



# VIRGINIA SOIL AND WATER CONSERVATION BOARD GUIDANCE DOCUMENT ON IMPOUNDING STRUCTURE HAZARD POTENTIAL CLASSIFICATIONS

(Approved XXXXXX, 2010)  
Working Draft Version January 14, 2010

## **Summary:**

This guidance document outlines the decision process to be utilized by the Virginia Soil and Water Conservation Board and an owner and his engineer in determining hazard potential classification of an impounding structure in accordance with the Virginia Impounding Structure Regulations.

## **Electronic Copy:**

An electronic copy of this guidance in PDF format is available on the Regulatory TownHall under the Virginia Soil and Water Conservation Board at <http://townhall.virginia.gov/L/GDocs.cfm>.

## **Contact Information:**

Please contact the Department of Conservation and Recreation's Division of Dam Safety and Floodplain Management at [dam@dcr.virginia.gov](mailto:dam@dcr.virginia.gov) or by calling 804-371-6095 with any questions regarding the application of this guidance.

## **Disclaimer:**

This document is provided as guidance and, as such, sets forth standard operating procedures for the Virginia Soil and Water Conservation Board and the Department of Conservation and Recreation that administers the program on behalf of the Board. This guidance provides a general interpretation of the applicable Code and Regulations but is not meant to be exhaustive in nature. Each situation may differ and may require additional interpretation of the Dam Safety Act and attendant regulations.

## **Impounding Structure Hazard Potential Classifications**

### **I. Background:**

Section 4VAC50-20-40 of the Impounding Structure Regulations stipulates that impounding structures shall be classified in one of three hazard classifications. This guidance document shall explain the process by which a determination is made regarding the proper hazard classification of an owner's dam.

### **II. Definitions (pursuant to § 10.1-604 and 4VAC50-20-30):**

"Dam break inundation zone" means the area downstream of a dam that would be inundated or otherwise directly affected by the failure of a dam.

"Normal or typical water surface elevation" means the water surface elevation at the crest of the lowest ungated outlet from the impoundment or the elevation of the normal pool of the impoundment if different than the water surface elevation at the crest of the lowest ungated outlet. For calculating sunny day failures for flood control impounding structures, stormwater detention impounding structures, and related facilities designed to hold back volumes of water for slow release, the normal or typical water surface elevation shall be measured at the crest of the auxiliary or emergency spillway.

"Sunny day dam failure" means the failure of an impounding structure with the initial water level at the normal reservoir level, usually at the lowest ungated principal spillway elevation or the typical operating water level.

### **III. Authority:**

The Dam Safety Act in the Code of Virginia contains the following authorities applicable to this guidance:

#### **§ 10.1-605. Promulgation of regulations by the Board.**

The Board shall promulgate regulations to ensure that impounding structures in the Commonwealth are properly and safely constructed, maintained and operated.

The Impounding Structure Regulations contain the following authorities applicable to this guidance:

#### **4VAC50-20-40. Hazard potential classifications of impounding structures.**

A. Impounding structures shall be classified in one of three hazard classifications as defined in subsection B of this section and Table 1.

B. For the purpose of this chapter, hazards pertain to potential loss of human life or damage to the property of others downstream from the impounding structure in event of failure or faulty operation of the impounding structure or appurtenant facilities.

Hazard potential classifications of impounding structures are as follows:

1. High Hazard Potential is defined where an impounding structure failure will cause probable loss of life or serious economic damage. "Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.

2. Significant Hazard Potential is defined where an impounding structure failure may cause the loss of life or appreciable economic damage. "May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and

agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways.

3. Low Hazard Potential is defined where an impounding structure failure would result in no expected loss of life and would cause no more than minimal economic damage. "No expected loss of life" means no loss of human life is anticipated.

C. The hazard potential classification shall be proposed by the owner and shall be subject to approval by the board. To support the appropriate hazard classification, dam break analysis shall be conducted by the owner's engineer. Present and planned land-use for which a development plan has been officially approved by the locality in the dam break inundation zones downstream from the impounding structure shall be considered in determining the classification.

