Three lines of thought about Lower Shaker Lake dam

1) Downsizing the NEORSD design would meet local needs
2) **Understanding the dam failure hazards and working towards a non-Class-I project**
3) The lake and the 15 minute city

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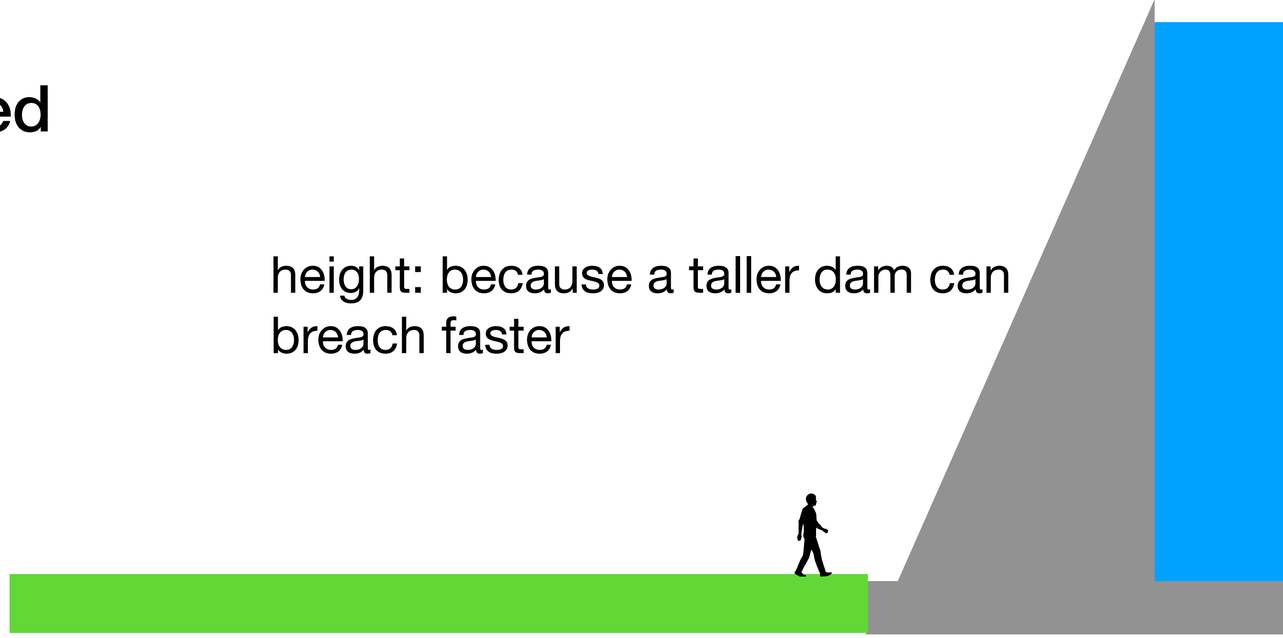
Shaker Heights
Professor of Physics, CWRU

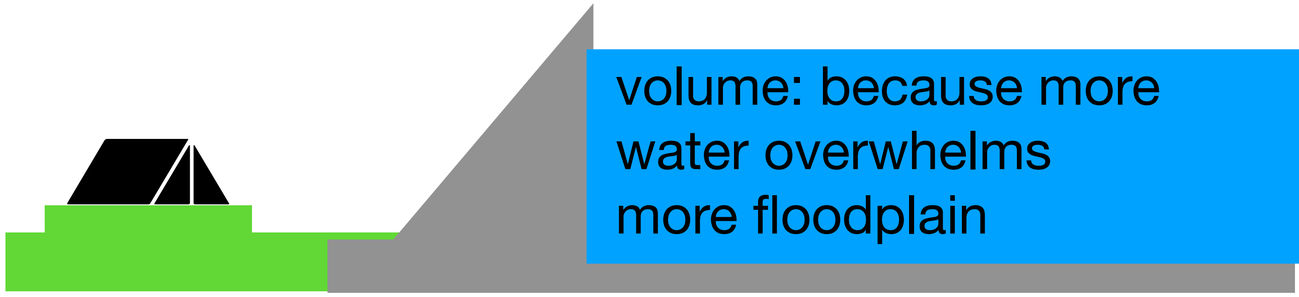
My qualifications:

