Appendix A: References

ACS Profiles, Missouri:

https://census.missouri.edu/acs/profiles/

American Meteorological Society. “Freezing Rain Events in the United States.”:

http://ams.confex.com/ams/pdfpapers/71872.pdf

Business Insider – Sinkholes:

http://www.businessinsider.com/where-youll-be-swallowed-by-a-sinkhole-2013-3

DamSafetyAction.org:

https://damsafety.org/missouri

DHSS Hyperthermia:

https://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/stat-report.pdf

http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper1.pdf

http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper2.pdf

EPA’s Hazard Mitigation for Natural Disasters Publication:
https://www.epa.gov/waterutilityresponse/hazard-mitigation-natural-disasters

EPAs Planning for an Emergency Drinking Water Supply Publication:
https://www.epa.gov/waterutilityresponse/water-utility-planning-emergency-drinking-water-supply

EPA Watershed Details:

http://cfpub.epa.gov/surf/locate/index.cfm

FEMA’s Climate Resilient Activities for Hazard Mitigation Assistance:
https://www.fema.gov/media-library/assets/documents/110202

FEMA Declaration Process:

https://www.fema.gov/declaration-process

FEMA Disaster Declarations and Grants:

https://www.fema.gov/data-visualization-summary-disaster-declarations-and-grants

FEMA Flood Insurance:
https://msc.fema.gov/portal

FEMA Flood Hazard Layer:
https://hazards.fema.gov/femaportal/wps/portal/NFHLWMS

FEMA Grant Eligibility Standards:
https://www.fema.gov/media-library-data/1582133514823-be4368438bd042e3b60f5cec6b377d17/Stafford_June_2019_508.pdf

FEMA Hazus Program:
https://www.fema.gov/hazus

FEMA HMP Grants in Christian County, 1993 – 2019:
https://www.fema.gov/openfema-dataset-hazard-mitigation-assistance-projects-v1

FEMA HMP Grants in Christian County, 1993 – 2019:
https://www.fema.gov/openfema-dataset-public-assistance-funded-projects-details-v1
https://www.fema.gov/openfema-dataset-public-assistance-applicants-v1

FEMA Local Mitigation Planning Handbook:
https://mtmitigation.com/wp-content/uploads/2017/05/fema_local_mitigation_handbook.pdf

FEMA Local Mitigation Plan Review Guide:
https://www.fema.gov/media-library-data/1425915308555-aba3a873bc5f1140f7320d1ebebd18c6/State_Mitigation_Plan_Review_Guide_2015.pdf

FEMA Local/Tribal Provisions:
https://www.fema.gov/pdf/help/fr02-4321.pdf

FEMA Mitigation Action Ideas Publication:
https://www.fema.gov/media-library/assets/documents/30627

FEMA Shelter from Storms:
https://www.fema.gov/pdf/library/ism2_s1.pdf
http://www.weather.gov/media/bis/FEMA_SafeRoom.pdf
https://www.fema.gov/fema-p-320-taking-shelter-storm-building-safe-room-your-home-or-small-business

FEMA “What Mitigation?”
https://www.fema.gov/what-mitigation

Firewise:
www.firewise.org

High Plains Regional Climate Center:
http://climod.unl.edu/

Impact of Earthquakes on the Central USA:
http://www.cusec.org/documents/aar/NMSZ_CAT_PLANNING_SCENARIO.pdf

James River Watershed and Inventory Assessment:
https://mdc.mo.gov/sites/default/files/downloads/page/170JamesRiver.pdf

LEPC Contacts:
https://sema.dps.mo.gov/docs/programs/executive/MERC/LEPC_Manual/LEPC-addresses.pdf

Midwestern Regional Climate Center:
http://mrcc.isws.illinois.edu/

Missouri Department of Conservation, Atlas of Missouri ecoregions (PDF download):
https://www.nrc.gov/docs/ML0923/ML092360302.pdf

Missouri Department of Conservation, Wildfire Data:
http://mdc7.mdc.mo.gov/applications/FireReporting/Report.aspx

Missouri Department of Natural Resources, Dam Hazard Classifications:

http://dnr.mo.gov/env/wrc/docs/rules_reg_94.pdf

Missouri Department of Natural Resources, Dam Safety:
https://dnr.mo.gov/geology/wrc/dam-safety/damsinmissouri.htm