D. Impounding structures shall be subject to reclassification by the board as necessary.

**4VAC50-20-50. Performance standards required for impounding structures.**

A....Impounding structures of regulated size and not exempted shall be constructed, operated and maintained such that they perform in accordance with their design and purpose throughout the life of the project. For impounding structures, the spillway(s) capacity shall perform at a minimum to safely pass the appropriate spillway design flood as determined in Table 1. For the purposes of utilizing Table 1, Hazard Potential Classification shall be determined in accordance with 4VAC50-20-40.

TABLE 1

Impounding Structure Regulations

Applicable to all impounding structures that are 25 feet or greater in height and that create a maximum impounding capacity of 15 acre-feet or greater, and to all impounding structures that are six feet or greater in height and that create a maximum impounding capacity of 50 acre-feet or greater and is not otherwise exempt from regulation by the Code of Virginia.

Hazard Potential Class of Dam	Spillway Design Flood (SDF) <sup>B</sup>	Minimum Threshold for Incremental Damage Analysis
High	PMF <sup>C</sup>	.50 PMF
Significant	.50 PMF	100-YR <sup>D</sup>
Low	100-YR <sup>D</sup>	50-YR <sup>E</sup>

B. The spillway design flood (SDF) represents the largest flood that need be considered in the evaluation of the performance for a given project. The impounding structure shall perform so as to safely pass the appropriate SDF. Reductions in the established SDF may be evaluated through the use of incremental damage analysis pursuant to 4VAC50-20-52. The SDF established for an impounding structure shall not be less than those standards established elsewhere by state law or regulations, including but not limited to the Virginia Stormwater Management Program (VSMP) Permit Regulations (4VAC50-60). Due to potential for future development in the dam break

inundation zone that would necessitate higher spillway design flood standards or other considerations, owners may find it advisable to consider a higher spillway design flood standard than is required.

C. PMF: Probable Maximum Flood is the flood that might be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is derived from the current probable maximum precipitation (PMP) available from the National Weather Service, NOAA. In some cases, a modified PMF may be calculated utilizing local topography, meteorological conditions, hydrological conditions, or PMP values supplied by NOAA. Any deviation in the application of established developmental procedures must be explained and justified by the owner's engineer. The owner's engineer must develop PMF hydrographs for 6-, 12-, and 24-hour durations. The hydrograph that creates the largest peak outflow is to be used to determine capacity for nonfailure and failure analysis. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area.

D. 100-Yr: 100-year flood represents the flood magnitude expected to be equaled or exceeded on the average of once in 100 years. It may also be expressed as an exceedence probability with a 1.0% chance of being equaled or exceeded in any given year. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area.

E..50-Yr: 50-year flood represents the flood magnitude expected to be equaled or exceeded on the average of once in 50 years. It may also be expressed as an exceedence probability with a 2.0% chance of being equaled or exceeded in any given year. Present and planned land-use conditions shall be considered in determining the runoff characteristics of the drainage area.

#### **4VAC50-20-54. Dam break inundation zone mapping.**

A. Dam break inundation zone maps shall be provided to the department to meet the requirements set out in Hazard Potential Classifications of Impounding Structures (4VAC50-20-40), Emergency Action Plan for High and Significant Potential Hazard Impounding Structures (4VAC50-20-175), and Emergency Preparedness for Low Hazard Potential Impounding Structures (4VAC50-20-177), as applicable.

B.....

C.....

D. For determining the hazard potential classification, a minimum of the following shall be provided to the department:

1. A sunny day dam break analysis utilizing the volume retained at the normal or typical water surface elevation of the impounding structure;
2. A dam break analysis utilizing the spillway design flood with a dam failure;
3. An analysis utilizing the spillway design flood without a dam failure; and
4. For the purposes of future growth planning, a dam break analysis utilizing the probable maximum flood with a dam failure.

