

GUIDELINES FOR EXISTING DAMS IN OKLAHOMA

# Hazard-Potential Reclassification

Under Oklahoma law, the Oklahoma Water Resources Board (OWRB) is charged with ensuring the safety of dams in the state. Oklahoma's dam safety laws are in place to protect against loss of life and property in the event of a dam failure. Periodically, OWRB's Dam Safety Program conducts a review of the hazard-potential classifications assigned to all jurisdictional dams to ensure proper classification relating to the degree of downstream development and possible hazard to life and property.

## BACKGROUND

State dam safety officials classify a dam according to the potential impact of a dam failure (breach) or inappropriate operation (unscheduled release) on downstream areas or at locations remote from the dam. OWRB rule 785:25-3-3(a)(2) describes the three hazard-potential classifications as follows:

The hazard-potential classification of a dam is determined by the downstream risk in the event of a failure, without regard to the size or physical condition of the dam, as follows:	
<b>LOW</b>	Failure would result in no probable loss of human life and low economic loss.
<b>SIGNIFICANT</b>	Failure would result in no probable loss of human life but can cause significant economic loss or disruption of lifeline facilities.
<b>HIGH</b>	Failure will likely cause loss of human life.

OWRB Rule 785:25-1-2 defines *loss of human life* as the human fatalities that would result from a failure of the dam, excluding the occasional passer-by or recreationist and without considering evacuation or other emergency actions. As with any classification system, all possibilities cannot be defined, and judgment and common sense must ultimately be a part of any decision. Further, no allowances for evacuation or other emergency actions by the population should be considered as they are not a substitute for appropriate design, construction, and maintenance of dam structures.

Within a reasonable timeframe, an owner must set a deadline for work to begin, based on the circumstances, and notify OWRB staff of their intentions. Understanding the significance of this undertaking, OWRB staff will work with dam owners to find the most equitable solution.

## RECLASSIFICATION OF EXISTING DAMS

Development below dams can change rapidly over time. Dam owners often cannot control the development of new homes and other structures within the dam's breach inundation area, though they are liable for losses that may occur in these areas should the dam fail. To protect against these liabilities, the dam owner should monitor downstream areas for new development and be aware that these changes may affect the hazard-potential classification of their dam.

OWRB rule 785:25-3-3(b)(3) states, "The hazard-potential classification of a dam may change as the area downstream from



the dam develops and the dam may be reclassified from time to time under the provisions of 785:25-9-10 and 785:25-9-11." Therefore, if a residence, business, or other occupied structure or roadway is built within the potential dam breach inundation area below the dam then the hazard-potential classification

of the dam may be changed. Once the determination has been made to reclassify the hazard-potential of the dam, the owner will be notified (785:25-9-10).

## Considerations

- A difference of one foot of water (or more) between the breach and non-breach inundation maps for a particular area indicates a potential hazard to life.
- The potential overtopping or failure of any downstream dam that could be caused by the failure of an upstream dam will be considered in the classification of the upstream dam.
- The Population at Risk (PAR) is the primary factor differentiating between a significant and high hazard-potential dam. When determining the PAR, OWRB assumes that three (3) people inhabit each dwelling. Site-specific information about the likely occupancy of non-residential structures (businesses, hospitals, manufacturing facilities, and other temporary use areas) is estimated.
- Any roadway that crosses a dam or is located below a dam that would be overtopped, at any depth, by a dam failure may be considered to be impacted. A dam is considered to have high hazard potential when an impacted roadway sees 1500 or more vehicles per day. To obtain these figures, OWRB consults the most recent AADT counts from the Oklahoma Department of Transportation.
- With regard to significant hazard-potential dams, the intent in considering economic loss is to identify the relative magnitude of losses against a broad scale of values. No attempt is made to assess actual fair market value of the losses.

## HAZARD-POTENTIAL EVALUATION PROCESS

The OWRB evaluates the hazard-potential of dams through a multi-step process. First, the dams that fall under state jurisdiction are viewed through aerial imagery to check for downstream development. Any developed areas that appear to be downstream of a dam are visited to confirm the presence and type of development. The dam may be immediately reclassified if downstream structures are found to be within the inundation area.

If the site visit is inconclusive, the OWRB uses a flood model and an associated map to estimate the extent of flooding that would be caused by a dam breach. Any development (including homes, major roadways, utilities, and businesses) that appears in the flood hazard zone is considered to be impacted, and the hazard-potential classification is assigned accordingly.

