University of Kentucky
Hazard Mitigation Plan Update
2023

University of Kentucky

Police Department

Table of Contents

Abbreviations

44 CFR	44 Code of Federal Regulations
ADD	Area Development District
BCP	Business Continuity Plan
BEAP	Building Emergency Action Plan
CAFE	College of Agriculture, Food, and the Environment
C-CERT	Campus Community Emergency Response Team
CHR	Center for Hazards Research and Policy Development
CMP	Division of Crisis Management & Preparedness
CPM	Capital Project Management
CRS	Community Rating System
DEM	Division of Emergency Management
DFIRM	Digital Flood Insurance Rate Map
DMA 2000	Disaster Mitigation Action of 2000
DOT	Department of Transportation
EBARS	Electronic Barcoded Assets Resource System
EHE	Excessive Heat Event
EM	Emergency Management
EOC	Emergency Operations Center
EOP	Emergency Operations Plan
EPA	Environmental Protection Agency
EVPFA	Executive Vice President for Finance & Administration
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HAZMAT	Hazardous Materials
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
IATA	International Air Transport Association
IRAA	Institutional Research and Advanced Analytics
ITS	Information Technology Services
KDF	Kentucky Division of Forestry
KDOW	Kentucky Division of Water

KGS	Kentucky Geological Survey
KRS	Kentucky Revised Statutes
KU	Kentucky Utilities
KYCC	Kentucky Climate Consortium
Ky EM	Kentucky Division of Emergency Management
LFUCG	Lexington Fayette Urban Country Government
MPWG	Mitigation Planning Workgroup
NCDC	National Climatic Data Center (NCDC)
NDSP	National Dam Safety Program
NEHRP	National Earthquake Hazard Reduction Program
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
RCARS	Robinson Center for Appalachian Resource Sustainability
REC	Research and Education Centre
PDSI	Palmer Drought Severity Index
PGA	Peak Ground Acceleration
PPD	Physical Plant Division
SCM	Steering Committee Meeting
SFHA	Special Flood Hazard Area
SVRGIS	Severe Weather Geographic Information System
TORRO	Tornado and Storm Research Organization
UK	University of Kentucky
USGS	United States Geological Survey
USDS	US Department of Agriculture
VOIP	Voice Over Internet Protocol

Hazard mitigation plans reduce risks from natural and human-caused hazards. These plans involve the development of a mitigation strategy and suite of actions based on a comprehensive risk assessment and input from a wide range of stakeholders who may also serve key roles in the implementation of mitigation actions. The mitigation strategy is organized, easily referenced and functions as a tool for tracking progress toward improved resilience.

The University of Kentucky (UK) experienced unprecedented impacts from two natural hazards in December 2021 and July 2022, in addition to serving the Commonwealth of Kentucky through the ongoing COVID-19 response. In December 2021, the Research and Education Center (REC) at Princeton took a direct hit from a tornado. Months later, in July 2022, eastern Kentucky experienced record flooding, impacting two UK facilities, the Robinson Center for Appalachian Resource Sustainability and Robinson Forest.

Figure 1: Research and Education Center after December 2021 Tornado

During the development of this plan, UK formed the Center for Disaster Recovery and Resilience (Center). The need for the Center was demonstrated in response to the tornado and flooding disasters. The Center will serve as the hub for plan implementation and documentation of hazard and disaster events. As a university located within Lexington-Fayette Urban County Government (LFUCG), UK is committed to becoming stronger and more resilient through continued strategic coordination with LFUCG.

Mission Statement

The *University of Kentucky Hazard Mitigation Plan Update (UK Hazard Mitigation Plan*) will sustain UK by mitigating damages and losses caused by natural hazards. It includes participation from both internal and external partner groups. These groups supported a strategic planning process that resulted in a risk assessment based on best available data and an updated mitigation strategy for UK to pursue from 2023-2028. This plan demonstrates UK's commitment to reducing the risks from natural hazards and shall serve as a guide for UK decision makers and partners.

In accordance with the Federal Emergency Management Agency (FEMA) Local Mitigation Planning Policy Guide, the *UK Hazard Mitigation Plan* update fulfills the following basic requirements:

- A well-documented and inclusive planning process that welcomes public participation during draft plan development prior to approval
- The opportunity for involvement of local and regional agencies, including but not limited to: Lexington Fayette Urban County Government, Kentucky Utilities and Kentucky Region American Red Cross
- The review and incorporation of existing plans, studies, reports and technical information
- A risk assessment that provides the factual basis for activities proposed in the mitigation strategy
- A mitigation strategy that provides UK's blueprint for reducing potential losses identified in the risk assessment

The *UK Hazard Mitigation Plan sets* a strategy for building a more resilient campus community that will mitigate damages and losses caused by natural, human-caused and technological hazard types. The plan is the result of a systematic evaluation of the nature and extent of the vulnerability posed by the effects of hazards (risk assessment). It includes a five-year action plan to minimize future vulnerability (mitigation strategy) and a schedule that outlines a method for monitoring and evaluating plan progress (plan maintenance). Based on the best available quantitative and qualitative input, vulnerability to natural hazard events was calculated with the top hazards for insured losses as:

- December 2021 tornado, $26 million in damages
- July 2022 flooding, more than $2 million in damages

In addition, this plan includes climate change considerations in the risk assessment and incorporates equity initiatives in the planning process, mitigation actions and subsequent plan implementation. The *UK Hazard Mitigation Plan* covers the following UK locations, which are depicted in **Figure 2:**

- Main Campus
- North Farm Campus
- South Farm Campus
- C. Oran Little Research Center
- College of Medicine at Northern Kentucky, Edgewood
- College of Medicine at Northern Kentucky, Highland Heights
- College of Medicine, Bowling Green
- College of Engineering at Paducah
- Robinson Forest

- Robinson Center for Appalachian Resource Sustainability (RCARS)
- Research and Education Center (UKREC)
- Center for Excellence in Rural Health
- 4-H Camps

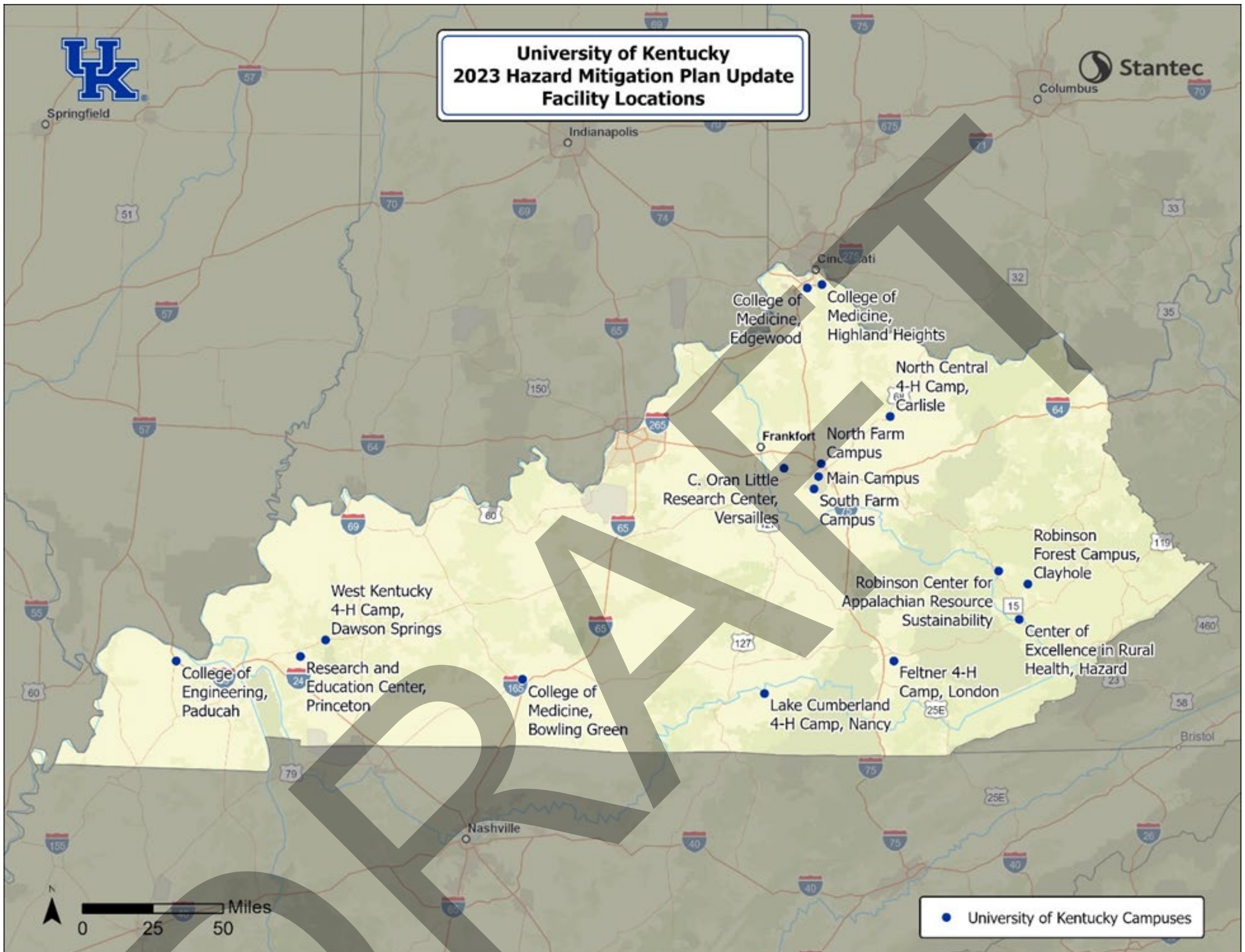


Figure 2: UK Campuses and 4-H Camps

The *UK Hazard Mitigation Plan Update* contains the following five sections, plus appendices:

- Planning Process
- Campus Profiles
- Risk Assessment
- Mitigation Strategy
- Plan Maintenance and Plan Approval

The **Planning Process details** how the plan was produced and who was involved. A steering committee of key stakeholders hosted four meetings. Input provided during these meetings, workgroup sessions and other individual stakeholder interviews informed the development of the risk assessment, mitigation strategy and plan maintenance sections of the plan.

The **Campus Profiles** include a summary for each campus and 4-H Camps included in the plan, to provide perspective on the uses, property, occupancy and contents at each location. The **Risk Assessment** includes a profile for each of the 15 identified hazards, including geographic areas of risk and previous occurrences. Hazard vulnerability was assessed on a building-by-building basis. The risk assessment building data consists of several factors including, but not limited to building values, content values, research contents and occupancy data. Ultimately, the hazard and building data as well as the risk assessment results were compiled in one Geographical Information Systems (GIS) database.

The **Mitigation Strategy** includes the determination of hazard mitigation goals and actions as identified during the planning process and based on a review of the risk assessment results. The plan developers also took inventory of UK's current capabilities and marked mitigation successes over the past five years.

The **Plan Maintenance and Plan Approval** chapter outlines the steps for plan implementation which includes monitoring, evaluating and updating the plan. The plan will be maintained through collaborative efforts of university departments to allow for better incorporation of existing planning mechanisms.

The **Plan Approval** demonstrates UK's commitment to fulfilling the mitigation strategy. This section provides a description and documentation of the plan update submittal process. Following a period for public comment, UK submits the plan to the Kentucky Division of Emergency Management (KYEM) for a state-level review, then makes any required revisions. KYEM then submits the plan to FEMA Region IV for review and approval, pending local (UK) adoption. Once certified approvable by FEMA, UK submits the plan to the Board of Trustees and UK President for formal adoption, then resubmits to the state and FEMA for final review and approval. A signed copy of the formal adoption is included in Appendix 3.

In summary, the *UK Hazard Mitigation Plan* serves as a guided work plan that integrates the planning efforts of UK departments and divisions, neighboring local agencies and private and nonprofit organizations for the creation and implementation of a comprehensive mitigation program.

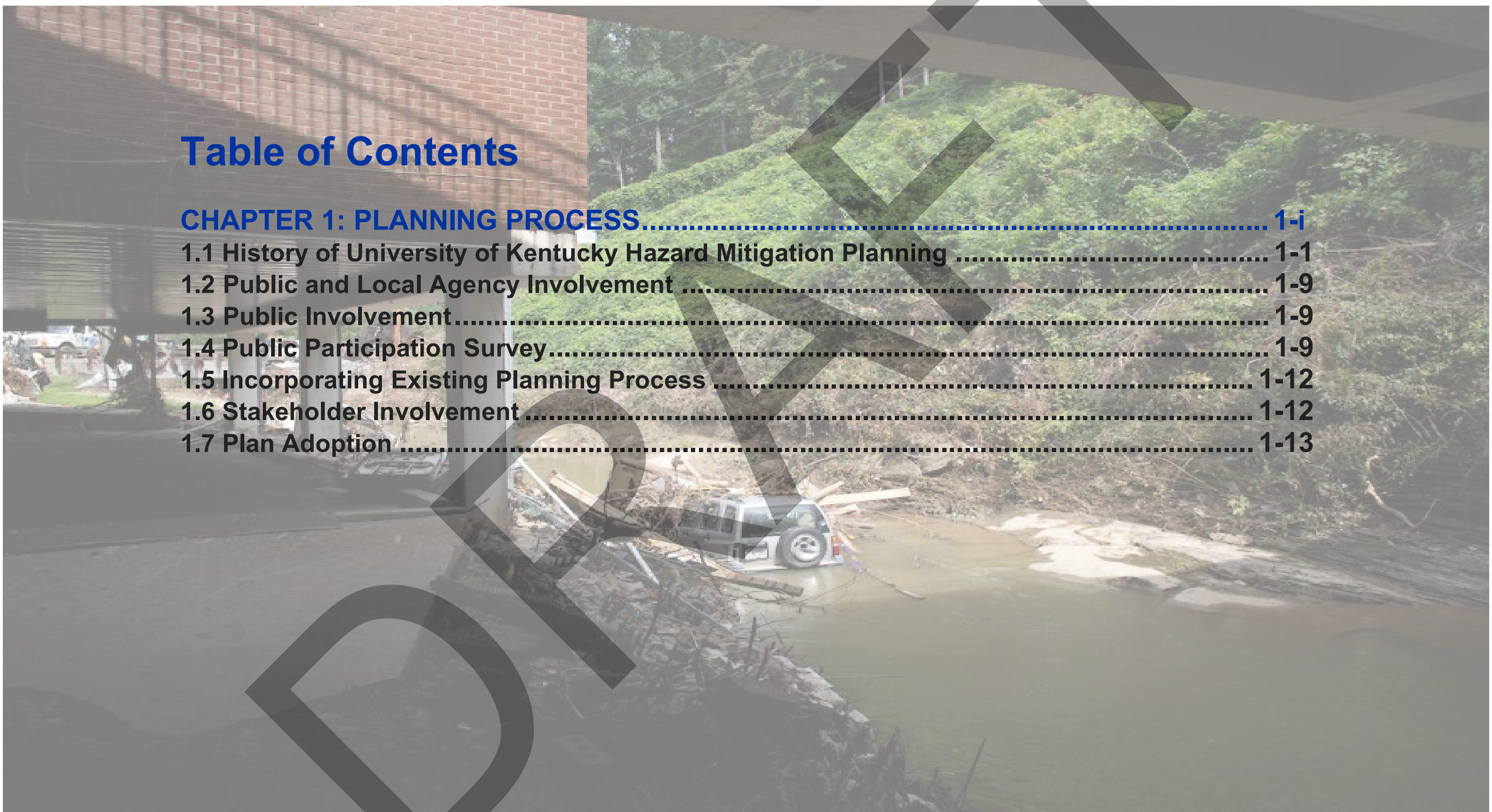


Table of Contents

Chapter 1: Planning Process

1.1 History of University of Kentucky Hazard Mitigation Planning

This plan serves as the third hazard mitigation plan for UK. The initial plan was completed in 2011 and was updated in 2016. In addition to UK mitigation planning efforts, UK participates in the *Lexington-Fayette Urban County Government (LFUCG) Hazard Mitigation Plan* and other emergency management initiatives with LFUCG, and also the *Kentucky Enhanced Statewide Mitigation Plan.*

The planning process for the *2023 University of Kentucky Hazard Mitigation Plan Update (UK Hazard Mitigation Plan)* was initiated in August 2022, following selection of Stantec Consulting Services Inc. (Stantec) to provide professional mitigation planning services and to prepare the mitigation plan document for submittal to Kentucky Emergency Management (KYEM), Federal Emergency Management Agency (FEMA) and UK leadership.

The planning team reviewed the proposed planning process, developed a schedule and facilitated discussions with the steering committee regarding which campuses and facilities to include in the plan.

The consultant team followed the latest mitigation planning process recommended by FEMA*: Local Mitigation Planning Handbook* (March 2013) and the *Local Mitigation Plan Review Guide* (April 2023). Additionally, the Local Mitigation Plan Review Tool, found in **Appendix A**, provides a detailed summary of FEMA's current minimum standards for compliance with DMA 2000 and notes the location where each requirement is met within this plan. These standards are based upon FEMA's final rule as published in the federal register in part 201 of the Code of Federal Regulations (CFR).

1.1.1 Documentation of the Planning Process

Leadership, staffing and institutional knowledge may change over time. A comprehensive description of the planning process informs the UK community and other readers about how the plan was developed. It serves as a permanent record explaining how decisions were reached through stakeholder input. The narrative:

- Documents steps as they are completed so plan developers can determine what needs to be done for a plan update.
- Becomes a detailed record of how and why the plan was prepared.
- Is a requirement under the rule.

The following section describes the *UK Hazard Mitigation Plan* update process, including the contributions of the Hazard Mitigation planning team, steering committee, workgroup, community participation, outreach methods and the incorporation of existing planning mechanisms.

The preparation of this plan required a series of steering committee meetings, workgroup meetings and interviews to facilitate discussion, gain consensus and initiate data collection efforts with stakeholders. More importantly, the meetings prompted continuous input and feedback from participants throughout the drafting stages of the plan. Public meetings were publicized to invite a broad range of stakeholders.

In total, ten hybrid meetings (in-person and online options) were conducted. In addition, 11 interviews were conducted and two open houses were held. The following paragraphs detail the planning team and key meetings.

Planning Team

UK's Division of Crisis Management and Preparedness (CMP) coordinated the *UK Hazard Mitigation Plan update*. To guide the development of this plan, a Hazard Mitigation Planning Team ("planning team") was created. The planning team consisted of representatives from UK Police, Crisis Management and Preparedness and the Center for Disaster Recovery and Resilience.

The planning team developed the project schedule and initiated outreach activities to the steering committee members, UK officials and the UK community. The planning team assisted with the following tasks:

- Participate in planning team, steering committee and workgroup meetings.
- Assist with data collection to obtain the best available data as required for the risk assessment portion of the plan.
- Provide information to support the capability assessment section of the plan.
- Support the development of the mitigation strategy, including the design and adoption of goal statements.
- Help design and propose appropriate mitigation actions.
- Review and provide comments on the study findings and draft plan deliverables.
- Support the adoption of the *UK Hazard Mitigation Plan*.

The following table lists members of the planning team

Table 1-1: Planning Members

Name	Department/Office
Laurel Wood	Director, Center for Disaster Recovery and Resilience
Deputy Chief, Nathan Brown	UK Police Department
Captain Corey Pelarski	UK Police Department
Major Robert Turner	UK Police Department
Jay Overman	Emergency Management
Mandi Bahanan	Marketing/Promotions Specialist, UK Police Department
Veronda Holcombe-Lewis	Clery Compliance Coordinator, UK Police Department
Kristen Sutherland	Center for Disaster Recovery and Resilience
Kristen Hewes	Stantec
John Bucher	Stantec

The steering committee was comprised of planning team and workgroup stakeholders, as well as local, regional and state agency partners. The list of steering committee members is located in **Appendix A.**

The workgroup engaged a targeted group of university stakeholders to discuss the following topics:

- Critical facilities
- Status of the 2016 mitigation actions
- Revised or new mitigation actions

Steering Committee Meetings, Open Houses and Workgroup Meetings

To encourage stakeholder involvement, the planning team conducted four steering committee meetings (one publicly advertised) and two open houses. Three workgroup meetings and 11 interviews were held. This section describes how the steering committee and workgroup meetings accomplished objectives for the *UK Hazard Mitigation Plan* update. Table 1-2 lists meeting dates from the plan development process (for meeting documentation see **Appendix A**).

Table 1-2 Meetings Summary

Meeting	Date
Planning Team Meeting	August 23, 2022
Steering Committee Meeting	September 29, 2022
Steering Committee Hazard Identification Meeting (Open to Public)	October 27, 2022
Hazard Identification Open House	October 27, 2022
Critical Facilities Workgroup	November 18, 2022
Capability Assessment Planning Team Meeting	December 7, 2022
Current Mitigation Actions Workgroup Team Meeting	January 13, 2023
Risk Assessment Planning Team Meeting	February 24, 2023
Risk Assessment Workgroup Meeting	March 9, 2023
Risk Assessment Steering Committee Meeting	March 21, 2023
Draft Plan Open House	April 29, 2023
Mitigation Actions/Draft Plan Steering Committee Meeting	May 23, 2023

Kick-Off Steering Committee Meeting, September 29, 2022

Prior to the first meeting, Dr. Eric Monday, executive vice president for finance and administration and co-executive vice president for health affairs distributed a letter via email to orient steering committee members to the plan update process and encourage participation. To start the meeting, Chief Joe Monroe of the UK Police Department provided opening comments emphasizing the importance of mitigation and the reasons for updating the plan. This was followed by an introduction to the planning team. Laurel Wood, director of the Center for Disaster Recovery and Resilience, provided an overview of the mitigation successes: Campus Blue Emergency Notification Tower, emergency power generators at WUKY Main Transmission Site, Robison Forest classroom retaining wall, 4-H Camp Tornado Safe Rooms and the Nicholasville Road FEMA Flood Mitigation Project. See "Mitigation Strategy" for more description on mitigation successes.

Kristen Hewes summarized the plan update process and the requirements of the FEMA Disaster Mitigation Act of 2000 and the Local Mitigation Plan Review Guide Criteria, including climate change and equity considerations. John Bucher provided an overview of the engagement tools to encourage plan participation: university-wide survey, online tools and interviews with stakeholders. Christina Hurley explained the purpose of the risk assessment and provided examples of data needs to inform the risk and vulnerability assessments. Kristen Hewes explained the mitigation actions and the need for an actionable plan. Other topics included the plan development timeline, mission statement, risk assessment and other mitigation accomplishments, including UK research and outreach over the past five years. Meeting materials are located in **Appendix A**.

Hazard Identification Steering Committee and Open House, October 27, 2023

The purpose of the Hazard Identification Steering Committee Meeting was to discuss the hazards that impact UK and collect details regarding specific events and associated observations.

This meeting and the subsequent open house were advertised to the UK community through *UKNow*. Laurel Wood introduced the project and provided an update regarding the timeline. For those not present at the first steering committee meeting, Kristen Hewes provided an overview of the planning process: hazards considered for the plan update, capability assessment and mitigation strategy. Christina Hurley provided an overview of the risk assessment and data needs to inform the assessment. John Bucher explained the survey and the online map to identify hazards and conducted a brief survey with participants regarding hazards that impact the UK community. In addition to the online map, paper maps were prepared for the main campus, Fayette County and a statewide map for attendees to mark-up with hazard risk information after the meeting. Participants were provided the opportunity after the meeting and during the open house to mark up the paper maps and speak with the planning team regarding hazard occurrences. The data collected from the paper maps was added to the online map tool. The following figures depict the online map and survey shared on the UK Police Hazard Mitigation Plan website to solicit input from the UK community. Meeting materials are located in **Appendix A**.