E.....

#### **4VAC50-20-52. Incremental damage analysis.**

A. When appropriate, the spillway design flood requirement may be reduced by the board in accordance with this section.

B. The owner's engineer may proceed with an incremental damage analysis. Once the owner's engineer has determined the required spillway design flood through application of Table 1, further analysis may be performed to evaluate the limiting flood condition for incremental damages. Site-specific conditions should be recognized and considered. This analysis may be used to lower the spillway design flood. In no situation shall the allowable reduced level be less than the level at which the incremental increase in water surface elevation downstream due to failure of an impounding structure is no longer considered to present an additional downstream threat. This engineering analysis will need to present water surface elevations at each structure that may be impacted downstream of the dam. An additional downstream threat to persons or property is presumed to exist when water depths exceed two feet or when the product of water depth (in feet) and flow velocity (in feet per second) is greater than seven.

C. The spillway design flood shall not be reduced below the minimum threshold values as determined by Table 1.

D. The required spillway design flood shall be subject to reclassification by the board as necessary to reflect changed conditions at the impounding structure and in the dam break inundation zone.

#### **IV. Discussion and Interpretation:**

In accordance with 4VAC50-20-40, three hazard potential classifications exist for regulated impounding structures: Low, Significant and High. As the classification increases, likewise the potential hazard to human life and/or economic damage increases.

This Hazard Class determination process is a simplified procedure to determine the potential impacts downstream of a regulated impounding structure, through conducting a dam break inundation zone analysis and developing the required dam break inundation zone map(s). This procedure does not allow the use of the *rule of seven* (impacts occur when the depth of water times the velocity of the flow at any given point in the inundation zone exceeds 7 ft<sup>2</sup>/sec.) or the use of water depths (impacts occur when total water depths exceed two feet) in the determination of the hazard classification. The procedure uses a simple mapping principle that determines the Hazard Class by evaluating whether a person or structure containing people is located within the dam break inundation zone. The *rule of seven* and the two foot depth at impact areas can be used in the Incremental Damage Analysis procedure to possibly reduce the size the required Spillway Design Flood (SDF) for the impounding structure once the Hazard Class has been determined.

Computer modeling of flood routings is not an exact science, therefore maintaining a conservative procedure in determining the Hazard Class of an impounding structure is critical in protecting public safety. The purpose of establishing the Hazard Class is to determine required design criteria and establishes the frequency of periodic inspections by the dam owner's professional engineer.

High Hazard Class dams are impounding structures where failure of the dam will cause probable loss of life or serious economic damage.

"Probable loss of life" means that impacts will occur that are likely to cause a loss of human life, including but not limited to impacts to residences, businesses, other occupied structures, or major roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, major roadways, railroads, personal property, and agricultural interests. "Major roadways" include, but are not limited to, interstates, primary highways, high-volume urban streets, or other high-volume roadways.

A dam break inundation zone map that depicts inundation impacts on any of the items listed above justifies a High Hazard Classification.

Significant Hazard Class dams are impounding structures where failure may cause the loss of life or appreciable economic damage.

"May cause loss of life" means that impacts will occur that could cause a loss of human life, including but not limited to impacts to facilities that are frequently utilized by humans other than residences, businesses, or other occupied structures, or to secondary roadways. Economic damage may occur to, but not be limited to, building(s), industrial or commercial facilities, public utilities, secondary roadways, railroads, personal property, and agricultural interests. "Secondary roadways" include, but are not limited to, secondary highways, low-volume urban streets, service roads, or other low-volume roadways. [NOTE: Low volume roadways are discussed in greater detail in the Board's Roadway Guidance Document.]

A dam break inundation zone map that depicts inundation impacts on any of the items listed above justifies, at a minimum, a Significant Hazard Class.

Low Hazard Class dams are impounding structures where failure would result in no expected loss of life and would cause no more than minimal economic damage.

"No expected loss of life" means no loss of life is anticipated.

