Hurricane Matthew in North Carolina

Dam Risk Management Assessment Report

FEMAP-1090 / DR-4285-NC / May 2017

Woodlake Dam (Moore County) post-flooding event; Credit: NC DEMLR

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Table of Contents

Preface

This report assesses dam safety within the context of the post-Hurricane Matthew environment in North Carolina. The findings demonstrate the importance of a coordinated approach towards managing risks associated with dams. A collaborative effort between the federal government, state, local, and tribal governments, local communities, and individuals will enable us to be better equipped to prepare for, respond to, mitigate against, and recover from dam failure. The authors' intent is to promote resiliency and reduce future dam-related risks in North Carolina and throughout the country. We greatly appreciate the support, coordination, information, and insights of the North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR) Dam Safety Program and the North Carolina Department of Public Safety (NC DPS), among many others.

This report is important reading for engineers and others with a responsibility for dams. The lessons learned and knowledge gained from this report could help in many areas that have dams within or with potential impact to their area(s) of responsibility.

Executive Summary

During the period of October 9 - 16, 2016, rainfall generated by Hurricane Matthew resulted in some areas of North Carolina experiencing precipitation totals of up to 15 inches of rainfall over 24 hours. The area of Fayetteville, North Carolina had received approximately 10" of rainfall in the week prior to Hurricane Matthew.

The United States Geological Survey (USGS) operates 263 real-time streamgages in North Carolina in cooperation with local, State, and Federal agencies. USGS deployed additional storm tide sensors prior to Hurricane Matthew. Based on information from USGS, at least 23 peaks of record were set on local rivers in North Carolina[1]. The 7-day observed precipitation totals from the National Oceanic and Atmospheric Administration (NOAA) and the recurrence interval estimates from the North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM) are provided in Figures 1 and 2, respectively.

Many dam breaches[2] occurred in North Carolina as a result of flooding from heavy rainfall generated by Hurricane Matthew. The North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR), the state agency responsible for dam regulation, confirmed twelve (12) state regulated dams[3] and eight (8) dams currently exempt from state regulation[4] breached during this event. In addition, the state responded to incidents at multiple dams where the dam did not breach. Over 400 inspections were completed by NC DEQ DEMLR over a 16 day period (before, during, and after the hurricane). Table 1 provides information on each of the 20 breached dams, including name, identification numbers, County, coordinates, hazard classification, and owner type. Fifteen (15) out of the twenty (20) dams are privately owned.

Over a period from October 2015 to October 2016, there have been 83 state regulated breached dams in two states, including the 12 state regulated dams in North Carolina during this event. In addition, South Carolina had 51[5] state regulated breached dams due to

[1] USGS Preliminary peak stage and streamflow data at selected stream-gaging stations in North Carolina and South Carolina for flooding following Hurricane Matthew, October 2016
https://pubs.er.usgs.gov/publication/ofr20161205

[2] Dam breach is defined in FEMA P-64 (2013) as an opening through the dam resulting in partial or total failure of the dam.

[3] Meets the state definition of a dam and does not qualify for an exemption from regulation

[4] Meets the state definition of a dam and qualifies for an exemption from regulation per the North Carolina Administrative Code

[5] SCDHEC Records on Breached Dams
http://www.scdhec.gov/HomeAndEnvironment/DisasterPreparedness/FloodUpdates/FailedDamReports/

flooding in October 2015 and 20[6] state regulated breached dams relating to flooding from Hurricane Matthew in 2016.

The full report addresses some key aspects of dam risk management such as mitigation planning, floodplain modeling and mapping, inspections, emergency action plans (EAPs) and evacuations, nonstructural actions, and dam risk communication and offers recommendations for improvement.

General Comments and Strategic Recommendations

The general comments and strategic recommendations within this report are provided for consideration by the varied organizations with a role in efficient and effective dam risk management. The goal is to provide information to assist in reducing risk related to dams and improving community resiliency. Some of the key recommendations are provided below. The complete list of general comments and strategic recommendations are available in Chapter 12 of this report.

Regulation

- **General Recommendation #2: Current Spillway Design Requirements**
  NC DEQ DEMLR should consider analyzing the percent Probable Maximum Precipitation (PMP) and recurrence interval experienced at each breached and overtopped dam site and determine whether any updates to the spillway design section of the North Carolina Administrative Code are needed.

- **General Recommendation #3: Exemptions to State Regulation**
  NC DEQ DEMLR should consider re-evaluating and possibly amending the policies and procedures for determining whether dams are regulated and the frequency by which their status is reassessed.

- **General Recommendation #6: NC DEQ DEMLR Funding for Emergency Dam Response Operations**
  The state of North Carolina should consider funding options for NC DEQ DEMLR to execute the authority to "take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir." These funds would assist in more pro-active risk reduction to residents of North Carolina from dam incidents and breaches.

[6] SCDHEC Hurricane Matthew-Related Updates on Dams; http://www.scdhec.gov/HomeAndEnvironment/DisasterPreparedness/FloodUpdates/MatthewDamBreaches/

Preparedness

- **General Recommendation #8: Lessons Learned from Emergency Action Plan (EAP) Activations and Evacuations**
  NC DPS and NC DEQ DEMLR should consider assessing the five EAP activations and three evacuations that occurred during this event and develop lessons learned. These lessons learned may be incorporated into policies, procedures, and protocols and inform outreach, training, and exercise efforts.

- **General Recommendation #10: Inclusion of Dams in State-Level Exercises**
  North Carolina Department of Public Safety (NC DPS), in coordination with NC DEQ DEMLR, should consider including realistic and challenging simulated dam incident and dam breaches in state-level exercises. These dam-related scenarios should incorporate complex conditions such as multiple dam breaches, road closures, and communication challenges. This will help test existing policies, procedures, protocols, EOC and dam safety operations, communications, reporting, confirmations, North Carolina's State Preparedness and Resource Tracking Application (NCSPARTA) usage, coordination, and accessing breached or flooded dam sites.

- **General Recommendation #12: Increase NC DEQ DEMLR Personnel Access to EAP Tool**
  NCEM-RM should consider coordinating with NC DEQ DEMLR to develop an agreeable number of authorized DEMLR users and then provide those users with the commensurate access and authorities to fully utilize the EAP Tool for NC DEQ DEMLR. It is important for life safety issues, such as dam breach, to have back-up plans and multiple points of coordination amongst the area's emergency responders. Allowing for multiple people would increase the ability to respond as needed should an emergency flood event occur.

- **General Recommendation #13: Communication of Emergency Action Plans (EAPs) Downstream**
  NC DPS, in coordination with NC DEQ DEMLR, should develop processes and procedures to ensure downstream states, counties, and jurisdictions potentially impacted by inundation from a breached dam are provided EAPs and inundation maps. These should be integrated by locals into their Emergency Operations Plans (EOPs), evacuation planning and maps, and consequence planning.

- **General Recommendation #14a: Emergency Action Plans (EAPs) and Downstream Consequence Education and Training**
  NC DEMLR DEQ, in coordination with NC DPS, with assistance from FEMA Region IV or others if requested, should provide training workshops and outreach materials to dam owners, local officials, and emergency managers to improve awareness of EAPs, inundation and evacuation maps, and the consequences of dam failures with the potential to impact their local jurisdiction.

- **General Recommendation #15: Integrate Emergency Action Plans (EAP) and inundation maps into Emergency Operations Plans (EOPs) and Evacuation and Consequence Planning**
  State and local communities should consider integrating EAP and inundation map information to help inform the development of their EOPs, evacuation maps, and consequence planning.

Response

- **General Recommendation #16: Dam Site Accessibility**
  NC DEQ DEMLR, in coordination with NC DPS, should consider developing plans, procedures, and protocols for developing backups to accessing key dam file related information, utilizing alternative methods to quickly and accurately assess dams of concern, and enable timely clarification or confirmations of reported incidents during future events when roadways are inaccessible.

- **General Recommendation #17: Dam Assessments and Reporting – Event Facts**
  NC DEQ DEMLR and NC DPS should consider developing or clarifying policies, procedures, or protocols for dam assessments, dam reporting, and confirming dam breaches and incidence in order to provide timely and consistent updates on the dam-related incidents and breaches and refute inaccurate information. A Communications Team or Point of Contact in the EOC that focuses on Rumor Control and clarification of the information is one way to accomplish this. NC DEQ DEMLR should consider having a staff member to update NCSPARTA regularly so that the latest updates are promptly placed in the system for all agencies and Public Information Officers (PIOs) to pull for reports.

- **General Recommendation #20: Policies, Procedures, or Guidance for FEMA Dam Safety Subject Matter Expertise in the National Response Coordination Center (NRCC), Regional Response Coordination Center (RRCC), Emergency Operations Center (EOC), or Joint Field Office (JFO)**
  FEMA should develop policies, procedures, or guidance for dam safety subject matter expertise in the NRCC, RRCC, EOC, or JFO. A FEMA Dam Safety liaison has

knowledge that can help inform the NRCC, RRCC, EOC, and JFO operations on dam related matters.

Recovery

- **General Recommendation #24: Dam Breach Analysis and Consequences**
  NC DEQ DEMLR should consider analyzing the probable failure modes of the breached dams identified in this report. NC DPS, in coordination with NC DEQ DEMLR, should consider analyzing some of the downstream consequences of the twelve regulated dam breaches and use this data to foster dam safety resilience. Appendix A includes considerations for additional analysis for each breached dam.

- **General Recommendation #25: Private Dams on Public Roads**
  NC DEQ DEMLR should consider coordinating with NC DPS, NC DOT, or others to develop procedures or protocols for providing information on dams of particular high public safety concern, due to inherent vulnerabilities (i.e. lack of adequate spillway capacity), NODs, or other reasons. These organizations can then use this information as is appropriate for inclusion into general annual budget planning, operations plans, emergency operations plans, mitigation plans, and coordination as needed.

Mitigation

- **General Recommendation #26: Dam Risk Communication in North Carolina Floodplain Management Program**
  Under their own authority, the North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM) should consider coordinating with NC DEQ DEMLR along with FEMA Region IV Risk MAP and Dam Safety to develop a strategy to more effectively capture dam risk. This will better enable communication of this information with appropriate entities in North Carolina. These measures might include, but are not limited to, referencing the dam name or State Dam ID on Flood Insurance Rate Maps (FIRMs), inclusion of dam outlet systems in the hydraulic modeling for the Flood Insurance Studies (FISs), and consideration of dams in hydrologic analysis for FISs. This might also include dams and residual dam risk in non-regulatory flood products and information into FRIS and FIMAN products as appropriate.

- **General Recommendation #27: Dam Risk and Mitigation Planning**
  NCEM-RM, in coordination with NC DEQ DEMLR, should consider undertaking more robust dam risk analyses and sharing this data with state and local mitigation planners and other relevant stakeholders tasked with updating mitigation plans.

- **General Recommendation #28: FEMA inclusion of LiDAR data in Decision Support System for Water Infrastructure Security (DSS-WISE) Lite**
  FEMA should consider investing resources to update the DSS-WISE Lite program enabling users to incorporate more accurate LiDAR data, where available.

- **General Recommendation #29: Dam Awareness Training and Outreach**
  NC DEQ DEMLR, in coordination with NC DPS, should consider providing dam awareness training and outreach on dam terminology, dam operations, spillway types, common failure modes, and EAPs for state and local emergency managers, local floodplain managers, county and city engineers, planners, local officials, and others. FEMA Region IV Dam Safety is available to support these efforts where appropriate and upon request by the state.

- **General Recommendation #30: Home Owner's Associations (HOA) and Dam Awareness**
  NC DEQ DEMLR, in coordination NC DPS or others, with support from FEMA Region IV as appropriate, should consider providing training, outreach, and exercises to amenable HOAs in helping them better understand their risks and carry out their responsibilities in maintaining, operating, repairing, rehabilitating, or removing their dams. This should include encouraging coordination between HOAs where a dam impacts multiple neighborhoods.

Table 1: Confirmed Dam Breach List from NC DEQ DEMLR as of November 7, 2016
(Sorted by County, then by State ID)

	NID ID	State ID	Dam Name	County	Latitude /Longitude	Hazard Classification	Owner Type
1	NC02137	CUMBE-025	Loch Lommond	Cumberland	35.0696, -78.9985	High	Private
2	NC01126	CUMBE-034	Long Valley Farm Lake Dam	Cumberland	35.2111, -78.9777	High	State
3	NC01142	CUMBE-050	Smith Lake Dam	Cumberland	34.863, -78.73	Low - Exempt	State
4	NC01144	CUMBE-052	Arran Lakes	Cumberland	35.029, -78.981	High	Private
5	NC01145	CUMBE-053	Rhodes Lake	Cumberland	35.2258, -78.6528	High	State
6	NC01148	CUMBE-055	Smith Lake Dam	Cumberland	35.224, -78.815	Low - Exempt	Private
7	NC02151	CUMBE-077	Mirror Lakes Dam	Cumberland	35.0549, -78.9218	High	Local Government
8	NC02160	CUMBE-086	Mount Vernon Estates	Cumberland	34.853, -78.876	High	Private
9	NC04797	CUMBE-088	Devonwood Lower Dam*	Cumberland	35.075, -78.995	High	Private
10	NC05621	CUMBE-099	Rayconda Upper	Cumberland	35.0267, -79.0222	High	Private
11	N/A	DUPLI-016	Rouse Pond	Duplin	35.14833, -77.79583	Low - Exempt	Private
12	NC01156	DUPLI-017	Maxwell Mill Pond*	Duplin	35.07, -77.78778	Low - Exempt	Private
13	NC01098	HARNE-047	Guy Lake Dam	Harnett	35.488, -78.71	Low – Exempt	Private
14	NC05301	HOKE-028	Sunset Lake Dam	Hoke	34.9438, -79.0722	High	Private
15	NC00948	LENOI-003	Tull Millpond Pond	Lenoir	35.155, -77.734	High	Private
16	NC01083	SAMP-016	Laurel Lake Dam	Sampson	35.011, -78.489	Intermediate - Exempt	Private
17	NC05468	SAMPS-047	House-Autry Dam	Sampson	35.18694, -78.3762	High	Private
18	NC00943	WAYNE-008	Durham Lake	Wayne	35.281, -78.057	Low - Exempt	Private
19	NC00944	WAYNE-009	H.F. Lee Power Station Cooling Lake Dam	Wayne	35.372075, -78.065632	High	Public Utility
20	NC00896	WILSO-009	Silver Lake	Wilson	35.802, -77.949	Intermediate - Exempt	Private

*Partially Breached per NC DEQ DEMLR

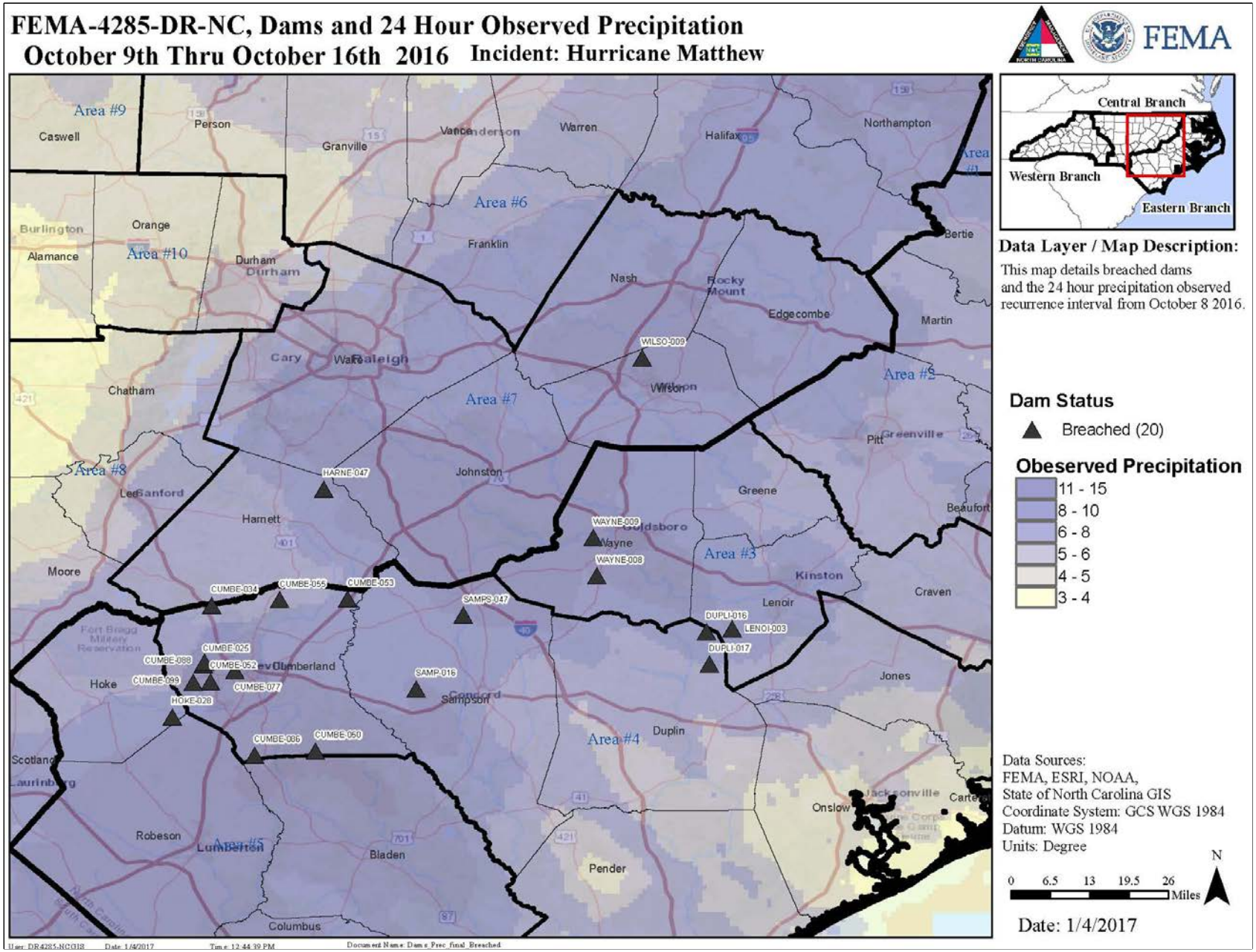

Figure 1: NOAA 7-day Observed Precipitation Totals and Dam Locations from Table 1

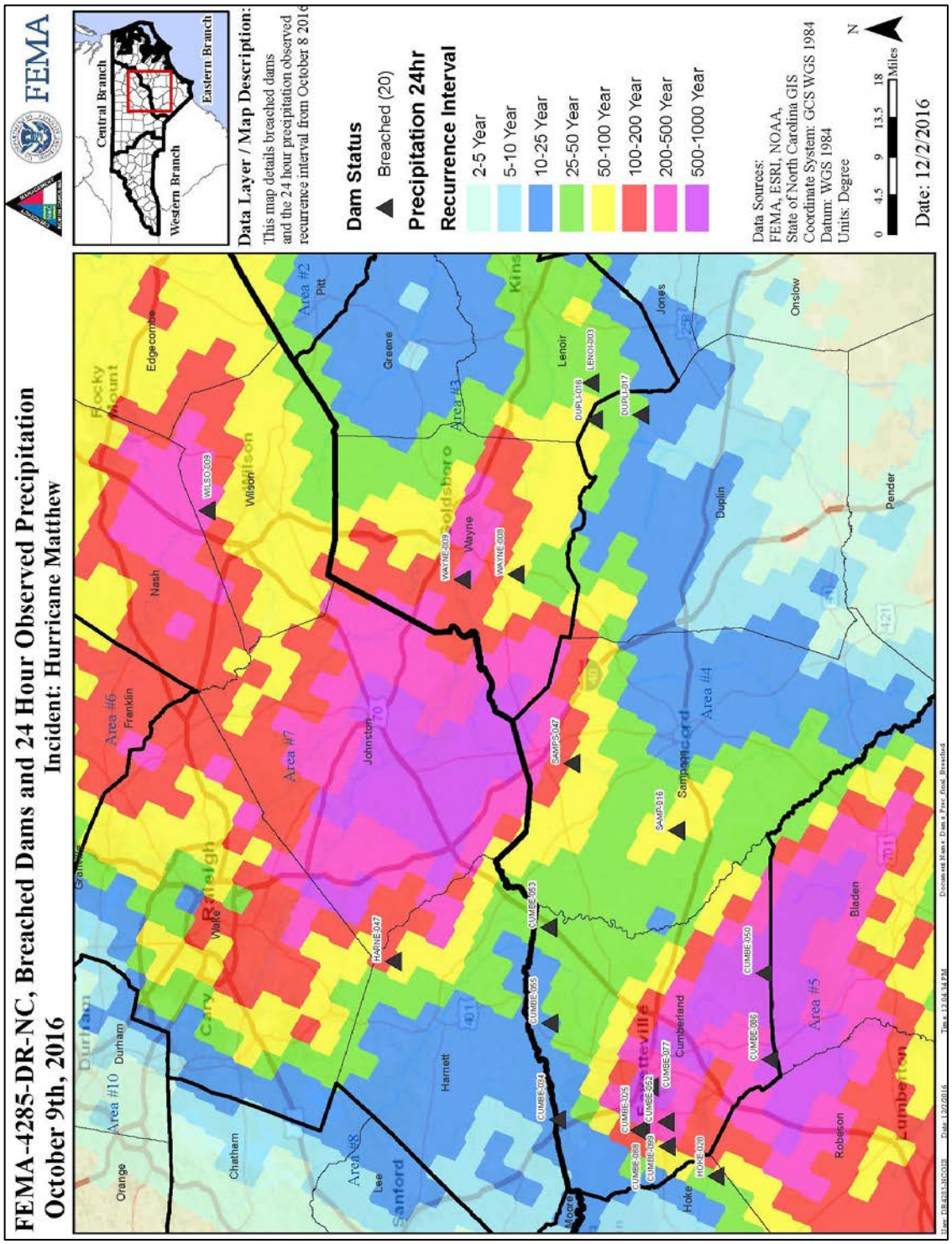

Figure 2: Dam Locations from Table 1 and Hurricane Matthew (October 8, 2016) 24-hour Recurrence Interval estimates from North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM) based on 24-hour precipitation data from the National Oceanic and Atmospheric Administration (NOAA)

[7] http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html

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Chapter 1 Purpose of Report

The purpose of this report is to provide general comments and strategic recommendations to improve dam risk management in North Carolina. "Risk", as applied to dams, is the product of the probability of a dam failure[1] multiplied by the consequences of the failure. Key aspects of dam risk management in the pre and post-disaster environment (floodplain modeling and mapping, mitigation planning, inspections, EAPs and evacuations, nonstructural actions, and dam risk communication) are discussed with the intent to improve coordination, resiliency, planning, and preparedness efforts related to dam safety in North Carolina.

This report contextualizes key management factors related to dam risk in North Carolina. The report describes each agency involved with dams and how they coordinate with one another as well as the current laws, rules, regulations, and initiatives applicable to dam safety within the state.

Improved coordination, communication, preparedness, mitigation, outreach, and response efforts relative to dams and dam safety will reduce future risks related to dams and dam failure.

[1] Dam Failure is defined in FEMA 148 as a catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. There are lesser degrees of failure, but any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. Lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Chapter 2 Introduction

Over a period from October 2015 to October 2016, there have been confirmed breaches of 83 state regulated dams in two states. North Carolina had 12 state regulated breached dams due to flooding from Hurricane Matthew in 2016. South Carolina had 51[2] state regulated breached dams due to flooding in October 2015 and 20[3] state regulated breached dams relating to flooding from Hurricane Matthew in 2016.

The Water Resources Reform and Development Act of 2014 (WRRDA)[4] - Title III, Subtitle A, Sec. 301 includes the following objectives for the National Dam Safety Program, which the Federal Emergency Management Agency (**FEMA**) is the lead agency:

- **Objective 2)** Encourage acceptable engineering policies and procedures to be used for dam site investigation, design, construction, operation and maintenance, and emergency preparedness
- **Objective 4)** Develop and implement a comprehensive dam safety hazard education and public awareness initiative to assist the public in preparing for, mitigating, responding to, and recovering from dam incidents

FEMA has a vital role in dam safety with a mission and commensurate authorities to extensively coordinate across all levels of government, the private sector, non-profits, and the general public to improve dam safety and reduce risk from dam failure.

To improve dam safety and reduce risk from dam failure, there must be a continued partnership with FEMA, other federal agencies, states, local government, the private sector, non-profits, and the general public.

In addition, the FEMA Administrator delegated authority for the following relevant National Dam Safety activities pursuant to Section 8 of the National Dam Safety Program Act, Pub. L. No. 92-367 (1972) (codified as amended at 33 U.S.C. § 467f) in February 2012:

a. Act as a liaison between FEMA and federal, state, local, and private partners to identify and assess high risk dams and to work with partners to develop community and regional preparedness, response, recovery, and mitigation strategies for those risks

b. Coordinate consideration of dam risks into multi-hazard planning, exercise planning and execution, and emergency operation planning and activities

[2] SCDHEC Records on Breached Dams
http://www.scdhec.gov/HomeAndEnvironment/DisasterPreparedness/FloodUpdates/FailedDamReports/
[3] SCDHEC Hurricane Matthew-Related Updates on Dams;
http://www.scdhec.gov/HomeAndEnvironment/DisasterPreparedness/FloodUpdates/MatthewDamBreaches/
[4] https://www.gpo.gov/fdsys/pkg/PLAW-113publ121/html/PLAW-113publ121.htm

c. Work across FEMA Directorates and with federal, state, local, and private partners to develop dam risk communication and public awareness strategies

d. Provide subject matter expertise in the FEMA Regional Response Coordination Center and/or Joint Field Office during dam-related emergencies and disasters

2.1 FEMA Regions and Dam Safety Community Build Partnerships

Prior to the Delegation of Authority, FEMA Regions did not generally coordinate directly with Federal or State dam safety programs. The FEMA Region IV Dam Safety Program has established relationships within the dam safety community, including some federal agencies, state agencies, and other stakeholders. This has broadened the awareness of dam safety and risk and prompted additional coordination by floodplain managers, emergency managers, design professionals, dam owners and operators, flood mappers, planners (land use, mitigation, response, preparedness, and others), FEMA recovery, and others. These partnerships have resulted in a heightened awareness of the risks associated with dams across agencies and organizations involved with preparedness, response, recovery, and mitigation activities, including: FEMA Region IV, the Regional Resource Coordination Center (RRCC), State Emergency Operations Centers (EOCs), Joint Field Offices (JFOs), at FEMA Headquarters, and with the National Dam Safety Review Board (NDSRB) and Interagency Committee on Dam Safety (ICODS)[5]. As demonstrated by the integral contributions of the FEMA Region IV Dam Safety liaison during response and recovery operations in North Carolina, it is imperative that FEMA Regions provide a dam safety presence in RRCCs, JFOs, and State EOCs when appropriate.

2.2 Importance of State Regulatory Agencies

State regulatory agencies fulfill a critical role by regulating tens of thousands of dams designed and constructed to various standards, if any, as many were constructed prior to state regulations. These agencies are essential to ensure state regulated dams are properly designed, constructed, and maintained.

2.3 Comprehensive Dam Risk Management

Comprehensive dam risk management includes, but is not limited to:

- Structural and nonstructural actions on a particular dam

[5] National Dam Safety Review Board and Interagency Committee on Dam Safety; https://www.fema.gov/national-dam-safety-review-board-and-interagency-committee-dam-safety

- Routine and special inspections, instrumented monitoring, structural analyses, and site investigations of a dam
- Development and exercising of dam owner emergency action plans for a particular dam or cascading dam breaches
- State and local preparedness through integration of emergency action plans into emergency operation plans, development of evacuation maps based on inundation maps, and exercises related to dam failure and incident
- Response operation planning and recovery planning for particular dam breach, incident, or operational release scenario
- Mitigation planning
- Floodplain modeling and mapping
- Community land use planning and floodplain management relating to dams
- Dam risk communication
- General dam terminology awareness outreach amongst stakeholders and the public

2.4 Important Elements of This Report

- Relevant Hurricane Matthew storm event information
- The overall context within which dam risk management currently operates before, during, and after a disaster
- Background information and context for Emergency Action Plans (EAP), dam breach inundation maps, Emergency Operations Plans (EOP), evacuation maps, mitigation plans, FEMA floodplain mapping, and dam regulation both through national guidance and within North Carolina
- An account of dam-related efforts in response, recovery, and mitigation for this event by some of the different organizations involved
- An account of the interim risk reduction actions taken on key dams of interest to reduce risk during this event
- Fundamental dam and dam risk information available on each of the state regulated breached dams and the breached dams exempt from state regulation
- General comments compiled for the reader based on assessment of the 20 breached dams
- Strategic comments and recommendations to help improve dam preparedness, response, recovery, and mitigation

Readers are encouraged to reference the South Carolina FEMA Mitigation Dam Task Force Strategic White Paper on Dam Risk (2015) as this report is a companion to the white paper. Although each disaster is different and this report is specific to the dam breaches and

incidents in North Carolina, the SC white paper provides additional insight into dam risk management prior to, during, and after a disaster.[6]

2.5 Intended Audience

- The Joint Field Office (JFO) leadership
  - Federal Coordinating Officer (FCO) and appropriate staff
  - State Coordinating Officer (SCO) and appropriate staff
  - JFO Mitigation Branch Director and appropriate staff
  - State Hazard Mitigation Officer (SHMO) and appropriate staff
  - Other state agencies as is appropriate
- FEMA and FIMA Leadership with further dissemination as is appropriate
- FEMA Mitigation Region IV Leadership with further dissemination as is appropriate
- FEMA Incident Management Assistance Team (IMAT) Infrastructure/Public Assistance (PA) as is appropriate
- The National Dam Safety Program
- The Regional Dam Safety Program
- The State Dam Safety Regulatory Agency
- State Emergency Management
- Dam Safety and Emergency Management professionals
- Mitigation Planners and Mitigation Grants Specialists
- Other stakeholders having an interest in dam risk management

2.6 Report Limitations

- This study focuses on 12 state regulated breached dams and 8 dams currently exempt from state regulations with specific information provided on several dams of interest. North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR) confirmed the list of breached dams in Table 1 of this report, as of November 7, 2016.
- The writers of this report did not perform site visits to each of the breached dams in Table 1.
- Information on each state regulated dam is primarily from the 2016 United States Army Corps of Engineers (USACE) National Inventory of Dams (NID) and the October 2016 North Carolina dam inventory. The NID and state inventories were referenced for name, stream or river, hazard class, NID ID, dam type, purpose, length, drainage area, surface area, max discharge, max storage, county, nearest downstream city/town, State ID,

[6] FEMA Mitigation Dam Task Force Strategic White Paper on Dam Risk
DR-SC-4241 November 17, 2015 Final Report; https://www.fema.gov/media-library/assets/documents/112356

owner type, year completed, year modified, height, EAP status, and pre-event condition for each state regulated failed dam in this report.

- The North Carolina dam inventory (October 2016), provided by NC DEQ DEMLR, was used for information in Appendix A. In a few instances their information was different than the field from the NID.
- Effective FEMA Flood Insurance Study (FIS), Flood Insurance Rate Map (FIRM), and FEMA Preliminary Flood Insurance Study information, with associated flood modeling, was retrieved from the FEMA Map Service Center and / or North Carolina's Flood Risk Information System (FRIS).
- This report was developed by a FEMA Mitigation Dam Risk Assessment Team within a short timeframe.

2.7 Applicability

Many of the recommendations relate to challenges applicable across states, not solely in North Carolina. Some recommendations may be applicable or beneficial to other states or organizations.

Chapter 3 Methodology

This report was developed by a team from FEMA, which consisted of two Civil Engineers from the FEMA Region IV Dam Safety Program, a Civil Engineer from the FEMA Risk Analysis Branch, an Emergency Management Specialist from FEMA Headquarters (HQ), and a Mitigation Planner from the FEMA Region IV Risk Analysis Branch. Reviews were provided by a team that included FEMA HQ (Dam Safety, National IMAT, Mitigation), FEMA Regions (IV and VIII), the NC JFO, the State Dam Safety Regulator, the State Risk Management Section, the State Emergency Management Division, and two members representing the Association of State Dam Safety Officials (one private sector dam engineer and an engineer who is the Chief of another state dam safety program).

Due to limited time and resources to complete this strategic assessment, the team focused on ***the 12 breached state regulated dams and the 8 breached dams that are currently exempt from state regulation.*** These dams are in the dam inventory of the NC DEQ DEMLR with more detailed information available on dams regulated by the state. Information on risk reduction response actions for key dams of interest has been provided to inform readers of important response actions taken that might be of benefit for readers or organizations in future events.

The North Carolina Dam Safety Law of 1967, S.L. 2009-390, S.L. 2015-7, the Coal Ash Management Act of 2014, and the North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety include the requirements for a state regulated dam, which will meet the state definition of a dam and will not qualify for an exemption from regulation. There are many breached impoundments that do not meet the state definition of a dam and are unregulated. These unregulated breached impoundments are not addressed in this report. Although a hog waste lagoon could meet the state definition of a "dam" and be regulated by NC DEQ DEMLR as a dam, none of the hog waste lagoons flooded during this event were identified by NC DEQ DEMLR as being regulated structures that breached. As such, lagoons are not addressed further in this report.

3.1 Resources Used for Report

The team gathered information from:

1) The 2016 National Inventory of Dams[7] for breached dams

[7] USACE October 2016 – The NID website states "The 2016 National Inventory of Dams database is now available!"

2) FEMA approved State and Local Mitigation Plans for communities having state regulated breached dams or breached dams that are exempt from state regulation
3) FEMA Mitigation Planning website
4) Google Earth and Google Maps for dam locations
5) Photos from the Civil Air Patrol
6) FEMA Flood Insurance Study (FIS) data from breached dams in eight impacted counties
7) FEMA Flood profiles within the FIS report
8) FEMA Flood Insurance Rate Maps (FIRMs) from breached dams in eight impacted counties
9) FEMA Preliminary Flood Insurance Studies
10) FEMA Risk MAP data from breached dams in eight impacted counties
11) NC DPS coordination and event information
12) NC DEQ DEMLR coordination and event information
13) NC DEQ DEMLR pre-event inspection reports
14) NC DEQ DEMLR post-event information and photos
15) North Carolina dam inventory (October 2016)
16) FEMA JFO Public Assistance
17) FEMA IMAT Infrastructure information
18) Department of Homeland Security (DHS) Infrastructure Protection (IP)
19) North Carolina Flood Risk Information System (FRIS)
20) North Carolina Flood Inundation Mapping and Alert Network (FIMAN)
21) FEMA JFO Environmental and Historic Preservation (EHP)
22) North Carolina dam safety legislation, administrative code, and policy
23) NOAA Precipitation data for this event
24) Recurrence interval estimates from the North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM)
25) FEMA WebEOC
26) North Carolina's State Preparedness and Resource Tracking Application (NCSPARTA)
27) NC DPS 2012 Emergency Operations Plan
28) NC DPS 2009 Emergency Operations Center; Standard Operating Guide

Comments and considerations relevant to each dam were reviewed to identify trends. The general comments and strategic recommendations are summarized in Chapter 12 of this report. They are written in actionable, practical language and can be executed to help improve future dam risk management not only in North Carolina, but in other organizations and states as is applicable.

Chapter 4 Flood Risk Program in North Carolina

The Floodplain Mapping Program in North Carolina is part of North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM). The State has been a Cooperating Technical Partner (CTP) since September 15, 2000. The CTP program focuses on stretching limited funding dollars, leveraging local knowledge and expertise and increasing local involvement and ownership of FEMA's Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs). NCEM-RM has continued to be on the innovative technology forefront on development of digital flood insurance rate maps, flood warning and alert systems, all hazard identification, risk management, and hazard mitigation planning, highlighted in some of the web applications below.

4.1 North Carolina Flood Risk Information System (FRIS)

The Flood Risk Information System (FRIS) contains digitally accessible Flood Insurance Studies, Flood Insurance Rate Maps (DFIRM), flood information, risk information, geospatial base map data, imagery, LIDAR data, and hydraulic and hydrologic models. Additionally, application functionalities include point and click regulatory base flood elevations, regulatory flood zones, flooding source, and other important information to the DFIRM. Also, the site contains building level flood risk information and financial vulnerability assessment tools, a flood insurance rate estimator, and digitally derived on-demand FIS reports, DFIRMs, and a flood risk data geospatial export tool. Finally, North Carolina collected state-wide legacy LIDAR data from 2001-2005 (3-meter bare earth spacing) and recent high-resolution QL2 (2 points per meter) level data for over 50 counties, which are available for download through the North Carolina Spatial Data Download (SDD) [9] website.

4.2 North Carolina Flood Inundation Mapping and Alert Network (FIMAN)[10]

The North Carolina Flood Inundation Mapping and Alert Network (FIMAN) provides rainfall and stream/coastal elevation information from a network of over 550 gages, and includes a number of tools to analyze, map, and communicate flood risks in

FIMAN can display areas that are currently being, or expected to be, inundated by flood waters during a storm event as the event is happening. This can be used to inform risk-based decisions during flooding.

[8] NC FRIS; http://fris.nc.gov/fris/Home.aspx?ST=NC
[9] NC SDD; https://rmp.nc.gov/sdd/
[10] NC FIMAN; https://fiman.nc.gov/fiman/

real-time. One of the most powerful aspects of FIMAN is the ability to display areas that are currently being, or expected to be, inundated by flood waters during a storm event as the event is happening. This real-time flood inundation mapping is based on a combination of current and forecasted gage information, pre-processed data sets, and sophisticated algorithms. FIMAN also generates, within selected areas, information on water depth in each building affected by current or forecasted flooding along with estimated flood damage costs. This information can be used to inform risk-based decisions during flooding. The FIMAN system was used prior to and during Hurricane Matthew to support NCEM preparedness, operations, response, and evacuation decisions.

4.3 The Risk Management Portal

The Risk Management Portal, developed in accordance with North Carolina General Statute 166A, provides access to information and web-based tools for improved dissemination of information, geospatial data, and planning for all-hazard risk management in North Carolina. The portal includes all hazard mapping and analysis information for coastal flooding, levee failure, wildfire, tornado, earthquake, dam failure, hurricane winds, thunderstorm winds, and extratropical winds. The web application also contains enhanced planning tools for development of risk management plans including County Disaster Recovery Plans, Emergency Action Plans for dams (Dam EAPs), Flood Risk Management Plans, ESF-12 Fuel Risk Management Plans, Child Care Emergency Preparedness and Response Plans, Licensed Care Facility Risk Management Plans, and Mental Health Care Facility Risk Management Plans. The risk management web-based automated Dam EAP tool was developed in coordination with NC DEQ DEMLR, which allows dam owners to develop an EAP through a series of on-line forms and supplementary data upload functionality. The data in the on-line Dam EAP tool is stored in a database and EAPs generated through the tool can be readily copied, updated, and maintained within the application for those having access to the tool.

Chapter 5 Flood Insurance Studies (FIS) and Dams

5.1 Overview of Flood Insurance Studies (FIS)

A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community, studied using hydraulic and hydrologic engineering methodology. When a flood study is completed for the National Flood Insurance Program (NFIP), the information and maps are assembled into a Flood Insurance Study (FIS). The FIS report contains detailed flood elevation data in flood profiles and data tables.[11] It is the official source for Base Flood Elevations (BFEs). The Flood Insurance Rate Map (FIRM) contains the graphical depiction of the Special Flood Hazard Area and floodway extents. The effective FIS is official and should be used for National Flood Insurance Program (NFIP) purposes. Preliminary data is presented as the best information available at the time.

A FIS typically includes:

- An introduction, with information on the NFIP, the Purpose of Flood Insurance Study, and FIS Components
- A Floodplain Management Applications section with information on Floodplains, Floodways, Base Flood Elevations, and the Watershed Characteristics
- A section on Insurance Applications
- Area Studied section with Basin Characteristics, Principal Flood Problems, Historic Flood Elevations, Flood Protection Measures, and Scope of Study
- Engineering Methods section with Hydrologic Analyses and Hydraulic Analyses
- A Mapping Methods section with Vertical and Horizontal Control, Base Map, and Floodplain and Floodway Delineation
- A section describing the main flood map revision processes that can be conducted to revise a community's effective flood map, Contracted Restudies, and Map Revision History
- A Study Contracting and Community Coordination section with Authority and Acknowledgements
- A Guide to Additional Information
- A Bibliography and References section

A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community, studied using engineering methodology.

[11] https://www.fema.gov/flood-insurance-study

The County Flood Insurance Studies for areas impacted by dam breaches during this event were assessed for information on dams. The following is dam information from these County FISs.

5.2 Cumberland County (Preliminary FIS dated April 30, 2014, Projected Effective date June 30, 2017, and Effective FIS dated June 18, 2007)

The Cape Fear River Basin is currently being studied county-wide in Cumberland County in North Carolina. The preliminary FIS for Cumberland County is available for information on the Cape Fear River Basin. Excerpts from the preliminary FIS that reference dams are included below.

The hydrologic analyses provides the following tables with references to dams:

Excerpts from *Table 13 – Summary of Discharges (Preliminary FIS)*

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Beaver Dam Creek (page 11)	*Approximately 750 feet downstream of Hayner Lake Dam*	*18.90*	*	*	*2,470*	*

*Information not available/calculated

In addition, Section 4.4 Flood Protection Measures states "*Flood protection measure may be structural (such as levees, dams and reservoirs) or non-structural (such as land use management ordinances, policies or practices)*."

Table 6 "Non-levee flood protection Measures' is not applicable in Cumberland County.

Table 7 "Levee protection measures" is not applicable in Cumberland County.

The effective Cumberland County FIS (revised June 18, 2007) provides information for basins not currently being studied county-wide with additional references to dams as follows:

Section 4.4 – Flood Protection Measures includes the following table with references to dams:

Excerpts from *Table 3 – Flood Protection Measures* (Page 12) (Effective FIS)

Type of Measure	*Description of Measure Or Location and Description of Structure*
Multiple-Purpose Reservoir Project	*B. Everett Jordan Dam, located on the Haw River 40 miles upstream of Cumberland County, constructed by the USACE. Began flood control operations in 1974 and provides an estimated 8 foot reduction in the 1 % annual chance flood stages at the USGS gage at Fayetteville in Cumberland County*
Dams (non- flood control)	*Tank Creek Tributary A*

Section 4.5 – Scope of Study includes the following table with references to dams:

Excerpts from *Table 5-Flooding Sources Studied by Detailed Methods: Redelineated (Effective FIS)*

Source	*Riverine Sources*		*Affected Communities*
	From	*To*	
Cedar Falls Creek (page 14 of FIS)	*The Confluence with Carvers Creek*	*Approximately 0.6 miles Upstream of Wooded Lake Dam*	*City of Fayetteville, Cumberland County (Unincorporated Areas)*
Little Cross Creek (page 15 of FIS)	*The Confluence with Cross Creek*	*Approximately 300 feet upstream of Kornbow Lake Dam*	*City of Fayetteville*

Section 5.1 Hydrologic Analysis includes the following table with references to dams:

Excerpts from *Table 7 – Summary of Discharges (Effective FIS)*

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Beaver Creek Tributary A[3] (page 21 of FIS)	*At dam*	*2.5*	*490*	*940*	*1,260*	*1,930*
Beaver Creek Tributary B[3] (page 21 of FIS)	*At dam*	*1.5*	*380*	*740*	*1,000*	*1,520*

Flooding						
						0.2% Annual Chance
Blounts Creek (page 23 of FIS)	*Approximately 0.4 miles upstream of Club Lake Dam*	*1.1*	*270*[2]	*570*[2]	*750*[2]	*1,430*[2]
Carvers Creek Tributary (page 25 of FIS)	*At dam*	*1.4*	*260*	*540*	*710*	*1,270*
Country Club Branch Tributary A (page 26 of FIS)	*At Country Club Lake Dam*	*2.7*	*520*	*1,040*	*1,350*	*2,520*
Little River (page 28 of FIS)	*Approximately 0.5 miles upstream of dam*	*318.8*	*4,460*	*7,000*	*8,210*	*11,700*
Little River Tributary 1 (page 30 of FIS)	*Approximately 200 feet downstream of dam*	*3.2*	*	*	*321*	*
Stewarts Creek (page 40 of FIS)	*Approximately 0.8 miles downstream of King Lake Dam*	*7.3*	*579*	*1,020*	*1,230*	*1,860*
Stewarts Creek (North) (page 40 of FIS)	*Below Dam*	*5.9*	*610*[2,3]	*1,320*[2,3]	*1,780*[2,3]	*2,650*[2,3]
Swans Creek (page 41 of FIS)	*Approximately 710 feet upstream of Swan Creek Dam*	*1.7*	*	*	*203*	*
Tank Creek Tributary A[2,3]	*At dam*	*2.0*	*320*	*570*	*750*	*1,050*

**-Information not available/calculated*

1-Discharges regulated by B. Everett Jordan Dam

2-Discharges reduced by storage

3-Discharges increased by urbanization in the watershed

5.3 Duplin County (Preliminary date April 30, 2014)

The Cape Fear River Basin and Lumber River Basin are currently being studied county-wide in Duplin County in North Carolina. The preliminary FIS for Duplin County is available. Excerpts from the preliminary FIS that reference dams are included below.

The flood protection measures section on page 9 (of Volume B) states that "*Flood protection measures may be structural (such as levees, dams, and reservoirs) or nonstructural (such as land-use management ordinances, policies, or practices)"* and provides the following table with references to lakes and reservoirs:

Excerpts from Table 6 – Non-Levee Flood Protection Measures

Flooding Source		*Measure*		*n of Structure*
Little Rockfish Creek	*CF033LRC_DAM1*	*DAM*	*	*

*Information not available/calculated

5.4 Harnett County FIS (Effective date October 6, 2006)

The Cape Fear River Basin is currently being studied county-wide in Harnett County in North Carolina. The preliminary FIS for Harnett County is not available.

In the basin characteristics section on page 9 of the FIS, the Cape Fear River basin is described as "*The Cape Fear River continues southeastward through a series of three locks and dams and finally enters the Atlantic Ocean. Everett Jordan Lake, a reservoir along the Haw River near its confluence with the Deep River, regulates flood flows for the entire Cape Fear River".*

The flood protection measures on Page 11 of the FIS states that "*Flood protection measures are not known to exist within the study area. Although there are small dams located on the streams studied, none provides measurable protection from major events such as the 1% annual chance flood".*

5.5 Hoke County FIS (Effective date October 6, 2006)

The Cape Fear River Basin is currently being studied county-wide in Hoke County in North Carolina. The preliminary FIS for Hoke County is not available.

