

Dams 101

Dam Information, Resources, and Training (DIRT)



Marco Alvarez-Rengifo
Dam Safety Section, DNR Division of Water

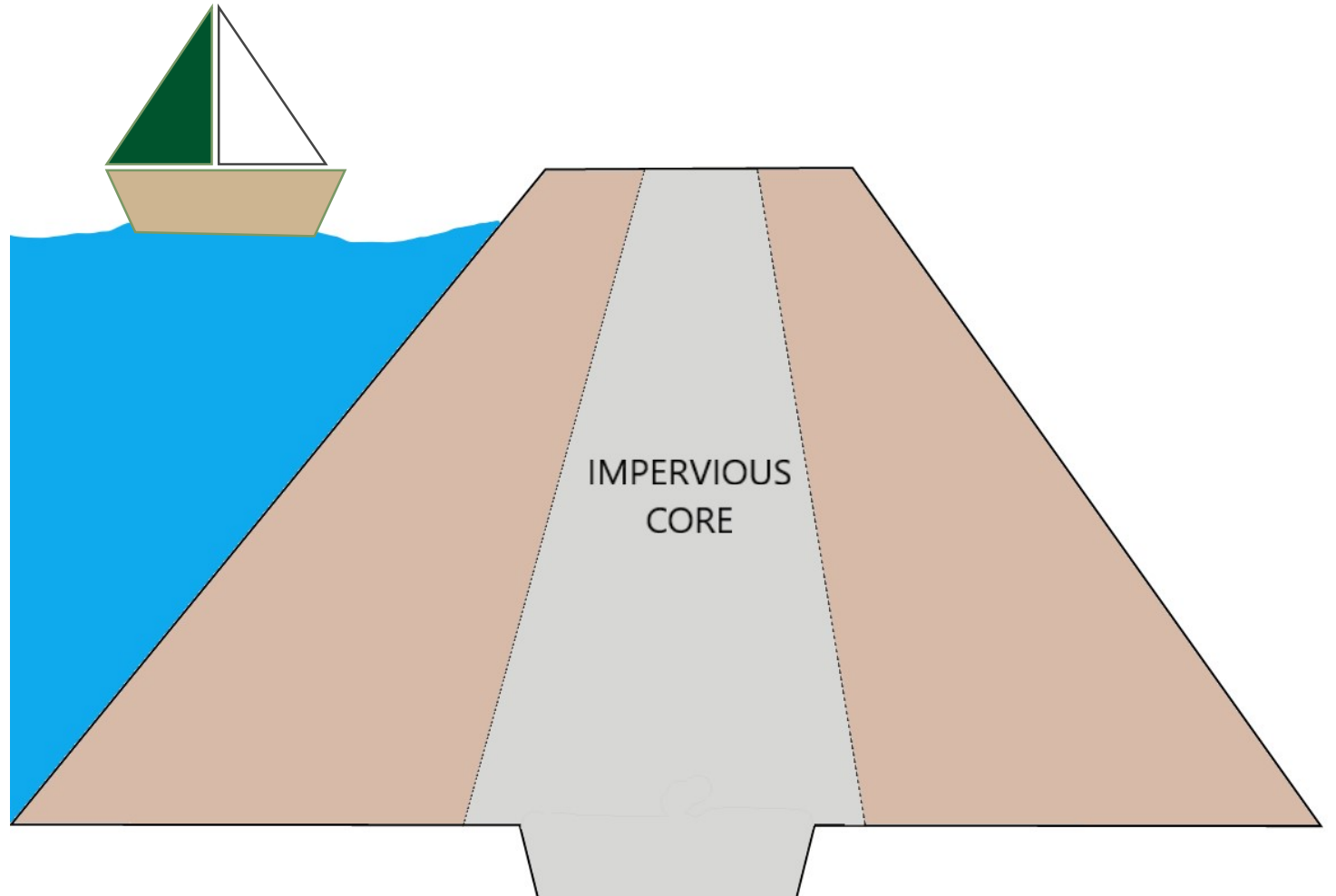
Chris Ritz
USDA Natural Resources Conservation Service

Alysson Oliger
Compliance Section, DNR Division of Water

Why a Dam?

A dam can impound (store) water or other liquid for one or more reasons:

- Recreation
- Water supply
- Flood control
- Energy generation
- Containment
- Sediment control
- Property value



Dam Safety

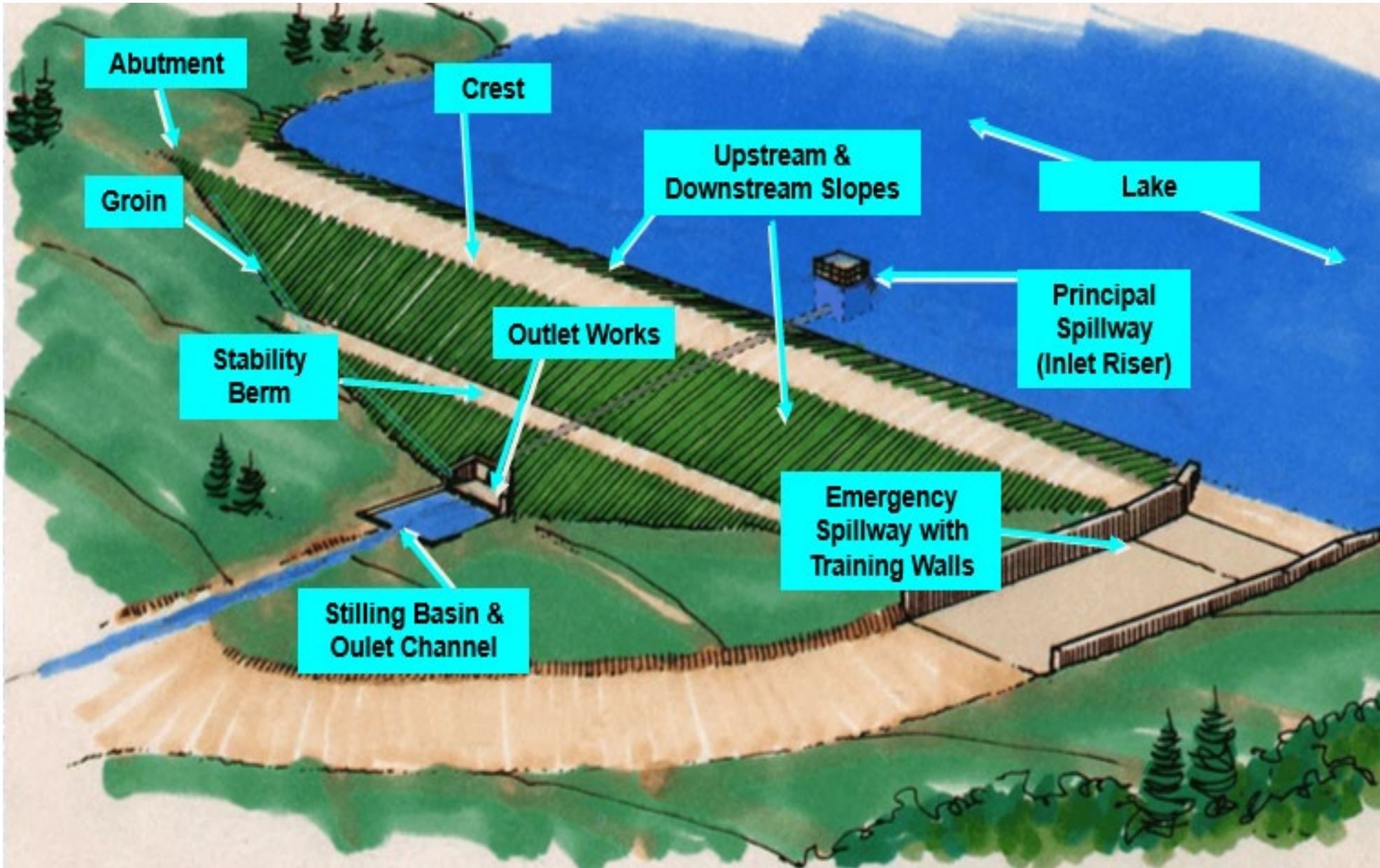
....and why we should care....

Short Answer:

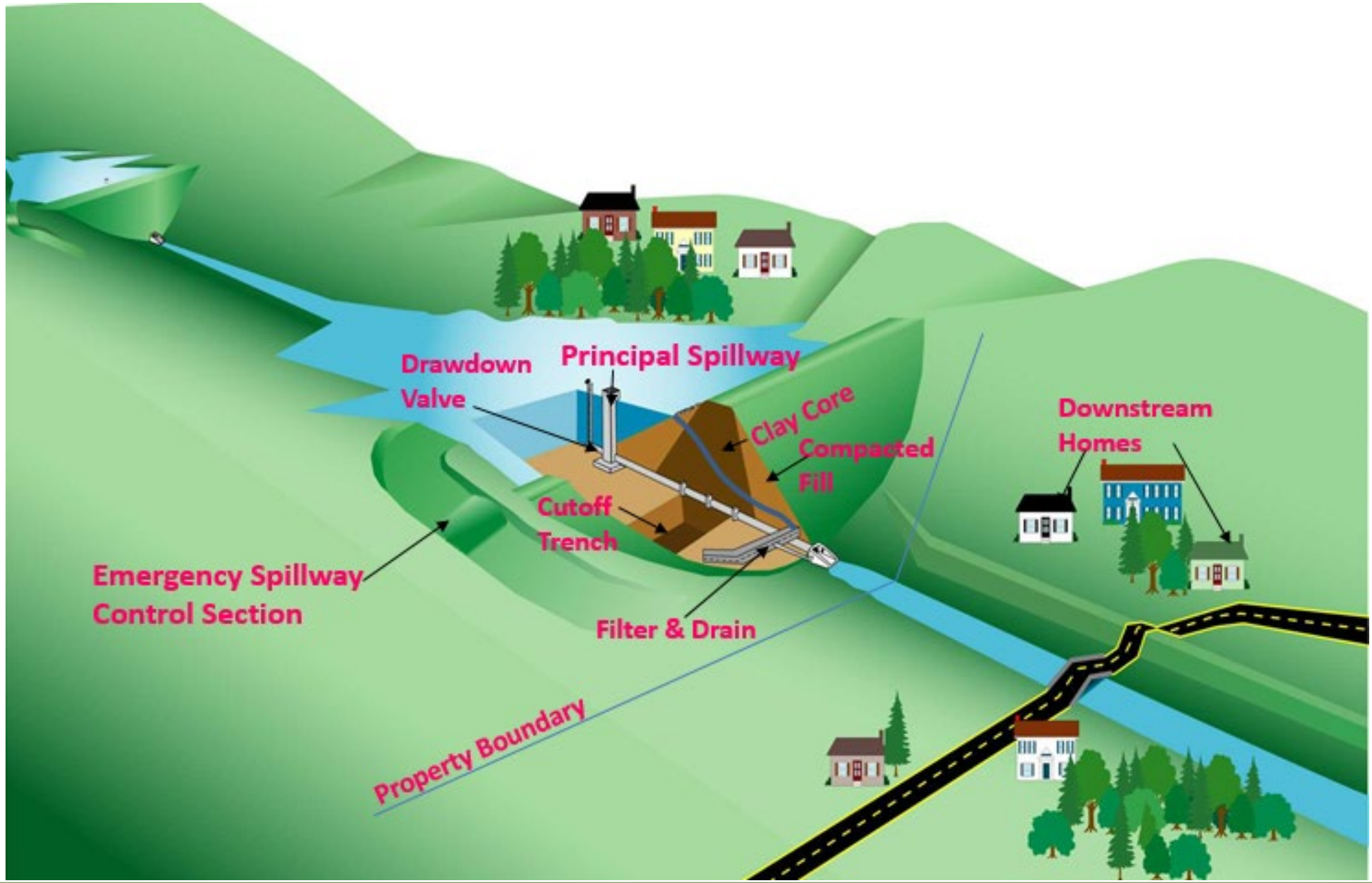
***Dams are Good
Floods can be Bad***



Embankment Dam Terminology



Some More Terminology

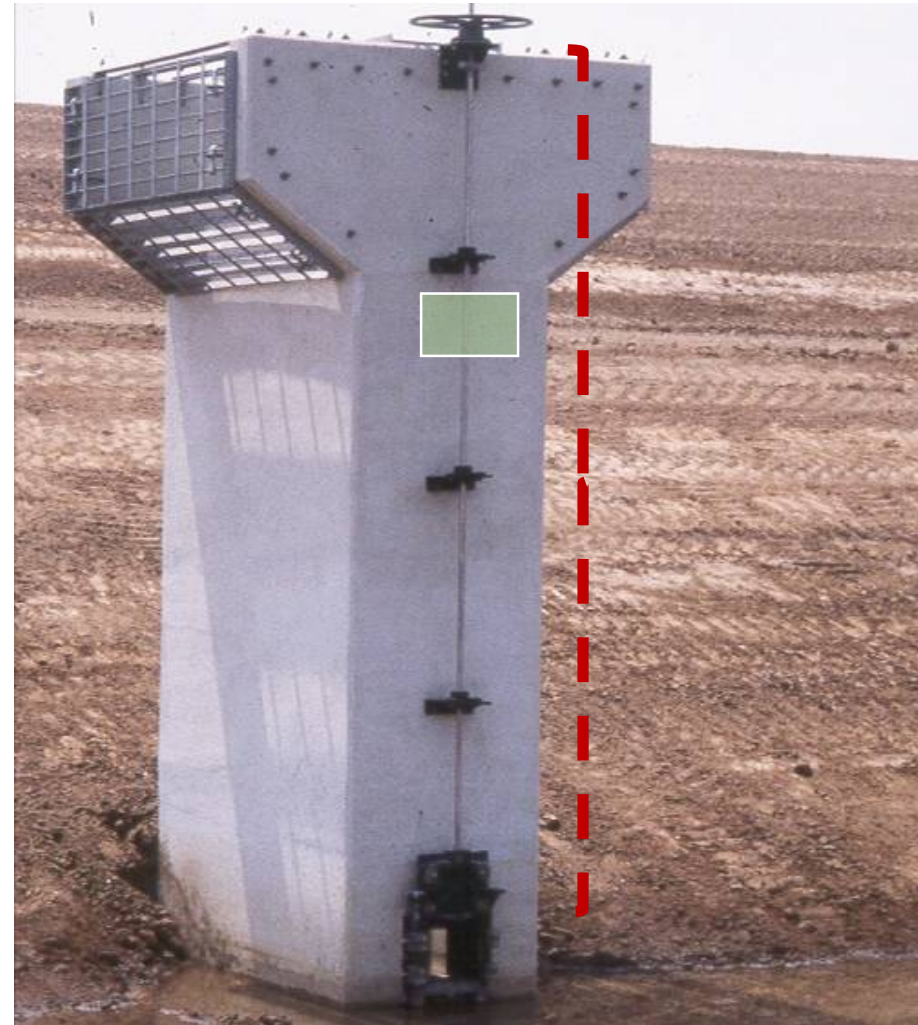




Principal Spillway
Inlet Riser



PS Riser – Drawdown Valve

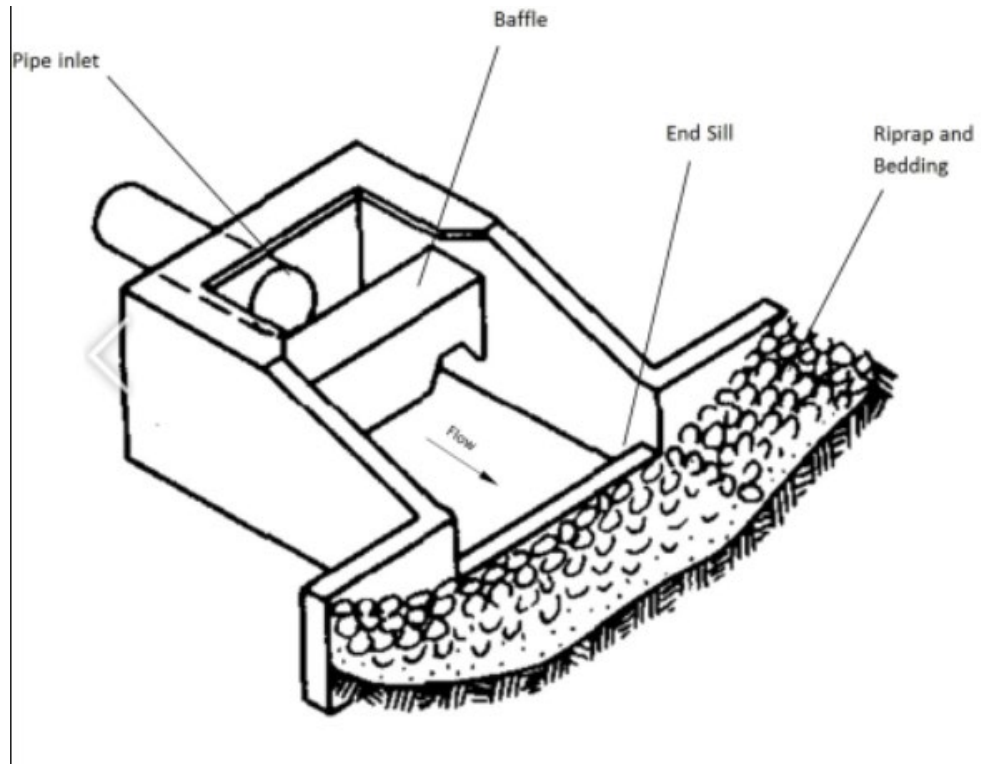




Principal Spillway Outlet Pipe



Stilling Basin or Plunge Pool



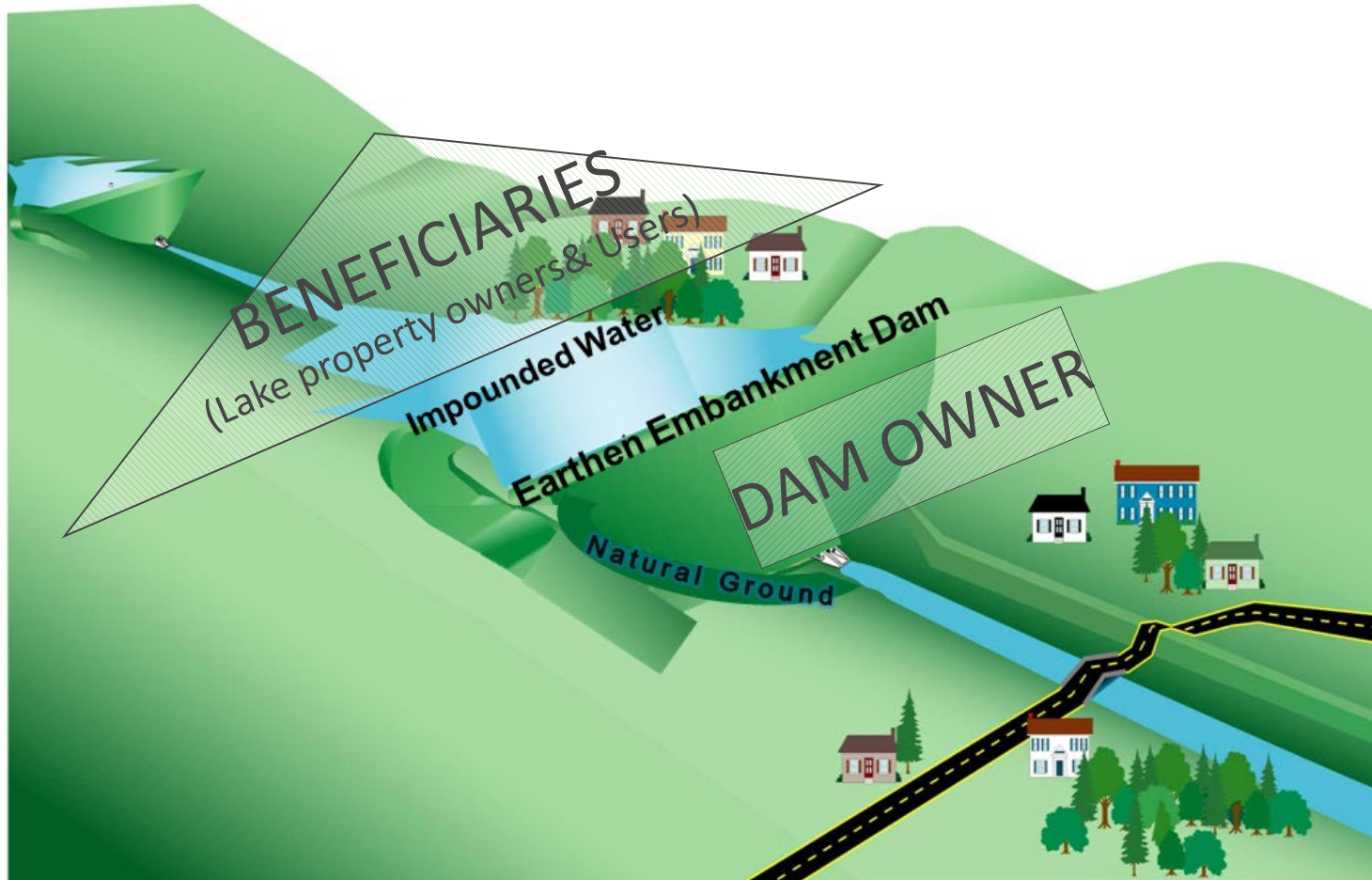
Principal Spillway Outlet Impact
Basin



Dam Safety

....and why we should care....

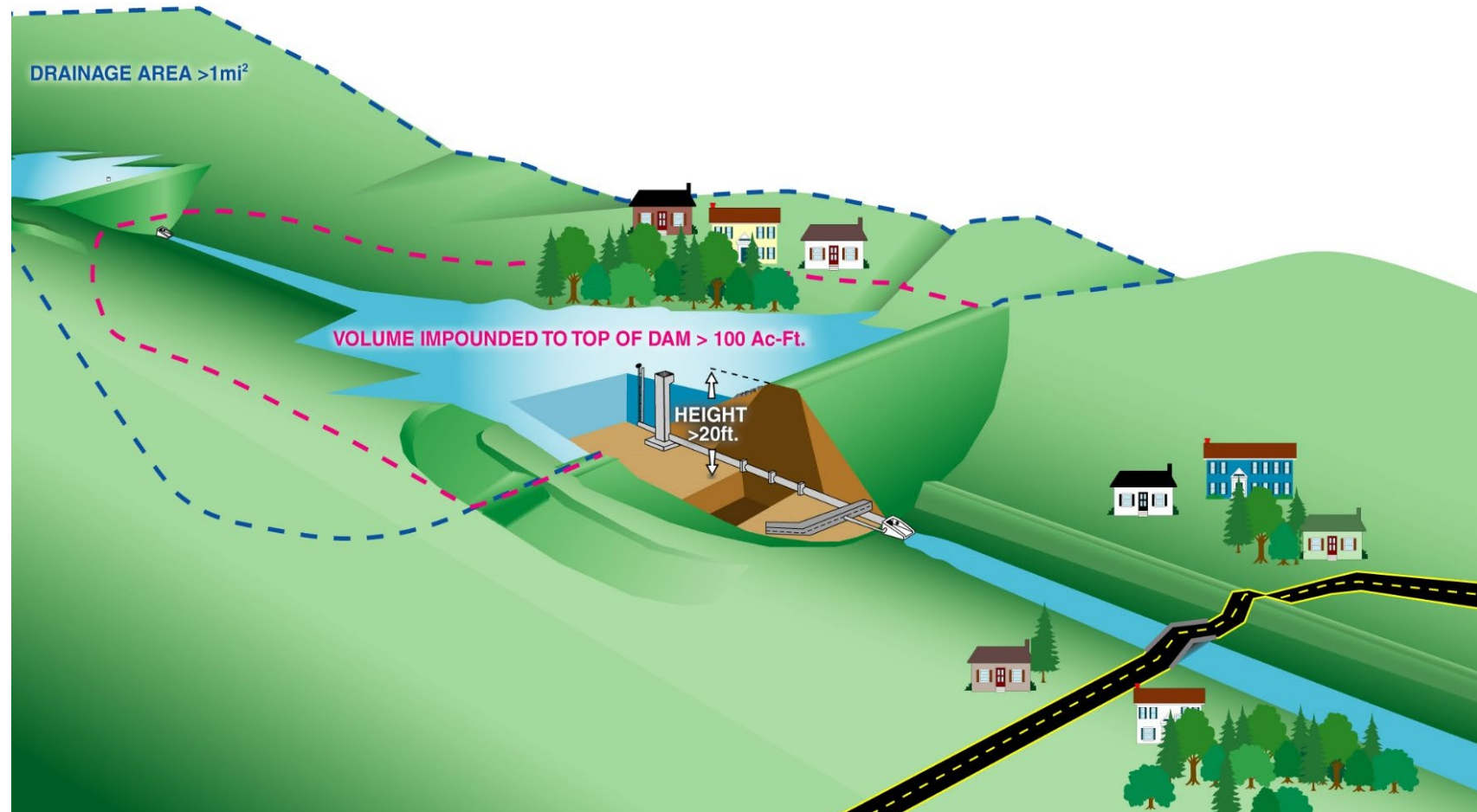
Main Purpose of a “Safety of Dam” Program (IC 14-27-7.5)



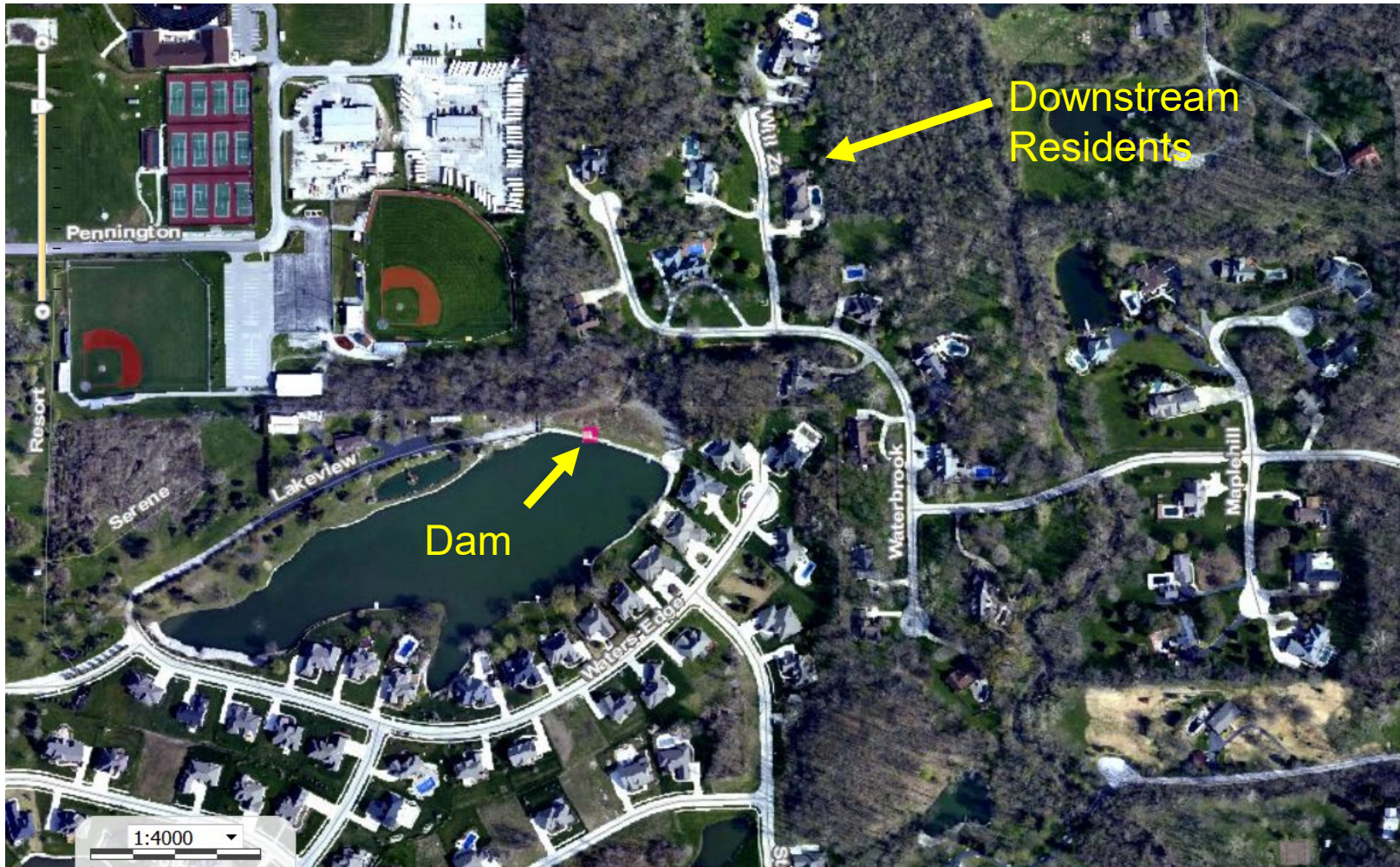
DOWNSTREAM PROPERTIES
AT RISK!!