Missouri Department of Natural Resources, Drought Response Plan and News:
http://dnr.mo.gov/pubs/WR69.pdf
https://dnr.mo.gov/drought.htm

Missouri Department of Natural Resources, National Register Listings:
http://dnr.mo.gov/shpo/mnrlist.htm

Missouri Department of Natural Resources, Sinkholes:
http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

Missouri School District and Information:
https://apps.dese.mo.gov/MCDS/Reports/SSRS_Print.aspx?Reportid=9cebc711-eb02-48bd-ae0e-47f11d8ef9f4

Missouri Major Non-Government Employers (by county):
https://missouriebs.weebly.com/employers.html

Missouri Hazard Mitigation Viewer:
http://amecei.maps.arcgis.com/apps/webappviewer/index.html?id=d97d80d5cff04996bff54b2250e47d83

Missouri Historical Agricultural Weather Database:
http://agebb.missouri.edu/weather/history/index.asp

Missouri Projected Earthquake Intensity:
https://.dps.mo.gov/docs/EQ_Map.pdf

Missouri Structure Exposure by County:
https://drive.google.com/drive/folders/0Bzg99s866kWocFB5Y3hCRlRuWWM

Missouri Tornado History Project:
http://www.tornadohistoryproject.com/tornado/Missouri

National Fire Incident Reporting System:
http://dfs.dps.mo.gov/programs/resources/fire-incident-reporting-system.php
National Inventory of Dams:
http://nid.usace.army.mil/cm_apex/f?p=838:12

National Weather Service, Heat Index Chart:
https://www.weather.gov/safety/heat-index

National Weather Service, Lightning and Thunderstorms:
http://www.vaisala.com/en/products/thunderstormandlightningdetectionsystems/Pages/NLDN.aspx
http://www.lightningsafety.noaa.gov/

National Weather Service, Tornado Damage Scale:
www.spc.noaa.gov/faq/tornado/ef-scale.html

National Weather Service, Wind Chill Chart:
https://www.weather.gov/safety/cold-wind-chill-chart
http://www.nws.noaa.gov/om/cold/wind_chill.shtml

The Nature Conservancy – Ozarks Ecoregional Conservation Assessment:
http://www.conservingarkansaswildlife.org/materials/2015/Appendix%203.1_Ozarks_Ecoregional_Conservation_Assessment.pdf

NCEI Storm Events Database:
https://www.ncdc.noaa.gov/stormevents/

National Drought Mitigation Center Home Page:
http://www.drought.unl.edu/

NFIP Community Status Book:
http://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-community-status-book

NFIP Claim Status:
http://bsa.nfipstat.fema.gov/reports/reports.html

Nixa, MO sinkhole article:
https://www.kspr.com/content/news/Nixa-sinkhole-is-closing-down-streets-and-part-of-the-junior-high-track-478345623.html

NOAA Climate Explorer:
https://toolkit.climate.gov/tools/climate-explorer

NOAA Low Precipitation:
http://www.hprcc.unl.edu

NRCS Home Page:
http://www.nrcs.usda.gov

NRCS Soil Survey:
https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=MO

National Resources Defense Council Home Page:
http://www.nrdc.org/globalWarming/watersustainability/

NSSL Hailstorm Probability and Wind, 1980 - 1994:
http://www.nssl.noaa.gov/users/brooks/public_html/bighail.gif
http://www.nssl.noaa.gov/users/brooks/public_html/bigwind.gif

OSEDA Growth and Fact Sheet (by county):
https://oseda.missouri.edu/countypage/

OTC Sinkhole:

https://www.news-leader.com/story/news/education/2019/02/12/sinkhole-opens-otc-campus-christian-county/2842660002/

Parks in Christian County:
http://mdc7.mdc.mo.gov/applications/moatlas/AreaList.aspx?txtUserID=guest&txtAreaNm=s

Populations served by groundwater in the U.S.:
http://maps.waterdata.usgs.gov/mapper/index.html

RiskMAP Study Status Maps:
http://fema.maps.arcgis.com/apps/webappviewer/index.html?id=48cfac9a9ffb4003b565aaccf464d0ac