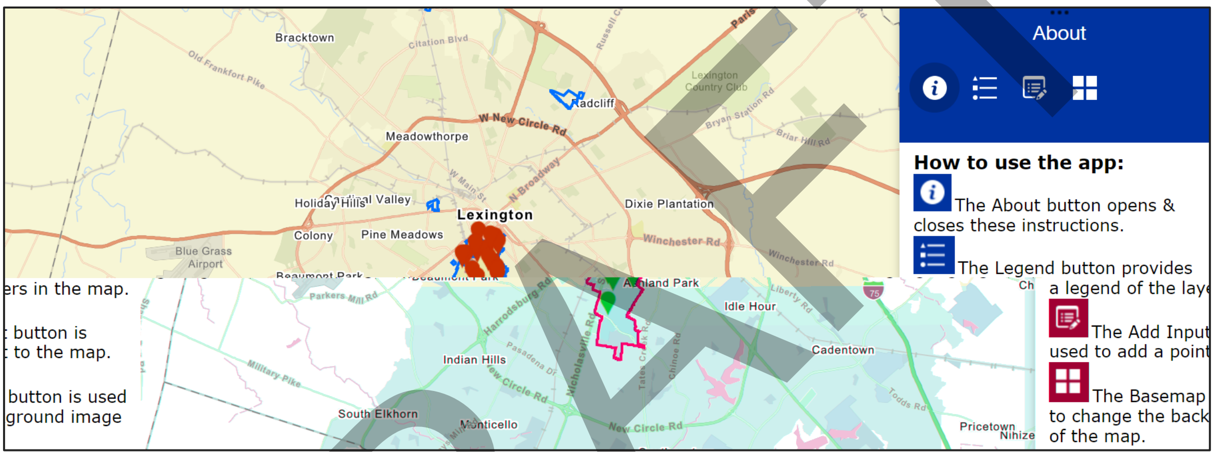


Figure 1-1: Online Map

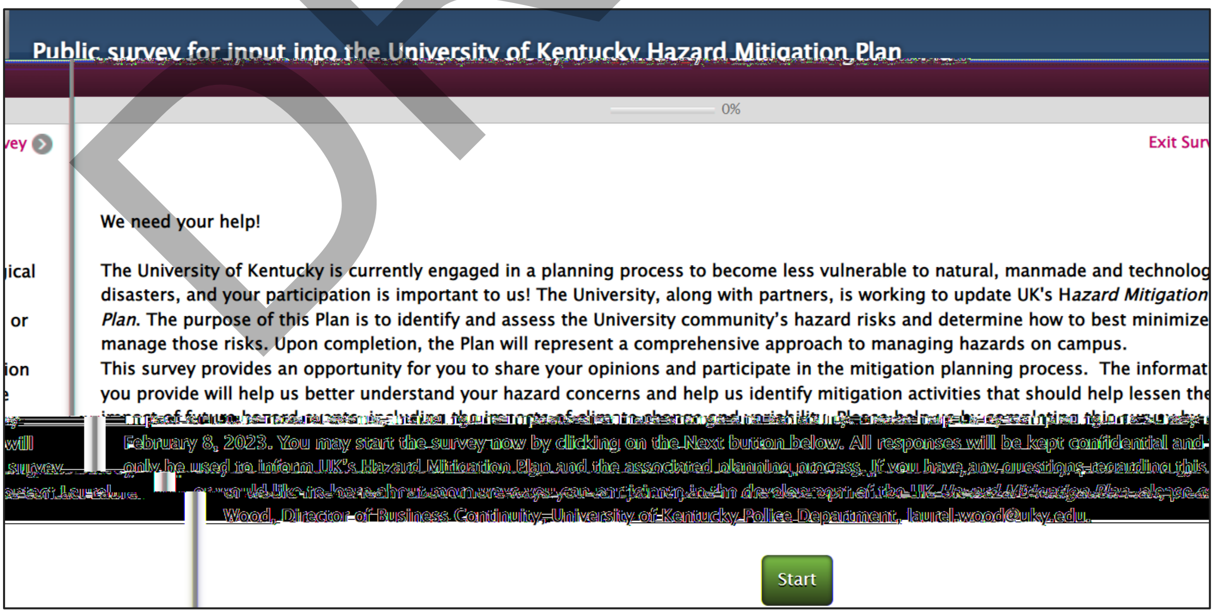


Figure 1-2: Online Survey

Open House, October 27, 2022

Following the hazard identification steering committee meeting, UK held an open house that was publicly advertised for students, staff and faculty to attend, ask questions regarding the plan and provide hazard data. Paper maps were available for attendees to mark up with hazard information; planning team members were available to answer questions.

Critical Facilities Workgroup Meeting November 18, 2022

The planning team identified workgroup members to assist with the review and modification of the critical facilities. Laurel Wood provided the welcome and an introduction regarding the meeting purpose. Kristen Hewes presented to the workgroup the revised definition for critical facilities with minor revisions (in red text) for the *UK Hazard Mitigation Plan: "Assets to the university, essential to its functioning and the destruction of which would cause a serious impact on the continued operation of the university. Assets selected under this definition include campus police, fire, emergency operations, major technology nodes, transportation, public health and structures containing major campus power feeds/supplies."*

The workgroup reviewed each of the 2016 critical facilities to determine whether they were still considered critical and then added facilities to the list. The workgroup considered the FEMA lifelines developed to increase effectiveness in disaster operations and better position FEMA to respond to catastrophic incidents.

Community lifelines include the following:

- Safety and Security
- Food, Hydration, Shelter
- Health and Medical
- Energy
- Communications
- Transportation
- Hazardous Materials
- Water Systems

By the end of the meeting, the workgroup developed the 2023 critical facilities list, which was emailed to the group for a final review.

Capability Assessment Planning Team Meeting, December 7, 2023

The planning team held an online meeting to review the UK Hazard Mitigation Capability Assessment (See **Appendix C** "Capability Assessment") and provide clarification and additional data to support the preparation of the capability assessment. The planning team went line-by-line through the assessment tool and provided feedback and points of contact.

Current Mitigation Actions Workgroup Meeting January 13, 2023

This meeting reviewed the current mitigation actions in the 2016 plan to determine the action status and which actions to include in the 2023 plan. The workgroup reviewed each mitigation action, provided a status update, decided whether to remove or include it in the 2023 plan and, if needed, refined the mitigation action. The worksheet was edited live with the group and emailed to the group after the meeting.

Risk Assessment Planning Team Meeting February 24, 2023

The planning team met on February 24, 2023, to review project status including meeting schedule, data collection, interviews completed, risk assessment profiles (tornado and flood), interview summaries, mitigation successes and survey results.

Risk Assessment Workgroup Meeting March 9, 2023

This meeting provided an overview of the risk assessment, survey results, interview findings, review the final mitigation goals and the first draft of the 2023 mitigation actions. The following risk assessment profiles were presented and discussed: extreme heat and cold, severe storm, severe winter storm, tornado, flood, drought, dam/levee failure, karst, cyber-attack and emerging infectious diseases. The final mitigation action goals (with revision in red) follow:

- Goal 1: Protect lives and reduce injuries from hazards and threats.
- Goal 2: Protect university property, organizational information and research from hazards and threats.
- Goal 3: Enhance existing or develop new university policies and practices that are designed to reduce damaging effects from hazards and threats.
- Goal 4: Build stronger partnerships between government, educational institutions, businesses and the community.
- Goal 5: Build disaster preparedness and response through education and outreach.

Risk Assessment Steering Committee Meeting, March 21, 2023

This meeting provided project updates, reviewed results from the risk and vulnerability assessments and solicited input regarding the mitigation actions. Laurel Wood provided introductions. Kristen Hewes provided an overview of the progress since the last steering committee meeting. The overview included defining critical facilities, updates regarding the 2016 mitigation actions summarizing their status, whether the 2016 mitigation actions are included in the plan update and discussion of new actions. Christina Hurley provided a summary of the risk assessment, which included the following hazards: flood, karst and hazardous materials. Kristen Hewes discussed the modifications to the goals and introduced the revised approach for the mitigation actions as well as some of the new actions developed by the workgroup. John Bucher led the discussion regarding the mitigation actions and reviewed each action to identify the appropriate responsible offices and departments, partners, funding sources, project types and project scoring for prioritization. More than 20 actions were reviewed by the steering committee and several more were added.

Open House, April 27, 2023

An open house was held in the Gatton Student Center on April 27, 2023, between 11 am – 1 pm. The open house was advertised in UKNow, social media and email. Advertising examples are in **Appendix A**. Planning team members were present at the open house to explain the intent of hazard mitigation planning, answer questions and collect information from attendees. The sign-in sheets for attendees are located in **Appendix A**.

Figure 1-3: Open House Visitors

Steering Committee Mitigation Strategy and Draft Plan Meeting, May 23, 2023

The mitigation strategy and draft plan meeting finalized the mitigation actions and provided an overview of the draft plan as well as the next steps. Kristen Hewes provided a summary of the plan progress, the top insurance losses and highlights from the risk assessment. Most of the meeting was spent reviewing and gaining consensus for each mitigation action, including the responsible offices/departments, other partners and prioritization.

Interviews

The planning team held 11 online interviews with the following departments to refine data collection for the risk assessment, capability assessment and mitigation strategy:

- Risk Management
- Martin-Gatton College of Agriculture, Food and Environment (two interview sessions)
- Environmental Health and Safety
- Office for Institutional Diversity
- Facilities Management
- Information Technology Services – Geographic Information System (GIS)
- Kentucky Climate Consortium
- Office of the Vice President of Research
- UK HealthCare (two interview sessions)

These interviews enabled the planning team to gather detailed information from specific groups for the plan, including input on the capability assessment, risk assessment and mitigation strategy.

Planning Team Calls

Members of the planning team engaged in ad hoc calls throughout the planning process to discuss data for the risk assessment, items for the capability assessment and mitigation actions as needed.

1.2 Public and Local Agency Involvement

Stakeholders participating in the plan update process represent a cross-section of the UK community, including key staff from university departments who are responsible for implementing the five-year action plan. Involvement from public and local agencies representing the community at-large include the American Red Cross Bluegrass Chapter, Columbia Gas, LFUCG Fire and Emergency Services, Kentucky American Water and Kentucky Division of Emergency Management.

1.3 Public Involvement

Public participation was an important component of the mitigation planning process. Input from the campus community (e.g., students, faculty and staff) provided the planning team with a greater understanding of local concerns and increased community investment, increasing the likelihood of successfully implementing mitigation actions. As members of the campus community become involved in decisions that affect their safety, they are more likely to recognize hazards present on campus and the other facilities covered by this plan and take the steps necessary to reduce their impact. Public awareness is a key component of any university's overall mitigation strategy aimed at making university properties safer from the potential effects of hazards.

Public involvement during the development of the *UK Hazard Mitigation Plan* was sought using six methods: (1) a public meeting and open houses during the planning process; (2) a public webpage that shared meeting information including dates, times, locations, agendas and PowerPoint presentations; (3) a public survey (described below) with open comments; (4) an online map for the public to identify hazards; (5) targeted emails soliciting input from university subject matter experts, Staff Senate, UK Police Department staff and others; (6) social media posts, UKNow articles and email announcements providing updates and encouraging campus-wide involvement; and (7) electronic copies of the draft plan deliverables were made available and advertised for public review and comment on UK's website.

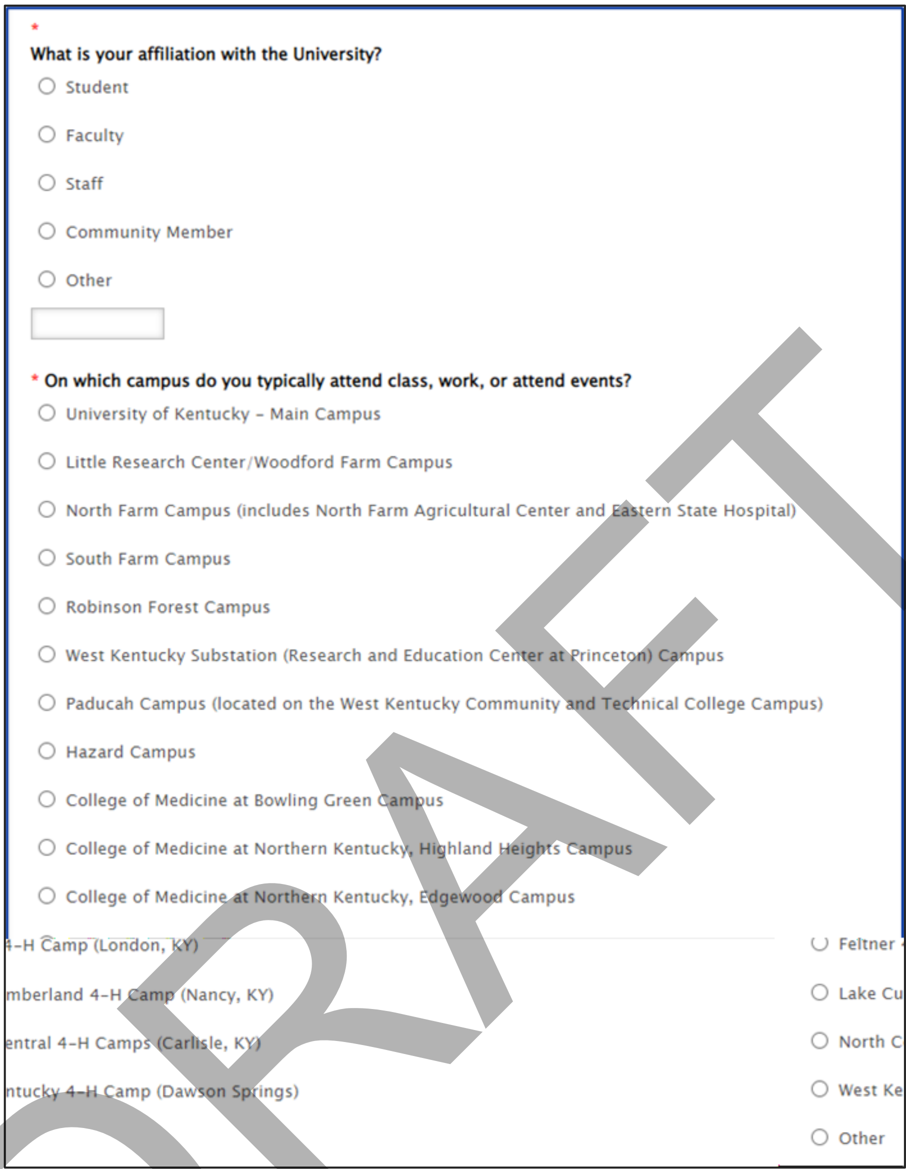
The public was provided two opportunities to be involved in the development of the plan at two distinct periods during the planning process: (1) during the drafting stage of the plan – four onsite public meetings; and (2) near completion of a final draft plan – draft plan review, but prior to official plan approval and adoption.

A link to an electronic version of the draft plan was posted and advertised via UK's social media channels and UK's website (INSERT DATES). **Appendix A** documents these advertisements. The final plan was reviewed and approved by UK's president on (INSERT DATE) (the adoption resolution can be found in **Appendix A**).

1.4 Public Participation Survey

Campus community members provided input on the mitigation planning process by responding to a public participation survey. The survey captured information from those who were unable to participate in meetings or through other means in the mitigation planning process.

A link to an electronic version of the survey was posted and advertised via UK's social media channels and the UK's hazard mitigation webpage. Public survey links were also disseminated by planning team members**. Figure 1-4** depicts two questions from the survey.



* What is your affiliation with the University?

- Student
- Faculty
- Staff
- Community Member
- Other

* On which campus do you typically attend class, work, or attend events?

- University of Kentucky – Main Campus
- Little Research Center/Woodford Farm Campus
- North Farm Campus (includes North Farm Agricultural Center and Eastern State Hospital)
- South Farm Campus
- Robinson Forest Campus
- West Kentucky Substation (Research and Education Center at Princeton) Campus
- Paducah Campus (located on the West Kentucky Community and Technical College Campus)
- Hazard Campus
- College of Medicine at Bowling Green Campus
- College of Medicine at Northern Kentucky, Highland Heights Campus
- College of Medicine at Northern Kentucky, Edgewood Campus

-H Camp (London, KY) | Feltner
mberland 4-H Camp (Nancy, KY) | Lake Cu
entral 4-H Camps (Carlisle, KY) | North C
ntucky 4-H Camp (Dawson Springs) | West Ke
Other

Figure 1-4: Hazard Mitigation Survey

The UK community completed 115 surveys. The planning team considered the data collected from the surveys to inform the development of the plan, including prioritizing mitigation actions. A summary of the results follows.

The majority of the survey participants were staff as depicted in **Figure 1-5**.

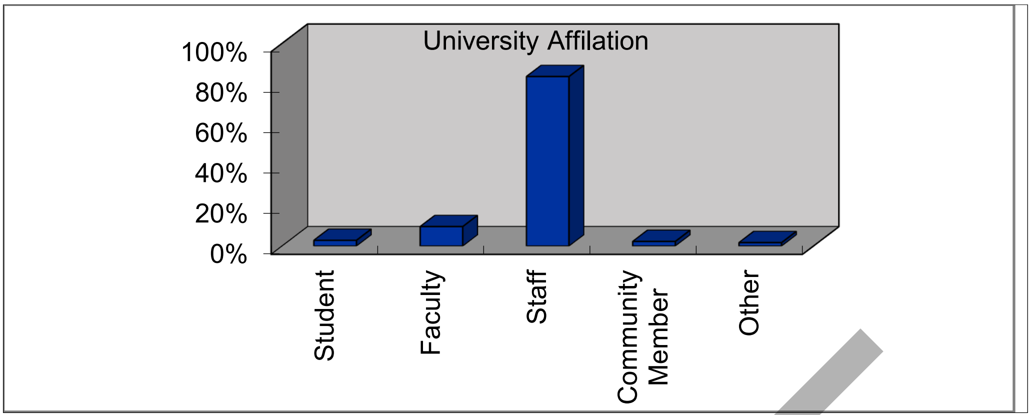


Figure 1-5: University Affiliation

Of the survey participants, 72 experienced or were impacted by a hazard.

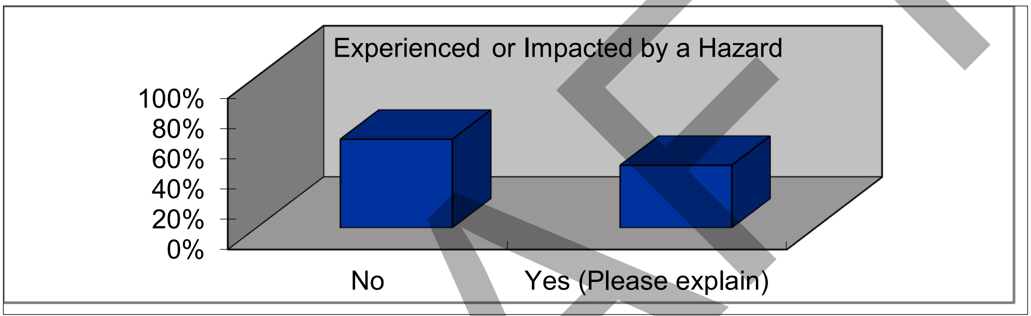


Figure 1-6: Participants Experienced or Impacted by a Hazard

Survey participants were asked which hazards they think are the greatest threat to UK. The top five results were severe winter storms, severe storms, cyber threats, tornadoes and hazardous materials. The survey summary for this question is in **Table 1-3**.

Table 1-3: Hazard Highest Threat to UK

Hazard	Percent
Dam/Levee Failure	1%
Drought	1%
Earthquake	2%
Emergent Infectious Disease	6%
Extreme Temperature	2%
Flood	3%
Forest Fire	0%
Hailstorm	0%
Hazardous Materials	8%
Karst/Sinkhole	1%
Landslide	0%
Severe Storm	18%
Severe Winter Storm	20%
Tornado	13%
Cyber Threats	17%
Other	8%
Total	100%

Survey participants were asked what they think is the second highest threat to the university. The top five responses were tornadoes, severe storms, severe winter storms, cyber threats and emergent infectious diseases. The survey summary for this question is in **Table 1-4**.

Table 1-4: Hazard Second Highest Threat to the University

Hazard	Percent
Dam/Levee Failure	1%
Drought	1%
Earthquake	2%
Emergent Infectious Disease	12%
Extreme Temperature	4%
Flood	4%
Forest Fire	0%
Hailstorm	0%
Hazardous Materials	7%
Karst/Sinkhole	2%
Landslide	0%
Severe Storm	17%
Severe Winter Storm	17%
Tornado	18%
Cyber Threats	13%
Other	3%
Total	100%

The survey results are located in **Appendix A**.

1.5 Incorporating Existing Planning Process

Several plans and studies were leveraged during the development of this plan. These sources are referenced at the end of each section; the majority of references are found in Section 3 through Section 5. Types of sources leveraged included:

- University planning documents (e.g., capital improvement plans, Campus Master Plan, Sustainability Plan, Transportation Plan, Utility Master Plan)
- Local, state and federal hazard technical information
- FEMA hazard mitigation plans and planning guidance

More information regarding the data sources is included in **Section 3.2.3** in the Risk Assessment. UK planning documents were also queried and reviewed. They are discussed further in **Chapter 4: Mitigation Strategy**.

1.6 Stakeholder Involvement

The planning team worked to provide an opportunity for a wide range of stakeholders, including staff from departments across campus, representatives from other campuses, students, faculty, community members and others to be involved in the planning process.

To involve a wide range of stakeholders, UK made a significant effort to broadly distribute the public survey, advertise public meetings and solicit comments on the draft plan. University officials, students, faculty, staff and community members were provided opportunities to be involved and offer input throughout the mitigation planning process.

Furthermore, the following demonstrates broad stakeholder involvement:

- The steering committee and workgroup included representation from the UK Police, Crisis Management and Preparedness, Center for Disaster Recovery and Resilience, Martin-Gatton College of Agriculture, Food and Environment (two interview sessions), Environmental Health and Safety, Facilities Management, Information Technology Services – GIS, Kentucky Climate Consortium, Office of the Vice President of Research, UK HealthCare, among others.
- Interviews with stakeholders allowed for more detailed conversations regarding risks, planning efforts and mitigation actions.
- Risk assessment data were leveraged from the aforementioned university representatives Lexington-Fayette Urban County Government, the county, the state and FEMA.
- Local and state agencies were included on the steering committee and were engaged at various points in the planning process for data and awareness.
- The final draft plan was publicized on websites for stakeholder review and input.

1.7 Plan Adoption

Adoption by UK demonstrates a commitment to fulfilling the hazard mitigation goals and actions outlined in the plan. Updated plans are adopted to recognize the current planning process and commit to prioritizing the five-year action plan.

The plan submittal process begins when UK sends the plan to KYEM for review and comments. Then, after UK addresses required revisions, KYEM submits the plan to FEMA Region IV for approval pending local adoption status.