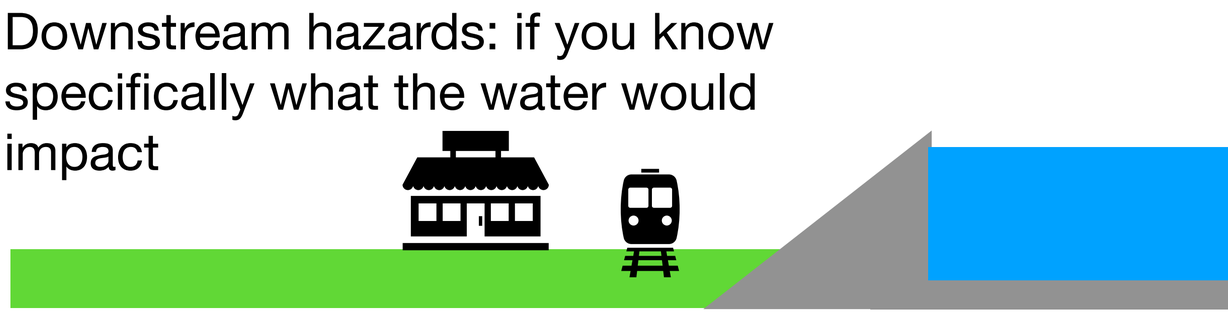
a) Taught environmental fluid mechanics at UC Santa Barbara: Physics 120 "Physics of California
b) Professional experience with complex regulatory systems, civil & geotechnical engineering
c) Live near and enjoy Lower Lake and adjacent parkland

Ohio Dept. Natural resources has decided Lower Lake Dam is "Hazard Class I"

- Strict rating means particularly stringent engineering code.
- Dams are classified by height *or* water volume *or* downstream hazards, whichever is more demanding.
- Lower Lake is short (Class IV) and smallish (Class III) but assesses as Class I due to downstream hazards.
  - Class I: "This dam would probably kill someone if it collapses. It absolutely must not collapse".
  - Class II: "This dam would damage homes, businesses, and major roads and railways if it collapsed. Build it carefully."
  - Class III: "Floods from a dam collapse would block traffic"
  - Class IV: "Nobody but the dam owner cares if it collapses or not"
- The PMF is 17-26" of rain in 24h. Like Hurricane Helene hitting Asheville in 2024.







Is Lower Lake dam classified correctly now?

a) It is not ODNR's job to downregulate dams based on vibes. They should apply the standards. BUT

b) Horseshoe Dam *was* a lot like its fellow Class I dams. Shaker Dam *is not*! It's very unusual as a Class I and we should ask why.

c) NEORSD mentions having "updated models"of downstream *stormwater* hazards and "mitigation via conveyance" Let's use those models for the dam failure hazards too!

During the Horseshoe Dam discussion we were told there is no point arguing about the ODNR hazard classification ... but this seems wrong.

> The Division, in accordance with the ORC Section 1521.062 and OAC Rule 1501:21-13-01 (C), has the right to reclassify any dam as a result of a change in circumstances not in existence at the time of the initial classification.

Could a *lower* dam in the same location earn a lower classification?

a) This question has not been asked!

What sort of dam failure do we need to talk about? All of them!

- "Fair weather" or "sunny day" failure: dam breaches while full due to construction defect, earthquake, etc.
  - "The normal pool elevation is recommended as the default volume for the fair weather failure", so 75 acre-feet
- "hydrologic" failure: dam breaches due to storm flow.
  - Dam failure during a storm may only *add* water to an already-hazardous flood; dam classification should be the *incremental* hazard. 178 acre-feet added to an ongoing flood.
- FEMA guidelines say to consider both of these and classify based on the worst one.

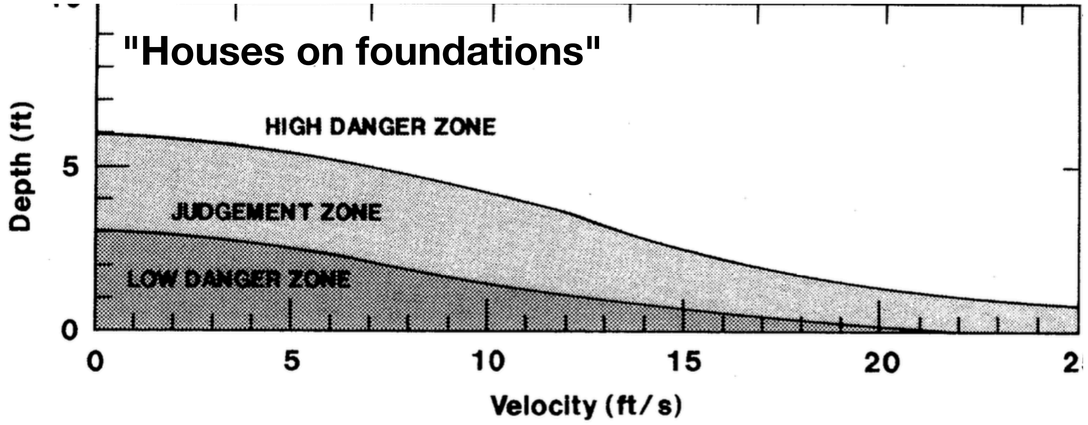
FEMA P-946, "Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures"