SEMA Flood Mapping Project Status in Missouri:
https://amecei.maps.arcgis.com/apps/webappviewer/index.html?id=2ac0864241b747b4b11302f2c4cc7bc9

Stanford University's National Performance of Dams Program:
http://npdp.stanford.edu/

Stafford Act:
https://www.fema.gov/media-library-data/1582133514823-be4368438bd042e3b60f5cec6b377d17/Stafford_June_2019_508.pdf

Tornado Chaser – Tornado Alley:
http://www.tornadochaser.net/tornalley.html

TORRO information:
http://www.torro.org.uk/site/hscale.php

University of Wisconsin Slivis Lab:
http://silvis.forest.wisc.edu/maps/wui/2010/download

U.S. Census Bureau, American Fact Finder:
https://data.census.gov/cedsci/

U.S. Census Population and Housing Unit Counts:
https://www.census.gov/geo/maps-data/data/tiger-data.html

U.S. Drought Monitor:
https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

U.S. Fish and Wildlife Service, Endangered Species of Missouri:
http://www.fws.gov/midwest/Endangered/lists/missouri-cty.html

U.S. Geological Survey Hazard Maps:
https://earthquake.usgs.gov/hazards/hazmaps/conterminous/2014/images/HazardMap2014_lg.jpg

U.S. Geological Survey Sinkholes:
https://www.usgs.gov/special-topic/water-science-school/science/sinkholes?qt-science_center_objects=0#qt-science_center_objects

U.S. Geological Survey Sinkholes Fact Sheet:
https://pubs.usgs.gov/fs/2007/3060/

U.S. Sinkhole Map:
http://strangesounds.org/2013/07/us-sinkhole-map-these-maps-show-that-around-40-of-the-u-s-lies-in-areas-prone-to-sinkholes.html

USDA Cause of Loss Historical Data Files / Insurance Claims:
http://www.rma.usda.gov/data/cause.html

USDA Missouri Cattle County Estimates:

https://www.nass.usda.gov/Statistics_by_State/Missouri/Publications/County_Estimates/2019/MO-Cattle-by-County.pdf

USDA Census of Agriculture:
https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Missouri

USDA Christian County Agriculture Profile:
https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Missouri/cp29043.pdf

USDA Risk Management Agency:
https://www.rma.usda.gov/data/cause

2018 Missouri State Hazard Mitigation Plan:
https://sema.dps.mo.gov/docs/programs/LRMF/mitigation/MO_Hazard_Mitigation_Plan2018.pdf

Dam Failure

Hazard Identification

A dam is defined by the National Dam Safety Act as an artificial barrier that impounds or diverts water and (1) is at least 6 feet high and stores at least 50 acre-feet of water, or (2) is at least 25 feet high and stores at least 15 acre-feet. Of the 80,000- plus dams in the United States, less than 5% are under the control of the federal government.

According to the Missouri Department of Natural Resources Dam and Reservoir Safety Program, Missouri had some 5,239 recorded dams in October 2009, the largest number of man-made dams of any state in the country. Missouri 's topography allows lakes to be built easily and inexpensively, which accounts for the high number of dams. Despite such a large number, only about 679 Missouri dams (13%) fall under state regulations, while another 85 dams are federally controlled. A non-federal dam can be anything from a large farm pond to a major lake such as Table Rock Lake. The great majority of non-federal dams are privately owned structures that were built either for agriculture or recreational use. Missouri also has some 600 dams which were built as small watershed projects under Public Law-566 (Watershed Protection and Flood Prevention Act of 1953).

These dams serve many functions, including flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Many are nearing the end of their 50-year lifespan and need repair. Another group of older dams in the state were originally built by railroads to create drinking water reservoirs for the towns where the railroads were built.

Within the State of Missouri, the Department of Natural Resources maintains a Dam and Safety Program within the Division of Geology and Land Survey. The objective is to ensure that the dams are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. Under state statute, a dam must be 35 feet or higher to be state regulated. These dams are surveyed by state inspectors at least every five years. However, most Missouri dams are less than 35 feet high and thus, not regulated. While the State has for many years encouraged dam owners to do owner inspections for those dams not under the law, the condition of many of these dams is deteriorating.

