the normal maximum pool. The standard operating procedure for Peppermill Dam includes removing stoplogs during large floods.

Since the water does not overtop the principal spillway during the 100-year flood, the most likely mode of failure would be a piping failure at the dam. A piping failure at the dam was modeled assuming that the breach has a bottom width of 13 feet with 2:1 side slopes at elevation 902.6 feet, which is the approximate bottom elevation of live storage of Peppermill Lake upstream of the dam.

The assumed starting pond elevation was 910.8 feet, equal to the top of the stoplogs. Failure was assumed to occur when the reservoir reached elevation 911.20 feet, which is 0.02 foot below the maximum water surface at the dam during the "dam with no failure" condition. The dam breach parameters for the Peppermill Lake Dam are listed in Table 2. The parameters are based on NR 333 and HEC-RAS guidelines.

Table 2
Dam Breach Parameters

Parameter	Value
Failure time	0.5 hours
Bottom of breach width	13.0 feet
Breach side slope (H:V)	2:1 (H:V)
Bottom of breach elevation	902.60 feet
Reservoir elevation when failure begins	911.20 feet
Initial reservoir elevation	910.80 feet

The model cross-section stationing is in feet, with the dam located at Section 100000. The routing reach extends approximately 8090 feet (1.53 miles) downstream from the dam to approximately 7050 feet (1.34 miles) upstream of the dam. The channel Manning's roughness coefficients ranged from 0.03 to 0.05 in the channel and from 0.05 to 0.07 on the overbanks. The modeling included dynamic routing upstream and downstream of the dam using the inline structure option to represent the dam in HEC-RAS. The “dam nonexistent” condition was modeled in HEC-RAS with the existing dam removed.

There are three stream crossings in the routing reach. The CTH G crossing (Station 99563) is a rural road with a 48-inch diameter culvert. CTH G would impound water but would not overtop during the “dam failure” condition. The McDougall Lake Dam crossing (Station 95620) is a concrete dam with a weir and stoplogs, concrete wingwalls, and a concrete walkway over the dam. It is 4.7 feet wide and 2.23 feet tall from the bottom of the weir to the top of the highest stoplog. The weir has a top elevation of 899.24 feet, and the lowest part of the walkway has an elevation of 901.16 feet. The walkway of the McDougall Lake Dam would overtop by a maximum of 1.01 feet during the “dam failure” condition. The CTH A crossing (Station 94530) is a rural road with a 54-inch diameter culvert. CTH A would not overtop during the “dam failure” condition.

Table 3 summarizes the peak flood elevations for the three conditions modeled. River miles are measured downstream from the dam. Exhibits 3 through 5 show the areas inundated for each condition modeled. Exhibit 3 shows the “dam nonexistent” condition, and Exhibit 4 shows the “dam in place with no failure” condition. Exhibit 5 shows the “dam in place with failure” condition, also referred to as the hydraulic shadow. Exhibit 6 shows the flood profiles for the three conditions modeled along the river reach being studied. The results are discussed in the next section.

Table 3
Flood Crest Summary

HEC-RAS River Station	Location	River Mile Below Dam	Maximum Water Surface Elevation (feet)		
			Dam Nonexistent	Dam in Place with No Failure (No Breach)	Dam in Place with Failure (Breach)
99900	Just downstream of Peppermill Lake Dam	0.02	906.61	905.20	911.12
99650		0.07	906.60	905.18	911.13
99610		0.07	906.60	905.17	911.13
99600	Just upstream of CTH G	0.08	906.60	905.16	911.13
99520	Just downstream of CTH G	0.09	902.02	901.78	902.51
99510		0.09	901.99	901.76	902.48
99470		0.10	902.05	901.78	902.60
98320		0.32	901.57	901.33	902.18
97420		0.49	901.57	901.33	902.17
96770	Just upstream of McDougall Lake Dam	0.61	901.57	901.33	902.17
95600	Just downstream of McDougall	0.83	894.71	894.29	896.35

	Lake Dam				
94600		1.02	892.72	892.08	895.43
94560		1.03	892.72	892.07	895.43
94550	Just upstream of CTH A	1.03	892.71	892.07	895.43
94510	Just downstream of CTH A	1.04	887.16	886.91	887.25
94500		1.04	887.39	887.10	888.15
94460		1.05	887.31	887.01	888.14
94210		1.10	886.82	886.53	887.59
92930		1.34	884.66	884.45	885.15
91910		1.53	883.15	882.96	883.71

Hazard Rating

The hydraulic shadow is the area of land downstream from a dam that would be inundated upon failure of the dam during the 100-year flood. The hydraulic shadow ends where the "dam failure" flood profile converges with the "dam nonexistent" flood profile. The convergence tolerance is one foot for rural areas and zero feet within incorporated areas.