In the basin characteristics section on page 10 of the FIS, the Cape Fear River basin is described as "*The Cape Fear River continues southeastward through a series of three locks and dams and finally enters the Atlantic Ocean. Everett Jordan Lake, a reservoir along the*

considered acceptable in such a spillway when its average frequency of use is predicted to be no more frequent than once in 25 years for existing class B and for class A dams except for small class A dams designed in accordance with all design criteria established by the U.S.D.A, Soil Conservation Service, and as contained in Engineering Standard 378 of the U.S.D.A., Soil Conservation Service; once in 50 years for new class B, small and medium new class C, and existing class C dams; and once in 100 years for large and very large new class C dams. The dam sizes referred to in this Subsection are defined in (e) of this Rule.

(c) *Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel lining, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water-tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or underseepage from the foundation which might cause saturation of underlying materials or uplift against the undersurfaces.*

(d) *Within 15 days following passage of the design storm peak, the spillway system shall be capable of removing from the reservoir at least 80 percent of the water temporarily detained in the reservoir above the elevation of the primary spillway.*

(e) *It is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, other hydrologic factors, and specific cultural features have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for specific site conditions based on quantitative analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. A design storm more frequent than once in 100 years will not be acceptable for any class C dam. In lieu of quantitative analysis, the following tables shall be used as criteria for spillway design storms and permissible velocities for vegetated earth spillways:*

Criteria for Spillway Design Storm[1] Size Classification[17]

Size	**Total Storage (Ac-Ft)[1]**	**Height (Ft)[1]**
Small	less than 750	less than 35
Medium	equal to or greater than 750 and less than 7,500	equal to or greater than 35 and less than 50

[17] North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety

The flood protection measures section on page 13 states that "*Flood protection measures may be structural (such as levees, dams, and reservoirs) or nonstructural (such as land-use management ordinances, policies, or practices)"* and provides the following table with references to lakes and reservoirs:

Table 4 – Flood Protection Measures

Type of Measure	*Description of Measure Or Location and Description of Structure*
Reservoir	*Fall Lake, multi-purpose reservoir on the Neuse River. Will effect about a 1 foot stage reduction in the 1 % annual chance flood in Lenoir County*
Watershed Improvement Project	*On Bear Creek that includes several small reservoirs and channel improvements. This project provides significant protection from the 10% and 2% annual chance floods but little protection from the 1% and 0.2% annual chance floods.*

It also mentions "*several small reservoirs along Bear Creek…This project provides significant protection from the 10% and 2% annual chance floods but little from the 1% and 0.2% annual chance floods*".

5.7 Sampson County (Preliminary date 4/30/2014)

The Cape Fear River Basin is currently being studied county-wide in Sampson County in North Carolina. The preliminary FIS for Sampson County is available. Excerpts from the preliminary FIS that reference dams are included below.

The scope of study provides the following tables with references to dams:

Excerpts from: *Table 10 - Flooding Sources Studied by Detailed Methods: Limited Detailed*

Source	*Riverine Sources*		*Affected Communities*
	From	*To*	
Encoh Mill Creek (page 12 of FIS)	*Confluence with South River*	*Approximately 1.4 miles upstream of dam*	*Sampson County*
Little Juniper Run (page 13 of FIS)	*Confluence with Big Juniper Run*	*Approximately 1,580 feet upstream of Little Juniper Dam*	*Sampson County*

Excerpts from *Table 13 - Summary of Discharges*

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Rowan Branch (page 29 of FIS)	*Approximately 1,420 feet downstream of unnamed dam crossing*	*7.9*	*	*	*1,506*	*
	Approximately 0.4 miles downstream of unnamed dam crossing	*3.3*	*	*	*917*	*
Mingo Swamp (page 28 of FIS)	*Approximately 750 feet downstream of Hayner Lake Dam*	*18.9*	*	*	*2,470*	*

*Information not available/calculated

5.8 Wayne County (Preliminary FIS dated 4/30/2014 and Effective FIS dated 04/16/2013)

The Neuse Basin is currently being studied county-wide in Wayne County, North Carolina. The preliminary FIS for Wayne County is available for information on the Neuse Basin. Excerpts from the preliminary FIS that reference dams are included below.

The flood protection measures and provides the following table with a reference to a dams:

Excerpts from (Page 8) *Table 6 - Non-Levee Flood Protection Measures* (Preliminary FIS)

Flooding Source	*Structure Name*	*Type of Measure*	*Location*	*Description of Measure*
Falls Lake	*N/A*	*Dam*	*Located upstream of Wayne County near Raleigh to lower the 1 % annual chance flood elevation by approximately 1 foot*	*Falls Lake*

N/A – Not Applicable

The effective Wayne County FIS (revised April 16, 2013) provides information for basins not currently being studied county-wide with additional references to dams as follows:

Section 4.1 – Basin Characteristics includes the following information regarding dams in the Cape Fear River Basin:

The Cape Fear River, the major waterway in the basin, begins at the confluence of the Haw and Deep Rivers, near the border of Chatham and Lee Counties. The Cape Fear River continues southeastward through a series of three locks and dams and finally enters the Atlantic Ocean. Everett Jordan Lake, a reservoir along the Haw River near its confluence with the Deep River, regulates flood flows for the entire Cape Fear River. (Page 10 in FIS)

Section 5.0 – Engineering Methods includes the following table with references to dams:

Excerpts from Table 10 – Summary of Discharges (Effective FIS)

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Burnt Mill Branch (page 30 of FIS)	*At dam at upper study limit*	*1.6*	*280*	*580*	*760*	*1,370*
Mills Creek (page 36 of FIS)	*At dam*	*2.7*	*500*	*946*	*1,210*	*2,180*
Walnut Creek (page 42 of FIS)	*Upstream of Walnut Creek Tributary A (downstream of dam)*	*15.4*	*800*	*1,575*	*2,190*	*4,110*
West Bear Creek (page 44 of FIS)	*Downstream of SCS Dam No. 3*	*4.2*	*25*	*395*	*750*	*1,925*

5.9 Wilson County (Effective April 16, 2013)

There are no on-going county-wide studies in Wilson County. A preliminary FIS is not available.

The flood protection measures section states that (page 10 in FIS) *"Flood protection measures may be structural (such as levees, dams, and reservoirs) or nonstructural (such as land-use management ordinances, policies, or practices)"*. The area study section provides the following tables with references to dams:

Excerpts from (page 17 in FIS) *Table 6-Flooding Sources Studied by Detailed Methods*

Source	*Riverine Sources*		*Affected Communities*
	From	*To*	
Moccasin Creek	*Approximately 60 feet downstream of Buckhorn Reservoir Dam*	*The Wilson/Nash County Boundary*	*Wilson County (Unincorporated Areas)*

Excerpts from *(page 36 in FIS) Table 8-Summary of Discharges*

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Moccasin Creek	*Approximately 1.1 mile downstream of Buckhorn Reservoir Dam*	*161.2*	*	*	*19,900*	*
	Approximately 0.4 mile downstream of Buckhorn Reservoir Dam	*143.9*	*	*	*18,300*	*

*Information not available/calculated

<u>Buckhorn Reservoir -</u> In the base map section (page 73 in FIS), there is the following information:

"Buckhorn Reservoir in Wilson County is a water supply reservoir. In 1998, a feasibility study recommended the expansion of the reservoir to fill an immediate need to increase the City of Wilson's water supply. Completed in May 1999, the new dam was constructed approximately 200 feet downstream of the existing dam, and raised the existing normal pool water surface elevation in the reservoir by 12 feet.

The location of the dam shown on the orthophoto and the DFIRM has been moved downstream based on the new dam. The shoreline of the lake is also not correctly shown on the orthophoto base due to the 12 foot increase in normal pool elevation caused by the construction of the new dam."

Chapter 6 FEMA Mitigation Planning[12]

State, tribal, and local governments engage their communities in multi-hazard mitigation planning to identify natural hazards that may impact them, identify strategies and activities to reduce any losses from those hazards, and establish a coordinated approach to implementing the plan. Currently, there are approximately 22,000 jurisdictions across the nation that have FEMA-approved hazard mitigation plans, and most of the plans are available online.

A FEMA-approved state hazard mitigation plan is a condition for receiving certain types of non-emergency disaster assistance, including funding for mitigation projects.

Developing hazard mitigation plans enables state, tribal, and local governments to:

- Increase education and awareness about threats, hazards, and vulnerabilities
- Build partnerships for risk reduction involving government, organizations, businesses, and the public
- Identify long-term strategies for risk reduction that are agreed upon by stakeholders and the public
- Identify cost effective mitigation actions, focusing resources on the greatest risks and vulnerabilities
- Align risk reduction with other state, tribal, or community objectives
- Communicate priorities to potential sources of funding

State, tribal, and local mitigation plans can advance several dam risk management goals.

6.1 Dam Risk in North Carolina Mitigation Plans

The FEMA Region IV Mitigation Planning Team assessed the state and multi-jurisdictional mitigation plans for areas impacted by dam breaches during this event. The following is dam information and summaries taken from these hazard mitigation plans, developed by the state, regional and local jurisdictions responsible for producing them.

North Carolina Enhanced State Plan (Updated 2013)

Dam failure is listed as a lesser hazard category in the North Carolina State Plan. Lesser hazards are identified in the enhanced state mitigation plan as hazards of secondary concern for North Carolina. The plan indicates that the number of North Carolina dams that were identified as structurally unsafe in 2010 was reported to be 39. The plan lists the

[12] http://www.fema.gov/hazard-mitigation-planning

historical occurrences of dam failure in North Carolina. The plan also illustrates the location of 1,055 high hazard dams based on information from the North Carolina dam inventory.

The majority of the counties in North Carolina participate in regional hazard mitigation plans, including all of the counties impacted by dam breach during this event. In the majority of cases, data was extrapolated from plans at the county level to include in the report. In a few instances, data in the report is at the regional level. Table 6.1 compiles the results of this analysis.

Table 6.1 Dam Referenced by Name in Multi-Jurisdictional Mitigation Plans

#	State ID	Name	County	Hazard Classification	Referenced by Name in Mitigation Plan
1	CUMBE-025	Loch Lommond	Cumberland	High	✓
2	CUMBE-034	Long Valley Farm Lake Dam	Cumberland	High	✓
3	CUMBE-050	Smith Lake Dam	Cumberland	Low - Exempt	X
4	CUMBE-052	Arran Lakes	Cumberland	High	✓
5	CUMBE-053	Rhodes Lake	Cumberland	High	✓
6	CUMBE-055	Smith Lake Dam	Cumberland	Low - Exempt	X
7	CUMBE-077	Mirror Lakes Dam	Cumberland	High	✓
8	CUMBE-086	Mount Vernon Estates	Cumberland	High	✓
9	CUMBE-088	Devonwood Lower Dam	Cumberland	High	✓
10	CUMBE-099	Rayconda Upper	Cumberland	High	✓
11	DUPLI-016	Rouse Pond	Duplin	Low - Exempt	✓
12	DUPLI-017	Maxwell Mill Pond	Duplin	Low - Exempt	✓
13	HARNE-047	Guy Lake Dam	Harnett	Low - Exempt	X
14	HOKE-028	Sunset Lake Dam	Hoke	High	✓
15	LENOI-003	Tull Millpond Pond	Lenoir	High	✓
16	SAMP-016	Laurel Lake Dam	Sampson	Intermediate - Exempt	✓
17	SAMPS-047	House-Autry Dam	Sampson	High	✓
18	WAYNE-008	Durham Lake	Wayne	Low - Exempt	✓
19	WAYNE-009	H.F. Lee Power Station Cooling Lake Dam	Wayne	High	✓
20	WILSO-009	Silver Lake	Wilson	Intermediate - Exempt	X

6.2 Cumberland County (Cumberland-Hoke Regional Hazard Mitigation Plan – Updated 2016)

The 2016 Cumberland-Hoke Regional Hazard Mitigation Plan includes Cumberland County. Cumberland County is located in the Cape Fear Basin, with only a small portion of the southern county boundary along Cold Camp Creek draining to the Lumber River Basin. There are 30 dams forming lakes or ponds within the County, ranging from under an acre up to 210 acres in size. Glenville Lake serves as a water supply to the City of Fayetteville. The dam on Hope Mills Lake, a 68 acre lake used for recreation located in Hope Mills, was breached. Dam failure is included as one of the hazards that is profiled in the Cumberland-Hoke Regional Plan.

Table 6.2 is a sample of the information on dams in the mitigation plan. The plan provides information from the North Carolina dam inventory (2014) with details for 52 dams classified as high hazard that are located within Cumberland County. The name, NID ID, height, NID storage, status, and river are included in the table. The location of the high hazard dams in the county is included as a figure in the plan. It should be noted that there are 61 additional dams located in Cumberland County (1 intermediate hazard, 60 low hazard). Dams that were either breached or drained were excluded from the vulnerability assessment.

Table 6.2 Sample of Dam Information available in Cumberland-Hoke Regional Hazard Mitigation Plan

Dam Dame	NIDID	County	Height (ft)	NID Storage (ac-ft)	Dam Status	River
Arran Lakes Dam	NC01144	Cumberland	21.0	120	IMPOUNDING	Little Beaver Creek
Rhodes Lake Dam	NC01145	Cumberland	15.2	1920	IMPOUNDING	Black River
Mt.Vernon Estates	NC02160	Cumberland	14.2	4056	IMPOUNDING	Kirks Mill Creek
Rayconda Upper Dam	NC05621	Cumberland	19.2	0	IMPOUNDING	Little Rockfish Creek TR

There have been known dam failures at the following locations: Hope Mills Dam, Evans and Lockwood Dams, Country Club Lake, Jaycees Pond, Lake Lynn Dam, and Wallace Lake Dam.

The sources of this information are the Association of State Dam Safety Officials, and the National Performance of Dams Program Database[13]. Known dam failures in the unincorporated areas of Cumberland County were at the following locations: Jaycees Pond, Lake Lynn Dam, and Wallace Lake Dam.

The Plan includes the following mitigation action for Cumberland County: *"Creek mitigation tied to Hope Mills Lake Dam. The Town of Hope Mills is currently making repairs to the Hope Mills Lake Dam with an anticipated completion of the end of 2016. At that time the lake will be filled back to the historical levels where there will then be a need for various activities tied to creek mitigation. These activities will assist in the preservation of the creek bank while reducing erosion levels. The Town of Hope Mills Public Works Department is responsible for this action."*

6.3 Duplin County (Sampson/Duplin Regional Hazard Mitigation Plan – Updated 2016)

The 2016 Sampson/Duplin Regional Hazard Mitigation Plan includes Duplin County. The plan includes information from the North Carolina dam inventory (2014). The plan states there are 34 dams that are located in Duplin County with two additional dams situated in the area such that a Duplin County municipality is the nearest municipality to be affected by a dam failure. The following information is included in the plan regarding those dams: the State identification code, name, river or stream, status, hazard classification, and the nearest town.

While dam failure was one of the natural hazards that was determined to be of concern for the Sampson/Duplin County Region, there have been no historical occurrences of dam/levee failure impacting the region. The Sampson/Duplin Regional Hazard Mitigation Plan states the likelihood of occurrence of a dam failure affecting the Sampson/Duplin County Region is "unlikely."

6.4 Harnett County (Cape Fear Regional Hazard Mitigation Plan – Updated 2016)

The 2016 Cape Fear Regional Hazard Mitigation Plan includes Harnett County. Dam failure was identified as a significant hazard to be addressed in the Cape Fear Regional Plan. Figure 6.1 below shows the dam location and the corresponding hazard ranking for each dam in the Cape Fear Region. The plan obtained this information from the North Carolina dam inventory. The plan shows there are 28 high hazard dams in Harnett County.

[13] Stanford University; National Performance of Dams Program http://npdp.stanford.edu/

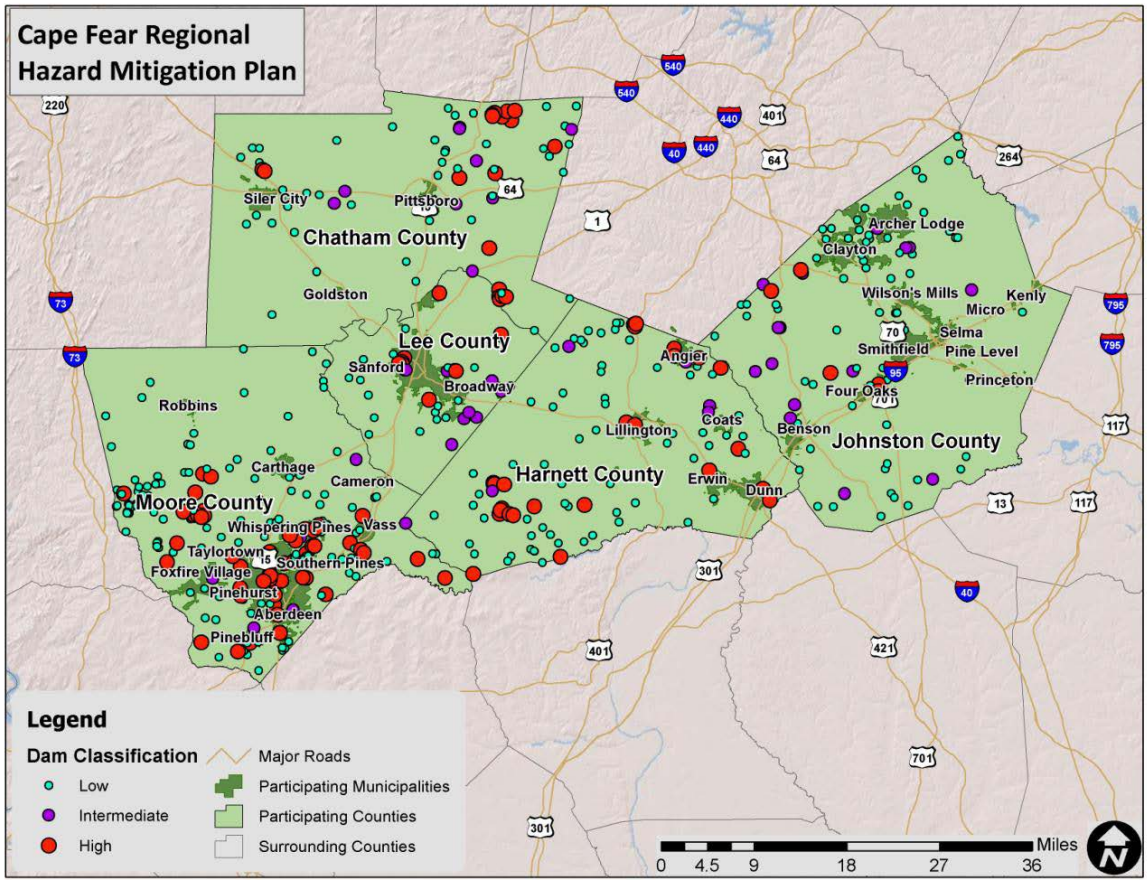


Figure 6.1: Cape Fear region dam location and hazard ranking

The plan shows two historical dam breaches reported in the Cape Fear Region. Neither breach was in Harnett County. In the previous hazard mitigation plan, no information on past dam failure events was provided for Harnett County.

The Cape Fear Regional Hazard Mitigation Plan states that, given the current dam inventory and historic data, a dam breach is unlikely (less than one percent annual probability) in the future.

6.5 Hoke County (Cumberland-Hoke Regional Hazard Mitigation Plan – Updated 2016)

The 2016 Cumberland-Hoke Regional Hazard Mitigation Plan includes Hoke County. Hoke County is located in two river basins: the Cape Fear River Basin to the north and east, and the Lumber River Basin to the south and west. The plan states *"There are thirty dams forming lakes or ponds within the County, ranging from 1.6 acres to 85 acres in size"*. The plan includes dam information from the North Carolina dam inventory. This information

includes dam name, NID ID, County, height (feet), NID storage (acre-feet), dam status, and river.

The Plan includes the following mitigation action for Cumberland County: *"Creek mitigation tied to Hope Mills Lake Dam. The Town of Hope Mills is currently making repairs to the Hope Mills Lake Dam with an anticipated completion of the end of 2016. At that time the lake will be filled back to the historical levels where there will then be a need for various activities tied to creek mitigation. These activities will assist in the preservation of the creek bank while reducing erosion levels. The Town of Hope Mills Public Works Department is responsible for this action."*

6.6 Lenoir County (Neuse River Basin Regional Hazard Mitigation Plan – Updated 2016)

The 2015 Neuse River Basin Regional Hazard Mitigation Plan includes Lenoir County. Dam failure was determined to be of concern for the Neuse River Basin Region.

The plan referenced the North Carolina dam inventory to determine that there are 15 dams in or affecting Lenoir County. The plan provides a table that contains information on these dams including state identification, name, river or stream, status, hazard classification, and nearest town.

The Neuse River Basin Regional Hazard Mitigation Plan states the likelihood of occurrence of a dam failure affecting the Neuse River Basin Region is "unlikely".

6.7 Sampson County (Sampson/Duplin Regional Hazard Mitigation Plan – Updated 2016)

The 2016 Sampson/Duplin Regional Hazard Mitigation Plan includes Sampson County.

The plan referenced the North Carolina dam inventory to determine there are 50 dams located in Sampson County.

The following information from the North Carolina dam inventory (2014) is included in the Plan regarding those dams: The State identification code, name, river or stream, status, hazard classification, and the nearest town.

While dam failure was one of the natural hazards that was determined to be of concern for the Sampson/Duplin County Region, there were no historical occurrences of dam/levee failure impacting the region. The Sampson/Duplin Regional Hazard Mitigation Plan states

the likelihood of occurrence of a dam failure affecting the Sampson/Duplin County Region was “unlikely”.

6.8 Wayne County (Neuse River Basin Regional Hazard Mitigation Plan – Updated 2016)

The 2015 Neuse River Basin Regional Hazard Mitigation Plan includes Wayne County.

According to data obtained from the North Carolina dam inventory there are 35 dams in or affecting Wayne County. The table that contains this information in the Plan includes state identification, name, river or stream, status, hazard classification, and nearest town.

While dam failure was determined to be of concern for the Neuse River Basin Region, the plan concluded the likelihood of occurrence of a dam failure affecting the region is “unlikely”. Related dated is not provided separately for Wayne County.

6.9 Wilson County (Nash-Edgecombe-Wilson Regional Hazard Mitigation Plan – Updated 2015)

The 2015 Nash-Edgecombe-Wilson Regional Hazard Mitigation Plan includes Wilson County. Dam failure was listed as a lesser hazard in the Plan.

Dam information for the plan was obtained from the North Carolina dam inventory. The plan states there is one dam in Wilson County with a high potential hazard and provides information on this dam: the river/stream on which it is located, the nearest city, the year constructed, the structural height, and the maximum impoundment of the dam.

The plan states there have been no documented dam failures in the Nash-Edgecombe-Wilson region according to the Association of State Dam Safety Official’s website.

Given the fact that there have been no documented dam failures in the five county region since records have been kept, the Nash-Edgecombe-Wilson Regional Hazard Mitigation Plan states the probability of any dam failure occurring in the region during any single year has been classified as “unlikely” – having a less than one percent annual chance. The plan further states that *“If such an event were to take place, the impact would be fairly localized in the area immediately downstream of the dam failure or behind the failed levee, unless the failure was associated with another more extensive hazard event (for example a flood)”*.

Chapter 7 The North Carolina Dam Safety Program

7.1 Overview

The North Carolina Dam Safety Program is located within the Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR). Their website includes links on information regarding the North Carolina dam inventory, permitting for existing and proposed dams, planning for a dam emergency, helpful links, computer animations of failure modes, additional resources, and laws and regulations.[14] Below are key excerpts from state laws and regulations defining a "dam", the Hazard Potential Classifications for those dams, the regulation and requirements regarding permitting, spillway design requirements, inspections, and the exemptions from state regulations. North Carolina regulates class A (low hazard), class B (intermediate hazard), and class C (high hazard) dams. The exemptions to state regulation are included in Section 7.4 of this report.

7.2 North Carolina Dam Definition and Inventory Process

The definition of a dam, according to North Carolina's Dam Safety Law of 1967, is *"Dam means a structure and appurtenant works erected to impound or divert water."*

The State updates their own dam database based on information from inspections, reclassifications, new dams constructed, rehabilitation of existing dams, and other information. This revised information is then sent to the U.S. Army Corps of Engineers (USACE), the agency responsible for the National Inventory of Dams[15]. The following table shows information from the Association of State Dam Safety Officials (ASDSO)[16] on the North Carolina Dam Safety Program from 2012 and 2015 and information from NC DEQ DEMLR from October 2016:

	ASDSO 2012	ASDSO 2015	NC Oct 2016
State regulated dams	3,684	2,561	2,548
High hazard potential	1,143	1,235	1,240
Intermediate hazard potential	488	324	320
Low hazard potential	2,053	1,002	988
State dam safety Full Time Equivalent (FTE) Staff:	16.62	20.85	20.85
Total Budget	$1,322,548	$2,064,352	$2,064,352

[14] https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety
[15] http://nid.usace.army.mil/cm_apex/f?p=838:12
[16] http://www.damsafety.org/map/state.aspx?s=33

The USACE 2016 NID database has **3,444** dams as being in North Carolina. The NID is updated roughly every two to three years by USACE as they receive information on dams from the regulating state and federal agencies.

7.3 Hazard Potential Classifications

Below are direct excerpts on dam hazard potential classifications and exemptions for dams from the **North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety**.

Hazard Potential Classifications

(a) *For the purposes of this Subchapter, dams shall be divided into three classes, which shall be known as class A (low hazard), class B (intermediate hazard), and class C (high hazard):*

(1) ***Class A*** *includes dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.*

(2) ***Class B*** *includes dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.*

(3) ***Class C*** *includes dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.*

7.4 Exemptions

(a) *Except as otherwise provided in this Part, this Part does not apply to any dam:*

(1) *Constructed by the United States Army Corps of Engineers, the Tennessee Valley Authority, or another agency of the United States government, when the agency designed or approved plans for the dam and supervised its construction.*

(2) *Constructed with financial assistance from the United States Soil Conservation Service, when that agency designed or approved plans for the dam and supervised its construction.*

(3) *Licensed by the Federal Energy Regulatory Commission, or for which a license application is pending with the Federal Energy Regulatory Commission.*

(4) *For use in connection with electric generating facilities regulated by the Nuclear Regulatory Commission.*

(5) *Under a single private ownership that provides protection only to land or other property under the same ownership and that does not pose a threat to human life or property below the dam.*

(6) *That is less than 25 feet in height or that has an impoundment capacity of less than 50 acre-feet, unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam. (2011)*

(7) *Constructed for the purpose of providing water for agricultural use, when a person who is licensed as a professional engineer under Chapter 89C of the General Statutes designed or approved plans for the dam, supervised its construction, and registered the dam with the Division of Land Resources of the Department. This exemption shall not apply to dams that are determined to be high-hazard by the Department. (2011)*

(b) *The exemption from this Part for a dam described in subdivisions (1) and (2) of subsection (a) of this section does not apply after the supervising federal agency relinquishes authority for the operation and maintenance of the dam to a local entity. (1993, c. 394, s. 3; 2009-390, s. 3(a); 2011-394, s. 10(a).)*

7.5 Permitting

Below are direct excerpts of permitting requirements for dams from the **North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety**.

SECTION .0200 - OBTAINING APPROVAL FOR DAM CONSTRUCTION: REPAIR OR REMOVAL

.0201 APPLICATIONS

(a) *Any person(s) who proposes to construct, repair, alter or remove a dam must file with the Director a statement concerning the location of the dam, including the name of the stream and county, height, purpose, and impoundment capacity, 10 days before start of construction. If the Director determines that the proposed dam is exempt from the law, the applicant will be notified and he may then proceed with the construction.*

(b) *If the Director determines that the proposed dam is not exempt from the Dam Safety Law of 1967, the applicant will be so notified within 10 days of receipt of the statement described in (a) of this Rule and construction may not commence until a full and complete application has been filed and approved. This application must be filed at least 60 days before the proposed start of construction:*

(1) *When an application to construct a dam has been completed pursuant to Subsection (a) of this Rule, the department shall refer copies of the completed application papers to the Department of Human Resources, the Wildlife Resources Commission, the Department of Transportation, and such other state and local agencies as it deems appropriate for review and comment.*

(2) *Before commencing the repair, alteration, or removal of a dam, application shall be made for written approval by the department, except as otherwise provided by this Subchapter or in accordance with G.S. 143-215.27(b). The application shall state the name and address of the applicant; shall adequately detail the changes it proposes to effect; and shall be accompanied by maps, plans, and specifications setting forth such details and dimensions as the department requires. The department may waive such requirements in accordance with G.S. 143-215.27(a). The application shall give such other information concerning the dam and reservoir required by the department concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed, it may be referred by the department for agency review and report as provided by G.S. 143-215.26(b) in the case of original construction*

7.6 Spillway Design Requirements

Below is a direct excerpt on the spillway design flood criteria requirements for dams from the **North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety**.

.0205 SPILLWAY DESIGN

(a) *All dams shall have a spillway system with capacity to pass a flow resulting from a design storm indicated in (e) of this Rule for a hazard classification appropriate for the dam, unless the applicant provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring.*

(b) *A vegetated earth or unlined emergency spillway will be approved when computations indicate that it will pass the design storm without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be*

considered acceptable in such a spillway when its average frequency of use is predicted to be no more frequent than once in 25 years for existing class B and for class A dams except for small class A dams designed in accordance with all design criteria established by the U.S.D.A, Soil Conservation Service, and as contained in Engineering Standard 378 of the U.S.D.A., Soil Conservation Service; once in 50 years for new class B, small and medium new class C, and existing class C dams; and once in 100 years for large and very large new class C dams. The dam sizes referred to in this Subsection are defined in (e) of this Rule.

(c) *Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel lining, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water-tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or underseepage from the foundation which might cause saturation of underlying materials or uplift against the undersurfaces.*

(d) *Within 15 days following passage of the design storm peak, the spillway system shall be capable of removing from the reservoir at least 80 percent of the water temporarily detained in the reservoir above the elevation of the primary spillway.*

(e) *It is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, other hydrologic factors, and specific cultural features have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for specific site conditions based on quantitative analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. A design storm more frequent than once in 100 years will not be acceptable for any class C dam. In lieu of quantitative analysis, the following tables shall be used as criteria for spillway design storms and permissible velocities for vegetated earth spillways:*

Criteria for Spillway Design Storm[1] Size Classification[17]

Size	**Total Storage (Ac-Ft)[1]**	**Height (Ft)[1]**
Small	less than 750	less than 35
Medium	equal to or greater than 750 and less than 7,500	equal to or greater than 35 and less than 50

[17] North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety

Size	Total Storage (Ac-Ft)[1]	Height (Ft)[1]
Large	equal to or greater than 7,500 and less than 50,000	equal to or greater than 50 and less than 100
Very Large	equal to or greater than 50,000	equal to or greater than 100

[1]The factor for determining the largest size shall govern.

Minimum Spillway Design Storms[18]

Hazard	Size	Spillway Design Flood (SDF)
Low (Class A)	Small	50 year
	Medium	100 year
	Large	1/3 PMP
	Very Large	1/2 PMP
Intermediate (Class B)	Small	100 year
	Medium	1/3 PMP
	Large	1/2 PMP
	Very Large	3/4 PMP
High (Class C)	Small	1/3 PMP
	Medium	1/2 PMP
	Large	3/4 PMP
	Very Large	PMP

PMP – Probable Maximum Precipitation

7.7 Inspections

Below is a direct excerpt from North Carolina's Dam Safety Law of 1967:

§ 143-215.32. Inspection of dams.

(a) *The Department may at any time inspect any dam, including a dam that is otherwise exempt from this Part, upon receipt of a written request of any affected person or agency, or upon a motion of the Environmental Management Commission. Within the limits of available funds the Department shall endeavor to provide for inspection of all dams at intervals of approximately five years.*

(b) *If the Department upon inspection finds that any dam is not sufficiently strong, is not maintained in good repair or operating condition, is dangerous to life or property, or does not satisfy minimum streamflow requirements, the Department shall present its*

[18] North Carolina Administrative Code - Title 15A, Department of Environment and Natural Resources, Subchapter 2K - Dam Safety

findings to the Commission and the Commission may issue an order directing the owner or owners of the dam to make at his or her expense maintenance, alterations, repairs, reconstruction, change in construction or location, or removal as may be deemed necessary by the Commission within a time limited by the order, not less than 90 days from the date of issuance of each order, except in the case of extreme danger to the safety of life or property, as provided by subsection (c) of this section.

(c) *If at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Environmental Management Commission, as not to permit sufficient time for issuance of an order in the manner provided by subsection (b) of this section, the Environmental Management Commission may immediately take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. The Environmental Management Commission may recover the costs of such measures from the owner or owners by appropriate legal action.*

(d) *An order issued under this Part shall be served on the owner of the dam as provided in G.S. 1A-1, Rule 4. (1967, c. 1068, s. 10; 1973, c. 1262, s. 23; 1977, c. 878, s. 3; 1987, c. 827, s. 154; 1993, c. 394, s. 7.)*

7.8 Emergency Action Plans (EAP) and Inundation Mapping

The Coal Ash Management Act of 2014[19] became law on September 20, 2014. This law included the requirement for owner submittal of Emergency Action Plans (EAP) for all high and intermediate hazard dams. The statutory deadline for submittal of an EAP by dam owners was December 31, 2015. As of October 2016, 675 of the 1,184 high hazard dams have EAPs. The state has a backlog of 147 EAPs for review.

In the two years since this requirement became law, NC DEQ DEMLR dam safety program has approved EAPs for over half of the high hazard dams in the state.

This type of action can help reduce loss of life and property downstream should a dam fail.

North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR) and North Carolina Department of Public Safety (NC DPS) collaborated on a web-based automated EAP tool for dams, which provides secure storage of the EAPs. This web-based EAP tool, developed by NC DPS, is accessible by dam owners, NC DPS, and NC DEQ DEMLR. Although dam owners are encouraged to use this tool, they may also complete their EAP and then upload it into

[19] http://www.ncleg.net/gascripts/BillLookUp/BillLookUp.pl?Session=2013&BillID=s729

the EAP tool. NC DEQ DEMLR also has a template for EAPs available on their website[20]. See Chapter 4, Section 4.3 Risk Management Portal, of this report, for more information.

NC DEQ DEMLR has scanned EAPs that pre-dated the web-based EAP tool. These EAPs have been provided to NC DPS in a digital format and hard copies. NC DPS is responsible for sharing EAPs with local emergency managers in the county where the dam resides.

Inundation maps or downstream hazard maps are required as part of the EAP submittal. For dams where there is clearly a road or a couple of houses downstream, the dam owner is allowed to submit a google earth image as a downstream hazard map at this time due to the cost of inundation map. If an engineer is involved, an inundation map or SIMS[21] is required. When a dam breach modeling program is utilized to determine the dam breach inundation extents, a copy of the model is required to be included with the EAP submittal.

[20] https://ncdenr.s3.amazonaws.com/s3fs-public/Energy%20Mineral%20and%20Land%20Resources/Land%20Quality/Dam%20Safety/EAPDocs/NCEAP_TemplateV5_20131212.docx

[21] https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety

Chapter 8 Coordinated Response to Reduce Risk at Dams

8.1 Coordinated Response Operations at Woodlake Dam

The North Carolina dam database shows Woodlake Dam as a privately owned, high hazard dam located in Moore County. It has a structural height of 23 feet, a crest length of 5200 feet, an impoundment reservoir of 10,000 acre feet, and a drainage area of 60,800 acres (approximately 95 square miles).

The Emergency Action Plan for Woodlake Dam was activated by the dam owner due to damage of the concrete spillway.

The Emergency Action Plan (EAP) for this dam was activated by the dam owner due to damage to the concrete spillway. The damage to the spillway was initially discovered by an NC DEQ DEMLR Regional Engineer. NC DEQ DEMLR personnel monitored the dam 24 hours a day for many days, providing vital information back to the North Carolina Emergency Operations Center (NC EOC). NC Department of Public Safety (DPS) coordinated with FEMA Incident Management Assistance Team (IMAT) Infrastructure, NC DEQ DEMLR, Moore County, and many others throughout this event.

Evacuation notices were sent by the local government to all residents downstream of the dam on October 9, 2016.

- The National Weather Service (NWS) provided a Flash Flood Warning at 8:09pm, October 10, 2016 (ET): *THE NATIONAL WEATHER SERVICE IN RALEIGH HAS ISSUED A * FLASH FLOOD WARNING FOR... A DAM FAILURE IN... EAST CENTRAL MOORE COUNTY IN CENTRAL NORTH CAROLINA... NORTH CENTRAL HOKE COUNTY IN CENTRAL NORTH CAROLINA... NORTHWESTERN CUMBERLAND COUNTY IN CENTRAL SOUTHEAST OF VASS IS IN RISK OF IMMINENT FAILURE. A FAILURE WOULD RESULT IN FLASH FLOODING DOWNSTREAM ON CRANE CREEK WITH FLOOD WATERS EVENTUALLY REACHING THE LITTLE RIVER. AUTHORITIES ARE BEGINNING EVACUATIONS. MOVE TO HIGHER GROUND NOW. LOCATION PARTICUALRLY AT RISK INCLUDE AREAS NEAR ROUTE 690 OR LOBELIA ROAD...CABINS CREEK ROAD AND MCPHERSON ROAD.*

- An evacuation order was in place by Moore County on October 11, 2016 and was finally lifted by them on October 16, 2016, after the dam owner's engineer provided the following statement, "As a result of the lower lake levels, ongoing lake water lowering activities, and current conditions of the spillway and the dam, it is our belief that the

imminently dangerous conditions which caused the evacuation order to be issued by Moore County have been sufficiently mitigated to the point that it is appropriate to rescind the order".[22] The National Guard helped the local Fire Department evacuate the population in the dam breach inundation zone utilizing High Water Evacuation Vehicles. Ultimately, roughly 200 people from 116 residences were evacuated to shelters. 90 people refused to evacuate. NC DEQ DEMLR modified an existing Hydrologic Engineering Center – River Analysis System (HEC-RAS)[23] dam breach model, which had been provided as part of the EAP from the owner, to better reflect the current conditions at the dam and in the drainage basin. The results were double checked by performing a DSS-WISE Lite Beta run. The HEC-RAS information was then used for an updated dam breach inundation map that was provided to the local Fire Chief and other appropriate interested parties to enable better response, evacuation, and potential consequence management planning.

While the dam owner maintains responsibility for the dam, there were coordinated response efforts to reduce the risk of dam breach from local, state, and federal officials.

- NC DEQ DEMLR, the regulator for the dam, had required the dam owner to lower the reservoir level by roughly five-feet prior to Hurricane Matthew in accordance with a Dam Safety Order (DSO) issued under authority of 15A NCAC 2K .0302 and the precipitation forecasts. Due to NC DEQ DEMLR concerns of imminent failure, FEMA IMAT Infrastructure coordinated with NC DEQ DEMLR on potential pump operations to reduce the reservoir level. FEMA IMAT Infrastructure advised NC DEQ DEMLR on a host of potential FEMA Public Assistance Category B (Emergency Protective Measures) measures that could be taken to help save the dam. They provided pump sizes, quantities available, and a "Go List" of contractors having the capability to provide timely delivery. NC DEQ DEMLR ordered three pumps, each 8" in diameter. The following day an additional five pumps, each 12" in diameter, were ordered. The local Fire Department and local DOT helped the pump contractor logistically in getting the pumps quickly in place and operational. The dam owner, with the assistance of their engineering consultant, was responsible for lowering the reservoir levels through the eight pumps and the dam's two large bottom drains in accordance with NC DEQ DEMLR requirements. In order to reduce the chance of slope instability or failure from lowering

States and local communities should prepare for dam incidents by strategically planning, training, exercising, coordinating and acquainting themselves with available options and resources, to include understanding "Emergency Protective Measures" from Public Assistance.

[22] Evacuation Lifted Damage Assessments Begin Below Woodlake Dam; http://www.aberdeentimes.com/index.php/local/item/6427-evacuation-lifted-damage-assessments-begin-below-woodlake-dam

[23] USACE HEC-RAS website; http://www.hec.usace.army.mil/software/hec-ras/

the lake level too quickly, the directive from NC DEQ DEMLR instructed the dam owner to lower the lake level no more than two feet per day. NC DEQ DEMLR required the dam owner to completely drain the reservoir and maintain that condition until repairs have been made.

Figure 8.1 Damaged concrete spillway at Woodlake Dam Credit: NC DEMLR

Figure 8.2 Pumps on Woodlake Dam Crest; Credit: NC DEMLR

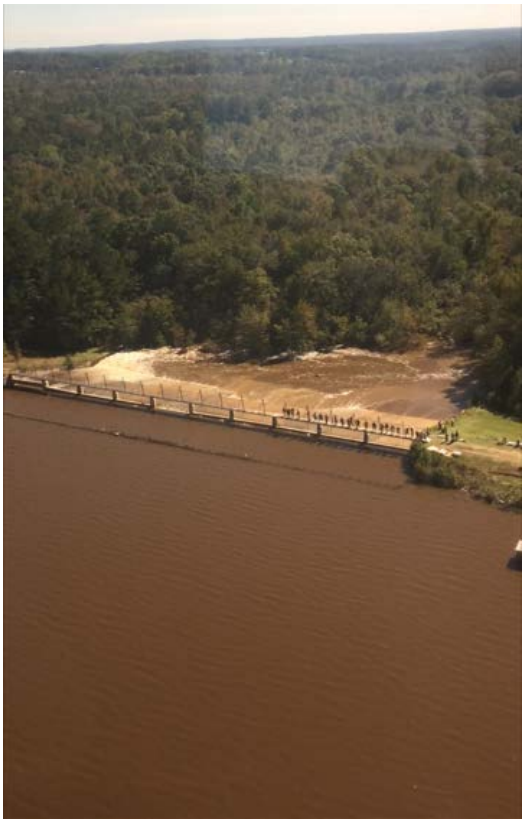
The dam owner hired divers to help provide information to their engineer in assessing the dam and spillway damage. National Guard soldiers, in coordination with FEMA IMAT Infrastructure and with specifics on optimal placement from NC DEQ DEMLR, initially placed 1000 sand bags on key areas of the spillway to reduce or eliminate continued erosion and scouring of the damaged area. An additional 300 sandbags were placed the following day on the concrete spillway upstream of the damage for the same purpose. Customs and Border Patrol (CBP), through a FEMA Mission Assignment (MA) from FEMA IMAT Infrastructure, performed five helicopter missions in support of NC DEQ DEMLR assessing the effectiveness of sandbag and protective measure operations at the dam.

Disaster coordination efforts for the Woodlake Dam included, in part: NC DEQ DEMLR, the local fire department, FEMA IMAT, NC DPS, the NC EOC, Moore County officials and emergency management, the National Weather Service, the North Carolina National Guard, US Army elements from Fort Bragg, USGS, FEMA Region IV Dam Safety, the dam owner, Customs and Border Patrol, and the Civil Air Patrol.

Figure 8.3 National Guard and others placing sandbags at Woodlake Dam Credit: NC DEMLR

Figure 8.4 Sandbags in center above damaged spillway area; Credit: NC DEMLR

- NC DEQ DEMLR requested assistance from the North Carolina National Guard who coordinated with Fort Bragg to get a U.S. Army helicopter with infrared capability to video Woodlake Dam at night to help NC DEQ DEMLR assess the situation. The video was reviewed by NC DEQ DEMLR to better understand the condition of the dam. This dam was identified by NC DEQ DEMLR as a priority dam prior to the event. Based on current spillway capacity and predicted precipitation estimates, it was added to a list for a Civil Air Patrol (CAP) fly over for situational awareness and monitoring. Personnel from NC DEQ DEMLR participated in the flight with CAP to develop a better understanding of the risk of overtopping at the dam and general situational awareness based on watershed and inflow conditions. It was determined the best course of action was to drain the reservoir as quickly as possible. NC DEQ DEMLR continued to coordinate with FEMA IMAT Infrastructure, NC DPS, and the dam owner as the reservoir was drained to reduce or eliminate water pressure on the damaged spillway. NC DEQ DEMLR is working with the dam owner on a long-term repair and overall solution.



Figures 8.5 and 8.6 Woodlake Dam Fly-over October 2016 mid response operations; Credit: NC DEMLR

Figure 8.7 Woodlake Dam drained reservoir October 27, 2016; Credit: NC DEMLR

8.2 Emergency Action Plan (EAP) Activation at H.F. Lee Cooling Pond

The owners of H.F. Lee cooling pond activated their EAP due to concerns of a potential overtopping from the rising Neuse River. The cooling pond dam did overtop due to the rise of the Neuse River located directly adjacent to the dam. Water first flowed backward over the dam's spillway from the river and subsequently over earthen portions of the dam. The partial breach occurred as the flood waters receded and water flowed over the saturated embankment back to the river side, causing a slough on the downstream slope and erosion through the dam's crest. More details on H.F. Lee can be found in Appendix A due to this partial breach.

Figure 8.8 H.F. Lee Cooling Pond Partial Breach; Credit: NC DEMLR

8.3 Emergency Action Plan (EAP) Activation at Weatherspoon Cooling Pond

Weatherspoon owner's initiated their EAP due to Jacob's Creek overtopping and entering the cooling pond. This caused the cooling pond to overtop into the Lumber River. Rip rap was placed by the owner on the dam slope to reduce erosion. Pumps were used to help reduce water levels on the cooling pond side to the creek side, as the creek water level dropped. No breach occurred at this dam and consequently it is not in Appendix A.

8.4 Emergency Action Plan (EAP) Activation at Sutton Cooling Pond

The owners of Sutton Cooling Pond activated their EAP due to concerns of a potential overtopping from the rising Cape Fear River. The Cape Fear River never overtopped this dam, but came within one foot of doing so. No breach occurred at this dam and consequently it is not in Appendix A.

Figure 8.9 Sutton Cooling Pond on right (river on left); Credit: NC DEMLR

8.5 Emergency Action Plan (EAP) Activation and Evacuations at Lake Benson

During this event, the North Carolina Governor received a call concerning this structure. The Governor contact NC DEQ DEMLR in the NC EOC. NC DEQ DEMLR shared the EAP for this dam with the state and local emergency managers. The owner of this dam, the local government, activated the EAP due to the lake level rising to within one foot of overtopping the dam. The local emergency managers coordinated evacuations of the population downstream of the dam. The dam did not overtop or breach. It is not in Appendix A.

Figure 8.10 Lake Benson Dam Credit: NC DEMLR

8.6 Evacuations Downstream of Lake Wilson Dam

The upstream dam, Silver Lake Dam, breached during this event (see Appendix A). Lake Wilson Dam overtopped due to the flood waters. Due to concerns regarding Lake Wilson Dam overtopping, the local government coordinated evacuations downstream of Lake Wilson Dam. This dam did not breach and is therefore not in Appendix A.

