Detailed Inspection Training for Consulting Engineers

Joshua Bomar, PE Kermit Applegate, PE Vanessa Rios, EIT Patterson Gambill, PE Ezzat Elalfy, PhD

February 2026

CDM Smith

Agenda

1. Detailed Inspections Overview
2. South Carolina Dams
3. Detailed Inspection Process
4. Special Considerations for South Carolina
5. Best Practices and Lessons Learned
6. Conclusion
7. Resources

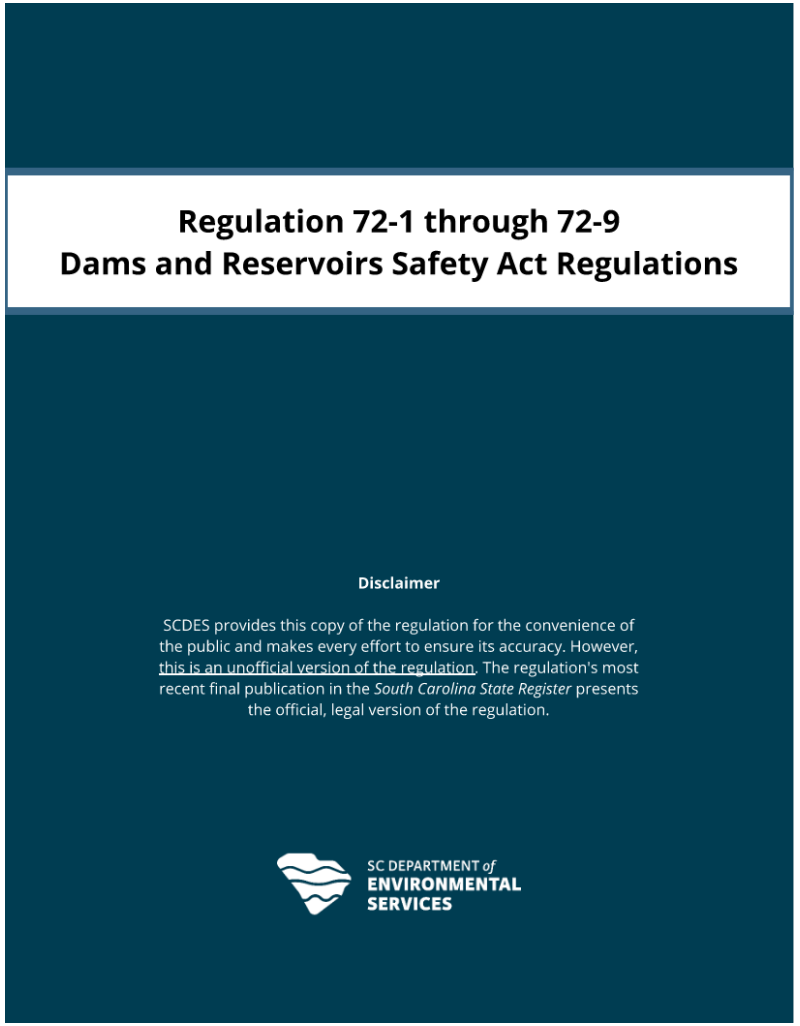
SC DEPARTMENT of ENVIRONMENTAL SERVICES

Detailed Inspections Overview

CDM Smith

Detailed Inspections Overview

- A "Detailed Inspection" is a specific and defined activity found in Regulation:
  - (R.72-1.J) "Detailed inspection" means all studies, investigations and analyses necessary to evaluate conclusively the structural safety and hydraulic capacity of a dam or reservoir and appurtenant works. This inspection may include but is not limited to soil analysis, concrete or earth stability analysis, materials testing, foundation explorations, hydrologic analysis, including basin studies and flood potential. This inspection shall be performed by a qualified registered professional engineer.



Detailed Inspections Overview

Why Detailed Inspections?

- SCDES Dam Safety has requested a Detailed Inspection following a Preliminary Inspection or ordered one as part of an Inspection and Repair Order.
- When dam is grossly inadequate or much is unknown (built prior to regulations, built when unregulated but now regulated, built as low hazard but now significant or high)
- Owner desires a complete understanding of the condition, safety and level of performance of their dam, and is willing to make necessary alterations to their dam that will require a permit from SCDES Dam Safety.

Objectives for this training:

- Outline the expectations and level of detail required for Detailed Inspections
- Emphasize the importance of engaging others as needed to form a multi-discipline team
- Provide resource information for consultants preparing Detailed Inspections, including SCDES Dam Safety Staff.

Detailed Inspections Overview

Dams and Reservoirs Safety Act Regulations (Cont'd)

- (R.72-4.D.1) Detailed Inspections may be performed voluntarily or pursuant to an order issued by the Department. The Department may order a detailed inspection after determining through a preliminary inspection that further investigation is required. The owner has the right to request a hearing before an Administrative Law Judge if the request is submitted within 30 days after receiving the preliminary inspection results.
- (R.72-4.D.2) A Detailed Inspection shall be performed by a professional engineer licensed in the State and be in sufficient detail so that appropriate plans and specifications correcting all deficiencies of the dam can be prepared by the engineer and submitted by the owner to the Department for approval. The submission shall contain the results of the detailed inspection and shall be in the form of a permit application requesting either a repair, alteration or removal permit as set forth in the Regulation on Permitting Procedures and Requirements.
- (R.72-4.C.4)... Although a Preliminary Inspection may identify only one specific problem area (such as inadequate spillway capacity, excessive seepage, apparent instability or others), this singular problem will be ample evidence to allow the Department, at its discretion to order a complete Detailed Inspection of all dam features, components and capabilities…

Detailed Inspections Overview

Preliminary Inspection

- Routine inspection based on dam condition and classification
- Identify maintenance/repair needs
- Visual inspection (erosion, seepage, etc.)
- Minimal engineering analysis
- Preliminary inspection report identifying observed conditions, and whether a detailed inspection is needed

Detailed Inspection

- Perform mainly when preliminary inspection indicates safety concerns
- Perform soil and water investigation programs
- Perform comprehensive geotechnical, hydraulic and structural analyses
- Detailed inspection report providing recommendations for maintenance, repair and/or remediation

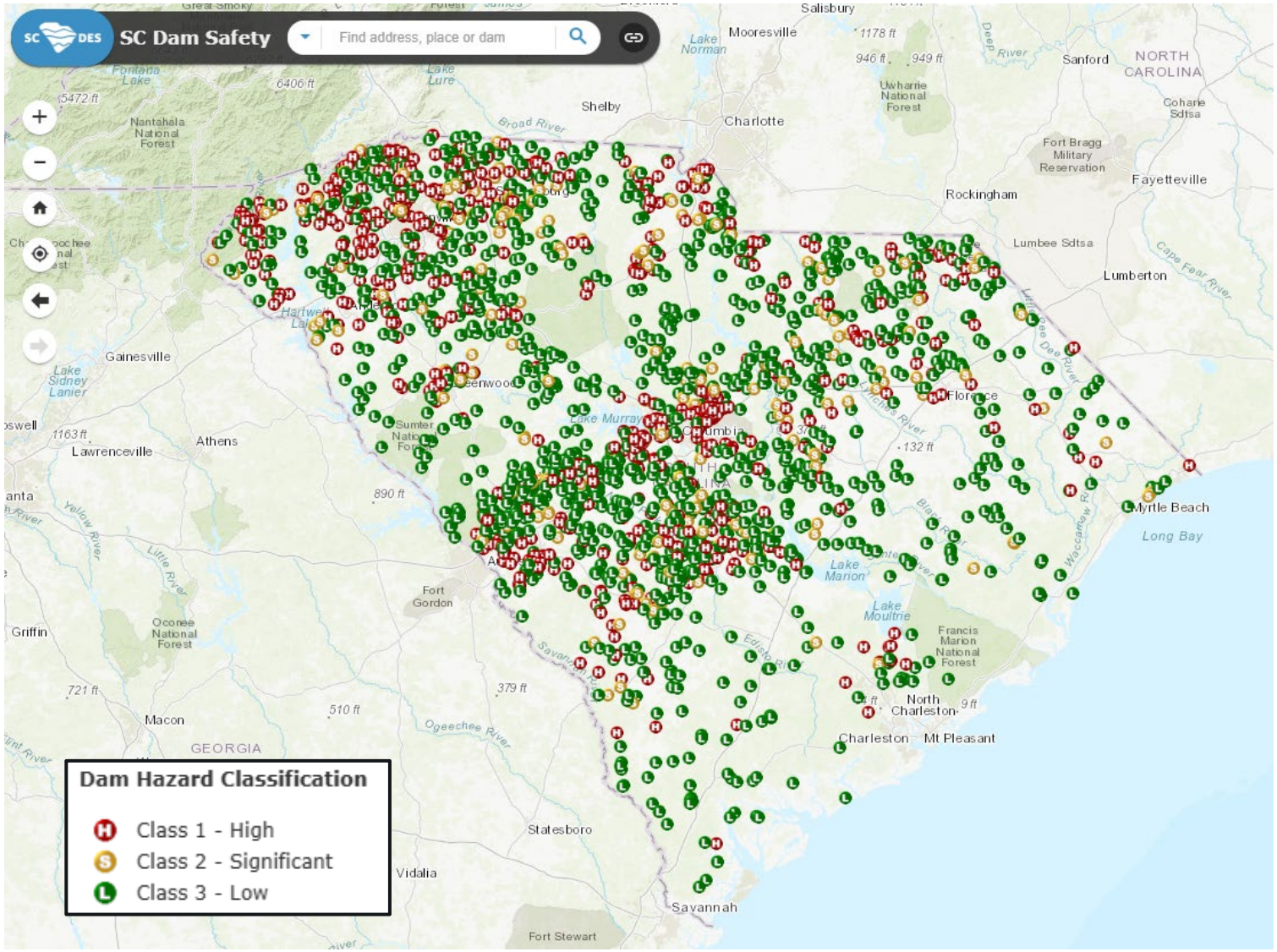
SC DEPARTMENT *of*
ENVIRONMENTAL
SERVICES

South Carolina Dams

CDM Smith

South Carolina Dams

- ~2,220 state regulated dams listed on National Inventory of Dams (NID) *as of September 2025*
- Tens of thousands of "Unregulated" dams
- ~80 federally owned or regulated dams
- NID statistics *as of September 2025*
  - 74% of high hazard dams have an EAP
  - 90% of dams are state-regulated
  - 4% of dams are federally regulated
  - 3% of dams have hydropower



Source: https://gis.dhec.sc.gov/gisportal/apps/webappviewer/index

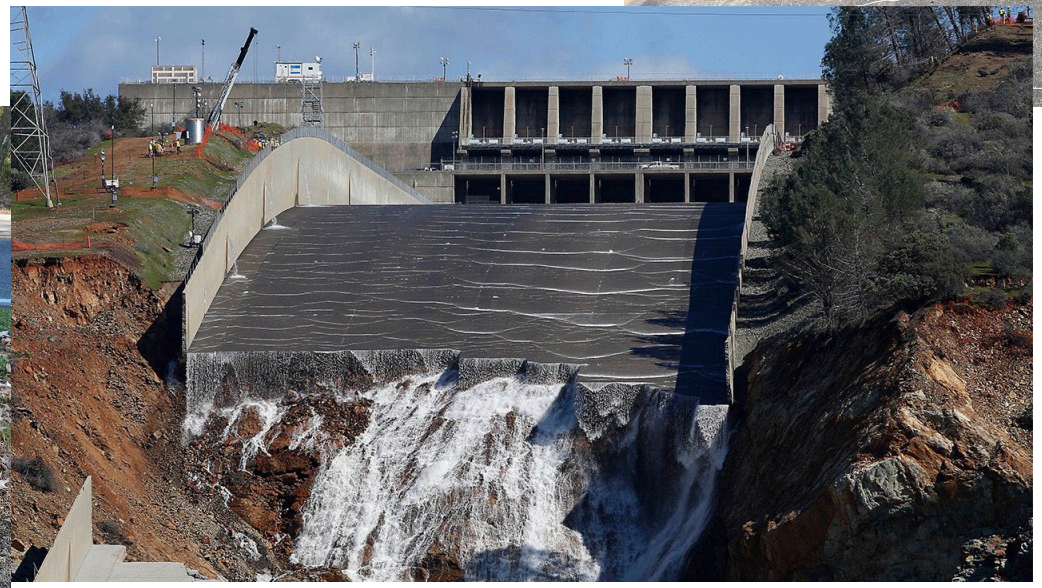
South Carolina Dams

- Aging Dams
  - Average age is 68 years (NID statistics)
  - Dams and Reservoirs Safety Act passed in 1977; Regulations enacted in 1978
- Lack of Maintenance
  - Vegetation, erosion, structure/outlet pipe clogged/not functioning, etc.
- Hazard Classification/ Spillway Capacity

Source: https://storymaps.arcgis.com/stories/1b0c518ac12e4e21924bec75dd0959ca

South Carolina Dams

- Common Issues with Aging Dams
  - Structural Deterioration and Cracking
  - Embankment Settlement/Stability
  - Seepage Issues
  - Pipes and conduits failing



Source: https://weather.com/news/news/2018 -01-23-california -oroville -dam-spillway -causes-unstable -ground

South Carolina Dams

- Lack of Maintenance
  - Trees and Woody Vegetation
  - Burrowing Animals
  - Erosion and Undercutting of Slopes
  - Spillway Intake or pipe clogged/ not functioning

Source: https://www.usbr.gov/damsafety/risk/BestPractices/Presentations/

South Carolina Dams

- Hazard Classification/ Spillway Capacity Issues
  - Overtopping of Dam Crest
  - Downstream Flooding
- Other Factors
  - Storm/Hurricane-induced floods
  - Utility Line Breaks
  - Absent/changing owners; complicated ownership structures

SC DEPARTMENT of ENVIRONMENTAL SERVICES

Detailed Inspection Process

CDM Smith

Detailed Inspection Process

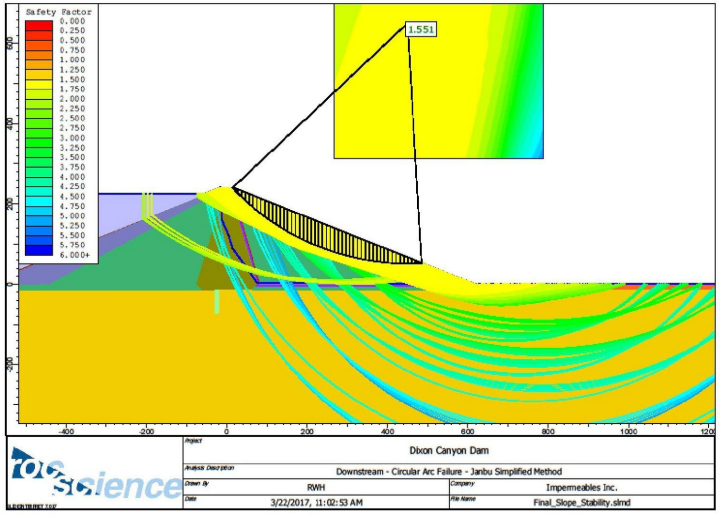
- Three Phases:

Phase 1: Planning and Desktop Study

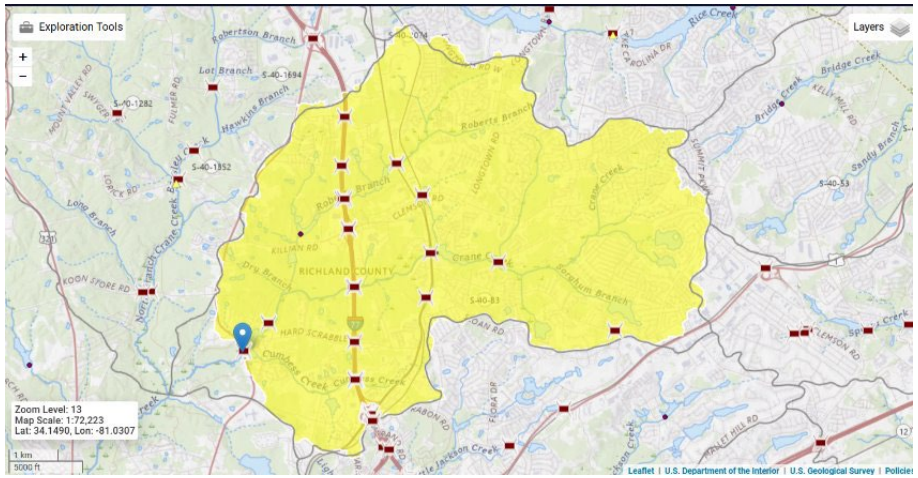
Team Formation

- Civil Engineers <u>with Dam Safety experience</u>
  - Hydrologic/Hydraulic Engineers
  - Geotechnical Engineers
  - Structural Engineers
- Surveyors, Geophysical/Geotechnical Drillers, CATV for pipes, Divers, Drones/Operators, etc.