Referring to Table 3, the 100-year flood profile resulting from a dam failure is within one foot of the "dam nonexistent" flood profile 1.04 miles downstream from the dam at river station 94510. Table 4 lists the hydraulic shadow floodway data. This information was extracted from Table 3 and the information in Appendix B for the three conditions modeled.

Table 4
Hydraulic Shadow Floodway Data

HEC-RAS River Station	River Mile Below Dam	Maximum Stage Elevation (feet)	Peak Discharge (cfs)	Maximum Velocity (feet/sec)	Floodplain Top Width (feet)
99900	0.02	911.12	238	0.81	186
99650	0.07	911.13	197	0.23	430
99610	0.07	911.13	171	0.21	430
99600	0.08	911.13	163	0.21	430
99520	0.09	902.51	154	4.35	47
99510	0.09	902.48	154	4.38	46
99470	0.10	902.60	155	1.95	48
98320	0.32	902.18	153	0.07	956
97420	0.49	902.17	153	0.05	717
96770	0.61	902.17	153	0.20	193
95600	0.83	896.35	153	4.65	27
94600	1.02	895.43	152	0.43	180
94560	1.03	895.43	152	0.77	180
94550	1.03	895.43	152	0.95	180
94510	1.04	887.25	152	6.34	32
94500	1.04	888.15	152	4.58	48
94460	1.05	888.14	152	3.95	48
94210	1.10	887.59	152	4.25	31
92930	1.34	885.15	152	2.48	65
91910	1.53	883.71	152	1.58	136

Field reconnaissance and reviews of a USGS quad map and an aerial photo showed no development that would be affected by the breach flood from the Peppermill Lake Dam. Three structures just downstream of the Peppermill Lake Dam are well above the hydraulic shadow. Two structures near the McDougall Lake Dam were surveyed and are out of the hydraulic shadow. The elevations of those structures are 907.04 and 908.38 feet. The water surface elevations in the “dam failure” condition upstream and downstream of the McDougall Lake Dam are 902.17 and 896.35 feet, respectively.

There are two additional homes off of County Highway EE on upper McDougall Lake at approximately Cross Section 97420. Lowest adjacent ground points at these structures were surveyed by reference to McDougall Lake (normal elevation 899) by Adams County staff. The lowest adjacent ground elevations for these structures are 905 and 906 feet, approximately 3 to 4 feet above the with-failure flood profile.

Spillway Capacity

The required spillway capacities according to NR 333 criteria are shown in Table 6. No development downstream of the dam would be flooded during a breach of the dam, and no bridges would be overtopped. Therefore, the Peppermill Lake Dam would have a low hazard rating if land use controls were in place within the hydraulic shadow.

Table 6
NR 333 Required Spillway Design Capacities

Dam Hazard Rating	Minimum Principal Spillway Capacity	Minimum Total Spillway Capacity
Low	Q_{10}	Q_{100}
Significant	Q_{50}	Q_{500}
High	Q_{100}	Q_{1000}

The dam was also modeled using HydroCAD to determine the spillway capacity even if the stoplogs were not removed. During the 100-year flood, the peak inflow to Peppermill Lake is 208 cfs, and the peak outflow is 35 cfs. The reservoir elevation would rise to elevation 912.68 feet, approximately 1.9 feet above the top of the stoplogs and 0.4 foot above the emergency spillway crest. During the 1000-year flood, the peak inflow to Peppermill Lake is 377 cfs. Due to the amount of available storage in the reservoir, the peak outflow is 53 cfs. The dam is currently able to pass the 1000-year flood without overtopping the principal spillway. During the 1000-year flood, the reservoir would rise to elevation 913.95 feet, approximately 1.0 foot below the spillway crest.

Recommendations

The results of the dam failure analysis indicate that no development would be flooded during a breach of the dam during the 100-year flood. The hydraulic shadow is currently not zoned. As a high hazard dam, the Peppermill Lake Dam is required to pass the 1000-year flood outflow through its principal and emergency spillways without overtopping. As it is currently configured, the dam is capable of doing this with a 0.6-foot surcharge above the normal pool elevation if the stoplogs are removed and a 3.1-foot surcharge if the stoplogs cannot be removed.

The hazard rating depends upon land use controls that prevent new development in the hydraulic shadow of the dam. There is currently no floodplain zoning in place downstream of the dam. For the dam to lower its hazard rating from “high” to “low”, the zoning should be amended to include the hydraulic shadow. The affected stream reach is 1.04 miles long, and the increase in the elevation profile ranges from 0.09 foot at Station 94510 to 4.53 feet downstream of the dam at Station 99650.

Appendix A

Hydrologic Analysis Computations

Appendix B

Dam Failure Analysis Computations