Figure 8.11 Lake Wilson Dam overtopping Credit: NC DEMLR

Figure 8.12 Consequences of Flooding and Lake Wilson Dam overtopping Credit: NC DEMLR

Chapter 9 North Carolina Response to Dams during Hurricane Matthew

9.1 North Carolina Emergency Operations Center (EOC)

The Department of Public Safety's Division of Emergency Management operates the North Carolina Emergency Operations Center (EOC). *"The EOC is the primary location from which State operations is conducted under the direction and control of the State Emergency Response Team (SERT) leader, normally the Director of the Division of Emergency Management."*[24]

The purpose of the Emergency Operations Center is to *"serve as an effective communications center, and information clearinghouse, a place to resolve confusion and conflicts, and an authoritative source of information and decisions. It is organized internally using the principles of the Incident Command System.* (ICS) *(The Incident Command System is a management system designed to control and direct the resources committed to an incident)".*[25]

"When local government resources are exhausted or a needed capability does not exist during an event, the local government can call for assistance from the State. Some events can occur slowly, such as with a hurricane, giving the State time to activate and plan. Other events may occur rapidly, such as with a tornado, earthquake, flash flooding, or winter storm causing an immediate activation of the State Emergency Response Team (SERT)."

Operational Roles and Responsibilities[26]
North Carolina Emergency Management operates under a modified ICS. During an event, all evacuations, conference calls, Regional Coordination Centers, County Deployment Teams, and most response and recovery efforts fall under the SERT Operations Section."

The Operations Section in the EOC is organized into four Groups overseen by the EOC Manager (Deputy Operations Chief). This includes a 24 hour operations center with a mission assignment coordinator and liaison officer, emergency services with emergency services SERT agencies, human services, and infrastructure with infrastructure SERT agencies.

[24] North Carolina Department of Public Safety; North Carolina Division of Emergency Management; 2012 NORTH CAROLINA EMERGENCY OPERATIONS PLAN
[25] NC Division of Emergency Management; Emergency Operations Center; Standard Operating Guide July 2009
[26] NC Division of Emergency Management; Emergency Operations Center; Standard Operating Guide July 2009

NC DEQ DEMLR is part of the Infrastructure group as the lead for dam safety in the SERT. The NC DEM EOC Standard Operating Procedure (SOP) includes duties for the Infrastructure Coordinator in Section 8. Some of these duties are as follows:

- *Notifies appropriate SERT agencies when conditions warrant for impending activation*
- *Attends briefings and/or conference calls to take notes on the information provided and share with Infrastructure SERT agencies*
- *Prepares briefings for the daily SERT briefings*
- *Monitors Web EOC messages and assigns mission requests to the appropriate SERT agency*
- *Develops and produces special plans as needed*
- *Informs SERT agencies of all road closures and re-openings*
- *Responsible for coordinating and assisting the efforts of restoring essential public services, power and fuel supplies*
- *Identifies current resource lists for debris clearance*
- *Produces information for the daily Situation Reports along with objectives for the Incident Action Plan and submits it to the Information and Planning Branch*

Following the activation of the N.C. Emergency Operation Center in response to Hurricane Matthew, personnel with the N.C. Division of Energy, Mineral and Land Resources' **Dam Safety Program** were deployed as liaisons at the EOC.

The Infrastructure SERT includes transportation, public works and engineering, energy, and debris management. The infrastructure SERT agencies and their roles are as follows:

a. *TRANSPORTATION*

i. *Department of Transportation - Division of Highways*

Coordinate transportation resources and the assessment and reconstruction of the transportation infrastructure. Clear all debris from state maintained roadways. Repair roads, bridges, culverts, etc. when damaged. Maintain the DOT web page to bring the latest update on road opening and closings. Assists with all evacuation plans when activated, i.e., I-40 Reversal Plan

b. *PUBLIC WORKS AND ENGINEERING*

i. *Department of Crime Control and Public Safety –Division of Emergency Management*
ii. *Department of Transportation – Division of Highways,*
iii. *Department of Administration – Division of Facility Management*
iv. *Department of Insurance – Division of Safety Services*

Provide technical advice and evaluations, engineering service, construction management and inspection, emergency contracting, emergency repair of wastewater and solid waste facilities. Provide emergency debris clearance for emergency personnel and equipment; temporary construction of emergency access routes that include damaged streets, roads, bridges, ports, etc.; emergency restoration of critical public services and facilities; emergency stabilization of damaged structures and facilities. Provide technical assistance to include damage/needs assessment, damage survey reports, and structural inspection of damaged structures.

c. *ENERGY*

i. Department of Commerce – Division of Energy
ii. Electricities
iii. Progress Energy
iv. Duke Power

Access energy systems damage, energy supply, energy demand and system restoration requirements. Provide assistance to state and local departments to obtain fuel for emergency operations. Enforce statutory authorities for energy priorities and allocations. Assist energy suppliers with repair and/or restoration on energy systems. Coordinate the requests for assistance regarding fuel and power from county EOC's.

d. *Debris Management*

i. Department of Environmental and Natural Resources - Division of Air Quality – Division of Water Quality - Division of Land Resources - Division of Waste Management – Division of Water Resources – Division of Soil and Water Conservation – Division of Forest Resources

9.2 North Carolina's State Preparedness and Resource Tracking Application (NCSPARTA)

North Carolina's Department of Public Safety (NC DPS) uses North Carolina's State Preparedness and Resource Tracking Application (NCSPARTA) for disaster and emergency management operations. This system is based on the WebEOC system but modified for North Carolina's purposes. NCSPARTA is a web-based, password protected application and provides a common operating picture (COP) for all those partners having access to it for emergency operations, including state and county emergency managers.

NCSPARTA is used not only to help coordinate information and resources, but to also help track costs incurred from internal and external sources throughout the event, beginning at

the State Emergency Operations Center (EOC) activation phase using the NCSPARTA Finance-Incident Expenditure board.[27]

9.3 Pre-Event Actions at NC DEQ DEMLR

Prior to the event, regional and central office staff completed inspections at dams with known drainage or structural issues documented in a Notice of Deficiency (NOD). These NODs required dam owners to address the noted issues and maintain a drained lake until repairs were completed. Central office staff went through existing hydrologic and hydraulic studies on dams with NODs to determine how much rain it would take to overtop these dams. This information was used to develop a priority list of concerns before the hurricane.

Pre-Event Risk Reduction Action - NC DEQ DEMLR called dam owners with known drainage or structural issues to discuss actions needed for the in-coming Hurricane.

9.4 NC DEQ DEMLR Dam Safety at the North Carolina Emergency Operations Center (EOC)

Following the activation of the N.C. Emergency Operation Center (EOC) in response to Hurricane Matthew, personnel with the N.C. Division of Energy, Mineral and Land Resources' Dam Safety Program, as a member of SERT, were deployed to work at the EOC. They provided a minimum of two staff members working 24-hour coverage for the entirety of the two-week dam disaster response SERT Level 1 activation as part of the Operations Infrastructure Branch. Staff monitored NCSPARTA for dam-related significant events and resource requests tasked to the Dam Safety Program. 12 two-person dam inspection teams proactively inspected dams of concern prior to and during the initial stages of the hurricane until road conditions became unsafe. Teams remained on-call immediately after the storm to respond when issues with dams or other concerns were reported. Inspection teams were mobilized from less affected regions to the eastern counties to assist with rapid assessment of post-event damage. Site inspections were coordinated based on priorities and road conditions. Dam safety personnel were also on site at high and significant hazard dams, monitoring overnight in some cases, to monitor conditions in regions that were most severely impacted by the storm. In addition, staff coordinated through the EOC to obtain dam-related resources from the NC National Guard, NC Department of Public Safety, NC Department of Transportation, and FEMA's Incident Management Assistance Team (IMAT).

Throughout deployment to the EOC, Dam Safety Program staff maintained a log of reports regarding dams based on information from NCSPARTA, media outlets, state Department of

[27] North Carolina Department of Public Safety; North Carolina Division of Emergency Management; 2012 NORTH CAROLINA EMERGENCY OPERATIONS PLAN

Environmental Quality regional offices, staff performing site visits, state and local government agencies, and other sources. This information provided real-time situational awareness to Division of Energy, Mineral and Land Resources leadership and staff, keeping them apprised of dam conditions throughout the impacted regions. Staff also used this information to write daily situation reports specific to dams, which included current status of dams of concern, priorities, resource assessments, and GIS needs. The daily situation report was provided internally to the EOC and externally to the NC Department of Environmental Quality, FEMA, Department of Homeland Security Office of Infrastructure Protection, and the South Carolina Department of Health and Environmental Control Dam Safety Program. Staff at the EOC also responded to a high volume of requests for information on dams and levees to assist other agencies.

Some dams were damaged to the extent there were concerns of imminent dam breach. Staff coordinated emergency response actions to reduce the risk of breach at damaged dams with other state agencies, FEMA, DHS-IP, and others.

Dams with hydrology and hydraulics studies on file and a NOD were prioritized for a post-storm Civil Air Patrol flight. A staff engineer was onboard each aircraft to assist in dam identification and assess the dam and the surrounding areas for situational awareness and monitoring.

The NC DEQ Fayetteville Regional Office has responsibility for inspecting dams in Anson, Bladen, Cumberland, Harnett, Hoke, Montgomery, Moore, Robeson, Richmond, Sampson, and Scotland Counties. Of the 20 dams breached during this event, 14 were located in the NC DEQ Fayetteville Region. During the flooding that resulted from Hurricane Matthew, the building for the Fayetteville Regional Office was flooded with eight to nine feet of water on the first floor, which prevented access to the office and the files located there.

9.5 North Carolina Department of Public Safety (NCDPS), Emergency Management, Risk Management Section (NCEM-RM)

During this event, the North Carolina Emergency Management, Risk Management Section (NCEM-RM) provided a dam safety supporting role to NC DEQ DEMLR, who is the lead for dam safety for the SERT. This support included providing supplemental geospatial information and analyses such as sharing LIDAR data terrain datasets and performing dam breach modeling utilizing the NCSIMs methodology. NC DEQ DEMLR coordinated with NCEM-RM to provide the detailed dam breach information to NC DPS Operations including digital copies of inundation mapping from NC Dam Safety Emergency Actions Plans (Dam EAPs) where available.

Chapter 10 FEMA and Other Federal Agencies Response to Dams during Hurricane Matthew

10.1 Overview of FEMA Hurricane Liaison Team (HLT)[28]

The Hurricane Liaison Team (HLT) is a FEMA sponsored team made up of federal, state, and local emergency managers who have extensive hurricane operational experience. When Hurricane Matthew was predicted to impact the southeast coast of the United States, the Director of the National Hurricane Center (NHC) requested that the HLT be activated. Once deployed, the team augments communication by bridging between scientists, meteorologists, and emergency responders during the event.

Understanding FEMA and other Federal Agencies along with what resources they bring to the Response planning table is a help when a state/territory is facing a hurricane.

The National Hurricane Center (NHC) [29], a component of the National Centers for Environmental Prediction (NCEP), is located in Miami, Florida at the Florida International University. NHC is responsible for issuing warnings, watches, forecasts, and analysis of hazardous tropical weather. During Hurricane Matthew, NHC issued periodic warnings, watches, and forecasts based on the current analysis and modeling at the time.

10.2 FEMA Region IV Regional Response Coordination Center (RRCC)

Each of FEMA's regional offices maintains an RRCC. When activated, RRCCs are multi-agency coordination centers generally staffed by Essential Support Functions (ESFs) in anticipation of or immediately following an incident. Operating under the direction of the FEMA Regional Administrator, the staff within the RRCCs coordinates Federal regional response efforts and maintains connectivity with FEMA Headquarters and with state EOCs, state and major urban area fusion centers, Federal Executive Boards, Tribal governments and other Federal, tribal, and state operations and coordination centers that potentially contribute to the development of situational awareness. The Unified Coordination Group (UCG) assumes responsibility for coordinating Federal response activities at the incident level once Unified Coordination is established, freeing the RRCC to deal with new incidents should they occur.[30]

[28] https://www.fema.gov/media-library/assets/documents/2719
[29] http://www.nhc.noaa.gov/
[30] DHS; National Response Framework Third Edition June 2016; https://www.fema.gov/media-library/assets/documents/117791

In anticipation of Hurricane Matthew, the Region IV Watch Center increased its operational status to Enhanced Watch on Tuesday, October 4, 2016. The FEMA Region IV RRCC activated on Wednesday, October 5, 2016 to Level 2 (Partial Activation) and increased to Level 1 (Full Activation) on Thursday, October 6, 2016. An engineer from the regional dam safety program was deployed to the RRCC as an information collection specialist on October 5th and was available to provide subject matter expertise on dams and dam breaches. This included coordinating with each of the state dam safety programs in the impacted area in addition to coordination within the RRCC with USACE, DHS-IP (Infrastructure Protection), FEMA Infrastructure, University of Mississippi National Center for Computational Hydroscience and Engineering (UM-NCCHE), the Regional GIS Resource Center, Planning, External Affairs, USDOT, the NRCC, and others on issues with dams. As information was collected on dams from the different resources, it was compiled into a briefing on the dams of concern, breached dams, and other on-going dam-related issues for each state with dam issues. This briefing was provided as an input for the daily RRCC situation reports and the leadership event summaries.

10.3 WebEOC

WebEOC is a web-based emergency operations center that can be used by federal, state, or local governments. The FEMA Region IV RRCC utilizes WebEOC 8.1 as a common platform with an activity log, a file library, a geospatial library, an Incident Action Plan (IAP) builder, NRCC significant events, regional significant events, a request for information (RFI) tracker, a RRCC sign in/out sheet, and other tools.

Information Collection Specialists in the RRCC monitored NCSPARTA, news sources, and other information sources to collect relevant information to RRCC operations. Any information collected is submitted into the FEMA Region IV WebEOC activity log for visibility by other users in the system.

10.4 Disaster operational use of Decision Support System for Water Infrastructure Security (DSS- WISE) Lite Modeling

In 2015, FEMA contracted with the University of Mississippi National Center for Computational Hydroscience and Engineering (UM-NCCHE) for “Developing a Standalone DSS-WISE Lite with Graphical User Interface and Additional Developments for the needs at FEMA and National Dam Safety Program (NDSP)”. The beta test of the University of Mississippi’s DSS-WISE™ Web and DSS-WISE™ Lite started August 1, 2016 and ended on October 1, 2016.

In order to allow this tool to be available during the flooding related to Hurricane Matthew, UM-NCCHE turned the beta test back on beginning Saturday, October 8, 2016. This enabled existing beta users to perform dam breach inundation models. The Region IV GIS Resource Center, in coordination with an engineer from the regional dam safety program deployed to the RRCC, modeled a breach of Woodlake Dam in Moore County. This information was used by FEMA to estimate potential downstream impacts of this dam breach for planning purposes internal to the RRCC.

10.5 FEMA National Response Coordination Center (NRCC)

When activated, the NRCC is a multiagency coordination center located at FEMA Headquarters. Its staff coordinates the overall Federal support for major disasters and emergencies, including catastrophic incidents and emergency management program implementation. FEMA maintains the NRCC as a functional component of the NOC for incident support operations.[31]

In anticipation of Hurricane Matthew, the FEMA NRCC activated on Thursday, October 6, 2016 to Level 1 (Full Activation). Representatives from the FEMA HQ Mitigation Directorate were deployed to the NRCC and coordinated internally and with the FEMA Region IV RRCC regarding information on dams of concern and dam breaches. This information was included in senior leadership briefs, which are shared with senior leadership in FEMA, DHS, other federal agencies and the White House.

The NRCC Planning Support Section is responsible for incident planning, which includes planning for short-term and long-term impacts. During this event, available information was shared with planning for their inclusion in plans.

10.6 FEMA Region IV Incident Management Assistance Team (IMAT)[32] at the North Carolina Emergency Operations Center (EOC)

Incident Management Assistance Teams are made up of emergency management professionals that are able to deploy upon a moment's notice when requested by the State. IMATs generally consist of 10 members, with expertise in operations, logistics, planning, and recovery. They are a rapidly deployable asset to anywhere in the region or the country, supporting states and territories in their emergency response efforts. Teams provide a forward federal presence to facilitate the management of the national response to catastrophic incidents. The primary mission is three-fold:

[31] DHS; National Response Framework Third Edition June 2016; https://www.fema.gov/media-library/assets/documents/117791

[32] FEMA Incident Management Assistance Teams; https://www.fema.gov/incident-management-assistance-teams

- Rapidly deploy to an incident or potentially threatened venue
- Identify ways federal assistance could be used to best support the response and recovery efforts, should it become available
- Work with partners across jurisdictions to support the affected State or territory

FEMA's role is to "support citizens and first responders". After a disaster, state and local emergency responders, along with voluntary agencies and faith-based groups, are called on to meet the immediate needs of the affected community, and IMATs stand ready and able to support them when called upon to do so.

From a dam safety perspective, one of the key members on an IMAT is their Infrastructure Branch Director and Deputy Director. They are responsible for helping to coordinate initial federal efforts, mission assignments, resources, capabilities, Category A (Debris) and Category B (Emergency Protective Measures) actions that can be used to help support state and local response operations on a wide range of infrastructure.

IMAT Infrastructure coordinated with NC DEQ DEMLR, NC National Guard, U.S. Customs and Border Patrol, USACE, private contractors, NC DPS, FEMA Region IV Dam Safety Liaison, and other organizations providing critical and timely support when needed for urgent dam related actions during this event. Of particular note are efforts coordinated on Woodlake Dam (see section 8.2.1 of this report).

10.7 FEMA Region IV Dam Safety at the North Carolina Emergency Operations Center (EOC)

In accordance with the FEMA Administrator's delegation of authority referenced in the introduction section, and as described here:

10. Implement the following National Dam Safety activities pursuant to Section 8 of the National Dam Safety Program Act, Pub. L. No. 92-367 (1972) (codified as amended at 33 U.S.C. § 467f):

    d. Provide subject matter expertise in the FEMA Regional Response Coordination Center and/or Joint Field Office during dam-related emergencies and disasters.

FEMA Region IV Dam safety personnel deployed to the NC EOC as a liaison within the North Carolina EOC between FEMA and the different state and Federal agencies, which is an advisory role. NC DEQ DEMLR is the state agency having responsibilities and authorities to regulate dams consistent with North Carolina law.

10.8 Department of Homeland Security Infrastructure Protection (DHS-IP)[33] at the North Carolina Emergency Operations Center (EOC)

The Department of Homeland Security, National Protection and Programs Directorate, Office of Infrastructure Protection operates the Protective Security Advisor (PSA) Program. PSAs facilitate local field activities in coordination with other Department of Homeland Security offices.

The PSA Program's primary mission is to proactively engage with federal, state, local, tribal, and territorial government mission partners and members of the private sector stakeholder community to protect critical infrastructure through five mission areas:

- Planning, coordinating, and conducting security and resilience surveys and assessments of nationally significant critical infrastructure through Enhanced Critical Infrastructure Protection visits, Infrastructure Survey Tool, Rapid Survey Tool, and the Regional Resiliency Assessment Program
- Planning and conducting outreach activities and providing access to critical infrastructure security and resilience resources, training, and information for critical infrastructure owners and operators, community groups, and faith-based organizations
- Supporting National Special Security Events (NSSEs) and Special Event Activity Rating (SEAR) Level I and II events, such as Super Bowls, Presidential Inaugurations, and Democratic and Republican National Conventions
- Serving as liaisons between federal and local government officials and private sector critical infrastructure owners and operators during and after an incident
- Coordinating and supporting improvised explosive device awareness and risk mitigation training, as well as Office of Cybersecurity & Communications assessments and resources

During incidents, PSAs serve as the infrastructure liaisons at the Federal Emergency Management Agency Joint Field Offices, Regional Coordination Centers, and state and county emergency operations centers.

PSAs also conduct joint site visits and vulnerability assessments of critical infrastructure assets with the Federal Bureau of Investigation. They work with the United States Secret Service to provide vulnerability assessments, security planning, and coordination during NSSEs and other large-scale special events.

DHS deployed two personnel to the NC EOC, one from DHS HQ from Washington DC and one was a Protective Security Advisor (PSA) from NC. PSA's have extensive knowledge of

[33] Protective Security Advisors; https://www.dhs.gov/protective-security-advisors

infrastructure information, have established relationships over the years with many varied and critical organizations and have access to a lot of information. Organizations at the NRCC, RRCC, EOC's, or JFO's that have access to DHS IP PSA's can inquire of them, when appropriate, for information, to help in their given program areas, run given scenarios to better understand, risk, vulnerabilities, consequences etc. Conversely, they can provide the PSAs information from their given areas to help inform DHS IP such that they can coordinate as needed for given scenarios, to better understand vulnerabilities, potential cascading effects, etc.

10.9 United States Geological Survey (USGS) High Water Marks (HWM) in North Carolina

On October 4, 2016, prior to Hurricane Matthew's landfall with the Southeast coast of the United States, FEMA Region IV RRCC mission-assigned the USGS to collect water resource data and information. The mission assignment (MA) was written in accordance with (IAW) a Memorandum of Understanding (MOU) between USACE, USGS, NOAA, and FEMA signed March 2016[34]. The MOU outlines the "complementary responsibilities" and "the national interest that such Federal programs be closely coordinated and mutually supportive to efficiently and effectively meet the growing demand for water resources data, information and services." The MA[35] requested:

> *"advance support, real-time field measurements, and daily reporting of water heights in direct support of federal response operations for flooding related to Hurricane Matthew in FEMA Region IV states."*

The advance support included water-level, wave-height and barometric pressure transducers in advance of the landfall. Post landfall support included retrieving transducers, collecting high water marks (HWM) near transducers to verify and calibrate data, field measurement of flood water heights, flag HWMs and collect evidence of flooding for flood impacted areas and communities, locate and record the latitude, longitude and elevation of HWMs to FEMA and USGS standards. The USGS has published standards for identifying and preserving

High Water Mark data can provide scientific evidence to the impacts and influences between the riverine flooding in the area and each dam. The HWM data can be used to help develop depth grids upstream and downstream from the dams and flood inundation extents.

[34] MOU between the Corps, USGS, NOAA, and FEMA on Collaborative Science, Services and Tools to Support Integrated and Adaptive Water Resources Management, Mar 2016; http://www.usace.army.mil/Portals/2/docs/civilworks/mous/mou_IAWRM.pdf

[35] Hurricane Matthew Mission Assignment

HWM data[36]. This data can be used to measure impacts of coastal and riverine flooding and the extent of flood inundation.

After Hurricane Matthew's landfall, the USGS began collecting HWMs. A FEMA regional dam safety engineer, who was deployed to the North Carolina Emergency Operations Center (EOC), provided a list of seven state regulated, high hazard dams that breached[37] as a result of flooding from Hurricane Matthew to FEMA engineers coordinating with USGS. FEMA engineers requested the USGS collect HWMs upstream and downstream of these seven high hazard dams to better understand the impacts and influences between the riverine flooding in the area and each dam.

FEMA engineers made this request after the hurricane landfall because the specific dams impacted by the flooding could not be identified in advance of Hurricane Matthew's impacts. After coordinating with the NC DEQ DEMLR, a prioritized list of breached dams was identified. Based on the records available, this might be one of the first times FEMA has requested HWMs collection at dams impacted by a hurricane or flood event.

FEMA engineers defaulted to the expertise of USGS to select from the top priorities of dams, to maximize the number of sites/points taken, given the constraints of the mission assignment, budget and USGS teams already in the field carrying out operations. The request specified the following:

1. HWMs be collected preferably on both the upstream and downstream slopes of the dam whenever possible.
2. HWMs be collected on both slopes such that "flood extents" or "surface of water" determinations can be made and used for GIS analytics. This might entail getting HWM points near, around or on the sides of dams to enable such surface determinations to be made, to include maybe how much a dam was overtopped (if that occurred).

This HWM data can provide scientific evidence to the impacts and influences between the riverine flooding in the area and each dam. The HWM data can be used to develop depth grids upstream and downstream from the dams and flood inundation extents. Depth grids and inundation extents can be used to:

- Compare to effective and preliminary FIRMs and FISs
- Compare to the dam breach extents calculated by dam breach modeling tools
- Compare to inundation maps provided in Emergency Action Plans (EAPs)
- Compare to evacuation maps provided in Emergency Operations Plans (EOPs)

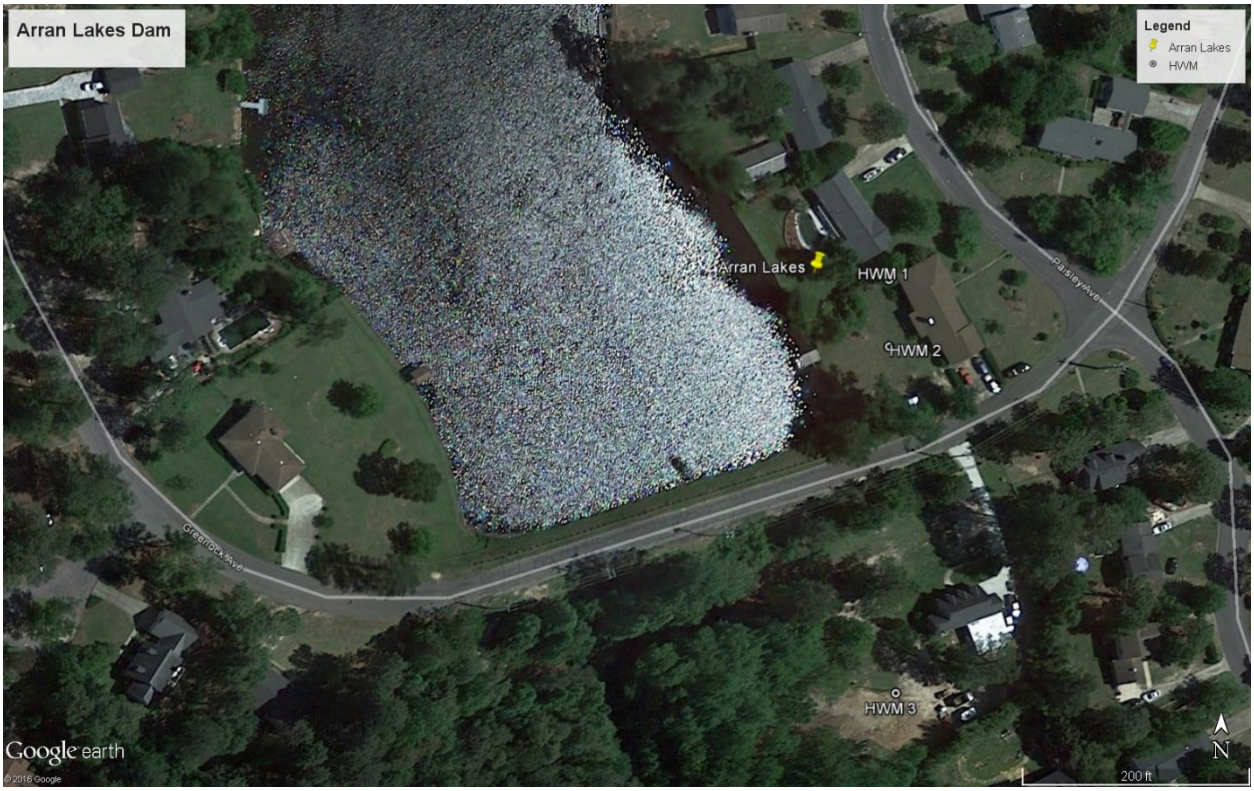
[36] Identifying and Preserving High-Water Mark Data Chapter 24 of Section A, Surface-Water Techniques Book 3, Applications of Hydraulics, 2016 http://pubs.usgs.gov/tm/03/a24/tm3a24.pdf

[37] Based on the latest information at that time from NC DEQ DEMLR

- Deploy gages prior to flooding at high hazard dams to increase monitoring capabilities during a flooding event

The USGS was able to fulfill the request of the FEMA dam safety engineers by collecting 17 HWMs at the seven high hazard dams FEMA dam safety engineers requested. Below is a summary of the preliminary data collected by the USGS[38].

Arran Lakes Dam, Cumberland County, NC (35.029, -78.981)



HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD 88)	Description
1	250’ right, 130’ behind (35.0290, -78.9808)	3.21	164.1	Good seedline in tree near shed and phone junction box near fence line.
2	230’ right, 70’ behind (35.0288, -78.9808)	0 (at ground level)	163.7	Good washline in back yard of house at 1544 Paisley Ave, Fayetteville, NC
3	115’ right, 180’ front (35.0280, -78.9808)	4.34’	153	Fair mudline on power pole 479128301 in back yard of house at 1603 Greenock Ave., Fayetteville, NC.

[38] USGS Flood Event Viewer http://stn.wim.usgs.gov/FEV/#MatthewOctober2016

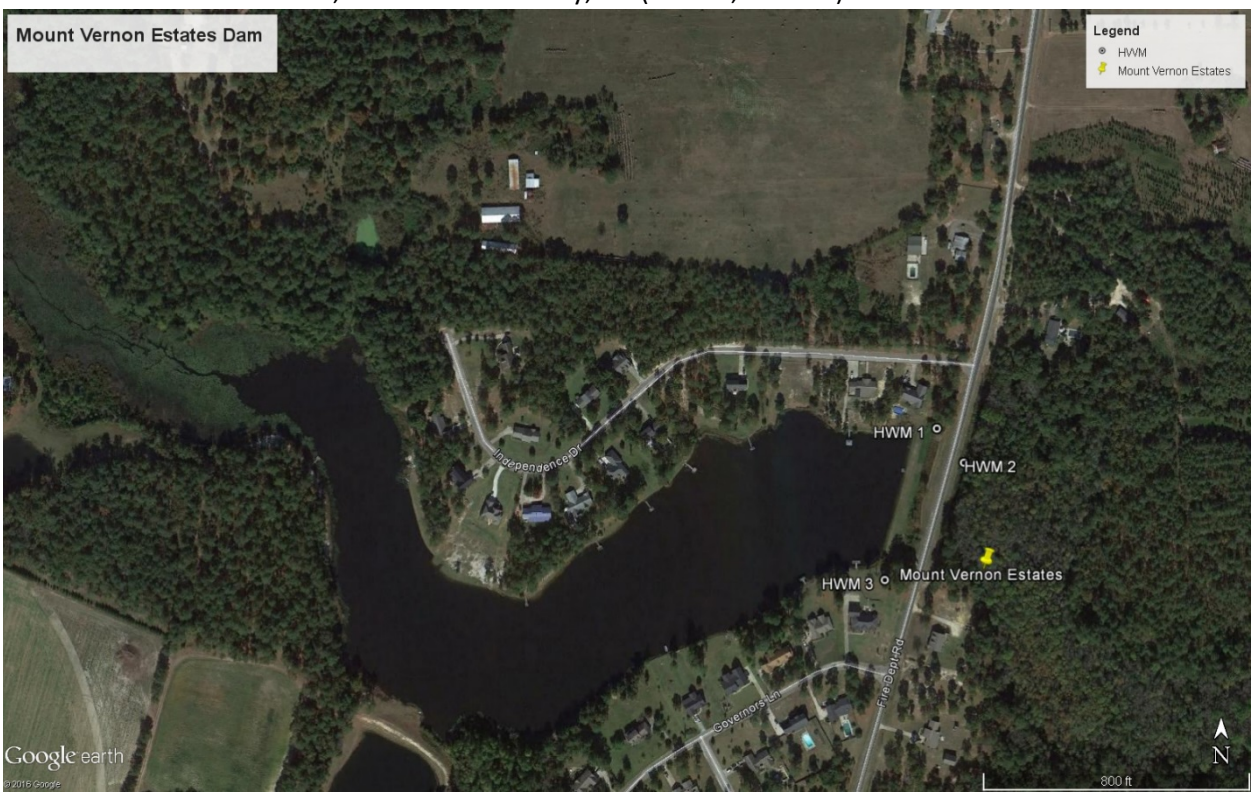
Photo of HWM3 at Fair mudline on power pole 479128301 in back yard of house at 1603 Greenock Ave., Fayetteville, NC. Marked with nail/hwm disc. Cumberland County, NC, 10/21/2016. Photograph by Chris Brown, USGS GA.

Rhodes Lake Dam, Cumberland County, NC (35.2258, -78.6528)

HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD 88)	Description
1	130’ right, 65’ front (35.2258, -78.6522)	3.79	129.6	Fair mudline on power pole 2vt87 on USS of Dunn Rd.
2	100’ right, 80’ front (35.2257, -78.6522)	1.87	132.4	Fair mudline on USS bridge abutment at Dunn Rd. bridge below Rhode Pond
3	65’ right, 120’ front (35.2256, -78.6523)	1.8	132.3	downstream on bridge
4	70’ right, 150’ front (35.2255, -78.6522)	4.15	129.9	30 FT from Dunn Rd. at start of tree line.
5	1700’ right, behind dam (35.2281, -78.6478)	0 (at ground level)	134.1	Right side of boat ramp near no littering sign.

Photo of HWM 4 at Tree marked with nail, HWM disc and pink flagging approx. 30 FT from Dunn Rd. at start of tree line. Cumberland County, NC, 10/20/2016. Photograph by Chris Brown, USGS GA.

Mount Vernon Estates Dam, Cumberland County, NC (34.853, -78.876)



HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD88)	Description
1	240’ right, front of dam (34.8541, -78.8765)	0 (at ground level)	132.1	Good seedline in tree near shed and phone junction box near fence line.
2	230’ right, 140’ front (34.8538, -78.8762)	1.02	123.4	HWM at Powerline 162432
3	240’ right, front of dam (34.8528, -78.8770)	0 (at ground level)	131.9	HWM at Cutline at right edge of dam

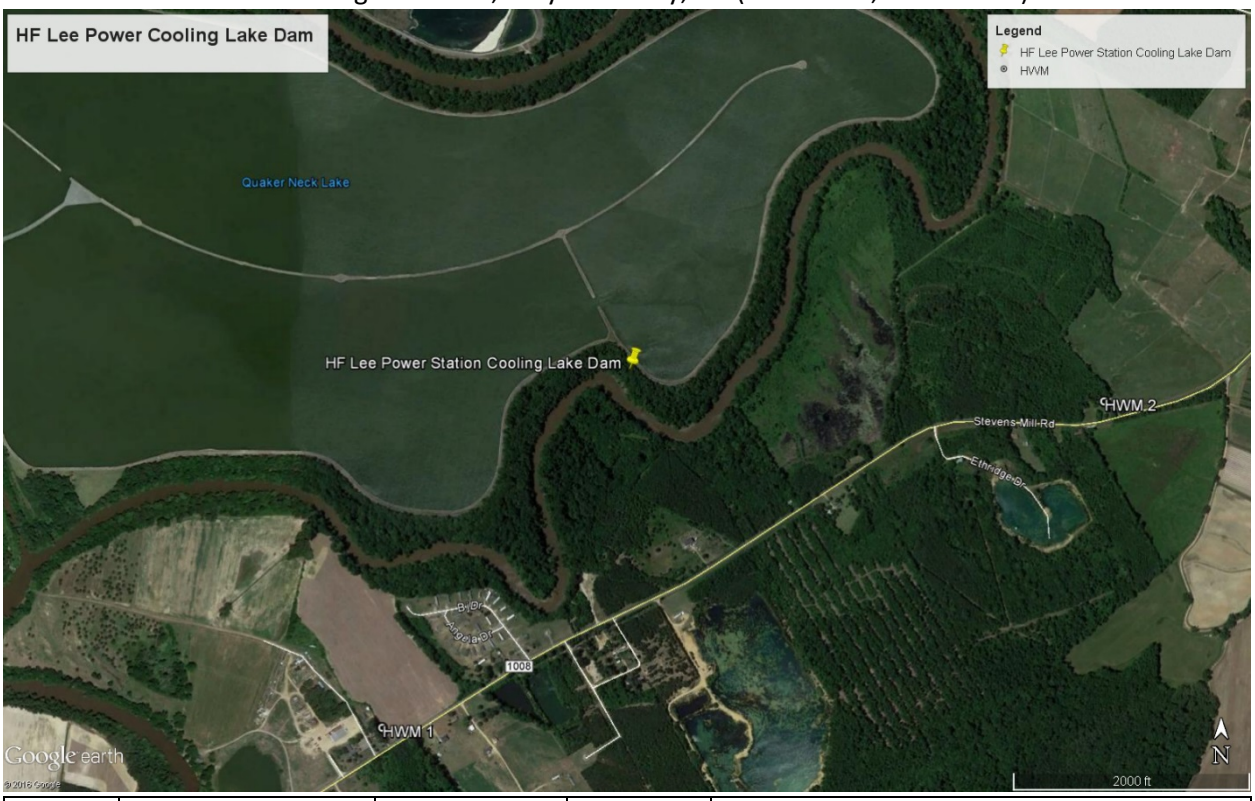
Photo of HWM2 at Powerline 162432 marked with nail and USGS disk downstream of dam approx. 60 Ft, Cumberland County, NC, 10/20/2016. Photograph by Chris Brown, USGS GA.

Rayconda Upper, Cumberland County, NC (35.0267, -79.0222)

HWM	Location	Height above ground (FT)	NAVD 88	Description
1	110’ right, 130’ behind	No data	176.4	Seedline marked with sharpie.

Photo of HWM1 at Dock at 2006 Galax Dr., Fayetteville, NC 28304. Seedline marked with sharpie. Cumberland County, NC, 10/20/2016. Photograph by Chris Brown, USGS GA.

H.F. Lee Power Station Cooling Lake Dam, Wayne County, NC (35.372075, -78.065632)

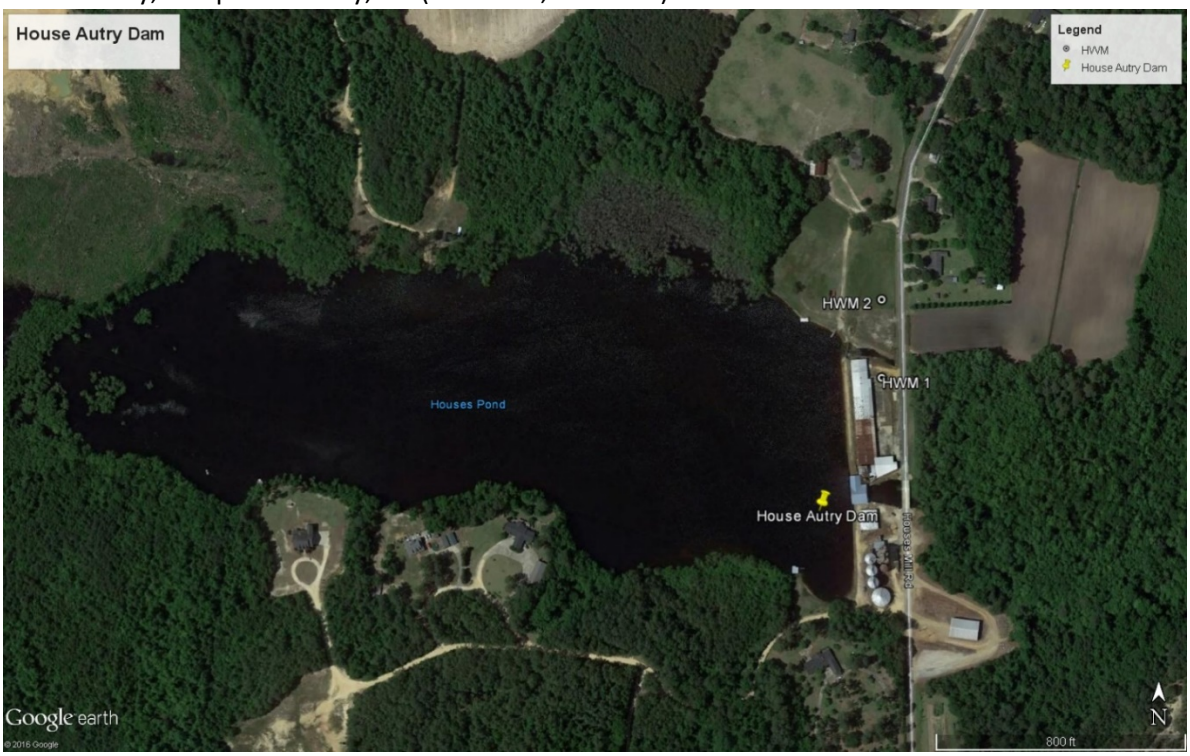


HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD)	Description
1	1800’ front of dam (35.3636, -78.0727)	2.77	76.5	1444 Stevens Mill Rd. large pine right of mid driveway
2	1800’ front of dam (35.3711, -78.0523)	3.72	---	910 Stevens Mill Rd.

Tull Mill Pond Dam, Lenoir County, NC (35.155, -77.734)

HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD88)	Description
1	530’ right, behind dam (35.1531, -77.7337)	No data	97.6	Good seedline on rear of house south of dam.

House Autry, Sampson County, NC (35.18694, -78.3762)



HWM	Location (Lat, Long)	Height above ground (FT)	Elevation (NAVD88)	Description
1	400’ right, front of dam (35.1880, -78.3756)	3.65	134.3	HWM on right side of Houses mill.
2	600’ right, front of dam (35.1887, -78.3756)	4.42	134.2	HWM on side of Houses mill

Photo of HWM2: On side of Houses mill. Marked with sharpie, Sampson County, NC, 10/23/2016. Photograph by Chris Brown, USGS GA.

Chapter 11 Dam-related Efforts in Recovery

11.1 North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources (NC DEQ DEMLR)

Inspections of dams in the impacted areas resumed once road conditions allowed access. Measurements of dam breaches were taken during post-event inspections. Over 300 dams were inspected post-event during a two-day period by 18 two-person teams. Field notes and photographs were taken for each dam. These field notes show that many dams overtopped without breaching. Information on some of the dams that overtopped without breaching is in Table 11.1.

Over 300 dams were inspected by NC DEQ DEMLR post-event during a two-day period by 18 two-person teams collecting critical information for recovery.

Table 11.1: Information on Some of the Overtopped Dams (Source NC DEQ DEMLR)

#	Dam ID	Dam Name	Latitude/ Longitude	Hazard Class H, I, L, Unknown (Ex=Exempt)	Notes
1	BLADE-017	Happy Valley Dam	36.6047, -78.6494	H	Overtopped by the storm caused large sink holes on the left and right downstream slopes and toe of the dam.
2	CUMBE-019	Rayconda Lower	35.022, -79.022	L-EX	Dam overtopped. Significant slope failure on downstream slope.
3	CUMBE-067	Arran Lakes West Dam	35.0099, -78.9876	H	Evidence of overtopping along entire length of dam. Dam is under NOD. Home on left side of dam downstream appears to have been flooded.
4	CUMBE-108	Strickland Bridge Road Dam	35.0087, -79.0214	H	Dam overtopped, entire length of dam.
5	CUMBE-114	Wooded Lake	35.1441, -78.8816	H	Overtopped. Significant damage/erosion on downstream slopes.
6	DUPLI-017	Maxwell Mill Pond	35.0701, -77.7878	L-EX	Discharge from spillway and possible overtopping caused severe damage to bridge abutments just downstream of dam.

7	HOKE-023	Kaco-English	34.9923, -79.0770	L-EX	Evidence of overtopping.
8	HOKE-024	Lupo Lake Dam	34.9925, -79.1403	H	The dam had overtopped with the emergency spillway fully activated. The dam is currently under NOD.
9	HOKE-025	Scull Lake Dam	35.0367, -79.1436	H	The dam had overtopped with the emergency spillway fully activated and erosion observed in the spillway. The number of boils observed in the outflow at the toe of the dam had increased in number and intensity.
10	HOKE-027	Thomas Lake Dam #2	34.98472, -79.275	H	The dam had overtopped.
11	SAMPS-010	Johnson Pond Dam	34.961, -78.36	H	The dam had overtopped and the emergency spillway activated with large scour holes noted along the left side of the downstream slope and left side of the toe of the dam.
12	SAMPS-011	Stafford Pond Dam	34.974, -79.575	H	The dam had overtopped and the emergency spillway activated with erosion noted in the spillway.
13	SAMPS-037	Melva Brook Pond Lower Dam	34.9574, -78.2604	H	The dam had overtopped with erosion noted on the downstream slope, exposing the principle spillway culvert. Dam is under a NOD.
14	WAKE-047	Panther Lake	35.718, -78.686	H	Dam overtopped, with erosion of some of the earth fill behind the US retaining wall.
15	WAKE-220	Byrd Dam	35.7106, -78.7131	H	Slight erosion on downstream slope above drain outlet
16	WAKE-236	Underwood Dam	35.7389, -78.6208	H	
17	WAYNE-002	Lake Wackena	35.304, -77.865	H	Severe eddy looking downstream on left side.