Once the plan is certified approvable by FEMA, UK submits the plan to the UK Board of Trustees and then resubmits to KYEM and FEMA for final review and approval. The signed copy of the executed resolution and adoption by the Board of Trustees and president will be included in **Appendix A**.

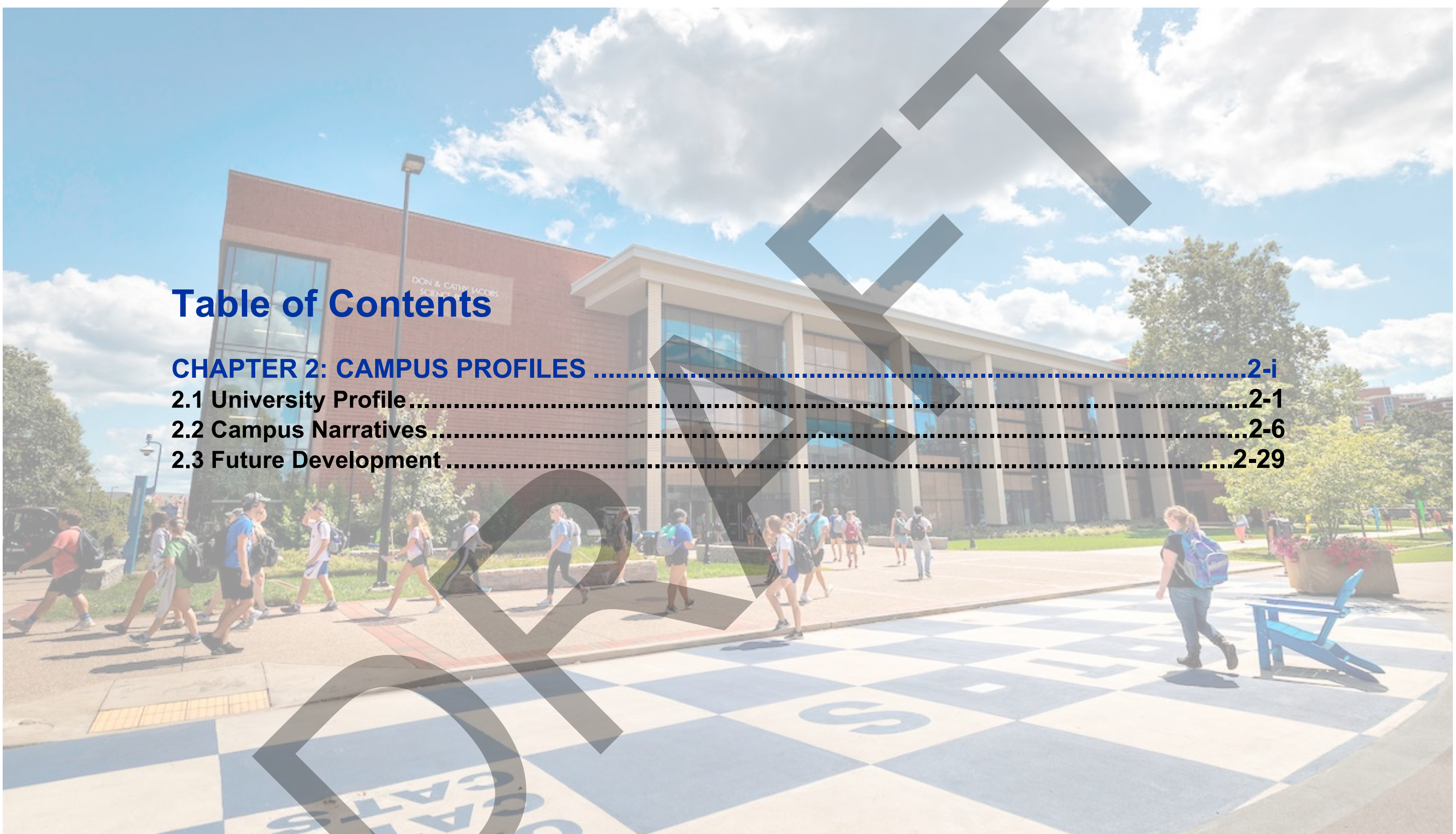


Table of Contents

Chapter 2: Campus Profiles

2.1 University Profile

To provide context for the *UK Hazard Mitigation Plan*, UK is described by its mission, history, campuses and properties, campus population, occupancy, research and economic impact and infrastructure. The following subsections outline each of these profile attributes. For more information, visit the UK Institutional Research and Advanced Analytics website.

2.1.1 Mission

The University of Kentucky is a public, land grant university dedicated to improving people's lives through excellence in education, research and creative work, service and health care[1]. As Kentucky's flagship institution, the university plays a critical leadership role by promoting diversity, inclusion, economic development and human well-being.

The University of Kentucky:

- *Facilitates learning, informed by scholarship and research.*
- *Expands knowledge through research, scholarship and creative activity.*
- *Serves a global community by disseminating, sharing and applying knowledge.*

The university contributes to the economic development and quality of life within Kentucky's borders and beyond. The university nurtures a diverse community characterized by fairness and equal opportunity.

2.1.2 Planning Context

UK was founded in February 1865 as a land-grant university adjacent to downtown Lexington[2]. UK started with only 190 students, 10 professors and 52 acres. It now covers more than 918 acres and is home to more than 33,000 students and approximately 13,500 employees. UK is one of eight universities in the United States that has colleges of agriculture, engineering, medicine and pharmacy on a single campus, leading to groundbreaking discoveries and unique interdisciplinary collaboration. UK consists of 16 academic and professional colleges. Students can choose from more than 200 majors and degree programs at the undergraduate and graduate levels. The student body is diverse, representing more than 100 countries, every state in the nation and all 120 Kentucky counties. Established in 1957, UK's medical center is among the nation's finest academic medical centers and includes the university's clinical enterprise, UK HealthCare. As a land-grant university, UK's reach extends far beyond the borders of the main campus. UK operates facilities throughout the Commonwealth of Kentucky; they are described in detail in the Campus Narratives section.

[1] "See Strategic Plan", UK Office of the President, https://pres.uky.edu/strategic-plan#:~:text=Mission%20Statement,work%2C%20service%20and%20health%20care.
[2] From "About the University", UK Public Relations and Marketing, https://www.uky.edu/prmarketing/about-university#:~:text=From%20its%20early%20beginnings%2C%20with,budget%20of%20nearly%20%243.9%20billion.

2.1.3 Enrollment

In fall 2022, UK enrolled 32,710 students[3]. UK's total enrollment consists of undergraduate students, graduate students, undergraduate auditors, post-doctoral students and house staff. The breakdown of the total enrollment is shown in **Table 2-1**. The fall enrollment from 2013 – 2022 is shown in **Figure 2-1**. The graph shows total enrollment and Full Time Equivalencies (FTE) as submitted to the Council on Postsecondary Education. FTE provide meaningful representations of full-time and part-time students by taking into account credit hours.

Table 2-1:UK Enrollment

Level	Full Time	Part Time	Total
Undergraduate	20,790	1,945	22,735
Graduate	6,830	1,982	8,812
Subtotal (IPEDS)	**27,620**	**3,927**	**31,547**
UG Auditors	-	32	32
Post-Doctoral	244	3	247
House-Staff	884	0	884
Subtotal (CPE)	**1128**	**35**	**1163**
Grand Total	**28,748**	**3,962**	**32,710**

[3] From "Enrollment and Demographics", UK Institutional Research, Analytics, and Decision Support, https://www.uky.edu/irads/enrollment-demographics

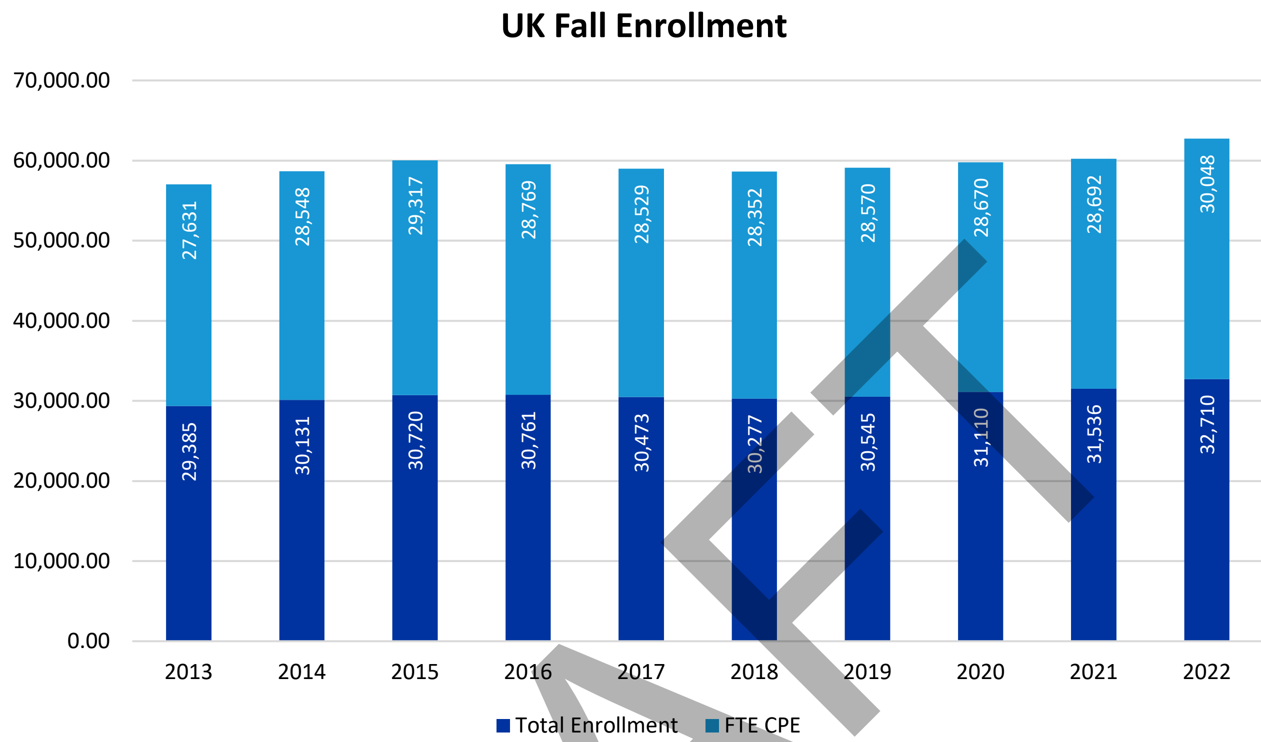


Figure 2-1: UK Fall Term Enrollment 2013 to 2022

2.1.4 Employees

UK is the largest employer in Lexington. Employee data is available for the 2020-2021 academic year[4]. Faculty are summarized by instructional type in **Table 2-2**. Employees are summarized in **Table 2-3.**

Table 2-2: UK Faculty by Instructional Type 2020 - 2021

Faculty		
Full Time	Instructional Faculty	1,754
	Non-Instructional Faculty	894
Part Time	Instructional Faculty	334
	Non-Instructional Faculty	13
Total		**2,995**

Table 2-3: UK Employees 2020 - 2021

Employees	
Full Time	16,221
Part Time	8,064
Total	**24,285**

[4] See "Quick Facts", UK Institutional Research, Analytics and Decision Support, https://www.uky.edu/irads/quick-facts

2.1.5 Revenue

UK receives funding from a variety of sources. The revenue sources for 2022-2023 are shown in **Table 2-4**[5]. The percentage of revenue by source is shown in **Figure 2-2.**

Table 2-4: UK Revenue Funding Sources 2022-2023

Source of Funds	2022-2023 (In Millions)
Appropriated Fund Balances	$ 452.40
Auxiliary Enterprises	$ 212.30
Clinical Services	$ 413.40
County Appropriations	$ 37.30
Endowment and Investment	$ 44.60
Federal Appropriations	$ 19.00
Gifts, Grants, and Contracts	$ 561.30
Hospital Services	$ 2,805.60
Other	$ 31.20
Recoveries of Facilities and Administrative Costs	$ 68.00
Sales and Services	$ 53.20
State Appropriations	$ 318.60
Student Tuition and Fees	$ 594.80
Transfers	-
UK Affiliated Corporations	-
Grand Total	**$ 5,611.70**

[5] From "University of Kentucky Budget", UK Institutional Research, Analytics and Decision Support, https://www.uky.edu/irads/university-kentucky-budget

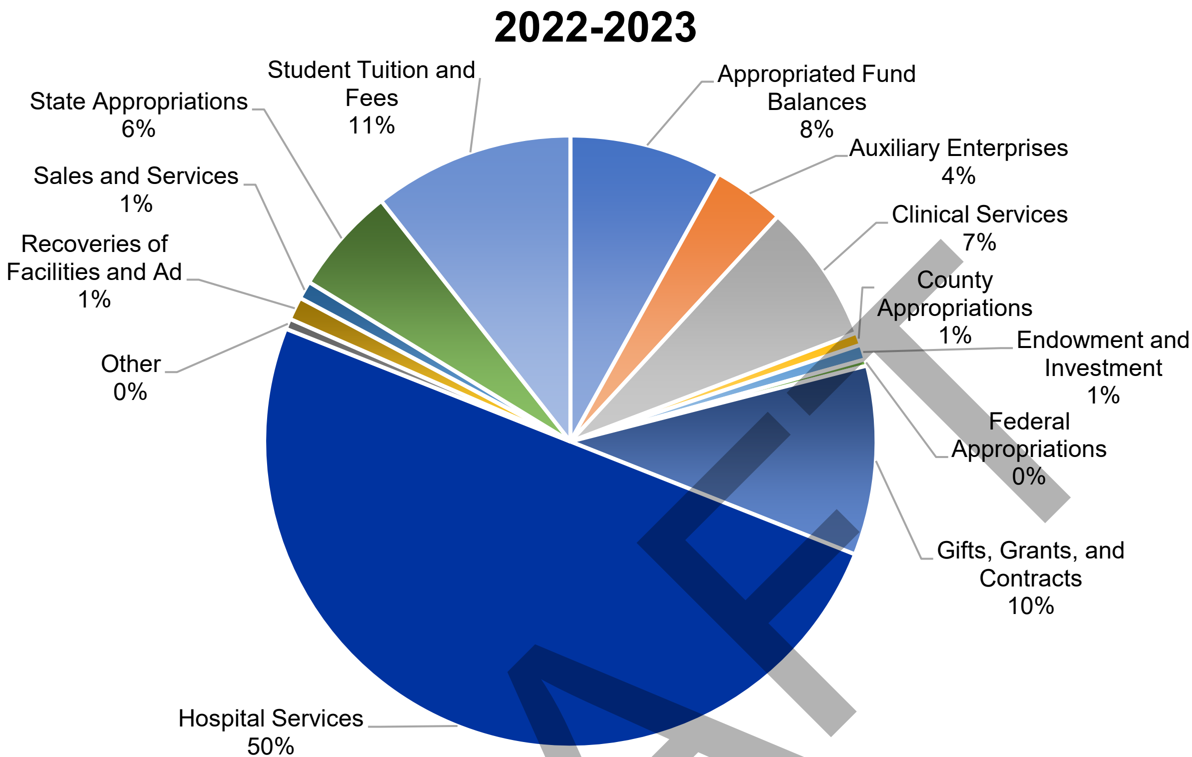


Figure 2-2: UK Revenue Funding Sources 2022-2023

2.1.6 Expenditures

The proposed expenditures by UK for 2022-2023 are shown in **Table 2-5**[6].

Table 2-5: UK Expenditures 2022-2023

Category	2022-2023 (In Millions)
Capital Outlay	$ 45.00
Capital Transfers	$ 199.00
Mandatory Transfers	$ 91.30
Operating Expenses	$ 2,614.90
Personnel Services	$ 2,393.20
Student Financial Aid	$ 268.30
Grand Total	**$ 5,611.70**

[6] From "University of Kentucky Operating and Capital Budget", University of Kentucky (June 2022), https://www.uky.edu/ubo/sites/www.uky.edu.ubo/files/FY2022-23%20Operating%20Budget%20Full%20Book.pdf

2.2 Campus Narratives

2.2.1 Introduction

To better serve the entire Commonwealth of Kentucky, UK runs a variety of campuses and facilities throughout the state. These campuses include medical schools, medical facilities, outreach facilities, research facilities and 4-H Camps. UK campuses and 4-H Camps in the Commonwealth were included in the Risk Assessment and Mitigation Strategy as a part of the *UK Hazard Mitigation Plan*. The campuses included in this plan are defined by the following factors:

- UK owns/controls the site.
- It is not reasonably geographically contiguous with the main campus.
- It has an organized program of study.
- There is at least one person on site acting in an administrative capacity.

The campuses and 4-H Camps are shown in **Figure 2-3** and described in **Table 2-6.**

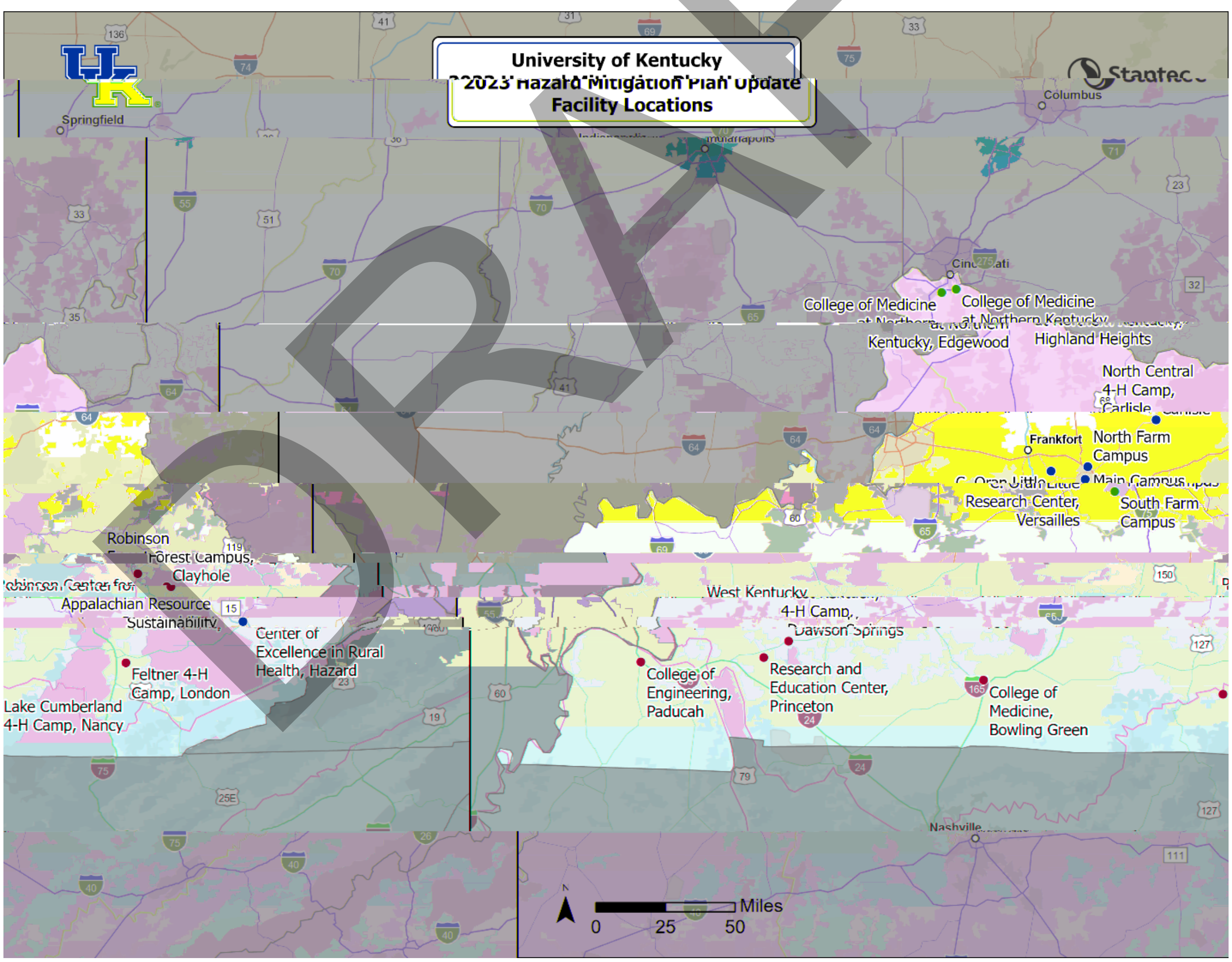


Figure 2-3: UK campuses Included in the UK Hazard Mitigation Plan

Table 2-6: UK Campuses Included in the UK Hazard Mitigation Plan

UK Campuses		
Campus	**City**	**County**
Main Campus	Lexington	Fayette
North Farm Campus	Lexington	Fayette
South Farm Campus	Lexington	Fayette
C. Oran Little Research Center	Versailles	Woodford
Center of Excellence in Rural Health	Hazard	Perry
College of Engineering, Paducah	Paducah	McCracken
College of Medicine, Bowling Green	Bowling Green	Warren
College of Medicine at Northern Kentucky, Edgewood	Edgewood	Kenton
College of Medicine at Northern Kentucky, Highland Heights	Highland Heights	Campbell
Research and Education Center (UKREC)	Princeton	Caldwell
Robinson Center for Appalachian Resource Sustainability (RCARS)	Quicksand	Breathitt
Robinson Forest Campus	Clayhole	Breathitt
UK 4-H Camps		
Campus	**City**	**County**
Feltner 4-H Camp	London	Laurel
Lake Cumberland 4-H Camp	Nancy	Pulaski
North Central 4-H Camp	Carlisle	Nicholas
West Kentucky 4-H Camp	Dawson Springs	Hopkins

2.2.2 Main Campus, Lexington

While UK has grown to include facilities across the state, the main campus is home to most UK facilities, students and staff. There are more than 400 buildings, including academic buildings, residence halls, recreation facilities, research centers and athletic facilities. From July 2011 to June 2023, UK has invested more than $4.4 billion in campus transformation projects with a majority occurring on the main campus[7]. Some notable facilities are highlighted below.

- **William T. Young Library** is the central library in the UK library system[8]. It is home to the general undergraduate collection as well as materials in agriculture, biology, business, humanities and the social sciences. The library contains additional resources such as the Student Media Department, Robert E. Hemenway Writing Center and the Ricoh Document Service Center. The library is 365,000 square feet and can seat 4,000 people[9].

[7] See "By the Numbers", University of Kentucky, https://www.uky.edu/
[8] From "William T. Young Library", UK Libraries, https://libraries.uky.edu/locations/william-t-young-library
[9] From "Visiting UK", University of Kentucky, https://www.uky.edu/nsfp/parent-family-association/visiting-uk

- **Gatton Student Center** serves as the hub for UK students. The facility contains a wide variety of dining options, entertainment and education opportunities and meeting and study spaces. The center includes Alumni Gym with 237 pieces of fitness equipment and Worsham Cinema, which can seat 560 people[10].
- **Healthy Kentucky Research Center** is a $265 million building dedicated to multidisciplinary research on health problems faced by Kentuckians[11]. The first phase opened in September 2018. Once completed, the center will be 300,000 square feet and will contain six floors of biomedical laboratories.
- UK established a **medical center** in 1957 on the main campus. Today the medical center at UK is among the nation's finest academic medical centers and includes UK's clinical enterprise, UK HealthCare. UK HealthCare is located on the main campus in Lexington but has other facilities and medical schools throughout the state. On-campus health care facilities include the 724-bed UK Albert B. Chandler Hospital and Kentucky Children's Hospital, along with 221 beds at UK Good Samaritan Hospital.