Source: US Army Corps of Engineers set to tackle problem of ageing dams International Waterpower



Source: https://www.csugeoeng.com/news/2017/4/22/rams -design-dams



Source. https://streamstats.usgs.gov/ss/

Source:

Phase 1: Planning and Desktop Study

Request Available Data:

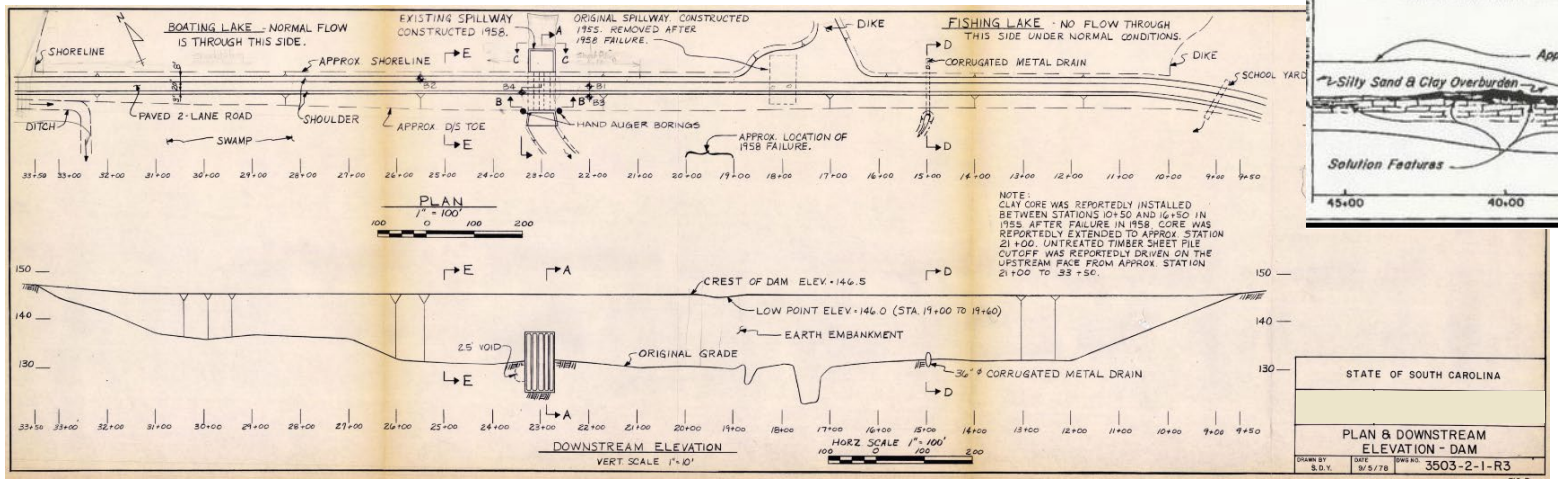
- Dam Owners (current and past)
- SCDES Dam Safety Office

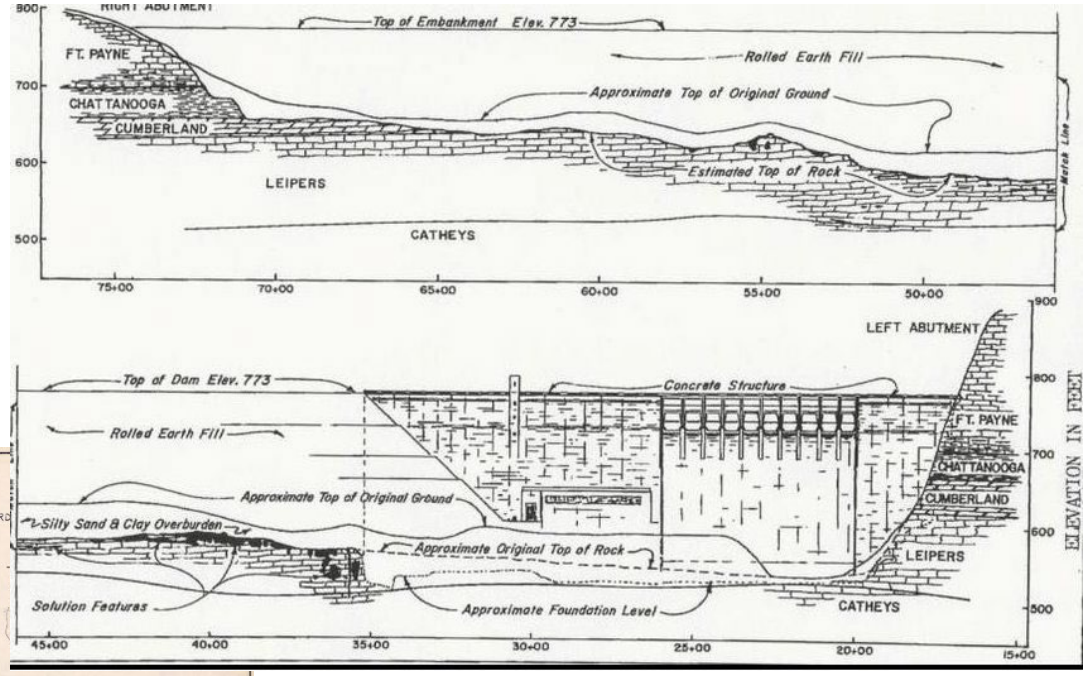
Search Publicly Available Data:

- USGS
- USDA
- NID
- FEMA
- SCDOT
- SCDNR
- Town/Utility GIS
- Other sources likely exist

Phase 1: Planning and Desktop Study

- Review historical and existing information
  - Design documents, specifications, construction records, and as-built drawings
  - Geotechnical data reports and USDA soil reports
  - Previous inspection reports and hazard classification reviews
  - Past incident reports (if any)
  - Previous repairs/alterations





Source: Geological section of Wolf Creek Dam. | Download Scientific Diagram

Phase 1: Planning and Desktop Study

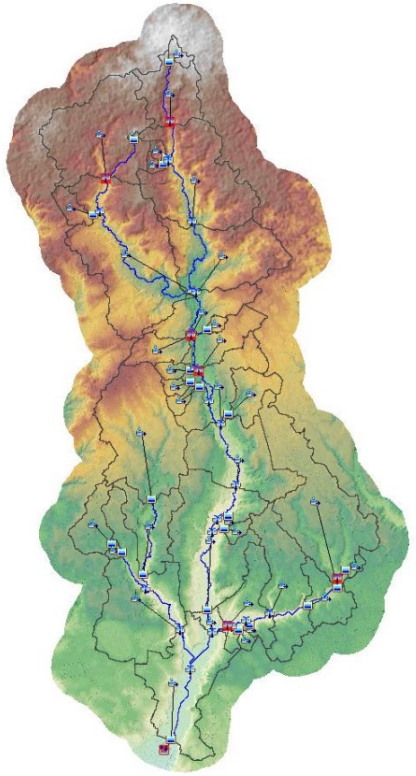
- Preliminary risk assessment
  - (Reference) FEMA'S Dam Safety Risk Assessment Framework
  - Common Failure Modes:
    - Overtopping,
    - Piping and Internal Erosion,
    - Global Stability (Static/Seismic)
- Existing Condition Factors (past deficiencies, etc.)
- Site-Specific Failure Modes

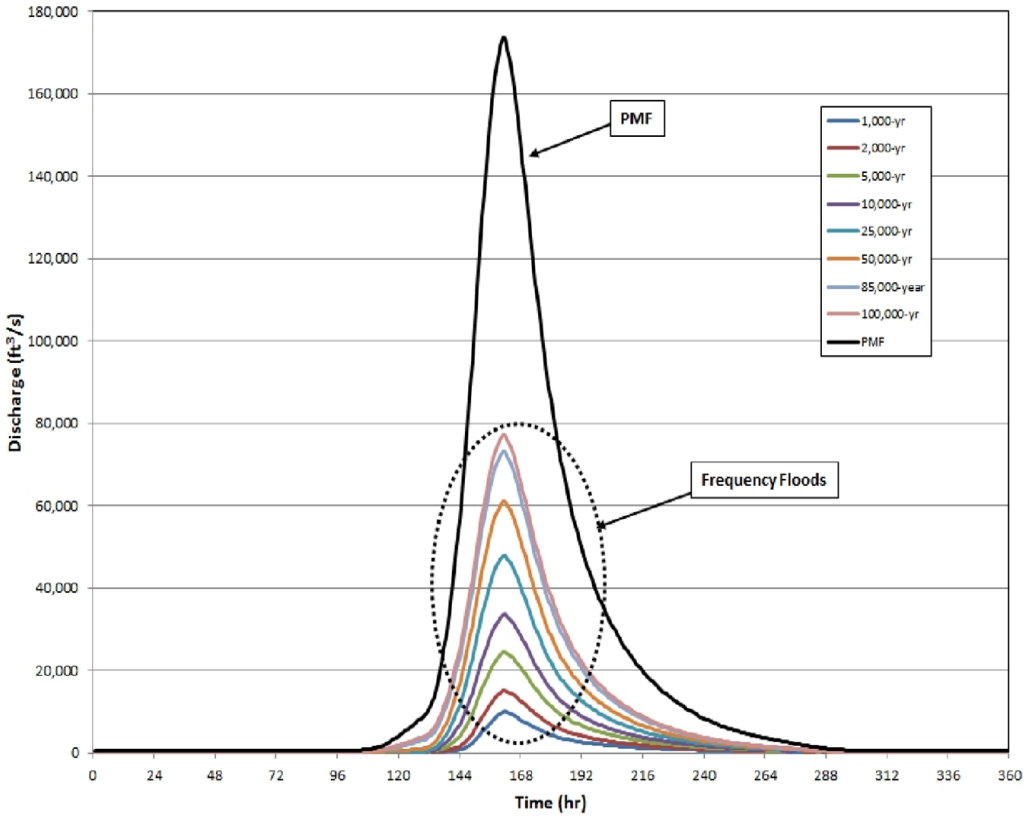

Source: https://nisee.Berkeley.edu/elibrary


Source: https://damfailures.org/lessons -learned/earth -and-rockfill -embankment -dams-must-be-stable -under-the -full -range-of-antici pated-loading -conditions

Phase 1: Planning and Desktop Study

- Hydrological and Hydraulic Analyses (Beginning in Phase 1and through Phase 3)
  - Spillway capacity, flood routing, and Probable Maximum Flood (PMF)
  - Historical flood events around the location





Source: The October Flooding Event of 2015: An indepth analysis. - Blog.WeatherFlow.com

Phase 2: Field Inspections and Investigations

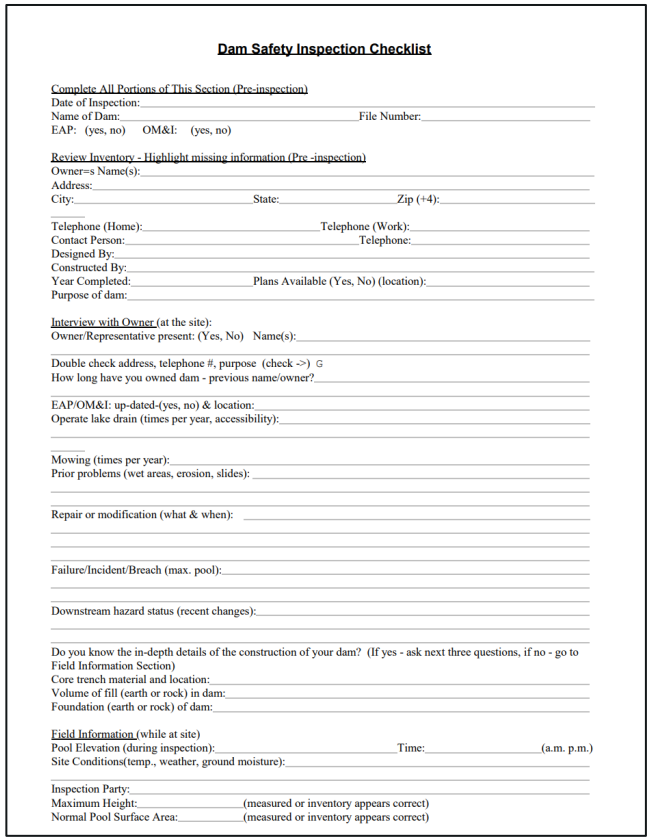
- Pre-inspection preparation
  - Safety protocols: PPE, team coordination, weather considerations
  - Equipment needed on site such as survey tools, piezometer readout device, etc

Source: https://www.army.mil/article/168900/surveys_one_element_of_dam_safety_program

Phase 2: Field Inspections and Investigations

Documentation

- Detailed notes, photographs, and GPS-tagged observations
- Complete inspection checklist for a Preliminary Inspection (example shown is from ASDSO)



Dam Safety Inspection Checklist

Complete All Portions of This Section (Pre-inspection)
Date of Inspection:
Name of Dam: File Number:
EAP: (yes, no) OM&I: (yes, no)

Review Inventory - Highlight missing information (Pre -inspection)
Owner=s Name(s):
Address:
City: State: Zip (+4):

Telephone (Home): Telephone (Work):
Contact Person: Telephone:
Designed By:
Constructed By:
Year Completed: Plans Available (Yes, No) (location):
Purpose of dam:

Interview with Owner (at the site):
Owner/Representative present: (Yes, No) Name(s):

Double check address, telephone #, purpose (check ->) G
How long have you owned dam - previous name/owner?

EAP/OM&I: up-dated-(yes, no) & location:
Operate lake drain (times per year, accessibility):

Mowing (times per year):
Prior problems (wet areas, erosion, slides):

Repair or modification (what & when):

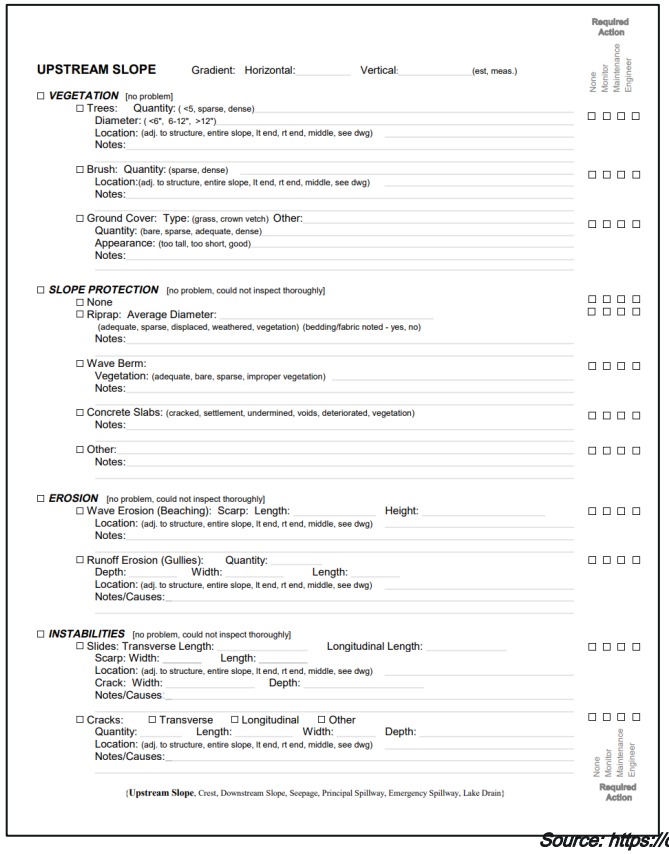
Failure/Incident/Breach (max. pool):

Downstream hazard status (recent changes):

Do you know the in-depth details of the construction of your dam? (If yes - ask next three questions, if no - go to Field Information Section)
Core trench material and location:
Volume of fill (earth or rock) in dam:
Foundation (earth or rock) of dam:

Field Information (while at site)
Pool Elevation (during inspection): Time: (a.m. p.m.)
Site Conditions(temp., weather, ground moisture):

Inspection Party:
Maximum Height: (measured or inventory appears correct)
Normal Pool Surface Area: (measured or inventory appears correct)



Required Action: None / Monitor / Maintenance / Engineer

UPSTREAM SLOPE Gradient: Horizontal: Vertical: (est, meas.)