Who are the potential victims?

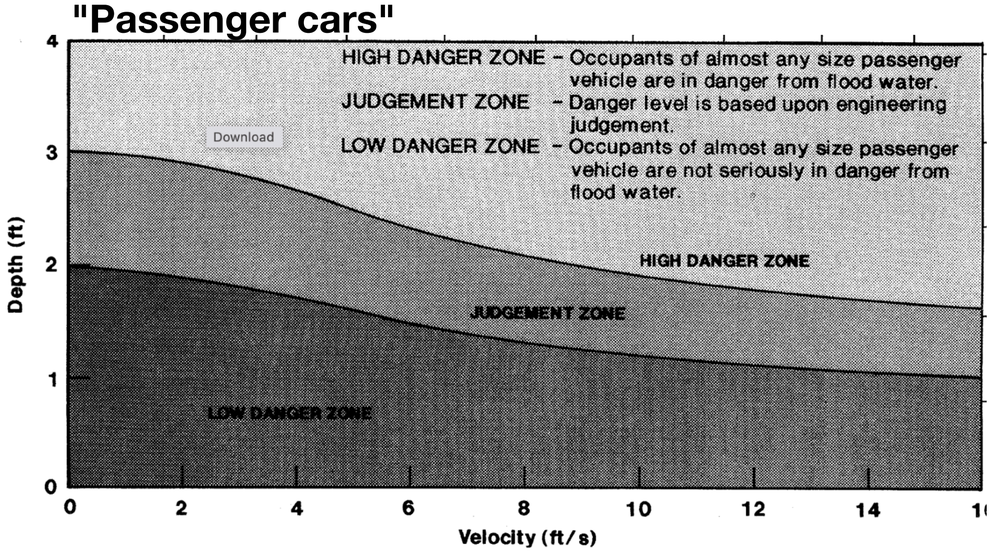
- Residents, workers in flooded buildings
  - Note: classification is about risk to life, not property
- Cars overtaken by floodwater
  - Not "idiot tries driving through the pool"
- Pedestrians
- Hikers, campers*

> If flood depth and velocity cannot be predicted with reasonable confidence, then the lives-in-jeopardy includes all [houses, cars, pedestrians, etc.] within the inundation boundaries.

US Bureau of Reclamations, Asst. Commissioner Eng. & Research, Technical Memo #11 (1989)



6 feet of still water is not "high danger"!!



< 3 feet of still water and <2 feet of fast water is still not "high danger" on this chart. I don't

Pedestrian routes include sidewalks, bicycle paths, and walking/hiking trails.

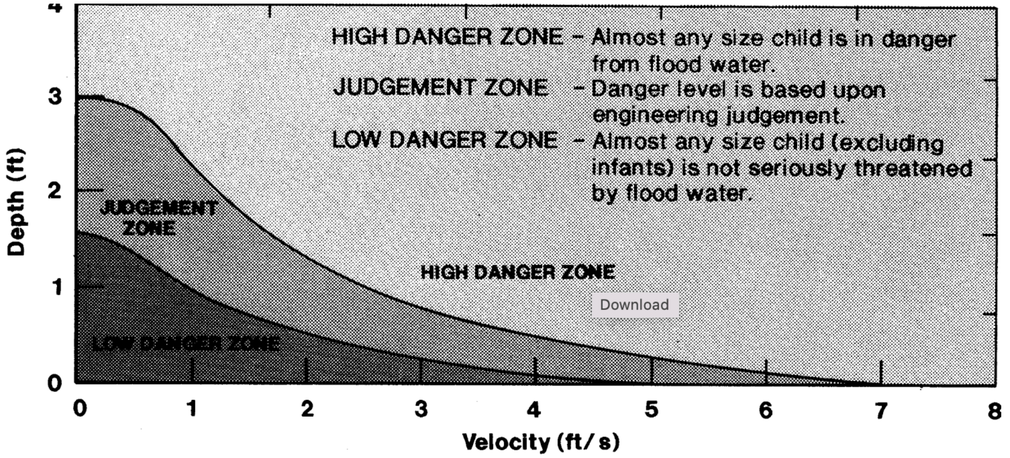


Figure 6. – Depth–velocity flood danger level relationship for children.