UK is dedicated to continuing to update facilities to improve student resources, research capabilities and the ability to serve Kentucky. UK has leveraged partnerships to invest billions in infrastructure to strengthen long-term health and success of the institution. Recent investments by UK are summarized below. A map of the main campus is shown in **Figure 2-4**.

- $459 million invested through a public/private partnership to revitalize student living and learning spaces. UK's public/private partnership with Education Realty Trust (EdR) has yielded more than 6,800 modern beds and more than 200 active learning spaces in 14 buildings.
- $201 million to renovate and expand the Bill Gatton Student Center and create a modern facility for the campus and community, financed with the support of donors and friends of the institution.
- $65 million to renovate and expand the Gatton College of Business and Economics.
- $110 million in the new Jacobs Academic Science Building that defines cutting-edge, interdisciplinary education and research.
- $120 million to enhance Kroger Field; $45 million to renovate and expand the E.J. Nutter Training Center.
- $20 million invested in the College of Fine Arts, including a new home for the School of Art and Visual Studies.
- More than $150 million to continue the fit-out of UK HealthCare's Chandler Hospital, financed with clinical revenue.
- More than $40 million to renovate and expand the J.D. Rosenberg College of Law.

[10] From "Gatton Student Center", University of Kentucky, https://www.uky.edu/gattonstudentcenter/
[11] From "Healthy Kentucky Research Building", University of Kentucky, https://www.research.uky.edu/healthy-kentucky-research-building

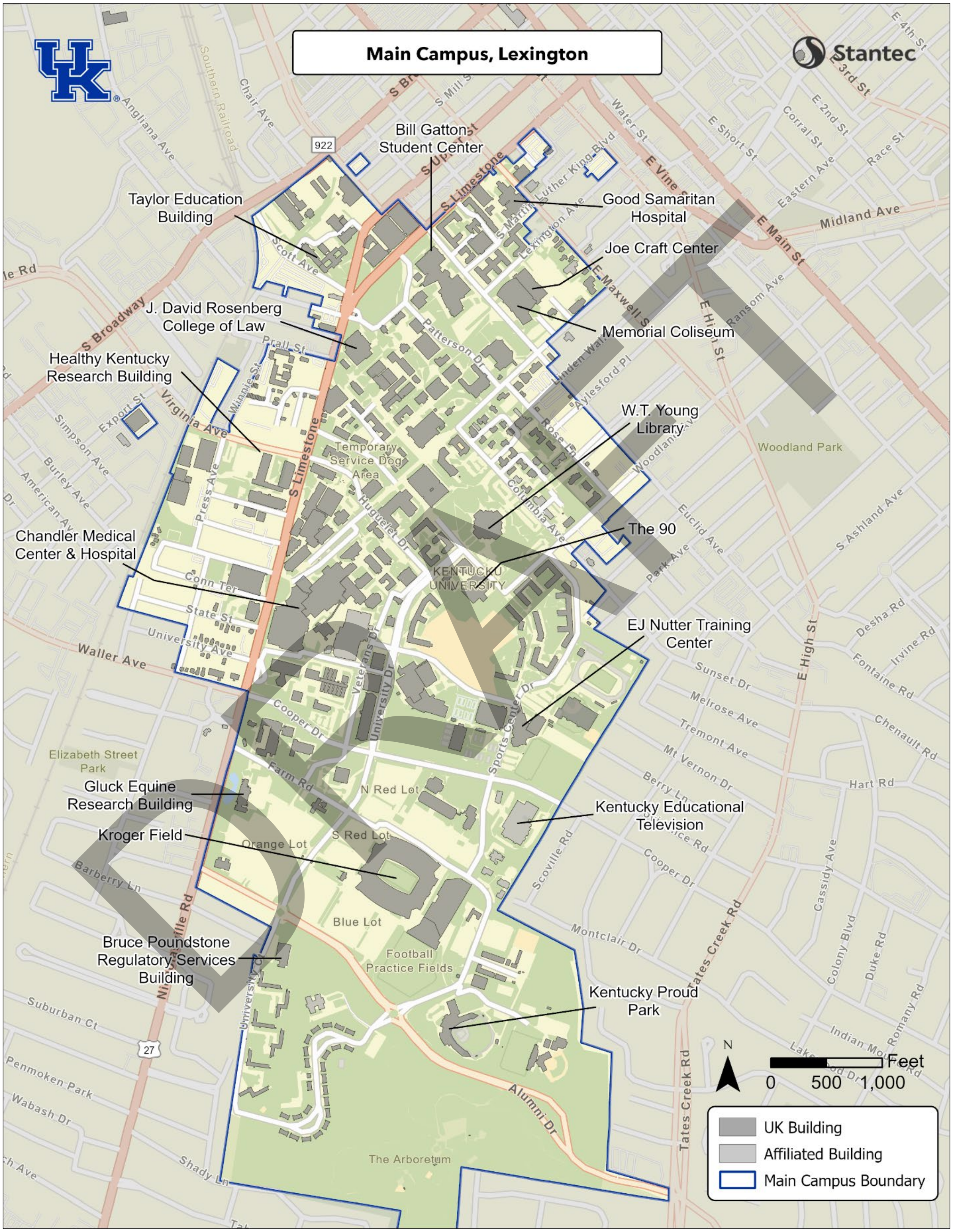


Figure 2-4: Map of Main Campus

Development surrounding UK includes Historic South Hill, Grosvenor/Woolfort, Aylesford Place, Transylvania Park and Woodland Triangle. These are neighborhoods between the north edge of campus and downtown Lexington. Each neighborhood has a significant number of high-quality, single-family homes mixed with student apartments of varying character.

The Columbia Heights, Hollywood/Mt. Vernon and Montclair neighborhoods to the northeast of campus also contain a mix of single-family homes and student housing.

Shadeland, Southern Heights and Glendover are located to the south of the main campus next to the campus arboretum.

2.2.3 North Farm Campus, Lexington

UK's North Farm is in Fayette County at 1925 Research Farm Road, Lexington, Kentucky 40511. North Farm consists of approximately 2,400 acres, which provides a vast array of teaching, research and extension opportunities for the faculty, staff and students in the Martin-Gatton College of Agriculture, Food and Environment (CAFE).

Currently, the North Farm research revolves around initiatives, projects and programs in the departments of veterinary science, animal and food science, plant and soil science, biosystems and agricultural engineering and entomology. In addition, the North Farm is an integral part of the Equine Initiative; the Equine Campus is located on the North Farm.

Improving water quality has been a major focus the past several years with emphasis on North Farm streams, which are in the Cane Run watershed. Setbacks and "no mow" zones have been established along the streams. Trees have been planted in the "no mow" zones along the streams. In addition, some stream crossings have been closed to vehicles and animals with new construction of environmentally friendly stream crossings.

The North Farm facilities provide outstanding resources expanding the classroom for many students who participate in field trips, laboratory exercises, judging team competitions and other events, which add to the undergraduate understanding of course concepts. Additionally, many students are employed on the farm as part of the student labor program, which enhances their college learning experience.

Eastern State Hospital is located at North Farm. It is managed by UK HealthCare through a contract with the Kentucky Department of Behavioral Health, Developmental and Intellectual Disabilities.

A map of the facilities located at North Farm is shown in **Figure 2-5.**

Figure 2-5: Map of North Farm Campus

2.2.4 South Farm Campus, Lexington Kentucky

The UK Horticulture Research Farm (South Farm) is in Fayette County and is run by the Department of Horticulture. South Farm was originally part of the Waveland Estate settled by Daniel Boone's family in the early 1800s. The 100-acre farm was originally purchased as 217 acres in 1956[12]. Past land transfers include 10 acres to the Commonwealth of Kentucky for the creation of the adjoining Waveland State Historic Site in 1971. In addition to research on fruit and vegetables, greenhouses and nurseries, biofuels, entomology, plant pathology and related crop sciences, Horticulture Research Farm (HRF) hosts the UK-CSA (Community Supported Agriculture) production unit.

Significant, applied research is ongoing at UK's HRF in Lexington. Federal and state-funded projects and trials include traditional and organic vegetable production, high tunnel production, fruit production, variety trials for disease and pest resistance, cover crops and hops. A map of the South Farm campus is shown in **Figure 2-6.**

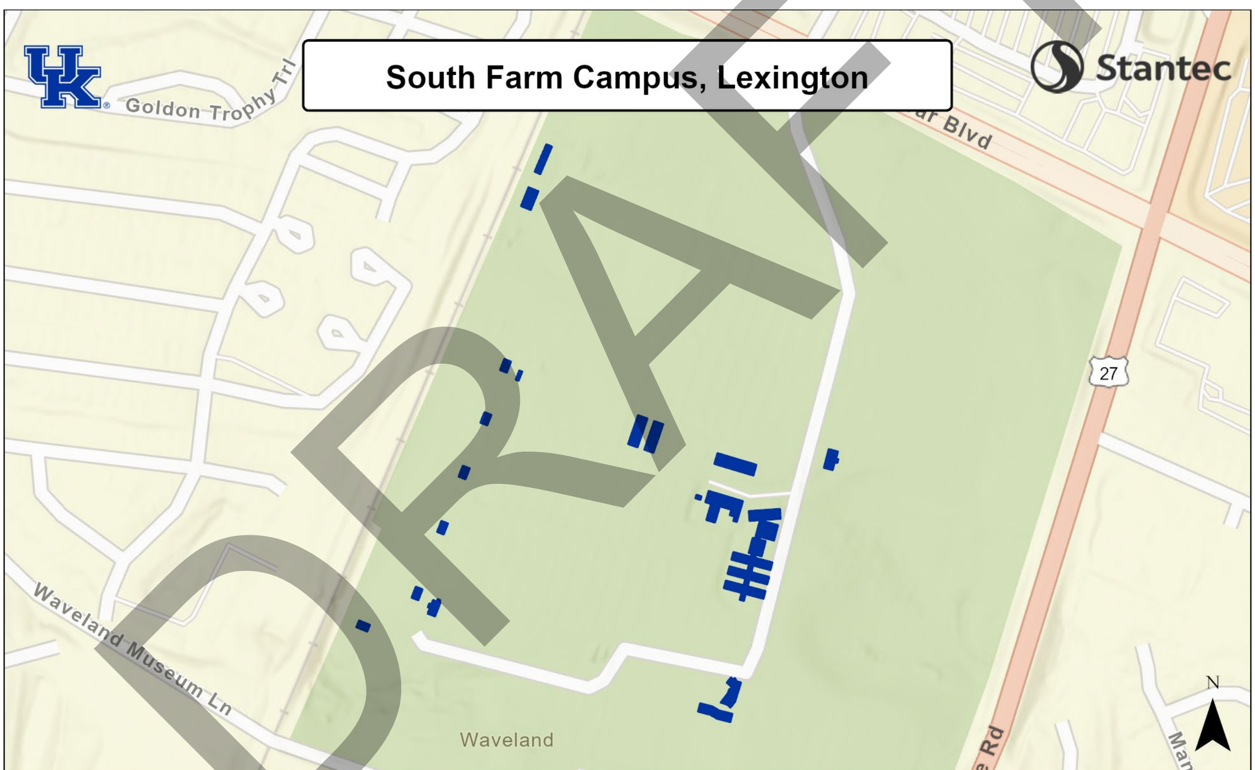


Figure 2-6: Map of South Farm Campus, Lexington

2.2.5 C. Oran Little Research Center, Versailles

The C. Oran Little Research Center is located in Woodford County at 1171 Midway Road Versailles, Kentucky 40383. The C. Oran Little Research Center is a 1,484-acre farm purchased in 1991 for the development of a state-of-the-art animal research facility[13].

[12] See "UK Horticulture Research Farm", UK College of Agriculture, Food and Environment, https://research.ca.uky.edu/content/SouthFarm

[13] See "C. Oran Little Research Center", UK College of Agriculture, Food and Environment, https://facilities.ca.uky.edu/little-research-center

Shortly after the farm was purchased, the state legislature approved funds for the construction of buildings and infrastructure to house beef, swine and sheep units. The swine research facility houses approximately 120 sows. The facility consists of three separate components: the headquarters, gestation and farrowing; the nursery; and the growing-finishing unit. Research focuses on nutrition and the prudent use of antibiotics in commercial swine production.

The sheep research unit consists of an approximately 350-ewe flock. The sheep facility, located on 110 acres of the C. Oran Little Research Center, contains a lambing barn, nutrition center, office complex, student living quarters and pastures for forage evaluation. Research focuses on improving the efficiency of sheep production for Kentucky producers. In addition to research, the beef, swine and sheep facilities are used for undergraduate course work and other educational programs. Also, faculty and staff of the departments of veterinary science, plant and soil science, and biosystems and agricultural engineering conduct research at the C. Oran Little Research Center. A map of the facility is shown in **Figure 2-7.**

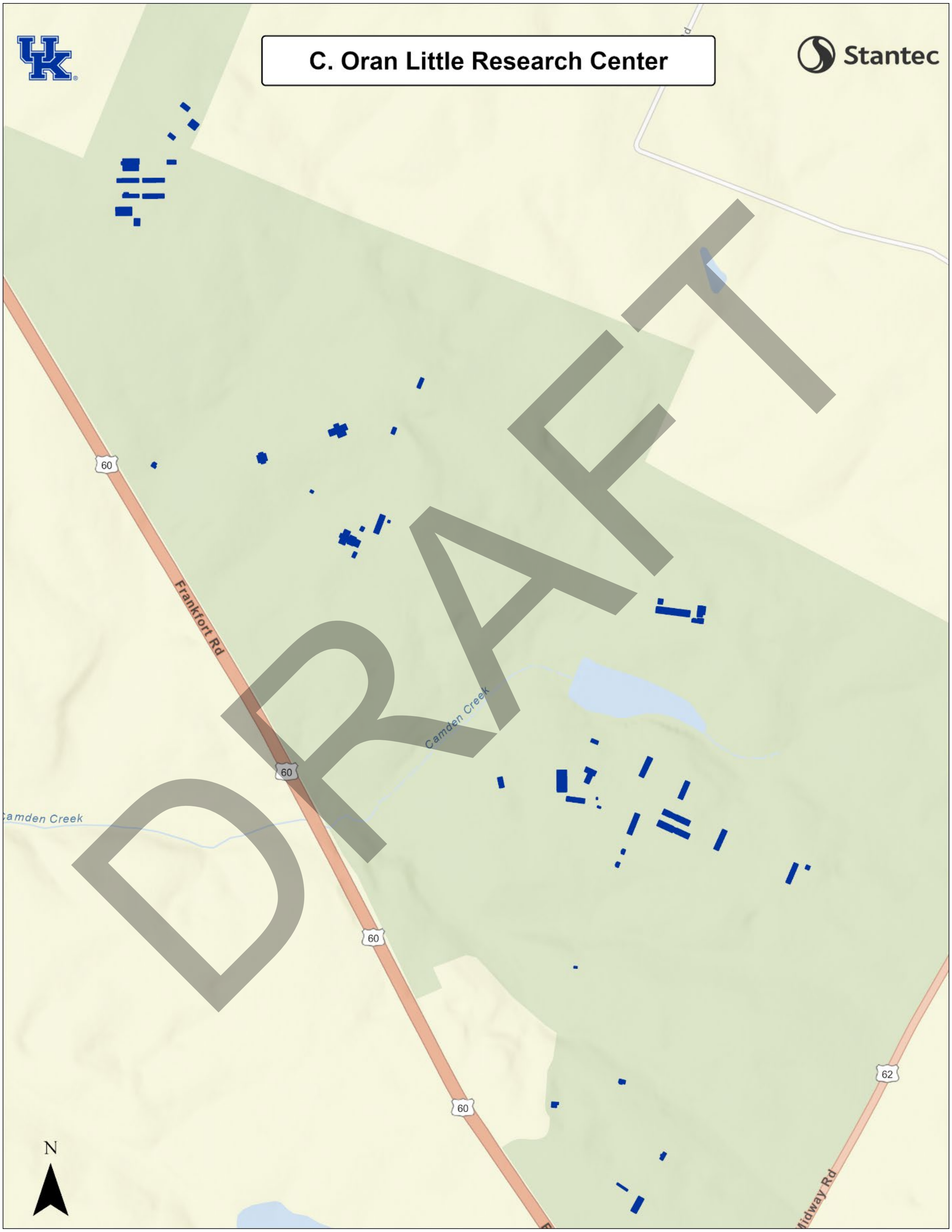


Figure 2-7: Map of C. Oran Little Research Center, Versailles

2.2.6 Center of Excellence in Rural Health, Hazard

The Center of Excellence in Rural Health is located at 650 Morton Boulevard, Hazard, Perry County, Kentucky. The UK Center of Excellence in Rural Health (CERH) was established by state legislation in 1990 to improve the health and wellbeing of rural Kentuckians. It addresses health disparities in rural Kentucky and the unique challenges faced by rural communities[14]. For more than three decades, the Center has partnered with communities, providers, students and individuals to provide health professions education, health policy research, health care service and community engagement toward reaching this mission.

The Center opened its doors in the former Appalachian Regional Healthcare (ARH) hospital. Shortly thereafter, the center seated their first class of physical therapists, followed by several other degrees, including nursing, social work and medical laboratory science. The Center now has more than 1,000 graduates[15]. Most of the UK CERH graduates are working to meet health care needs in rural communities across Kentucky.

The Kentucky Office of Rural Health (KORH) was established by a federal-state partnership authorized by federal legislation. It was a natural fit that the UK CERH would serve as the federally designated KORH to begin developing a framework to link small rural communities with local, state and federal resources while working toward long-term solutions to rural health issues. The KORH assists clinicians, administrators and consumers in finding ways to improve communications, finances and access to quality health care. It ensures that funding agencies and policymakers are aware of the needs of rural communities. The KORH administers the Kentucky Student Loan Repayment Program and the National Health Service Corps.

Much of the UK CERH's research has centered around health disparities. One of the UK CERH's early research projects led to the establishment of Kentucky Homeplace, a highly successful community health worker (CHW) initiative that has served more than 100,000 clients in the last 25 years. Today, Kentucky Homeplace is a robust operation with 22 CHWs who help underserved clients in 30 rural Appalachian counties access much needed health, social and environmental services. Kentucky Homeplace is supported by a long-term partnership with the Kentucky Department of Public Health.

In recent years, the Center has established a research conference, a rural health magazine and a youth leadership and research development program. Through partnerships with other organizations, the UK CERH has been instrumental in creating grass-root opportunities like the Community Leadership Institute of Kentucky to invest in community leaders. Other opportunities include Project CARAT, which provides assistance to individuals needing durable medical equipment; Operation Change, designed to support women who want to take charge of their health; and Eastern Kentucky's first ever Stroke Survivor and Caregiver Support Group. A map of UK CERH is shown in **Figure 2-8**.

[14] See "About the Center", UK College of Medicine, https://medicine.uky.edu/centers/ruralhealth/about
[15] See "Our History", UK College of Medicine, https://medicine.uky.edu/centers/ruralhealth/our-history

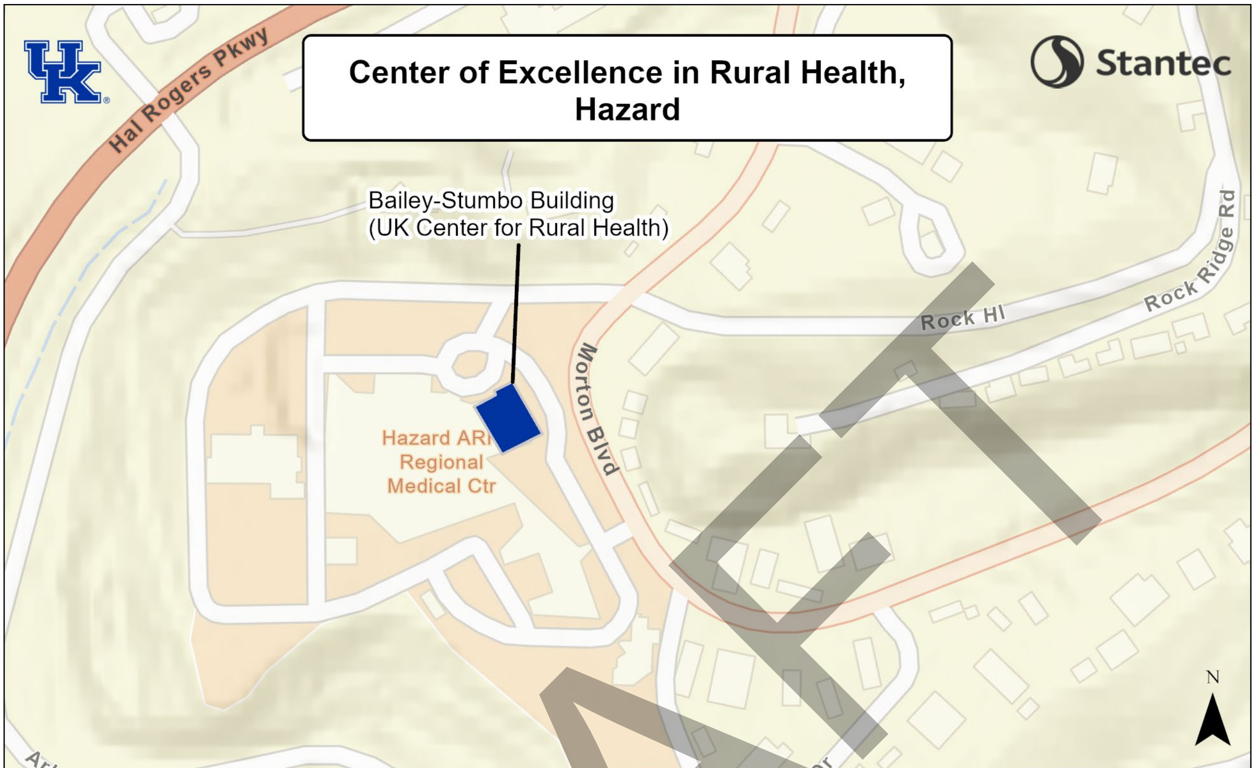


Figure 2-8: Map of Center of Excellence in Rural Health, Hazard

2.2.7 College of Engineering, Paducah

UK, in collaboration with West Kentucky Community and Technical College, offers studies leading to bachelor's degrees from UK in mechanical engineering and chemical engineering in Paducah, McCracken County, Kentucky[16]. The mechanical engineering and chemical engineering programs, initiated in 1997, are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (ABET). The College of Engineering in Paducah adds to the range of opportunities for students while also meeting the regional need for professional engineers in this highly industrialized part of the Commonwealth.

The campus offers modern facilities located on the West Kentucky Community and Technical College campus. As part of the partnership, UK leases space on the West Kentucky Community and Technical College campus. The dedicated UK facilities include the $2.6 million Fred Paxton Engineering Research Center (Paxton ERC), which provides outstanding research facilities for UK Paducah students and faculty[17]. As part of the 75,000-square-foot Emerging Technology Center, the Paxton ERC features an industrial-scale wind tunnel, a fully instrumented industrial compressor, a biodiesel pilot plant and other items used in engineering research.