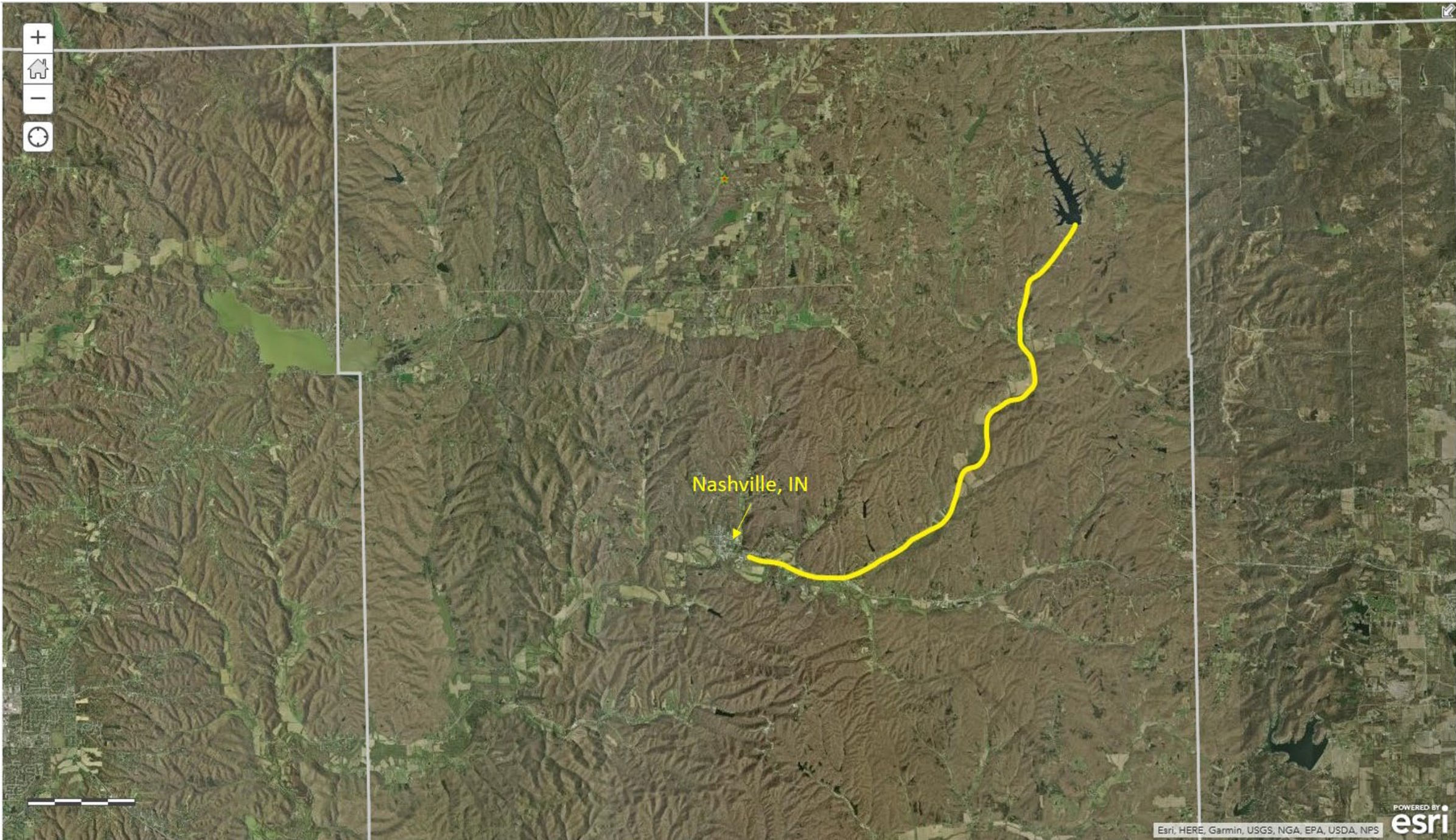


Not all dams are in a “Safety of Dam” Program



Properties Downstream of Dams





Nashville, IN

Notable Dam Incidents in the U.S.



A damaged spillway with eroded hillside is seen in an aerial photo taken over the Oroville Dam in Oroville, California, U.S. February 11, 2017. **California Department of Water Resources/William Croyle/Handout via Reuters**

Notable Dam Incidents in the U.S.

Johnstown, Pennsylvania
May 31, 1889

Failure of the South Fork Dam
caused an estimated \$17 million in
damages.

Fatalities: 2,209



- *National Weather Service*

Notable Dam Incidents in Indiana

Sylvan Lake Dam, Indiana
Constructed in 1839 for
canal system, 25 ft. high

- Failed 1839 during construction
- Failed 1844 by breach of dam, 3 lives lost
- Failed 1855 water level in lake rose 11 feet above previous levels
- Failure narrowly averted 1877 by emergency placement of fill on embankment
- Failure in progress in 1993, emergency lake drawdown



Notable Dam Failure in Indiana



Notable Incidents and Near Failures in Indiana

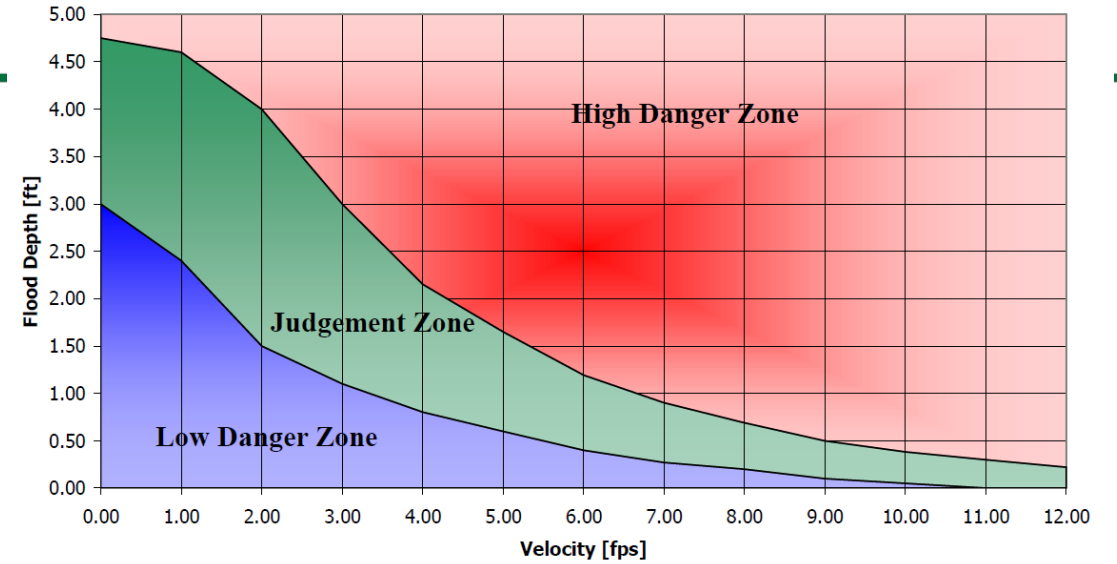


Does not include a “Safety **at** Dam” Program

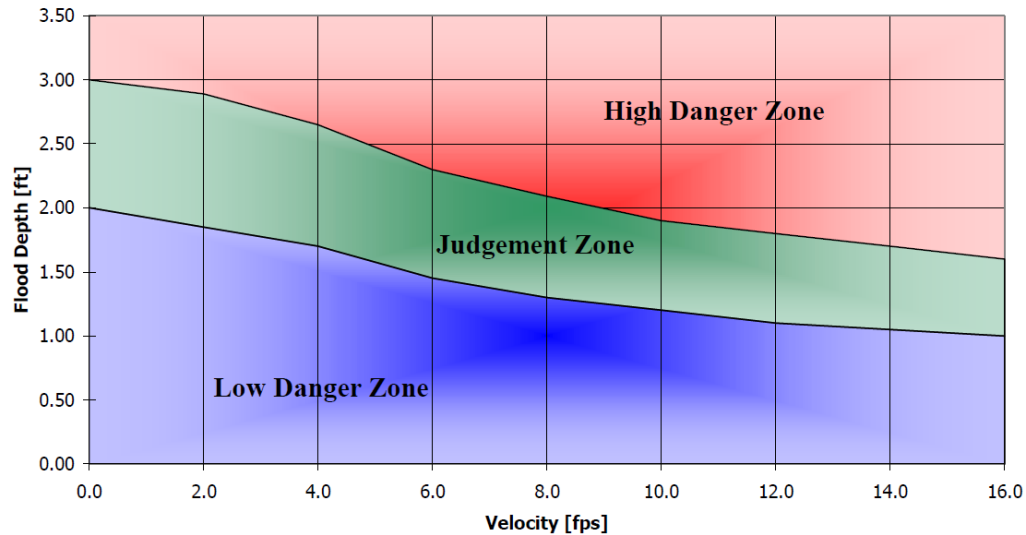


Danger Levels?

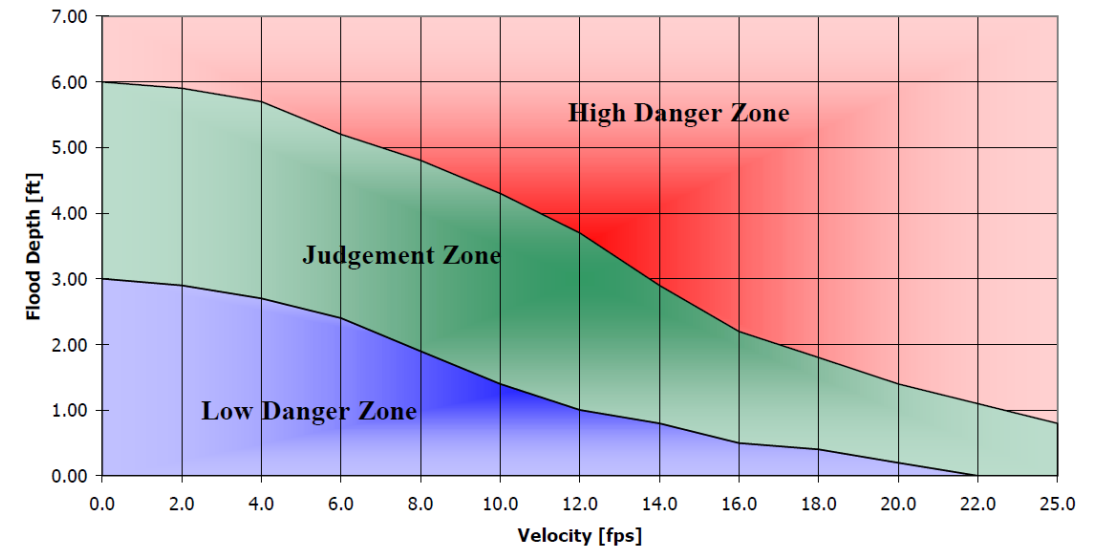
Flood Danger for Adults



Flood Danger for Cars



Flood Danger for Houses



Danger Levels?



The DNR determines the hazard classification for each jurisdictional dam. Hazard Classifications are separated into three categories:

- High
- Significant
- Low

The classification is determined based on potential damage to downstream property.

IC 14-27-7.5-8 Powers and duties of department; hazard classifications

(b) The department shall establish by rule the criteria for assigning a hazard classification to a structure that is based on the potential consequences resulting from the uncontrolled release of the structure's contents due to a failure of the structure. The hazard classification system must include the following classes of structures:

(1) High hazard: A structure the failure of which may cause the loss of life and serious damage to homes, industrial and commercial buildings, public utilities, major highways, or railroads.

(2) Significant hazard: A structure the failure of which may damage isolated homes and highways, or cause the temporary interruption of public utility services.