## DAM BREACH MAPPING

In a breach inundation map, a set of equations (Froehlich 2008) based on studies of previous dam breaches are used to estimate the potential breach flow of a particular dam under piping conditions. This assumes that the failure of the dam is caused by the progressive development of internal erosion by seepage. The equations consider factors like the height of the dam, the volume of water in the reservoir, and the reservoir surface area. The model is created under the assumption of a 'sunny-day' breach, which means that the dam is assumed to be full when it breaks but that there will be no additional inflow into the reservoir or the downstream area. This method isolates the effects of the dam breach and excludes flooding impacts due to rainfall runoff in the area. This assumption also disregards the capacity of the spillway, which is difficult to ascertain without extensive surveying.



The resultant flow, calculated in cubic feet per second (cfs), is then routed through the downstream channel with the help of streamflow modeling software. The shape of the downstream channel and overbank areas is taken from topographic maps. The calculated height of water above the streambed is then mapped to show the extent of flooding under the model conditions.

### Limitations of Study

The flood hazard area shown in a breach map is intended to aid in the evaluation of a dam's hazard-potential. The flood area is an estimation of the expected flood in the event of a dam breach. Actual inundation may differ from the breach inundation map.

The use of more detailed topographic data for the specified area may improve the breach inundation model and alter projected flood extents.

### Method for Estimating Embankment Breach Characteristics

The breach parameters are calculated as follows:

$$B_{avg} = 8.239 K_0 V_w^{0.32} H_b^{0.04}$$

$$T_f = 3.664 \sqrt{\frac{V_w}{g H_b^2}}$$

Where:

- $B_{avg}$  = Average breach width in feet
- $K_0$  = Piping failure mode factor: 1.0
- $V_w$  = Reservoir volume stored in acre-feet
- $H_b$  = Height of breach in feet
- $T_f$  = Breach development time in hours
- $g$  = Acceleration due to gravity: 32.2 ft/s<sup>2</sup>

The peak breach flow is calculated using the above parameters as follows:

$$Q_p = 3.1 B_{avg} H_w^{1.5} \left( \frac{\gamma}{\gamma + T_f \sqrt{H_w}} \right)^3$$

Where:

- $Q_p$  = Dam breach peak discharge in cubic feet per second (cfs)
- $H_w$  = Maximum depth of water stored behind the breach in feet
- $\gamma$  = Instantaneous flow reduction factor (23.4  $A_s / B_{avg}$ )
- $A_s$  = Surface area of the reservoir in acres corresponding to  $H_w$



## Reclassification: Actions to Take

**1** When a dam has been reclassified, the first step the owner should take is to develop an **emergency action plan**. This document outlines important contact information and the steps that should be taken if an emergency at the dam is occurring or rapidly developing. This can be done at no cost to the owner and can reduce the owner's liability in the event of a failure. A free emergency action plan template is available on the OWRB's website and may be completed by the owner or an engineer.

**2** Owners of reclassified dams need to **contact a professional engineer** who is registered in the State of Oklahoma to conduct an initial inspection. Any deficiencies noted by the engineer should be corrected in a timely manner to ensure the safety of people and property downstream. As laid out in Chapter 25 of OWRB rules, an owner may seek a compliance schedule with the Board that sets the timeframes for various stages of work to be performed.

**3** The owner is also responsible for hiring an engineer for **routine inspections**. These are to be required once a year for high hazard-potential dams and once every three years for significant hazard-potential dams as per Oklahoma Law (OAC 785:25-9-1).

**4** Before making adjustments to the dam, **coordinate with OWRB's** Dam Safety staff to ensure the appropriate paperwork is filed. OWRB will work directly with the contracted engineer and approve plans and specifications for any needed repairs or modifications.

Alternatively, if dam safety regulations cannot be reasonably followed, a dam owner has the option to remove or decommission the dam. The owner may also dispute this reclassification by seeking an individual proceeding to contest the OWRB's findings and present evidence (i.e. a breach analysis and inundation map developed by a registered professional engineer) to show that the dam should be classified at a lower hazard-potential level.

## REFERENCES

- Annual Average Daily Traffic Maps by County and Year, Oklahoma Department of Transportation, <http://www.okladot.state.ok.us/>.
- Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams, U.S. Department of Homeland Security, Federal Emergency Management Agency, October 1998.