[16] See "UK College of Engineering Paducah Campus", UK College of Engineering, http://engr.uky.edu/research-faculty/departments/paducah-campus

[17] See "Research", UK Paducah Campus, https://www.engr.uky.edu/research-faculty/departments/paducah-campus/research

UK Paducah students, faculty and staff also maintain active involvement in the Western Kentucky community. Whether it involves large participation, such as organizing the annual Engineers Day Open House, or small participation, such as judging a local science fair, they consistently work to educate the community in the world of science and engineering. A map of the College of Engineering, Paducah is shown in **Figure 2-9.**

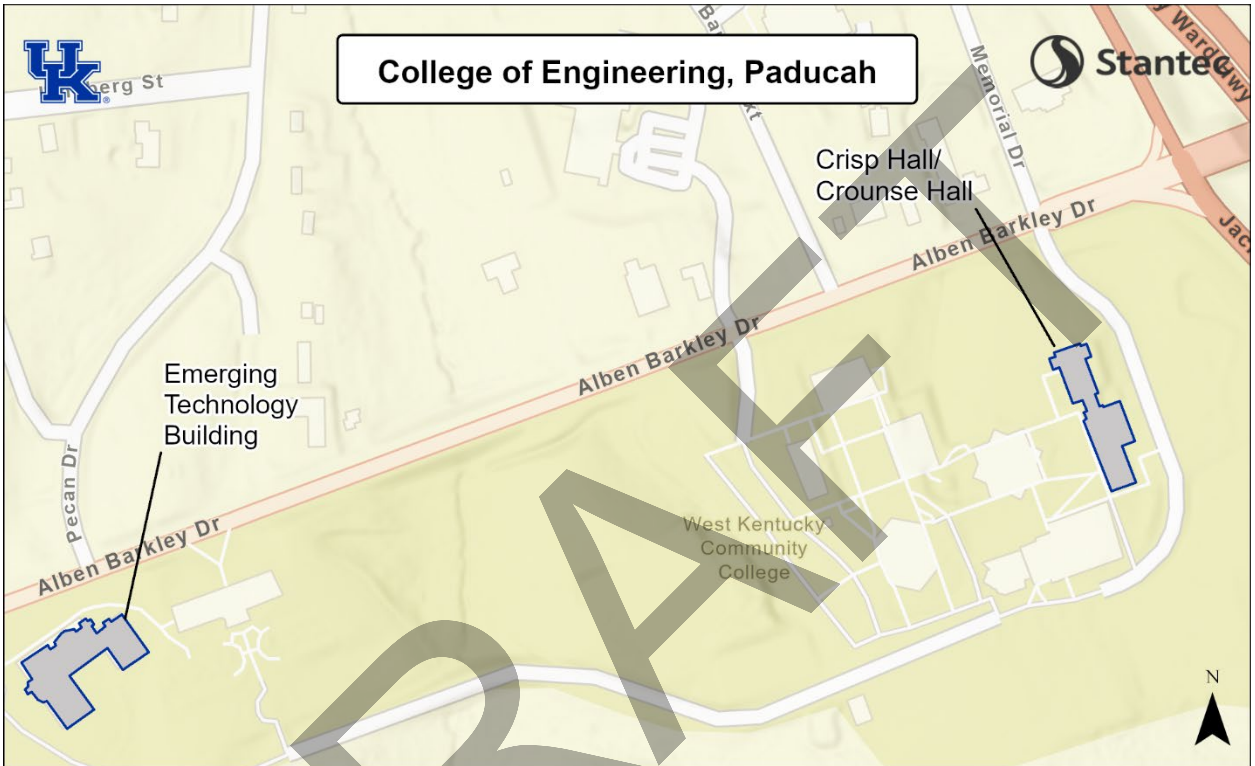


Figure 2-9: Map of College of Engineering, Paducah campus

2.2.8 College of Medicine, Bowling Green

In 2018, the UK College of Medicine-Bowling Green Campus, in partnership with Western Kentucky University (WKU) and Med Center Health, opened its newly constructed and state-of-the-art, 24,000 square foot facility, which is leased by UK. [18] The partnership makes it possible for medical students to access a full range of student services and activities at WKU while enjoying the same curriculum as UK's medical campus in Lexington. The curriculum is live streamed from UK's Lexington campus. Students engage in interactive group teaching by WKU faculty and local physicians from The Medical Center Health. Students also participate in a combination of interactive learning and on-site classes, emphasizing collaborative interactions, individual attention and early clinical experiences.

The program admits 30 students per year, who spend all four years at the Bowling Green Campus. The UK College of Medicine-Bowling Green graduated its first class of medical students in spring 2022. Partner medical facilities include the Medical Center at Bowling Green and the Medical Centers at Scottsville and Franklin.

[18] See "Bowling Green Campus", UK College of Medicine, https://medicine.uky.edu/sites/meded/bowling-green-campus

The medical campus features multiple classrooms and group study rooms along with a high-fidelity simulation area, computer lab and simulated patient exam rooms. A map of the facility is shown in **Figure 2-10**

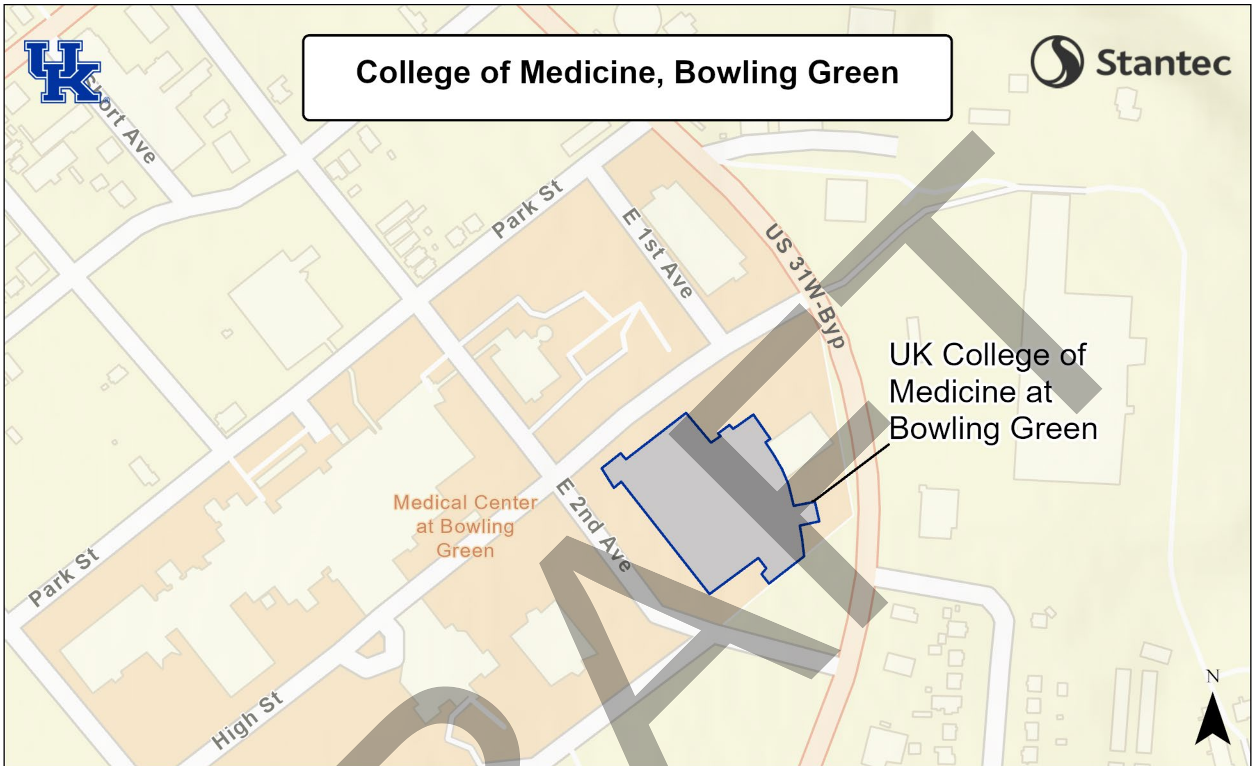


Figure 2-10: Map of College of Medicine, Bowling Green

2.2.9 College of Medicine at Northern Kentucky

The UK College of Medicine-Northern Kentucky Campus, in partnership with St. Elizabeth Healthcare and Northern Kentucky University, welcomed its inaugural class of 35 students in the fall of 2019[19]. The program is located at Northern Kentucky University (NKU). The curriculum is live streamed from the Lexington campus. Students also engage in interactive group teaching in conjunction with faculty at NKU and local physicians from St. Elizabeth Healthcare. Students spend the preclinical years at a newly remodeled facility on the NKU campus, which UK leases. The four-year medical school campus complements educational programs currently offered at the academic medical center on the Lexington campus, the Rural Physician Leadership Program based in Morehead and the UK College of Medicine-Bowling Green Campus. A map of the facility is shown in **Figure 2-11**.

[19] See "University of Kentucky College of Medicine – Northern Kentucky Campus", College of Medicine, https://medicine.uky.edu/sites/meded/northern-kentucky-campus

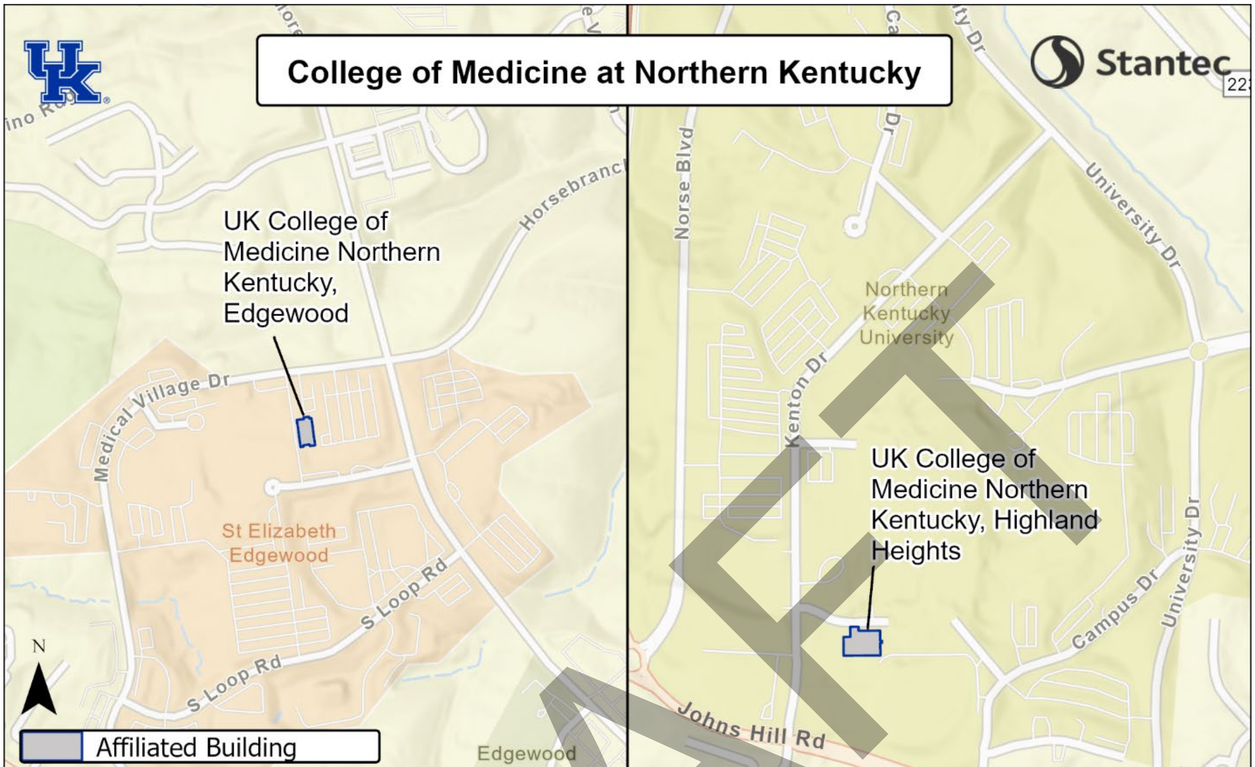


Figure 2-11: Map of College of Medicine at Northern Kentucky

2.2.10 Research and Education Center, Princeton (UKREC)

The UK Research and Education Center (UKREC) at Princeton is located in Caldwell County at 348 University Drive, Princeton, Kentucky 42445. The Agricultural Experiment Station was established in 1885 as the research arm of CAFE. In fulfillment of statewide responsibilities to serve the research needs of agriculture and rural citizens, experimental work is conducted under a variety of climatic and soil conditions in all parts of the state.

The West Kentucky Substation at Princeton was established in 1925 and is a center of agricultural activities in western Kentucky. Great advancements have been made in agriculture at this location, with considerable progress being made in improving utilization and conservation of resources, increasing yields of crops and livestock, better management of capital and labor, expanding markets and finding solutions for problems facing rural people and communities. Increased returns to Kentucky farmers total millions of dollars annually just from the use of new production technologies resulting from research findings and educational programs of the CAFE.

This site is the headquarters for more than 50 faculty and staff members representing eight different departments in CAFE. The modern facility is used to conduct research, provide diagnostic testing services and develop educational programs on topics of concern to Kentucky farmers, agribusinesses and families.

The property consists of almost 1,300 acres, including soils of both sandstone and limestone origin, characteristic of soil types throughout the state. Researchers conduct approximately 100 different research/demonstration projects each year at the Experiment Station Farm or on farms in western Kentucky.

County offices of the Cooperative Extension Service deliver to farmers and the public information derived from projects or research conducted elsewhere. Extension Specialists located at the center have expertise in a broad spectrum of food and agriculture topics.

Service laboratories located at UKREC provide information needed to make management decisions in the following areas:

- Soil testing enables farmers to develop nutrient management plans for growing crops.
- The plant disease diagnostic laboratory helps identify plant health problems and provides recommendations for disease prevention and control. Once insect and plant pests are identified, specialists can give advice on integrated pest management strategies to control them.

The Rottgering-Kuegel Agricultural Research and Extension Building is available to large and small groups for classes and meetings in agriculture, home economics and 4-H. It is also used for a wide variety of meetings by government agencies, industry and the public. Each year there are approximately 450 different meetings held in this building, attended by about 14,000 people. Many of these visitors come from other states and foreign countries.

Agricultural engineering specialists conduct research and educational programs related to both crop and livestock production. Crops such as corn, wheat, soybeans, tobacco, fruits, vegetables and ornamentals are studied for ways to increase yields and income, improve handling and storage, protect the environment and address other problems farmers may have. A beef herd consisting of 400 animals is involved in many different experiments and demonstrations. An aquaculture program is conducted in cooperation with Kentucky State University.

Annual field days and demonstrations showcase the work of the UKREC and attract more than 3,000 people.

The UKREC took a direct hit from a tornado in December 2021. A map of UKREC prior to the December 2021 tornado is shown in **Figure 2-12**. The campus is currently being redeveloped to serve the university community and Commonwealth of Kentucky. **Figure 2-13** depicts UKREC in December 2022 approximately one year after the tornado.

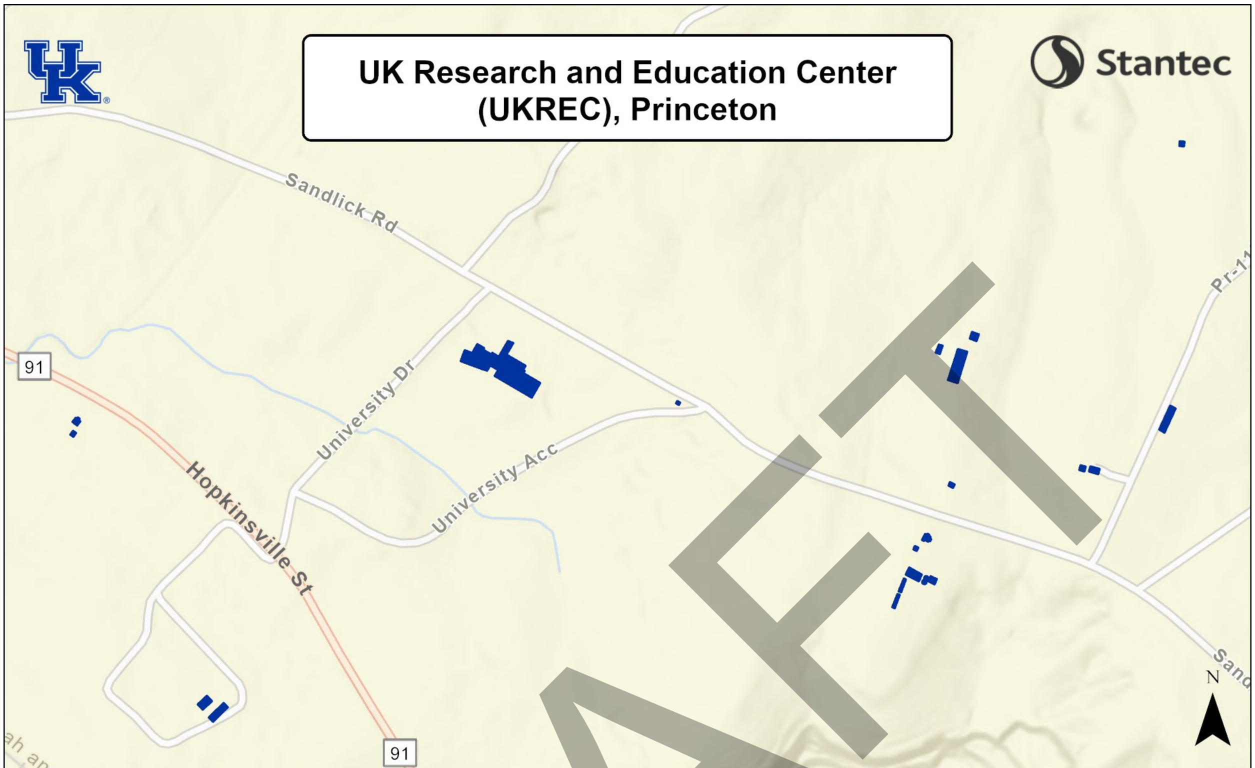


Figure 2-12: Map of UKREC, Princeton

Figure 2-13 UKREC December 2022[20]

[20] See "A year after the tornado, UK Research and Education Center looks back, pushes forward", College News (uky.edu)

2.2.11 Robinson Center for Appalachian Resource Sustainability (RCARS), Quicksand

The Robinson Center for Appalachian Resource Sustainability (RCARS) is in Breathitt County at 130 Robinson Road, Jackson, Kentucky 41339. RCARS is headquartered at the facility formerly known as "Robinson Station" in Quicksand, Kentucky. It includes operations involving Robinson Station, Robinson Forest and the Wood Utilization Center[21].

The mission statement of RCARS is to "...increase the long-term value added, sustainable income and sustainable flow of economic, ecological and social goods and services from the land, natural resources and people of Eastern Kentucky and the Appalachian Region." RCARS hosts visitors frequently for workshops, training, research, education and classes.

Programming at this center includes:

- Family and Consumer Science Nutrition Education Program
- Fruit and Vegetable Production/Marketing
- Farmer's Market – Production and Nutrition Program
- Grow Appalachia Partner
- High Tunnel Research and Demonstrations
- Livestock Forage Variety Testing
- Kentucky Annual Small Ruminant Grazing Conference
- Wood Utilization Technical Training Series
- Entrepreneur Development in Wood Products
  - Win With Wood Educational Program
  - Product Design and Development Program
- Workshops and Events
  - Mountain Ag Week
  - Robinson Forest Research
  - Robinson Forest Camp Management
  - Kentucky State University – Small Scale Farm Grant Program

A map of the RCARS campus is shown in **Figure 2-14.**

[21] From "Robinson Center for Appalachian Resource Sustainability (RCARS)", UK College of Agriculture, Food, and Environment, https://rcars.ca.uky.edu/

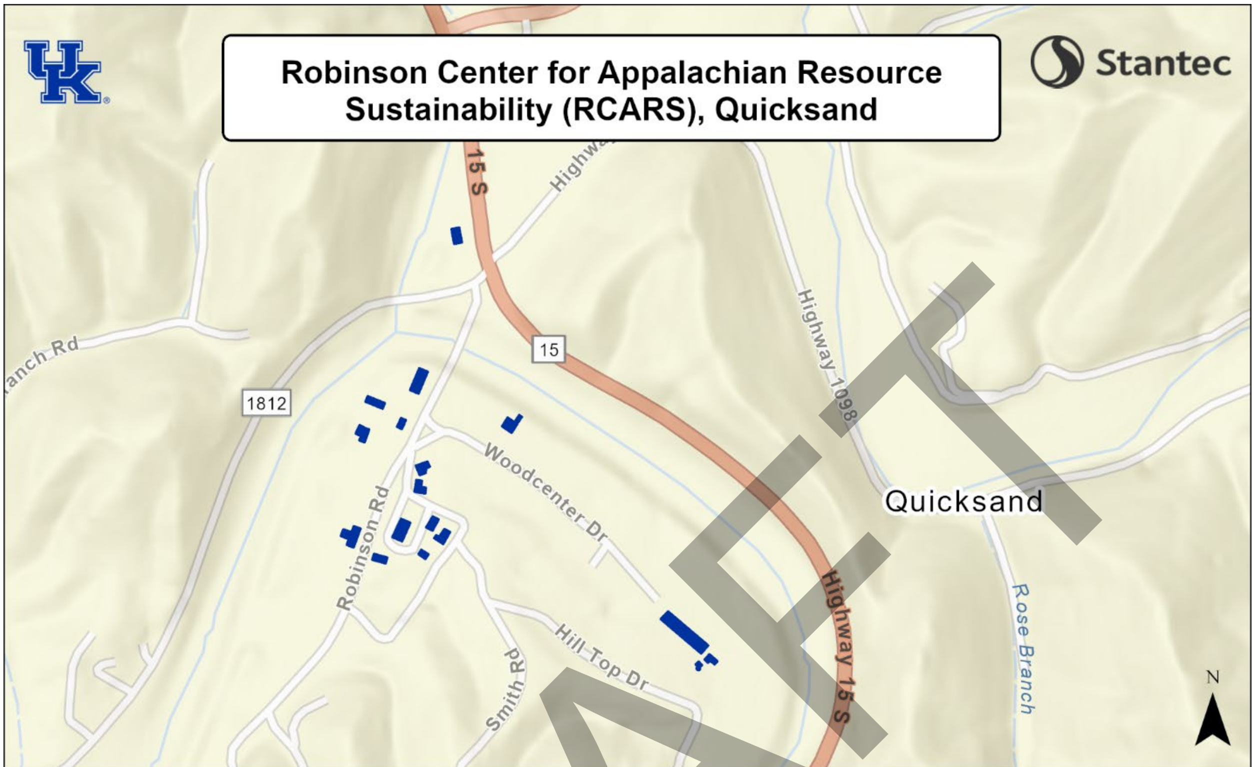


Figure 2-14: Map of RCARS, Quicksand

2.2.12 Robinson Forest Campus, Clayhole

Robinson Forest is in Breathitt County at 617 Clemons Fork Road, Clayhole, Kentucky 41317. This site is a teaching, research and extension forest administered by the Department of Forestry and Natural Resources in cooperation with RCARS at UK[22]. The campus includes approximately 14,800 acres in the interior rugged section of the Cumberland Plateau.