Could any sidewalk in the floodplain flood this deep? (High danger zone only, as with cars)

- Near the lake: *if* it's possible now I am pretty sure the NEORSD second culvert totally prevents it
- University Circle: not sure

USBR guidelines say: If you don't have analysis that predicts depth and flow, you have to assume high hazard anywhere there is water (!)

Images from US Bureau of Reclamations, Asst. Commissioner Eng. & Research, Technical Memo #11 (1989).

Are *hikers* in Doan Canyon a risk ODNR considered?

F. Designated Campgrounds and Recreation Areas

A designated campground and/or recreational area downstream from a dam is treated the same as pedestrian routes. Such a facility can be one that is owned, operated, and maintained by a Government agency or by private interests, and is advertised via signs, brochures, maps, etc.

I am tempted to nitpick about whether Doan Canyon is "a designated recreational area" but let's assume it is *or will be.*

Also relevant: unlike e.g., Southerly Park, there is little or no recreation in the creekbed itself due to the CSO

> Hazard potential classification systems do not typically take into account improbable (transient) loss of life, such as that of a passer-by or occasional, non-overnight recreational user of the downstream area.

FEMA P-946, "Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures"

My opinion: this is a case where "approximate analysis" ("there are hikers downstream, let's call it Class I and go home") and full hydraulic model ("footpath A has predicted inundation B which is below threshhold C") may be relevant.

All the small Class I dams in Cuyahoga and Geauga

	height (feet)	volume (acre-feet) when dam at crest	what's downstream?
Briar Lake	24	54	houses within 500'
Charbonneau Lake	20	109	houses within 500'
Lake Lucerne	30	160	house within 500'
Tanglewood Lake	37.4	228	1000' to Lake Lucerne
Lake in the Woods	26.4	245	houses right on dam apron
Shadow Hill Lake	20.6	35	houses within 400'
Loecy Pond	23.3	66	whole subdivision within 300'
Schloss Pond	35.9	103	houses within 400'
Hollenbeck Lake	22	64.5	houses within 200'
Horseshoe Lake*	30	155	4000' to Nature Center
Lower Lake	17	178	200' to Coventry culvert 1000' to Kemper culvert 7000' to University Circle

Question 1: Was ODNR correct to label Lower Dam as a Class I hazard?

Most of these are dams on tiny creeks with little flow capacity. Lake in the Woods = 200 acre watershed

Doan Canyon is huge and routinely carries huge flows. Upper watershed = 3840 acres

Lower Dam is already the lowest dam with Class I status..

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Question 3: Would a smaller dam remove the hazard?

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Far-downstream hazards are not just "big house right below the dam"

Lower Dam is already the lowest dam with Class I status.. and we can rebuild it even lower (14-15')

Would a lower volume take us off this list?

Compare to some Class II dams ...

	height (ft)	volume (acre-feet) when at crest	what's downstream?
Lower Lake (Class I)	17	178	200' to Coventry culvert 1000' to Kemper culvert 7000' to University Circle
Green Lake	24	71.3	Houses, Marshall Lake
Marshfield Lake	15.3	82	Houses within 600'
Hayes Lake	44.7	93.8	2000' to Rocky River
Lake Forest Estates	21.4	58	houses right on dam apron, many houses 2000' downstream
Lake Forest Country Club	16.3	405	Golf clubhouse on top of dam, utility bldgs below, sewage treatment plant across the highway
Hudson Springs Lake	17.7	500	Parkland, but creekside homes right across highway
Lake Louise	24.8	76	Houses within 800'
Kerem Lake	41	326	three culverts, 4000' to Aurora Branch Chagrin River
Acacia Reservation	38	148	Euclid Creek canyon