A dam break inundation zone map that depicts inundation impacts on properties other than those owned by the dam owner justifies, at a minimum, a Low Hazard Class.

It should be understood that with this Hazard Class determination process, all possible situations with impacted structures/facilities cannot be defined in this procedure. Judgment and common sense should be applied in making any decision on classifications. No allowance for evacuation or other emergency actions for the public can be considered in determining the Hazard Class, because emergency procedures are not a substitute for appropriate design, construction, and maintenance of impounding structures. Consultation with DCR Dam Safety staff by the dam owner and the dam owner's consulting professional engineer is highly recommended in unusual situations that might vary from this procedure.

Engineering analyses performed by the dam owner's engineer to evaluate a sunny-day dam failure and review the complete range of storm event failures (50-year flood to the full PMF) may result in no impacts other than to non-productive lands within the floodplain. Such analyses may be used to justify a Low Hazard classification.

### **Hazard Procedures Matrix for Determining the Hazard Class of a Dam**

**Step 1.** Run an approved computer model to simulate a sunny day dam break to determine potential inundation downstream of the dam.

Are there any residences, major roadways etc. located within the inundation zone?

**Yes:** Assign High Hazard Class, proceed to:

- As 4VAC50-20-50 indicates that the established Spillway Design Flood (SDF) is the PMF, the owner's engineer must run approved computer models to simulate the full PMF with a dam break and then without a dam break.
- The owner's engineer must complete a Dam Break Inundation Zone Map that must include inundation lines that represent downstream flooding for a sunny day dam break, a dam break during a full PMF and full PMF without a dam break.

**No:** Hazard Class unknown, go to Step 2.

**Step 2.** Run an approved computer model to simulate a dam break during the Probable Maximum Flood to determine potential inundation downstream of the dam.

Are there any impacted residences or major roadways etc. located within the inundation zone?

**Yes:** Assign High Hazard Class, proceed to:

- As 4VAC50-20-50 indicates that the established SDF is the PMF, the owner's engineer must run an approved computer model to simulate the full PMF without a dam break.
- The owner's engineer must complete a Dam Break Inundation Zone Map that must include inundation lines that represent downstream flooding for a sunny day dam break, a dam break during a full PMF and full PMF without a dam break

**No:** Hazard Class unknown, proceed to determine:

Are there any secondary roadways, major nonresidential structures or utilities etc. within the inundation zone?

**Yes:** Assign Significant Hazard Class, proceed to:

- As 4VAC50-20-50 indicates that the established SDF is the ½ PMF, the owner's engineer must run an approved computer model to simulate the ½ PMF without a dam break.
- The owner's engineer must complete a Dam Break Inundation Zone Map that must include inundation lines that represent downstream flooding for a sunny day dam break, a dam break during a full PMF, a dam break during a ½ PMF and ½ PMF without a dam break.

**No:** Assign Low Hazard Class, proceed to:

- The owner's engineer must run approved computer models to simulate the 100-Year Flood with a dam break and the 100-Year Flood without a dam break.

- Complete a Dam Break Inundation Zone Map that must include inundation lines that represent downstream flooding for a sunny day dam break, a dam break during the 100-Year Flood and the 100-Year Flood without a dam break and the full PMF with a dam break.

Note: If the dam owner decides to authorize his consulting professional engineer to perform an Incremental Damage Analysis (IDA) and the IDA results in the reduction in the spillway design flood, the final Dam Break Inundation Zone Map must contain the inundation zones associated with the dam failure during a PMF, a sunny day dam break, the spillway design flood with a dam break and the spillway design flood without a dam break. At no time will a spillway design flood be allowed that would be less than that listed as the Minimum Threshold for Incremental Damage Analysis in Table 1 of the Virginia Impounding Structure Regulations.

#### **V Adoption, Amendments, and Repeal:**

This document was adopted by the Board on XXXX, 2010 and may be amended or repealed as necessary by the Board.