☐ ***VEGETATION*** [no problem]
☐ Trees: Quantity: (<5, sparse, dense)
Diameter: (<6", 6-12", >12")
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes:

☐ Brush: Quantity: (sparse, dense)
Location:(adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes:

☐ Ground Cover: Type: (grass, crown vetch) Other:
Quantity: (bare, sparse, adequate, dense)
Appearance: (too tall, too short, good)
Notes:

☐ ***SLOPE PROTECTION*** [no problem, could not inspect thoroughly]
☐ None
☐ Riprap: Average Diameter:
(adequate, sparse, displaced, weathered, vegetation) (bedding/fabric noted - yes, no)
Notes:

☐ Wave Berm:
Vegetation: (adequate, bare, sparse, improper vegetation)
Notes:

☐ Concrete Slabs: (cracked, settlement, undermined, voids, deteriorated, vegetation)
Notes:

☐ Other:
Notes:

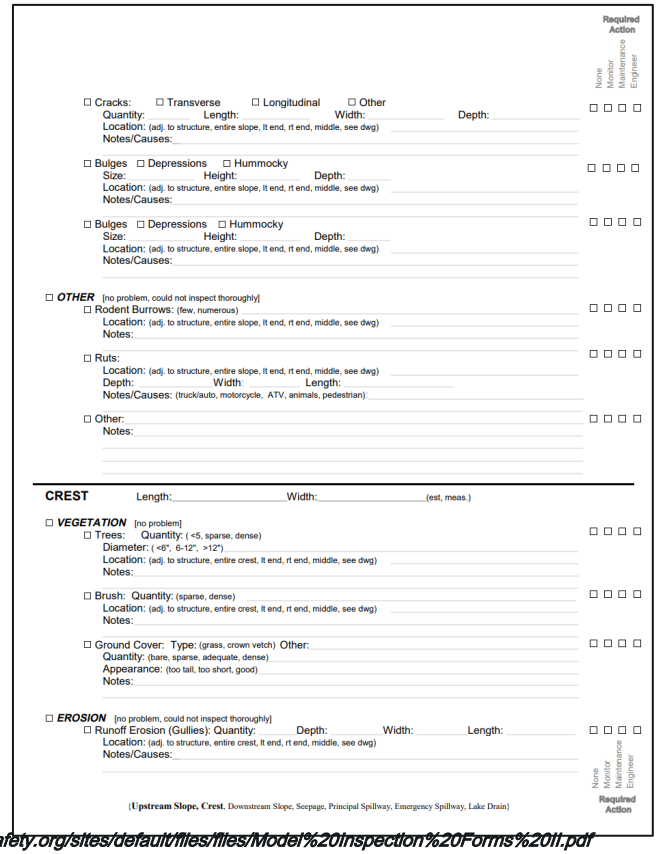
☐ ***EROSION*** [no problem, could not inspect thoroughly]
☐ Wave Erosion (Beaching): Scarp: Length: Height:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes:

☐ Runoff Erosion (Gullies): Quantity:
Depth: Width: Length:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes/Causes:

☐ ***INSTABILITIES*** [no problem, could not inspect thoroughly]
☐ Slides: Transverse Length: Longitudinal Length:
Scarp: Width: Length:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Crack: Width: Depth:
Notes/Causes:

☐ Cracks: ☐ Transverse ☐ Longitudinal ☐ Other
Quantity: Length: Width: Depth:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes/Causes:

{**Upstream Slope**, Crest, Downstream Slope, Seepage, Principal Spillway, Emergency Spillway, Lake Drain}



Required Action: None / Monitor / Maintenance / Engineer

☐ Cracks: ☐ Transverse ☐ Longitudinal ☐ Other
Quantity: Length: Width: Depth:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes/Causes:

☐ Bulges ☐ Depressions ☐ Hummocky
Size: Height: Depth:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes/Causes:

☐ Bulges ☐ Depressions ☐ Hummocky
Size: Height: Depth:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes/Causes:

☐ ***OTHER*** [no problem, could not inspect thoroughly]
☐ Rodent Burrows: (few, numerous)
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Notes:

☐ Ruts:
Location: (adj. to structure, entire slope, lt end, rt end, middle, see dwg)
Depth: Width: Length:
Notes/Causes: (truck/auto, motorcycle, ATV, animals, pedestrian)

☐ Other:
Notes:

CREST Length: Width: (est, meas.)

☐ ***VEGETATION*** [no problem]
☐ Trees: Quantity: (<5, sparse, dense)
Diameter: (<6", 6-12", >12")
Location: (adj. to structure, entire crest, lt end, rt end, middle, see dwg)
Notes:

☐ Brush: Quantity: (sparse, dense)
Location: (adj. to structure, entire crest, lt end, rt end, middle, see dwg)
Notes:

☐ Ground Cover: Type: (grass, crown vetch) Other:
Quantity: (bare, sparse, adequate, dense)
Appearance: (too tall, too short, good)
Notes:

☐ ***EROSION*** [no problem, could not inspect thoroughly]
☐ Runoff Erosion (Gullies): Quantity: Depth: Width: Length:
Location: (adj. to structure, entire crest, lt end, rt end, middle, see dwg)
Notes/Causes:

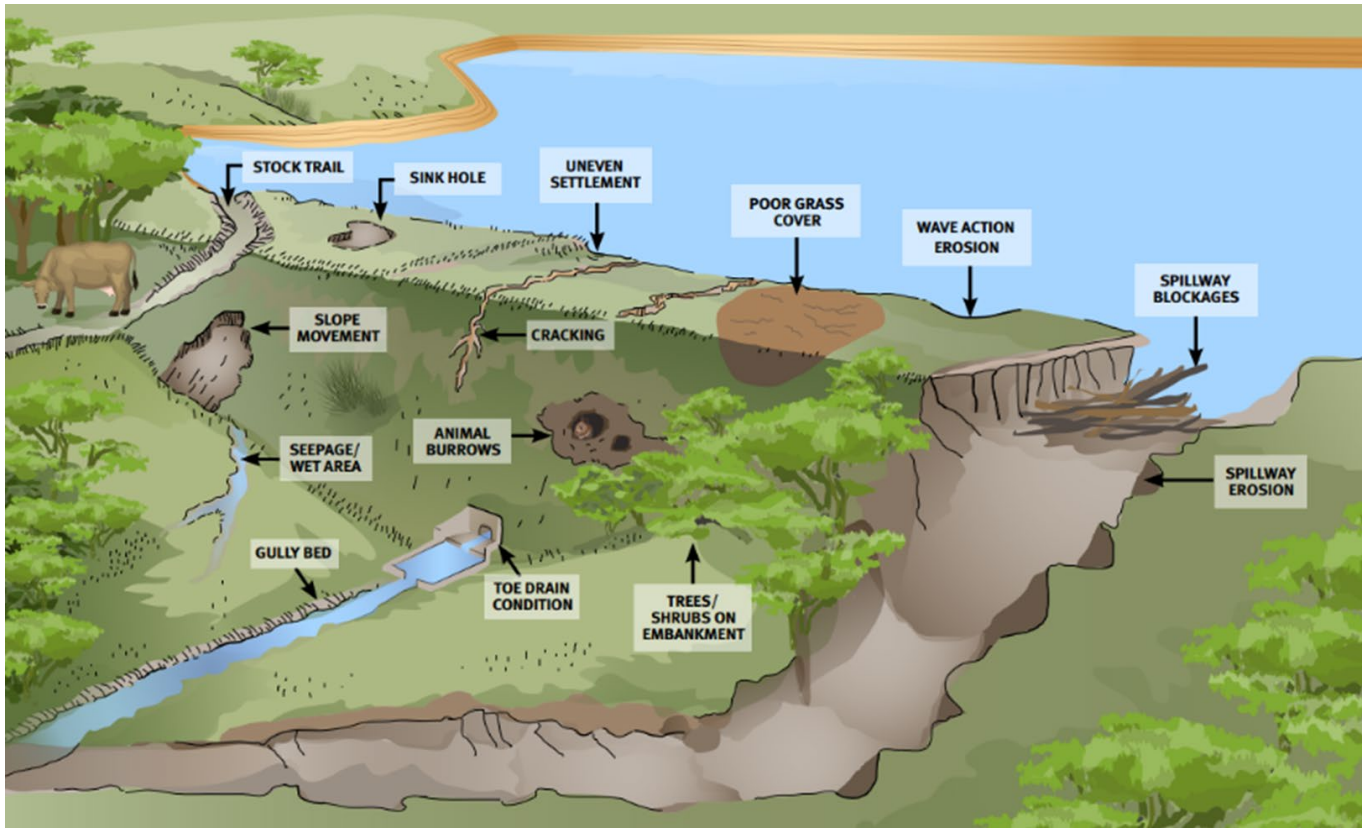
{**Upstream Slope, Crest**, Downstream Slope, Seepage, Principal Spillway, Emergency Spillway, Lake Drain}

Required Action: None / Monitor / Maintenance / Engineer

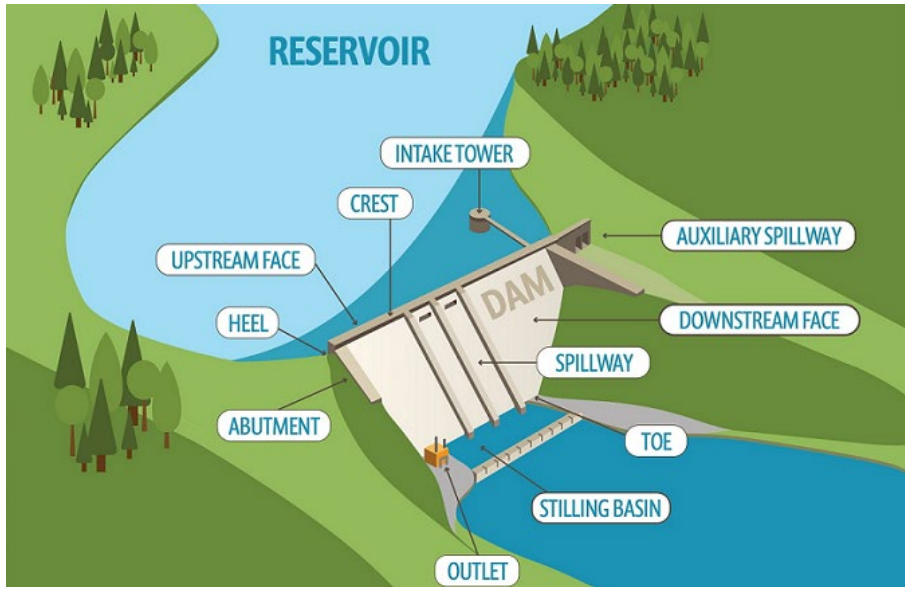
Source: https://damsafety.org/sites/default/files/files/Model%20Inspection%20Forms%20II.pdf

Phase 2: Field Inspections and Investigations

- Main areas for inspection:
  - Crest and embankment slopes
  - Abutments
  - Foundation
  - Spillway(s) and outlets works
  - Other structural appurtenances



Source: https://www.damsafety.nsw.gov.au/publications/small -dams-safety-a-guide-for-owners



Source: https://www.nab.usace.army.mil/Missions/Dams -Recreation/Raystown -Lake/Raystown -Lake-Dam-Risk-Communication/

Phase 2: Field Inspections and Investigations

- Potential Stability Concerns
  - Cracks along crest or slope
  - Scarping near crest or along slope
  - Bulging near the toe
  - Tilting/cracking/disjointing structures and pipes
  - Leaning/curved trees

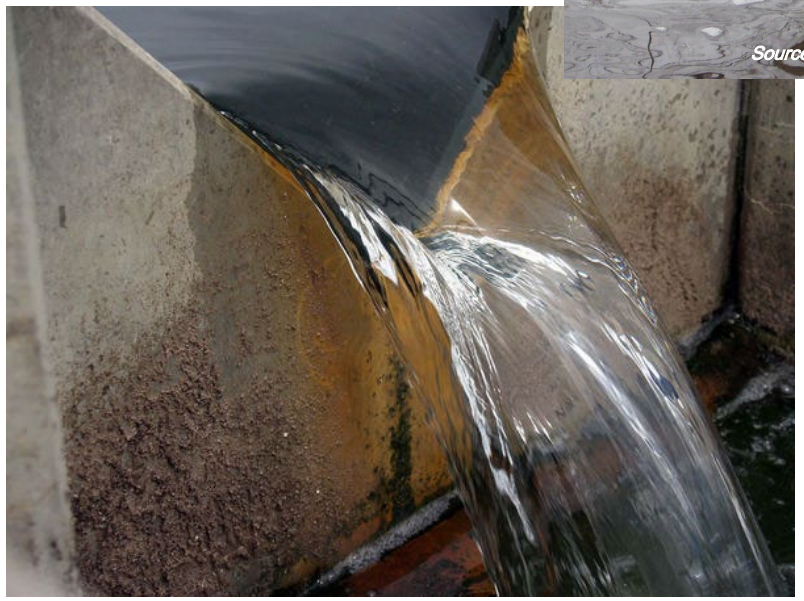
Phase 2: Field Inspections and Investigations

- Potential Seepage Concerns
  - Wet or soft spots
  - Changes in vegetation
  - Depressions or sinkholes
  - Flowing water (flow rate?...water clarity?)
  - Whirlpools in reservoir
  - Muddy water from downstream or outlets
  - Sand boils

Phase 2: Field Inspections and Investigations

- Field Instrumentation
  - Piezometers/Inclinometers
  - Observation wells
  - Staff gauges and recorders
  - Weirs
  - Survey monuments
  - Drains