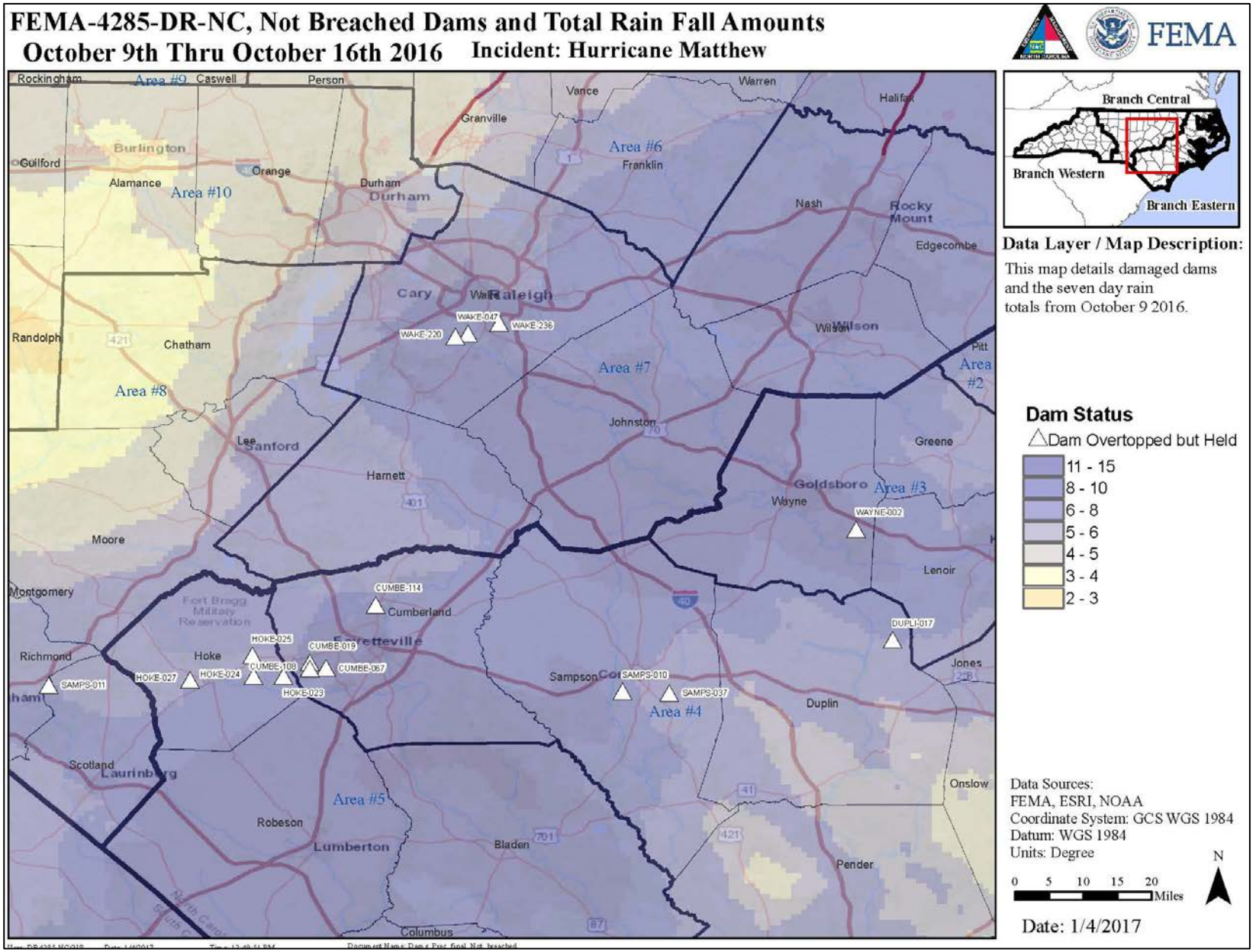


Figure 11.1: NOAA 7-day Observed Precipitation Totals and Dam Locations from Table 11.1

11.2 FEMA's Public Assistance (PA) Program and Dams

The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as Amended (Stafford Act), Title 42 of the United States Code (U.S.C.) § 5121 et seq.,1 authorizes the President to provide Federal assistance when the magnitude of an incident or threatened incident exceeds the affected State, Territorial, Indian Tribal, and local government capabilities to respond or recover.[39]

FEMA's Public Assistance grant program provides federal assistance to government organizations and certain private nonprofit organizations following a Presidential disaster declaration. Disaster survivors who need information on grant programs for homeowners and renters should visit FEMA's Individual Assistance page.

Public Assistance provides grants to state, tribal and local governments, and certain types of private nonprofit organizations so that communities can quickly respond to and recover from major disasters or emergencies. Through the PA program, FEMA provides supplemental federal disaster grant assistance for debris removal, life-saving emergency protective measures, and the repair, replacement, or restoration of disaster-damaged publicly owned facilities, and the facilities of certain private non-profit organizations. The PA program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process.

The federal share of assistance is not less than 75 percent of the eligible cost. The recipient (usually the state) determines how the non-federal share (up to 25 percent) is split with the sub recipients (eligible applicants).[40]

FEMA FP 104-009-02 Public Assistance Program and Policy Guide (PAPPG) from January 2016 (as amended)[41], provides for the overall PA program and policies for implementing these grants. Within this important program, dams are addressed for Restoration: Permanent Repair or Replacement Work in Category D; Water Control Facilities. However, dams can also be included in other categories of work as shown in Appendix K of the PAPPG: Work Eligibility Considerations by Type of Facility.[42] Other categories of Work

[39] FEMA FP 104-009-02 Public Assistance Program and Policy Guide PAPPG Jan 2016 (as amended)
[40] Public Assistance: Local, State, Tribal and Private Non-Profit; https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit
[41] FEMA FP 104-009-02 Public Assistance Program and Policy Guide PAPPG Jan 2016 (as amended) (Public Assistance: Local, State, Tribal and Private Non-Profit; https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit)
[42] FEMA FP 104-009-02 Public Assistance Program and Policy Guide PAPPG Jan 2016; p111,

Eligibility Considerations for dams might include Category A; Debris Removal and Category B; Emergency Protective Measures, as delineated in Appendix K.

FEMA Pubic Assistance personnel determine applicant (state, local, tribal officials or non-profits) eligibility, facility eligibility, work eligibility and cost eligibility consistent with the PA program and policies.[43] Part of this process includes traveling, in this case, to the sites of breached or damaged dams for those eligible applicants. Many dams breached in North Carolina for this event are private and therefore not eligible for Public Assistance Grants. FEMA Environmental personnel would also usually visit these sites with PA, as did the FEMA Region IV Dam Safety liaison for a few of these dams. The environmental staff are there for helping in the recovery to ensure various projects comply with FEMA environmental policies and procedures. The dam safety liaison was there in an advisory role to PA for dams as well as for the strategic value for information in writing this report.

FEMA PA, environmental, Region IV Dam Safety liaison, the applicant (state government), and NC DEQ DEMLR all visited the Jessup Mill Pond to view the damages for not only the pond, but also state road NC-53 that was washed out downstream of the breached dam. Figure 11.2 shows Jessup Mill Pond (Smith Lake Dam) and Figure 11.3 shows state highway NC-53 washed out. FEMA PA will work with the applicant in writing up Project Worksheets to reimburse the applicant for eligible repairs / replacement work consistent with FEMA PA policies on the road and the pond. Jessup Mill Pond is listed as Smith Lake Dam in the state inventory (CUMBE-050), but is currently exempt from regulation by the state. See Chapter 7 within this report for more information as well as Appendix A. NC DEQ DEMLR is responsible for re-evaluating this dam to determine whether it should be regulated, the hazard classification, and coordinating with the owner accordingly on what requirements must be met for repair and reconstruction. Since the state road is located below the dam and its culverts received flow from the dam outlet works, careful coordination is needed for appropriate sizing of the culverts in relation to any dam inflow spillway and outlet work sizing requirements based on hazard classification of the dam. This is only one example of the critical work PA performs with their FEMA (environmental, mitigation, RIV Dam Safety Liaison), state and dam regulatory counterparts, in helping applicants recover as soon as possible.

[43] FEMA FP 104-009-02 Public Assistance Program and Policy Guide PAPPG Jan 2016 (as amended)

Figure 11.2 Jessup Mill Pond breach (Smith Lake Dam); Credit: FEMA; Plisich

Figure 11.3 State route (NC-53) road washout due to Jessup Mill Pond (Smith Lake Dam) breach; Credit: FEMA; Plisich

Chapter 12 General Comments and Strategic Recommendations

12.1 Regulation

General Comment #1: Emergency Action Plans (EAPs)
Since September 20, 2014, North Carolina requires EAPs for state regulated high and significant hazard dams to be in accordance with the Coal Ash Management Act of 2014. NC DEQ DEMLR noted a few EAP activations during this event. It is unclear how the existing EAPs compare to best practices for life and property safety downstream, such as FEMA P-64 Federal Guidelines for Dam Safety; Emergency Action Planning for Dams (July 2013).

- **General Recommendation #1: Consider Comparison of Emergency Action Plans (EAPs) to Current Best Practices for Life and Property Downstream**
  NC DEQ DEMLR should consider a small pilot project to review a sample of existing EAPs to compare them to current federal guidance and best practices, such as FEMA P-64 Federal Guidelines for Dam Safety; Emergency Action Planning for Dams July 2013. Based on the findings from the pilot program, NC DEQ DEMLR should consider the best strategy forward for improving EAPs and existing EAP guidance.

General Comment #2: Current Spillway Design Requirements
The North Carolina Administrative Code requires very large dams to pass the Probable Maximum Precipitation (PMP). Large, medium, and small high hazard dams are required to pass ¾ PMP, ½ PMP, and 1/3 PMP, respectively. Reference Chapter 7, Section 7.6 in this report for more information on size classification and spillway requirements

- **General Recommendation #2: Current Spillway Design Requirements**
  NC DEQ DEMLR should consider analyzing the percent Probable Maximum Precipitation (PMP) and recurrence interval experienced at each breached and overtopped dam site and determine whether any updates to the spillway design section of the North Carolina Administrative Code are needed.

General Comment #3: Exemptions to State Regulation
Eight (8) of the North Carolina inventoried dam breaches that occurred during this event were dams exempt from state regulation. The consequences of one dam breach (Smith Lake Dam; Cumbe-050) contributed to a state road, NC-53, being washed out. Further, based on NC DEQ DEMLR inspection reports reviewed for this report, some exempt dams were inspected after a five year period and others had inspection cycles upwards of ten years.

The dam safety section of the North Carolina Administrative Code allows for exemptions. Reference Chapter 7, Section 7.4 in this report for more information on exemptions to state regulation.

Table 12.1 Dams exempt to state regulations that breached during this event

State ID	Dam Name	County	Hazard Classification
CUMBE-050	Smith Lake Dam	Cumberland	Low - Exempt
CUMBE-055	Smith Lake Dam	Cumberland	Low - Exempt
DUPLI-016	Rouse Pond	Duplin	Low - Exempt
DUPLI-017	Maxwell Mill Pond	Duplin	Low - Exempt
HARNE-047	Guy Lake Dam	Harnett	Low - Exempt
SAMP-016	Laurel Lake Dam	Sampson	Intermediate - Exempt
WAYNE-008	Durham Lake	Wayne	Low - Exempt
WILSO-009	Silver Lake	Wilson	Intermediate - Exempt

- **General Recommendation #3: Exemptions to State Regulation**
  NC DEQ DEMLR should consider re-evaluating and possibly amending the policies and procedures for determining whether dams are regulated and the frequency by which their status is reassessed.

General Comment #4: Breached Impoundments

NC DEQ DEMLR records at the NC EOC show that there were multiple impoundments which breached during this event that were not on the North Carolina dam inventory.

- **General Recommendation #4: Statewide Assessment of Impoundments**
  NC DEQ DEMLR, in coordination with NCEM-RM, should consider performing a statewide assessment of impoundments utilizing the highly accurate LiDAR data available in North Carolina. The data can be analyzed relatively quickly to determine whether there are impoundments warranting more detailed assessment for incorporation into the state dam inventory or to be regulated as a dam.[44]

General Comment #5: Monitoring and Notification of Breached Dams

The Coal Ash Management Act of 2014 requires the EAP to include "*emergency notification procedures to aid in warning and evacuations during an emergency condition at the dam*". According to the state, most dam failures occurred without prior monitoring or notification. (Monitoring can include geotechnical, structural, or environmental instrumentation and early warning systems.)

[44] As only two examples, Mississippi Dam Safety used a similar methodology and found 4000+ dams, while Florida Dam Safety found over 400 dams.

- **General Recommendation #5: Monitoring and Notification of Dams**
  In order to better support warning and evacuation processes included in EAPs, NC DEQ DEMLR should consider reviewing the guidance and regulations which govern emergency notification procedures. NC DEQ DEMLR should consider improvements to guidance for dam owners on remote sensors and other instrumentation to help facilitate more accurate monitoring during heavy rainfall events. This guidance might include having dam owners provide key thresholds for notifications to encourage timely EAP activation and increased warning time for evacuations.

General Comment #6: NC DEQ DEMLR Funding for Emergency Dam Response Operations
NC DEQ DEMLR currently has the authority by state statute to "take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. The Environmental Management Commission may recover the costs of such measures from the owner or owners by appropriate legal action." However, DEMLR has no funding source by which they can actually carry out this authority. This hampered their efforts, in particular, at Woodlake Dam.

- **General Recommendation #6: NC DEQ DEMLR Funding for Emergency Dam Response Operations**
  The state of North Carolina should consider funding options for NC DEQ DEMLR to execute the authority to "take such measures as may be essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir." These funds would assist in more pro-active risk reduction to residents of North Carolina from dam incidents and breaches.

General Comment #7: Woody Vegetation and Trees on Dams
Inspection reports and photographs from the breached dams reviewed for this report indicate woody vegetation and trees on the embankment, which may have been one of the contributing factors to the breach of eleven of these dams.

- **General Recommendation #7: Woody Vegetation and Trees on Dams**
  NC DEQ DEMLR should consider further assessing the breached dams to more fully understand and document the woody vegetation on these dams and their potential impacts. DEMLR is encouraged to maximize the usage of best practices regarding woody vegetation and trees on dams found in FEMA P-534 (Technical Guidance for Dam Owners: Impacts of Plants on Earth Dams) for their policies, procedures, inspection reports, among others.

12.2 Preparedness

General Comment #8: Emergency Action Plan (EAP) Activations and Evacuations
NC DEQ DEMLR records at the NC EOC show that five EAPs were activated and residents below three dams were evacuated during this event.

Table 12.2 EAP activations and evacuations recorded during this event

State ID	Dam Name	County	Notes
Moore-040	Woodlake Dam	Moore	EAP activation, evacuations
Wayne-009	H.F. Lee Cooling Pond	Wayne	EAP activation
Robes-004	Weatherspoon Cooling Pond	Robeson	EAP activation
Newha-003	Sutton Cooling Pond	New Hanover	EAP activation
Wake-034	Lake Benson	Wake	EAP activation, evacuations
Wilso-007	Lake Wilson Dam	Wilson	Evacuations

- **General Recommendation #8: Lessons Learned from Emergency Action Plan (EAP) Activations and Evacuations**
  NC DPS and NC DEQ DEMLR should consider assessing the five EAP activations and three evacuations that occurred during this event and develop lessons learned. These lessons learned may be incorporated into policies, procedures, and protocols and inform outreach, training, and exercise efforts.

General Comment #9: Dam Exercises for State Regulated Dams
Currently, state regulations do not require the exercise of state regulated dams.

- **General Recommendation #9: Dam Exercises for State Regulated Dams**
  NC DEQ DEMLR, in coordination with NC DPS, should encourage amenable dam owners and jurisdictions to voluntarily exercise their EAPs, EOPs, and evacuation plans.

General Comment #10: Inclusion of Dams in State-Level Exercises
It is unclear whether state-level exercise scenarios include realistic and challenging dam incidents and breaches that will adequately test policies, procedures, protocols, and authorities between various state agencies and EOC operations.

- **General Recommendation #10: Inclusion of Dams in State-Level Exercises**
  North Carolina Department of Public Safety (NC DPS), in coordination with NC DEQ DEMLR, should consider including realistic and challenging simulated dam incident and dam breaches in state-level exercises. These dam-related scenarios should incorporate complex conditions such as multiple dam breaches, road closures, and communication challenges. This will help test existing policies, procedures,

protocols, EOC and dam safety operations, communications, reporting, confirmations, North Carolina's State Preparedness and Resource Tracking Application (NCSPARTA) usage, coordination, and accessing breached or flooded dam sites.

General Comment #11: Staffing for EAP Submittal Reviews

Five additional positions to assist in reviewing EAPs were included in the Coal Ash Management Act of 2014. The Act states the owner of high and intermediate hazard dams shall develop Emergency Action Plans and they will update the EAPs and send them in annually for review and approval. The positions are at present two-year term positions. As of October 2016, 675 of the 1,184 high hazard dams have EAPs. There are more than 300 additional intermediate hazard dams regulated by the state. The state has a backlog of 147 EAPs for review.

- **General Recommendation #11: Staffing for EAP Submittal Reviews**
  Due to the sheer number of EAPs required in the state and the annual statutory review requirement in the law, NC DEQ DEMLR should consider permanent position(s) for reviewing, coordinating, and potentially exercising EAPs and providing outreach and training to dam owners, community officials, emergency managers, and other appropriate stakeholders.

General Comment #12: NC DEQ DEMLR Access to EAP Tool

Currently, NCEM-RM controls access to the EAP tool. NC DEQ DEMLR has only one authorized user to access this tool. See **General Comment #11** above for the level of effort involved with EAP reviews by DEMLR.

- **General Recommendation #12: Increase NC DEQ DEMLR Personnel Access to EAP Tool**
  NCEM-RM should consider coordinating with NC DEQ DEMLR to develop an agreeable number of authorized DEMLR users and then provide those users with the commensurate access and authorities to fully utilize the EAP Tool for NC DEQ DEMLR. It is important for life safety issues, such as dam breach, to have back-up plans and multiple points of coordination amongst the area's emergency responders. Allowing for multiple people would increase the ability to respond as needed should an emergency flood event occur.

General Comment #13: Communication of Emergency Action Plans (EAPs) Downstream

If there is more than one county impacted by a potential dam breach, it is unclear whether each county in the inundation zone is receiving a copy of the dam owner's EAP. It is also unclear whether or not each county in the inundation zone across state borders receives a

copy of the dam owner's EAP. This includes dams that are in North Carolina that could impact neighboring states or dams in neighboring states that could impact North Carolina.

- **General Recommendation #13: Communication of Emergency Action Plans (EAPs) Downstream**
  NC DPS, in coordination with NC DEQ DEMLR, should develop processes and procedures to ensure downstream states, counties, and jurisdictions potentially impacted by inundation from a breached dam are provided EAPs and inundation maps. These should be integrated by locals into their Emergency Operations Plans (EOPs), evacuation planning and maps, and consequence planning.

General Comment #14: Awareness of Emergency Action Plans (EAPs) and Downstream Consequences
It is unclear as to the degree of understanding of EAPs, inundation maps, and the potential downstream consequences associated with dam breaches by dam owners, local officials, county and city engineers, floodplain managers, planners, the general public, and emergency managers. This includes either dam breaches within their local jurisdictions or by dams outside of their jurisdictions that would still impact them.

- **General Recommendation #14a: Emergency Action Plans (EAPs) and Downstream Consequence Education and Training**
  NC DEMLR DEQ, in coordination with NC DPS, with assistance from FEMA Region IV or others if requested, should provide training workshops and outreach materials to dam owners, local officials, and emergency managers to improve awareness of EAPs, inundation and evacuation maps, and the consequences of dam failures with the potential to impact their local jurisdiction.

- **General Recommendation #14b: Assessment of Consequences to Dam Breach**
  NC DPS should consider providing workshops or outreach material to their local EMAs, local officials, or others in analyzing dam owner inundation maps to more fully determine and understand the potential risks, vulnerabilities, and consequences associated with potential dam failures for their given areas. NC DPS should consider coordinating with NC DEQ DEMLR, FEMA Region IV Dam Safety, or others as needed.

General Comment #15: Emergency Action Plan (EAP) and Inundation Map Integration into Emergency Operations Plans (EOPs) and Evacuation and Consequence Planning
It is unclear to what degree state and local communities and emergency managers are integrating EAPs into EOPs and using EAP and inundation maps for informing their own development of consequence planning and evacuation maps.

- **General Recommendation #15: Integrate Emergency Action Plans (EAP) and inundation maps into Emergency Operations Plans (EOPs) and Evacuation and Consequence Planning**
  State and local communities should consider integrating EAP and inundation map information to help inform the development of their EOPs, evacuation maps, and consequence planning.

12.3 Response

General Comment #16: Dam Site Accessibility
Some dam sites with reported incidents were initially inaccessible to state regulators attempting to assess the damages due to road closures, debris, and flooding conditions. In addition, the building for the Fayetteville Regional Office (FRO) was flooded by 8-9 feet during the event, preventing access to files in the office during response operations. The lack of access to sites delayed dam assessments or confirmations until after the water receded. Critical files, including hardcopy EAPs, were in-accessible through the FRO.

- **General Recommendation #16: Dam Site Accessibility**
  NC DEQ DEMLR, in coordination with NC DPS, should consider developing plans, procedures, and protocols for developing backups to accessing key dam file related information, utilizing alternative methods to quickly and accurately assess dams of concern, and enable timely clarification or confirmations of reported incidents during future events when roadways are inaccessible.

General Comment #17: Accuracy of Dam-Related Reports – Rumor Control
There were numerous reports of dam breach or failures that were inaccurate, which created a challenge for NC DEQ DEMLR in dealing with getting ground truth and accurate situational awareness.

- **General Recommendation #17: Dam Assessments and Reporting – Event Facts**
  NC DEQ DEMLR and NC DPS should consider developing or clarifying policies, procedures, or protocols for dam assessments, dam reporting, and confirming dam breaches and incidence in order to provide timely and consistent updates on the dam-related incidents and breaches and refute inaccurate information. A Communications Team or Point of Contact in the EOC that focuses on Rumor Control and clarification of the information is one way to accomplish this. NC DEQ DEMLR should consider having a staff member to update NCSPARTA regularly so that the latest updates are promptly placed in the system for all agencies and Public Information Officers (PIOs) to pull for reports.

General Comment #18: High Water Marks (HWMs) around Dams
FEMA and USGS do not currently have a standard operating procedure in place for collecting HWMs around dams.

- **General Recommendation #18: High Water Marks (HWMs) around Dams**
  FEMA and USGS should consider developing procedures and protocols for collecting HWMs around dams during flooding events.

General Comment #19: Dam Safety and the FEMA Qualification System (FQS)
FQS does not have a title for FEMA dam safety liaisons to the RRCC, EOC, or JFO operations.

- **General Recommendation #19: Dam Safety and the FEMA Qualification System (FQS)**
  FEMA Dam safety liaisons should be considered by FEMA Headquarters for inclusion into the FQS for deployments to the RRCC, EOC, or JFO during dam-related events. A FEMA Dam Safety liaison has knowledge that can help inform the NRCC, RRCC, EOC, and JFO operations on dam related matters.

General Comment #20: Dam Safety Subject Matter Expertise in the National Response Coordination Center (NRCC), Regional Response Coordination Center (RRCC), Emergency Operations Center (EOC), and Joint Field Office (JFO)
There is currently no policies, procedures, guidance, or job aids for FEMA dam safety liaisons for carrying out NRCC, RRCC, EOC, or JFO operations.

- **General Recommendation #20: Policies, Procedures, or Guidance for FEMA Dam Safety Subject Matter Expertise in the National Response Coordination Center (NRCC), Regional Response Coordination Center (RRCC), Emergency Operations Center (EOC), or Joint Field Office (JFO)**
  FEMA should develop policies, procedures, or guidance for dam safety subject matter expertise in the NRCC, RRCC, EOC, or JFO. A FEMA Dam Safety liaison has knowledge that can help inform the NRCC, RRCC, EOC, and JFO operations on dam related matters.

General Comment #21: Awareness of FEMA Support Capabilities for Dam Incidents during Response in Federally Declared Emergencies and Disasters
It is unclear the degree to which state personnel at the North Carolina EOC were aware of some of the Category B Emergency Protective Measure capabilities that exist for dams, accessible through FEMA IMATs during a federally declared emergency. During this incident, multiple pumps were provided through FEMA IMAT Infrastructure at the North Carolina EOC to the state to the local government, which helped reduce the risk of failure at the dam.

- **General Recommendation #21: Training on FEMA Category A and B Measures Applicable to Dams during Federally Declared Emergencies and Disasters**
  FEMA PA and FEMA Dam Safety should consider developing Fact Sheets and providing training to NC DEQ DEMLR, NC DPS, or others on Public Assistance Category A (Debris Removal) and Category B (Emergency Protective Measures) measures that can potentially be used for dams during emergency situations. These measures (i.e. pumps, siphons, debris removal from clogged spillways, clogged outlet works, clogged trash racks) should be considered for incorporation into training the state does with local jurisdictions as well. These can be critical resources or concepts available in helping to reduce the risk of dam failure. FEMA PA, FEMA Dam Safety, NC DEQ DEMLR, and NC DPS should consider developing a list of potential options for use by dam owners and local jurisdictions to help reduce the potential for dam failure during future events. It is important to note these categories are merely mechanisms for reimbursement. However, some of the concepts can be used regardless of whether reimbursement occurs or not.

General Comment #22: Dams in National Response Coordination Center (NRCC) Operations

It is unclear to what degree the NRCC has risks related to dams and dam breach incorporated into their planning, protocols, processes, and procedures for response operations.

- **General Recommendation #22: Dams in National Response Coordination Center (NRCC) Operations**
  The NRCC, in coordination with Essential Support Function (ESF) #3 (Infrastructure) and FEMA Headquarters Dam Safety Program, should consider reviewing their processes, procedures, protocols, and planning factors to further incorporate dam risk.

General Comment #23: Decision Support System for Water Infrastructure Security (DSS-WISE) Lite

The DSS-WISE Lite program was utilized on a dam of concern at the RRCC and NC EOC. Currently, policies and protocols do not exist for using this dam breach modeling program during a disaster at the RRCC or EOC.

- **General Recommendation #23: Develop FEMA Operational Protocols for Decision Support System for Water Infrastructure Security (DSS-WISE) Lite**
  FEMA should develop policies, procedures, and protocols for FEMA usage of the DSS-WISE Lite program at the RRCC and EOC's during a potential flooding emergency or disaster operation.

12.4 Recovery

General Comment #24: Dam Breach and Consequences
At this time, there is minimal information regarding the cause of the twenty dam breaches and the consequences to those communities, both upstream and downstream of the dams.

- **General Recommendation #24: Dam Breach Analysis and Consequences**
  NC DEQ DEMLR should consider analyzing the probable failure modes of the breached dams identified in this report. NC DPS, in coordination with NC DEQ DEMLR, should consider analyzing some of the downstream consequences of the twelve regulated dam breaches and use this data to foster dam safety resilience. Appendix A includes considerations for additional analysis for each breached dam.

General Comment #25: Private Dams on Public Roads
A few of the private dams that breached had public roads on them. For a neighborhood where the road was the only access route, the houses were inaccessible by vehicles until such time as the locals were able to restore vehicular access.

- **General Recommendation #25: Private Dams on Public Roads**
  NC DEQ DEMLR should consider coordinating with NC DPS, NC DOT, or others to develop procedures or protocols for providing information on dams of particular high public safety concern, due to inherent vulnerabilities (i.e. lack of adequate spillway capacity), NODs, or other reasons. These organizations can then use this information as is appropriate for inclusion into general annual budget planning, operations plans, emergency operations plans, mitigation plans, and coordination as needed.

12.5 Mitigation

General Comment #26: Dams Largely Not Referenced in North Carolina Flood Insurance Studies (FIS), Flood Risk Information System (FRIS), and Flood Inundation Mapping and Alert Network (FIMAN)
Based on the information reviewed for this report, the Flood Insurance Studies (FIS), North Carolina's Flood Risk Information System (FRIS), and North Carolina's Flood Inundation Mapping and Alert Network (FIMAN) appear to largely not reference dams, nor analyze dams in the hydraulic modeling. FEMA has minimal policies and procedures in place for incorporating dams and dam risk into Flood Insurance Studies.[45]

[45] https://www.fema.gov/media-library/assets/documents/112356

- **General Recommendation #26: Dam Risk Communication in North Carolina Floodplain Management Program**
  Under their own authority, the North Carolina Department of Public Safety, Emergency Management, Risk Management Section (NCEM-RM) should consider coordinating with NC DEQ DEMLR along with FEMA Region IV Risk MAP and Dam Safety to develop a strategy to more effectively capture dam risk. This will better enable communication of this information with appropriate entities in North Carolina. These measures might include, but are not limited to, referencing the dam name or State Dam ID on Flood Insurance Rate Maps (FIRMs), inclusion of dam outlet systems in the hydraulic modeling for the Flood Insurance Studies (FISs), and consideration of dams in hydrologic analysis for FISs. This might also include dams and residual dam risk in non-regulatory flood products and information into FRIS and FIMAN products as appropriate.

General Comment #27: Dam Risk and Mitigation Planning
Dam failure is listed as a lesser hazard in the North Carolina Enhanced Mitigation Plan. Based on information reviewed for this report, several of the multi-jurisdictional hazard mitigation plans state the likelihood of occurrence of a dam failure impacting the multi-jurisdictional area is "unlikely".

- **General Recommendation #27: Dam Risk and Mitigation Planning**
  NCEM-RM, in coordination with NC DEQ DEMLR, should consider undertaking more robust dam risk analyses and sharing this data with state and local mitigation planners and other relevant stakeholders tasked with updating mitigation plans.

General Comment #28: Topographical Data in Decision Support System for Water Infrastructure Security (DSS-WISE) Lite
The DSS-WISE Lite program was utilized on a dam of concern by NC DEQ DEMLR. However, North Carolina has very accurate LiDAR data, while the program uses 30-meter Digital Elevation Model (DEM). The state was unable to utilize their LiDAR data in DSS-WISE, as errors occurred that prevented the model from completing. The state was able to run the model using 30-meter DEM, which is less accurate.

- **General Recommendation #28: FEMA inclusion of LiDAR data in Decision Support System for Water Infrastructure Security (DSS-WISE) Lite**
  FEMA should consider investing resources to update the DSS-WISE Lite program enabling users to incorporate more accurate LiDAR data, where available.

General Comment #29: Dam Risk Awareness
Based on the number of inaccurate reports of dam failures and breaches received at the North Carolina EOC, there appears to be a lack of general understanding and awareness of

dam terminology, dam incidents, failure modes, basic dam operations, spillway activations, EAP requirements, and other dam-related topics.

- **General Recommendation #29: Dam Awareness Training and Outreach**
  NC DEQ DEMLR, in coordination with NC DPS, should consider providing dam awareness training and outreach on dam terminology, dam operations, spillway types, common failure modes, and EAPs for state and local emergency managers, local floodplain managers, county and city engineers, planners, local officials, and others. FEMA Region IV Dam Safety is available to support these efforts where appropriate and upon request by the state.

General Comment #30: Home Owner's Associations (HOA) and Dam Awareness
Based on information from the state, it is unclear how HOAs with dam ownership are made aware of their dam related responsibilities.

- **General Recommendation #30: Home Owner's Associations (HOA) and Dam Awareness**
  NC DEQ DEMLR, in coordination NC DPS or others, with support from FEMA Region IV as appropriate, should consider providing training, outreach, and exercises to amenable HOAs in helping them better understand their risks and carry out their responsibilities in maintaining, operating, repairing, rehabilitating, or removing their dams. This should include encouraging coordination between HOAs where a dam impacts multiple neighborhoods.

Appendix A: Information for Each Breached State Regulated and Exempt Dam

Breached Dam Information provided by NC DEQ DEMLR (Sorted by County, then State ID)

#	NID ID	State ID	Name	County	Hazard Classification	Owner Type
1	NC02137	CUMBE-025	Loch Lommond	Cumberland	High	Private
2	NC01126	CUMBE-034	Long Valley Farm Lake Dam	Cumberland	High	State Govt
3	NC01142	CUMBE-050	Smith Lake Dam	Cumberland	Low - Exempt	State Govt
4	NC01144	CUMBE-052	Arran Lakes	Cumberland	High	Private
5	NC01145	CUMBE-053	Rhodes Lake	Cumberland	High	State Govt
6	NC01148	CUMBE-055	Smith Lake Dam	Cumberland	Low - Exempt	Private
7	NC02151	CUMBE-077	Mirror Lakes Dam	Cumberland	High	Local Govt
8	NC02160	CUMBE-086	Mount Vernon Estates	Cumberland	High	Private
9	NC04797	CUMBE-088	Devonwood Lower* Dam	Cumberland	High	Private
10	NC05621	CUMBE-099	Rayconda Upper	Cumberland	High	Private
11	Not Available	DUPLI-016	Rouse Pond	Duplin	Low - Exempt	Private
12	NC01156	DUPLI-017	Maxwell Mill Pond*	Duplin	Low - Exempt	Private
13	NC01098	HARNE-047	Guy Lake Dam	Harnett	Low - Exempt	Private
14	NC05301	HOKE-028	Sunset Lake Dam	Hoke	High	Private
15	NC00948	LENOI-003	Tull Millpond Pond	Lenoir	High	Private
16	NC01083	SAMP-016	Laurel Lake Dam	Sampson	Intermediate - Exempt	Private
17	NC05468	SAMPS-047	House-Autry Dam	Sampson	High	Private
18	NC00943	WAYNE-008	Durham Lake	Wayne	Low - Exempt	Private
19	NC00944	WAYNE-009	H.F. Lee Power Station Cooling Lake Dam	Wayne	High	Public Utility
20	NC00896	WILSO-009	Silver Lake	Wilson	Intermediate - Exempt	Private

*Partially Breached per NC DEQ DEMLR

A1) State Dam Name: Loch Lommond Dam Latitude: 35.07, Longitude: -78.998;
Regulator: NC DEQ DEMLR

Table A1 Loch Lommond Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the Oct 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Loch Lommond	County	Cumberland
Stream or River	Stewarts Creek	Owner Type	Private
NID Hazard Class	High	State Hazard Class	High
NID ID	NC02137	EAP	No
Dam Type	Earthen	Year Modified	No information
Purpose	Recreational	Surface Area (ac-ft)	13
Length (ft)	250	Condition Assessment	Fair
Drainage Area (sq mi)	3.491	Normal Storage (ac ft)	No Information
Nearest Downstream City/Town	Fay.	Nearest Downstream City/Town	Fay.
Fields where the 2016 NID Differs from the Oct 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	21	N/A	N/A
Drainage Area (sq mi)	3.491	Drainage Area (ac)	2234
Structural Height (ft)	No Information	Structural Height (ft)	21
State ID	No longer cross references state ID	State ID	CUMBE-025
Year Completed	No information	Year Constructed	No information
Max Storage (ac-ft)	109.2	max impoundment capacity (ac-ft)	109
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040800J	FIS Effective Date	June 18, 2007
FIRM Effective Date	1/5/2007	Preliminary Date	April 30, 2014

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A1.1: Loch Lommond pre-event image; Credit: 2016 Google Earth Streetview

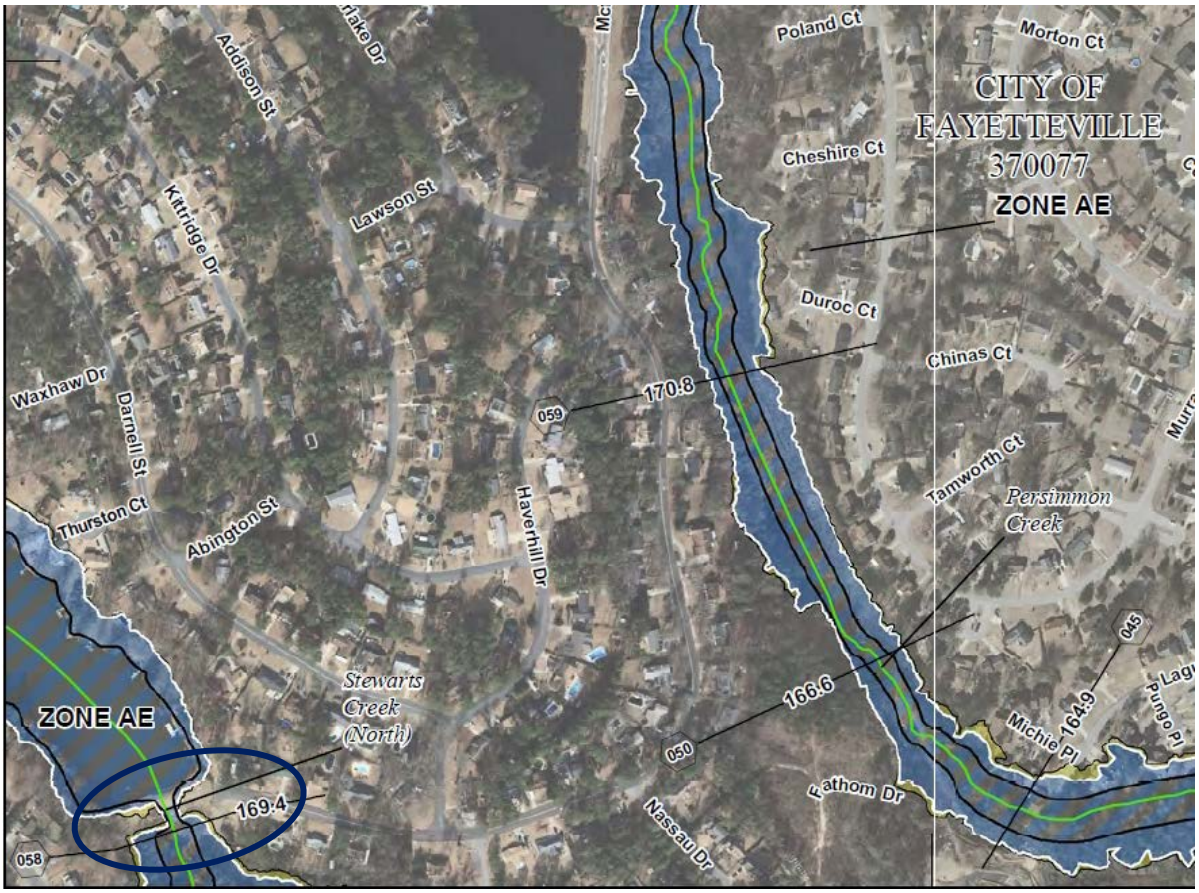


Figure A1.2: Loch Lommond Dam in blue circle; FEMA FIRM cropped

Figure A1.3: Loch Lommond Dam Site Area Map; Credit: Map data: 2016 Google Earth


Figure A1.4: Loch Lommond Dam post-event photo; Credit: NC DEMLR

General Loch Lommond Dam Comments:

- This dam is classified as High Hazard by NC DEQ DEMLR and inventoried as High Hazard in the 2016 NID.
- No Civil Air Patrol (CAP) photos were found for this dam.
- The FIRM shows this dam as being on Stewarts Creek (North). The NID and the North Carolina dam inventory also have this dam being on Stewarts Creek.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 8"-10" in the area of Loch Lommond Dam.
- USGS HWMs were not collected upstream and downstream of Loch Lommond Dam
- A review of the effective and preliminary FEMA Flood Insurance Study for Cumberland County:
  - In searching for "Loch", "Lommond", and "Dam" on the Cumberland County FIS, nothing was found for Loch Lommond Dam by name.
  - A flood profile appears to exist for this dam, Flood Profile 76P. However, "Loch Lommond" is not named on the profile. The dam named on the profile is "Devenwood Dam" on McFayden Drive. There is a "Devonwood" dam 0.4 miles away from "Loch Lommond" on McFayden Drive. It is unclear whether "Devonwood" is "Loch Lommond" or another dam.
  - Stewarts Creek (North) has a HEC-RAS model available. It does not include Loch Lommond Dam.
  - A FIRM panel does exist on which Loch Lommond Dam can be located, as shown in Figure A1.2 above. However, a generic "dam" is not identified on the FIRM, nor is Loch Lommond Dam identified by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- According to NC DEQ DEMLR, an EAP does not exist for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County
- The NID and North Carolina dam inventory have no information on the year this dam was completed / constructed.
- This dam was inspected on December 21, 2010 and January 20, 2012 by DEMLR and both stated, "This inspection revealed no apparent problems with the dam."
- The 2016 NID and the October 2016 North Carolina inventory have the condition of this dam as "Fair".

Considerations for Loch Lommond Dam:

- Consider determining the percent PMP and flood recurrence intervals experienced for this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode as a result of this event.

- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time of construction.
- Consider collecting and documenting dam breach parameters at this dam.

A2) State Dam Name: Long Valley Farm Lake Dam Latitude: 35.21114, Longitude: -78.97776; Regulator: NC DEQ DEMLR

Table A2 Long Valley Farm Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the Oct 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Long Valley Farm Lake Dam	County	Cumberland
Stream or River	Jumping Run Creek	Max Discharge (cfs)	511
NID ID	NC01126	Hazard Class	High
Dam Type	Earthen	Normal Storage (ac ft)	560
Purpose	Recreation, Irrigation	Surface Area (ac-ft)	90
Length (ft)	624	Nearest Downstream City/Town	Linden
Owner Type	State	Year Modified	2010
EAP	No	Condition Assessment	Fair
Fields where the 2016 NID Differs from the Oct 2016 NC Dam Inventory* Information			
NID Field Name	**NID Value**	**State Field Name**	**State Value**
State ID	No longer cross references state ID	State ID	CUMBE-034
Drainage Area (sq mi)	25.3	Drainage Area (ac)	16192
Dam Height (ft)	18	N/A	N/A
Structural Height	No Information	Structural Height	18
Year Completed	1750	Year Constructed	1750
Max Storage (ac-ft)	672	max impoundment capacity (ac-ft)	672
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720050300K	FIS Effective Date	June 18, 2007
FIRM Effective Date	January 5, 2007	FIS Preliminary Date	April 30, 2014

*NC Dam Inventory Information provided by NC DEQ DEMLR

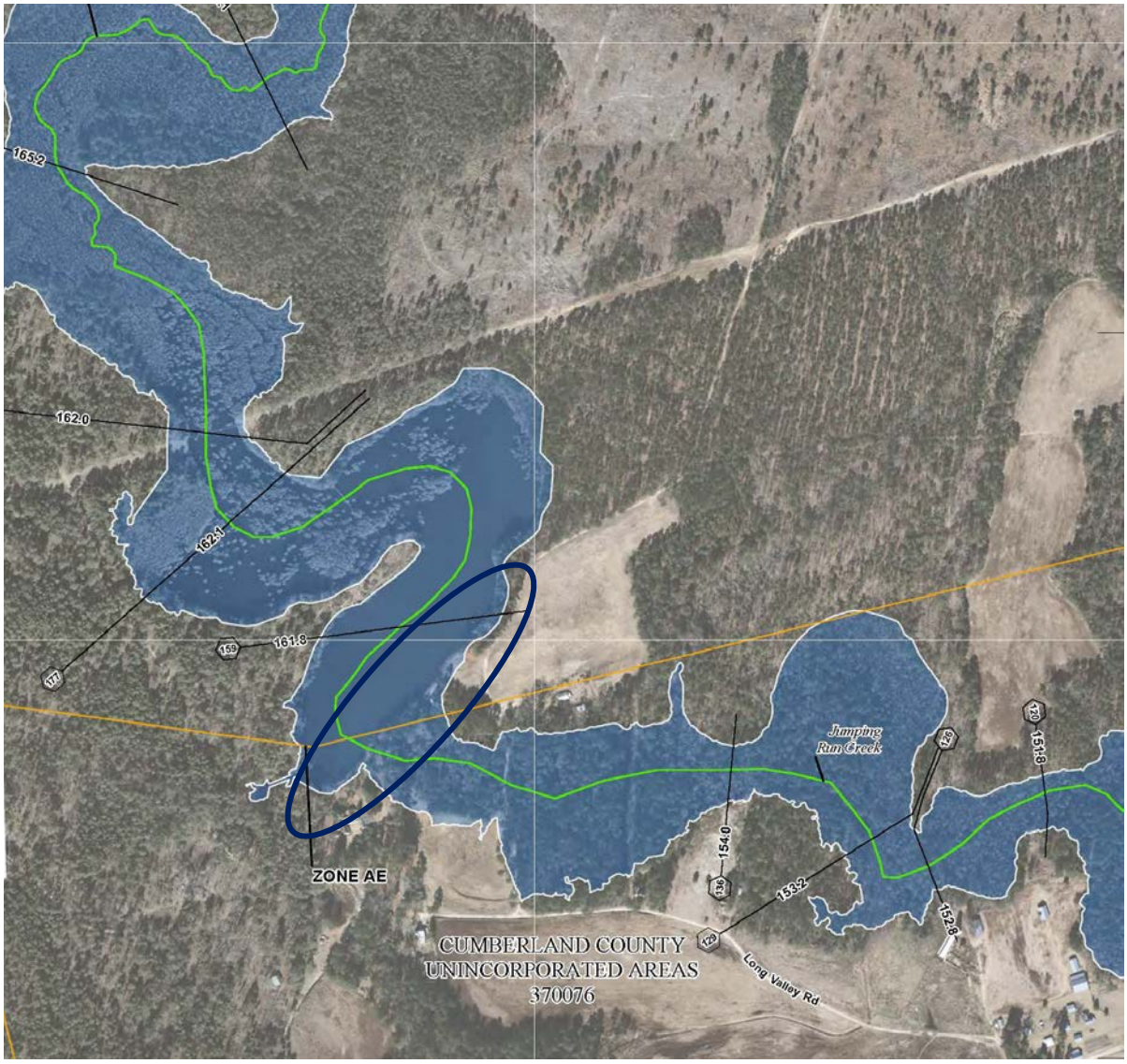


Figure A2.1: Long Valley Farm Lake Dam in blue circle; FEMA FIRM cropped; See FIRM in spreadsheet above

Figure A2.2: Long Valley Farm Lake Dam Site Area Map; Credit: Map data: 2016 Google Earth

Figure A2.3: Long Valley Dam post-event photo; Credit: NC DEMLR

General Long Valley Farm Lake Dam Comments:

- This dam is classified as High Hazard in the North Carolina dam inventory and the 2016 NID.
- Civil Air Patrol (CAP) photos were not found for this dam.
- The FIRM shows the dam on Jumping Run Creek, which is consistent with the NID and North Carolina dam inventory.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 5"-6" in the area of Long Valley Farm Lake Dam.
- A review of the effective and preliminary FEMA Flood Insurance Study for Cumberland County:
  - Long Valley Farm Lake Dam is not referenced by name.
  - Specific Hydraulic and Hydrologic modeling was not found for this dam.
  - A FIRM panel does exist on which Long Valley Farm Lake Dam can be located, as shown in Figure A2.1 above. However, a generic "dam" is not identified on the FIRM, nor is Long Valley Farm Lake Dam identified by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP does not exist for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County.
- The NID and the North Carolina dam inventory have this dam as modified in 2010.
- The 2016 NID and the North Carolina dam inventory have the condition of the dam as "Fair".