Robinson Forest is nationally recognized for the educational and research benefits that it provides. It is managed specifically to provide public benefit through environmental and conservation educational programs for all ages, including continuing education for natural resource professionals and research designed to address critical environmental, forest and wildlife conservation issues. The public benefits directly through education (K-12, post-secondary and continuing education) conducted at Robinson Forest, as well as through the research that has been used to protect water quality, conserve threatened and endangered species and maximize conservation and use of forest resources. The maintenance of these benefits is contingent upon maintaining forest hydrologic monitoring and research stations; providing a safe environment for the public, students and those working to provide programs at Robinson Forest; and facilities infrastructure.

Research at Robinson Forest includes but is not limited to:

- Restoration research (active restoration and use as a reference site)
- Long-term hydrology and water quality monitoring

[22] See “Robinson Forest”, UK College of Agriculture, Food, and Environment, https://robinson-forest.ca.uky.edu/

- Environmental gradient research
- Large-scale manipulative studies
- Wildlife biology, including elk, black bear, bats, fish, and salamanders.

Robinson Forest hosts visitors frequently for workshops, training, research, education and classes. Some of the events host more than 1,000 children at the site. The forest is busiest from January through June when it hosts on-site forestry classes and camps.

A map of the Robinson Forest campus is shown in **Figure 2-15.**

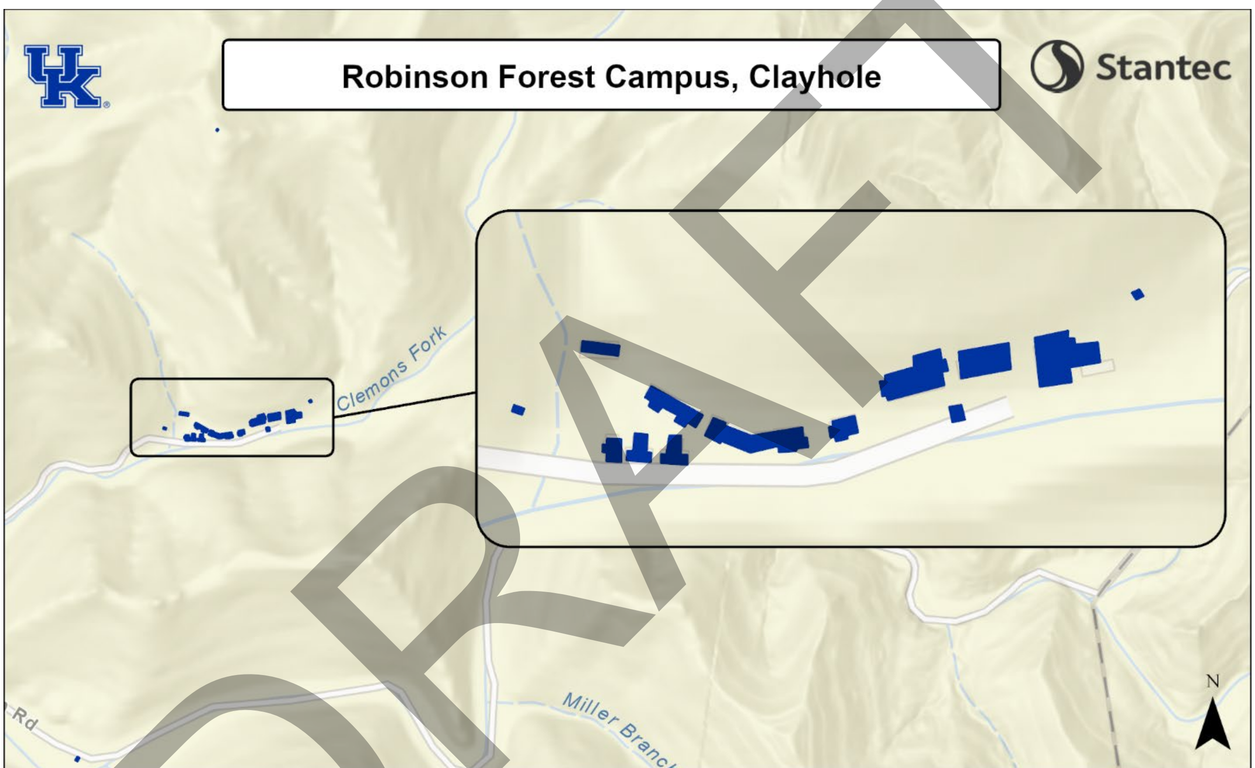


Figure 2-15: Map of Robinson Forest Campus, Clayhole

2.2.13 J.M. Feltner 4-H Camp, London

J.M. Feltner Memorial 4-H Camp, near London, KY covers more than 200 acres of foothills near the Daniel Boone National Forest and Levi Jackson Park[23]. The camp serves 34 counties and accommodates up to 370 campers and counselors per session in its cabins plus 12 additional campers and counselors in the outpost for primitive camping. Approximately 20 resident staff and 20 workers support the camp and facilities operations.

Camp facilities include a dining hall, a multipurpose building, shelter house (including a stage and restrooms), nature cabin, deluxe cabin with a storm bunker, country store for souvenirs and snacks and a

[23] See "J.M. Feltner", UK College of Agriculture, Food, and Environment, https://4-h.ca.uky.edu/feltner-camp

swimming pool with waterslide and rock wall. The camp buildings are equipped with A/C, and the bathhouses have heat.

A one-and-a-half-acre lake provides opportunities for fishing, canoeing, paddle boating and pond studies in nature class. The camp offers facilities for archery, riflery, football, soccer, volleyball, basketball and hiking. The camp also has a playground area that includes swings, monkey bars, gaga, carpet ball, roof ball, 9-square and ring toss. The Campfire Amphitheater provides seating for more than 400 people and is available for public rental for weddings, concerts and other events. A map of the facility is shown in **Figure 2-16.**

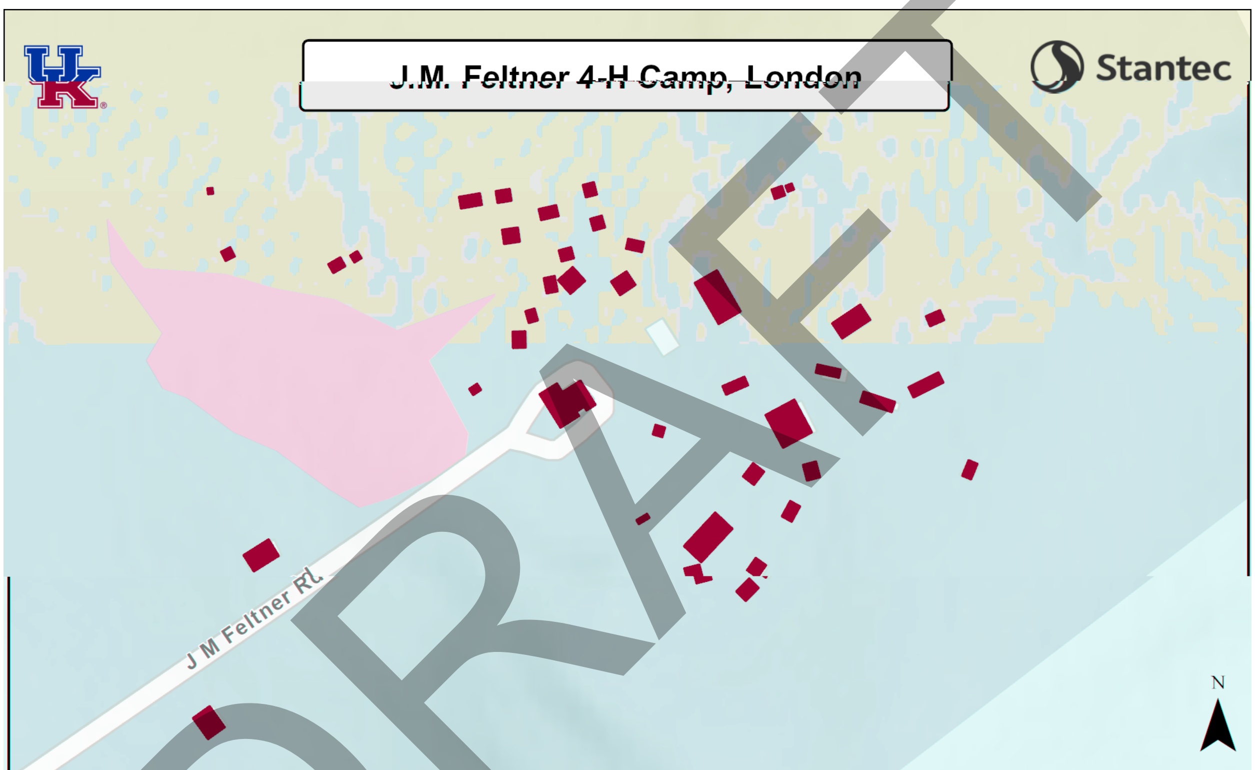


Figure 2-16: Map of J.M. Feltner 4-H Camp, London

2.2.14 Lake Cumberland 4-H Camp, Nancy

The Lake Cumberland 4-H Camp is in Jabez, Russell County, Kentucky. It is the largest 4-H camp in Kentucky[24]. Located on Lake Cumberland, the camp contains six miles of shoreline and 1,500 acres of rolling hills and forested land. The Lake Cumberland 4-H Camp serves 20 counties for summer camp. The facilities include heated cabins with toilet and shower facilities, a swimming pool with a waterslide, shelter house, dining hall, country store for souvenirs and snacks, low ropes challenge course, high element zip line and a craft and nature building. The camp accommodates 377 campers and counselors per camping session and an additional 24 campers and counselors at an outpost for primitive camping. There is a cave and miles of nature trails for exploring. In addition, the camp provides areas for riflery, archery, canoeing/kayak and fishing, football and basketball. The camp is open to the public and

[24] See "Lake Cumberland", UK College of Agriculture, Food, and Environment, https://4-h.ca.uky.edu/lake-cumberland-camp

includes facilities and equipment to support schools, leadership trainings and weekend camps. A map of the facility is shown in **Figure 2-17.**

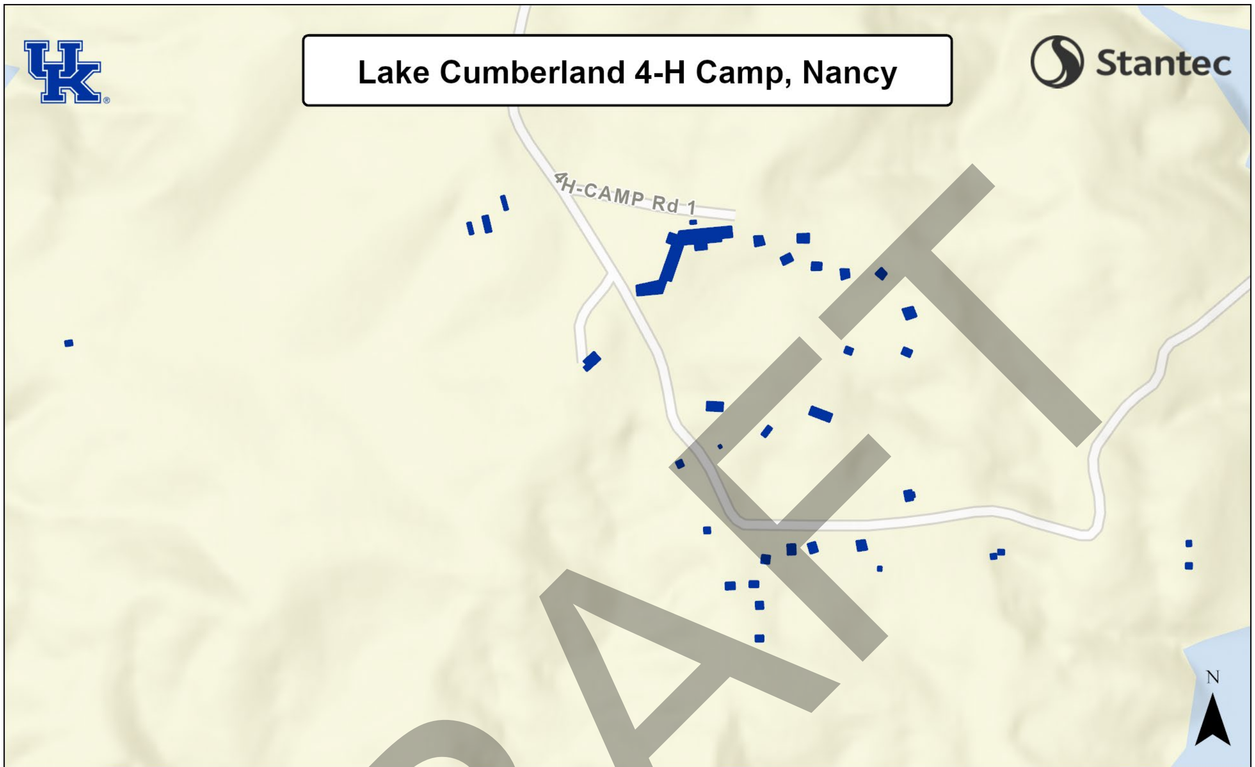


Figure 2-17: Map of Lake Cumberland 4-H Camp, Nancy

2.2.15 North Central 4-H Camp, Carlisle

North Central 4-H Camp is located in Carlisle, Nicholas County, Kentucky. The camp sits on 350 acres of rolling hills and forested land near Lake Carnico[25]. North Central serves 28 Kentucky counties and accommodates 422 guests in the air-conditioned and heated cabins, 32 guests in the air-conditioned and heated Yurt Village and 24 guests in the primitive camping 'Outpost'. There are 20 resident staff and 20-day workers to support camp operations.

The camp offers an air-conditioned and heated dining hall, multi-purpose building and bathhouses; an open-air shelter house; restored, historic log cabin; country store for souvenirs and snacks; and swimming pool with waterslide. Program facilities include rifle and archery ranges, bird blind for nature classes, observation beehive, low and high ropes, challenge course, basketball, volleyball and athletic field. The six-acre 4-H lake holds the North Central AquaPark, a 130-foot floating obstacle course. The lake also offers opportunities for fishing, canoeing, kayaking, pond studies and hiking in nature classes. The shelter house and the lakeside campfire area are used for evening programs and special events. A map of the facility is shown in **Figure 2-18.**

[25] See "North Central", UK College of Agriculture, Food and Environment, https://4-h.ca.uky.edu/north-central-camp

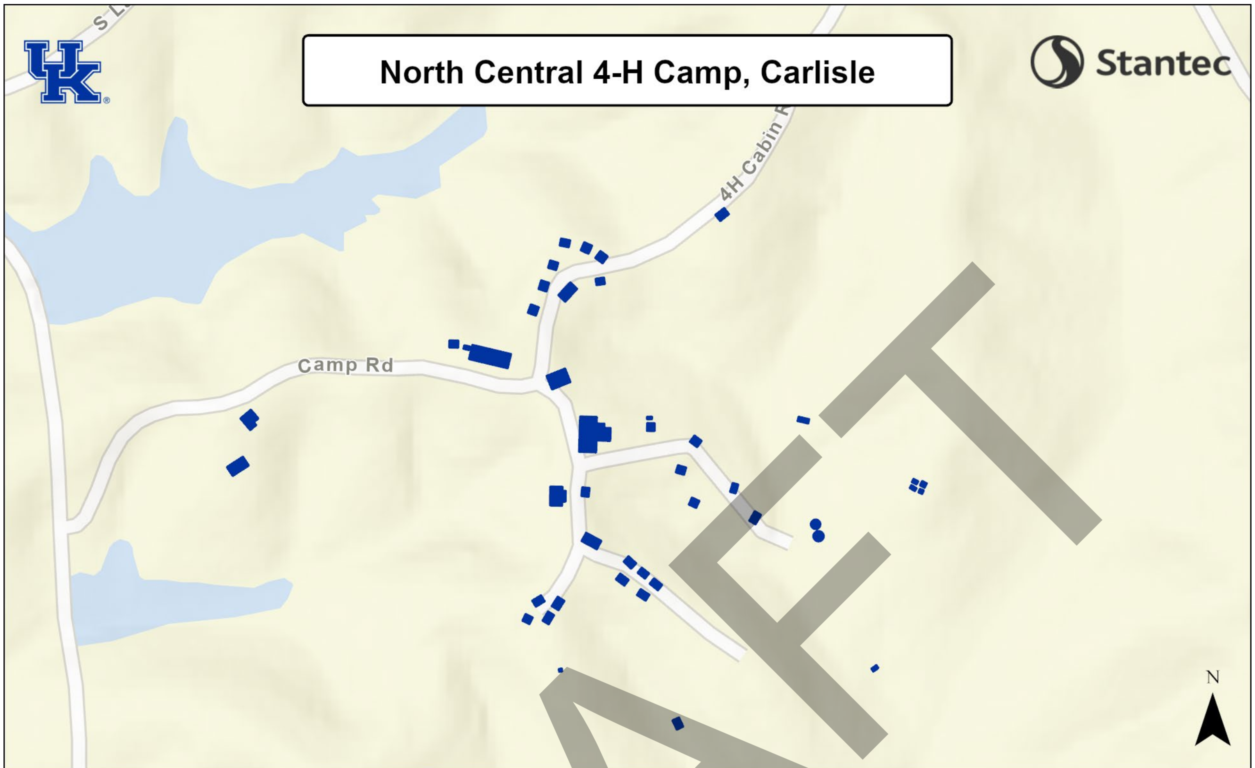


Figure 2-18: Map of North Central 4-H Camp, Carlisle

2.2.16 West Kentucky 4-H Camp, Dawson Springs

West Kentucky 4-H Camp is a 465-acre facility serving 38 counties in Western Kentucky[26]. Located in Dawson Springs, Ky. It is home to a 4-H summer camp and is available for group rentals throughout the year. The facilities include a 17-acre fresh-water lake, fishing dock, a high and low ropes challenge course, archery and riflery ranges, a swimming pool, multi-purpose buildings, athletic fields, two dining halls and 22 cabins with a total capacity of 486. The camp hosts a variety of groups and events including school overnight trips, church retreats, leadership trainings and weekend camps. A map of the campus is shown in **Figure 2-19**.

[26] See "West Kentucky", UK College of Agriculture, Food, and Environment, https://4-h.ca.uky.edu/west-ky-camp

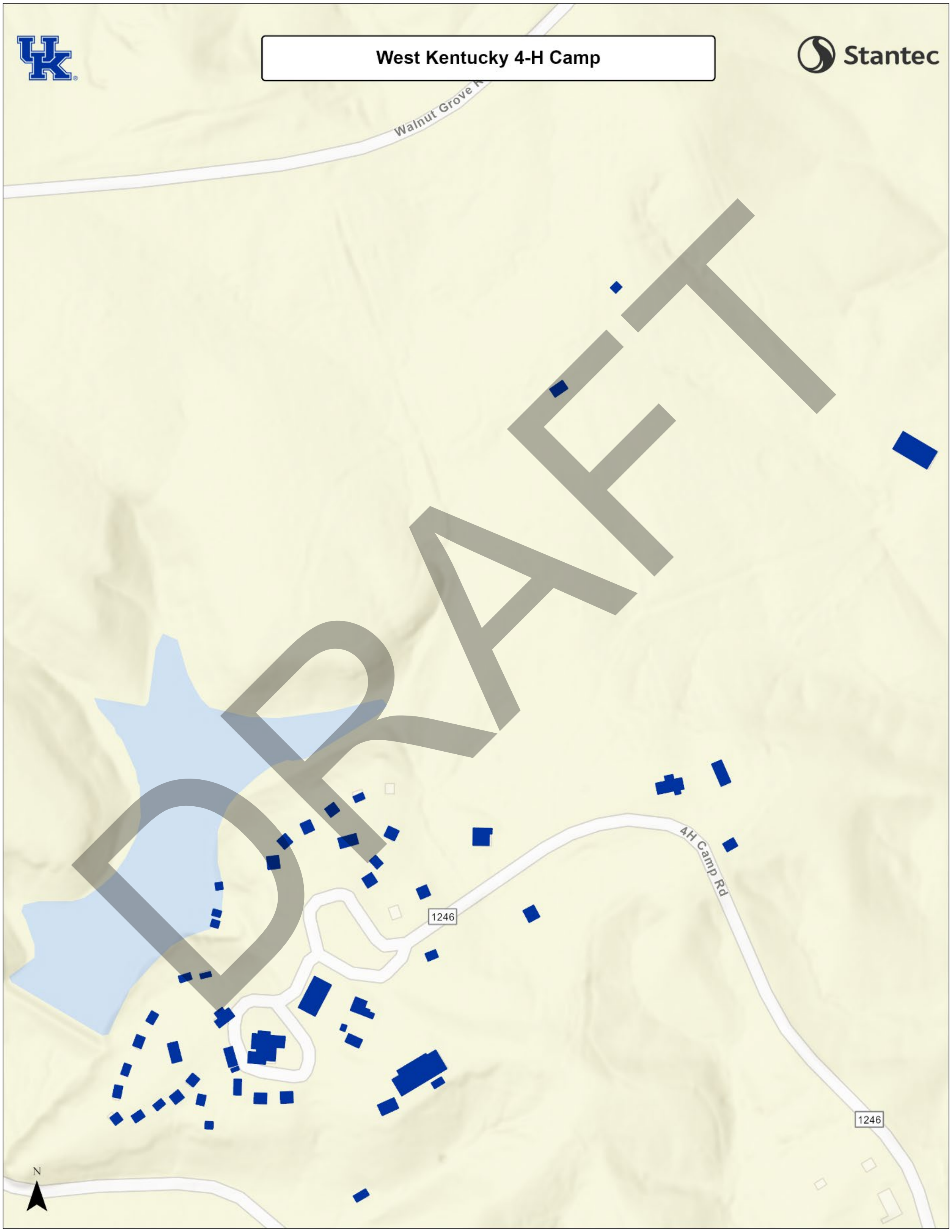


Figure 2-19: Map of West Kentucky 4-H Camp

2.3 Future Development

Significant design and construction projects have occurred since the last *UK Hazard Mitigation Plan*. UK maintains a website for the public to view current and past construction projects. **Figure 2-20** depicts the current construction at Alumni Commons. Development includes improvements and new buildings on the main campus and outlying campuses such as UKREC in Princeton, Kentucky as well as the King's Daughters Hospital acquisition in Ashland, Kentucky.

The UK Board of Trustees approved a $38 million project to rebuild the main building at UKREC after it was destroyed by a tornado in December 2021. The project includes a whole station planning effort and the design of a new Grain and Forage Center of Excellence.

UK and King's Daughters have been working together as members of Royal Blue Health LLC (RBH) for nearly two years. During this time, King's Daughters experienced significant growth in employees and revenues. It started to build and expand important infrastructure to improve access and care for people in the region. In October 2022, the UK Board of Trustees approved plans for the King's Daughters to become part of UK and the transition was complete as of Dec. 1, 2022.