Source: https://www.usgs.gov/media/images/staff -gage-a-wisconsin-stream

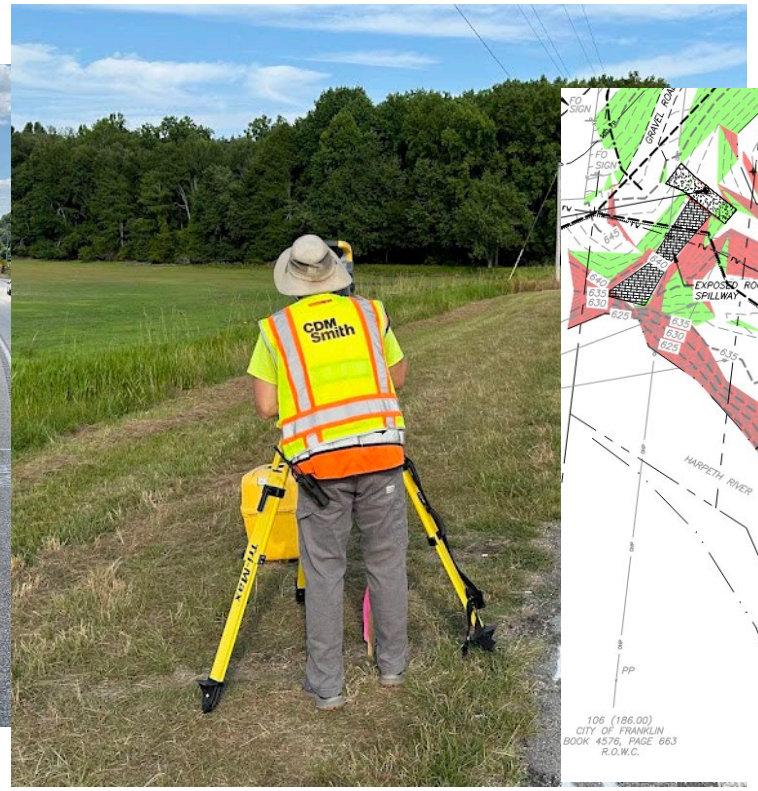


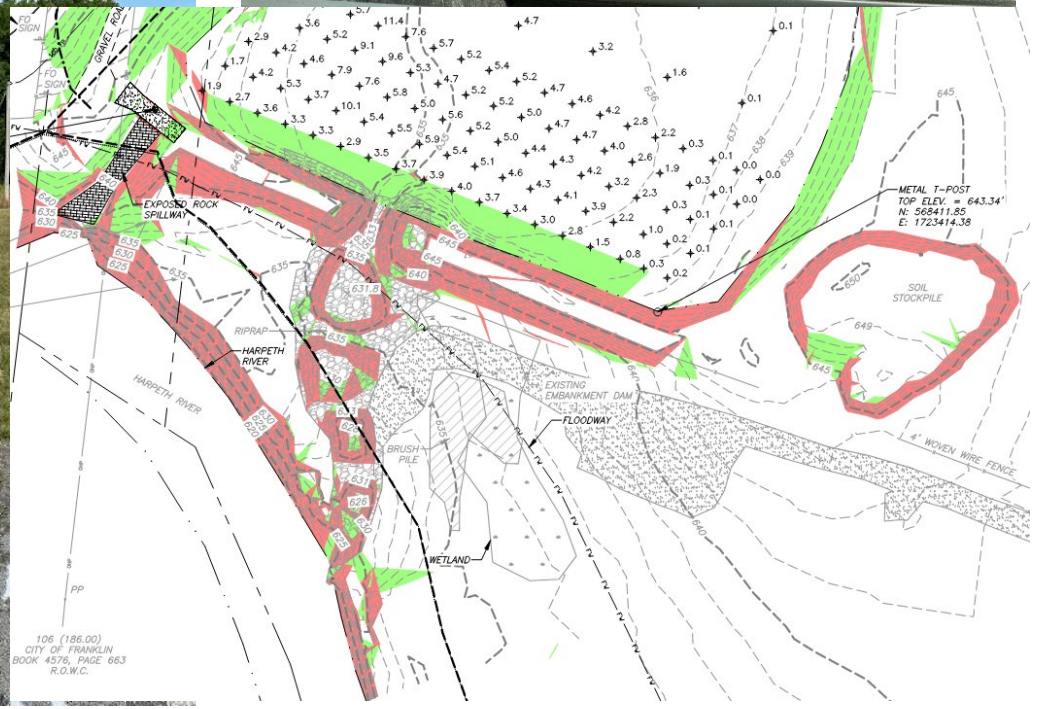
Phase 2: Field Inspections and Investigations

- Dams and Reservoirs Safety Act Regulations
  - (R72-4.D.2) A Detailed Inspection shall be performed by a professional engineer licensed in the State and be in sufficient detail so that appropriate plans and specifications correcting all deficiencies of the dam can be prepared by the engineer and submitted by the owner to the Department for approval. The submission shall contain the results of the detailed inspection and shall be in the form of a permit application requesting either a repair, alteration or removal permit as set forth in the Regulation on Permitting Procedures and Requirements.
- Field investigation scopes should include, surveying, subsurface investigations, and geotechnical explorations to support Final Design and Permit Application requirements.
- Additional investigations may be needed later based on the selective alternative and the Final Design refinements (e.g., more soil borings or more detailed surveys).

Phase 2: Field Inspections and Investigations

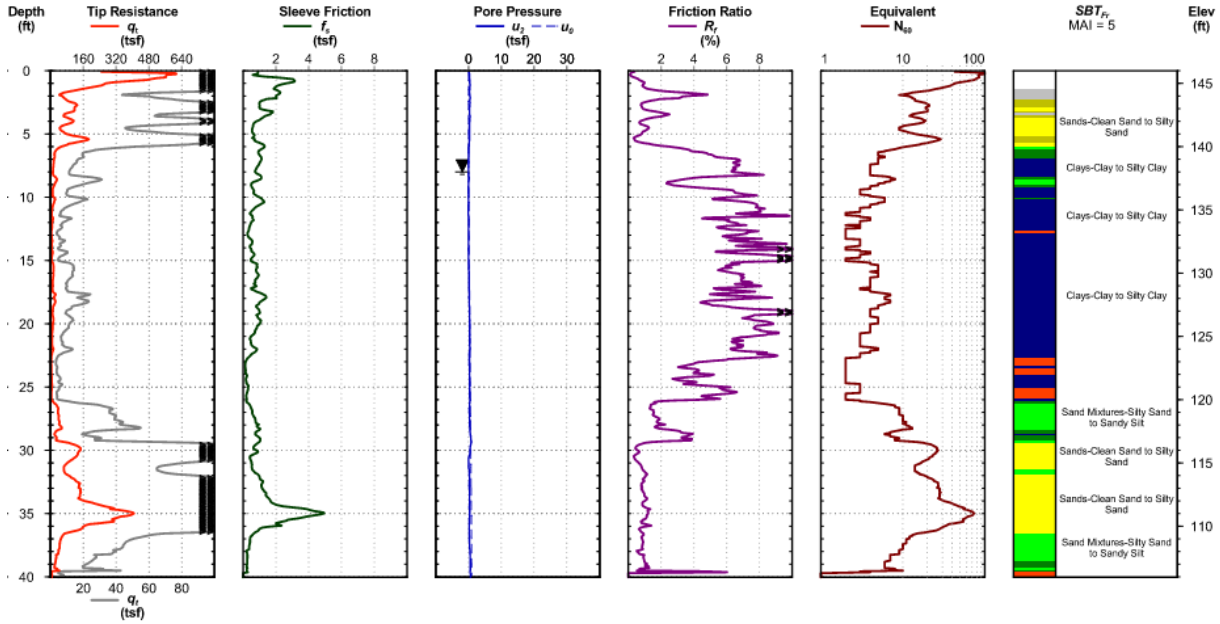
- Surveys
  - Topographic, bathymetric, wetlands delineation, etc
  - Locate spillways, inlets, embankment features, and auxiliary structures

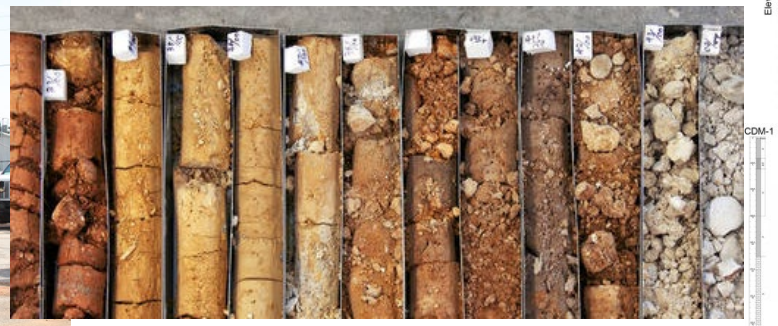


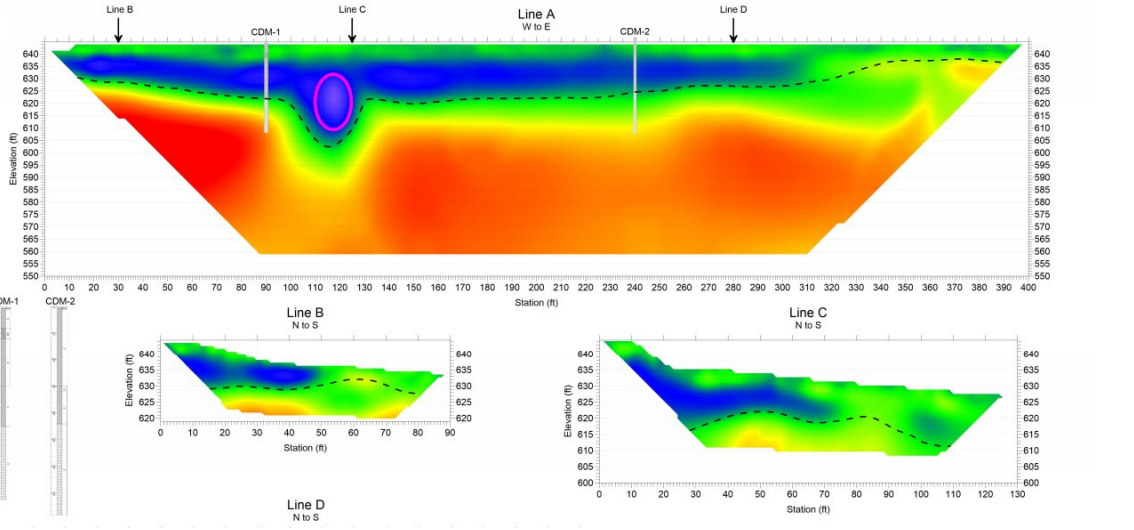


Phase 2: Field Inspections and Investigations

- Subsurface Investigation
  - Standard Penetration Test (SPT) Borings
  - Cone Penetration Test (CPT) Soundings
    - Piezocone soundings
    - Seismic soundings
    - Dissipation testing
  - Geophysical and Non-Destructive Testing
  - Subsurface Utility Engineering (SUE) Survey

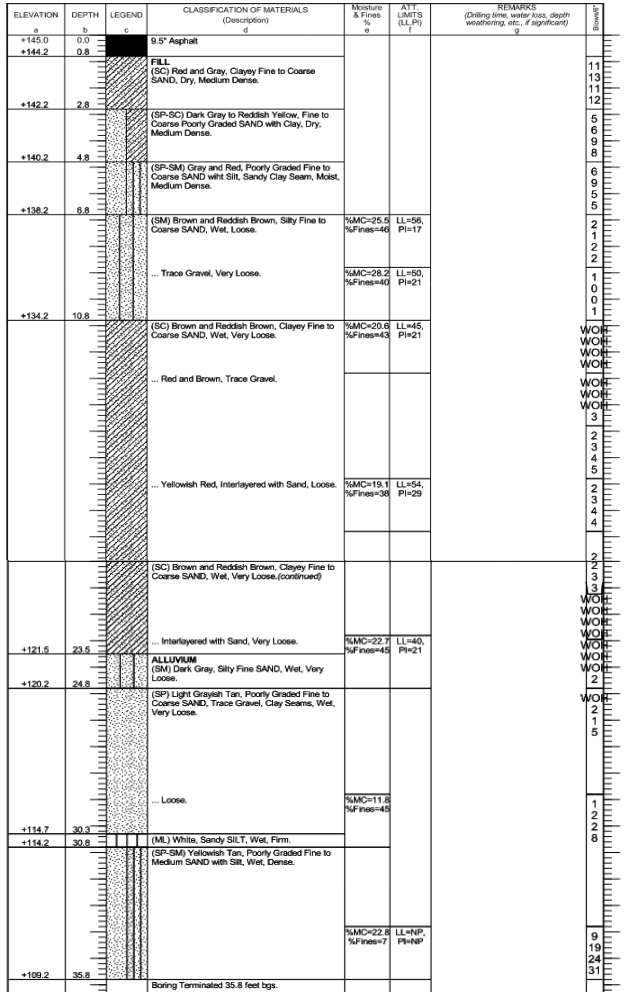


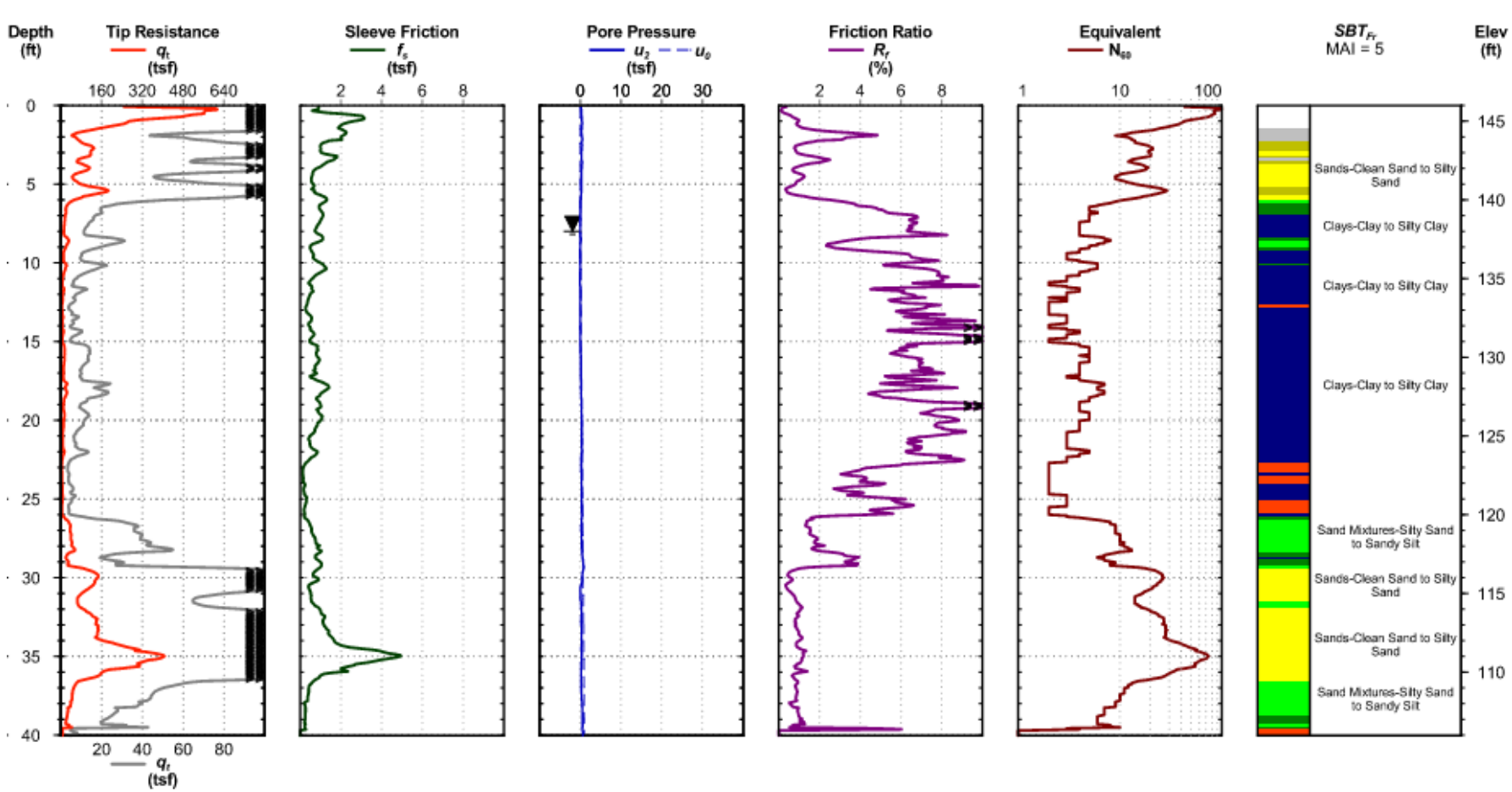




Phase 3: Detailed Analysis and Reporting

- Data Compilation
  - Organize field data, photos and measurements





Phase 3: Detailed Analysis and Reporting

- Hydrological and Hydraulic Analyses (Beginning in Phase 1and through Phase 3)
  - Details presented on **Part 02 - Detailed Inspection Training Hydrologic and Hydraulics**

Source: https://des.sc.gov/news/lake -conestee-dam-restoration -achieves-major -milestone -replacing -130-year-old-upstate -dam

Phase 3: Detailed Analysis and Reporting

Dam Breach Analysis

- Evaluates potential failure scenarios and resulting downstream impacts
- Hydraulic failure during extreme flood (e.g. PMF/ 100-yr)
- Hydrologic and hydraulic modeling (e.g. USACE HEC-HMS and HEC-RAS)
- Supports hazard classification and Emergency Action Plan (EAP)

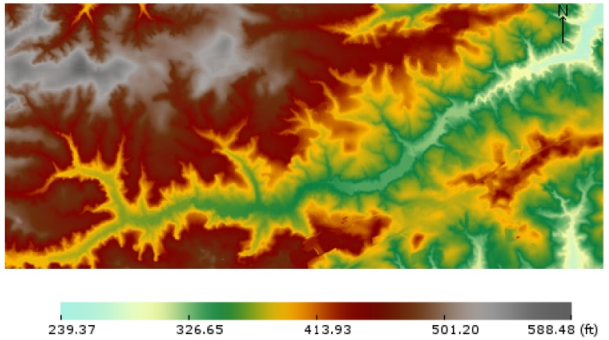


Image Dimensions: N-S: 3.875 miles E-W: 8.769 miles
Figure 1. Map of Digital Elevation Model with Levees for AOI.