Considerations for Long Valley Farm Lake Dam:

- Consider determining the percent PMP and flood recurrence interval experienced for this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider collecting and documenting dam breach parameters at this dam.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A3) State Dam Name: Smith Lake Dam Latitude: 34.863, Longitude: -78.73;
Regulator: Exempt from State Regulation

Table A3 Smith Lake Dam 2016 NID and October 2016 NC Dam Inventory Information

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Smith Lake Dam	County	Cumberland
Stream or River	Harrison Creek-Os	Nearest Downstream City/Town	Elizabethtown
NID Hazard Class	Low	State Hazard Class	Low - Exempt-HB-Size (Not regulated)
NID ID	NC01142	Year Modified	No Information
Dam Type	Earthen	Condition Assessment	Not Rated
Purpose	Recreation	Normal Storage (ac ft)	64
Length (ft)	582	Surface Area (ac-ft)	No Information
Drainage Area (sq mi)	No Information	Owner Type	Private**
Max Discharge (cfs)	26	EAP	No
Fields where the NID Differs from the October 2016 NC Dam Inventory Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
State ID	No longer cross references state ID	State ID	CUMBE-050
Dam Height (ft)	10	N/A	N/A
Structural Height	No Information	Structural Height	10
Year Completed	1947	Year Constructed	1947
Max Storage (ac-ft)	77	max impoundment capacity (ac-ft)	77
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720048000J	FIS Effective Date	June 18, 2007
FIRM Effective Date	January 5, 2007	FIS Preliminary Date	April 30, 2014

*NC Dam Inventory Information provided by NC DEQ DEMLR

** This is a state owned dam. See the comments section below.

Figure A3.1: Smith Lake Dam pre-event image; Credit: 2016 Google Earth Streetview

Figure A3.2: Smith Lake Dam in blue circle; FEMA FIRM cropped; See FIRM in Table above

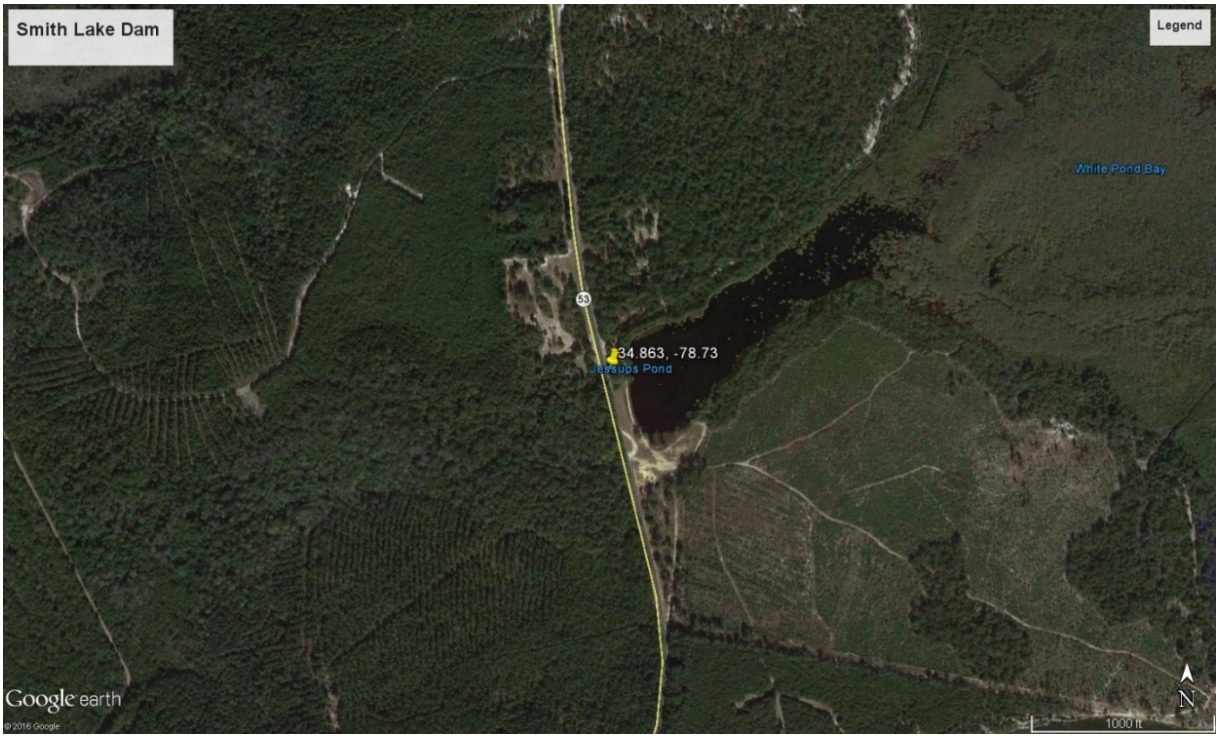


Figure A3.3: Smith Lake Dam Site Area Map; Credit: Map data: 2016 Google Earth

Figure A3.4: Smith Lake Dam post-event photo; Credit: FEMA; Plisich

General Smith Lake Dam Comments:

- This dam is classified as Low Hazard in the 2016 NID and the North Carolina dam inventory.
- Civil Air Patrol (CAP) photos were not found for this dam.
- The NID and North Carolina dam inventory have this dam as being on Harrison Creek-Os. The FIRM shows it as not on a mapped stream.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 8"-10" in the area of Smith Lake Dam.
- A review of the preliminary and effective FEMA Flood Insurance Study for Cumberland County
  - Smith Lake Dam is not referenced by name
  - A FIRM panel does exist on which Smith Lake Dam can be located, as shown in Figure A3.2 above. However, a generic "dam" is not identified on the FIRM, nor is Smith Lake Dam (Jessup Mill Pond) identified by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- An EAP does not exist for this dam. However, since this dam was exempt from regulations, an EAP is not required.
- Both the 2016 NID and the Oct 2016 NC dam inventory have this as being a private dam. However, this dam was visited by Public Assistance with the state applicant and is state owned.
- This dam is not referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County
- The 2016 NID has the condition of the dam as "Not Rated".
- A follow up dam inspection report by NC DEQ DEMLR on August 2, 2013 confirming the dam was still "exempt", stated their next recommended inspection date was August 2, 2023.
- This dam is referenced by a sign on site as Jessup Mill Pond with no reference to the official name in the NID and state inventories as "Smith Lake Dam".
- Based on information from a site visit with PA, there was woody vegetation on the embankment.

Considerations for Smith Lake Dam:

- Consider determining the percent PMP and flood recurrence interval experienced for this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider collecting and documenting dam breach parameters at this dam.
- The state should consider re-assessing this dam to determine whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

- NC DEQ DEMLR should consider reducing the inspection cycle for this dam to somewhere longer than low hazard dams but less than 10 years, should the owner decide to repair / reconstruct it.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A4) State Dam Name: Arran Lakes Dam Latitude: 35.029 Longitude: -78.981;
Regulator: NC DEQ DEMLR

Table A4 Arran Lakes Dam 2016 NID and October 2016 NC Dam Inventory Information

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Arran Lakes Dam	County	Cumberland
Stream or River	Little Beaver Creek	Nearest Downstream City/Town	Fayetteville
NID Hazard Class	High	State Hazard Class	High
NID ID	NC01144	Year Modified	N/A
Dam Type	Earth	EAP	No
Purpose	Recreation	Condition Assessment	Poor
Length (ft)	302	Normal Storage (ac ft)	120
Drainage Area (sq mi)	N/A	Max Discharge (cfs)	63
Owner Type	Local Government	Surface Area (ac-ft)	18
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	21	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	21
State ID	No longer cross references state ID	State ID	CUMBE-052
Year Completed	1958	Year Constructed	1958
Max Storage (ac-ft)	144	max impoundment capacity (ac-ft)	144
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040600J	FIS Effective Date	January 5, 2007
FIRM Effective Date	1/5/2007	FIS Preliminary Date	April 30, 2014

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A4.1: Arran Lakes Dam pre-event image; Credit: 2016 Google Earth Streetview

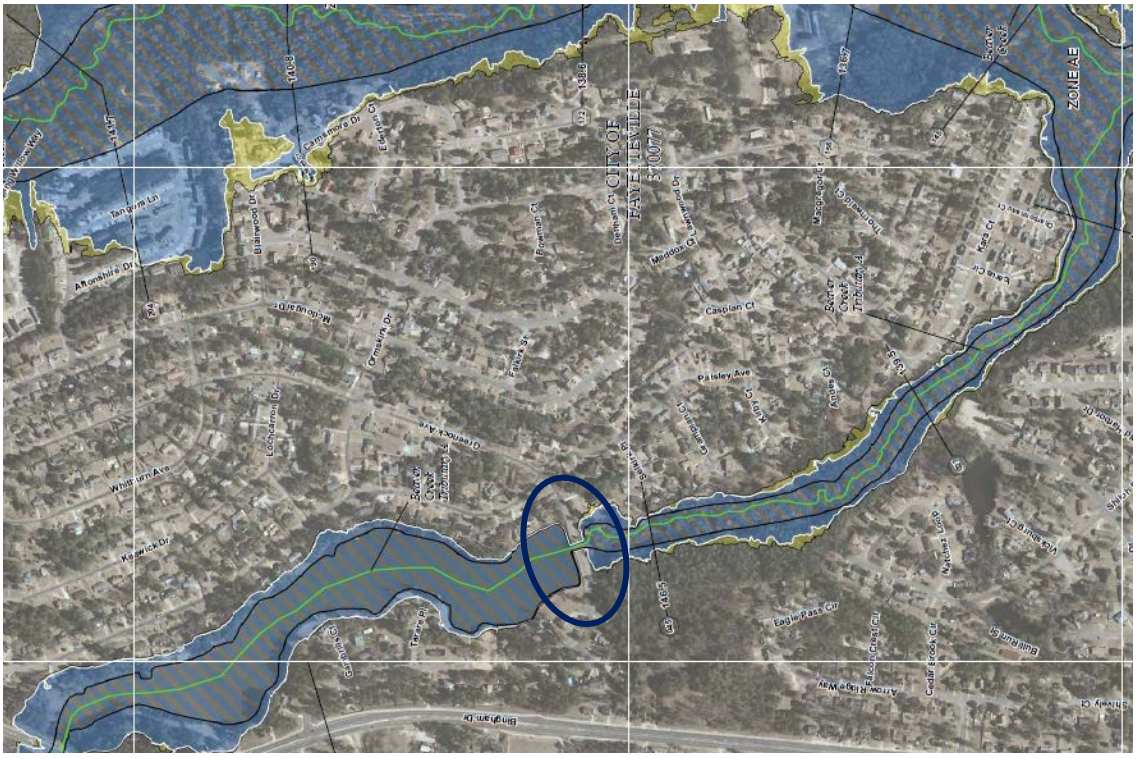


Figure A4.2: Arran Lakes Dam in blue circle; FEMA FIRM cropped; See FIRM in Table above

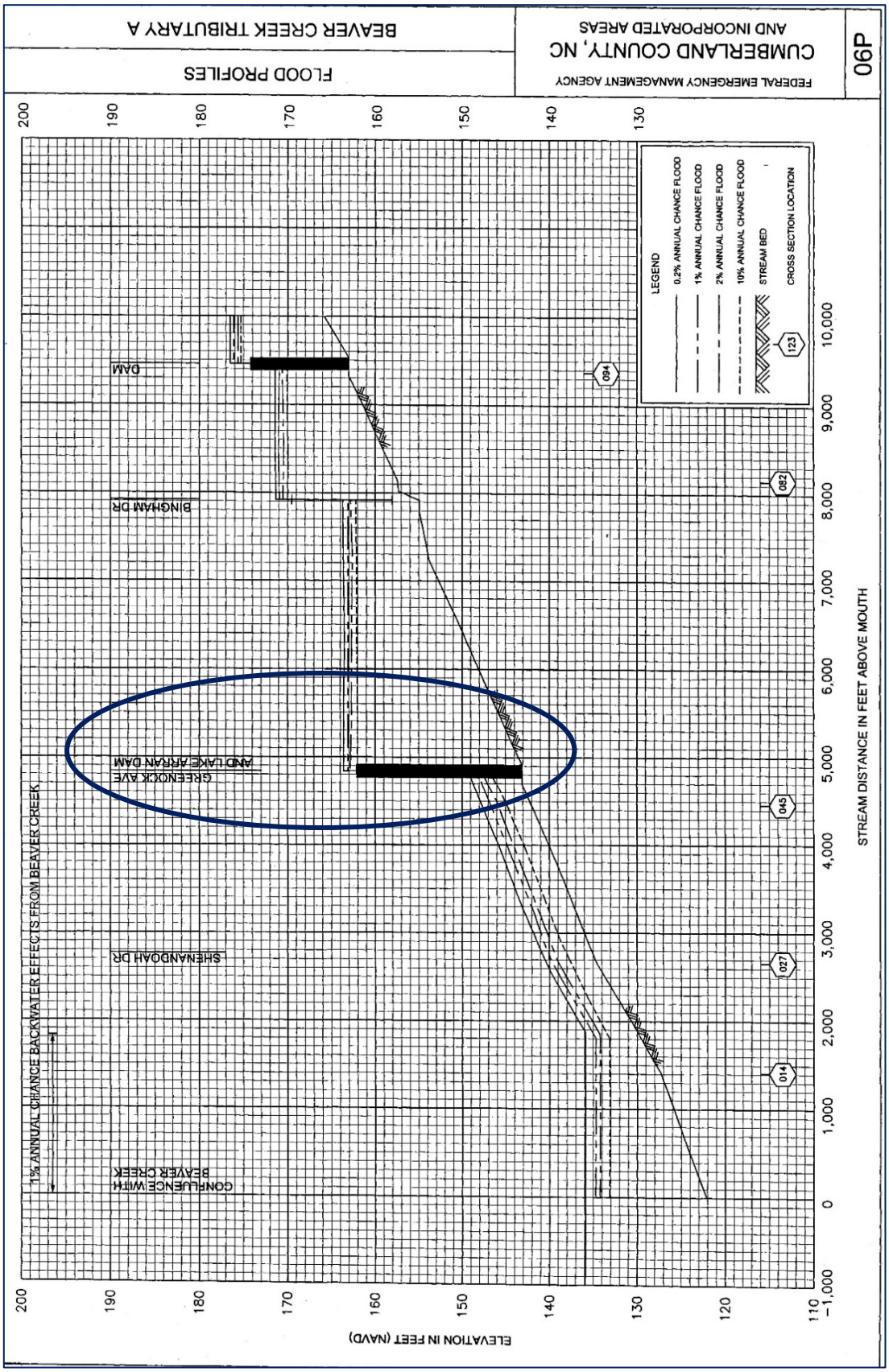


Figure A4.3: Arran Lakes Dam Flood Profile 06P from the FIS on Beaver Creek Tributary A

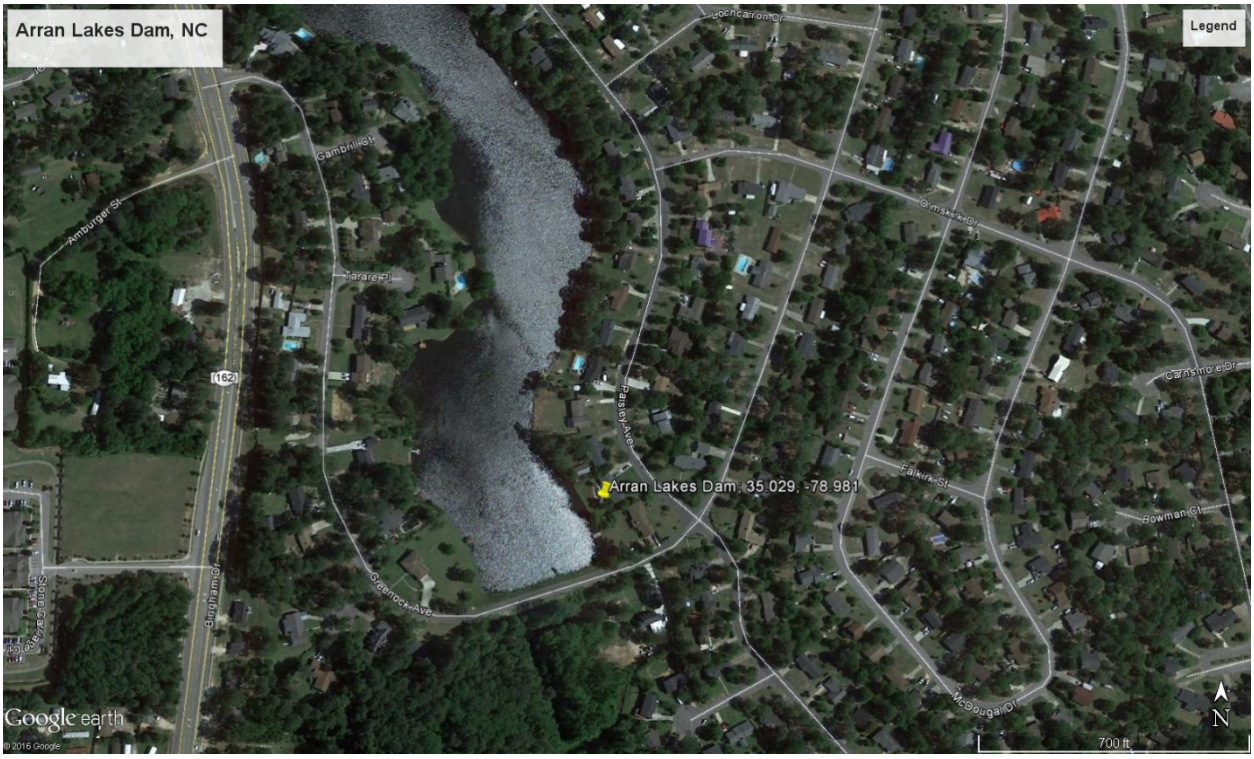


Figure A4.4: Arran Lake Dam Site Area Map; Credit: Map data: 2016 Google Earth


Figure A4.5: Arran Lake Dam post-event photo; Credit: NC DEMLR

General Arran Lake Dam Comments:

- This dam is classified as High Hazard in the North Carolina dam inventory and in the 2016 NID.
- The NID has maximum storage of 144 acre feet while the state has the same value of 144 acre feet but names that field maximum impoundment capacity.
- Civil Air Patrol (CAP) photos were found for this dam.
- The Flood Source from the NC FRIS website, which pulls information from the FIS, shows the Beaver Creek Tributary A as the flood source for this dam. The NID and North Carolina dam inventory have this dam as being on Little Beaver Creek.

- NOAA's National Weather Service recorded an observed 7-day precipitation of 8"-10" in the area of Arran Lake Dam.
- USGS HWMs were collected upstream and downstream of Arran Lake Dam
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Arran", and "Dam" in the effective Cumberland County FIS, nothing was found for Arran Lakes Dam. However, Lake Arran Dam is by name in the FIS Profile, but cannot be found by electronically searching for the name in the pdf file. It must be manually found. The preliminary FIS does not have profiles.
  - Table 7-Summary of Discharges from the effective FIS on page 21, has the following information:

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Beaver Creek Tributary A[3]	*At dam*	*2.5*	*490*	*940*	*1,260*	*1,930*

[3] Discharges increased by urbanization in the watershed

On the NC FRIS website, when a user places a yellow pin on the dam spillway in the floodway and clicks on the "Summary of Discharges" to the right, it will result in the following values (reference the same columns headings above):

Beaver Creek Tributary 2[3]	*At dam*	*2.5*	*490*	*940*	*1,260*	*1,930*

The FRIS website map viewer shows the dam on Tributary A and the FRIS Summary of Discharge Table uses the correct data for Beaver Creek Tributary A, but references it as Tributary 2 in the Summary of Discharge function on the right. Tributary 2 comes from the Preliminary FIS.

  - Specific Hydraulic and Hydrologic modeling was not found for this dam on the FRIS website.
  - The effective FIS Profile has this dam as being overtopped by roughly two feet in the 1% annual chance of exceedance flood event.
  - A FIRM panel does exist on which Arran Lake Dam can be located, as shown in Figure A4.2 above. However, a generic "dam" is not identified, nor is Arran Lake Dam identified by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP does not exist for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County

- The NID has this dam as completed in 1958. The North Carolina dam inventory has this dam as constructed in 1958.
- The 2016 NID has the condition of the dam as “Poor”.
- Highlights from inspection reports :
  - North Carolina Department of Environment and Natural Resources Division of Land Resources noted: *Large trees and dense undergrowth on downstream slope, could not fully/properly inspect. Erosion noted on downstream slope where stormwater leaves paved road and runs down slope. Upper 1/3 of downstream slope is very "soft" underfoot. Voids and erosion noted around both wingwalls on outlet headwall. Spalling and holes on concrete apron noted. Damage appears to have progressed since last inspection.* (Inspections report NC DENRDLR, 120815).
  - Dam Safety Inspection Report: *Downstream slope/Face - Trees and dense undergrowth. Cannot properly inspect. Erosion noted in areas where stormwater runoff travels over slope. Old slides noted. Material on downstream slopes very soft and spongy. Principal Spillway - Voids, holes and erosion noted around both wingwalls on outlet headwall, spalling on concrete apron. Damage appears to be progressing.* (Inspections report, CUMBE-052-NOI-20151218)

<u>Considerations for Arran Lake Dam</u>:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further research into whether or not the recommendations provided in the last NC DEQ DEMLR inspection were addressed.
- Consider collecting and documenting dam breach parameters at this dam.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A5) State Dam Name: Rhodes Lake Dam Latitude: 35.2258 Longitude: -78.6528
Regulator: NC DEQ DEMLR

Table A5 Rhodes Lake Dam 2016 NID and October 2016 NC Dam Inventory Information

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Rhodes Lake Dam	County	Cumberland
NID Hazard Class	High	State Hazard Class	High
Stream or River	Black River	Nearest Downstream City/Town	Falcon
NID ID	NC01145	Owner Type	State
Dam Type	Earth	EAP	Yes
Purpose	Recreation	Surface Area (ac-ft)	120
Length (ft)	3300	Condition Assessment	Unsatisfactory
Max Discharge (cfs)	594		
Fields where the NID Differs from the October 2016 Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Year Modified	2011	Modify / Repair Year	2011
Drainage Area (sq mi)	60	DRAINAGE AREA (Ac)	38,400
Normal Storage (ac ft)	1920	NORMAL POOL CAPACITY (Ac-Ft)	1920
Dam Height (ft)	15.2	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	15.2
State ID	No longer cross references state ID	State ID	CUMBE-053
Year Completed	1770	Year Constructed	1770
Max Storage (ac-ft)	2304	max impoundment capacity (ac-ft)	2304
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040600J	FIS Effective Date	January 5, 2007
FIRM Effective Date	1/5/2007	FIS Effective Date	Revised 06/18/2007
		Preliminary FIS	4/30/2014

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A5.1: Rhodes Lake Dam Spillway pre-event photo; Credit: 2016 Google Earth Streetview

Figure A5.2: Rhodes Lakes Dam in blue circle; FIRM cropped; FIRM details above; Dam is just north and a separate structure from Dunn Road

Figure A5.3: Rhodes Lake Dam Site Area Map; Credit: Map data: 2016 Google; Google Earth

Figure A5.4: Rhodes Lake Dam failed left embankment nearest the spillway post-event photo; Note the root system in foreground in the embankment; October 19, 2016; Credit: NC DEMLR

Figure A5.5: Rhodes Lake Dam root system in failed dam embankment left of spillway; same root system seen in Fig A5.4; October 31, 2016 Credit: FEMA; Plisich

General Rhodes Lake Dam Comments:

- This dam is classified as High Hazard in the North Carolina dam inventory and the 2016 NID.
- CAP photos were taken of this dam.
- The NID and North Carolina dam inventory list the stream name as Black River, which is consistent with the FIRM.
- NOAA's National Weather Service recorded a 7-day precipitation of 6-8" in the area around the Rhodes Lake dam.
- USGS HWMs were collected upstream and downstream of Rhodes Lake Dam.
- A review of the preliminary and effective FEMA Flood Insurance Study for Cumberland County:
  - Specific Hydraulic and Hydrologic modeling was not found for this dam on the FRIS website.
  - Rhodes Lake Dam is not referenced by name in the preliminary or effective FIS.

- A FIRM panel does exist on which Rhodes Lake Dam can be located, as shown in Figure A5.2 above. However, Rhodes Lake Dam is not named on the FIRM panel.
- Based on information from NC DEQ DEMLR, there is an EAP for this dam. There is no information to indicate this EAP was activated during this event.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County.
- The NID and the North Carolina dam database have the year completed/constructed as 1770, and modified/repaired in 2011.
- The NID and the North Carolina dam inventory have the condition of this dam rated as "Unsatisfactory".
- Based on information from a site visit with PA, heavy vegetation existed on this dam.
- According to the NC DEQ DEMLR pre-event inspection reports:
    - On June 17, 2013, a Letter of Deficiency was sent to owner stating in part: "*the center gate of the three bottom drains is non-functional; it does not appear that this dam meets the spillway capacity requirements of 15A NCAC 2K .0205. Further, the lake should be immediately drained and the gates should be left open in the interest of public safety and damage to downstream property.*
    - On January 27, 2015, a second inspection was performed by NC DEQ DEMLR finding and stating in part: "*There is head cutting and erosion noted around the left wingwall, on the downstream side of the dam, which is now temporarily stabilized with concrete slabs; Minor head cutting/erosion is noted on the downstream side of the dam, directly below the pier, which is also now temporarily stabilized with concrete slabs; the center gate of the three bottom drains is nonfunctional. Woody debris is partially obstructing the right gate of the bottom drain. It does not appear that this dam meets the spillway capacity requirements of I SA NCAC 2K .0205; The lake has been lowered several feet below normal pool level and the gates are being left open in the interest of public safety and damage to downstream property."*
    - The same investigation determined that *"failure of the dam could result in severe property damage and/or possible loss of life downstream, as a result the dam was to be listed in the "High Hazard" category."* In order to ensure the safety of this dam, the owner was directed to retain the services of a registered professional engineer or an experienced engineering firm to make a study of the conditions outlined in the inspections.
    - Based on a site visit between FEMA Public Assistance, the applicant (state), FEMA Region IV Dam Safety, and NC DEQ DEMLR on October 31, 2016 looking at damages to the site from Hurricane Matthew, this dam was under construction and being repaired when flooding occurred due to Hurricane Matthew.

<u>Considerations for Rhodes Lake Dam</u>:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.

- Consider this dam for further analysis to determine the capacity of the new spillway / outlet work system already approved for construction in relation to the flood event that occurred.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider collecting and documenting dam breach parameters from the breach at this dam.
- Consider this dam for whether the local EMA had integrated the EAP for this dam into the local EOP.
- Consider assessing whether the heavy woody vegetation along the length of this dam was part of the repair / rehabilitation project under construction. If it was not, consider adding the removal of woody vegetation to the dam rehabilitation project.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A6) State Dam Name: Smith Lake Dam Latitude: 35.224, Longitude: -78.815; Regulator: Exempt from State Regulation

Table A6 Smith Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the Oct 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Smith Lake Dam	County	Cumberland
Stream or River	CAPE FEAR RIVER-TR	Nearest Downstream City/Town	FAYETTEVILLE
NID Hazard Class	Low (Not Regulated)	State Hazard Class	Low – Exempt-HB-Size (Not regulated)
NID ID	NC01148	Owner Type	Private
Dam Type	Earth	Year Modified	N/A
Purpose	N/A	EAP	Not Required
Length (ft)	520	Condition Assessment	Not Rated
Max Discharge (cfs)	330	Normal Storage (ac ft)	60
Surface Area (ac)	20		
Fields where the NID Differs from the Oct 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Drainage Area (sq mi)	1.291	Drainage Area (ac)	826
Dam Height (ft)	10	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	10

State ID	No longer cross references state ID	State ID	CUMBE-055
Year Completed	N/A	Year Constructed	N/A
Max Storage (ac-ft)	73	max impoundment capacity (ac-ft)	73
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040600J	FIS Effective Date	January 5, 2007
FIRM Effective Date	1/5/2007	Preliminary FIS	4/30/2014

*NC Dam Inventory provided by NC DEQ DEMLR

Figure A6.1: Smith Lake Dam in blue circle; FIRM cropped; FIRM details in spreadsheet above

Figure A6.2: Smith Lake Dam Site Overview Credit: Map data: 2016 Google Earth

General Smith Lake Dam Comments:

- This dam is classified as Low-Exempt in the North Carolina dam inventory and inventoried as Low-Not Regulated in the 2016 NID.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation of 5-6" in the area around the Smith Lake dam.
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Smith", "Lake", and "Dam" in the Cumberland FIS, nothing was found for Smith Lake Dam.
  - A FIS flood profile does not appear to exist for this dam, nor was a HEC-RAS run found for this dam. This is consistent with it being on a stream that did not have a detailed or limited flood study performed.
  - A FIRM panel does exist on which Smith Lake Dam can be located, as shown in Figure A6.1 above. However, a generic "dam" is not indicated, nor is Smith Lake Dam indicated by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- The 2016 NID and NC October 2016 dam inventory both indicate there is no EAP requirement for this dam, which is consistent with a dam that is exempt from NC DEQ DEMLR regulations.
- This dam is not referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County

- The NID and the North Carolina dam database have no information on the year completed or constructed for this dam.
- The NID has this dam as “Not Rated”.
- This dam was inspected on January 10, 2012 and the next inspection is scheduled for January 10, 2017.

Considerations for Smith Lake Dam:

- Consider collecting and documenting dam breach parameters at this dam.
- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.
- Based on Figure A6.2, consider assessing and documenting the dam site for woody vegetation and any contributions this may have had in the breach, such as root systems in the embankment.

A7) State Dam Name: Mirror Lakes Dam Latitude: 35.0549, Longitude: -78.9218; Regulator: NC DEQ DEMLR

Table A7 Mirror Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Mirror Lakes Dam	County	Cumberland
Stream or River	HYBART'S BRANCH	Nearest Downstream City/Town	FAYETTEVILLE
NID Hazard Class	High	State Hazard Class	High
NID ID	NC02151	Year Modified	2002
Dam Type	Earth	EAP	Yes
Purpose	Recreation	Condition Assessment	Fair
Length (ft)	300	Normal Storage (ac ft)	No Information
Drainage Area (sq mi)	No Information	Surface Area (ac-ft)	5
Max Discharge (cfs)	No Information	Owner Type	Local
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	12	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	12
State ID	No longer cross references state ID	State ID	CUMBE-077
Year Completed	1959	Year Constructed	1959

Max Storage (ac-ft)	24	max impoundment capacity (ac-ft)	24
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720042700J	FIS Effective Date	January 5, 2007
FIRM Effective Date		Preliminary FIS	

*NC Dam Inventory Information provided NC DEQ DEMLR

Figure A7.1: Mirror Lakes Dam pre-event image; Credit: 2016 Google Earth Streetview

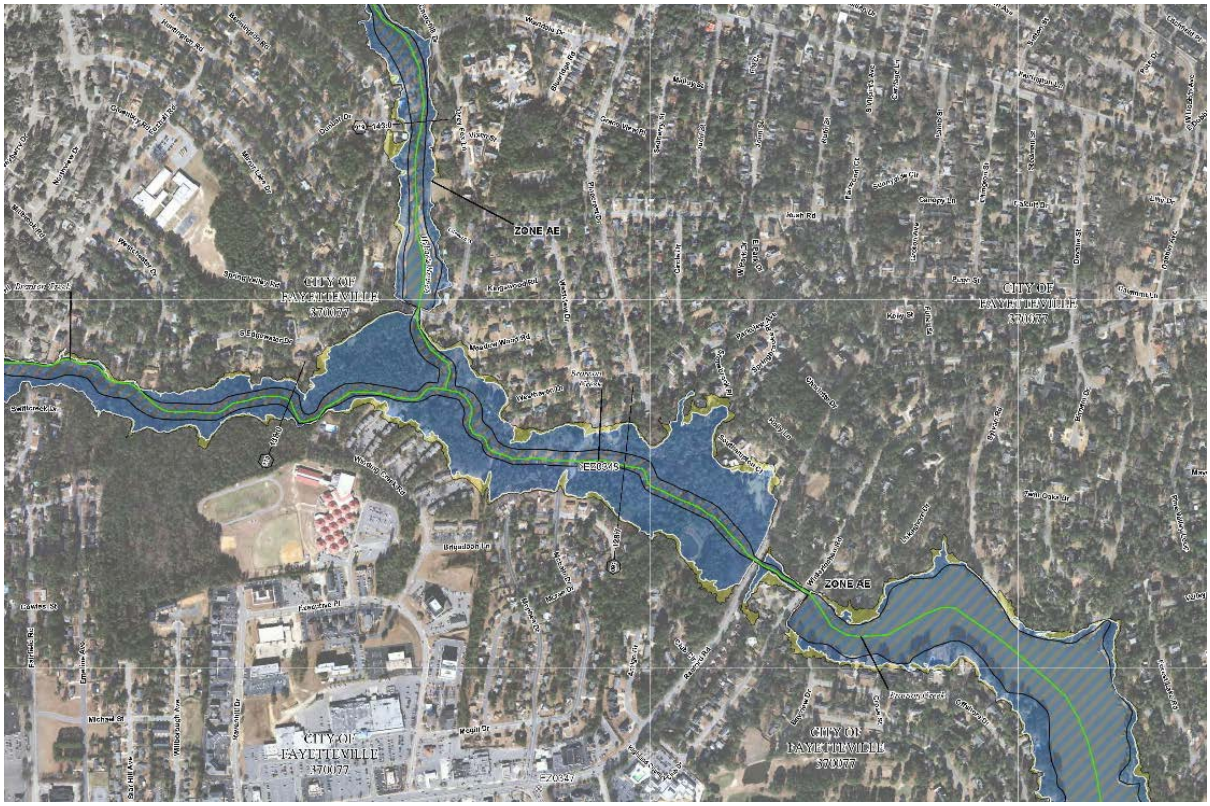


Figure A7.2: Mirror Lakes Dam in blue circle; FEMA FIRM cropped; See FIRM in spreadsheet above

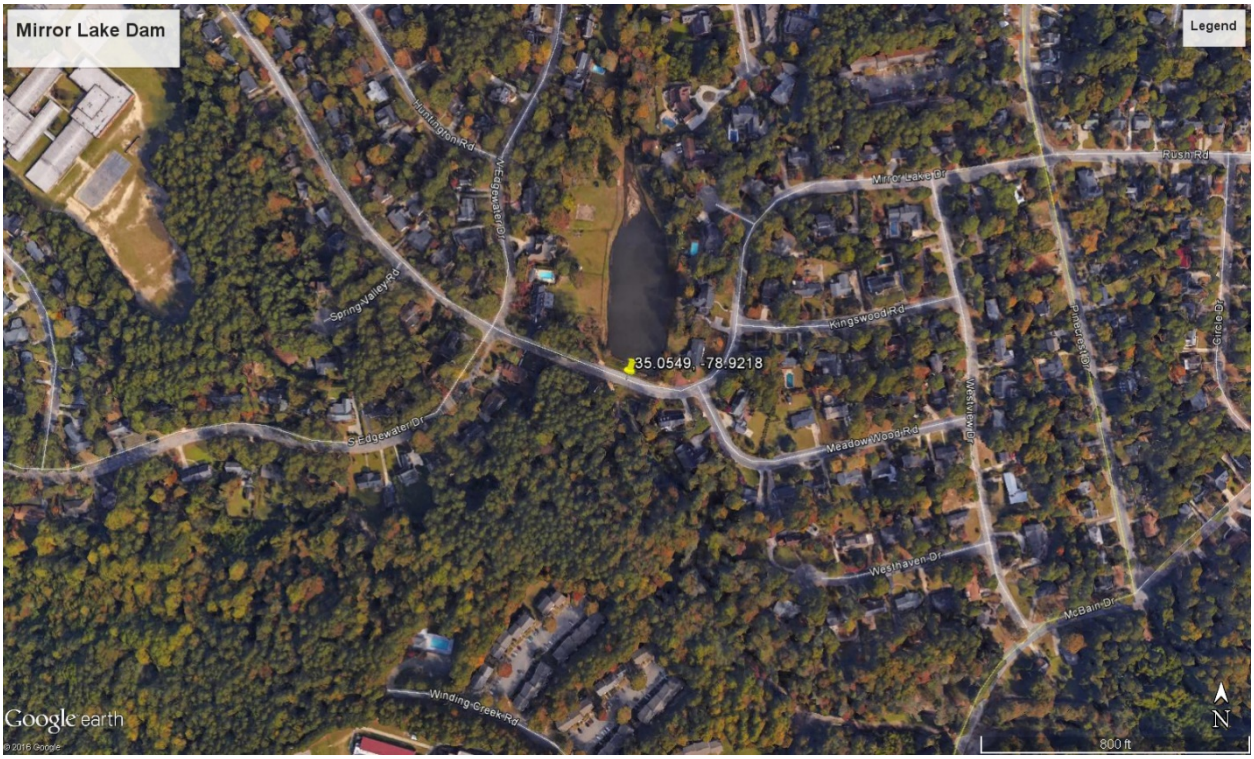


Figure A7.3: Mirror Lakes Dam Site Area Map; Credit: Map data: 2016 Google Earth

General Mirror Lakes Dam Comments:

- This dam is classified as High Hazard in the North Carolina dam inventory and in the 2016 NID.
- The North Carolina dam inventory and the 2016 NID have this dam as being owned by the local government.
- Civil Air Patrol (CAP) photos were not found for this dam.
- The FIRM, NID, FRIS, and the North Carolina dam inventory have this dam as being on Hybarts Branch.
- NOAA's National Weather Service recorded an observed 7-day precipitation in the area of Mirror Lakes Dam of 8"-10".
- A review of the FEMA Flood Insurance Study for the dam location indicates:
  - The preliminary and effective Cumberland County FIS do not reference this dam by name
  - Specific Hydraulic and hydrologic modeling was not found for this dam.
  - A FIRM panel does exist on which Mirror Lakes Dam can be located, as shown in Figure A7.2 above. However, Mirror Lakes Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP does exist for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County
- The NID and the North Carolina dam inventory have this dam as completed / constructed in 1959.
- A post-event photo was not available at the time of this final report.
- The 2016 NID has the condition of the dam as "Fair".

Considerations for Mirror Lakes Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode of this dam as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider this dam for whether the local EMA had integrated the EAP for this dam into the local EOP.

A8) State Dam Name: Mount Vernon Estates Dam Latitude: 34.853 Longitude: -78.876; Regulator: NC DEQ DEMLR

Table A8 Mount Vernon Estates Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Mount Vernon Estates Dam	County	Cumberland
Stream or River	Kirks Mill Creek	Nearest Downstream City/Town	Tar Heel
NID Hazard Class	High	State Hazard Class	High
NID ID	NC02160	Year Modified	N/A
Dam Type	Earth	EAP	No
Purpose	Recreation	Condition Assessment	Fair
Length (ft)	375	Normal Storage (ac ft)	4056
Drainage Area (sq mi)	N/A	Surface Area (ac-ft)	14
Max Discharge (cfs)	N/A	Owner Type	Private
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	14.2	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	14.2
State ID	No longer cross references state ID	State ID	CUMBE-086
Year Completed	1989	Year Constructed	1989
Max Storage (ac-ft)	79.52	max impoundment capacity (ac-ft)	80
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040600J	FIS Effective Date	January 5, 2007
FIRM Effective Date	1/5/2007	Preliminary FIS	4/30/2014

*NC Dam Inventory information provided by NC DEQ DEMLR

Figure A8.1: Mount Vernon Estates Dam pre-event photo; Credit: Google Maps Streetview

Figure A8.2: Mount Vernon Estates Dam in blue circle; FIRM cropped; FIRM details in spreadsheet above

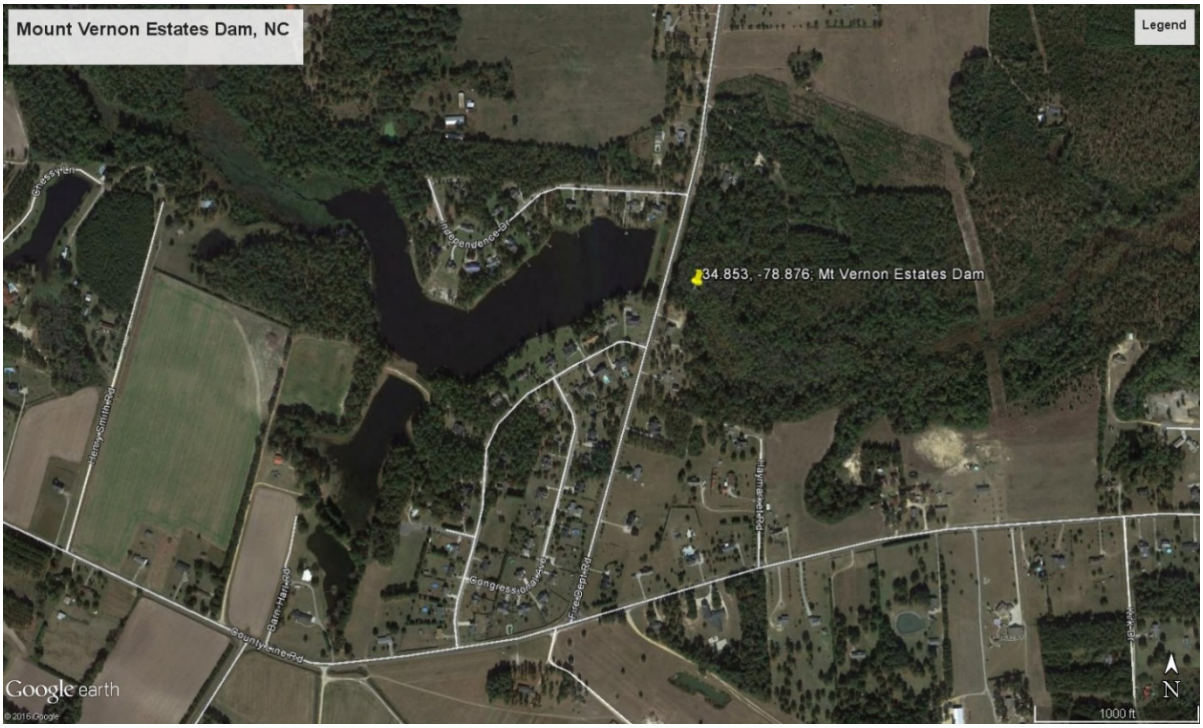


Figure A8.3: Mount Vernon Estates Dam Site Area Map Credit: Map data: 2016 Google; Google Earth

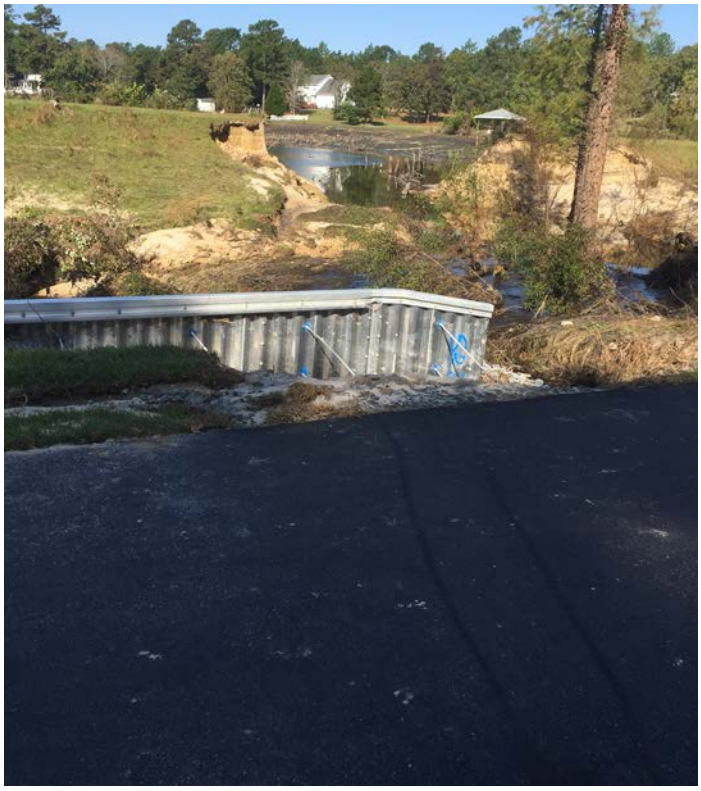


Figure A8.4: Mount Vernon Estates Dam post-event photo; Credit: NC DEMLR

General Mount Vernon Estates Dam Comments:

- This dam is classified as High Hazard dam in the 2016 NID and the North Carolina dam inventory.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation of 6"-8" in the area around the Mount Vernon Estates Dam.
- USGS HWMs were collected upstream and downstream of Mount Vernon Estates Dam.
- A review of the preliminary and effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Mount", "Mt.", "Vernon", "Estates", and "Dam", in the Cumberland County FIS, Mount Vernon Estates Dam is not mentioned by name.
  - A detailed or limited study was not performed on this stream and therefore a FIS flood profile does not exist, nor a HEC-RAS run for this dam or the area.
- A FIRM panel does exist on which Mount Vernon Estates Dam can be located, as shown in Figure A8.2 above. However, Mount Vernon Estates Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, there is no EAP for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County
- The NID has the year completed as 1989. The North Carolina dam database shows the year constructed for this dam as 1989.
- The NID has a condition rating for this dam of "Fair".
- NC DEQ DEMLR inspection highlights:
  - On 1/11/2012 a Dam Safety Inspection was completed and stated much of the same as the 11/7/2012 with the addition of a Christmas tree needs to be removed from the emergency spillway, and the Principal spillway has trash and weeds growing in it.
  - On 5/13/2013 a letter from NC DEQ DEMLR, along with a Dam Safety Inspection reported to the owner much of the same as the 11/7/2012 letter, however a hole in the upstream slope on the left side of the dam was noted.
  - On 2/27/2014 a letter from NC DEQ DEMLR was sent to the owner noting much of the same vegetation, trash, and tree issues around and on the dam. The letter encouraged the owner to remove the items and continue to maintain a safe dam.
  - On 1/27/2015 a letter from the NC DEQ DEMLR, along with a Dam Safety Inspection, was sent to the owner stating that the upslope stream to the dam has high bushes and animal trails, and wetness noted at the toe of the dam, and the trash guard was partially obstructed by woody debris. The letter asked the owner for improvements and proper maintenance of the dam.
  - On 4/7/16 a Notice of Inspection was sent to the owner of the dam by NC DEQ DEMLR noting the same issues of vegetation. Trash and woody debris in the same areas as noted in past inspections was also noted in this inspection. Two new items

noted on the inspection were seepage at the toe of the dam, and soil erosion on the left and right of the principal spillway. The owner was alerted to the fact that continued seepage at the toe of the dam as well as soil erosion could result in the failure of the dam. The letter asked the owner to repair the noted items and continue proper maintenance to ensure a safe dam.

Considerations for Mount Vernon Estates Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider this dam for further research into whether or not the recommendations provided in the last NC DEQ DEMLR inspection were addressed.
- Consider collecting and documenting dam breach parameters for this dam.