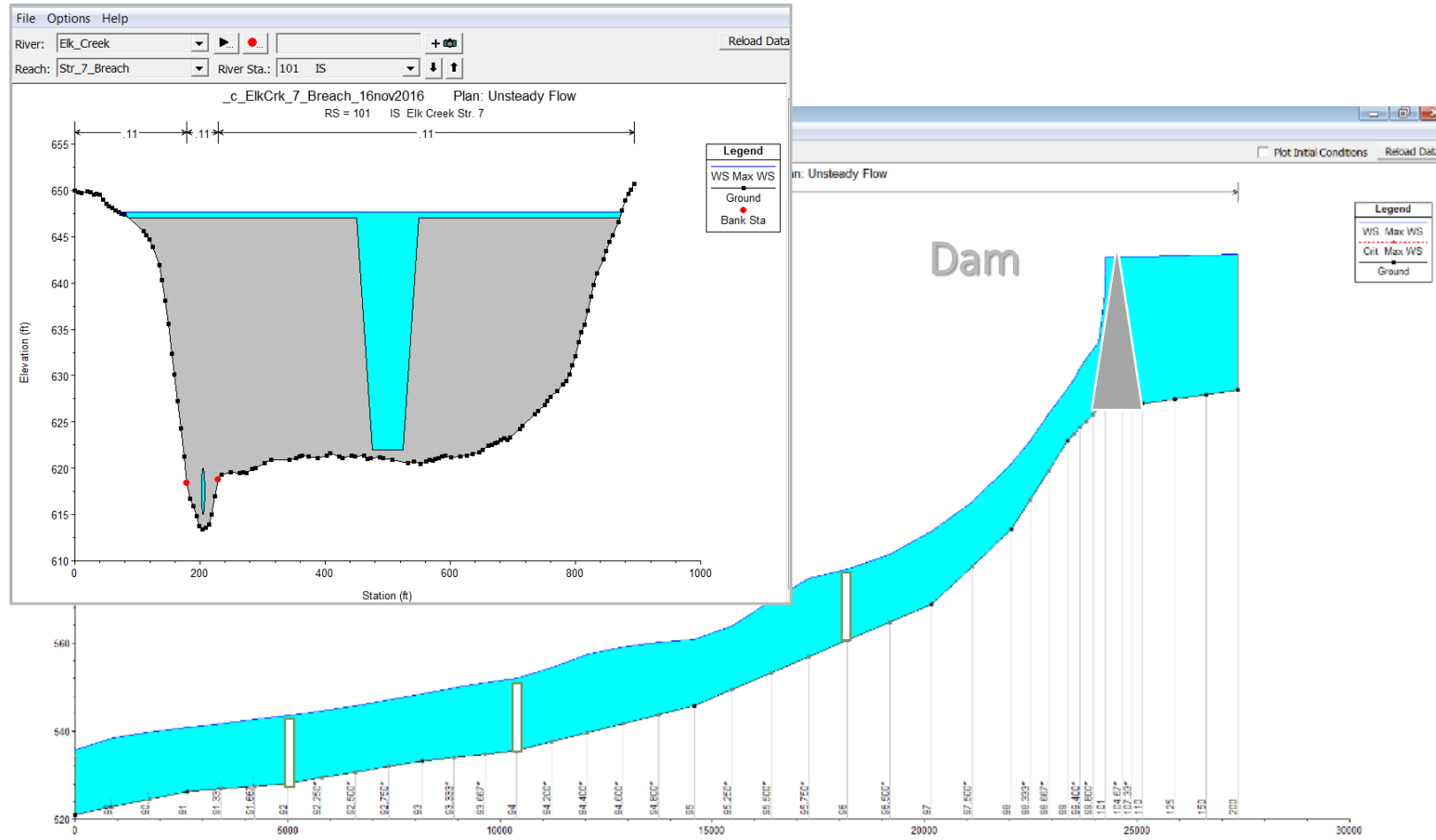
(3) Low hazard: A structure the failure of which may damage farm buildings, agricultural land, or local roads.

NRCS Hazard Classification (NEM Part 520.21)

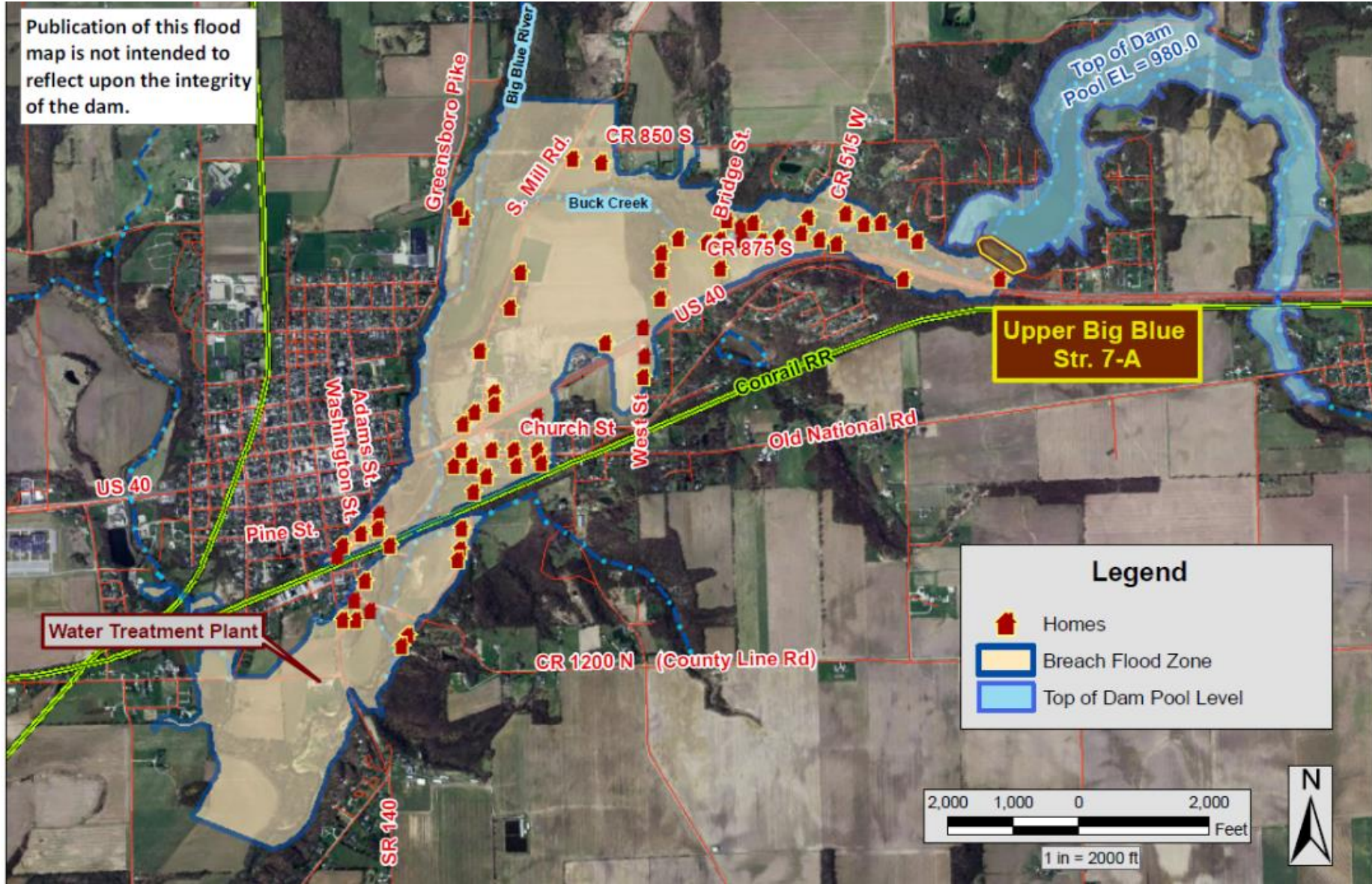
Dams are classified according to the potential hazard to life and property if the dam should suddenly breach or fail. Existing and future downstream development, including controls for future development, must be considered when classifying the dam.

- (1) **Low Hazard.**—Dams in rural or agricultural areas where failure may damage farm buildings, agricultural land, or township and country roads.
- (2) **Significant Hazard.**—Dams in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, or minor railroads or interrupt service of relatively important public utilities.
- (3) **High Hazard.**—Dams where failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.

Breach Inundation Mapping



Breach Inundation Mapping

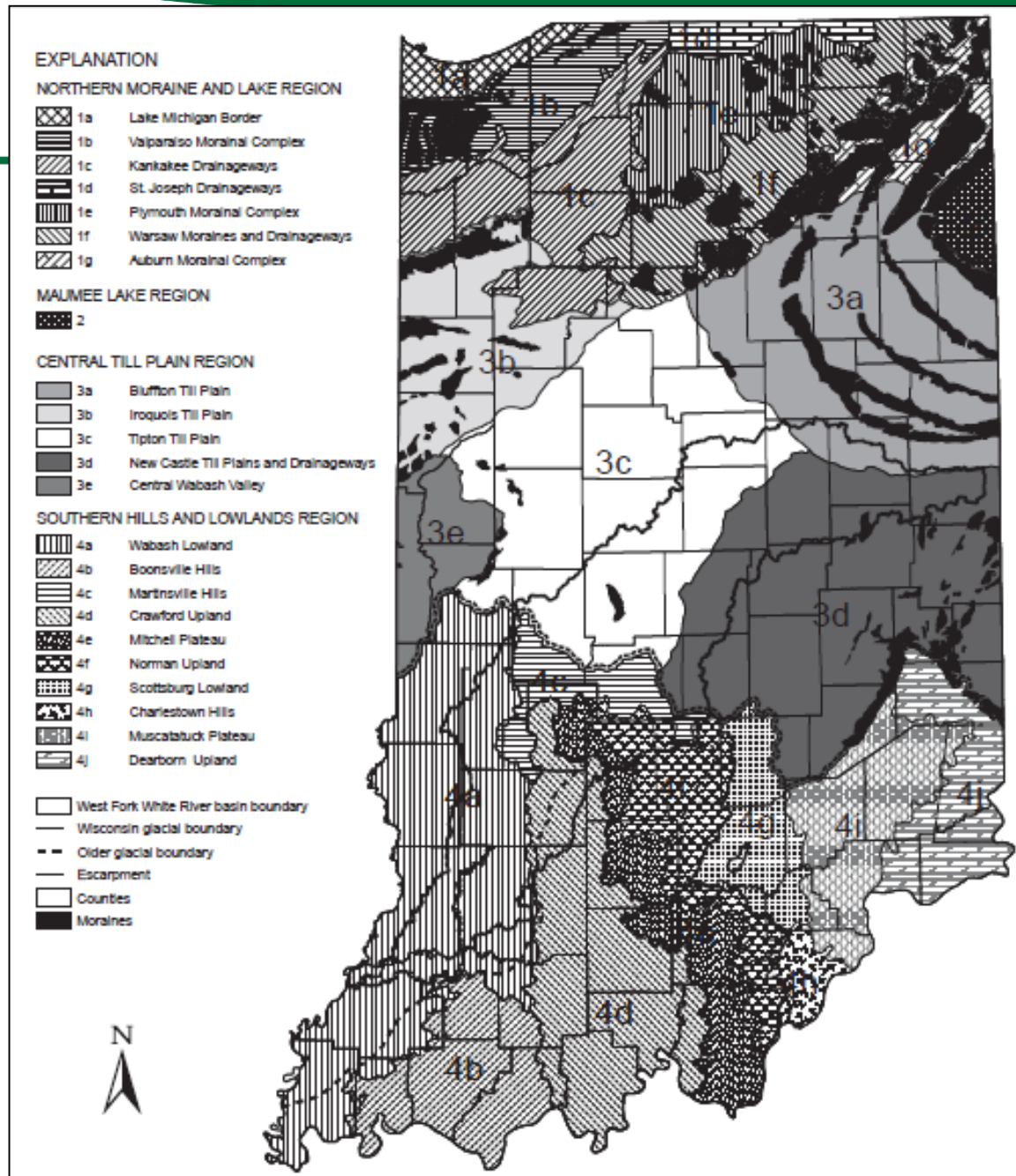
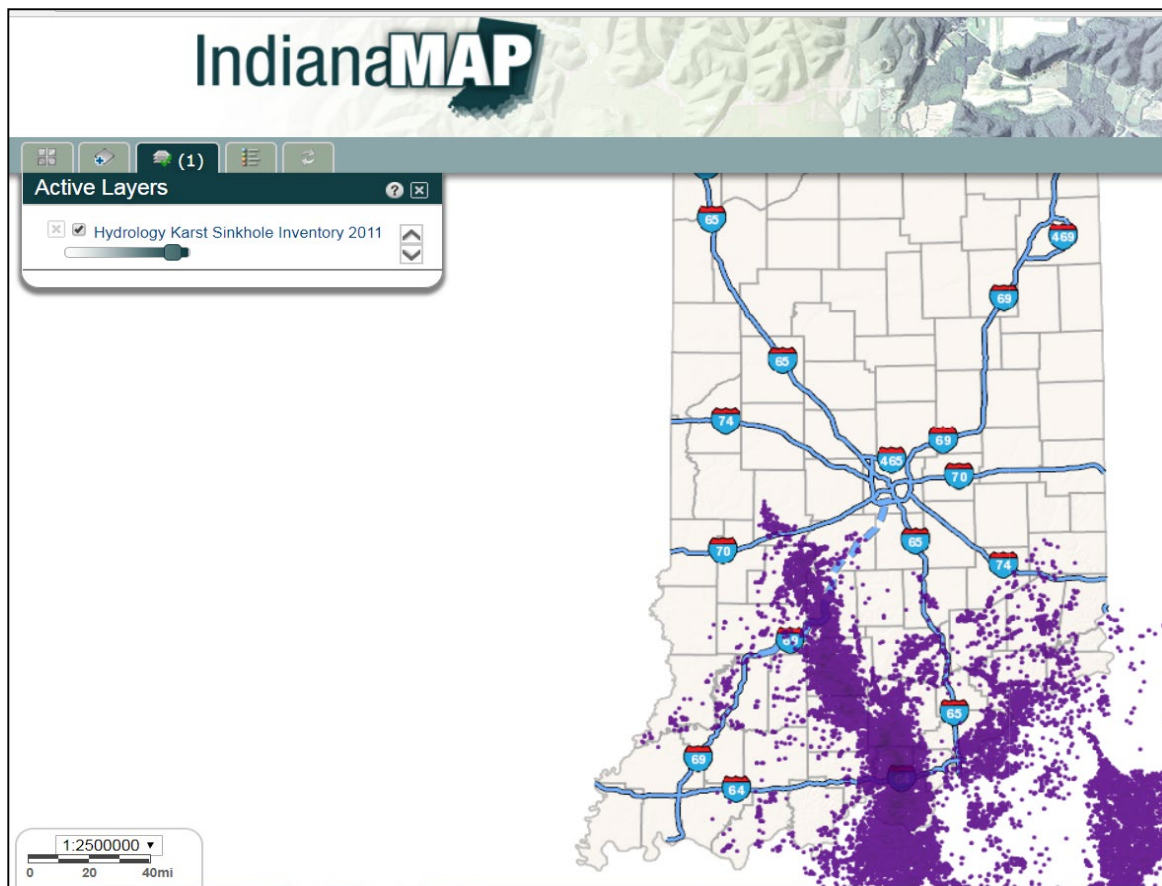