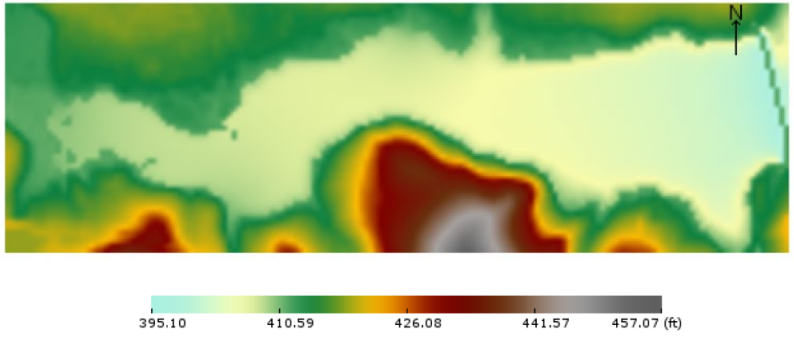


Image Dimensions: N-S: 0.201 miles E-W: 0.629 miles
Figure 2. Map of Reservoir Boundary and Breached Structure.

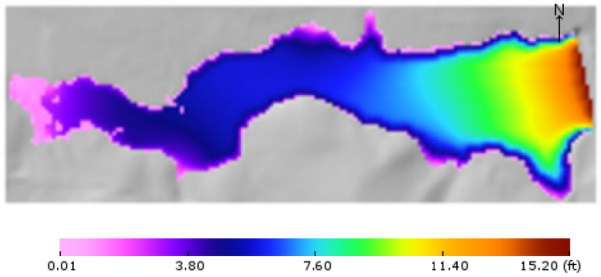


Image Dimensions: N-S: 0.216 miles E-W: 0.636 miles
Figure 3. Map of Initial Depths in Reservoir at Failure Conditions.

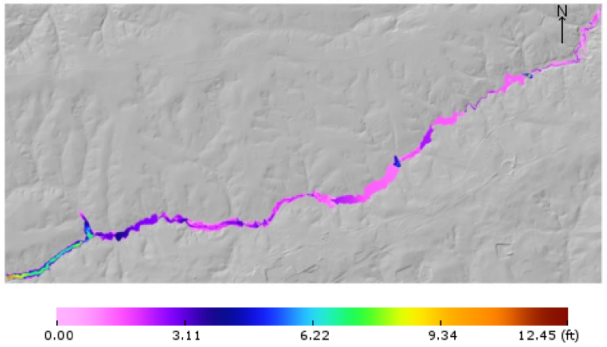


Image Dimensions: N-S: 3.826 miles E-W: 8.186 miles
Figure 4. Maximum Flood Depth Map.

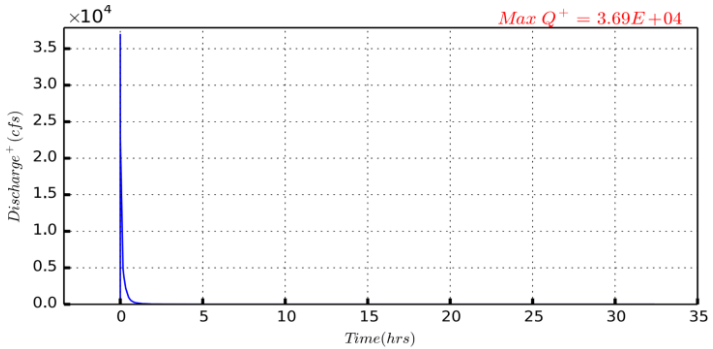
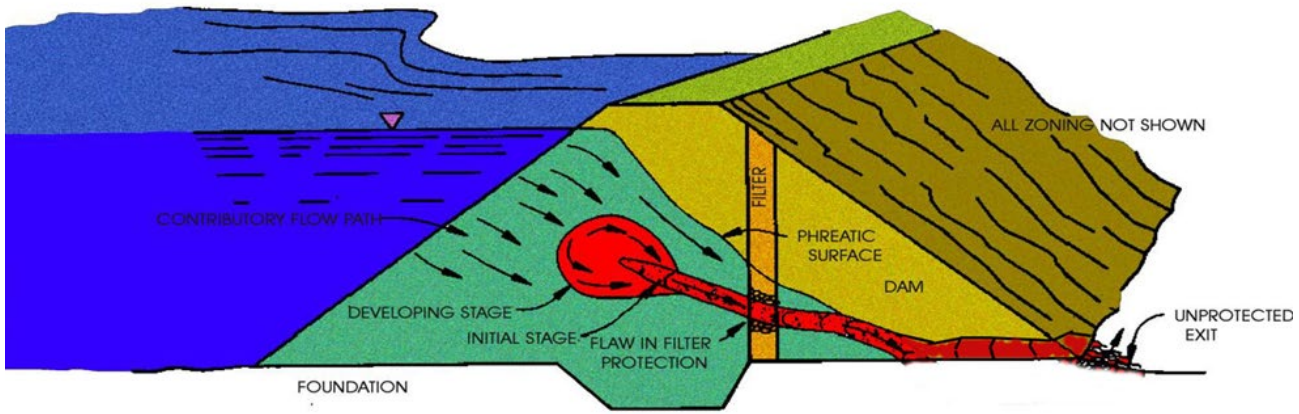


Figure 5. Breach Discharge Measured at: Dam.

Phase 3: Detailed Analysis and Reporting

- Geotechnical Analyses
  - Seepage Analyses
  - Global Slope Stability Analyses
  - Internal Erosion and Piping Potential
  - Liquefaction Hazard Analyses



Source: https://www.ferc.gov/sites/default/files/2020 -06/internal -erosion.pdf

Source: https://www.usgs.gov/faqs/what -liquefaction#multimedia

Phase 3: Detailed Analysis and Reporting

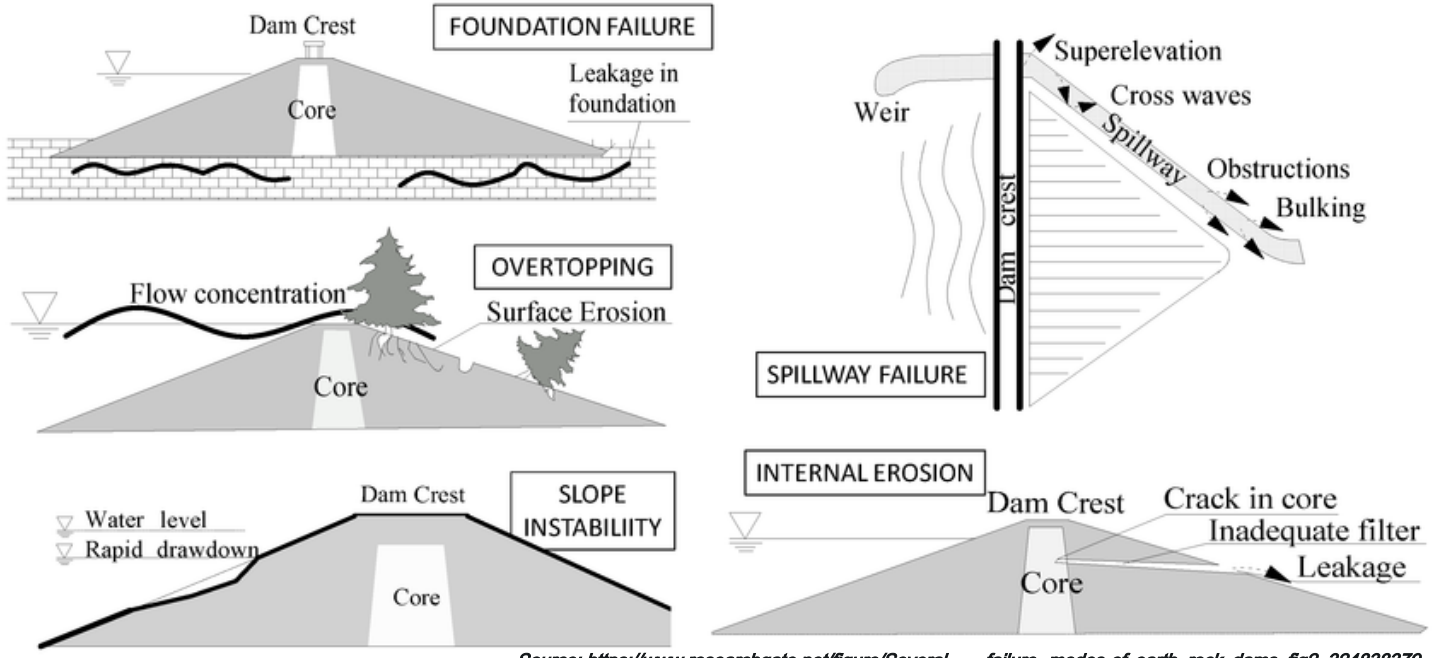
- Structural Analyses
  - Stability/Condition of Appurtenant Structures
    - Spillways
    - Inlet structures
    - Outlet works
    - Gates and valves
    - Etc.

Source: https://deeply.thenewhumanitarian.org/water/articles/2017/04/07/oroville -disaster-may-have-been-caused-by-weak-soil-under-spillway

Phase 3: Detailed Analysis and Reporting

- Risk Assessment
  - Identify potential failure modes
  - Prioritize issues: Immediate, short term, long term

Note: Not a requirement for Detailed Inspection, but strongly recommended!



Source: https://www.researchgate.net/figure/Several -failure -modes-of-earth -rock-dams_fig2_324838379

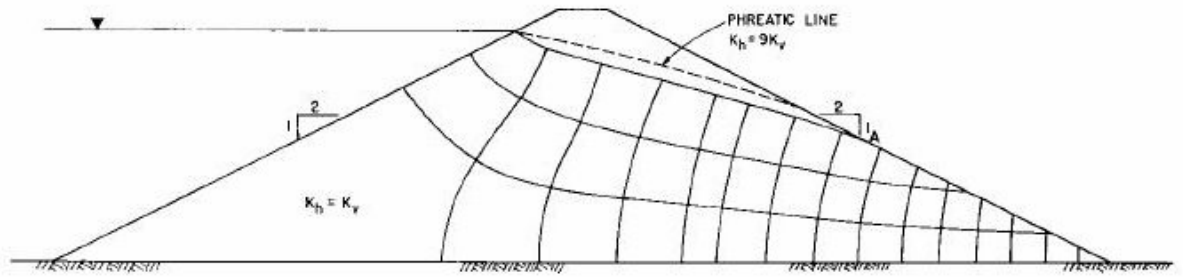
Source: https://damfailures.org/lessons -learned/regular -operation -maintenane -and-inspection -of-dams-is-important -to-the-early-detection -and-prevention -of-dam-failure

Source: https://damfailures.org/lessons -learned/earth -and-rockfill -embankment -dams-must-be-stable-under-the-full -range-of-anticipated -loading -conditions

Phase 3: Detailed Analysis and Reporting

Remedial Alternatives Evaluation

- Spillway Capacity Issues:
  - Spillway Upgrade/Replacement
  - Increase Reservoir Storage
  - Overtopping Protection
  - Incremental Damage Assessment
  - FEMA/Permitting Issue Considerations
- Stability/Seepage Issues:
  - Regrading/Stability Berms
  - Grouting/Ground Improvement
  - Anchors/Piles
  - Internal/Toe Drains



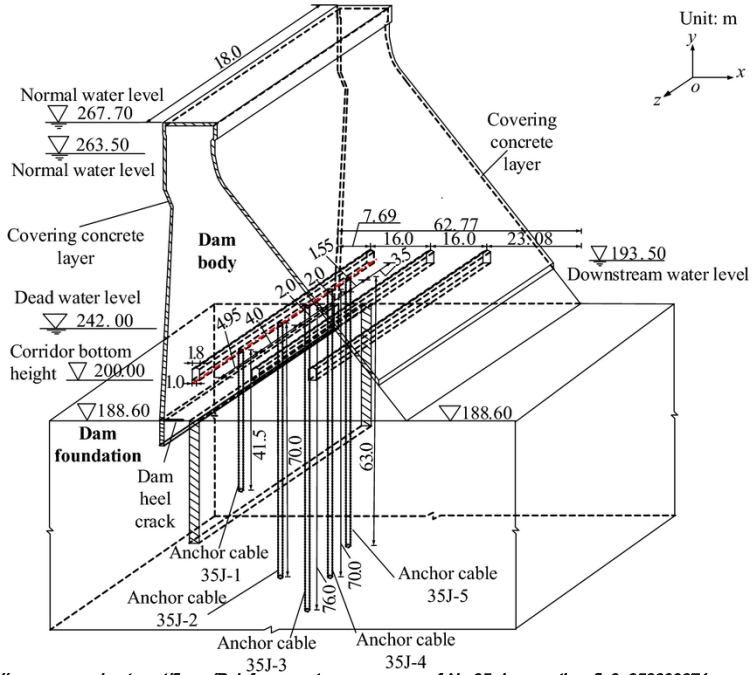
FLOW NET FOR HOMOGENEOUS DAM – NO UNDERDRAINS

Source: https://engineeringcivil.org/articles/geotechnical -engineering/seepage -in-earth -dam-seepage-analysis-control -measures/

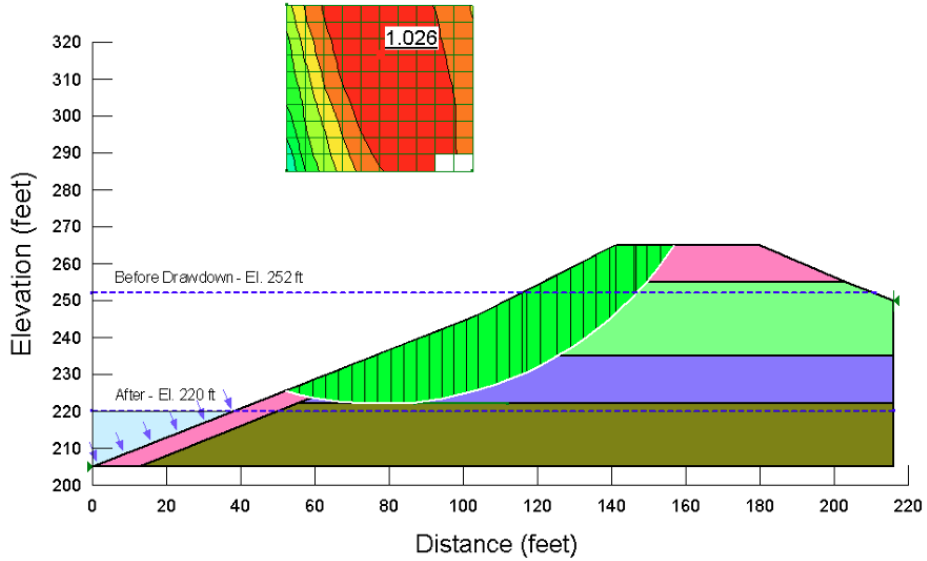
Phase 3: Detailed Analysis and Reporting

Remedial Alternatives Evaluation

- Conceptual Design of Feasible Alternative(s)
  - H/H Analyses
  - Geotechnical/Structural Analyses
  - Permitting Considerations
  - Schedule
  - Opinions of Probable Construction Cost (NOT an SCDES requirement, but may be useful to Owners for evaluating alternatives and securing funding)
- Recommended Alternative
  - Rehabilitation, Removal or Repair
  - Recommendations for Final Design



Source: https://www.researchgate.net/figure/Reinforcement -measures-of-No-35-dam-section_fig8_358600674