A9) State Dam Name: Devonwood Lower Dam Latitude: 35.075, Longitude: -78.995; Regulator: NC DEQ DEMLR

Table A9 Devonwood Lower Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Devonwood Lower Dam	County	Cumberland
Stream or River	PERSIMMON CK-TR	Nearest Downstream City/Town	Fayetteville
NID Hazard Class	High	State Hazard Class	High
NID ID	NC04797	Year Modified	2002
Dam Type	Earth	EAP	Yes
Purpose	Recreation	Condition Assessment	Fair
Length (ft)	250	Normal Storage (ac ft)	70
Max Discharge (cfs)	No Information	Surface Area (ac-ft)	7
Owner Type	Private	Drainage Area (sq mi)	No Information
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	25	N/A	N/A

Structural Height (ft)	No Information	Structural Height (ft)	25
State ID	No longer cross references state ID	State ID	CUMBE-088
Year Completed	No Information	Year Constructed	No Information
Max Storage (ac-ft)	175	max impoundment capacity (ac-ft)	175
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040800J	FIS Effective Date	January 5, 2007
FIRM Effective Date	January 5, 2007	Preliminary FIS	4/30/2014

*NC Dam Inventory information provided by NC DEQ DEMLR

Figure A9.1: Devonwood Lower Dam pre-event image; Credit: 2016 Google Earth Streetview

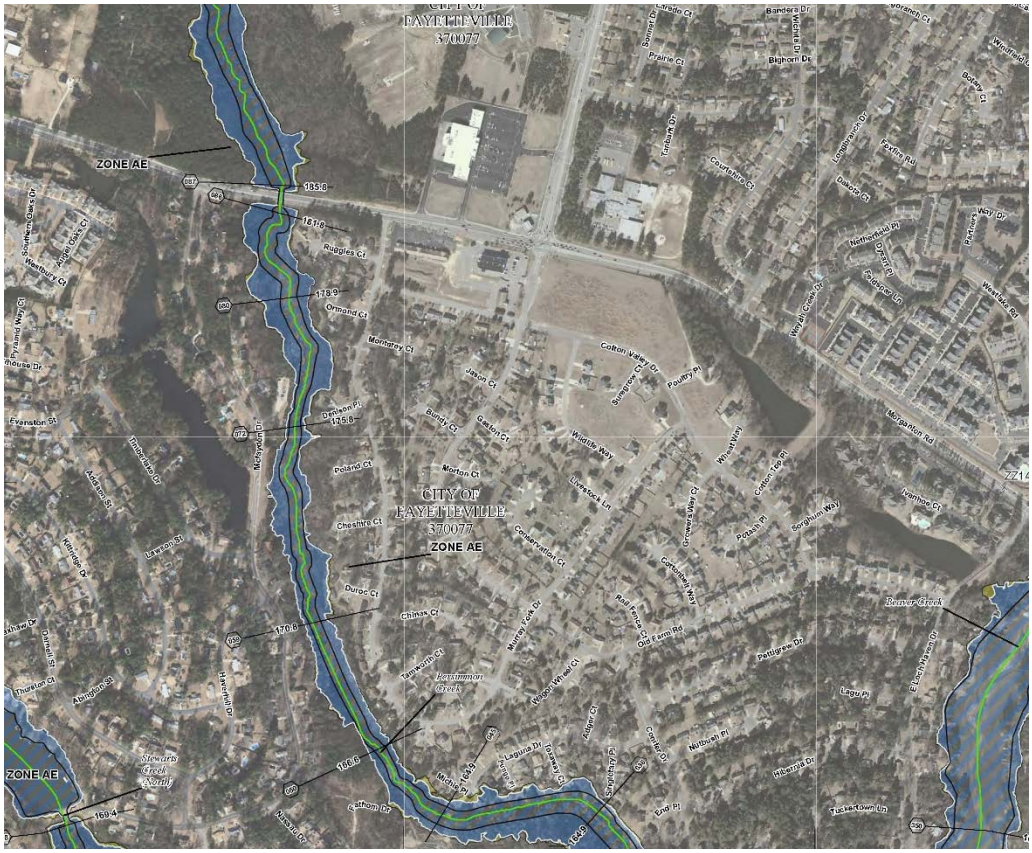


Figure A9.2: Devonwood Lower Dam in blue circle; FEMA FIRM cropped; See FIRM in spreadsheet above

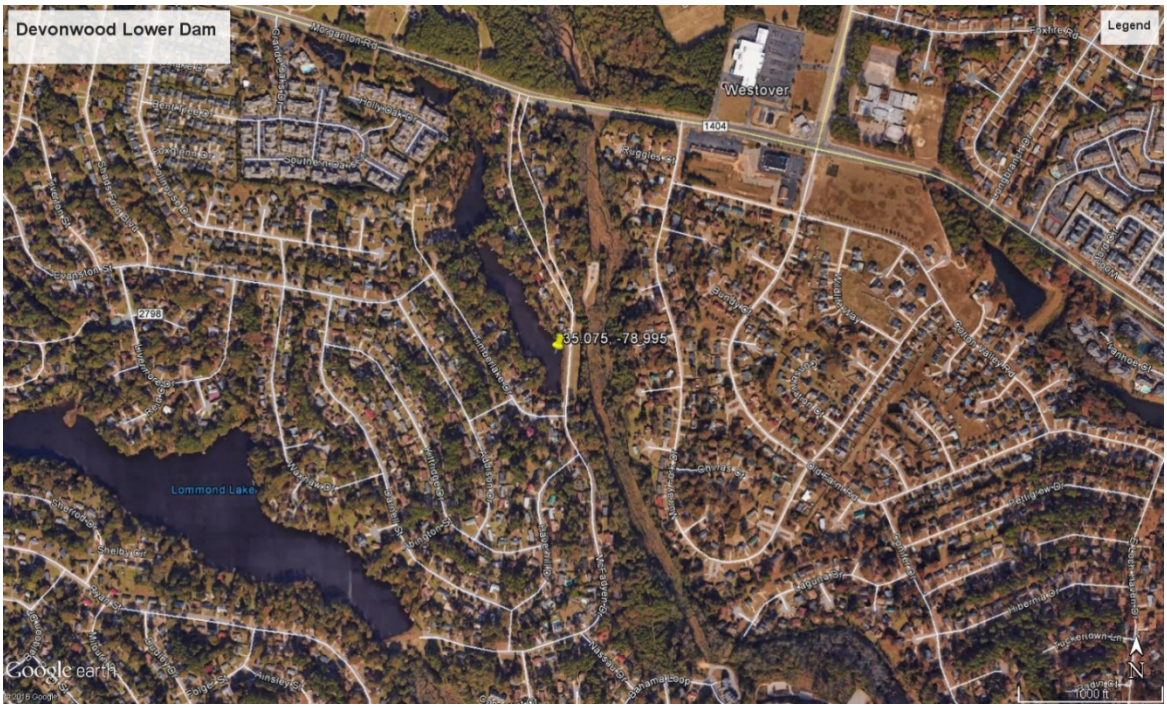


Figure A9.3: Devonwood Lower Dam Site Area Map; Credit: Map data: 2016 Google Earth

Figure A9.4: Devonwood Lower Dam post-event photo; Credit: NC DEMLR

General Devonwood Lower Dam Comments:

- This dam is classified as High Hazard in the 2016 NID and the North Carolina dam inventory.
- Civil Air Patrol (CAP) photos were not found for this dam.
- The NID and North Carolina dam inventory have this dam as being on Persimmon CK-TR. The FIRM shows this dam as not in a mapped area.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 8-10" in the area of Arran Lake Dam.
- A review of the preliminary and effective FEMA Flood Insurance Study for the dam location indicates:
  - This dam was not referenced by name.
  - A FIRM panel does exist on which Devonwood Lower Dam can be located, as shown in Figure A9.2 above. However, Devonwood Lower Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP does not exist for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County

- The NID and the North Carolina dam inventory have no information on the year this dam was completed/completed. Both show modification in 2002.
- The 2016 NID has the condition of the dam as "Fair".
- NC DEQ DEMLR provided a letter to the owner on December 28, 2015 stating, *"Trees and bushes are growing on the dam. This type of growth can cause problems and even failure of the dam by creating holes when trees are uprooted due to wind or ice; by leaving possible seepage holes when trees die and their roots decay; and by causing erosion of the dam around this growth should the dam overtop during heavy rains. Therefore, we recommend that this type of growth be removed and a good grass cover be established on the dam."*
- NC DEQ DEMLR provided a post event assessment stating this dam was partially breached; *"Dam overtopped; partially breached and roadway down to one lane."*

Considerations for Devonwood Lower Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider this dam for further research into whether or not the recommendations provided in the last NC DEQ DEMLR inspection were addressed.
- Consider collecting and documenting dam breach parameters at this dam.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A10) State Dam Name: Rayconda Upper Dam Latitude: 35.0267 Longitude: -79.0222; Regulator: NC DEQ DEMLR

Table A10 Rayconda Upper Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Field**	**NID/State Field**	**NID/State Field**
NID Dam Name	Rayconda Upper Dam	County	Cumberland
Stream or River	LITTLE ROCKFISH CREEK TR	Nearest Downstream City/Town	Hope Mills
NID Hazard Class	High	State Hazard Class	High
NID ID	NC05621	Owner Type	Private

Dam Type	Earth	Year Modified	2003
Purpose	Recreation; P (Fire Protection, Stock, or Small Farm Pond)	EAP	No
Length (ft)	200	Surface Area (ac)	2.6
Max Discharge (cfs)	N/A	Normal Storage (ac ft)	N/A
		Condition Assessment	Poor
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Drainage Area (sq mi)	0.613	Drainage Area (ac)	392
Dam Height (ft)	19.2	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	19.2
State ID	No longer cross references state ID	State ID	CUMBE-099
Year Completed	N/A	Year Constructed	N/A
Max Storage (ac-ft)	20	max impoundment capacity (ac-ft)	20
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720040600J	FIS Effective Date	January 5, 2007
FIRM Effective Date	1/5/2007	Preliminary FIS	4/30/2014

*NC Dam Inventory Information Provided by NC DEQ DEMLR

Figure A10.1: Rayconda Upper Dam pre-event photo; Credit: Google Maps Streetview

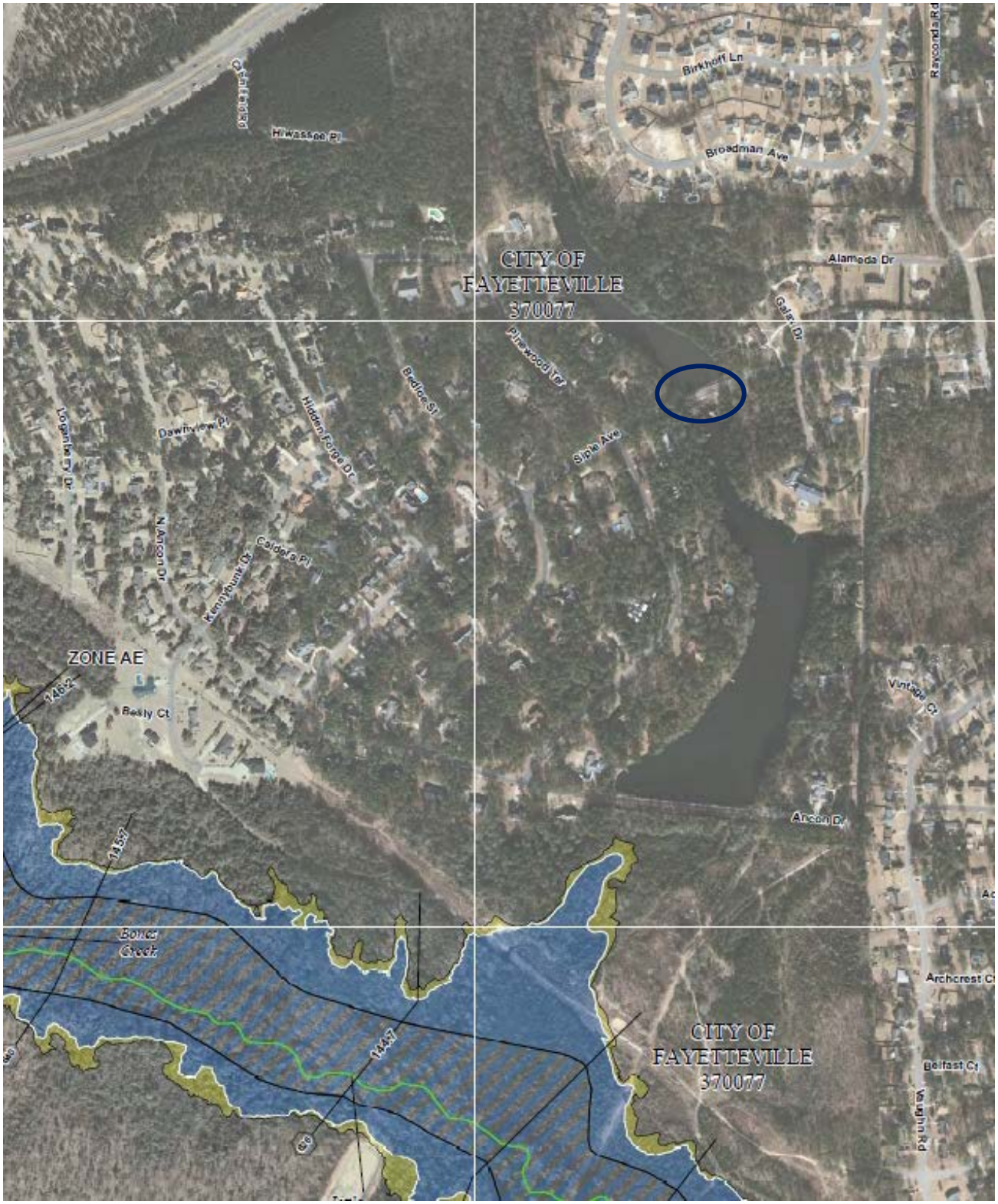


Figure A10.2: Rayconda Upper Dam in blue circle; FIRM is cropped - details in spreadsheet above

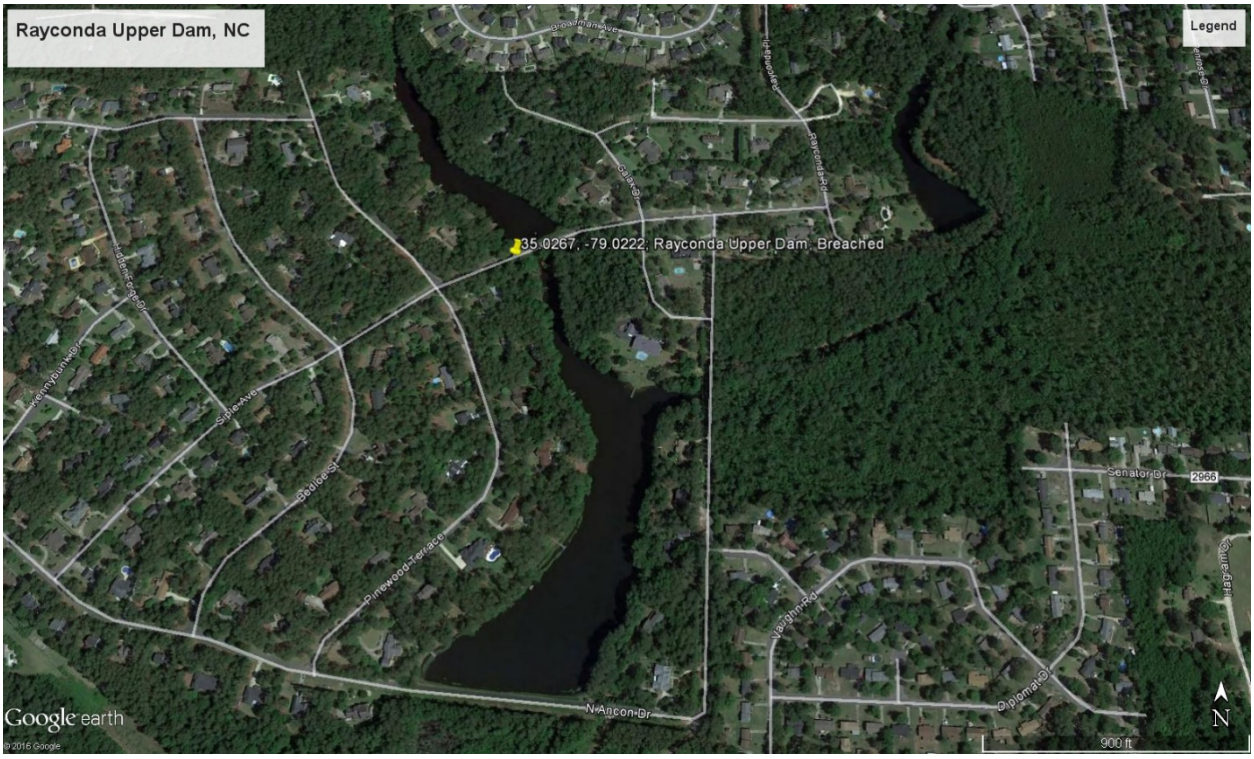


Figure A10.3: Rayconda Upper Dam Site Area Map Credit: Map data: 2015 Google; Google Earth

Figure A10.4: Rayconda Upper Dam post-event photo; Credit: NC DEMLR

General Rayconda Upper Dam Comments

- Rayconda Upper Dam is classified High Hazard in the 2016 NID and the North Carolina dam inventory.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation of 8"-10" in the area around the Rayconda Upper dam.
- A USGS HWM was collected near the Rayconda Upper Dam.
- A review of the preliminary and effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Rayconda", "Lake" and "Dam" on the Cumberland County FIS, Rayconda Upper Dam was not found by name.
- A detailed or limited study was not performed on this stream and therefore a FIS flood profile does not exist, nor a HEC-RAS run for this dam or the area.
- A FIRM panel does exist on which Rayconda Upper Dam can be located, as shown in Figure A10.2 above. However, Rayconda Upper Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- The NID and the North Carolina dam inventory show that there is no EAP for this dam.
- This dam is referenced by name in the Cumberland-Hoke Regional Hazard Mitigation Plan, which includes Cumberland County.
- There is no information on year completed or year constructed in the NID or the North Carolina dam inventory. However, the North Carolina dam inventory and the NID list 2003 as the year it was last modified.
- The NID and the North Carolina dam inventory have the condition as being "Poor".
- NC DEQ DEMLR inspection highlights:
  - 8/20/2004 – A letter from NC DEQ DEMLR stating a Notice of Deficiency for the Rayconda Upper Dam was sent to owner of dam and a copy sent to NC DOT noting that *"dam is a High Hazard Dam, that in event of dam failure Siple Avenue would incur damage, vehicle traffic on road would be endangered, and access to homes would be restricted."* An inspection of the dam found in part: significant erosion and sloughing off of downstream slope in center portion of dam starting at edge of SR 3380 and extending to barrel pipe outlet. The letter stated that repairs to the dam were needed.
  - 11/7/2008 – A Dam Safety Inspection report notes in part that: vegetation is present on the upstream slope, there is a hole near the guardrail, the asphalt drain chute is breaking up, and there is a slide on the left of the spillway.
  - 2/14/2012 – A Dam Safety Inspection report notes in part: vegetation has been mowed, there are old slides and depressions, trees and brush have been mowed and cut but debris was left on the slope, there is wetness at the toe of the dam, a noted seepage could be in the bottom of the drain - rust colored water with an oily sheen was noted, also the outlet pipe in the Principal Spillway is completely submerged.

- 2/15/2012 – A letter from NC DEQ DEMLR stating a Notice of Deficiency was sent to the owner of the dam and a copy was sent to the City Manager. The NOD listed the deficiencies noted in the 2/14/2012 inspection that was done in the presence of staff from NC DEQ DEMLR, the City, the Dam Safety Engineer, and the owners of the dam. In part some of these are: downstream slope is steep and not stable, asphalt drainage chute is deteriorating resulting in erosion of the dam, the trash guard over the spillway is inadequate, the existing spillway doesn't meet capacity requirements in "NCAC Title 15A, Subchapter 2K-Dam Safety." The letter also states that the condition of the dam is serious and justifies further an engineering study to determine remedial action for the dam. The letter explains the NOD issued in 2004 in which a repair plan was submitted by the owner's attorney in 2008. However, that plan was not completed or approved. A follow-up letter sent by NC Dam Safety Engineer requested information from the owner and no response was received. Another NOD was issued on 3/12/2010 to the owner. No response was received by the NC DEQ DEMLR from the owner. The letter (2/15/2012) further ordered the owner to retain the services of an engineer to make a study of the issues outlined in the current NOD. The letter further stated that the plan for repairs and specifications must be filed with the Directors of Land Resources for approval pursuant to "NC Administration Code, Title 15A, Subchapter 2K-Dam Safety."
- 4/10/2013 – A letter on behalf of the private owners of the Rayconda Upper Dam was sent by their attorney to the City. The letter states that the private owners' have requested help from the City to make the repairs needed on the dam. The reason given was that the owners' do not have the funds to repair the High Hazard dam.
- 1/21/2015 – A letter stating a Notice of Deficiency from the NC DEQ DEMLR was sent to the owners of the Rayconda Upper Dam. In the letter it was noted that previous NODs had been issued and sent to the owners. In 2004 a NOD sent to the owners, and copied to the NCDOT, resulted in repairs made by the NCDOT to Siple Avenue. Other NODs were issued to the owners of the dam in March of 2010, February of 2012, and April of 2013. It further stated that letters from both parties in 2013 were exchanged in hopes of providing an alternate route into the subdivision which uses Siple Avenue, where the dam is located. However, stated the letter, despite the responses the deficiencies were still unresolved. The letter acknowledges that the City has been providing monthly updates on the progress of the suggested alternate route. In the letter dated 1/21/2015 the NC DEQ DEMLR ordered the owners of the dam to drain the dam until the needed repairs have been made.
- 3/10/2015 – A letter on behalf of the private owners of Rayconda Upper Dam was sent by their attorney in reply to a letter from the NC DEQ DEMLR, dated 1/21/2015. In the letter by the owners' attorney, specific actions of repair by the owners are agreed to. However, it is stated in the letter that since the dam is the main structural

support of a City street, any major work would need to be coordinated with or repaired by the City.

Considerations for Rayconda Upper Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for event specific dam breach modeling and incremental consequence assessment to compare the flood event versus the dam breach inundation.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A11) State Dam Name: Rouse Pond Dam Latitude: 35.14833 Longitude: -77.79583

Regulator: Exempt from State Regulation

Table A11 Rouse Pond Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Differs from the Oct 2016 NC Dam Inventory* Information			
NID Field	**NID Field**	**State Field**	**State Field**
County	N/A	County	Duplin
Nearest Downstream City/Town	N/A	Nearest Downstream City/Town	N/A
NID Dam Name	N/A	State Dam Name	Rouse Pond Dam
Stream or River	N/A	Stream or River	Ne Cape Fear-Tr
NID Hazard Class	N/A	State Hazard Class	Low - Exempt (Not regulated)
NID ID	N/A	State ID	DUPLI-016
Dam Type	N/A	Dam Type	Earth
Purpose	N/A	Purpose	Recreation
Length (ft)	N/A	Length (ft)	N/A
Drainage Area (sq mi)	N/A	Drainage Area (sq mi)	N/A

Max Discharge (cfs)	N/A	Max Discharge (cfs)	N/A
Owner Type	N/A	Owner Type	Private
Surface Area (ac)	N/A	Surface Area (ac)	N/A
Year Modified	N/A	Year Modified	N/A
Structural Height (ft)	N/A	Structural Height (ft)	15
EAP	N/A	EAP	No
Condition Assessment	N/A	Condition Assessment	Not Rated
Normal Storage (ac ft)	N/A	Normal Storage (ac ft)	N/A
Year Completed	N/A	Year Constructed	N/A
Max Storage (ac-ft)	N/A	max impoundment capacity (ac-ft)	N/A
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720354000K	FIS Effective Date	February 16, 2006
FIRM Panel	3720356100J		

*NC Dam Inventory Information provided by NC DEQ DEMLR

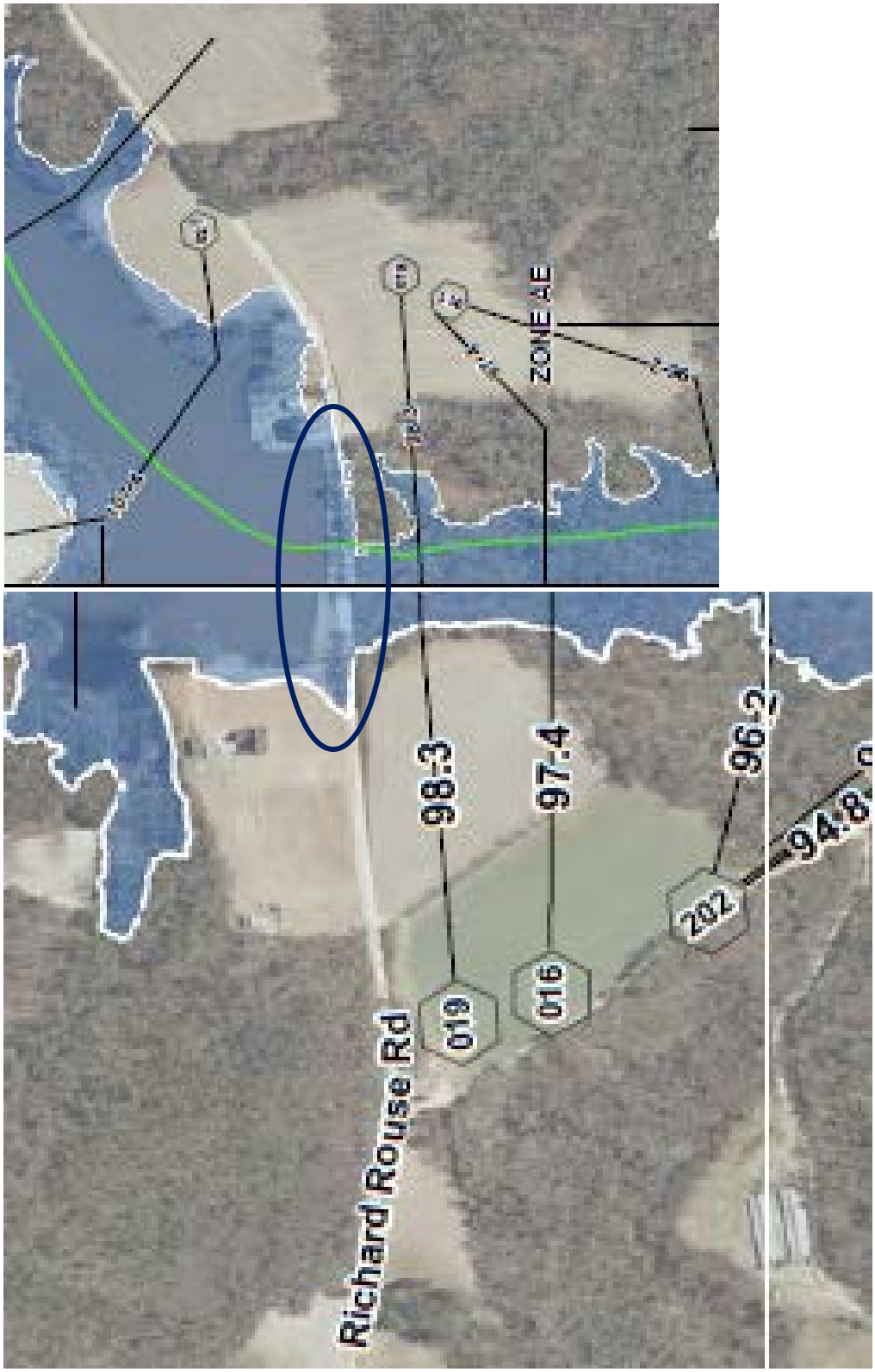


Figure A11.1: Rouse Pond Dam in blue circle crosses over two FIRMs, both cropped. FIRM details are in spreadsheet above.

Figure 11.2: Rouse Pond Dam Overview Credit: Map data: 2016 Google; Google Earth

General Rouse Pond Dam Comments

- The NC dam inventory has an NID ID number of NC02260. However, this dam was searched and not found in the 2016 NID.
- Rouse Pond Dam is classified as Low-Exempt by NC DEQ DEMLR
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation 6"-8" in the area around Rouse Pond Dam.
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Rouse", "Pond" and "Dam" on the Duplin FIS, nothing was found for Rouse Pond Dam.
  - A flood profile does not exist for this dam. A HEC-RAS run was performed for the Beaverdam Branch (near Gracys Crossroads) stream on which this dam exists. The HEC-RAS run has Richard Rouse Road Top of Road (TOR) modeled at river station 2122.9. There is a generic label for "upstream section of bridge/culvert/weir" at river station 2157.9, which is where Rouse Pond dam is located.
- A FIRM panel does exist on which Rouse Pond dam can be located, as shown in Figure A11.1 above. However, a generic "dam" is not indicated on the FIRM, nor is Rouse Pond Dam indicated by name on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP does not exist for this dam. This is consistent with no requirement for an EAP for an exempt dam.

- This dam is referenced by name in the Sampson/Duplin Regional Hazard Mitigation Plan, which includes Duplin County.
- The year constructed is not available on the NC Dam Inventory for this dam.
- The North Carolina dam database shows the condition of the dam as "Not Rated", consistent with a dam that is not regulated.
- According to the NC Oct 2016 dam inventory, this dam was last inspected on October 6, 2015 and will have its next inspection on (or around) April 22, 2020.

Considerations for Rouse Pond Dam

- Consider collecting and documenting the dam breach parameters at this dam.
- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

A12) State Dam Name: Maxwell Mill Pond Dam; Latitude: 35.07; Longitude: -77.78778
Regulator: Exempt from State Regulation

Table A12 Maxwell Mill Pond Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Field**	**NID/State Field**	**NID/State Field**
NID Dam Name	Maxwell Mill Pond Dam	County	Duplin
Stream or River	Maxwell Creek	Nearest Downstream City/Town	Pink Hill
NID Hazard Class	Low	State Hazard Class	Low
NID ID	NC01156	Owner Type	Private
Dam Type	Earth	Year Modified	N/A
Purpose	Recreation	EAP	No
Length (ft)	840	Surface Area (ac-ft)	N/A
Drainage Area (sq mi)	N/A	Max Discharge (cfs)	N/A
Fields where the NID Differs from the October 2016 Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Condition Assessment	Unsatisfactory	Condition Assessment	Poor
Dam Height (ft)	14	N/A	N/A
Structural Height (ft)	No Information	Structural Height (ft)	14
State ID	No longer cross references state ID	State ID	DUPLI-017

Year Completed	N/A	Year Constructed	N/A
Max Storage (ac-ft)	130	max impoundment capacity (ac-ft)	130
Normal Storage (ac ft)	N/A	Normal Pool Capacity (ac-ft)	N/A
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	February 16, 2006
FIRM Panel	3720346800J	FIRM Effective Date	02/16/06

*NC Dam Inventory Information Provided by NC DEQ-DEMLR

Figure A12.1: Maxwell Mill Pond Dam north spillway and Maxwell Road pre-event photo; Credit: Google Maps Streetview

Figure A12.2: Maxwell Mill Pond Dam South spillway and Maxwell Mill Road pre-event photo; Credit: Google Maps Streetview

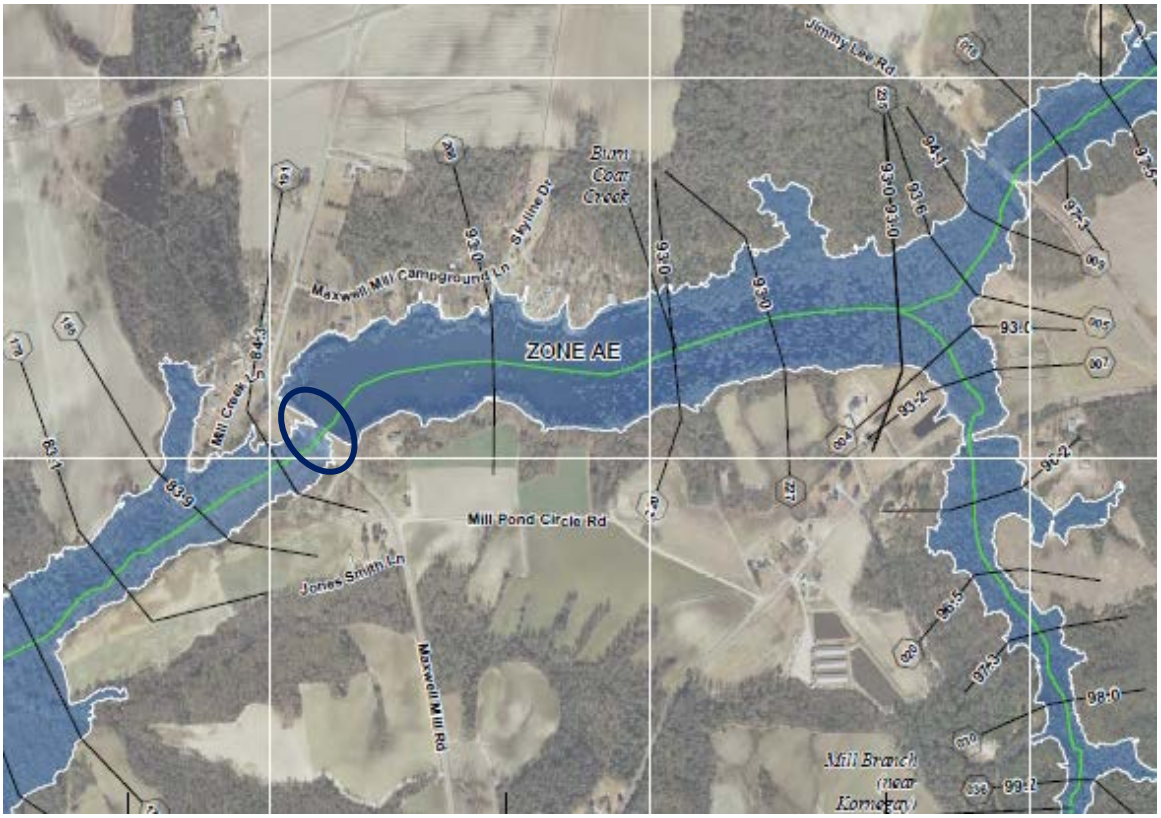


Figure A12.3: Maxwell Mill Pond Dam in blue circle; FIRM is cropped - details in spreadsheet above

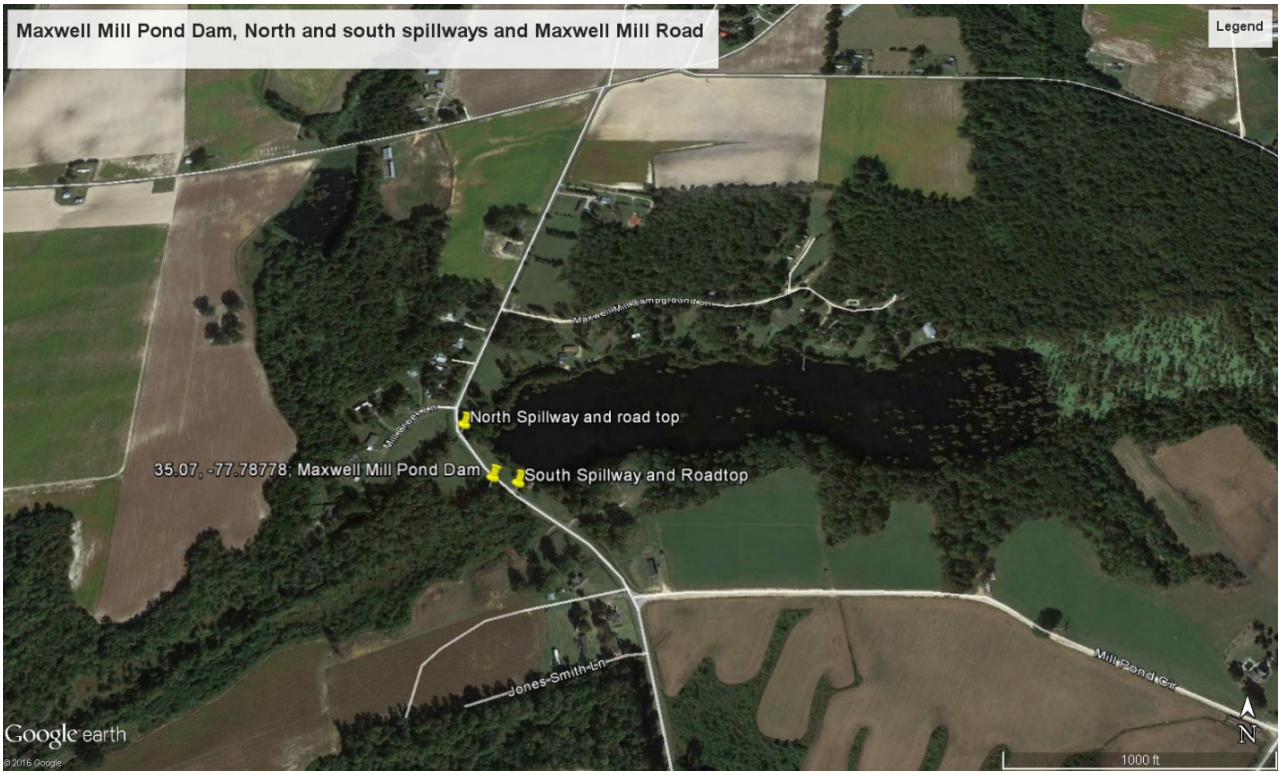


Figure A12.4: Maxwell Mill Pond Dam Overview Credit: Map data: 2016 Google; Google Earth

Figure A12.5: Maxwell Mill Pond Dam post-event photo; Credit: NC DEMLR

General Maxwell Mill Pond Dam Comments

- Maxwell Mill Pond Dam is classified as a Low Hazard dam in the 2016 NID and in the October 2016 North Carolina dam inventory.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation of 5" – 6" in the area around the Maxwell Mill Pond dam.
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - In searching for "Maxwell", "Mill", "Pond", and "Dam", on the Duplin FIS, Maxwell Mill Pond Dam was not found by name.
  - A flood profile does not exist for this dam. A HEC-RAS run was performed for the Burn Coat Creek on which this dam exists. The HEC-RAS run modeled the Maxwell Mill Pond Dam by name upstream, but not downstream as well as the Maxwell Mill Road northerly roadtop up and downstream. They did not appear to fully model the southerly road top over the spillway / channel coming from the old Mill, both upstream and downstream. The NC FRIS website has the road over the southerly spillway / channel being overtopped in the 100 year event, but not the northerly road.
  - FIS states in Table 8 Summary of Discharges on page 30:

Flooding Source	*Location*	*Drainage Area (square miles)*	*Discharges*			
			10% Annual Chance	*2% Annual Chance*	*1% Annual Chance*	*0.2% Annual Chance*
Burnt Coat Creek	*Approximately 0.2 mile downstream of Maxwell Mill Road*	*5.29*	*	*	*1,201*	*

*Data not available/calculated

- A FIRM panel does exist on which Maxwell Mill Pond dam can be located, as shown in Figure A12.3 above. However, Maxwell Mill Pond Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- The NID and North Carolina dam inventory show that no EAP exists for this dam. NC regulations do not require EAPs for low hazard dams.
- This dam is referenced by name in the Sampson/Duplin Regional Hazard Mitigation Plan, which includes Duplin County.
- No information on year complete or year constructed is available.
- The NID has the condition assessment of this dam as "Unsatisfactory". The North Carolina dam inventory has the condition of this dam as "Poor".

Considerations for Maxwell Mill Pond Dam

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.

- Consider assessing the dam for probable failure mode as a result of this event.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

A13) State Dam Name: Guy Lake Dam Latitude: 35.488 Longitude: -78.71

Regulator: Exempt from State Regulation

Table A13 Guy Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Guy Lake Dam	County	Harnett
Stream or River	Black River	State Hazard Class	Low - Exempt
NID Hazard Class	Low	Year Modified	None Listed
NID ID	NC01098	Surface Area (ac-ft)	12
Dam Type	Earth	EAP	Not Required
Purpose	Recreation	Condition	Not Rated
Length (ft)	600	Normal Storage (ac ft)	60
Nearest Downstream City/Town	Dunn	Max Discharge (cfs)	79
		Owner Type	Private
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Dam Height (ft)	14	N/A	N/A
State ID	No longer cross references state ID	State ID	HARNE-047
Structural Height (ft)	No Information	Structural Height (ft)	14
Drainage Area	4.33	Drainage Area (sq mi)	2771
Year Completed	1950	Year Constructed	1950
Max Storage (ac-ft)	72	max impoundment capacity (ac-ft)	72
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	October 3, 2016
FIRM Panel	0682	FIRM Effective Date	October 3, 2016

*NC Dam Inventory Information Provided by NC DEQ DEMLR

Figure A13.1: Guy Lake Dam pre-event image; Credit: Google Maps Streetview

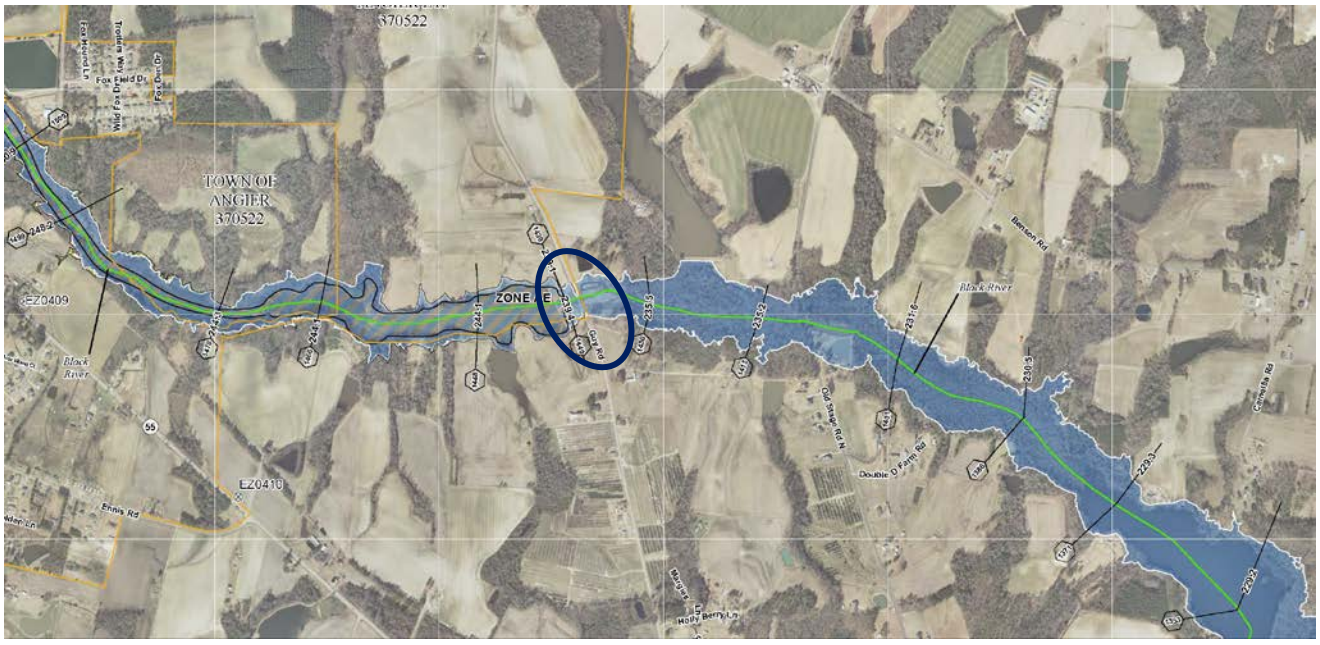


Figure A13.2: FIRM cropped; Guy Lake Dam in blue circle; detailed above

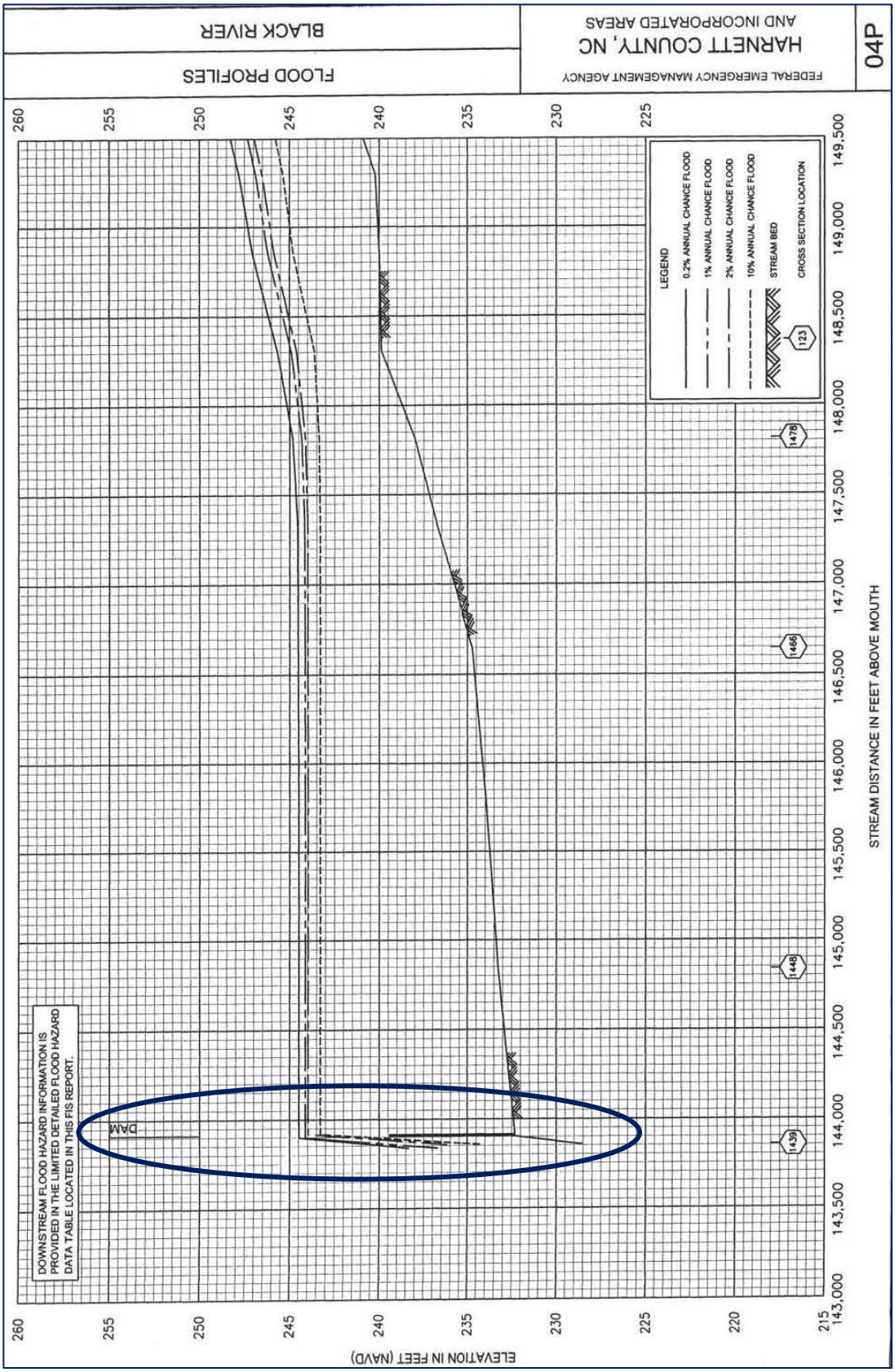


Figure A13.3 FEMA Flood Insurance Flood Profile for Guy Lake Dam in blue circle

Figure A13.4: Guy Lake Dam Overview Credit: Map data: 2016 Google; Google Earth


Figure A13.5: Guy Lake Dam post-event photo; Credit: NC DEMLR

General Guy Lake Dam Comments

- Guy Lake Dam is classified as Low hazard dam exempt from regulation in the Oct 2016 NC Dam Inventory. It is also classified as Low hazard in the 2016 NID and not regulated by the state.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded an observed a 7-day precipitation of 6"-8" in the area of this dam.
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - Information regarding the hydrologic and hydraulic modeling of Black River shows that Guy Lake Dam was included in the model as an in-line weir. This indicates that the model assumed there was no outlet control structure on the dam and that the water would flow over the dam as if it were a weir.
  - In searching for "Guy", "Lake" and "Dam" on the single FIS volume for Harnett County, nothing was found for Guy Lake Dam.
  - Black River is referenced in the FIS report.
  - The FIS profile shows the dam being overtopped by over 8 feet for the 1% annual chance of exceedance flood event.
- A FIRM panel does exist on which Guy Lake Dam can be located, as shown in Figure A13.2 above. Guy Lake Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- The 2016 NID indicates an EAP is not required for this dam and the NC inventory has an EAP not required for this dam, which is consistent with the regulatory requirements for an exempt dam.
- This dam is not referenced by name in the Cape Fear Regional Hazard Mitigation Plan, which included Harnett County.
- The NID has this dam being completed in 1950 with no modification date.
- The condition of this dam was not assessed by the state since it is not regulated.