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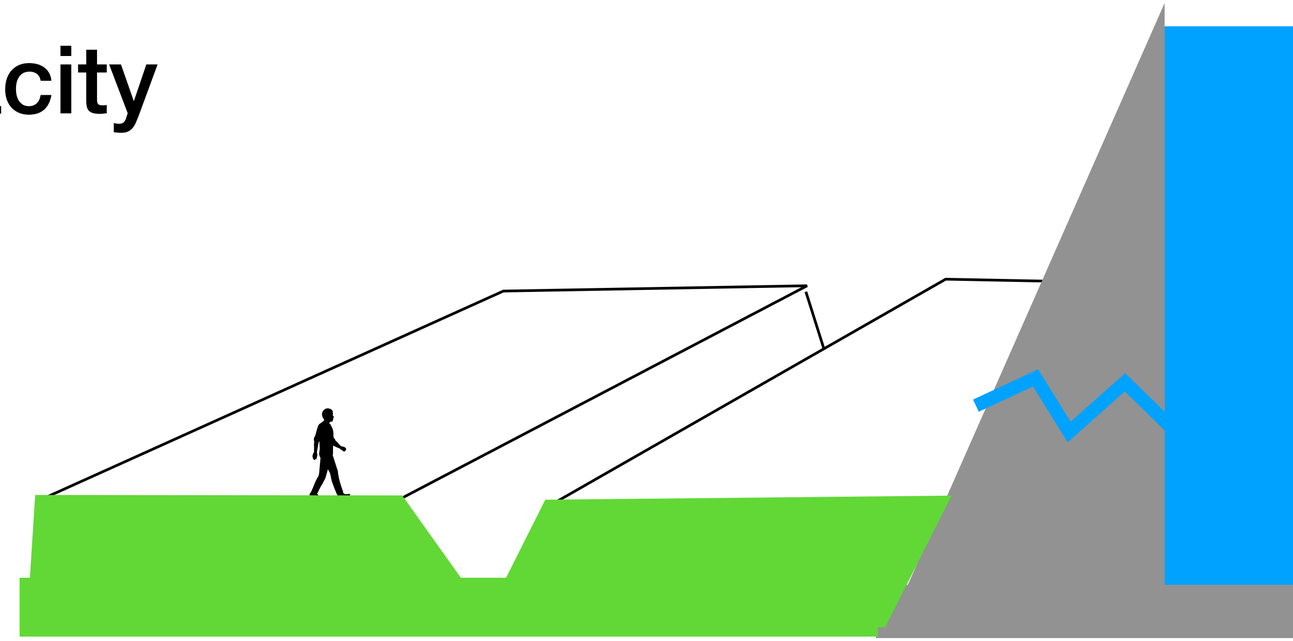
Question 3: Would a smaller dam remove the hazard?

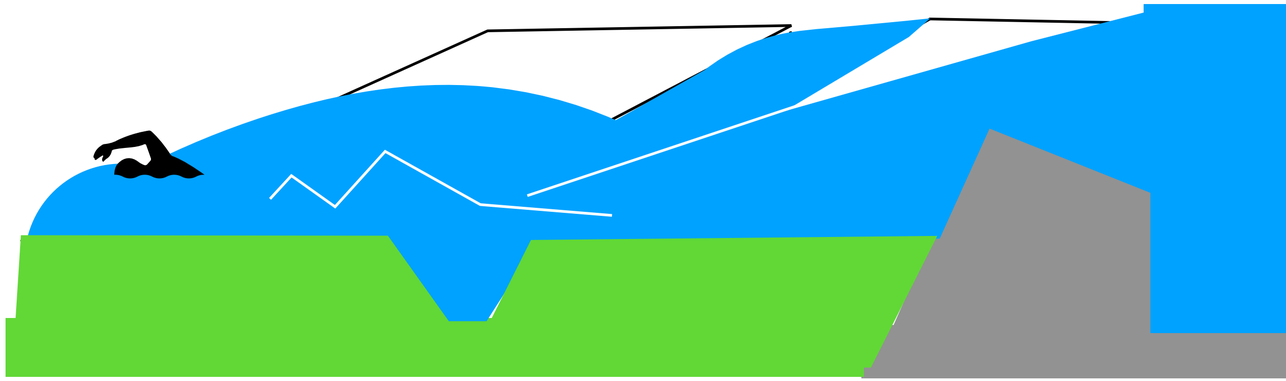
based on this one I am assuming downstream conveyance limits are relevant

based on this one I am assuming the hazard evaluation is not just "imagine a hiker in the canyon"? what is it?