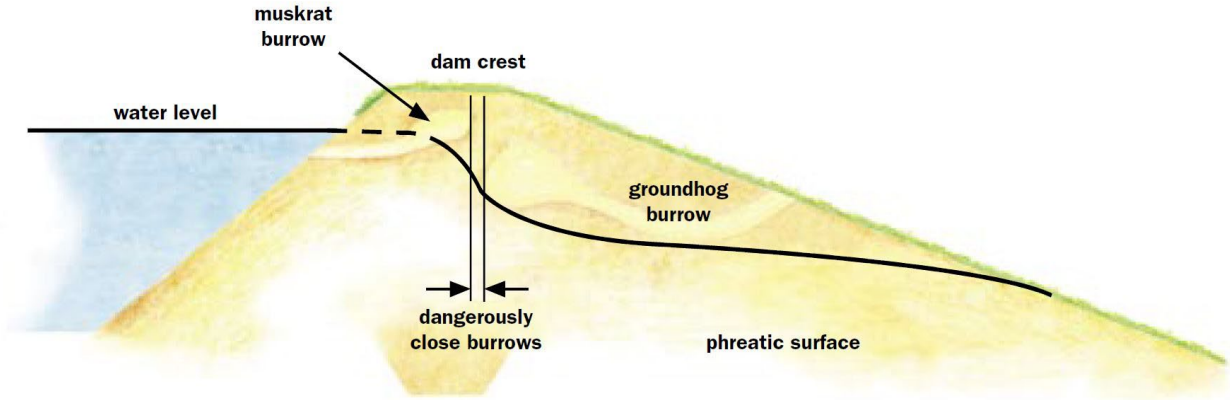


Source: https://bentleysystems.service -now.com/community?id=kb_article_view&sysparm_article=KB0046446

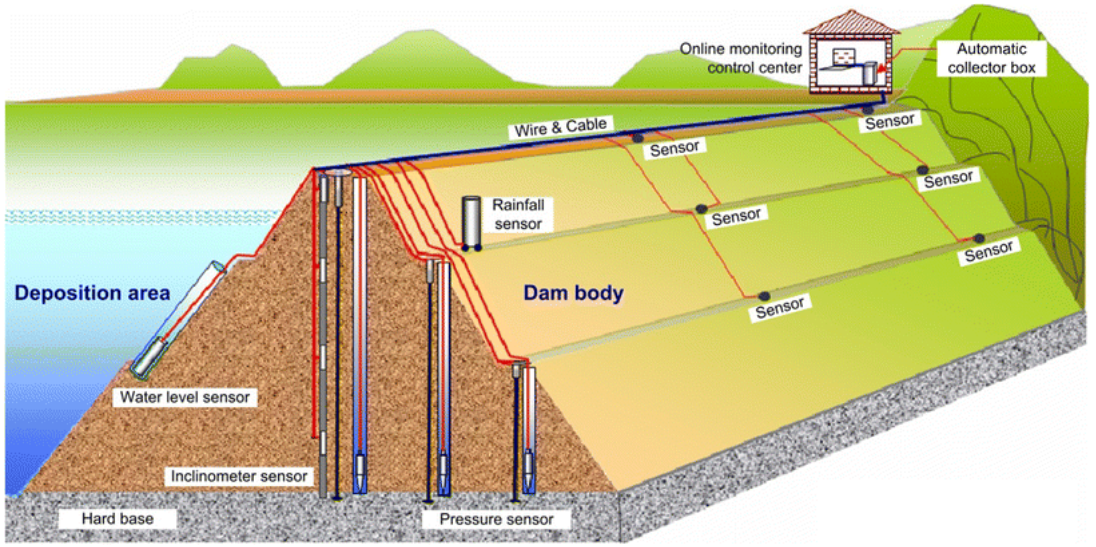
Phase 3: Detailed Analysis and Reporting

Recommendations

- Maintenance:
  - Vegetation removal
  - Minor repairs
- Remediation (permit required):
  - Large tree removal (for trees >4" diam. at breast height)
  - Grouting
  - Spillway upgrades
- Monitoring and Instrumentation:
  - Piezometers
  - Inclinometers
  - Weirs, etc.



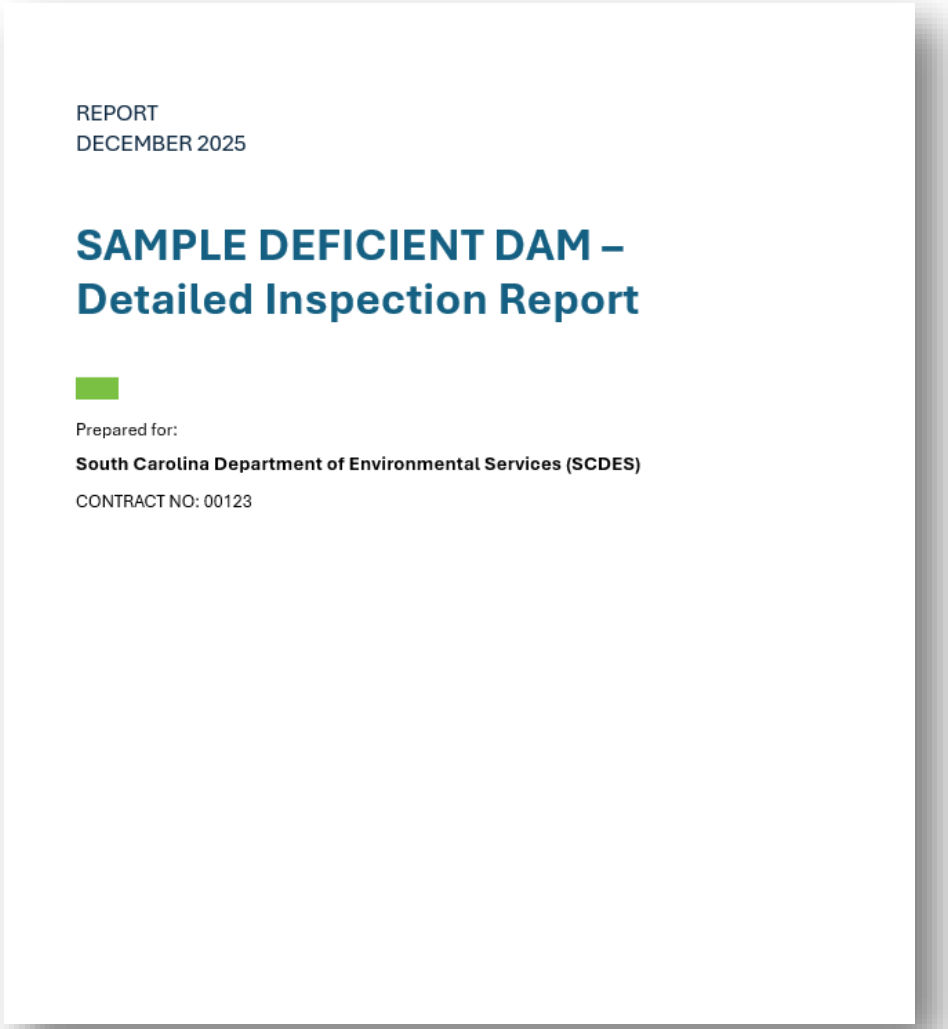
Source: Embankment dams and levees are vulnerable to damage from wildlife intrusions and animal impacts. | ASDSO Lessons Learned



Source: Data collection network in the online dam monitoring system

Phase 3: Detailed Analysis and Reporting

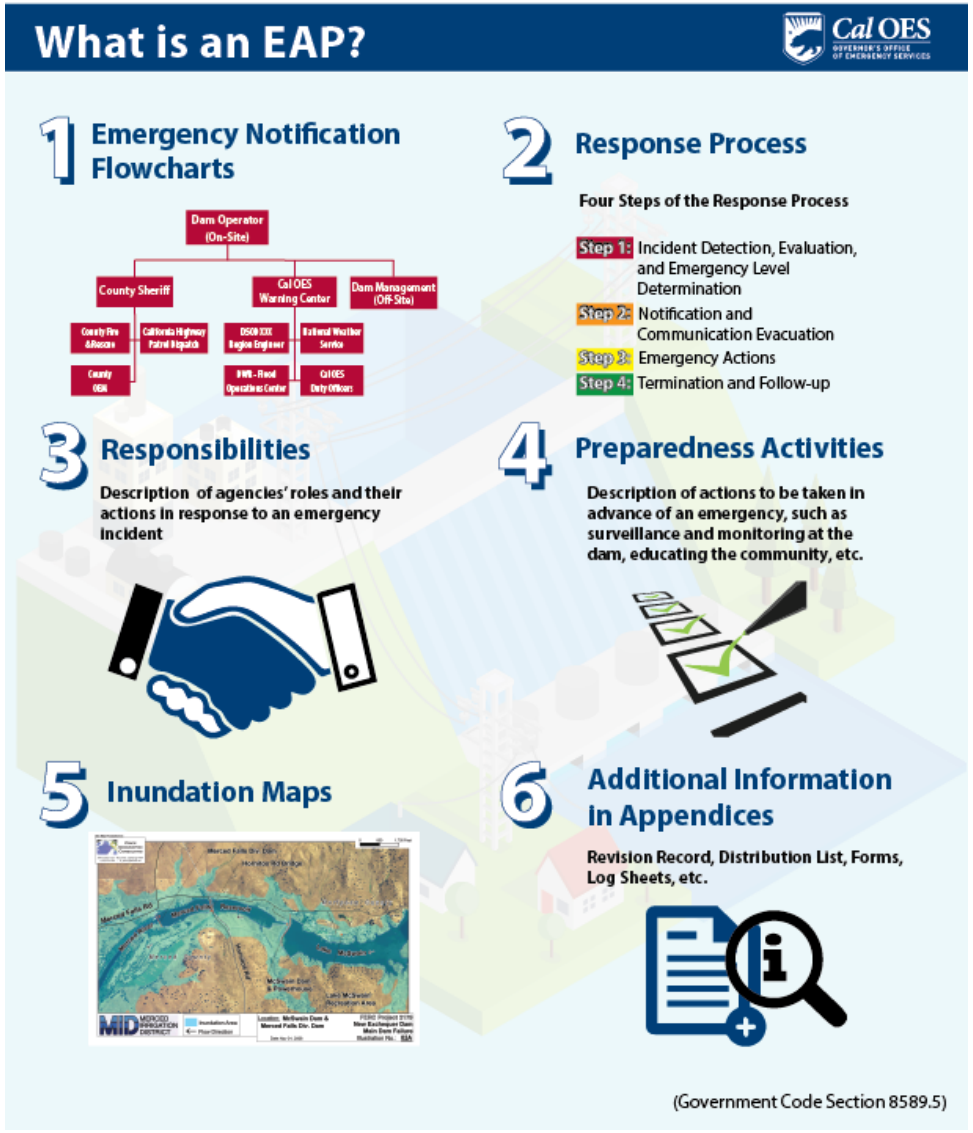
- Draft Report (not required, but good practice and may be necessary if SCDES has identified a timeline to address deficiencies)
  - Summary and discussion of findings and analysis
  - Presentation of Alternatives Evaluation
  - Recommendations to dam owner and SCDES



Phase 3: Detailed Analysis and Reporting

- Final Report
  - Updates to Draft Report
  - Permit application to address deficiencies
  - Modified Emergency Action Plan (EAP)

Source: Emergency Action Planning | Association of State Dam Safety



Source: Dam Safety Planning | California Governor's Office of Emergency Services

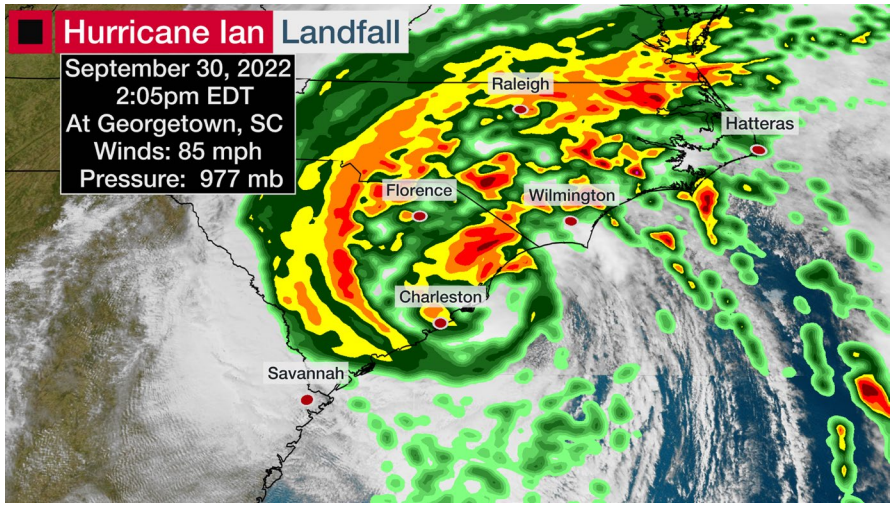
SC DEPARTMENT *of*
ENVIRONMENTAL
SERVICES

Considerations for South Carolina

CDM Smith

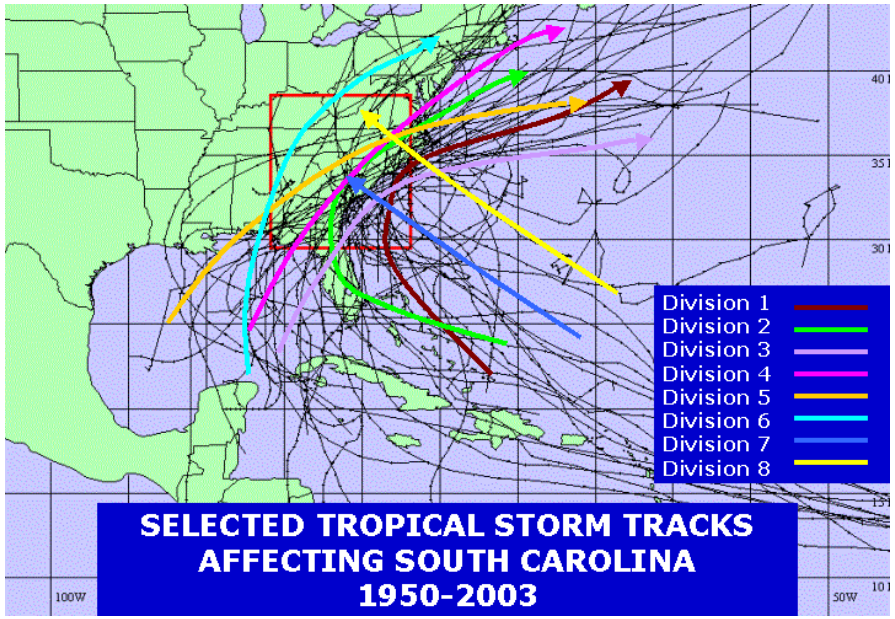
Considerations for South Carolina

- Hurricane and storm risks
  - Tropical system rainfall and resultant flooding
  - Spillway capacity and overtopping prevention



Source: https://weather.com/storms/hurricane/news/2022 -09-30-hurricane -ian-landfall -south-carolina

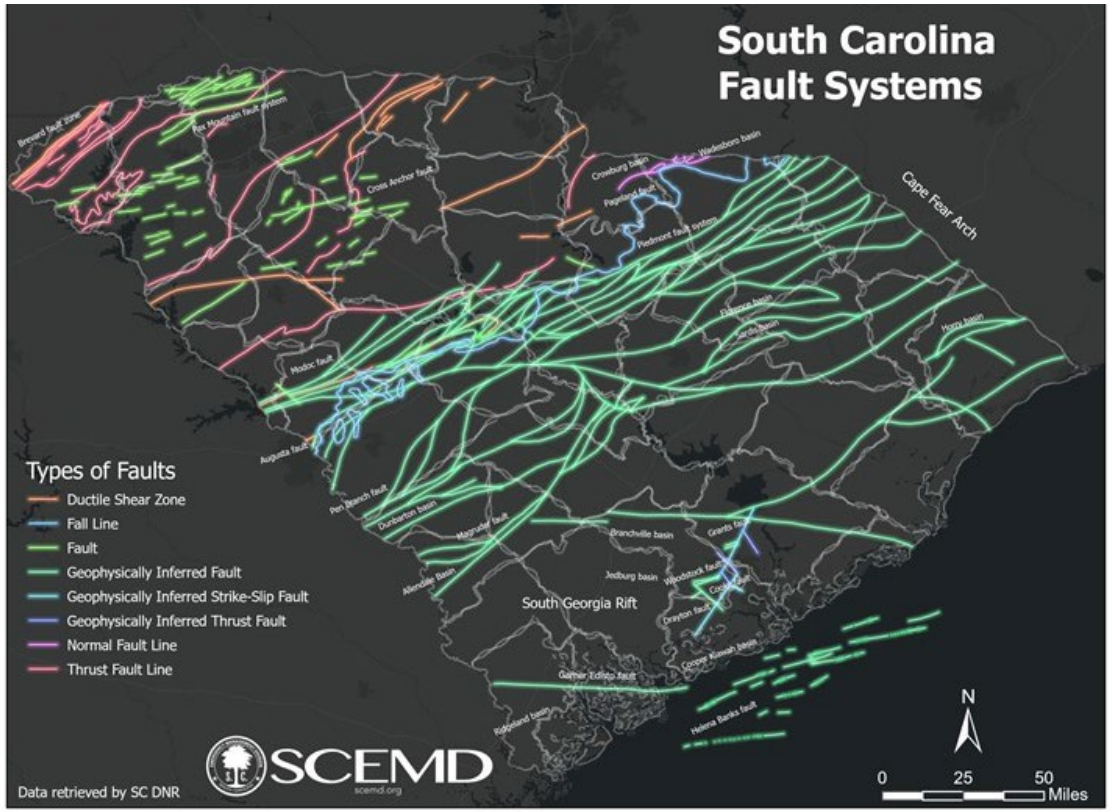
Source: https://13wham.com/news/nation -world/gallery/south -carolina -pond-drained -after -rain -from-debby-breaks-dikes-tropical -storm -cavanaugh -road-colleton -county -mcgrady -dam?photo=5