Considerations for Guy Lake Dam

- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.

A14) State Dam Name: Sunset Lake Dam Latitude: 34.9438, Longitude: -79.0722; Regulator: NC DEQ DEMLR (NC DEQ DEMLR records show this as a Controlled Breach Dam)

Table A14 Sunset Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Sunset Lake Dam	County	Harnett
Stream or River	Black River	Nearest Downstream City/Town	Dunn
NID Hazard Class	Low	State Hazard Class	Low
NID ID	NC01098	Year Modified	No Information
Dam Type	Earth	EAP	Not Required
Purpose	Recreation	Condition Assessment	Not Rated
Length (ft)	600	Normal Storage (ac ft)	60
Max Discharge (cfs)	79	Owner Type	Private
Fields where the NID Differs from October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Drainage Area (sq mi)	4.33	Drainage Area (ac)	2771
Dam Height (ft)	14	N/A	N/A
State ID	No longer cross references state ID	State ID	HOKE-028
Structural Height (ft)	No Information	Structural Height (ft)	14
Surface Area (ac-ft)	12	Surface Area (ac-ft)	12
Year Completed	1950	Year Constructed	1950
Max Storage (ac-ft)	72	max impoundment capacity (ac-ft)	72
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3710947300J	FIS Effective Date	October 6, 2006
FIRM Effective Date	10/17/2006		

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A14.1: Former Sunset Lake Dam turned into dry retention pond; pre-event image; October 21, 2010 Credit: NC DEML

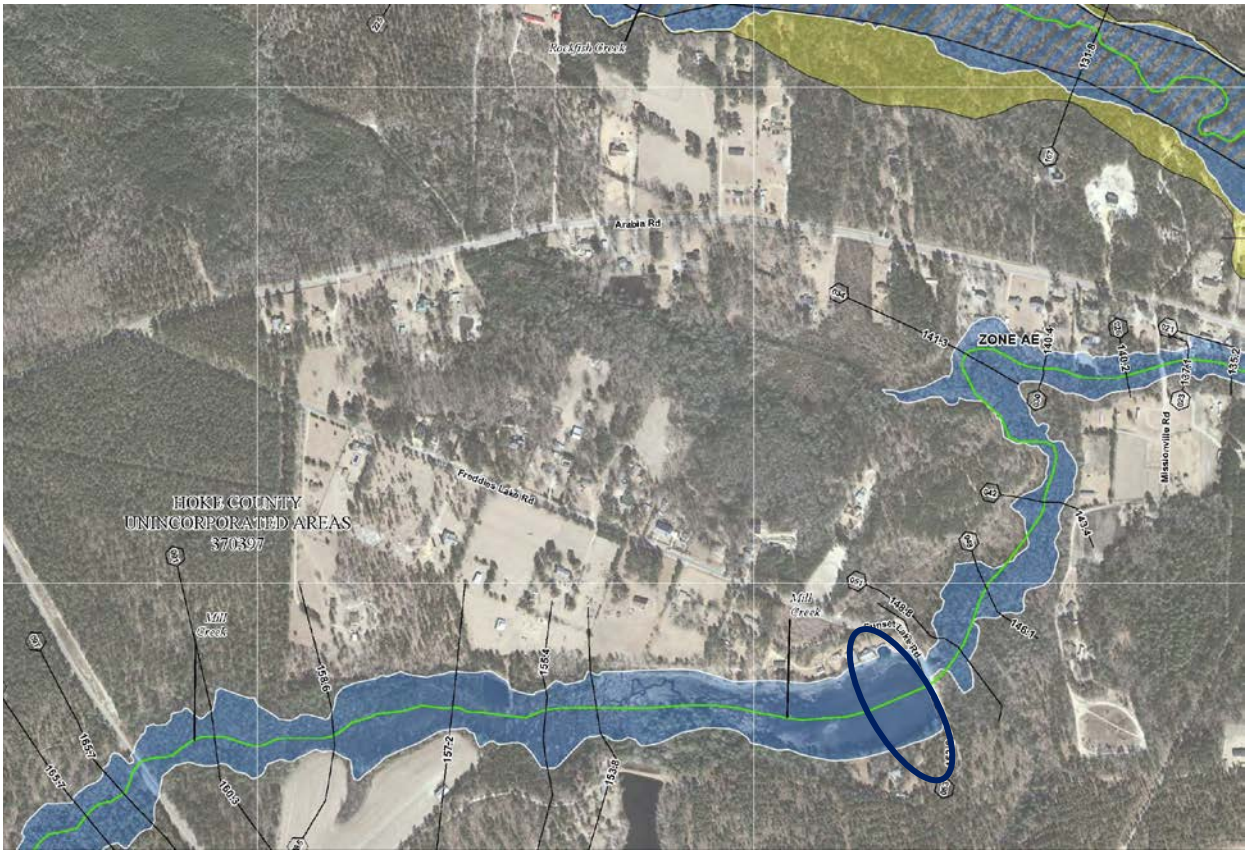


Figure A14.2: Sunset Lake Dam in blue circle; FEMA FIRM cropped; See FIRM in table above

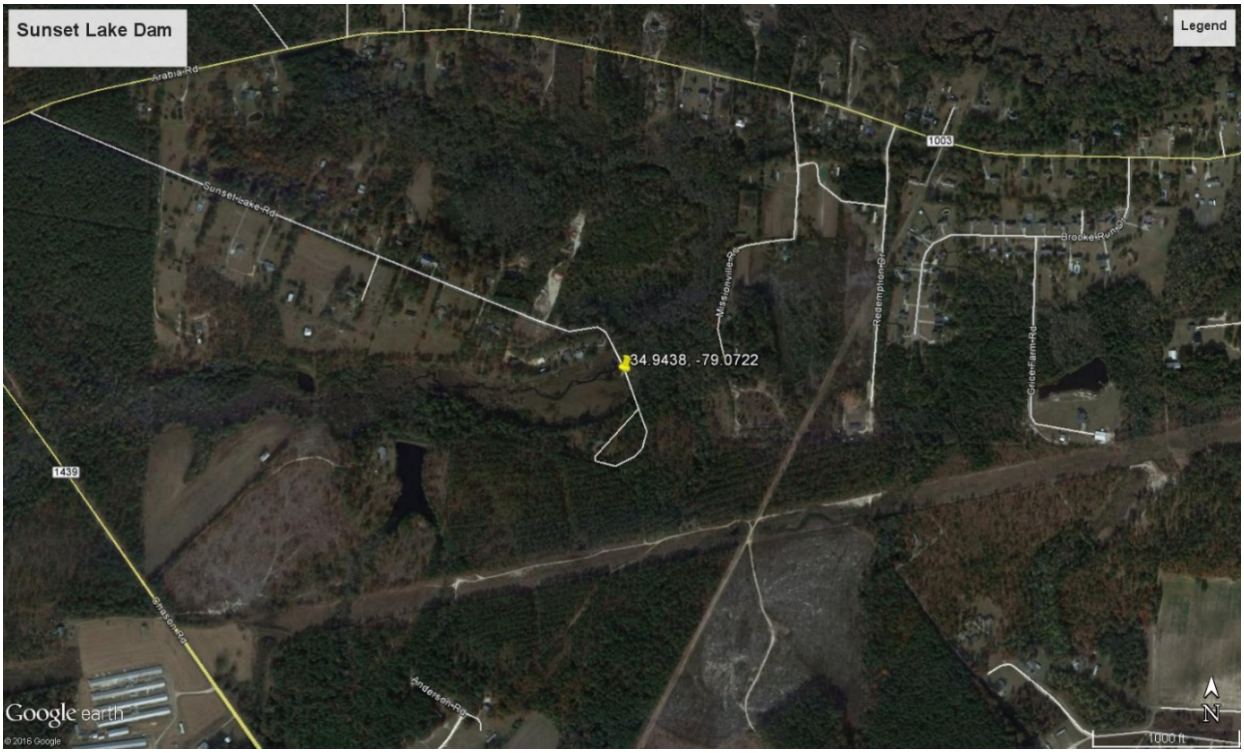


Figure A14.3: Sunset Lake Dam Site Area Map; Credit: Map data: 2016 Google Earth

General Sunset Lake Dam Comments:

- This dam is classified as a High Hazard dam in the 2016 NID but it is not regulated by the state. The North Carolina dam inventory (October 2016) indicates this is a high hazard dam but is "breached" and therefore no longer regulated. See note below.
- Civil Air Patrol (CAP) photos were not found for this dam.
- The FIRM shows this dam on Mill Creek. The 2016 NID and the North Carolina dam inventory show this dam on Black River.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 6"-8" in the area of Sunset Lake.
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - Sunset Lake Dam is not mentioned by name in the County FIS.
  - The HEC-RAS model for Mill Creek shows Sunset Lake Dam modeled as a bridge with a description of "*Sunset Lake Dam. Breached and repaired in March '00. Riser and 36" barrel. Dam elevation at 154.5' Emergency Spillway at elevation 151.5' and 30' wide*."
  - A FIRM panel does exist on which Sunset Lake Dam can be located, as shown in Figure A13.3 above. However, Sunset Lake Dam is not named on the FIRM panel.
  - There is no flood profile for Mill Creek.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP is not required for this dam.
- This dam is referenced by name in the Cape Fear Regional Hazard Mitigation Plan, which includes Harnett County.

- The 2016 NID and the North Carolina dam inventory have this dam as constructed in 1950.
- The 2016 NID has the condition of the dam as "Not Rated".
- NC DEQ DEMLR post-event notes states, "*The dam was manually breached under approval from NC Dam Safety over 5 years ago by culvert installation rendering it a dry detention pond. The storm fully breached dam at culvert location."* NC DEQ DEMLR also states, *"Sunset Lake had the breach culvert plugged. It is unsure whether it was intended or not. Due to the plugged conduit the dam was functioning as a dam typically does and failed during the storm, completely breaching the dam."*

Considerations for Sunset Lake Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.

A15) State Dam Name: Tull Millpond Dam; Latitude: 35.155, Longitude: -77.734; Regulator: NC DEQ DEML

Table A15 Tull Millpond Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Tull Millpond Dam	County	Lenoir
Stream or River	Southwest Creek	State Hazard Class	High
NID Hazard Class	High	Year Modified	None Listed
NID ID	NC00948	Surface Area (ac-ft)	160
Dam Type	Earth	Condition	Fair
Purpose	Recreation	Normal Storage (ac ft)	432
Length (ft)	1000	Owner Type	Private
Nearest Downstream City/Town	Deep Run	Max Discharge (cfs)	248
EAP	No		
Fields where the NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Structural Height (ft)	No Information	Structural Height (ft)	8
Drainage Area (sq mi)	7.297	Drainage Area (ac)	4670
Dam Height (ft)	8	N/A	N/A
State ID	No longer cross references state ID	State ID	LENOI-003
Year Completed	1875	Year Constructed	1875

Max Storage (ac-ft)	518	max impoundment capacity (ac-ft)	518
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	April 16, 2013
FIRM Panel	3571	FIRM Effective Date	April 16, 2013

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A15.1: Tull Millpond Dam pre-event photo; Credit: Google Earth

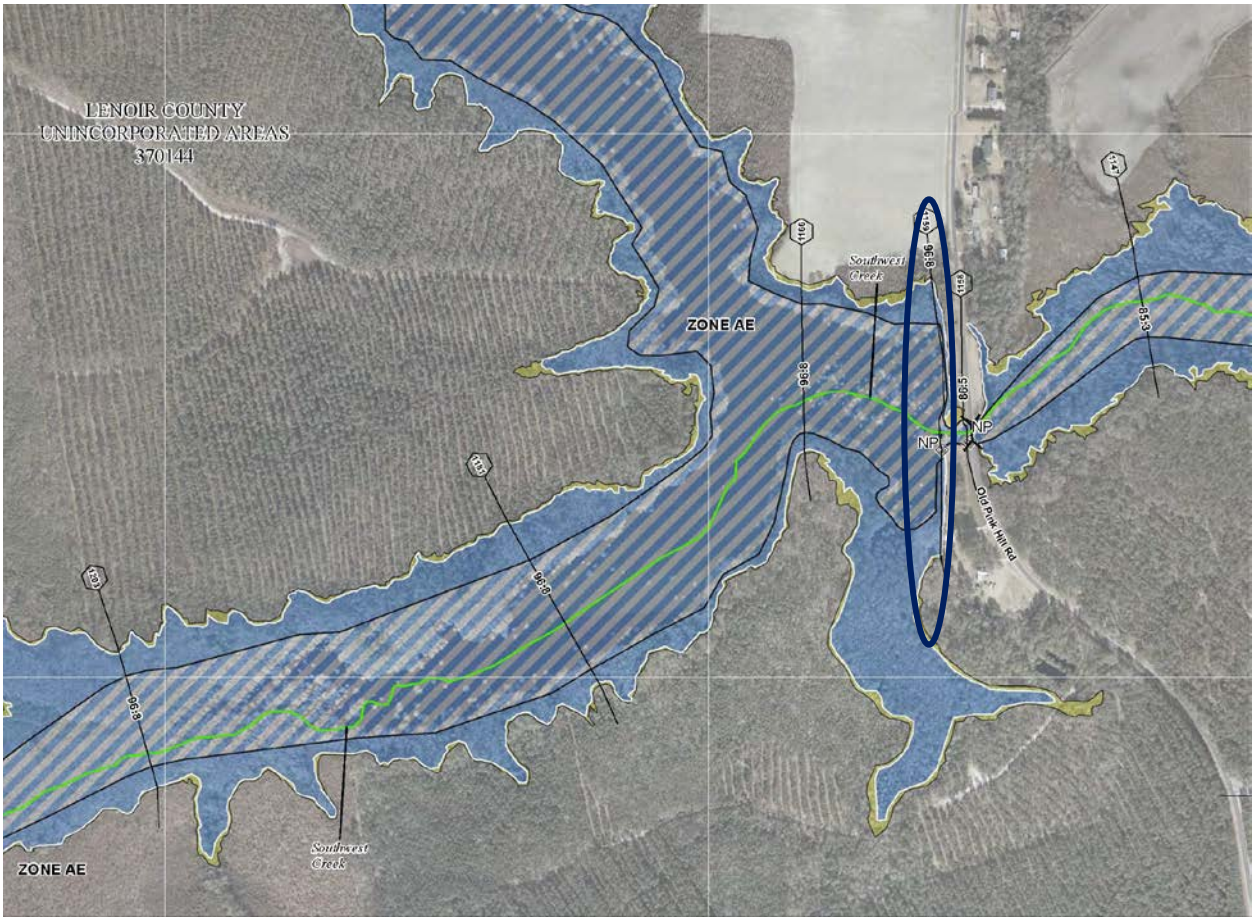


Figure A15.2: FIRM cropped; Tull Millpond Dam circled in blue; FIRM details are in table above

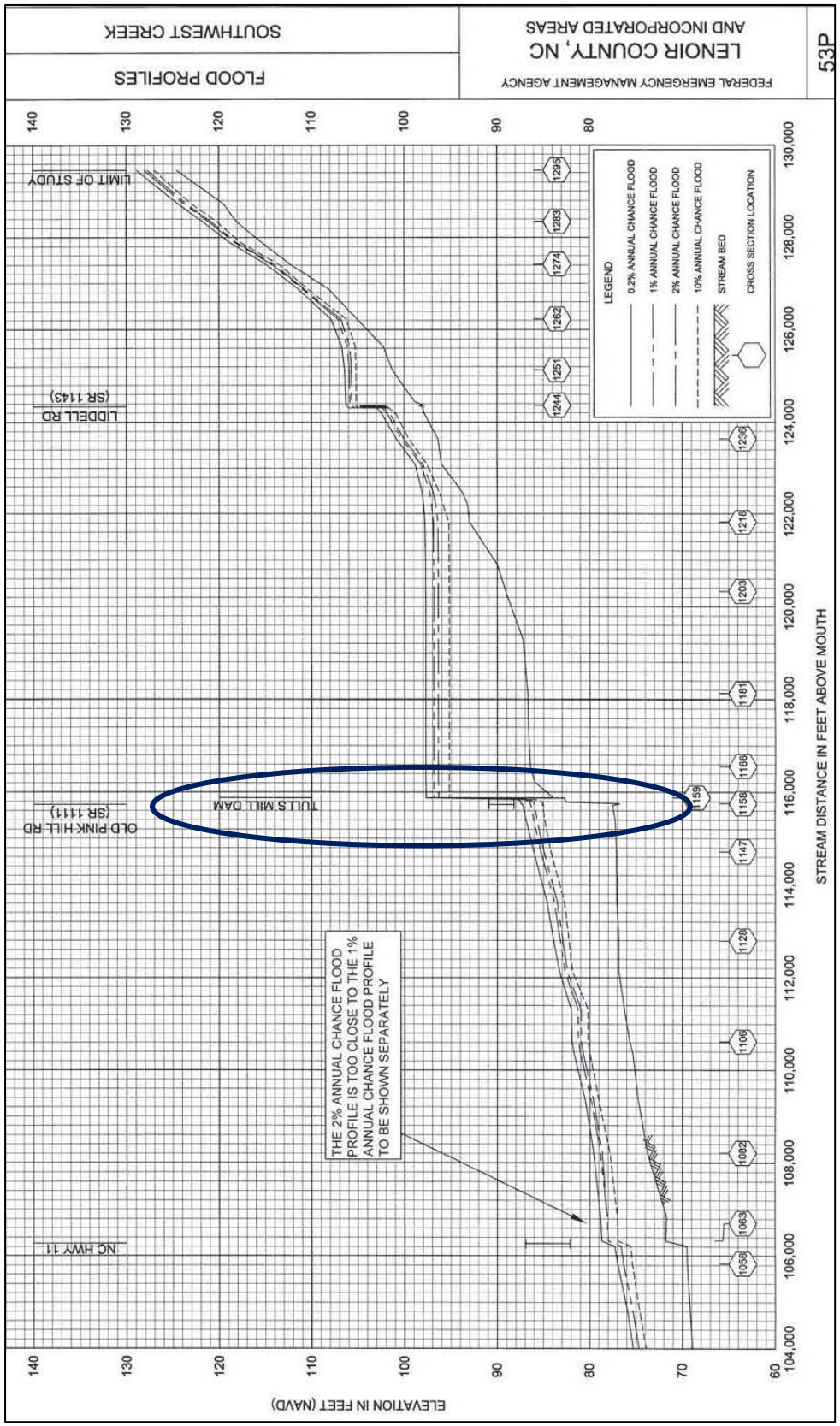


Figure A15.3 FEMA Flood Insurance Flood Profile for Tull Millpond Dam in blue circle

Figure A15.4: Tull Millpond Dam Site Area Map; Credit: Map data: 2016 Google; Google Earth


Figure A15.5: Tull Mill Pond Dam post-event photo; Note trees on embankment and tree root system within embankment Credit: NC DEMLR

General Tull Millpond Dam Comments

- Tull Millpond Dam is classified as High Hazard in the North Carolina dam inventory and in the 2016 NID.
- Civil Air Patrol (CAP) photos were not found for this dam.
- NOAA's National Weather Service recorded a 7-day precipitation of 6"-8" in the area around Tull Millpond dam.
- A USGS HWM was collected near Tull Millpond Dam
- A review of the effective FEMA Flood Insurance Study for the dam location indicates:
  - The NID has this dam being on Southwest Creek as does the FIS.
  - Information regarding the hydrologic and hydraulic modeling of Southwest Creek shows that Tull Millpond Dam was included in the model as an in-line weir. This indicates that the model assumed there was no outlet control structure on the dam and that the water would flow over the dam as if it were a weir.
  - The FIS profile shows the dam as Tulls Mill Dam.
- A FIRM panel does exist on which Tull Millpond can be located, as shown in Figure A15.2 above. Tull Millpond Dam is not specifically named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- The NID shows that an EAP is not required for this dam. NC DEQ DEMLR shows that there is no EAP for this dam.
- This dam is referenced by name in the Neuse River Basin Regional Hazard Mitigation Plan, which includes Lenoir County.
- The NID shows this dam as being completed in 1875 with no information inputted regarding modifications.
- The NID shows the condition assessment for this dam as "Fair".
- The Notice of Inspection (NOI) from NC DEQ DEMLR dated April 3, 2003 provided maintenance recommendations of *"periodically remove trees less than about six inches in diameter and thick undergrowth from the slopes and crest of the dam; periodically remove all trees from the emergency spillway; and periodically monitor the subject dam and appurtenant works with respect to elements affecting its safety".*
- The Notice of Inspection (NOI) from NC DEQ DEMLR dated January 10, 2011 provided maintenance recommendations as follows:
  - *Trees and bushes are growing on the dam. This type of growth can cause problems and even failure of the dam by creating holes when trees are uprooted due to wind or ice; by leaving possible seepage holes when trees die and their roots decay; and by causing erosion of the dam around this growth should the dam overtop during heavy rains. Therefore, we recommend that this type of growth be removed and a good grass cover be established on the dam.*
  - *There was minor seepage noted on the along the entire toe of the downstream slope of the dam. Excessive seepage can cause failure due to internal erosion and/or*

embankment sliding. You should inspect the seepage periodically and notify this office if there is an increase in the amount of seepage, or embankment sliding occurs.

- *Maintain a ground cover sufficient to restrain accelerated erosion on all earthen portions of the structure.*
- *Periodically monitor the subject dam and appurtenant works with respect to elements affecting its safety. This is in light of the legal duties, obligations, and liabilities arising from the ownership and/or operation of a dam.*

Considerations for Tull Millpond Dam

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for event specific dam failure modeling and incremental consequence assessment to compare the flood event versus the dam breach inundation.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider this dam for further research into whether or not the recommendations provided in the last NC DEQ DEMLR inspection were addressed.
- Consider collecting and documenting the dam breach parameters at this dam
- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A16) State Dam Name: Laurel Lake Dam Latitude: 35.011 Longitude: -78.489;
Regulator: Exempt from State Regulation

Table A16 Laurel Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Laurel Lake Dam	County	Sampson
Stream or River	Rye Swamp	State Hazard Class	Intermediate
NID Hazard Class	Significant	Year Modified	None Listed
NID ID	NC01083	Surface Area (ac-ft)	20
Dam Type	Earth	Condition	Not Rated
Purpose	Recreational	Normal Storage (ac ft)	42

Length (ft)	453	Owner Type	Private
Nearest Downstream City/Town	Clear Run	Max Discharge (cfs)	330
EAP	No		
Fields where the 2016 NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Structural Height (ft)	No Information	Structural Height (ft)	12
Drainage Area (sq mi)	5.2	Drainage Area (ac)	3328
Dam Height (ft)	12	N/A	N/A
State ID	No longer cross references state ID	State ID	SAMPS-016
Year Completed	1947	Year Constructed	1947
Max Storage (ac-ft)	50	max impoundment capacity (ac-ft)	50
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	January 5, 2007
FIRM Panel	1444	FIRM Effective Date	January 5, 2007

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A16.1: Laurel Lake Dam pre-event photo; Credit: Google Earth

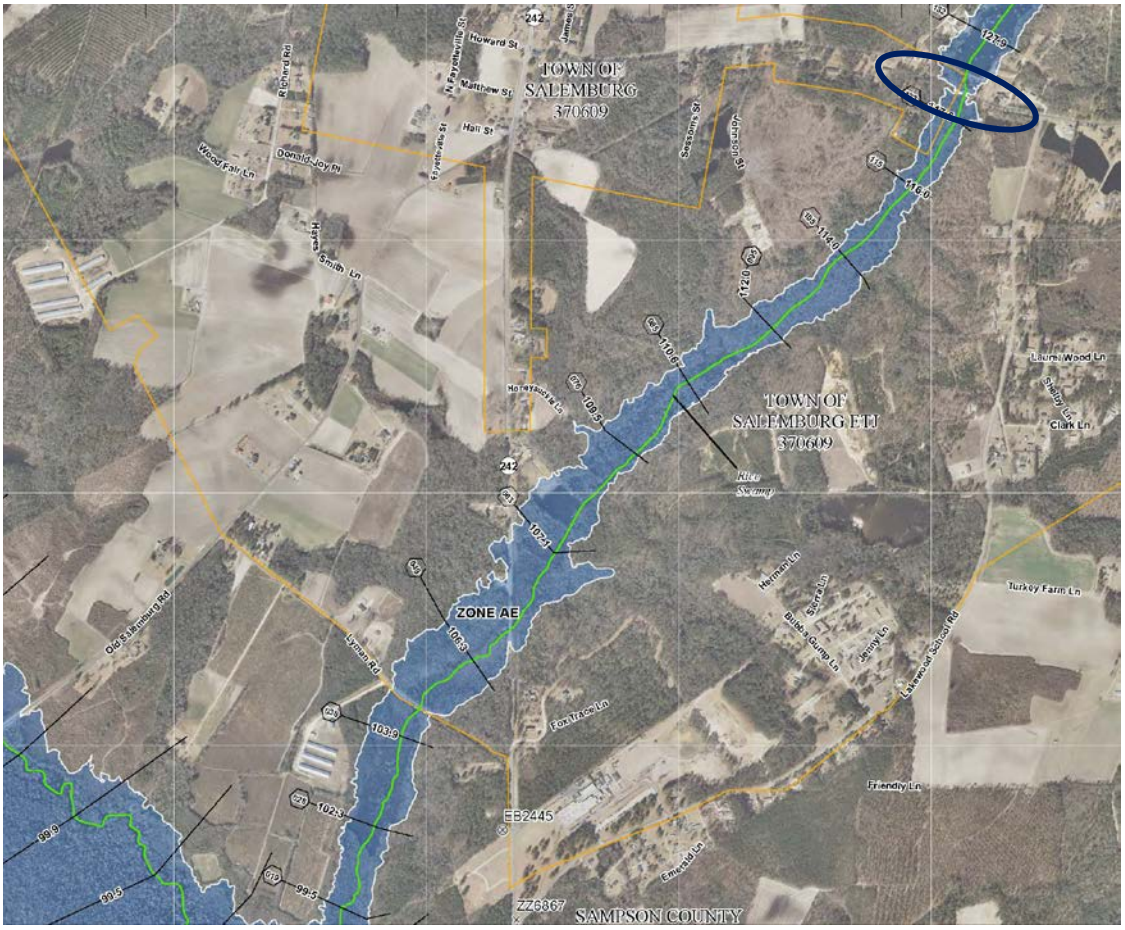


Figure A16.2: Laurel Lake Dam in blue circle; FIRM is cropped, detailed above

Figure A16.3: Laurel Lake Dam Site Area Map Credit: Map data: 2015 Google; Google Earth


Figure A16.4: Laurel Lake Dam post-event photo; Credit: NC DEMLR

General Laurel Lake Dam Comments

- The National Inventory of Dams shows this dam as a Significant Hazard dam. The NC Dam Inventory classifies this dam as Intermediate exempt from regulations.
- There are no pictures from the Civil Air Patrol of this dam.
- NOAA National Weather Service recorded an observed a 7-day precipitation of 8”-10” in the area of this dam.
- A review of the preliminary and effective FEMA Flood Insurance Study indicates:
  - No reference to Laurel Lake Dam.
  - The stream for this dam is listed as Rice Swamp. The National Inventory of Dams lists the stream for this dam as Rye Swamp.
  - Information regarding the hydrologic and hydraulic modeling of Rice Swamp shows that Laurel Lake Dam was included in the model as an in-line weir. This indicates that the model assumed there was no outlet control structure on the dam and that the water would flow over the dam as if it were a weir.
  - There is no flood profile for Rice Swamp.
- A review of the latest Flood Insurance Rate Map (FIRM) indicates:
  - This dam is not labeled.
- The 2016 NID and Oct 2016 NC Dam inventory indicate this dam as an earthen dam.
- Based on information from the North Carolina dam inventory, there was no emergency action plan for this dam. This is consistent with this dam being classified as exempt and therefore not required to have an EAP.
- The Sampson/Duplin Regional Hazard Mitigation Plan, which includes Sampson County, did reference this dam by name
- The National Inventory of Dams records this dam as constructed in 1947 with no modifications recorded.
- According to the NC DEQ DEMLR post-event notes, this dam breached and Laurel Lake Road just south of the dam was washed out.

Considerations for Laurel Lake Dam

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider collecting and documenting the dam breach parameters at this dam.
- Based on Laurel Lake Road being washed out from this dam breach, the state should consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

- Consider assessing and documenting the dam site for tree and woody vegetation and any contributions this may have had in the failure, such as root systems in the embankment.

A17) State Dam Name: House-Autry Dam Latitude: 35.18694 Longitude: -78.3762; Regulator: NC DEQ DEMLR

Table A17 House-Autry Dam 2016 NID and the October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	House-Autry Dam	County	Sampson
Stream or River	Seven Mile Swamp	State Hazard Class	High
NID Hazard Class	High	Year Modified	None Listed
NID ID	NC05468	Surface Area (ac-ft)	41
Dam Type	Earth	Condition	Fair
Purpose	Recreation	Normal Storage (ac ft)	No Information
Max Discharge (cfs)	No Information	Owner Type	Private
Nearest Downstream City/Town	None Listed	EAP	Yes
Fields where the 2016 NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Structural Height (ft)	No Information	Structural Height (ft)	9
Drainage Area (sq mi)	18.2	Drainage Area (ac)	11648
Dam Height (ft)	9	N/A	N/A
State ID	No longer cross references state ID	State ID	SAMPS-047
Length (ft)	887.5	Length (ft)	888
Year Completed	1850	Year Constructed	1850
Max Storage (ac-ft)	307.5	max impoundment capacity (ac-ft)	308
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	January 5, 2007
FIRM Panel	1582	FIRM Effective Date	January 5, 2007

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A17.1: House-Autry Dam pre-event photo; Credit: Google Maps 2016

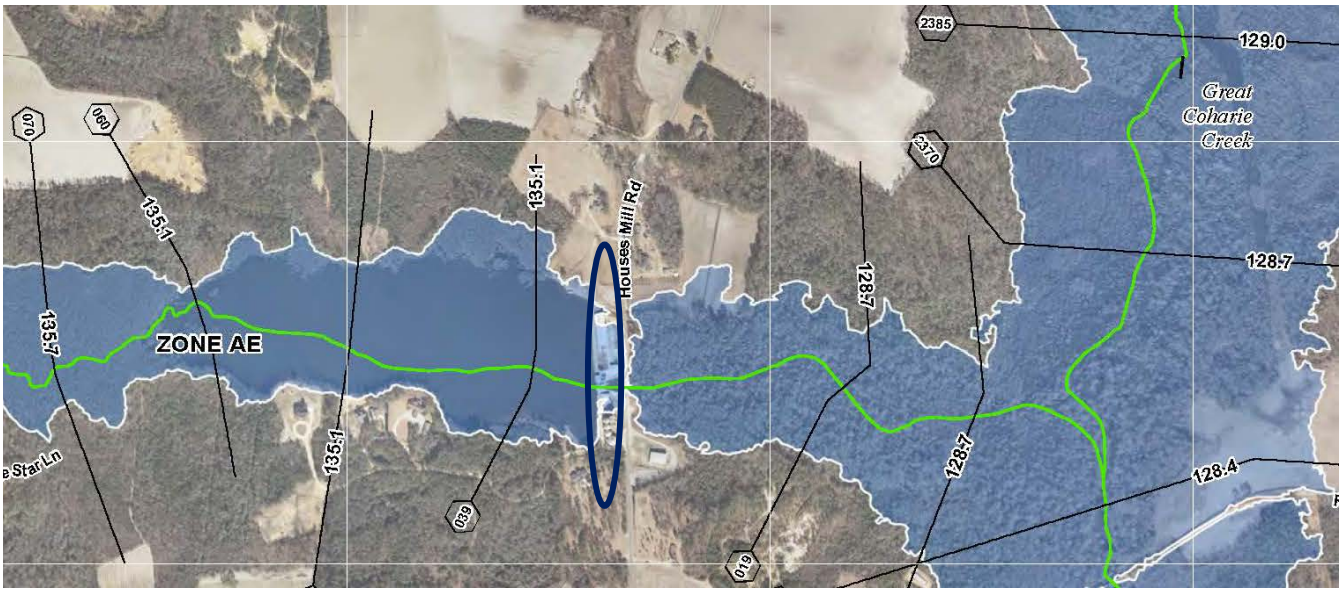


Figure A17.2: House-Autry Dam in blue circle; FIRM is cropped, detailed above

Figure A17.3: House-Autry Dam Site Area Map Credit: Map data: 2016 Google; Google Earth


Figure A17.4: House Autry Dam post-event photo; Credit: NC DEMLR

General House-Autry Dam Comments

- The 2016 NID indicates this dam as a High Hazard dam. NC DEQ DEMLR also classifies this dam as High Hazard.
- There are no pictures from the Civil Air Patrol of this dam.
- NOAA National Weather Service recorded an observed a 7-day precipitation of 8”-10” in the area of this dam.
- USGS HWMs were collected downstream of House-Autry Dam
- A review of the preliminary and effective FEMA Flood Insurance Study indicates:
  - There is no reference to House-Autry Dam.
  - The stream for this dam is listed as Sevenmile Swamp. The National Inventory of Dams lists the stream for this dam as Seven Mile Swamp.
  - Information regarding the hydrologic and hydraulic modeling of Sevenmile Swamp shows that House-Autry Dam was included in the model as an in-line weir. This indicates that the model assumed there was no outlet control structure on the dam and that the water would flow over the dam as if it were a weir.
  - There is no flood profile for Sevenmile Swamp.
- This dam is not labeled on the FIRM as a dam, or by its name.
- The 2016 NID and Oct 2016 NC Dam Inventory indicates this dam as earthen.
- Based on information from NC DEQ DEMLR, there is an emergency action plan for this dam.
- The Sampson/Duplin Regional Hazard Mitigation Plan, which includes Sampson County, did reference this dam by name.
- The 2016 NID and NC Oct 2016 Inventory records this dam as completed in 1850 with no modifications.
- The NID and the North Carolina dam inventory have the condition of this dam pre-event as “Fair”.
  - 3/2/2012 – A letter of Notice of Inspection sent by NC DEQ DEMLR to owners of the dam. The letter explained that the dam had been inspected on 2/22/2012 by the “Land Quality Section”. The inspection determined the dam to be a High Hazard dam. Conditions found in part included: erosion still occurring in the emergency spillway on right side of downstream slope, holes on the crest of the dam, some repair of holes from last inspection has been done – however soil not compacted, wetness at right side of toe of dam, woody debris is partially obstructing the emergency spillway. The letter advised the owner that erosion is usually progressive in nature and that debris in the spillway can cause overtopping of dam during heavy rains. The letter also recommended general maintenance of: maintain ground cover to restrain erosion on all earthen portions, periodically remove all trees from emergency spillway, check operation of drain valve facilities, and monitor the dam and appurtenant works. The letter shared with owner that tropical weather and intense thunderstorms in past few years had caused flooding in NC, and during these

events dams could be at higher risk of failure. An EAP was suggested to be developed by the owner and shared with the NC DEQ DEMLR. Lastly, the letter stated that should the dam fail and there was loss of life or property downstream, the owner could face liability.

- 1/14/2013 - A letter of Notice of Inspection sent by NC DEQ DEMLR to owners of the dam. The letter explained that the dam had been inspected on 1/9/2013 by the "Land Quality Section". The inspection determined the dam to be a High Hazard dam. The letter noted that erosion was repaired in the emergency spillway but that there were was still erosion (holes) on the left side of the upstream slope, woody debris was partially obstructing the emergency spillway. The Dam Safety Inspection also noted water seepage along the length of the toe of the dam. The letter recommended the holes be repaired and a groundcover planted to slow the erosion, as well as the removal of the woody debris. The letter recommended general maintenance as explained in the 3/12/2012 Letter of Inspection, and recommended the development of an EAP for the dam.
- 3/17/2015 – A letter of Notice of Inspection was sent by the NC DEQ DEMLR to owners of the dam. The letter explained that the dam had been inspected on 3/12/2015 by the "Land Quality Section". Determined the dam to be a High Hazard dam. The inspection revealed in part: flow from the emergency spillway has caused erosion at the culvert under Houses Mill Road, erosion along the bank of the emergency spillway channel, and holes near the concrete portion of the spillway, and that woody debris is partially obstructing the principal spillway. The letter also recommended general maintenance as outline in the 3/2/2012 Notice of Inspection.
- 1/27/2016 - A letter of Notice of Inspection sent by NC DEQ DEMLR to owners of the dam. The letter explained that the dam had been inspected on 1/27/2016 by the "Land Quality Section". The inspection determined the dam to be a High Hazard dam. The inspection revealed conditions of: seepage underneath the mill building near the principal spillway, erosion was observed on the upstream slope near the auxiliary concrete spillway, significant erosion was observed in the road shoulder at and above the culvert under House Mill Road. The erosion under House Mill Road was noted to have worsened since the previous inspection on 3/17/2015 and the owners were told it needed to be adequately repaired and stabilized. Further it was recommended to the owners to contact the NCDOT office for assistance in the matter. The letter again reminded the owners of their responsibilities for general maintenance and their possible liability should the dam fail.

<u>Considerations for House-Autry Dam</u>

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.

- Consider this dam for event specific dam failure modeling and incremental consequence assessment to compare the flood event versus the dam breach inundation.
- Consider this dam for comparison of dam breach modeling results (HEC-RAS, DSS-WISE, FLO-2D, etc.) to high water mark inundation downstream.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider this dam for further research into whether or not the recommendations provided in the last NC DEQ DEMLR inspection were addressed.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider this dam for whether the local EMA had integrated the EAP for this dam into the local EOP.

A18) State Dam Name: Durham Lake Dam Latitude: 35.281, Longitude: -78.057;
Regulator: Exempt from State Regulation

Table A18 Durham Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Durham Lake Dam	County	Wayne
Stream or River	Yellow Marsh Branch	Nearest Downstream City/Town	Stevens Mill
NID Hazard Class	Low	State Hazard Class	Low
NID ID	NC00943	Year Modified	No Information
Dam Type	Earth	EAP	Not required
Purpose	Recreation	Owner Type	Private
Length (ft)	600	Normal Storage (ac ft)	93
Max Discharge (cfs)	66	Surface Area (ac-ft)	22
Fields where the 2016 NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Condition Assessment	Not Rated	Condition Assessment	Poor
Drainage Area (sq mi)	3.5	Drainage Area (acres)	2240
Structural Height (ft)	No Information	Structural Height (ft)	12.7
Dam Height (ft)	12.7	N/A	N/A
State ID	No longer cross references state ID	State ID	WAYNE-008
Year Completed	1920	Year Constructed	1920

Max Storage (ac-ft)		max impoundment capacity (ac-ft)	
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
FIRM Panel	3720258500J	FIS Effective Date	
FIRM Effective Date		FIS Preliminary Date	

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A18.1: Durham Lake Dam pre-event image; Credit: 2016 Google Earth Streetview

Figure A18.2: Durham Lake Dam in blue circle; FEMA FIRM cropped; See FIRM in spreadsheet above

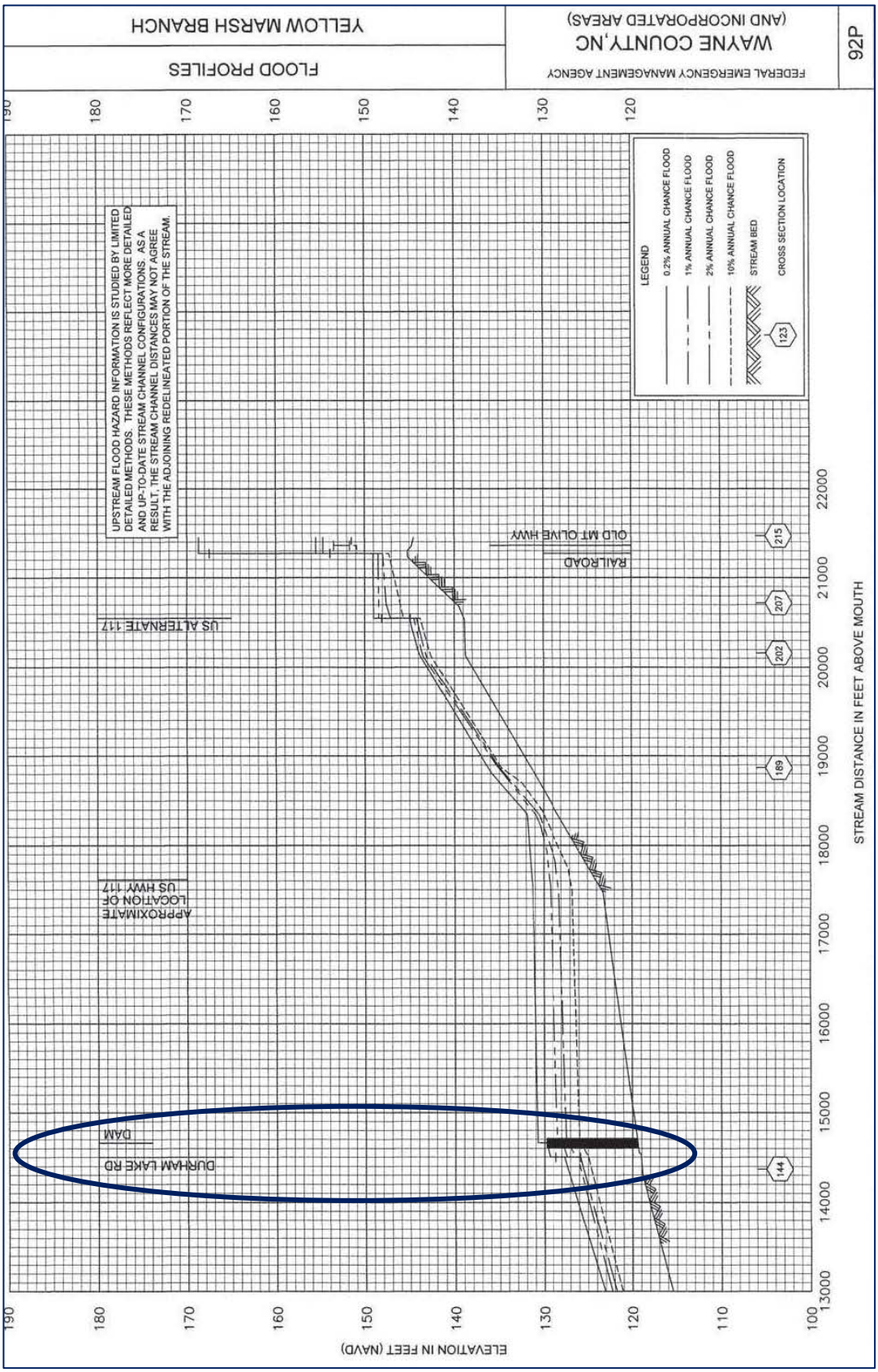


Figure A18.3: Durham Lake Dam Flood Profile 06P from the FIS

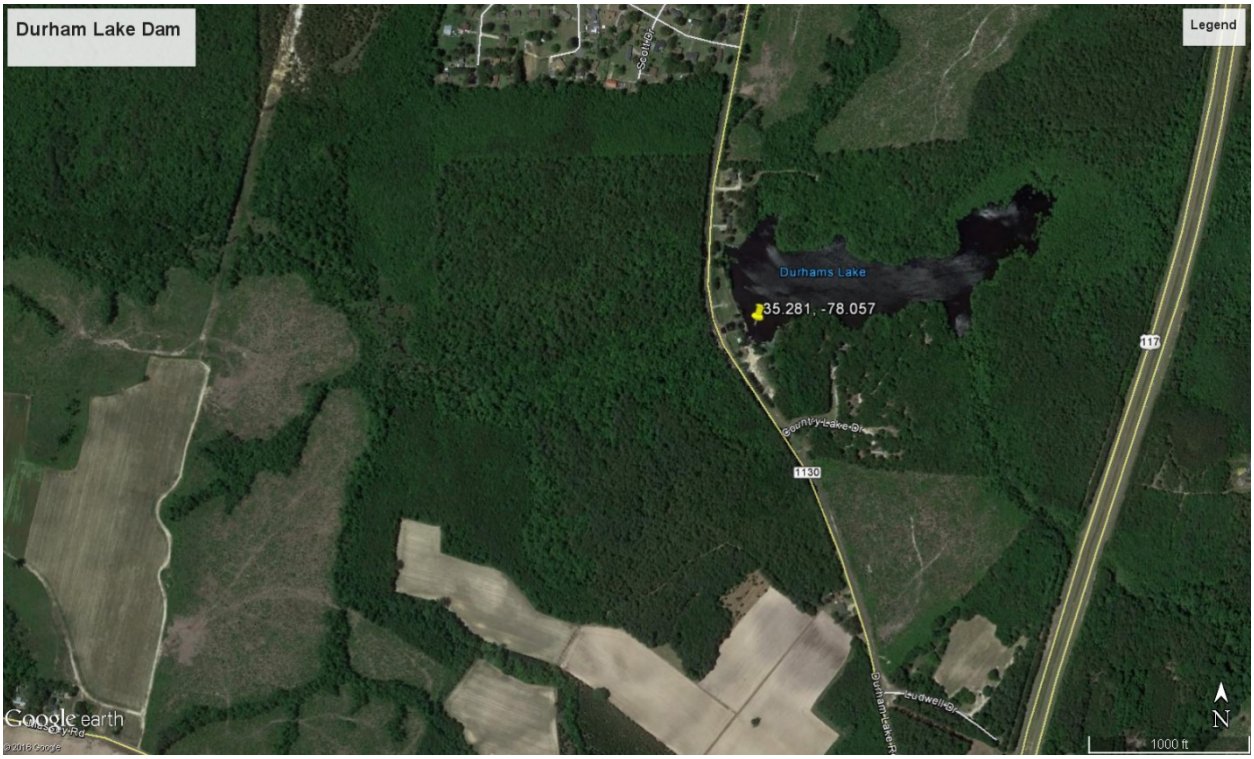


Figure A18.4: Durham Lake Dam Site Area Map; Credit: Map data: 2016 Google Earth

General Durham Lake Dam Comments:

- This dam is classified as Low Hazard in the 2016 NID and not regulated by the state. The Oct 2016 North Carolina dam inventory has this dam as low hazard and exempt from regulation.
- No Civil Air Patrol (CAP) photos were found for this dam.
- The FIRM, 2016 NID, and the North Carolina dam inventory have this dam on Yellow Marsh Branch.
- NOAA's National Weather Service recorded an observed 7-day precipitation of 6"-8" in the area of Durham Lake Dam.
- A review of the effective and preliminary FEMA Flood Insurance Study for Wayne County:
  - Durham Lake Dam was not referenced by name.
  - Specific Hydraulic and Hydrologic modeling was available for Yellow Marsh Branch. Durham Lake Dam is not included in the model.
  - A FIRM panel does exist on which Durham Lake Dam can be located, as shown in Figure A18.2 above. However, Durham Lake Dam is not named on the FIRM panel.
- The Dam Type in the NID is Earthen.
- Based on information from NC DEQ DEMLR, an EAP is not required for this dam.
- This dam is referenced by name in the Neuse River Basin Regional Hazard Mitigation Plan, which includes Wayne County
- The 2016 NID and the Oct 2016 North Carolina dam inventory this dam as constructed in 1920.