The Department of Natural Resources Geological Survey and Resources Assessment Division resumed inspecting regulated dams effective July 1, 2004. Because of budget cuts in FY'03, dam owners were required to hire private professional engineers to conduct dam surveys for required permits.

Dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They are responsible for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials. The state has ultimate responsibility for public safety and many states regulate construction, modification, maintenance, and operation of dams. MDNR's Dam Safety Division maintains a database of all dams regardless of federal, state, local or private ownership.

- Piping – internal erosion caused by embankment leakage, foundation leakage and deterioration of pertinent structures appended to the dam

- Erosion – inadequate spillway capacity causing overtopping of the dam, flow erosion, and inadequate slope protection

• Structure Failure – caused by an earthquake, slope instability or faulty construction

These failures types often are interrelated. For example, erosion, either on the surface or internal, may weaken the dam or lead to structural failure. Additionally, a structural failure may shorten the seepage path and lead to a piping failure.

Location

Within the City of Ozark there is one dam. The dam locally referenced as the Mill Pond Dam. The dam's construction date and design are unknown. The dam is a concrete dam with overflow across the top. The length of the dam is approximately 300 feet long and height of approximately 8.67 feet. The water impoundment is estimated to be approximately 100 acre-feet. The dam is in a developed urban area. Within the area downstream of the dam there are numerous structures and public and private utilities, including the City of Ozark water and sewer lines.

Extent (Magnitude/Severity)

The National Inventory of Dams categorized dam failure hazard as:

• High Hazard – If the dam were to fail, extensive injuries and property damage could result

• Medium or Significant Hazard – Failure could possibly result in injuries and appreciable property damage

• Low Hazard – Failure results in only minimal property damage

The Missouri Dam and Reservoir Safety Council Rules and Regulations uses three classes of downstream environmental zone used when considering permits. The downstream environment zone is the area below the dam that would become inundated should the dam fail. Inundation is defined as water two feet or more over the submerged ground outside of the stream channel. These classes are based on the number of structures and types of development contained within the inundation area as presented in Table 2-49. The downstream environment zone classification is also used to prescribe the frequency of inspection.

Classes of Downstream Environment Zone

Class I

The area downstream from the dam that would be affected by inundation contains ten (10) or more permanent dwellings or any public building. Inspection of these dams must occur every two years

Class II

The area downstream from the dam that would be affected by inundation contains one to nine permanent dwelling, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings. Inspection of these dams must occur once every three years.

Class III

The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class I or Class II dams. Inspection of these dams must occur once every five years

Source: http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=modamreg94

Aerial photography from the National Agricultural Imagery Program was utilized along with assessor's parcel data from Douglas County to inspect the downstream environmental zones or likely inundation areas coincident with the 2 Significant 92 Hazard dams in the county. The resulting Dam Failure Probable Severity is shown in Table 2-50:

Dam Failure Probable Severity Downstream Environment Zone Future Probable Severity

Class 3 Negligible

Class 2 Limited

Class 1 N/A

Past Occurrences Dam failures in the United States have resulted in death, injuries and billions of dollars in property damage. Dam failure events in Missouri include dams in Lawrenceton in 1968, Washington

County in 1975, Fredericktown in 1977, and a near failure in Franklin County in 1978, and Lesterville in 2005

A large-scale example of a dam failure in Missouri occurred at the Tom Sauk in 2005. The stone retaining wall around the huge mountaintop reservoir near the town of Lesterville collapsed before daybreak releasing a billion-gallon torrent of water that swept away at least two homes and several vehicles and critically injured three children according to authorities. After the breach opened, within minutes the 50-acre reservoir had emptied itself out with terrifying effect, turning the surrounding area into a landscape of flattened trees and clay-covered grass and temporally evacuating the city of Lesterville. (National Weather Service).

Probability

The age and ownership of the dams are the largest factors in the risk of failure. With all of Douglas County's dams being privately owned, lacking exact information on the design, operation, and maintenance of these dams, it is difficult to assess the risk. The likelihood of a dam failure is possible, but the amount of damage downstream that might result is the most critical consideration.

According to Stanford University's National Performance of Dams Program, between 1975 and 2001 there were 17 dam failures in Missouri. These data translate into a 65% probability that there will be a dam failure in any given year statewide.