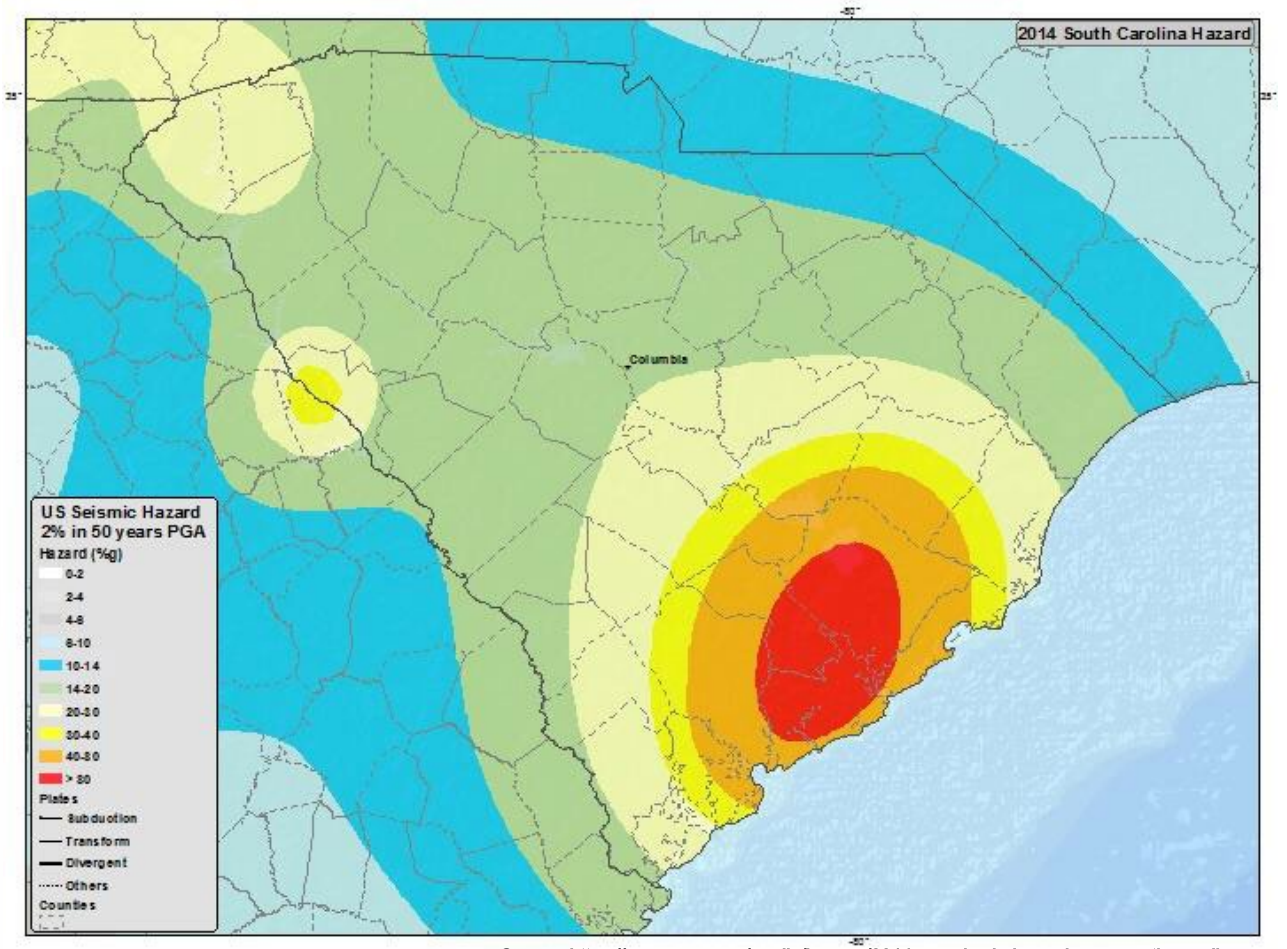
Source:
https://www.dnr.sc.gov/climate/sco/Tropics/TropicalRainfall/tropical_Rainfall.php

Considerations for South Carolina

- Seismic Risk



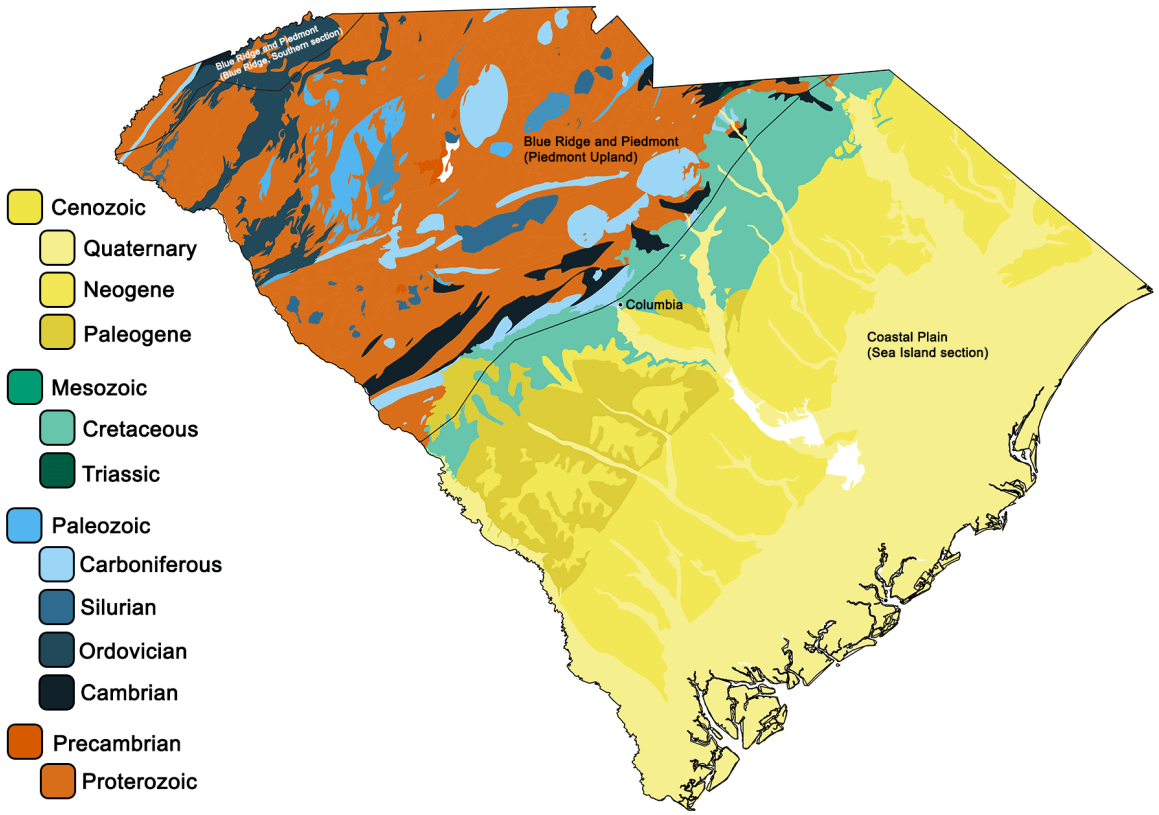
Source: https://www.scemd.org/news/midlands -earthquake -swarm-longest -in-recent -history/



Source: https://www.usgs.gov/media/images/2014 -seismic-hazard-map-south-carolina

Considerations for South Carolina

- Soil Conditions
  - Blue Ridge and Piedmont
    - Highly weathered rock
    - Erratic bedrock depths – differential settlement
  - Coastal Plain Physiographic Unit
    - Loose sandy soil – liquefaction, piping/ seepage
    - Soft, compressible clayey soil – consolidation settle



Source: https://earthathome.org/hoe/us -earth-science-quick-facts/sc/

Considerations for South Carolina

- Regulations
  - South Carolina DES requirements for high-hazard dams
  - Local emergency management coordination
- Community Impacts

Source: Emergency Action Planning | Association of State Dam Safety

Source: https://www.washingtonpost.com/national/michigan -dam-disaster-infrastructure/2020/05/22/26bc380a -9c34-11eaac72-3841fcc9b35f_story.html

Source: https://www.scemd.org/recover/get -help/help -for-individuals/

Considerations for South Carolina

- Meteorological Evaluation
  - Probable Maximum Precipitation (PMP)
  - Represents worst-case maximum rainfall.
  - Probable Maximum Flood (PMF)
- Meteorological Evaluation Methods
  - HMR51- Hydrometeorological Report No. 51 (PMP charts)
  - HMR52 - Hydrometeorological Report No. 52 (Storm Program)
  - USACE HEC-HMS
  - USACE MetVue software

HMR51- Hydrometeorological Report No. 51

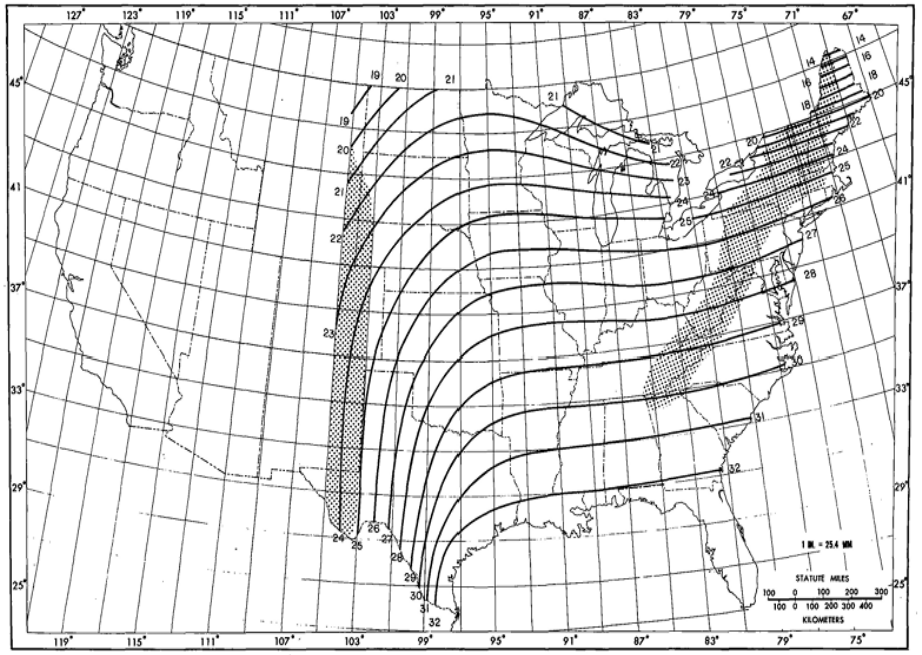
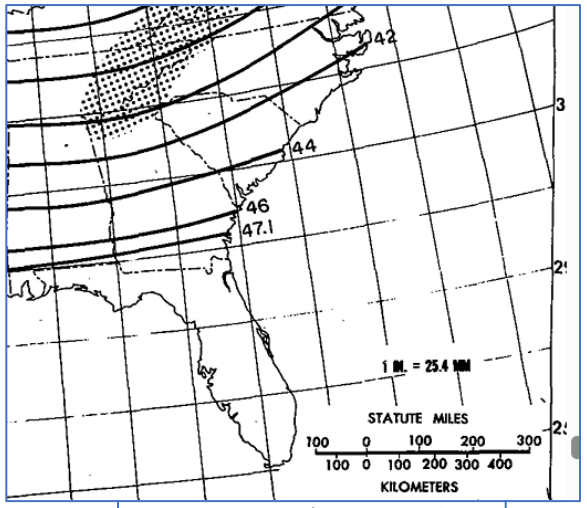


Figure 18.--All-season PMP (in.) for 6 hr 10 mi^2 (26 km^2).



24 hr 10 mi^2 (26 km^2).