- The North Carolina dam inventory has the condition of the dam as “Poor”.
- A letter from NC DEQ DEMLR to the dam owner on October 28, 2016 indicated the dam was low hazard- exempt and stated the dam overtopped and had significant damage along the crest. Should the dam owner decide to repair the dam, they would be required to submit their plans in accordance with state law to NC DEQ DEMLR who would review the plans for approval and would also re-evaluate the hazard classification at that time. The letter requested the dam owner provide them a written response as to their intended actions for the breached dam.

Considerations for Durham Lake Dam:

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider assessing the dam for probable failure mode as a result of this event.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

A19) State Dam Name: H.F. Lee Power Station Cooling Lake Dam; Latitude: 35.381; Longitude: -78.085; Regulator: NC DEQ DEMLR

Table A19 H.F. Lee Power Station Cooling Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	H.F. Lee Power Station Cooling Lake Dam	County	Wayne
Stream or River	Neuse Riv Off Stream	State Hazard Class	High
NID Hazard Class	High	Year Modified	None Listed
NID ID	NC00944	Length (ft)	24288
Dam Type	Earth	Normal Storage (ac ft)	3808
Purpose	Other	Surface Area (ac-ft)	562.9
Condition Assessment	Fair	EAP	No
Max Discharge (cfs)	No Information	Nearest Downstream City/Town	Goldsboro
Fields where the 2016 NID Differs from the October 2016 NC Dam Inventory* Information			

NID Field Name	2016 NID Value	State Field Name	State Value
Structural Height (ft)	No Information	Structural Height (ft)	17
Drainage Area (sq mi)	0.852	Drainage Area (ac)	545
Owner Type	Public Utility	Owner Type	Utility
Dam Height (ft)	17	N/A	N/A
State ID	No longer cross references state ID	State ID	WAYNE-009
Year Completed	1955	Year Constructed	1955
Max Storage (ac-ft)	5446	max impoundment capacity (ac-ft)	5446
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	April 16, 2013
FIRM Panel		FIRM Effective Date	

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A19.1: H.F. Lee Power Station Cooling Lake Dam pre-event photo; Credit: Google Maps

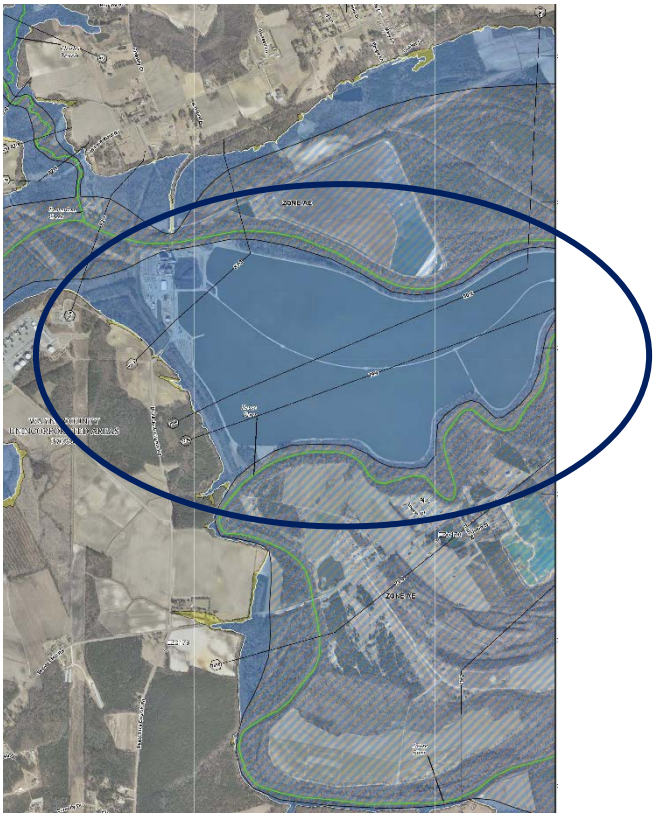


Figure A19.2: H.F. Lee Power Station Cooling Lake Dam in blue circle; FIRM is cropped, detailed above

Figure A19.3: H.F. Lee Power Station Cooling Lake Dam Site Area Map Credit: Map data: 2016 Google; Google Earth

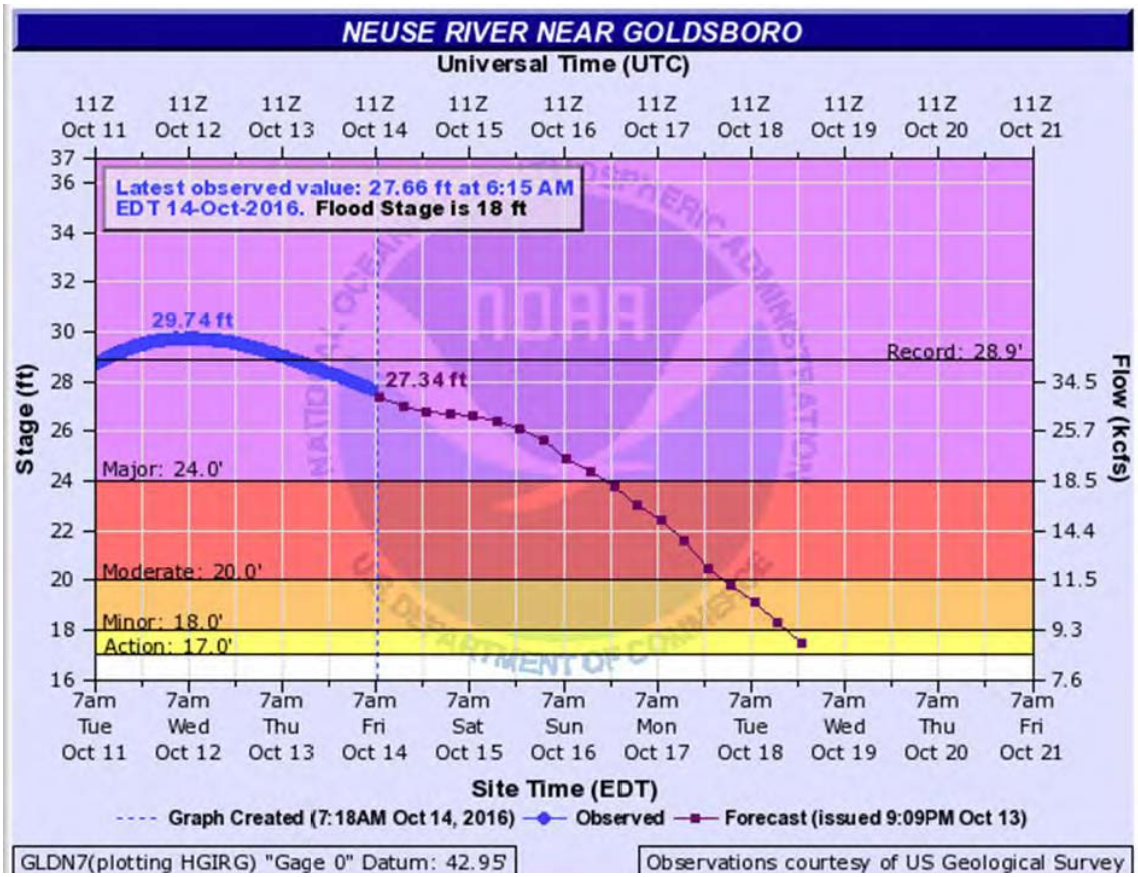


Figure A19.4: USGS gage data near H.F. Lee Power Station Cooling Lake Dam

Figure A19.5: H.F. Lee Power Station Cooling Lake Dam post-event photo; Credit: NC DEMLR

General H.F. Lee Power Station Cooling Lake Dam Comments

- The 2016 National Inventory of Dams indicates this dam as a High Hazard dam. NC DEQ DELMR classifies this dam as a High Hazard Dam.
- There are Civil Air Patrol photos of this dam.
- NOAA National Weather Service recorded an observed a 7-day precipitation of 8”-10” in the area of this dam.
- USGS gage data shows that the Neuse River near this dam reached record flood levels. The Neuse River initially entered the cooling lake through the emergency spillway and then overtopped the dam.
- USGS HWMs were collected downstream of H.F. Lee Power Station Cooling Lake Dam
- This dam is off stream. It is not expected to have been included in the Flood Insurance Study or the Flood Insurance Rate Map, and is not there. There is no reference to H.F. Lee Power Station Cooling Lake Dam.
- The National Inventory of Dams shows this dam as an earthen dam.
- The 2016 NID and the North Carolina dam inventory show that there is no EAP for this dam. However, NC DEQ DEMLR confirmed that there is an EAP on this dam and it was activated during this event.
- The Neuse River Basin Regional Hazard Mitigation Plan, which includes Wayne County, references this dam by name
- The 2016 NID shows this dam as completed in 1955 with no information on year modified.
- The post-event Plan of Action from the dam owner states that:
  - *A coffer dam has been constructed in the area of the breach to reduce and eliminate the discharge from the breach.*
  - *Duke Energy will works with DEQ to get the necessary permits for a permanent repair of this breach.*
- The following are conditions noted in a Notice of Deficiency (NOD) from NC DEQ DEMLR dated June 1, 2016:
  - *Trees were noted to be growing out of the top of the outlet end of the barrel pipe for the flood/drain control gate on the southeast side of the dam.*
  - *A tree located on the lower half of the downstream slope of the dam in the same vicinity as the flood/drain control gate, was observed to be leaning on other trees. The roots of the tree were partially exposed. This was historical in nature, but poses a risk during significant storm events.*
  - *Heaving and broken asphalt was observed on the upstream slope of the dam near the picnic area. It is understood that this area is currently under plan proposal/modification.*
  - The NOD states further ‘*These conditions appear serious and justify further engineering study to determine appropriate remedial measures. In the event of a dam failure, human life and significant property would be endangered because of the downstream location of residential areas. Tree growth on the earthen portion of a*

dam can cause problems and even failure of the dam by creating holes when trees are uprooted due to wind or ice; by leaving possible seepage holes when trees die and their roots decay; and by causing erosion of the dam around this growth should the dam overtop during heavy rains. Therefore, we recommend that this type of growth be removed and a good grass cover be established on the dam. Trees growing in pipe structures on dams are typically found in pipe joints. This type of growth can create cracks, joint displacement and potential failure. In order to ensure the safety of this dam, you are directed to retain the services of a registered professional engineer or an experienced engineering firm to make a study of the conditions outlined in this letter. Plans and specifications for repair based on the results of the study must be filed with the Division of Energy, Mineral, and Land Resources for approval pursuant to the North Carolina Administrative Code, Title 15A, Subchapter 2K - Dam Safety (15A NCAC 2K)."

Considerations for H.F. Lee Power Station Cooling Lake Dam

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider this dam for further analysis to determine the capacity of the spillway / outlet work system in relation to the flood event that occurred.
- Consider this dam for further assessment of the design and construction of the dam and any major rehabilitations, including the design and construction standards at the time.
- Consider this dam for further research into whether or not the recommendations provided in the NC DEQ DEMLR NOD were addressed.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider this dam for whether the local EMA had integrated the EAP for this dam into the local EOP.

A20) State Dam Name: Silver Lake Dam Latitude: 35.802 Longitude: -77.949; Regulator: Exempt from State Regulation

Table A20 Silver Lake Dam 2016 NID and October 2016 NC Dam Inventory

Fields where the 2016 NID Matches the October 2016 NC Dam Inventory* Information			
NID/State Field	**NID/State Value**	**NID/State Field**	**NID/State Value**
NID Dam Name	Silver Lake	County	Wilson
Stream or River	Toisnot Swamp	State Hazard Class	Intermediate
NID Hazard Class	Significant	Year Modified	None Listed
NID ID	NC00896	Surface Area (ac-ft)	74
Dam Type	CNPGRE	Condition	Not Rated
Purpose	Recreation	Normal Storage (ac ft)	325
Drainage Area (sq mi)	No Information	Owner Type	Private

Max Discharge (cfs)	No Information	Nearest Downstream City/Town	None Listed
Length (ft)	600	EAP	None
Fields where the 2016 NID Differs from the October 2016 NC Dam Inventory* Information			
NID Field Name	**2016 NID Value**	**State Field Name**	**State Value**
Structural Height (ft)	No Information	Structural Height (ft)	13.1
Dam Height (ft)	13.1	N/A	N/A
State ID	No longer cross references state ID	State ID	WILSO-009
Year Completed	1785	Year Constructed	1785
Max Storage (ac-ft)	538	max impoundment capacity (ac-ft)	538
FIRM & FIS data taken from FEMA mapping service center and NC FRIS (Flood Risk Information System) website			
		FIS Effective Date	April 16, 2013
FIRM Panel	3714	FIRM Effective Date	April 16, 2013

*NC Dam Inventory Information provided by NC DEQ DEMLR

Figure A20.1: Silver Lake Dam pre-event photo; Credit: Google Maps Streetview

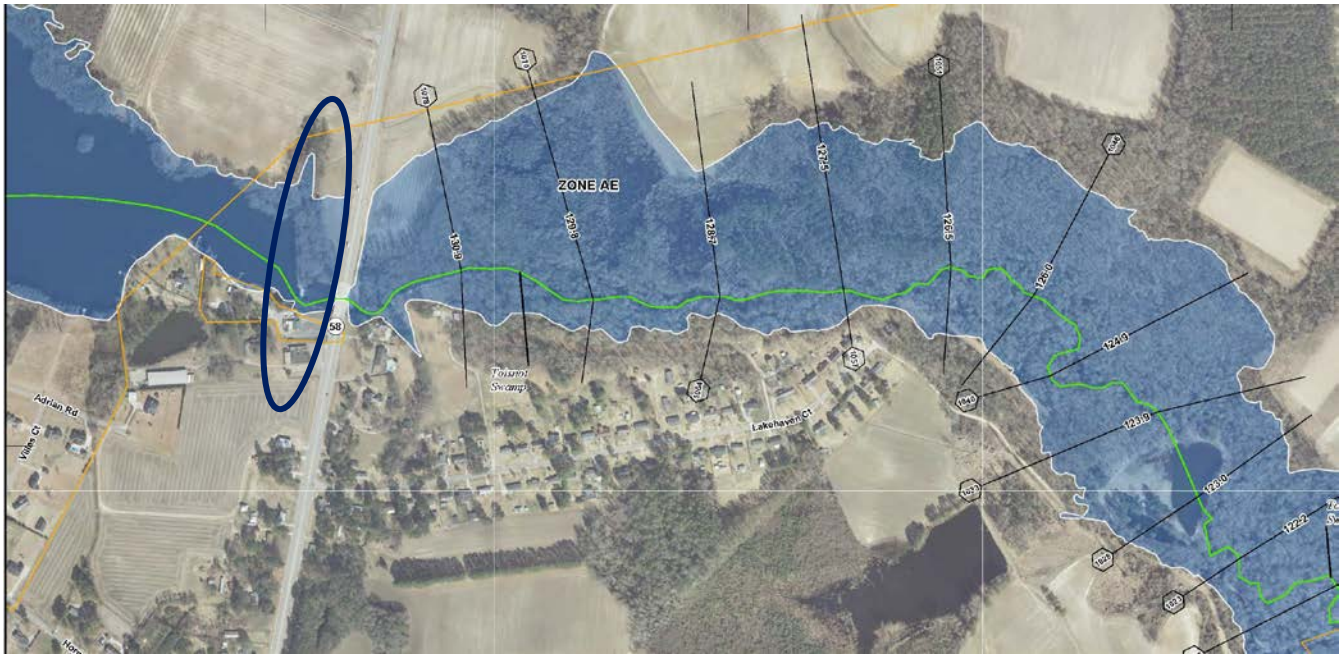


Figure A20.2: Silver Lake Dam in blue circle; FIRM is cropped, detailed above

Figure A20.3: Silver Lake Dam Site Area Map Credit: Map data: 2016 Google; Google Earth

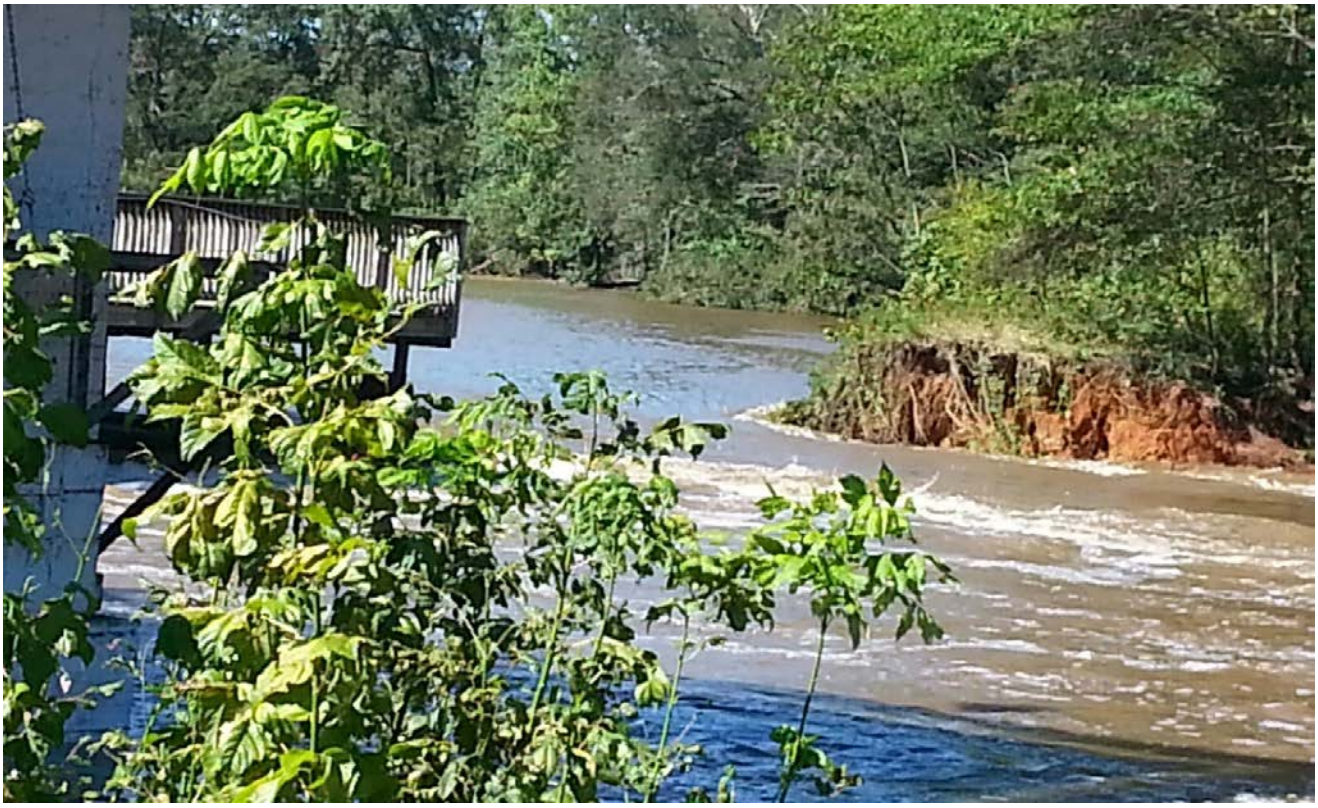


Figure A20.4: Silver Lake Dam post-event photo; Credit: NC DEMLR

General Silver Lake Comments

- The NID shows this dam as a Significant Hazard dam but the state does not regulate it. The North Carolina dam inventory classifies this dam as Intermediate hazard and exempt from state regulation.
- There are no pictures from the Civil Air Patrol of this dam.
- NOAA National Weather Service recorded an observed 7-day precipitation of 8”-10” in the area of this dam.
- A review of the latest FEMA Flood Insurance Study indicates:
  - The stream for this dam is listed as Toisnot Swamp. This is consistent with the stream listed in the National Inventory of Dams.
  - Information regarding the hydrologic and hydraulic modeling of Toisnot Swamp shows that Silver Lake was included in the model as an in-line weir. This indicates the model assumed there was no outlet control structure on the dam and the water would flow over the dam as if it were a weir.
  - The Toisnot Swamp Profile ends downstream of Silver Lake
- This dam is not shown on the FIRM as a dam, nor by its name.
- The National Inventory of Dams indicates this dam as earthen.
- Based on information from the 2016 NID and the October 2016 North Carolina dam inventory, there was no emergency action plan for this dam, nor is it required for a dam exempt from regulations.

- The Nash-Edgecombe-Wilson Regional Hazard Mitigation Plan, which includes Wayne County, did not reference this dam by name.
- The 2016 National Inventory of Dams records this dam as completed in 1784 with no year modified, as does the NC inventory.
- Silver Lake is approximately 20 feet upstream of NC Highway 58 and approximately 2 miles upstream of Lake Wilson (State ID WILSO-007). Records from NC DEQ DEMLR indicate that Lake Wilson overtopped as a result of the breach at Silver Lake. The local community evacuated downstream of Lake Wilson, which does have an EAP. Lake Wilson did not breach as a result of the overtopping from this event.

<u>Considerations for Silver Lake</u>

- Consider determining the percent PMP and flood recurrence interval experienced at this dam location.
- Consider collecting and documenting the dam breach parameters at this dam.
- Consider this dam for further analysis of the influence its breach had on the overtopping of Lake Wilson Dam.
- Consider re-assessing this dam for determining whether it remains exempt from regulation, should the owner decide to repair / reconstruct it.

Appendix B: Emergency Operational Planning for Dams Overview

B.1 Federal Guidelines for Emergency Action Plans (EAP)[1]

An EAP is a formal document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize loss of life and property damage. The EAP includes:

- Actions the dam owner will take to moderate or alleviate a problem at the dam
- Actions the dam owner will take, and in coordination with emergency management authorities, to respond to incidents or emergencies related to the dam
- Procedures dam owners will follow to issue early warning and notification messages to responsible downstream emergency management authorities
- Inundation maps to help dam owners and emergency management authorities identify critical infrastructure and population-at-risk sites that may require protective measures, warning, and evacuation planning
- Delineation of the responsibilities of all those involved in managing an incident or emergency and how the responsibilities should be coordinated

B.2 Federal Guidelines for Inundation Maps[2]

The primary purpose of an inundation map is to show the areas that would be flooded and travel times for wave front and flood peaks at critical locations if a dam failure occurs or there are operational releases during flooding conditions. Inundation maps are a necessary component of the EAP and are used both by the dam owner and emergency management authorities to facilitate timely notification and evacuation of areas potentially affected by a dam failure or flood condition. Inundation maps should be developed by the dam owner in coordination with the appropriate emergency management authorities. The purpose of this coordination is to ensure that (1) the authorities understand how to interpret the maps and (2) the maps contain sufficient and current information for the authorities to warn and evacuate people at risk from a dam failure.

B.3 Emergency Operations Plans (EOP)

It is important for state and local officials, often through their emergency managers, to develop emergency operations plans that address all hazards reasonably anticipated in their communities. These plans should be well coordinated amongst the various state, local or

[1] FEMA 64 Federal Guidelines for Dam Safety; Emergency Action Planning for Dams July 2013; pI-1; https://www.fema.gov/media-library/assets/documents/3357

[2] FEMA 64 Federal Guidelines for Dam Safety; Emergency Action Planning for Dams July 2013; pI-1; https://www.fema.gov/media-library/assets/documents/3357

other organizations and stakeholders that would play a role in the given scenarios anticipated. Dam incidence are only one such hazards that state and local communities should plan, prepare and provide for in their EOP's when applicable. Even if a community might not have a dam in their jurisdiction, they should still consider whether dams from other jurisdictions might have incidence that would potentially inundate their communities. Fortunately, FEMA has developed guidance documents to help with EOP's with information regarding dam incidence and potential dam failures. Below are a few references from that document to provide readers the context of EOPs and inclusion of the hazard of dam failure in an EOP.

"*Comprehensive Preparedness Guide (CPG) 101 provides Federal Emergency Management Agency (FEMA) guidance on the fundamentals of planning and developing emergency operations plans (EOP). CPG 101 shows that EOPs are connected to planning efforts in the areas of prevention, protection, response, recovery, and mitigation. Version 2.0 of this Guide expands on these fundamentals and encourages emergency and homeland security managers to engage the whole community in addressing all risks that might impact their jurisdictions.*

Planners must keep in mind that hazard or threat lists pose two problems. The first is exclusion or omission. There is always a potential for new and unexpected risks (part of the reason why maintaining all-hazards, all-threats capability is important). The second is that such lists involve groupings, which can affect subsequent analysis. A list may give the impression that hazards or threats are independent of one another, when in fact they are often related (e.g., an earthquake might cause dam failure). Lists may vary different causes or sequences of events that require different types of responses under one category. For example, "Flood" might include dam failure, cloudbursts, or heavy rain upstream. Lists also may group a whole range of consequences under the category of a single hazard. "Terrorism," for example, could include use of conventional explosives against people or critical infrastructure; nuclear detonation or release of lethal chemical, biological, or radiological material.

Flood/Dam Failures
This section of the annex should identify and describe the jurisdiction's specific concerns, capabilities, training, agencies, and resources that will be used to mitigate against, prepare for, respond to, and recover from flood/dam emergencies/disasters (e.g., flash floods, inundation floods, floods resulting from dam failures or ice jams). Include a hazard summary that discusses where (e.g., 100-year and common floodplains) and how floods are likely to impact the jurisdiction."[3]

[3] https://www.fema.gov/plan

B.4 Evacuation Maps for Dams

Evacuation planning and implementation is typically the responsibility of State or local emergency management authorities. As such, an EAP generally does not include an evacuation map or plan as that is the responsibility of the local government. However, it can indicate who is responsible for evacuations and whose plan will be followed. Inundation maps developed by the dam owner should be coordinated in advance with emergency management authorities and included in the EAP (see Figure 1 on page II-19 for an example of an inundation map). These maps can be used by the appropriate state and local governments in helping them develop their Emergency Operations Plans (EOPs), warning and evacuation plans. It is critically important for dam owners to properly coordinate with their appropriate emergency management and local authorities and provide information from dam inundation studies that can assist with EOPs and evacuation maps and planning.

Dam emergency evacuation plans should be coordinated, developed and exercised before an incident occurs. The plans are recommended to be based on a worst-case scenario and to address the following, at a minimum:

- Initiation of emergency warning systems
- Pre-incident planning
- Identification of critical facilities and sheltering
- Evacuation procedures, including flood wave travel time considerations (e.g., evacuation of special needs populations, lifting evacuation orders)
- Distance and routes to high ground
- Traffic control measures and traffic routes
- Potential impact of weather or releases on evacuation routes such as flooded portions of the evacuation route before the dam incident occurs
- Vertical evacuation/sheltering in place
- Emergency transportation
- Safety and security measures for the perimeter and affected areas
- Re-entry into affected areas

Appendix C: Resources and Useful Links

North Carolina

North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources Dam Safety Program - https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety

North Carolina Flood Risk Information - http://fris.nc.gov/fris/Home.aspx?ST=NC

North Carolina Inundation Mapping and Alert Network - https://fiman.nc.gov/fiman/About.aspx

North Carolina Risk Management Portal - https://rmp.nc.gov/portal/

North Carolina Department of Public Safety Emergency Management Risk Management - http://www.ncdps.gov/Emergency-Management/Risk-Management

North Carolina Department of Public Safety Emergency Management Emergency Management Operations - http://www.ncdps.gov/Emergency-Management/EM-Operations

North Carolina Department of Public Safety Hurricane Matthew 2016 - http://www.ncdps.gov/hurricane-matthew-2016

Federal Emergency Management Agency (FEMA)

FEMA Dam Safety Program - https://www.fema.gov/dam-safety

FEMA Hazard Mitigation Planning - https://www.fema.gov/hazard-mitigation-planning

FEMA Risk Mapping, Assessment and Planning (Risk MAP) - https://www.fema.gov/risk-mapping-assessment-and-planning-risk-map

FEMA Publication 1032 - Evaluation and Monitoring of Seepage and Internal Erosion - https://www.fema.gov/media-library/assets/documents/107639

FEMA Publication 1069 – FEMA National Dam Safety Program Fact Sheet - https://www.fema.gov/media-library/assets/documents/5865

National Dam Safety Review Board and Interagency Committee on Dam Safety - https://www.fema.gov/national-dam-safety-review-board-and-interagency-committee-dam-safety

FEMA Publication 1015 - Technical Manual: Overtopping Protection for Dams - https://www.fema.gov/media-library/assets/documents/97888

FEMA Publication 64 - Federal Guidelines for Emergency Action Planning for Dams - https://www.fema.gov/media-library/assets/documents/3357

Technical Guidance for Dam Owners: Impacts of Plants on Earth Dams - https://www.fema.gov/media-library/assets/documents/1027

Dam Safety Training - https://www.fema.gov/dam-safety-training

FEMA Be Aware of Potential Dam Failure in Your Community Fact Sheet - https://www.fema.gov/media-library/assets/documents/18361

FEMA Living With Dams: Know Your Risks - https://www.fema.gov/media-library/assets/documents/28161

FEMA Geospatial Dam Break, Rapid EAP, Consequence and Hazards GIS Toolkit and User Manual (GeoDAM-BREACH) - https://www.fema.gov/media-library/assets/documents/94670

FEMA Risk Prioritization Tool for Dams - https://www.fema.gov/media-library/assets/documents/13523?id=3296

FEMA Emergency Action Planning Video - https://www.fema.gov/media-library/assets/documents/3929?id=1838

FEMA Mitigation Dam Task Force Strategic White Paper on Dam Risk - https://www.fema.gov/media-library/assets/documents/112356

FEMA Hurricane Liaison Team (HLT) - https://www.fema.gov/media-library/assets/documents/2719

FEMA Incident Management Assistance Teams - https://www.fema.gov/incident-management-assistance-teams

Public Assistance: Local, State, Tribal and Private Non-Profit; https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit

FEMA Strategic and Operational Planning - https://www.fema.gov/plan
FEMA Flood Insurance Study - https://www.fema.gov/flood-insurance-study

Department of Homeland Security (DHS)

Protective Security Advisors; https://www.dhs.gov/protective-security-advisors

DHS National Response Framework - https://www.fema.gov/media-library-data/1466014682982-9bcf8245ba4c60c120aa915abe74e15d/National_Response_Framework3rd.pdf

Other Federal Agencies

United States Department of Agriculture Forest Service Pocket Safety Guide for Dams and Impoundments - http://www.fs.fed.us/eng/php/library_card.php?p_num=1273%202805P

United States Army Corps of Engineers (USACE) – National Inventory of Dams https://nid.usace.army.mil/cm_apex/f?p=838:12

United States Geological Survey (USGS) Matthew October 2016 Flood Event Viewer - https://water.usgs.gov/floods/events/2016/matthew/

NOAA's National Weather Service Hydrometeorological Design Study Center - http://www.nws.noaa.gov/ohd/hdsc/

USACE Hydrologic Engineering Center – River Analysis System (HEC-RAS) - http://www.hec.usace.army.mil/software/hec-ras/

NOAA National Hurricane Center (NHC) - http://www.nhc.noaa.gov/

USGS Identifying and Preserving High-Water Mark Data Chapter 24 of Section A, Surface-Water Techniques Book 3, Applications of Hydraulics, 2016 http://pubs.usgs.gov/tm/03/a24/tm3a24.pdf

Organizations/Associations

Association of State Dam Safety Officials (ASDSO) - http://www.damsafety.org/

Association of State Floodplain Managers (ASFPM) - https://www.floods.org/

Appendix D: NID Field Definitions

- *(1) Dam Name (Alphanumeric)*
  The official name of the dam. No abbreviations unless the abbreviation is a part of the official name. For dams that do not have an official name, the popular name is used.

- (4) *State or Federal Agency ID (Alphanumeric)*
  The Official State or Agency identification number for the dam.

- (5) *NID ID (Alphanumeric)*

The official NID identification number for the dam, known formerly as the National ID. This is a required field, and must have an entry for each dam included in the NID. This field is used as the unique identifier for each dam record. The first two characters of the identity are the state two-letter abbreviation, based on the location of the dam. Typically, the last five characters of the identity are a unique number (AB#####); although States are allowed to use alphanumeric combinations in these last five characters.

For saddle dams or dikes, the NID ID is the same as the main dam. See saddle dam definition in Number Separate Structures Field (listed below).

- (11) *County (Alphanumeric)*
  The name of the county in which the dam is located.

- (12) *River or Stream (Alphanumeric)*
  The River or Stream designation may be entered in one of two ways. For the convenience of some organizations, an alternative field entry is provided which is consistent with the "tributary and offstream" designations used in the 1995-96 NID. If the alternative form is used, the NID Data Team will convert it to the standard form prior to inclusion in the national inventory.

  River or Stream Standard Entry: The official name of the river or stream on which the dam is built. If the stream is unnamed, identify it as a tributary to a named river, e.g., *Snake-TR.* If the dam is located offstream, enter the name of the river or stream plus "-OS", e.g., *Snake-OS.*

  River or Stream Alternative Entry: The official name of the river or stream on which the dam is built. If the stream is unnamed, identify it as a tributary to a named river, e.g., *TR-Snake.* If the dam is located offstream, enter the name of the river or stream plus the word, "OFFSTREAM," e.g., *Snake OFFSTREAM.*

- (13) *Nearest Downstream City/Town (Alphanumeric)*

Name of the nearest downstream city, town, or village that is most likely to be affected by floods resulting from the failure of the dam.

- (16) *Owner Type (Alphanumeric)*
  Code to indicate the type of owner:
  F for Federal;
  S for State;
  L for Local Government (defined as have taxing authority or is supported by taxes);
  U for Public Utility;
  P for Private
  X for Not Listed.
  Codes are concatenated if the dam is owned by more than one type. For example, if the dam is owned by a lake association and a public utility, the owner type would be listed as PU. For multiple owners under the same type, one code is used. For example, if multiple individuals own one dam, it will list P for private dam ownership.
  Some examples of owner types. Local Government should have taxing authority or is supported by taxes. A Lake District is supported by taxes and considered Local Government. A lake association is supported by association dues and would not be a Local Government owner type but rather Private owner type.

- (19) *Dam Type (Alphanumeric)*
  Codes, in order of importance, to indicate the type of dam:
  RE for Earth;
  ER for Rockfill;
  PG for Gravity;
  CB for Buttress;
  VA for Arch;
  MV for Multi-Arch;
  RC for Roller-Compacted Concrete;
  CN for Concrete;
  MS for Masonry;
  ST for Stone;
  TC for Timber Crib;
  OT for Other.
  Codes are concatenated if the dam is a combination of several types. For example, the entry *CNCB* would indicate a concrete buttress dam type.

- (22) Purposes (Alphanumeric)
  Code(s) to indicate the current purpose(s) for which the reservoir is used:
  I for Irrigation;
  H for Hydroelectric;
  C for Flood Control and Storm Water Management;

N for Navigation;
S for Water Supply;
R for Recreation;
P for Fire Protection, Stock, Or Small Farm Pond;
F for Fish and Wildlife Pond;
D for Debris Control;
T for Tailings;
G for Grade Stabilization;
O for Other.

The order should indicate the relative decreasing importance of the purpose. Codes are concatenated if the dam has multiple current purposes. For example, *SCR* would indicate the primary purposes, *Water Supply,* followed by *Flood Control and Storm Water Management,* and then *Recreation.*

- (23) *Year Completed (Number)*
  Year (four digits) when the original main dam structure was completed. If unknown, and reasonable estimate is unavailable, "0000" is used.

- (24) *Year Modified (Alphanumeric)*
  Year (four digits) when major modifications or rehabilitation of dam or major control structures were completed. Major modifications are defined as a structural, foundation, or mechanical construction activity which significantly restores the project to original condition; changes the project's operation; capacity or structural characteristics (e.g. spillway or seismic modification); or increases the longevity, stability, or safety of the dam and appurtenant structures. Entries should be followed by *one of more of the following codes* indicating type of modification:
  S for structural;
  F for foundation;
  M for mechanical;
  E for seismic;
  H for hydraulic;
  O for other.
  Up to ten modifications can be entered, separated by semicolons.

- (25) *Dam Length (Feet, Number)*
  Length of the dam, in feet, which is defined as the length along the top of the dam. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam, these structures should not be included.

- (26) *Dam Height (Feet, Number)*

Height of the dam, in feet to the nearest foot, which is defined as the vertical distance between the lowest point on the crest of the dam and the lowest point in the original streambed.

- (30) Maximum Discharge (Cubic Feet/Second, Number)
  Number of cubic feet per second (cu ft/sec) which the spillway is capable of discharging when the reservoir is at its maximum designed water surface elevation.

- (31) Maximum Storage (Acre-Feet, Number)
  Maximum storage, in acre-feet, which is defined as the total storage space in a reservoir below the maximum attainable water surface elevation, including any surcharge storage.

- (32) Normal Storage (Acre-Feet, Number)
  Normal storage, in acre-feet, which is defined as the total storage space in a reservoir below the normal retention level, including dead and inactive storage and excluding any flood control or surcharge storage. For normally dry flood control dams, the normal storage will be a zero value. If unknown, the value will be blank and not zero.

- (34) Surface Area (Acres, Number)
  Surface area, in acres, of the impoundment at its normal retention level.

- (35) *Drainage Area (Square Miles, Number)*

Drainage area of the dam, in square miles, which is defined as the area that drains to a particular point (in this case, the dam) on a river or stream.

- (36) *Downstream Hazard Potential (Alphanumeric)*

Code to indicate the potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities:

L for Low;
S for Significant;
H for High
U for Undetermined.

Definitions, as accepted by the Interagency Committee on Dam Safety, are as follows:

1. LOW HAZARD POTENTIAL

Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

2. SIGNIFICANT HAZARD POTENTIAL

Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss,

environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

3. HIGH HAZARD POTENTIAL
Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

4. UNDETERMINED HAZARD POTENTIAL
Dams for which a downstream hazard potential, as defined in 1-3 above, has not been designated or is not provided. Note that dams with a code "U" will be considered for NID inclusion (see Chapter 3) the same as a dam with low hazard potential. If included in the NID, the undetermined classification will be used in publication.

- (37) *Emergency Action Plan (Alphanumeric)*

Code indicating whether this dam has an Emergency Action Plan (EAP) developed by the dam owner. An EAP is defined as a plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Y for Yes;
N for No;
NR for Not Required by submitting agency.

If an EAP is required (or not required) and has one, it will be listed Y for Yes. If an EAP is required and does not have one, it will be listed N for No. If there is not an EAP and one is not required, it will be listed NR for Not Required.

FIRM Panel is not part of the NID Database
FIS Effective Date is not part of the NID Database
FIRM Effective Date is not part of the NID database.

- (41) *Condition Assessment (Alphanumeric)*

Assessment that best describes the condition of the dam based on available information.

Satisfactory;
Fair;
Poor;
Unsatisfactory;
Not Rated.

Definitions, as accepted by the National Dam Safety Review Board, are as follows:

1. SATISFACTORY
No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

2. FAIR
No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

3. POOR
A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. POOR may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.

4. UNSATISFACTORY
A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

5. NOT RATED
The dam has not been inspected, is not under state jurisdiction, or has been inspected but, for whatever reason, has not been rated.

Appendix E: Acronyms

ASDSO – Association of State Dam Safety Officials
CAP – Civil Air Patrol
COP – Common Operating Picture
COR – Contractor Officers Representative
CSLF – Changes Since Last FIRM
CTP – Cooperating Technical Partner
DHS-IP – Department of Homeland Security Infrastructure Protection
DHS – Department of Homeland Security
DOT – Department of Transportation
DSAT – Dam Sector Analysis Tool
DSS-WISE – Decision Support System for Water Infrastructure Security
EAP – Emergency Action Plan
EHP – (FEMA) Environmental and Historic Preservation
EMA – (local) Emergency Management Agency
EOC – Emergency Operations Center
ESF – Emergency Support Function
FCO – Federal Coordinating Officer
FDRC – Federal Disaster Recovery Coordinator
FEMA – Federal Emergency Management Agency
FERC – Federal Energy Regulatory Commission
FIMAN – North Carolina Flood Inundation Mapping and Alert Network
FIRM – Flood Insurance Rate Map
FIS – Flood Insurance Study
FMA – Flood Mitigation Assistance
FRD – Flood Risk Database
FRIS – (North Carolina) Flood Risk Information System
FRM – Flood Risk Map
FRR – Flood Risk Report
FTE – Full Time Equivalent
GeoDamBREACH – Geospatial Dam Break, Rapid EAP, Consequence and Hazards
GIS – Geographical Information System
HAZUS – Hazards United States
HEC-RAS – Hydrologic Engineering Center – River Analysis System
HH – High Hazard
HLT – Hurricane Liaison Team
HMA – Hazard Mitigation Assistance
HMGP – Hazard Mitigation Grant Program
HWM – High Water Marks

IAP – Incident Action Plan
IAW – In Accordance With
ICODS – Interagency Committee on Dam Safety
IMAT – (FEMA's) Incident Management Assistance Team
IP – Infrastructure Protection
JFO – Joint Field Office
MA – Mission Assignment
NC DEQ DEMLR – North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources
NCDPM – North Carolina Department of Public Safety Risk Management
NC DPS – North Carolina's Department of Public Safety
NCEP – National Centers for Environmental Prediction
NCSPARTA – North Carolina's State Preparedness and Resource Tracking Application
NDSP – National Dam Safety Program
NDSRB – National Dam Safety Review Board
NFHL – National Flood Hazard Layer
NFIP – National Flood Insurance Program
NHC – National Hurricane Center
NID – National Inventory of Dams
NOAA – National Oceanic and Atmospheric Administration
NOD – Notice of Deficiency
NOFO – Notice of Funding Opportunity
NRCC – National Response Coordination Center
NSSE – National Special Security Events
PA – (FEMA) Public Assistance
PDM – Pre-Disaster Mitigation
PMF – Probable Maximum Flood
PSA – Protective Security Advisor
RFI – Request for Information
Risk MAP – Risk Mapping, Assessment and Planning
RPO – Regional Project Officer
RRCC – Regional Response Coordination Center
SBA – Small Business Administration
SCO – State Coordinating Officer
SDRC – State Disaster Recovery Coordinator
SEOC – State Emergency Operations Center
SERT – State Emergency Response Team
SFHA – Special Flood Hazard Area
SHMO – State Hazard Mitigation Officer
SIMS – Simplified Inundation Maps
TADS – Training Aids for Dam Safety

TVA – Tennessee Valley Authority
UM-NCCHE – University of Mississippi National Center for Computational Hydroscience and Engineering
UCG – Unified Coordination Group
USACE – United States Army Corps of Engineers
U.S.C. – United States Code
USDA – United States Department of Agriculture
USGS – United States Geological Survey
WRRDA – Water Resources Reform and Development Act
WSEL – Water Surface Elevation

Appendix F: Association of State Dam Safety Officials (ASDSO)[1],[2],[3]

The failure of dams and the great destruction and loss of life failures often cause, is a matter of deep concern to the members of the Association of State Dam Safety Officials (ASDSO). ASDSO is a national non-profit organization serving state dam safety programs and the broader dam safety community, which includes federal dam safety professionals, dam owners and operators, engineering consultants, emergency managers, manufacturers, suppliers, academia, contractors, and others interested in improving dam safety.

Vision

A future where all dams are safe.

Mission

Improve the condition and safety of dams through education, support for state dam safety programs, and fostering a unified dam safety community.

Goals

Goal #1:
Improve state dam safety programs.

Goal #2:
Increase awareness of dam safety and its benefits to all stakeholders.

Goal #3:
Increase the technical expertise of dam safety professionals and owners/operators.

Goal #4:
Develop and implement financial instruments to improve dam safety programs.

Goal #5:
Promote and facilitate a consistent approach to standardization for dam safety regulation and technical criteria in all states and federal agencies.

Goal #6:
Support levee safety activities consistent with dam safety principles and interests.

[1] ASDSO; http://www.damsafety.org/

[2] Who is ASDSO Brochure: http://www.damsafety.org/media/Documents/AboutASDSO/Who%20Is%20ASDSO_Final.pdf

[3] Technical Resources; http://www.damsafety.org/resources/?p=509f4d33-9565-4619-ab35-18aa6936a6b0

ASDSO History

ASDSO was formed in 1983. The first conference, held in 1984 in Denver, attracted nearly 300 attendees and saw the ASDSO constitution and by-laws adopted by 34 states.

ASDSO's origins date from November 1977, when 39 people were killed by the Kelly Barnes dam failure in Toccoa Falls, Georgia. President Jimmy Carter immediately issued an executive order directing the U.S. Army Corps of Engineers to inspect dams nationwide. This 3-year "Phase I" program revealed deficiencies in the great majority of non-federal dams.

On the heels of the Phase I inspections, two investigations - by the National Academy of Engineering and FEMA - revealed the inadequacy of state dam safety laws and programs. Their reports recommended an interstate forum on dam safety.

ASDSO began with organizational meetings in 1983 in Orlando, Florida and Lexington, Kentucky. By February 1985, 37 states and Puerto Rico had officially joined the association. ASDSO's membership stood at 165: 90 associate (government employees) and 75 affiliate.

Today, ASDSO has more than 3,000 members representing state, federal and local governments; academia; dam owners; manufacturers and suppliers; consultants and others.

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