Purpose of Breach Analysis

- **Dam Classification (NEM 520.23)**
- **Emergency Action Plans (NEM 520.27)**
- **Potential Impact Area Mapping (NEM 520.28)**



LOCATION, LOCATION, LOCATION



Spillway Capacity

- Watershed Runoff
- Ratio of Watershed
to Lake Pool Surface Area



**INVESTIGATE,
TEST,
ANALYZE,
DESIGN**

WARNING!

Design options will vary
in service life,
maintenance needs,
repair frequency, risk
and performance



Limit Overtopping...

Design Criteria for specific rain events

→ 50% PMP

→ Full PMP
storm event



Roller Compacted Concrete (RCC) Spillway



Rehabilitation for a Dam

Labyrinth Weir Spillway



Sandy Creek 15
An aerial view of completed spillway

Labyrinth Weir Spillway



Koontz Lake, Starke Co. , IN

Cheap “Design” vs. Adequate Design



CONSTRUCT PER PLANS



**MAINTAIN
INDEFINITELY**

WARNING!

Lack of proper
maintenance & repair will
compromise the safety of a
dam and will result in a
major reconstruction
project

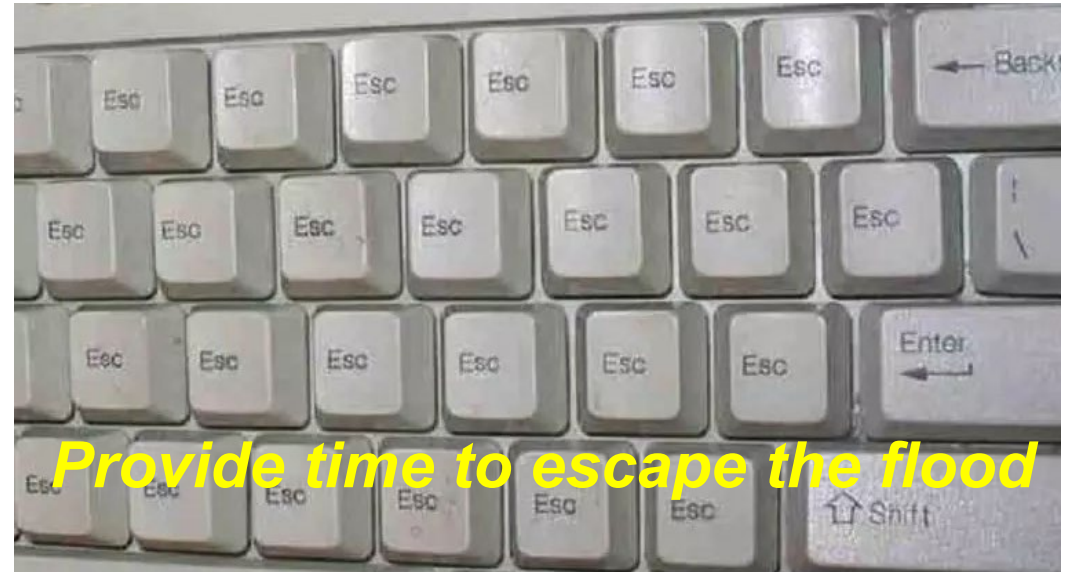


Emergency Action Plans

- Information derived from a breach analysis is used by sponsors/local emergency personnel in the event of a sudden dam failure.
 - projected downstream water levels
 - time from failure to peak conditions
- Required by NRCS for all Class C dams

Q: What is an emergency action plan?

A: it includes the projected downstream flood levels and travel times of a flood wave. This provides important information for local emergency workers to plan an evacuation in the event of an emergency.



National O&M Manual, Part 500, Subpart F, Emergency Action Plan

- *“...outlines procedures to minimize risks to life and property when the integrity of a dam or similar structure may be in jeopardy. The EAP shall consider all potential emergency situations, both natural and manmade, and shall identify appropriate responses.” (NO&M 500.5(A))*
- *For new or rehabilitated high hazard dams (and other structures as required by State and local regulations) designed with NRCS assistance an EAP shall be prepared prior to construction. (NO&M 500.5(B))*

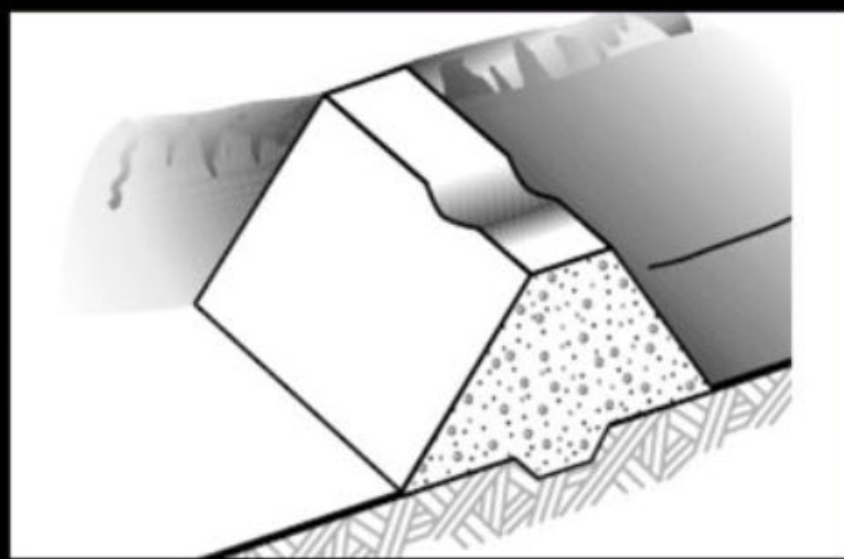
Might Be a Problem



Vigilance of Operation & Maintenance

- Know your dam & spillway system
- Walk it after storm events
- Record, Report, and Communicate
- Reach out for help when needed

LOW AREA IN THE CREST OF A DAM—a depression on the top of a dam. Low areas are caused by uneven settling of the embankment or foundation, internal eroding of the embankment, spreading of the foundation, or improper grading of a road on the crest after construction.



Click on the images to view larger versions.

Low areas can reduce the available freeboard, the distance between the normal reservoir elevation and the crest of the dam. Reduced freeboard may allow water to spill over the top of the dam. Overtopping can erode the downstream face and toe of the dam and an eventual dam failure.

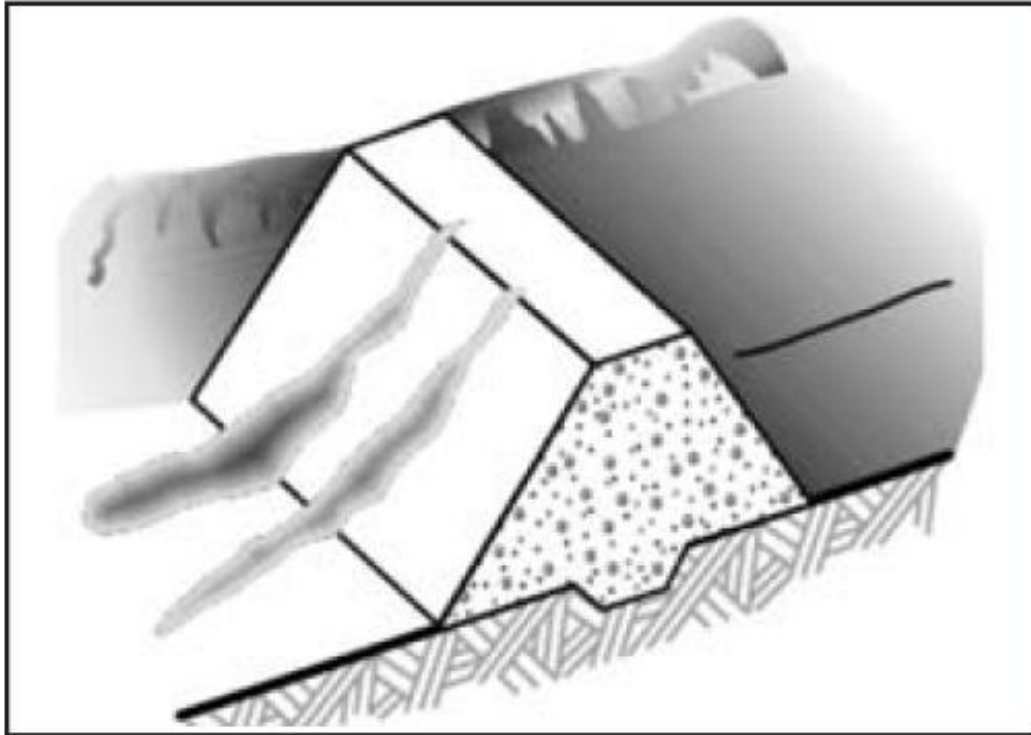
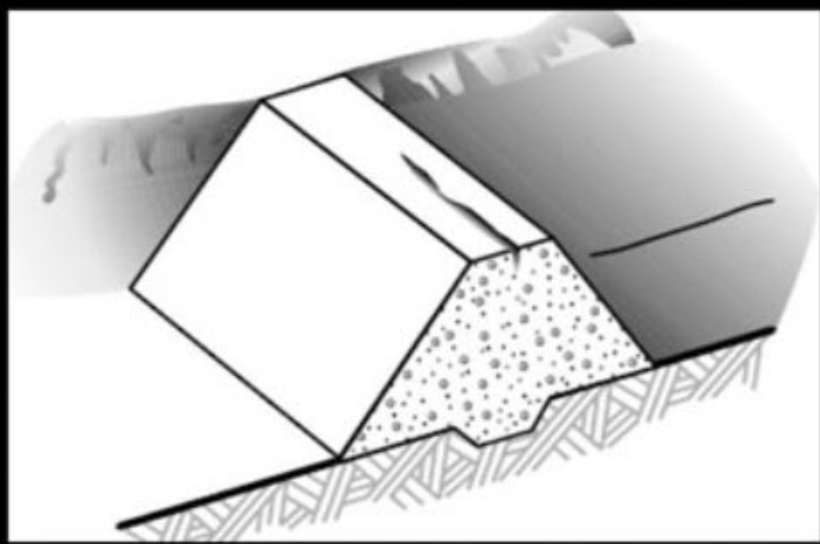


Figure 11—Erosion.



Figure 12—Erosion on the downstream face of a dam.

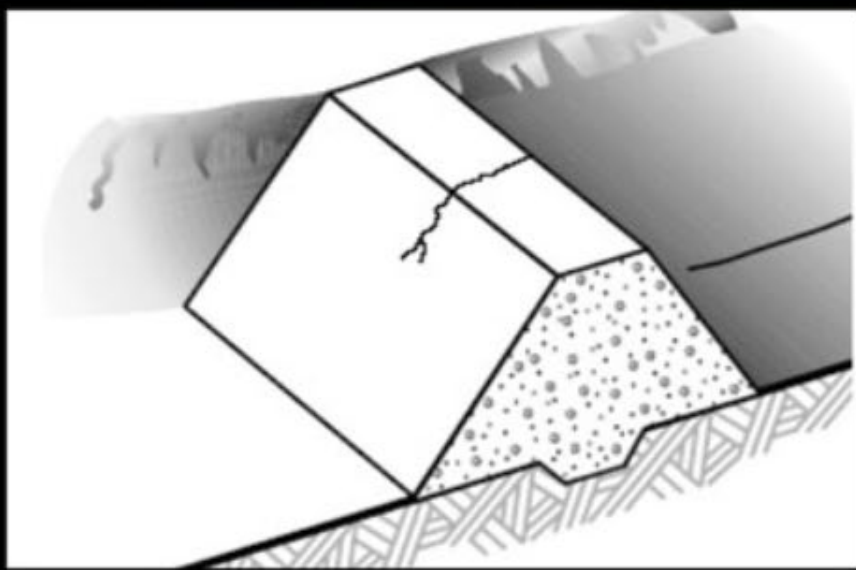
LONGITUDINAL CRACKING—where the embankment of a dam has separated lengthwise. Longitudinal cracking is caused by uneven settlement between the adjacent sections or zones of the embankment. It can also be caused by a foundation failure or embankment slide.