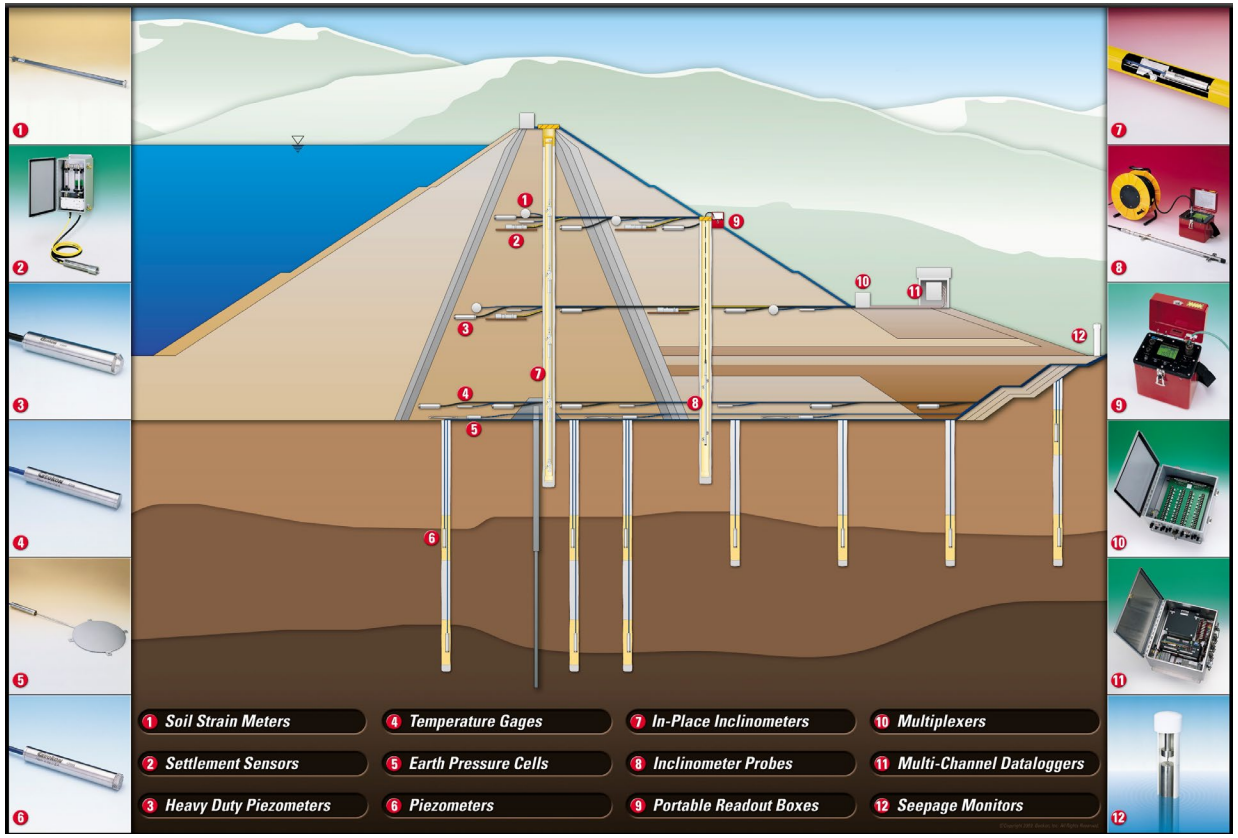
SC DEPARTMENT of ENVIRONMENTAL SERVICES

Best Practices and Lessons Learned

CDM Smith

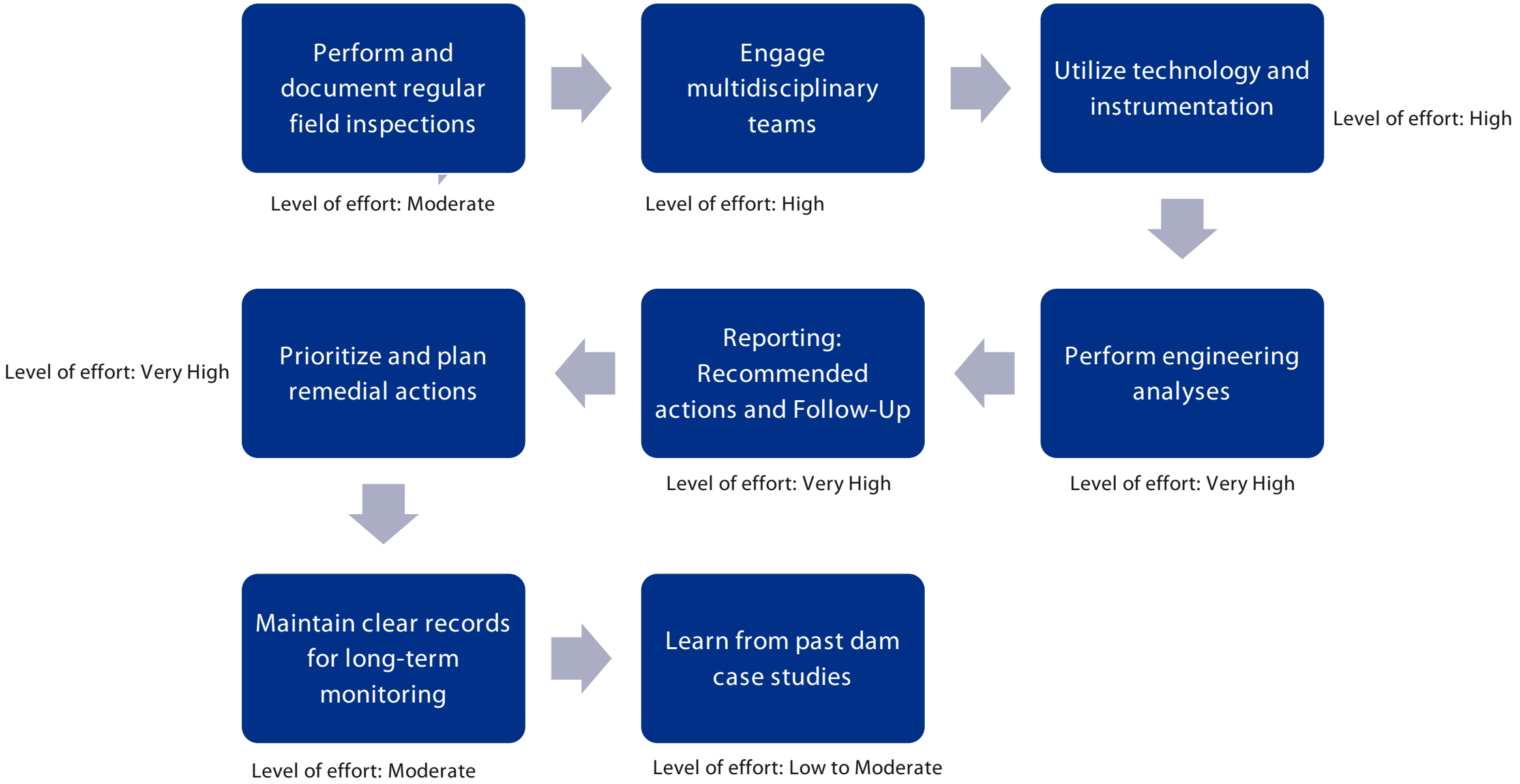
Best Practices and Lessons Learned

- Perform and document regular field inspections
- Engage multidisciplinary teams
- Utilize technology and instrumentation
- Conduct post-event inspections promptly after weather-related events
- Maintain clear records for long-term monitoring
- Learn from past dam case studies



Source: https://www.geokon.com/content/posters/Earth_Dam_Poster_LARGE.jpg

Best Practices and Lessons Learned



SC DEPARTMENT of ENVIRONMENTAL SERVICES

Example Timelines and Level-of-Effort

CDM Smith

Detailed Inspection Timeline – Example: Low-Complexity Dam

Example Project:
Earthen Embankment: 25 feet high / 400 feet long
Principal Spillway: Riser Barrel System (36-inch CMP riser with trash rack connected to a 36-inch CMP outlet pipe)
Emergency Spillway: Unlined earthen channel that is vegetated
Instrumentation: None

Task	Phase I- Planning & Desktop Study*	Phase II- Field Inspections & Investigations*	Phase III- Detailed Analysis & Reporting*
Surveying (Topographic, Bathymetric, LiDAR, Geophysical, Utilities)	5 days	10 days	20 days
Hydrological and Hydraulic Engineering	5 days	3 days	20 days
Geotechnical Engineering	5 days	30 days**	20 days
Structural Engineering	3 days	3 days	10 days
Drafting	2 days	2 days	7 days
Conceptual Design Alternatives	-	-	15 days
Stakeholder / Regulatory Coordination	3 days	-	15 days
***Typical Timeline	2 weeks	6 weeks	10 weeks
Typical Total Timeline	6 months		

**Schedule values are indicative and represent typical durations observed for similar dam safety inspection efforts. Actual durations may vary based on site conditions, data availability, weather, access constraints, and regulatory coordination.*
***Timeline accounts for scoping and executing investigations.*
****Typical timelines assume some of the activities will be performed concurrently.*

Detailed Inspection Timeline – Example: Medium-Complexity Dam

Example Project:
Earthen Embankment: 35 feet high / 750 feet long
Principal Spillway: Concrete intake tower with low-level sluice gate
Emergency Spillway: Concrete-lined channel with control sill
Instrumentation: Piezometers and weirs

Task	Phase I- Planning & Desktop Study*	Phase II- Field Inspections & Investigations*	Phase III- Detailed Analysis & Reporting*
Surveying (Topographic, Bathymetric, LiDAR, Geophysical, Utilities)	5 days	10 days	20 days
Hydrological and Hydraulic Engineering	5 days	5 days	30 days
Geotechnical Engineering	5 days	35 days**	25 days
Structural Engineering	5 days	20 days**	20 days
Drafting	2 days	2 days	7 days
Conceptual Design Alternatives	-	-	20 days
Stakeholder / Regulatory Coordination	5 days	-	20 days
***Typical Timeline	3 weeks	8 weeks	18 weeks
Typical Total Timeline	8 months		

**Schedule values are indicative and represent typical durations observed for similar dam safety inspection efforts. Actual durations may vary based on site conditions, data availability, weather, access constraints, and regulatory coordination.*
***Timeline accounts for scoping and executing investigations.*
****Typical timelines assume some of the activities will be performed concurrently.*

Detailed Inspection Timeline – Example: High-Complexity Dam

Example Project:

Earthen Embankment: 50 feet high / 1000 feet long
Principal Spillway: Concrete gravity structure with a gated ogee crest
Gates: Tainter gates and low-level sluice gates
Emergency Spillway: Concrete-lined channel with control sill
Instrumentation: Piezometers, inclinometers, settlement monuments, weirs

Task	Phase I- Planning & Desktop Study*	Phase II- Field Inspections & Investigations*	Phase III- Detailed Analysis & Reporting*
Surveying (Topographic, Bathymetric, LiDAR, Geophysical, Utilities)	5 days	15 days	20 days
Hydrological and Hydraulic Engineering	7 days	5 days	30 days
Geotechnical Engineering	7 days	40 days**	30 days
Structural Engineering	7 days	35 days**	25 days
Drafting	3 days	5 days	10 days
Conceptual Design Alternatives	-	-	35 days
Stakeholder / Regulatory Coordination	5 days	-	25 Days
***Typical Timeline	3 weeks	14 weeks	25 weeks
Typical Total Timeline	12 months		

**Schedule values are indicative and represent typical durations observed for similar dam safety inspection efforts. Actual durations may vary based on site conditions, data availability, weather, access constraints, and regulatory coordination.*
***Timeline accounts for scoping and executing investigations.*
****Typical timelines assume some of the activities will be performed concurrently.*

Approximate Level of Effort

These values reflect indicative professional service costs commonly used for early planning, budgeting, and risk discussion for dam safety detailed inspections. They are not bids, fee proposals, or not-to-exceed values.

	Low-Complexity		Medium -Complexity		High-Complexity	
Component	Low	High	Low	High	Low	High
Surveying (Topographic/LiDAR, Bathymetric, Geophysical, Utilities)	$15,000	$ 20,000	$ 20,000	$ 30,000	$ 30,000	$ 45,000
Hydrological and Hydraulic Engineering	$25,000	$ 45,000	$ 45,000	$ 60,000	$ 60,000	$ 70,000
Geotechnical Engineering	$20,000	$ 40,000	$ 50,000	$ 80,000	$100,000	$ 130,000
Structural Engineering	$10,000	$ 20,000	$ 30,000	$ 60,000	$ 70,000	$ 130,000
Drafting	$10,000	$ 20,000	$ 30,000	$ 50,000	$ 60,000	$ 90,000
Programmatic Costs (Project Management, QA/QC, Regulatory Coordination, typically 10-20% of technical fee)	$ 15,000	$ 20,000	$ 30,000	$ 44,000	$ 60,000	$ 95,000
Engineering Contingency (10-25% of total fee)	$ 15,000	$ 40,000	$ 35,000	$80,000	$ 70,000	$ 135,000
Typical Cost Estimate Range	**$110,000**	**$ 205,000**	**$ 240,000**	**$ 324,000**	**$ 450,000**	**$695,000**

- *In addition to discipline-specific engineering costs, dam safety inspection efforts typically include project management, quality control, and regulatory coordination activities. These costs are often proportional to project complexity and inspection findings and should be considered in overall budgeting.*
- *Indicative cost ranges are provided for planning purposes and reflect typical professional service effort for dam safety detailed inspections. Actual costs may vary based on site conditions, data availability, inspection findings, regulatory coordination, and project-specific requirements. These values are intended for comparative and informational budgeting purposes only and do not represent fee proposals or not-to-exceed costs.*
- *Cost estimates were developed in 2026. 5% annual escalation should be included for inflation when estimating future costs.*

Detailed Inspection Timeline and LOE Assumptions

1. Surveying
   - Personnel has unimpeded access to the site
   - Minimal work (clearing) needed to conduct survey
   - Weather conditions are suitable for surveying method (e.g., drone-based LiDAR survey)
2. Hydrologic and Hydraulic Engineering
   - New models (HMS and RAS) need to be developed for any of the following reasons
     - Changes in regulations (PMP, SDF, etc.)
     - Significant changes in land usage within the watershed
     - Development downstream triggering hazard reclassification
     - No access to electronic files
   - Inspection of other structures and stream gages within the watershed
   - Inspection of downstream areas prone to flooding due to dam failure
3. Geotechnical Engineering
   - Inspect dam and appurtenant structures for signs of distress
   - Geotechnical subs available to start work shortly after request
   - Drill rigs can access site
   - Seepage modeling
   - Slope stability modeling w/ pseudo-static seismic analysis
   - Dynamic seismic analysis (high hazard dams in high-risk seismic zones)

Assumptions Continued

4. **Structural Engineering**
   - Inspect concrete structures for signs of distress
   - Perform concrete condition survey with non-destructive testing if no as-builts are available
   - Concrete coring and laboratory testing to evaluate alkali aggregate reactivity
   - Stability of concrete structures
5. **Iterative Regulator Feedback**
   - Assume one meeting with SCDES and stakeholders to discuss findings and recommendations
   - Assume two iterations of comment/response with SCDES
   - SCDES may request supplemental analyses after draft submission, requiring more time in Phase 3
6. **Data Quality Risk**
   - Poor as-builts or missing historical records shift effort from “analysis” to “reconstruction.”
7. **Detailed Inspection History**
   - Lean towards high estimates for dams without prior detailed inspections

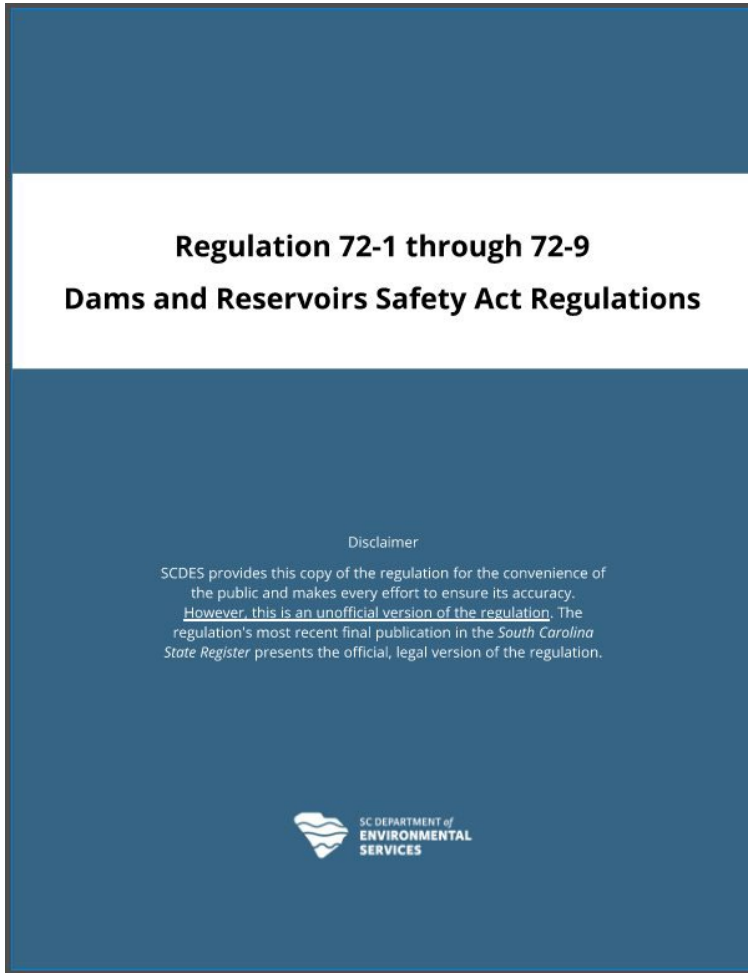
SC DEPARTMENT *of*
ENVIRONMENTAL
SERVICES

Conclusion

CDM Smith

Conclusion

- Detailed Dam Inspection Reports:
  - Document and Evaluate potential safety issues identified by a preliminary inspection or other SCDES order;
  - Identify alternatives and provide recommendations to address spillway capacity or concerns with dam/spillway structural integrity;
  - Provide the basis for preparation of a complete permit application with Final Design Plans and Specifications.



FEMA

Association of State Dam Safety Officials®

SC DEPARTMENT of ENVIRONMENTAL SERVICES

SC DEPARTMENT *of*
ENVIRONMENTAL SERVICES

Resources

CDM Smith

Resources

- South Carolina Department of Environmental Services (SCDES)
  - Dams and Reservoirs Safety Program
- Federal Emergency Management Agency (FEMA)
  - Dam Safety Guidelines
- U.S. Army Corps of Engineers (USACE)
  - Dam Safety Inspection Manual
- Association of State Dam Safety Officials (ASDSO)
  - Technical Manuals and Guidelines
- American Society of Civil Engineers (ASCE)
  - Dam Safety and Investigation Publications

Resources

- Link: https://des.sc.gov/programs/bureau-water/dams-reservoirs
- South Carolina Department of Environmental Services (SCDES) Dam Safety Program
  - Formerly: SC Department of Health and Environmental Control (SCDHEC)

SC DEPARTMENT *of* ENVIRONMENTAL SERVICES

During an emergency, call the Dam Safety Program 24/7: 803-898-1939