Notable future development announcements made during the development of this plan include:

- Expansion of the Chandler Medical Campus to include a new patient care tower and renovation of the existing Mother Baby and Labor and Delivery units, expanding operating rooms, relocation and renovation of endoscopy units and establishment of a new observational unit.[27]
- Renovation of Memorial Coliseum expected to be completed in the fall of 2024 with an estimate cost of $82 million, The modernization will encompass all of the building interior and bring climate-control improvements; modern seating for campus, community and athletic events; systems-related upgrades such as life safety, security, and lighting and sound.[28]
- A $10 million gift will support the renovation and expansion of the Funkhouser Building, adding 100,000 square feet of state-of-the-art teaching and research spaces to UK engineering. The project aims to support enrollment growth, additional faculty members and research goals.[29]

It is anticipated that continued growth will continue on university campuses and through potential acquisitions. The following paragraphs, figures, and tables summarize development since the last hazard mitigation plan, construction projects and future development. UK is expected to develop a map during the summer of 2023 summarizing future development.

[27] See "Plans announced for Chandler medical campus expansion to allow for more inpatient beds, access and services, https://uknow.uky.edu/uk-healthcare/plans-announced-chandler-medical-campus-expansion-allow-more-inpatient-beds-access-and?j=600274&sfmc_sub=251374175&l=7849_HTML&u=21687511&mid=10966798&jb=8009"

[28] See "UK Athletics Committee Approves Renovation of Memorial Coliseum", https://ukathletics.com/news/2023/02/16/uk-athletics-committee-approves-renovation-of-memorial-coliseum/?j=578287&sfmc_sub=122679007&l=23219_HTML&u=20332250&mid=10966798&jb=0

[29] UK Engineering graduate makes history with $34.5 million gift to advance the college, support students University of Kentucky, https://kentuckycan.uky.edu/your-gifts-at-work/uk-philanthropy-news/Pigman-gift

Figure 2-20: Current Construction at Alumni Commons

Completed projects include:

Table 2-7: Completed Projects

Completed Projects
Alumni Drive Stream Restoration
Construct Greek Housing - Alpha Delta Pi
Construct Research Building 2 - Fit-up of two wet labs
Construct Research Building 2
Expand Student Center (Dining)
Gatton College of Business
Gatton Student Center Construction (2016-2018)
Fit-up Pav. A, Ground Floor for COVID19-virus Patient Treatment
Improve Building Mechanical Systems - Ag North HVAC
Improve Campus Parking and Transportation System - PS #5 Addition
Improve Campus Parking & Transportation System - 2021 Parking Maintenance
Improve Good Samaritan Hospital Facilities - 3rd Floor Renovation
Jacobs Science Center

Completed Projects
Kentucky Proud Park
Renew/Modernize Facilities - Patterson Office Tower, 18th Floor
Renew/Modernize Facilities - White Hall Classroom Building - Phase 1
Renew/Modernize Facilities - White Hall Classroom Building - Phase 2
Renovate Housing (Alpha Gamma Delta)
Renovate/Expand Student Center
Renovate/Upgrade UK HealthCare Facilities (Phase I-I) - Interventional Services
Renovate/Upgrade HealthCare Facilities (Phase I-F) - Kentucky Children's Hospital NICU
Repair/Upgrade/Improve Building Systems - UK HealthCare - Pav HA AHU #'s 1, 2 & 3
Research Building 2
Rosenberg College of Law
UK HealthCare Disparities Initiative Research Building 2 - Phase II)

As construction continues across campus, tools are utilized to alert the public regarding:

- Utility work and road closures: University of Kentucky Construction (uky.edu)
- Alerts regarding construction: University of Kentucky Construction (uky.edu)
- Details regarding projects, including building improvements and impacts to campus: University of Kentucky Construction (uky.edu)

A list of projects currently in the design phase Capital Project Management | seeblue (uky.edu) are shown in **Table 2-8.**

Table 2-8: Projects in the Design Phase

Design
Construct Agriculture Research Facility 2 (Poultry Office Building)
Construct Ambulatory Facility - UK HealthCare (Cancer Treatment Center/Ambulatory Surgery Center) Design Only
Construct College of Medicine Building (Design Only)
Construct/Expand/Renovate Ambulatory Care - UK HealthCare (Pavilion HA Forensics/Pediatric Sleep Study)
Construct Indoor Track
Construct/Improve Greek Housing - Delta Gamma

Design
Construct Research Building 2 (Final Phase)
Forage Animal Production Research Lab - USDA Laboratory
Grain and Forage Center Emergency Project Design
Improve Athletics Facility 2 (Nutter Fieldhouse)
Improve Center for Applied Energy Research Facilities - Carbon Fiber Development Facility
Improve Memorial Coliseum
Improve Parking/Transportation System UK HealthCare (Parking Structure #8 Expansion - Design Only)
Improve Sanders-Brown Center on Aging/Neuroscience Facilities
Parking Structure 2 Partial Renovation
Patient Care Facility (Fit-up Pavilion A Basement and Other Improvements Phase I-J)
Renew/Modernize Facilities - Reynolds Building #1 - Design Only
Renew/Modernize Facilities - Rose Street Enabling Phase II
Renovate/Improve Nursing Units - UK HealthCare (Pav H 3rd Floor Behavioral Health)
Renovate/Upgrade UK HealthCare Facilities (Phase I-I) - (c) Fit-up 12th Floor Pavilion A
Repair/Upgrade/Expand Central Plants (Expand Central Plants - Design Only)
Upgrade/Renovate/Expand Research Labs (Biosafety Lab Renovation - Health Science Research Building)
Upgrade, Renovate, Expand Research Labs (Educe Lab)
Construct Agriculture Research Facility #2 – Poultry Research Facility Relocation
Construct Beam Institute 1 – Still Building (Beam Institute)
Construct Beam Institute 2 – Construct Maturation Building
Construction Facilities Shops and Storage Facility (Vaughan Warehouse #1 and #7 Replacement UK Healthcare
Cooling Plan #1 Tower Replacement
Facilities Renewal, Modernization and Deferred Maintenance - Chemistry/Physics 3rd Floor
Improve Academic/Administrative Space 1 - Cooper House
Improve Building Systems -UK HealthCare - Pav WH AHU 4 and 5
Improve Building Systems - UK HealthCare Pavilion H - Replace AHU S1 and S1A

Design
Improve Campus Parking and Transportation System - 2022 Maintenance
Improve Center for Applied Energy Research Facilities - Mineral Process Building Expansion
Improve Coldstream Research Campus (Public Infrastructure)
Improve Electrical Infrastructure - Ag Complex
Improve Kroger Field Stadium (Audio Visual Improvements)
Renew/Modernize Facilities - Chemistry/Physics Phase II
Renovate/Upgrade UK HealthCare Facilities (Phase I-I) - (c) Fit-up 5th
Repair/Upgrade/Expand Central Plant – Deaerators

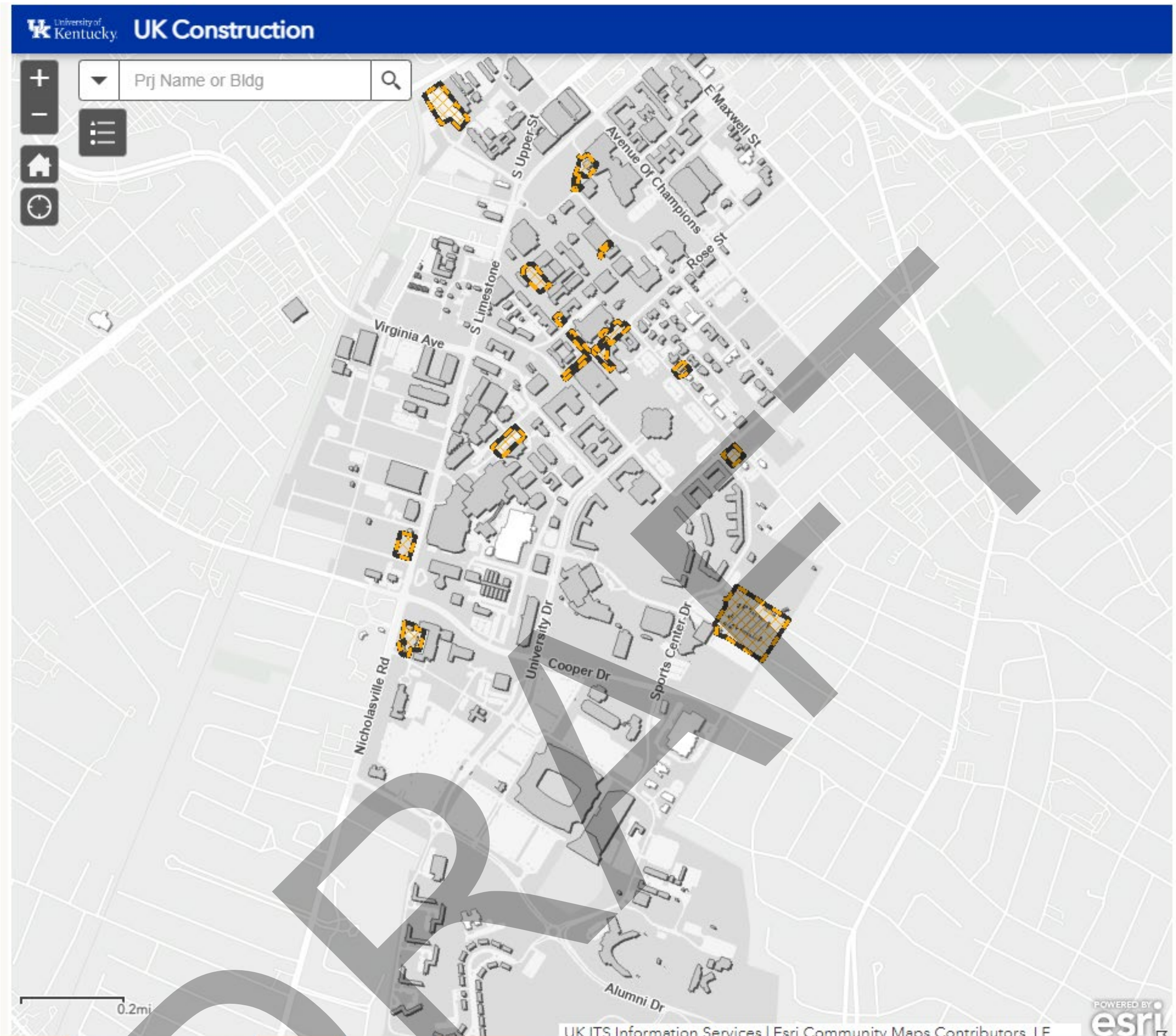


Figure 2-21: UK Construction Map

Table 2-9 provides a summary of the projects that are in the construction phase.

Table 2-9: Projects in the Construction Phase

Construction
Construct Agriculture Research Facility #2 - Poultry Research Facility Relocation
Construct Beam Institute 1 - Still Building (Beam Institute)
Construct Beam Institute 2 - Construct Maturation Building)
Construct Facilities Shops & Storage Facility (Vaughan Warehouse #1 & #7 Replacement for UK Healthcare)
Cooling Plant #1 Tower Replacement
Facilities Renewal, Modernization and Deferred Maintenance - Chemistry/Physics 3rd Floor
Improve Academic/Administrative Space 1 - Cooper House
Improve Building Systems -UK HealthCare - Pav WH AHU 4 & 5
Improve Building Systems - UK Healthcare Pavilion H - Replace AHU S1 and S1A
Improve Campus Parking and Transportation System - 2022 Maintenance
Improve Center for Applied Energy Research Facilities - Mineral Process Building Expansion
Improve Coldstream Research Campus (Public Infrastructure)
Improve Electrical Infrastructure - Ag Complex
Improve Kroger Field Stadium (Audio Visual Improvements)
Renew/Modernize Facilities - Chem/Physics Ph II
Renovate/Upgrade UK HealthCare Facilities (Phase I-I) - (c) Fit-up 5th
Repair/Upgrade/Expand Central Plant – Deaerators

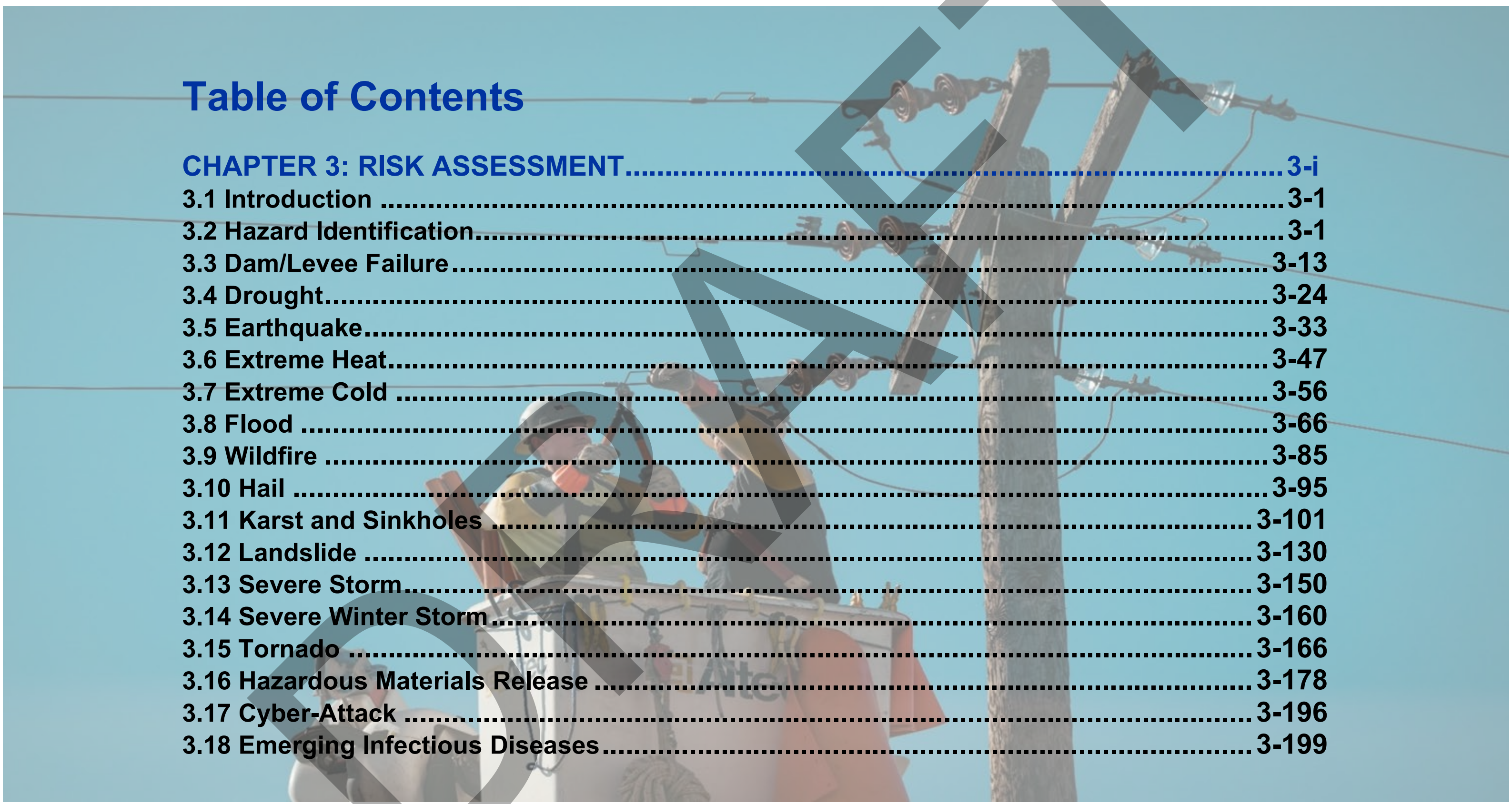


Table of Contents

Chapter 3: Risk Assessment

3.1 Introduction

This chapter provides a risk assessment of natural, technological and human-related hazards that could impact the University of Kentucky (UK) and its facilities. All hazards include a profile and a vulnerability assessment. All hazards include a qualitative analysis of the university's vulnerability and, when data permits, a quantitative analysis.

The hazard profile includes a description of the nature of the hazard, location, past occurrences and damages, extent (or magnitude) of the hazard and likelihood or probability of the hazard occurring in the future. UK's assets have been examined to estimate the potential health, safety and property damages attributable to hazards in the vulnerability assessment. In addition, each hazard includes climate change considerations, as applicable.

3.2 Hazard Identification

Hazard identification is the process of identifying the types of hazards that can affect the mitigation plan study area – UK and its facilities. Hazards were identified from various sources: the 2015 *University of Kentucky Hazard Mitigation Plan*, the *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* and previous disaster declarations. Input from the planning team was also solicited and used to identify hazards. These sources and the process are further explained below.

3.2.1 Disaster Declarations

Since reporting began in 1953, 12 hazard events have resulted in damage severe enough to warrant a federal Presidential Disaster Declaration in Fayette County, where UK's main campus is located. Presidential Disaster Declarations are declared at the county-level; declarations made for Fayette County are considered as applicable to UK's main campus. Presidential Disaster Declarations are declared at the county-level; declarations made for Fayette County are considered as applicable to UK's main campus. Details for these declarations are presented in **Table 3-1**.

Table 3-1: Disaster Declarations in Fayette County since 1953

Declaration Date	Disaster Number	Incident
12/12/1978	568	Severe storms and flooding
02/24/1989	821	Severe storms and flooding
03/16/1994	1018	Severe weather, freezing rain, sleet, snow
01/13/1996	1089	Blizzard of 1996
03/04/1997	1163	Severe storm, flooding and tornadoes
03/14/2003	1454	Severe winter ice and snowstorms, heavy rain, flooding, tornadoes and mudslides
06/10/2004	1523	Severe storms, tornadoes, flooding and mudslides
02/21/2008	1746	Severe storms, tornadoes and straight-line winds
02/05/2009	1818	Severe winter storm and flooding
05/11/2010	1912	Severe storms, flooding, mudslides and tornadoes
03/28/2020	4497	COVID-19 Pandemic
04/23/2021	4595	Severe storms, flooding, landslides and mudslides

As part of its dedication to serving the entire Commonwealth of Kentucky, the university runs a variety of campuses throughout the state. These campuses include medical schools, outreach facilities, research facilities and 4-H camps. These facilities are further detailed in proceeding sections and in **Chapter 2 Campus Profile**.

Since 1953, there have been 73 federal disaster declarations in Kentucky. Disaster declarations are made at the county level and can cover more than one county. The number of disaster declarations, by county, for those with UK facilities are shown in **Table 3-2.**

Table 3-2: Disaster Declarations in Counties with UK Facilities

County	Number of Disaster Declarations
Breathitt	35
Caldwell	15
Campbell	9
Fayette	12
Hopkins	20
Kenton	8
Laurel	16
McCracken	15
Nicholas	22
Perry	35

County	Number of Disaster Declarations
Pulaski	14
Warren	15
Woodford	14

3.2.2 Hazard List

This plan was developed as an update to the 2015 *University of Kentucky Hazard Mitigation Plan*. To develop the list of hazards, several sources were reviewed including the 2015 *University of Kentucky Hazard Mitigation Plan*, 2020 *Lexington-Fayette County Hazard Mitigation Plan* and 2018 *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan (CK-EHMP 2018).* Input was gathered from the planning team to discern hazards that should be added or removed from a preliminary list derived from the plans above. Hazards were reviewed with the planning team and steering committee and finalized afterward. **Table 3-3**: presents the final hazards list for this plan update and whether each hazard was recognized in CK-EHMP 2018. **Table 3-4** indicates the hazards from CK-EHMP 2018 that were excluded from this plan update and provides a justification for exclusion.

Table 3-3: Hazards identified for the 2023 UK Hazard Mitigation Plan

2023 UK Hazard Mitigation Plan	CK-EHMP 2018 Identified Hazard
Weather Hazards	
Extreme Heat	Yes (Under Extreme Temperatures)
Extreme Cold	Yes (Under Extreme Temperatures)
Wildfire	Yes
Hail	No
Severe Storm	Yes (Under Wind Profile)
Severe Winter Storm	Yes
Tornado	Yes (Under Wind Profile)
Hydrological Hazards	
Flood	Yes
Drought	No
Dam / Levee Failure	Yes
Geological Hazards	
Earthquake	Yes
Landslide	Yes
Karst	Yes
Industrial Hazards	
Hazardous Materials Release	No
Human-Caused Hazards	
Cyber Attack	No
Emerging Infectious Disease	No

Table 3-4: Justification for Excluded Hazards

CK-EHMP 2018 Identified Hazard (Excluded from 2023 UK HMP)	Justification
Mine Subsidence	Mine Subsidence was not included as a separate hazard in the 2018 plan and was not noted as a hazard of concern by the planning team. Mine Subsidence is addressed under the Karst Profile.

3.2.3 Sources of Information

Information and data for UK facilities and infrastructure was provided by various UK departments and included geospatial data, loss information, damage descriptions, statistical information and campus plans. This information was used to assess the assets, including critical facilities, owned by and affiliated with UK during the hazard vulnerability assessment process. Data from the university was used to provide spatial locations for assets when applicable. Hazard information and data was collected for all hazards from hazard studies, historic datasets, previous weather and climate publications and ongoing research. Spatial data was collected for hazards as available and used to assess hazard vulnerability for a number of the natural hazards using GIS-based analysis. This information is cited throughout the plan.

UK staff and student input was an invaluable resource throughout the planning process. Stakeholders attended steering committee and planning team meetings, completed a hazard identification exercise and provided information regarding hazards and university assets. Steering committee members discussed issues such as how past events impacted the university community and properties. Targeted interviews with UK faculty and staff provided insight into unique university vulnerabilities, including those around sensitive materials, research and equity considerations. Lastly, student input was gathered at public meetings and incorporated into the risk assessment as appropriate.

Local Sources

- *Lexington-Fayette Urban County Hazard Mitigation Plan*
- Local news sources

UK Sources

- 4-H Youth Development
- Auxiliary Services
- Campus Planning
- Capital Asset Accounting
- Martin-Gatton College of Agriculture, Food and Environment (CAFE)
- College of Medicine
- Crisis Management and Preparedness
- Environmental Health and Safety
- Information Technology Services
- Risk Management
- Office of the Vice President of Research
- Information gathered from steering committee meetings and calls
- Information gathered from interviews with university officials

- Reports, studies and memos provided by UK

State Sources

- *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan (CK-EHMP 2018)*
- Kentucky state agency maps, data reports and webpages applicable to the planning area, including but not limited to those from the Kentucky Geological Survey, Kentucky Emergency Management and the Kentucky Energy and Environment Cabinet

Federal Sources

- Environmental Protection Agency (EPA) information
- Federal Emergency Management Agency (FEMA) mapped flood hazards areas
- Midwestern Regional Climate Center
- National Oceanic and Atmospheric Association (NOAA) National Centers for Environmental Information (NCEI) Storm Events Database
- National Risk Index
- National Weather Service
- U.S. Climate Resilience Toolkit
- U.S. Department of Agriculture (USDA) Forest Service wildfire hazard potential and wildland-urban interface data
- U.S. Drought Monitor
- U.S. Geological Survey (USGS) data and information
- U.S. Department of Transportation (DOT) Pipeline Hazard Safety Administration data
- U.S. Transportation Safety Administration information
- U.S. Centers for Disease Control information
- U.S. Global Change Research Program information and data

Data Limitations

Although UK has a wealth of available data, data limitations constrict the planning team at certain points. Data limitations are described below.