Click on the images to view larger versions.

If longitudinal cracking is not corrected, the weakened area may cause additional movement, further deformation, or even failure. In other instances, water may enter the crack, saturate the surrounding area, and lead to a localized failure.

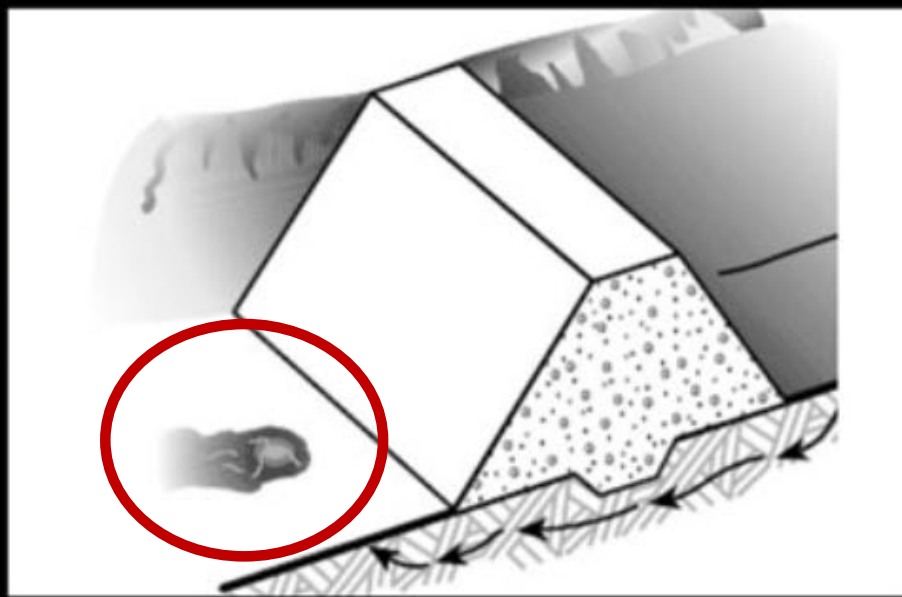
TRANSVERSE CRACKING—where the embankment of a dam has separated along a line perpendicular to the crest of the dam. This kind of cracking can be caused by uneven movement between adjacent zones within the embankment. It can also be caused by structural stress or instability.



Click on the images to view larger versions.

If transverse cracking is not corrected, the weakened area may cause additional movement, further deformation, or even failure. In other instances, water may enter the crack and saturate the surrounding area leading to a localized failure.

SEEPAGE WATER EXITING AS A BOIL IN THE FOUNDATION—when water bubbles out from underneath the foundation of a dam. Boils may be caused by a sand or gravel layer in the foundation that provides a pathway for water to flow.



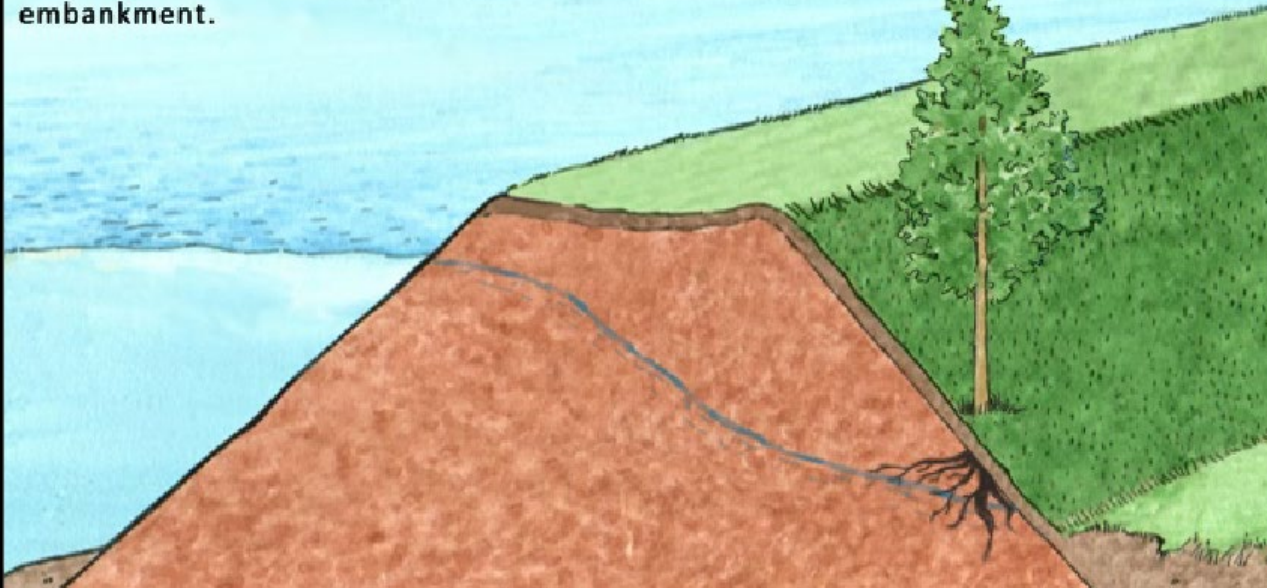
Click on the images to view larger versions.

Unfixed boils can cause the foundation to erode and lead to a dam failure.

Dam Failure Caused by a Tree

0 1 2 3 4 5 6

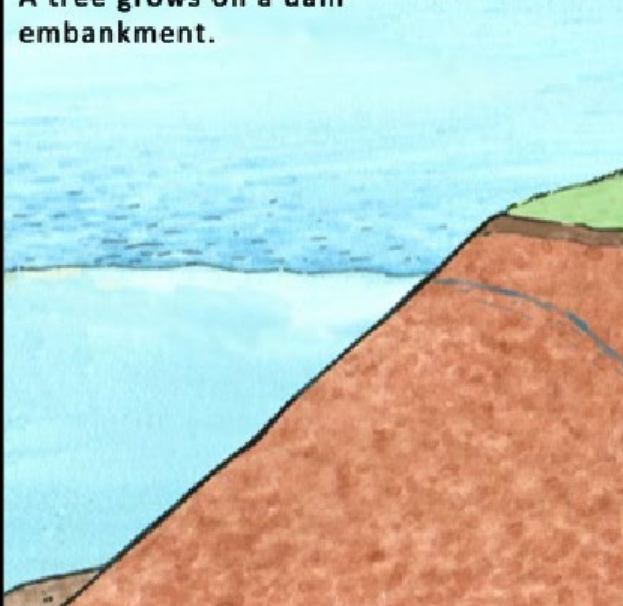
A tree grows on a dam
embankment.



Dam Failure Caused by a Tree

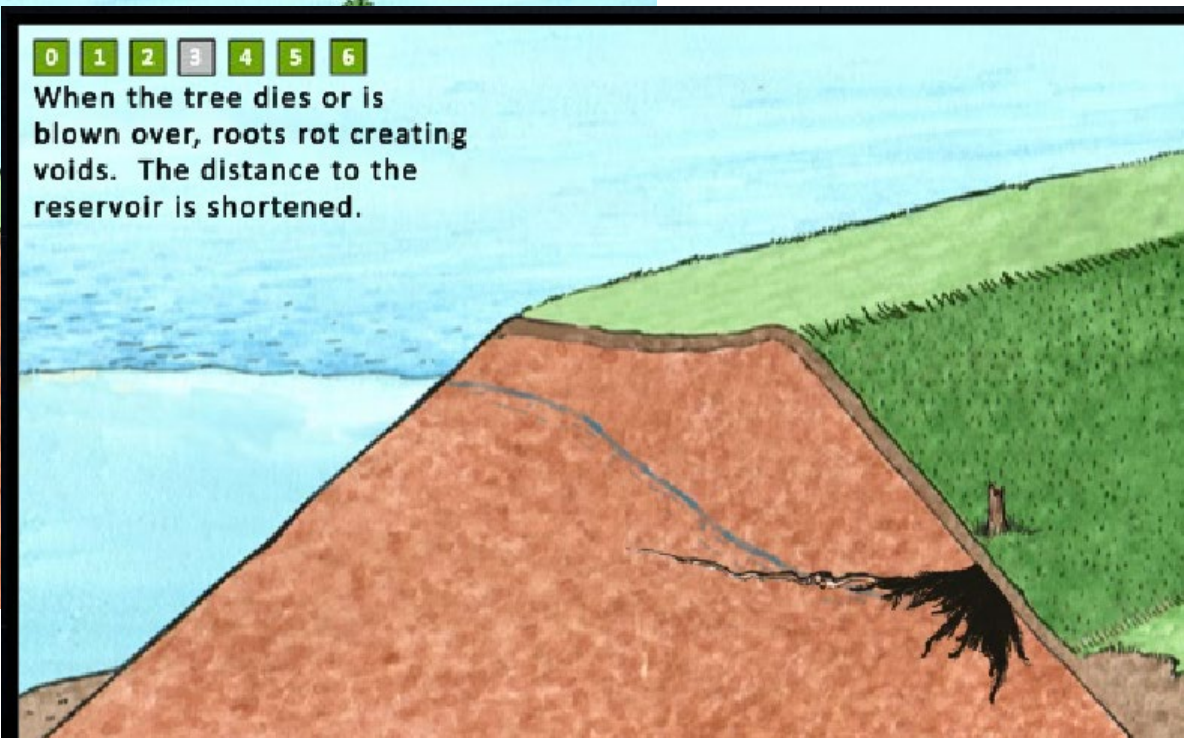
0 1 2 3 4 5 6

A tree grows on a dam embankment.



0 1 2 3 4 5 6

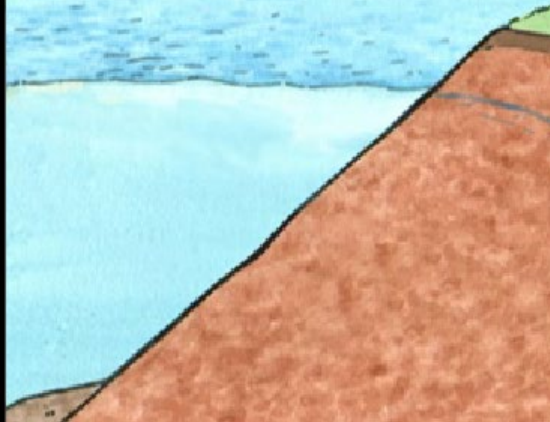
When the tree dies or is blown over, roots rot creating voids. The distance to the reservoir is shortened.



Dam Failure Caused by a Tree

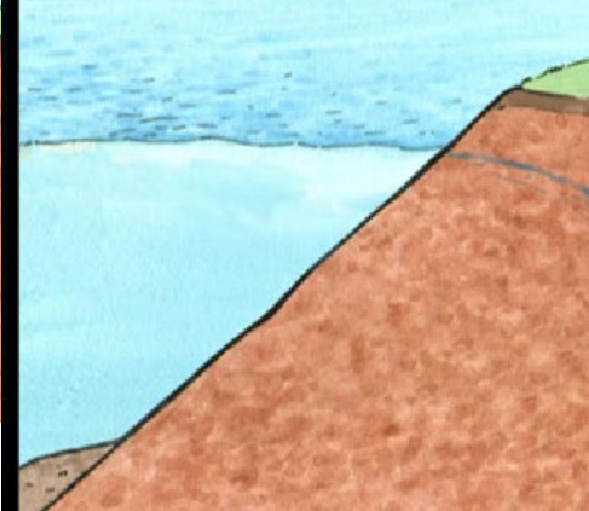
0 1 2 3 4 5 6

A tree grows on a dam embankment.



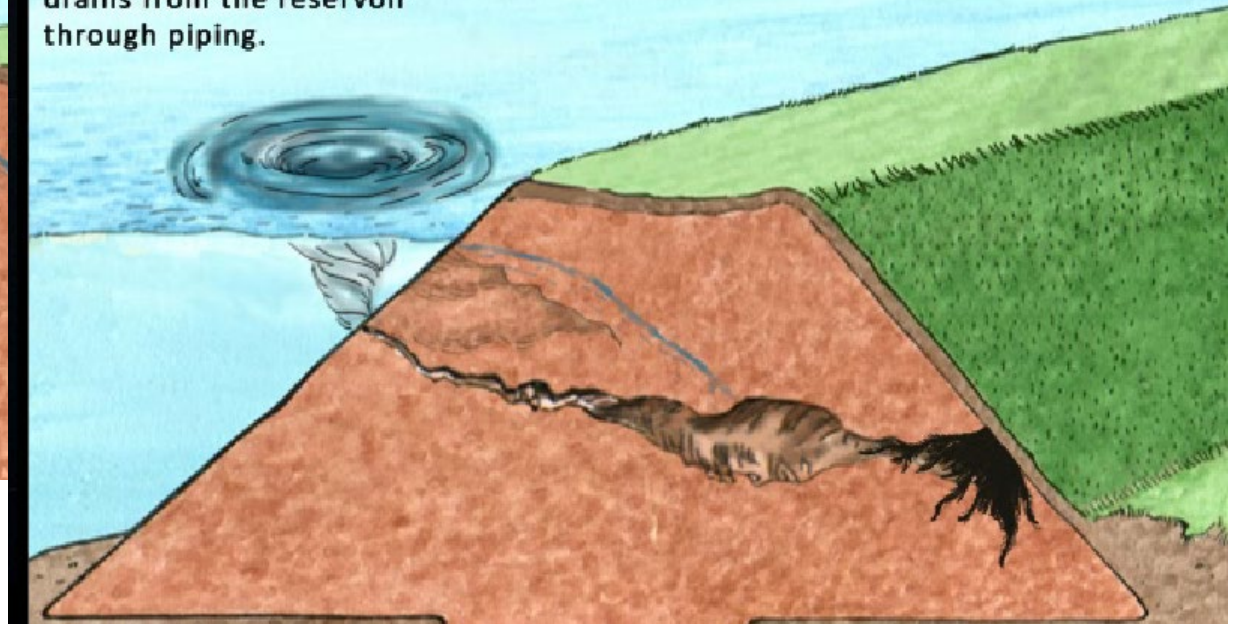
0 1 2 3 4 5 6

When the tree dies or is blown over, roots rot creating voids. The distance to the reservoir is shortened.