Doan Canyon flood capacity is relevant



- Dumping a lot of water into a tiny channel that's not used to it = overflow = hazard



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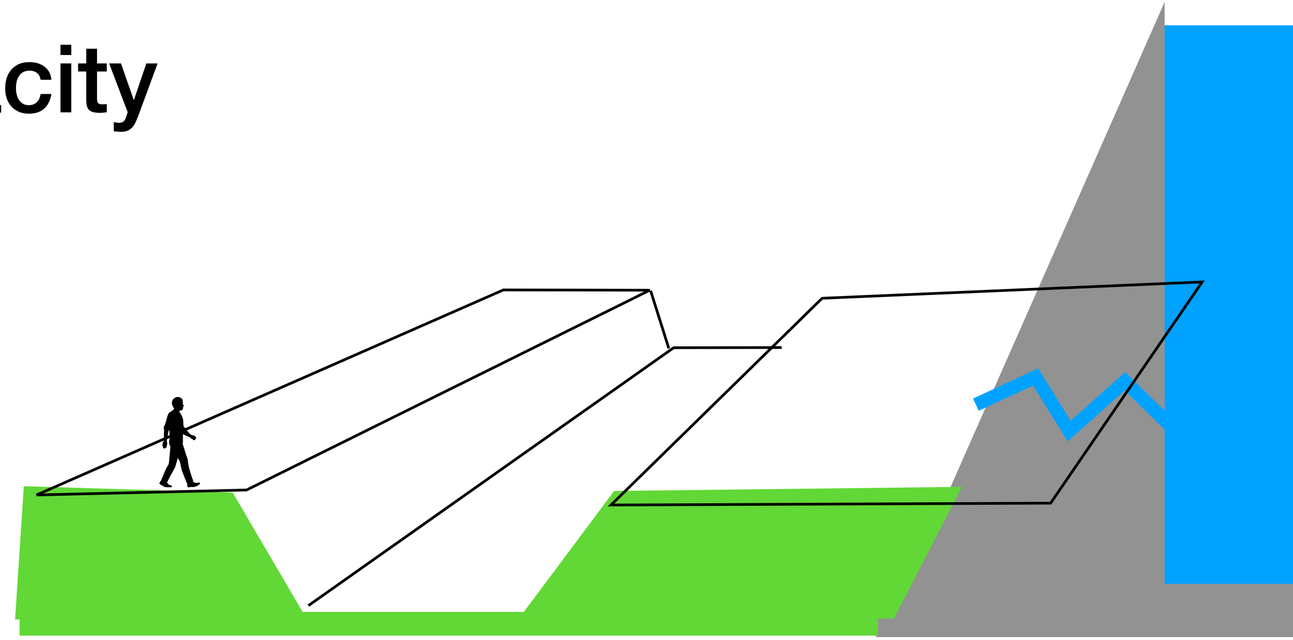
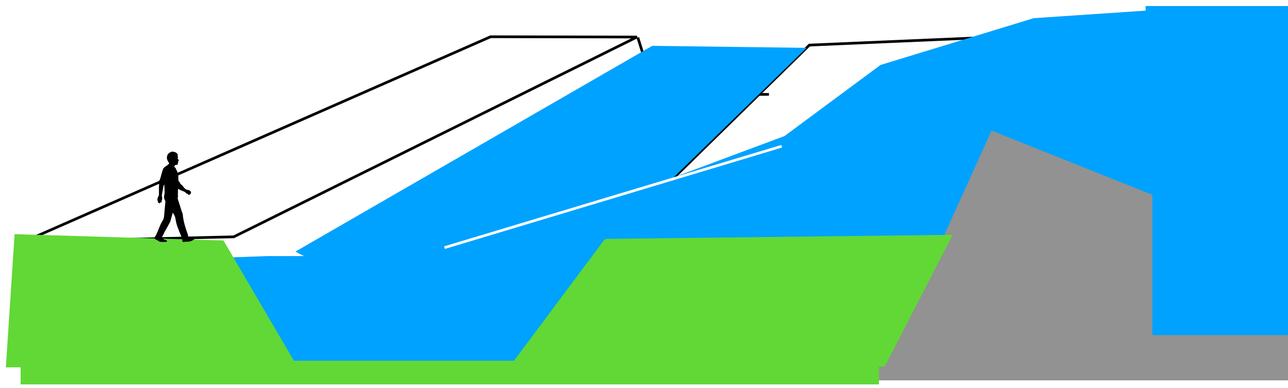
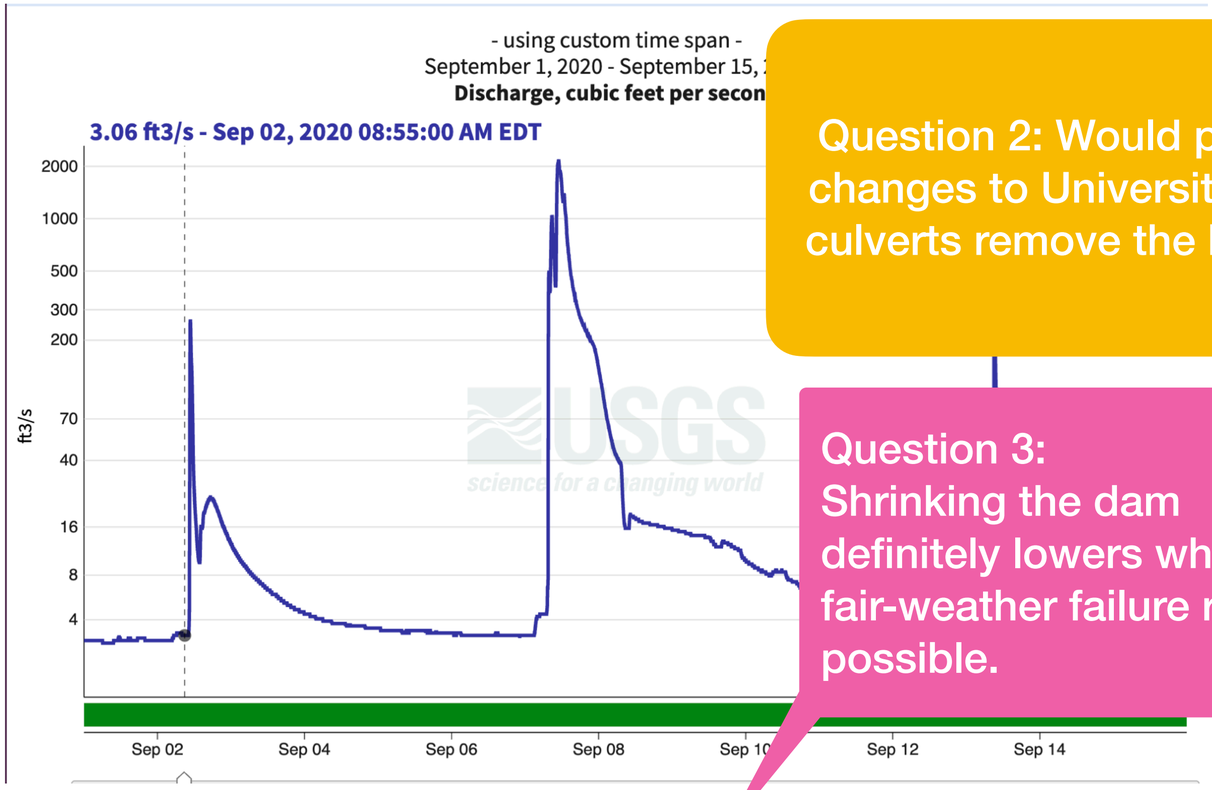