0 1 2 3 4 5 6

A whirlpool forms as water drains from the reservoir through piping.



Concrete:

- Cracking
- Spalling
- Exposed rebar



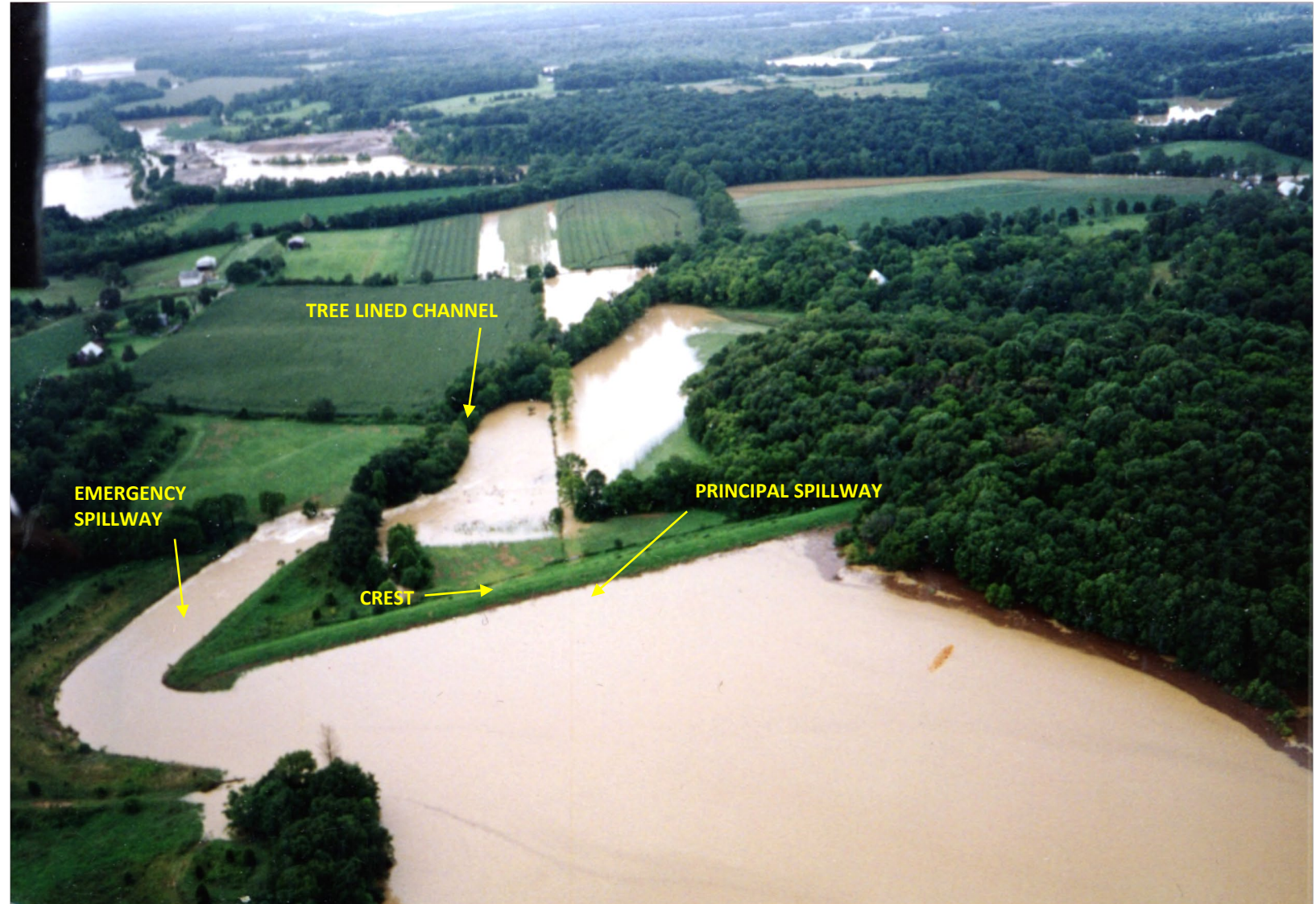
Principal Spillway Inlet



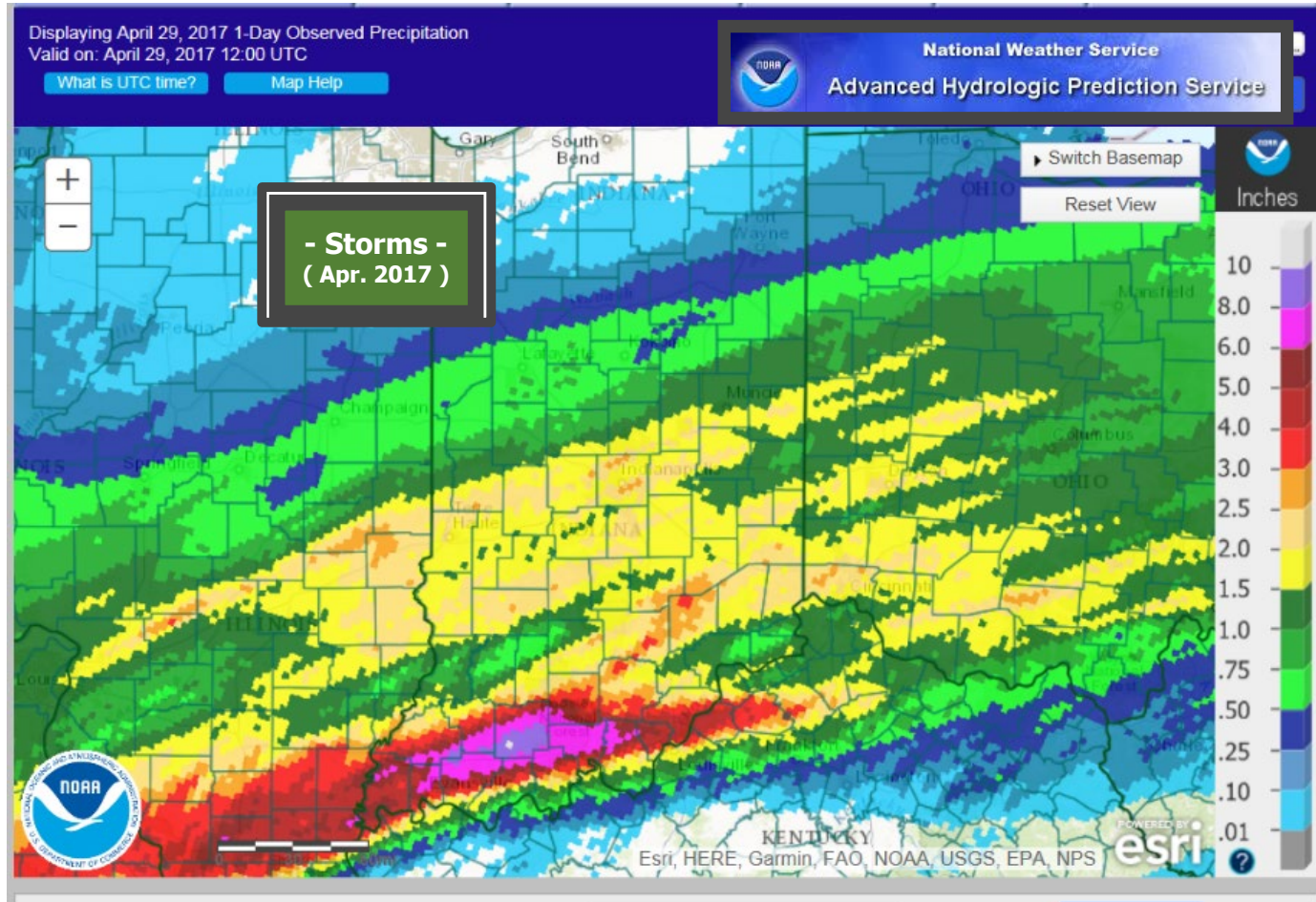


Might
Be a
Problem

Midterm Exam!



<http://water.weather.gov/precip/>













Dam Inspection Requirements

- High Hazard Structures:
 - Licensed Professional Engineer makes inspection every 2 years and submits report to DNR
 - If repairs or alterations are needed, the owner performs the maintenance or repair activity
- Significant Hazard Structures:
 - The DNR (or private engineer) inspects every 3 years
 - The DNR charges the owner \$200 for the inspection
- Low Hazard Structures:
 - The DNR (or private engineer) inspects every 5 years
 - The DNR charges the owner \$100 for the inspection



2018

Lincoln Lake Dam
Spencer County
Engineering Inspection Report
State Identification # 74-8



1 - Spillway, Downstream Slope, and Moon Tree in October 2018

Dam Safety Office
Department of Natural Resources
- Division of Water
10/3/2018



EARTH DAM VISUAL INSPECTION REPORT

Select or Reset Form

Indiana Department of Natural Resources
Division of Water, Dam Safety Section
402 West Washington Street, Room W264
Indianapolis, Indiana 46204
Telephone: (317)232-4160 or toll free (within Indiana) 1-877-928-3755

Dam Name		Quart		Date of Inspection	
State Dam ID	Permit	County	Sec	T	R
Owners Name			Owner's Phone		
Address/Zip Code			Owner's E-mail Address		
Contact's Name		Contact's Phone		Spillway Width	
				Top Bot	
Hazard	Drainage Area MP	Surface Area AC	Height FT	Crest Length FT	Crest Width FT
					Inlet Below Crest FT
					Slope: Up Down
FIELD CONDITIONS OBSERVED			DRAWDOWN STRUCTURE		
Water Level - Below Dam Crest <input type="checkbox"/> FL <input checked="" type="checkbox"/> FT			<input type="checkbox"/> Yes <input type="checkbox"/> None		
Ground Moisture Condition: Dry <input type="checkbox"/> Wet <input type="checkbox"/> Snowcover <input type="checkbox"/> Other			Comment		
MONITORING <input type="checkbox"/> Yes <input type="checkbox"/> None <input type="checkbox"/>					
<input type="checkbox"/> Gage Rod <input type="checkbox"/> Piezometers <input type="checkbox"/> Seepage Weirs <input type="checkbox"/> Survey Monuments <input type="checkbox"/> Other <input type="checkbox"/> Comments					
NOTICE TO OWNERS: PLEASE READ BOTH SIDES OF THESE TWO PAGES AND FOLLOW RECOMMENDATIONS MADE HEREIN.					
This visual inspection notes the obvious surficial problems of your dam and appurtenant works. This is not a detailed engineering evaluation. There may be serious defects and/or design deficiencies with your dam that may render your dam unsafe during unusual conditions such as high pool levels and/or earthquake loading. Since you are liable for any property damage, injury or loss of life resulting from failure of your dam, you should consult with an engineer experienced in dam design about the current safety of your dam.					
OWNER INSPECTION: The owner (or owner's representative) should inspect this dam routinely under normal conditions and more frequently under unusual loading conditions.					
A	UPSTREAM SLOPE	PROBLEMS NOTED: <input type="checkbox"/> (A-1) None <input type="checkbox"/> (A-2) Riprap - Missing, Sparse, Displaced, Weathered <input type="checkbox"/> (A-3) Wave Erosion-with Scarp <input type="checkbox"/> (A-4) Cracks-with Displacement <input type="checkbox"/> (A-5) Sinkhole <input type="checkbox"/> (A-6) Appears Too Steep <input type="checkbox"/> (A-7) Depressions or Bulges			
	GOOD	<input type="checkbox"/> (A-8) Slides <input type="checkbox"/> (A-9) Animal Burrows <input type="checkbox"/> (A-10) Trees, Brush, Briars <input type="checkbox"/> (A-11) Other			
	ACCEPTABLE	Comments:			
	DEFICIENT				
	POOR				
B	CREST	PROBLEMS NOTED: <input type="checkbox"/> (B-1) None <input type="checkbox"/> (B-2) Ruts or Puddles <input type="checkbox"/> (B-3) Erosion <input type="checkbox"/> (B-4) Cracks with Displacement			
	GOOD	<input type="checkbox"/> (B-5) Sinkholes <input type="checkbox"/> (B-6) Not Wide Enough <input type="checkbox"/> (B-7) Low Area <input type="checkbox"/> (B-8) Misalignment <input type="checkbox"/> (B-9) Inadequate Surface Drainage			
	ACCEPTABLE	<input type="checkbox"/> (B-10) Trees, Brush, Briars <input type="checkbox"/> (B-11) Other			
	DEFICIENT	Comments:			
	POOR				
C	DOWNSTREAM SLOPE	PROBLEMS NOTED: <input type="checkbox"/> (C-1) None <input type="checkbox"/> (C-2) Livestock Damage <input type="checkbox"/> (C-3) Erosion or Gullies <input type="checkbox"/> (C-4) Cracks with Displacement <input type="checkbox"/> (C-5) Sinkholes <input type="checkbox"/> (C-6) Appears too Steep <input type="checkbox"/> (C-7) Depression or Bulges <input type="checkbox"/> (C-8) Slide			
	GOOD	<input type="checkbox"/> (C-9) Soft Areas <input type="checkbox"/> (C-10) Trees, Brush, Briars <input type="checkbox"/> (C-11) Animal Burrows <input type="checkbox"/> (C-12) Other			
	ACCEPTABLE	Comments:			
	DEFICIENT				
	POOR				
D	SEEPAGE	PROBLEMS NOTED: <input type="checkbox"/> (D-1) None <input type="checkbox"/> (D-2) Saturated Embankment Area <input type="checkbox"/> (D-3) Seepage Exits on Embankment <input type="checkbox"/> (D-4) Seepage Exits at Point Source <input type="checkbox"/> (D-5) Seepage Area at Toe <input type="checkbox"/> (D-6) Flow Adjacent to Outlet <input type="checkbox"/> (D-7) Seepage Clear/Muddy <input type="checkbox"/> (D-8) Flow Clear/Muddy <input type="checkbox"/> (D-9) Flow Clear/Obstructed			
	GOOD (NONE)	<input type="checkbox"/> (D-10) Other			
	ACCEPTABLE	Describe location of drains and indicate amount and quality of discharge.			
	DEFICIENT	Comments:			
	POOR				

If following box is checked, see additional comments added to Page 2 of 4.

Form

REPORT FOR LOW HAZARD IN-CHANNEL DAM, NOMINAL INSPECTION

(Primarily site observations made from the stream bank)

DAM NAME: _____ DATE: _____ TIME: _____ I.D. # _____

INSPECTION WEATHER CONDITIONS: _____

OBSERVED FLOW OVER THE WEIR: None _____ Slight _____ Moderate _____ Substantial _____ (Attach Photo)

WAS DEBRIS CAUGHT ON THE DAM? YES _____ NO _____ (if yes, Attach Photo)

NEAREST TOWN OR LANDMARK: _____ COUNTY: _____

_____/14, ____/14, ____/14, SEC. _____ T. _____ N/S, R. _____ E/W UTMN _____ UTME _____

QUADRANGLE MAP _____ STREAM _____

ACCESS NOTES: _____

DID INSPECTOR OBSERVE ANY SIGNAGE AT THE DAM? YES _____ NOT OBSERVED _____

APPARENT OWNER'S NAME(S): _____ TELEPHONE _____

ADDRESS: _____

OWNERSHIP HISTORY: _____

DAM HISTORY HIGHLIGHTS: _____

DESCRIPTION OF STRUCTURE: (All dimensions are in feet and taken from plans, aerial photos, or are estimated)

TOTAL DAM LENGTH: _____ OVERFLOW LENGTH: _____ DAM HEIGHT: _____ TOP WIDTH: _____

LIST APPURTENANT WORKS: _____

DESCRIPTION OF ABUTMENTS: _____

DESCRIPTION OF FOUNDATION/ABUTMENT MATERIALS: _____

CONDITION OF OVERFLOW SECTION: _____

CONDITION OF ABUTMENTS: _____

in channel form_20180125 Page 1 of 2

Dam Violations

Violations occur when there is a failure to meet the inspection requirements, or a failure to maintain a dam in a safe state.

The DNR contacts owners of dams in writing when a violation is found.

Depending on the severity of the violation, the owner may receive a warning letter or a formal Notice of Violation.

IC 14-27-7.5-11

Notice of violation

If the department finds that a structure is:

- (1) not sufficiently strong;
- (2) not maintained in a good and sufficient state of repair or operating condition;
- (3) not designed to remain safe during infrequent loading events; or
- (4) unsafe and dangerous to life and property;

the department may issue a notice of violation under IC 14-25.5-2.

As added by P.L.148-2002, SEC.15. Amended by P.L.71-2004, SEC.14.

IC 14-27-7.5-13 Violations

An owner who knowingly fails to effect the maintenance, alteration, repair, reconstruction, change in construction or location, or removal within the time limit set forth in the notice of violation of the department under:

- (1) section 11 of this chapter; or
- (2) IC 13-2-20-4 (before its repeal);

commits a Class B infraction. Every day of failure constitutes a separate infraction.

As added by P.L.148-2002, SEC.15. Amended by P.L.71-2004, SEC.15.

Notices of Violation

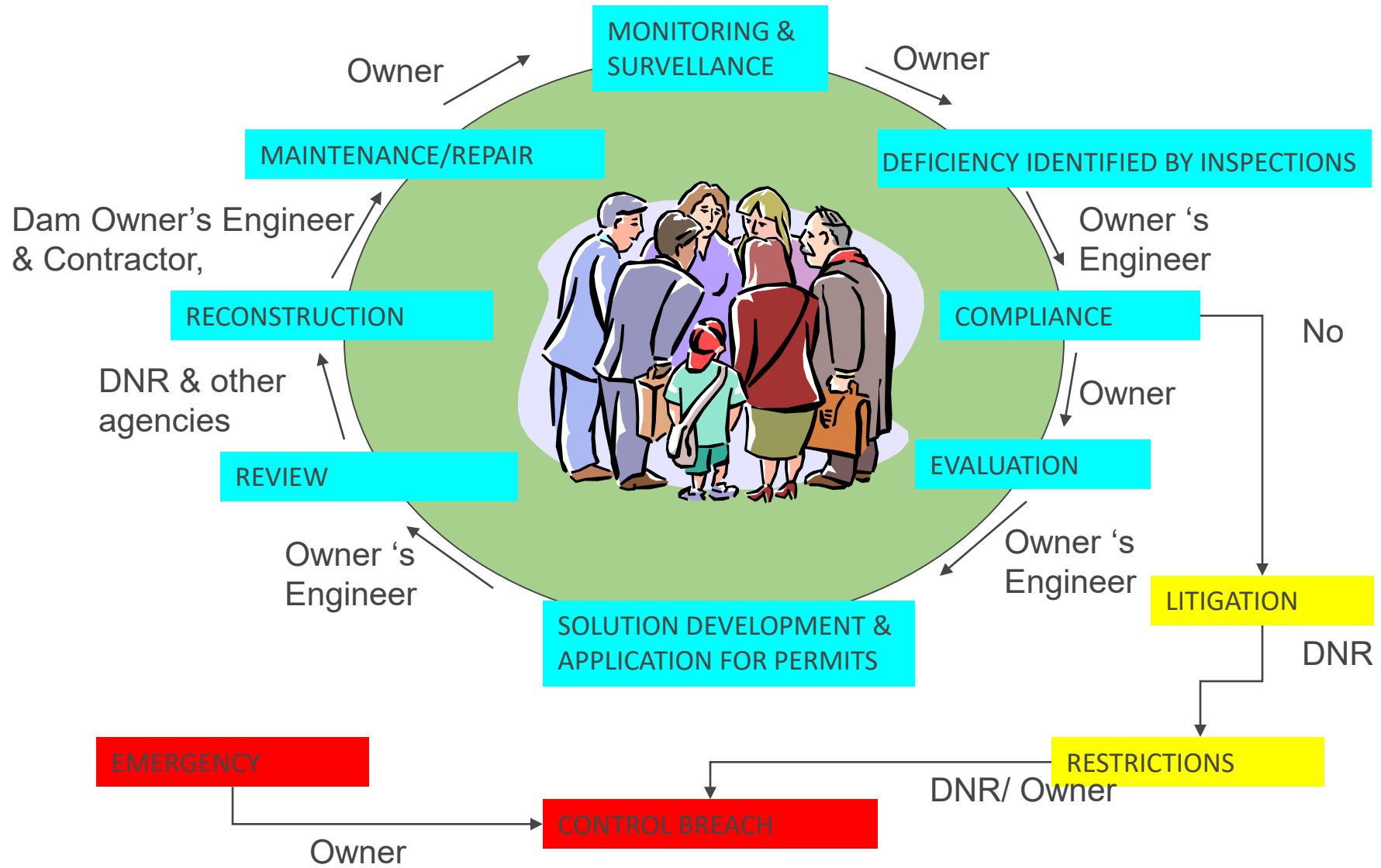
Notices of Violation (NOV) are effective 30 days after receipt of the notice. If a NOV is not appealed, the violation file is referred to the Attorney General's office for filing in the county court to enforce the NOV.

If a NOV is appealed, the case is brought before an administrative law judge.

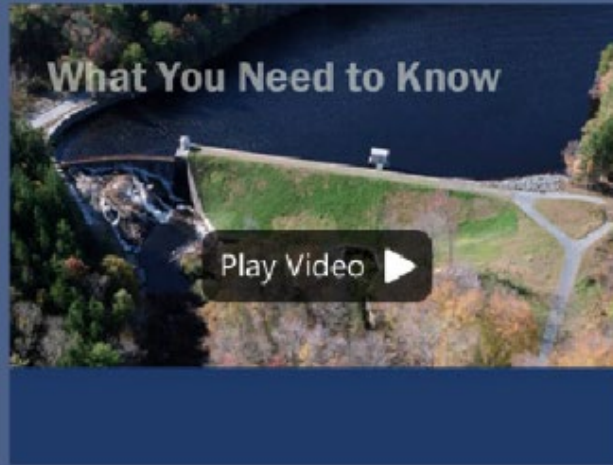
Either path typically leads to years of litigation and thousands of dollars.

It's always best to work with us and respond to our letters and NOV's!

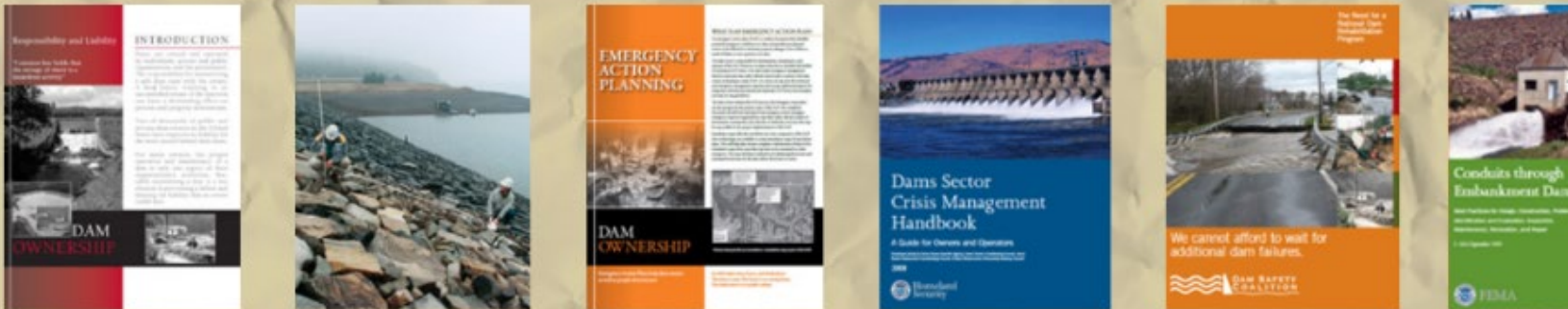
The Ongoing Dam Safety Cycle



RESPONSIBLE DAM OWNERSHIP



INFORMATION, GUIDELINES & TOOLS



<https://damsafety.org/dam-owners/operation-maintenance-and-inspection>



Association of State Dam Safety Officials



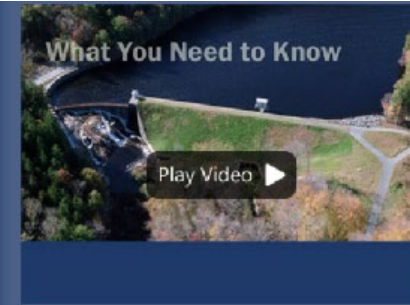
Association of State Dam Safety Officials

<https://damsafety.org/dam-owners/operation-maintenance-and-inspection>



Indiana Association for
Floodplain and Stormwater Management
Promoting sustainable floodplain and stormwater management

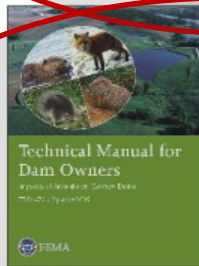
RESPONSIBLE DAM OWNERSHIP



INFORMATION, GUIDELINES & TOOLS



Pocket Safety Guide for Dams and Impoundments (FEMA National Dam Safety Program)



Impacts of Animals on Earthen Dams (FEMA National Dam Safety Program)

www.in.gov/dnr/water/

The screenshot shows the Indiana Department of Natural Resources (DNR) website. The top navigation bar includes links for IN.gov, DNR, Calendar, Inn Reservations, State Park Permits, Hunting/Fishing License, and Camping Reservations. A search bar is located on the right. Below the navigation bar, there are social media icons and dropdown menus for Online Services, I Want To, and FAQs. The main content area is titled 'Dams & Levees' and is divided into two sections: 'Dams' and 'Levees'. The 'Dams' section contains four links: Indiana Dam Safety Inspection Manual, General Guidelines for New Dams & Improvements to Existing Dams in Indiana, IC 14-27-7.5 Regulation of Dams, 312 IAC Article 10.5 Regulation of Dams, and Incident and Emergency Action Plans. The 'Levees' section contains one link: IC 14-27-7 Dams, Dikes and Levees; Regulation Act. A left sidebar menu lists various categories, with 'Dams & Levees' highlighted and circled in green. A green arrow points to this link from the left side of the image.

IN.gov **DNR** Indiana Department of Natural Resources

Calendar Inn Reservations State Park Permits Hunting/Fishing License Camping Reservations

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Related Links

WATER / DAMS & LEVEES

Dams & Levees

Dams

- [Indiana Dam Safety Inspection Manual](#)
- [General Guidelines for New Dams & Improvements to Existing Dams in Indiana](#)
- [IC 14-27-7.5 Regulation of Dams](#)
- [312 IAC Article 10.5 Regulation of Dams](#)
- [Incident and Emergency Action Plans](#)

Levees

- [IC 14-27-7 Dams, Dikes and Levees; Regulation Act](#)

Useful links

- [Association of Dam Safety Officials](#)

Questions?