- Dumping a lot of water into a big channel = just looks like a rainstorm = not a hazard



Can Lower Doan Brook handle the fair-weather failure case?

- Imagine someone dynamited the dam *at its crest* (178 acre-feet) or at normal pool (75 acre-feet) and the lake drained completely in 60 minutes. What would that look like?
    - FEMA recommended: 75 acre-feet (3,300,000 ft^3) divided by 60 minutes (3600 seconds) = 900 cubic feet per second. *Doan Brook sees this all the time.*
    - Conservative: 178 acre-feet (7,700,000 ft^3) divided by 60 minutes (3600 seconds) = 2000 cubic feet per second. *Doan Brook has seen this flow before.*
- Conclusion: I don't think fair-weather failure effects on University Circle can be the source of the Class I designation.
- *Caveats: The MLK gauge doesn't tell us what flow entered University Circle. And I am not an engineer licensed to do this in any way.*



Question 2: Would planned changes to University Circle culverts remove the hazard?

Question 3:
Shrinking the dam definitely lowers whatever fair-weather failure risk is possible.

Date	acre-feet of water at MLK	over this many minutes
2018-04-16	283	335.0
2018-05-19	87	80.0
2019-09-13	101	85.0
2020-03-29	224	215.0
2020-05-15	116	140.0
2020-09-07	83	80.0
2020-09-07	499	280.0
2020-10-21	291	255.0

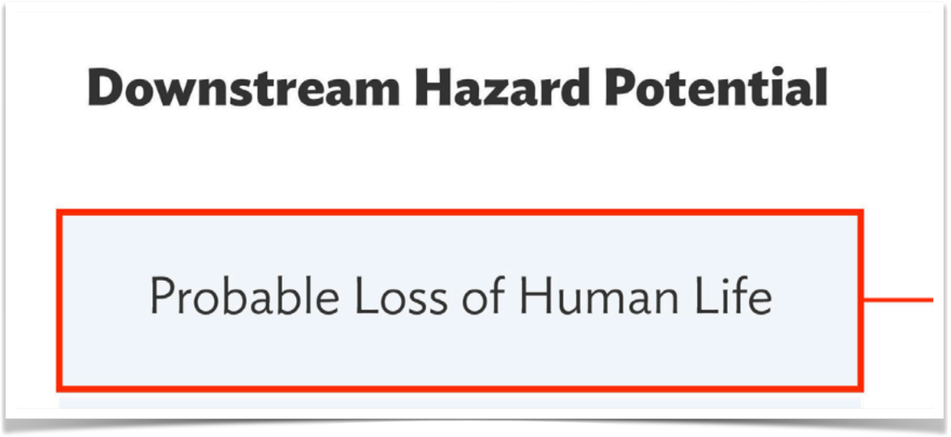
If *this* is what NEORSD's models say about 103 a-f of lower lake *storage*:

- No longer notable flooding benefit: The flood reduction in University Circle from the Lower Lake Class I High Hazard dam reconstruction is no longer considered notable. With updated stormwater models, we now know that the flood reduction benefits for specific buildings and roadways in University Circle are limited.

And *this* is what NEORSD's models say about 7000 a-f megastorms:

redesigning the Wade Lagoon area within the CMA's Fine Arts Garden. This redesign would provide us the opportunity to reduce downstream flooding in University Circle by installing an additional culvert pipe under the Wade Lagoon to convey more flow from Doan Brook underneath University Circle. Based on the updated modeling, this additional capacity will reduce the flooding in University Circle.

It is hard to understand how ODNR concluded this *even about the current hydrology* ... and easy to be optimistic about the effect of proposed changes



There are multiple levels of analysis depending how accurate the answer needs to be. Was Lower Lake's classification a "Tier 1" job to begin with?

Table 6-3: Tiered Approach Dam Breach Inundation Mapping for use in EAPs

Tier Level	Applicable to	Breach Parameter Prediction	Peak Breach Discharge Prediction	Downstream Routing of Breach Hydrograph
Tier 1 – Basic level Screening and Simple Analysis	• Low-hazard potential / small size • First level screening for significant- or high-hazard dams	Empirical Equations	Simplified Models (SMPDBK, GeoDam-BREACH, or Technical Release [TR]-66) or HEC-HMS	GeoDam-BREACH, SMPDBK, DSAT,1D HEC-RAS Steady State, or HEC-HMS Hydrologic Routing
Tier 2 – Intermediate	• Significant-hazard potential / intermediate size • High-hazard dams with limited population at risk	Empirical Equations	HEC-HMS or HEC-RAS Unsteady Model	HEC-RAS (Steady or Unsteady Modeling) 1-D or 2-D models
Tier 3 – Advanced	• High-hazard potential / large size dams with sufficient population at risk to justify advanced analyses	Empirical Equations, NWS BREACH, or WinDAM	HEC-RAS Unsteady Model	HEC-RAS Unsteady Model or 2-D models

Tier 1 and 2 analyses are most appropriate for low-hazard potential / small sized and significant-hazard potential / intermediate-sized dams with a limited number of structures. More detailed surveying or modeling may be warranted for Tier 3 analyses for high-hazard potential / large-sized dams, those with a large population in the evacuation area, or those with significant downstream hydraulic complexities, such as major diversion structures, split flows, or potential for a series of dam failures such as a “domino effect” (NDSRB, 2009).

- **My opinion:**
  - Contra what NEORSD said about Horseshoe Dam, it's worth asking whether ODNR's Class I hazard classification is correct:
    - Is it correct now? (Numbers suggest *to me* it's marginal at best.)
    - Will it still be correct after NEORSD upgrades University Circle culverts?
    - Would it still be correct if the dam were lower and the lake were smaller?
  - If Lower Lake can exist safely behind a Class-II-standard dam, we can probably build a *much cheaper* earth fill dam