Previous occurrences for many hazards were gathered from the NOAA NCEI Storm Events Database, which is not reflective of all hazard events that have occurred. In general, the Storm Events Database includes events that are noted through news sources and/or weather radios. It also does not include specific insurance claims; the occurrence of certain hazards is likely under-reported.

Hazard data, including previous occurrences and risk information, is often available at the county-level or city-level and events specific to UK campuses could not be discerned. Additional sources for previous occurrences, such as university loss data, were considered when available.

Building values obtained from UK's Risk Management Office are from 2022 and may not be inclusive of new buildings or improvements constructed after 2022. The original building footprint dataset was expanded to include structures at the 4-H camps and the outlying campuses.

Furthermore, the building dataset used throughout the risk assessment is a compilation of multiple datasets provided by the university. Attributes of the final building dataset were added from appropriate university sources, including building structure and content value, research expenditure estimates, insurance claims information and an indication of whether the building is a critical facility. The information included in these attributes is based on data provided by UK and reflects the best available data at the time it was gathered. Therefore, certain datasets may not reflect recent improvement to university assets. For example, the Building Condition dataset is from 2014 and does not reflect the condition of structures that have been renovated in recent years.

Not all hazards have identified geographic boundaries; therefore, a GIS Intersection analysis could not be performed to identify vulnerable buildings, infrastructure and populations. In this case, it was assumed that all current and future buildings and populations are at risk.

Several different sources of climate change data were used to analyze future risk. Different sources use different scenarios, geographic regions and timelines. Therefore, projections are not always consistent. In addition, future conditions (e.g., emissions, radiative forcing, subsequent impacts) are difficult to predict, and there is a known uncertainty associated with climate projections and models. Uncertainty differs for hazards; for instance, temperature models are considered more certain than precipitation models. For certain hazards, climate impacts were not available or were inconclusive.

Uncertainties are inherent in any vulnerability assessment, arising in part from incomplete scientific knowledge concerning natural and man-made hazards and their effects on the built environment. Uncertainties can also result from approximations and simplifications that are necessary for a comprehensive analysis (such as incomplete inventories, demographics, loss data or economic parameters).

3.2.4 Summary of Data Analyzed

UK is one of only eight academic institutions in the country that offers a full complement of liberal arts, engineering, professional, agricultural and medical colleges and disciplines on one campus. The main campus, shown in **Figure 3-2**, is located in the heart of the City of Lexington. In total, UK offers over 200 academic programs. As a result, UK has facilities across the entire Commonwealth of Kentucky. In addition to the main campus, there are 11 other campuses, as well as facilities utilized by the College of Medicine, the Martin-Gatton College of Agriculture, Food and Environment and the 4-H Youth Development program. The risk assessment assesses risk to UK's campuses and 4-H Camps, detailed in **Table 3-5.** These locations are shown in **Figure 3-1**.

Table 3-5: Risk Assessment Facilities

Risk Assessment Facilities	
Campus Name	**Location**
Center for Excellence in Rural Health	Hazard, KY
Stanley and Karen Pigman College of Engineering, Paducah Campus	Paducah, KY
College of Medicine at Bowling Green	Bowling Green, KY
College of Medicine at Northern Kentucky, Edgewood Campus	Edgewood, KY
College of Medicine at Northern Kentucky, Highland Heights Campus	Highland Heights, KY
J.M. Feltner 4-H Camp	London, KY

Risk Assessment Facilities	
Lake Cumberland 4-H Camp	Nancy, KY
Little Research Center/Woodford Farm Campus	Versailles, KY
Main Campus	Lexington, KY
North Central 4-H Camp	Carlisle, KY
North Farm Campus (includes North Farm Agricultural Center and Eastern State Hospital)	Lexington, KY
Research and Education Center	Princeton, KY
Robinson Center for Appalachian Resource Sustainability	Quicksand, KY
Robinson Forest Campus	Clayhole, KY
South Farm Campus	Lexington, KY
West Kentucky 4-H Camp	Dawson Springs, KY

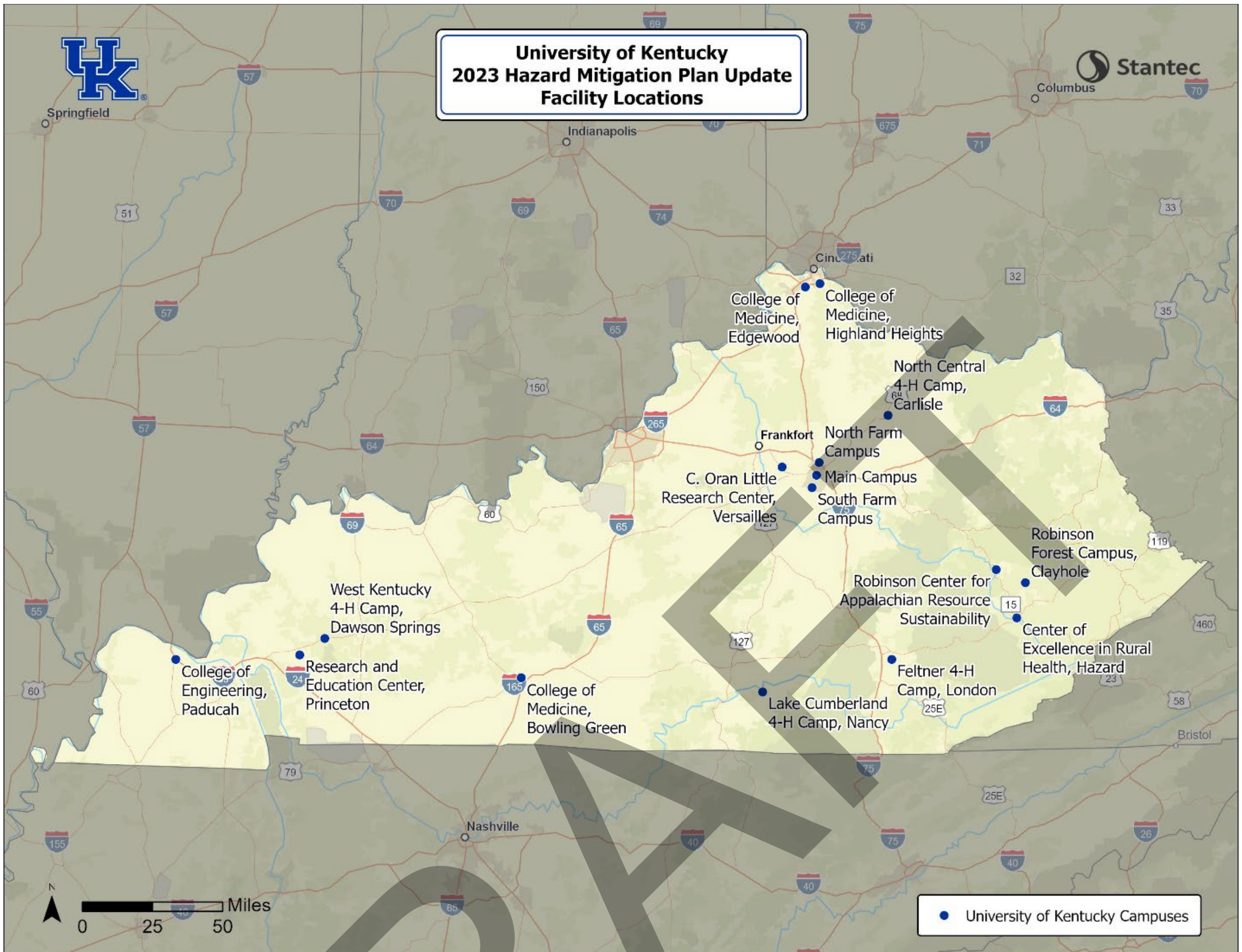


Figure 3-1: UK Campuses and 4-H Camps

Figure 3-2: UK Main Campus

Building footprint data was provided by UK's Information Technology Services (ITS) for nearly all structures owned or affiliated with the university. Several of UK's outlying campuses and camps did not have building footprints for all buildings; a building footprint was created from open-source building footprint data or by digitizing a building footprint from satellite imagery for existing buildings not included in UK's building footprint dataset.

As discussed in **3.2.3 Sources of Information**, university staff from various departments provided datasets used to understand building-level vulnerability to hazards. As available, this data was combined with building footprint data provided by ITS to develop a geodatabase of all university buildings, inclusive of campuses and 4-H camps. **Table 3-6** details the building-level information, or attributes, assessed for each building. Where possible, a GIS intersection analysis was performed using building footprint data and hazard data to determine the number and value of buildings at risk and to estimate potential losses. However, data limitations hinder the ability to conduct this analysis on all hazards (and many hazards impact the entire planning area). Appendix B summarizes all university buildings and associated information for the attributes presented below.

Table 3-6: Building Footprint Data Attributes

Attribute	Description
Ownership	Ownership Status
Campus	Identifies the UK campus a building resides within
Structure Value	Building structure value provided by Risk Management
Content Value	Building content value provided by Risk Management
Critical Facility	Indicates whether a building was identified by the planning team as a critical facility
Research Expenditure Estimate	An estimated research expenditure associated with each building, provided by the Vice President of Research's Office
Condition Rating	Indicates the building condition of each building, provided by Campus Planning Office
Infectious Disease Agent Presence	Indicates if the building stores infectious disease agents; provided by Environmental Health and Safety
Insurance Claims Associated with a Specific Hazard	Insurance claims for the building from 2012 and 2022 associated with an identified hazard
Damages from Hazard-related Claims	Hazard-related damages claimed for the building from 2012 and 2022, rounded to the nearest hundred-dollar amount
Karst Hazard Risk Rating	Karst hazard risk rating for the building, based on data from KGS
Earthquake Hazard Risk Rating	Earthquake hazard risk rating for the building, based on data from USGS
Landslide Hazard Risk Rating	Landslide hazard risk rating for the building, based on data from USGS

Attribute	Description
Wildfire Hazard Risk Rating	Wildfire hazard risk rating for this building, based on data from USDA
Dam Failure Hazard Risk Rating	Dam failure hazard risk rating for this building, based on data from the Kentucky Division of Water
Flood Hazard Risk Rating	Flood hazard risk rating, based on data from FEMA
HAZMAT Fixed Sites Risk Rating	HAZMAT hazard risk rating, based on EPA data
HAZMAT Highways/Freeways Risk Rating	HAZMAT hazard risk rating, based on U.S. DOT data

Areas of growth and future development were identified by university staff and members of the steering committee. These areas are presented in **2.2.4 Areas of Future Development**.

3.2.5 Profiling Hazards

Due to UK's geology, climate and wide-spanning geography (e.g., many campuses throughout the state), the area is vulnerable to a wide array of hazards that threaten university life and property. Each hazard is profiled separately to describe the hazard and potential impacts to UK. Where data exists, specific information on location will also be included. When applicable, impacts from climate change are integrated throughout each hazard profile, including observed climate trends, projected impacts on hazard extent and future probability and expected impacts on vulnerability. The profile for each hazard includes:

- Description: A scientific explanation of the hazard including potential magnitude (or severity) and impacts (including climate change considerations);
- Location: Geographical extent of the hazard;
- Previous occurrences: The number of previous impacts from the hazard on campuses and 4-H camps in the past;
- Extent (or magnitude): The severity of the hazard in the past and potential severity in the future (including climate change considerations). Measures may include wind speed, temperature extremes or property damage, for example;
- Probability of future events: The likelihood of future events impacting the university (including climate change considerations). Given that an exact probability is often difficult to quantify, this characteristic is categorized into ranges to be used in hazard profiles:
    - Unlikely: Less than one percent annual probability
    - Possible: Between one percent and 10 percent annual probability
    - Likely: Greater than 10 percent and less than 90 percent annual probability
    - Highly Likely: Greater than 90 percent annual probability
- Vulnerability assessment: The vulnerability assessment investigates the potential number of and type of structures at risk, potential dollar loss and potential impacts resulting from each hazard based on available data and information. Potential impacts to buildings, critical facilities, infrastructure, life safety, public health and university operations are considered applicable.

Hazards Assessed Geospatially

Hazard information was collected for all hazards under consideration using hazard studies, GIS data and descriptions of previous events. This information is cited throughout the plan.

GIS tools provide a mechanism to perform quantitative analysis. Hazards that have specified geographic boundaries permit analysis using GIS. Profiled hazards that were assessed using GIS include:

- Dam Failure
- Earthquake
- Flood
- Karst and Sinkholes
- Landslide
- Wildfire
- Hazardous Materials Releases

The objective of the GIS-based analysis was to determine the estimated vulnerability of critical facilities and structures for the identified hazards on campus using best available geospatial data. ESRI® ArcGIS Pro™ 2.9 was used to assess hazard vulnerability utilizing digital hazard data, such as FEMA Flood Insurance Rate Maps (FIRMs), karst potential and wildfire probability maps. Using these data layers, hazard vulnerability can be assessed by estimating the number and type of structures determined to be in identified geographic hazard area boundaries.

3.3 Dam/Levee Failure

3.3.1 Description

A dam is an artificial barrier constructed across a stream channel or a man-made basin for the purpose of storing, controlling or diverting water. Dams typically are constructed of earth, rock, concrete or mine tailings. The area directly behind the dam where water is impounded or stored is referred to as a reservoir.

A dam failure is the partial or total collapse, breach or other failure of a dam that causes flooding downstream. Dam failures can result from natural events such as a flood event, earthquakes or landslides, human-induced events such as improper maintenance, or a combination of both. In the event of a dam failure, the people, property and infrastructure downstream could be subject to devastating damage.

Dam failures can result from one or more of the following:

- Prolonged periods of rainfall and flooding (the cause of most failures)
- Inadequate spillway capacity resulting in excess flow overtopping the dam
- Internal erosion caused by embankment or foundation leakage
- Improper maintenance (including failure to remove trees, repair internal seepage problems, maintain gates, valves and other operational components, etc.)
- Improper design (including use of improper construction materials and practices)
- Negligent operation (including failure to remove or open gates or valves during high flow periods)
- Failure of an upstream dam on the same waterway

- Landslides into reservoirs which cause surges that result in overtopping of the dam
- High winds which can cause significant wave action and result in substantial erosion
- Earthquakes which can cause longitudinal cracks at the tops of embankments that can weaken entire structures

Dam regulation and classification in Kentucky. Kentucky Revised Statute (KRS) 151 establishes the State Dam Safety Program. The State Dam Safety Program is administered by the Dam Safety Program within the Energy and Environment Cabinet (EEC), Department for Environmental Protection (DEP), Division of Water (DOW).

KRS 151.293, Section 6 authorizes the EEC to inspect existing structures that meet the definition of a dam[1]. In determining the frequency of inspection of a particular dam, the cabinet takes into consideration the size and type, topography, geology, soil condition, hydrology, climate, use of the reservoir, the lands lying in the floodplain downstream and the hazard classification of the dam.

The Dam Safety Program administers the following activities[2]:

- Inspecting existing dams
- Assessing and ranking dams based on conditions and risks
- Issuing permits for dam construction/rehabilitation
- Managing dam-related risks to minimize hazard creep
- Preparing and reviewing Emergency Action Plans (EAPs)
- Communicating dam-related risks
- Managing the State-Owned Dam Repair (SODR) program

A levee is a is an earthen embankment, floodwall or structure along a water course whose purpose is flood risk reduction of water conveyance[3]. While levees reduce flood risk, they do not eliminate the risk of flooding[4]. Like dams, levees can deteriorate over time and lose their effectiveness. When levees fail, the results can be greater than if the levee was not in place.

Levees that are designed to reduce the one percent annual chance of flooding may be accredited by FEMA with the areas behind them designated as moderate-hazard zones[5]. Levees accredited by FEMA must be certified for compliance with Section 65.10 of the NFIP regulations. Levees that are not accredited by FEMA are not recognized as providing flood hazard reduction on the impacted FIRM panels.

[1] From "Dam Safety Division of Water", Kentucky Energy and Environment Cabinet, https://eec.ky.gov/Environmental-Protection/Water/FloodDrought/Pages/DamSafety.aspx
[2] From "2018 Kentucky Hazard Mitigation Plan Update – Dam Risk Assessment", Division of Water (2018)
[3] From "Levee Terms & Definitions", *Levee Safety Program, U.S.* Army Corps of Engineers, https://www.mvr.usace.army.mil/Missions/Flood-Risk-Management/Levee-Safety-Program/Levees/Terms-Definitions/#:~:text=Levee%3A%20An%20earthen%20embankment%2C%20floodwall%2C%20or%20structure%20along,map%20the%20floodplain%20behind%20a%20given%20levee%20system.
[4] See "Living with Levees", FEMA (2020), https://www.fema.gov/flood-maps/living-levees
[5] From "Living with Levees: Cooperating Technical Partners and Engineers", FEMA (2021), https://www.fema.gov/flood-maps/living-levees/technical-partners-engineers

3.3.2 Location

Areas downstream of dams, specifically those within mapped inundation areas, are considered at risk. The U.S. Army Corps of Engineers National Inventory of Dams (NID) identifies twenty-one dams in Fayette County. Six dams are classified as High Hazard Potential Dams (HHPDs). HHPDs are those in which a failure or faulty operation may result in loss of life, economic impacts, environmental impacts and lifeline impacts. HHPDs do not classify the condition of the dam or risk of the dam failing. **Table 3-8** describes the dams in Fayette County and **Figure 3-4** shows their locations. The Kentucky Division of Water[6] developed inundation maps for all six HHPDs located in Fayette County, which are included throughout this section as applicable.

Table 3-7: Identified Dams in Fayette County

Number	Name	Owner	River	Hazard Potential Classification
1	Colony Unit 4	Private	Unnamed Tributary to Wolf Run	High
2	Don Jenkins Dam	Private	Unnamed Tributary to North Elkhorn Creek	Low
3	Earl Levy Lake Dam	Private	West Hickman Creek	Significant
4	Firebrook No 1	Private	South Elkhorn Creek	Low
5	Firebrook No 2	Private	South Elkhorn Creek	Low
6	Gess Property Lake Dam	Local Government	-	Low
7	Hank Whitman Dam	Private	Jacks Creek	Low
8	Hidden Hollow Dam	Private	Elk Lick Creek	Low
9	Kelly Lake	Private	Trib-Elk Lick Creek	Low
10	Kentucky Horse Park Dam	State	Cane Run	Low
11	Lexington Reservoir No 3	Private	West Hickman Creek	High
12	Lexington Reservoir No 4	Private	East Hickman Creek	High
13	Lochdale Dam	Private	Waveland Tributary	Significant
14	Man-O-War Dam	Private	North Elkhorn Creek	Significant
15	Masterson Station Unit 11-C	Private	Town Branch	Low
16	Overbrook Farm Dam	Private	-	Low
17	Saddle Club Subdivision Dam	Private	Unnamed Tributary Wolf Run Creek	High
18	Sharp Lake	Private	Trib-Boone Creek	Low
19	Walnut Hill Dam	Private	North Elkhorn Creek	Low

[6] See "Dam Inundation Area Viewer", Kentucky Division of Water, https://kygis.maps.arcgis.com/apps/webappviewer/index.html?id=a4b89b6d79434adc9a4d3b0c9d644019

Number	Name	Owner	River	Hazard Potential Classification
20	Wellington Unit 1-B	Local Government	South Elkhorn Creek	High
21	Wellington Unit 4	Local Government	South Fork Elkhorn Creek	High

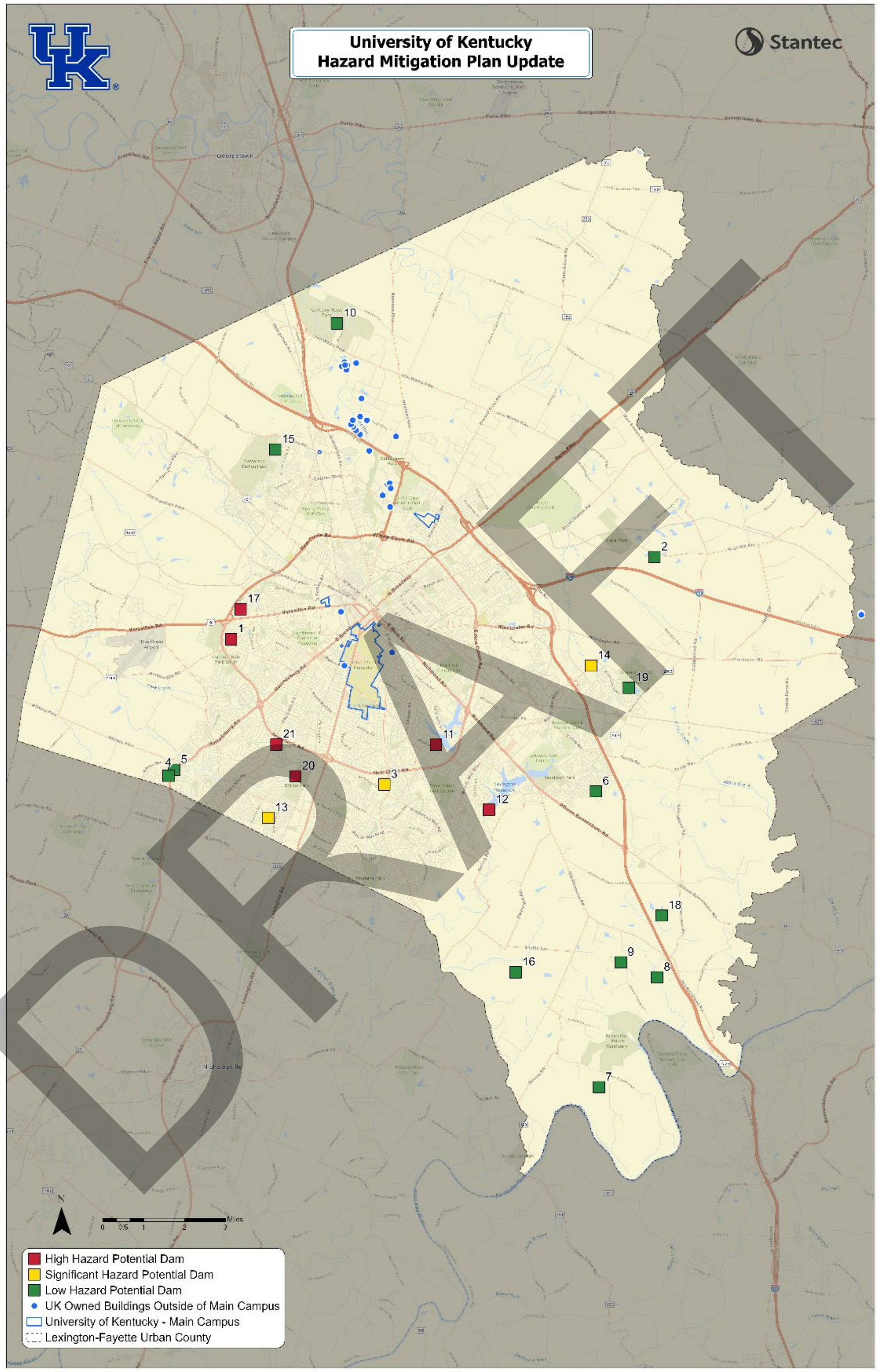


Figure 3-3: Fayette County Identified Dams and Hazard Potential

Kentucky has 35 levee systems and approximately 150 miles of levees[7]. There are no levees in Fayette County, however there are levees in Campbell County, Kenton County and McCracken County where the university has outlying facilities. Areas that have their flood hazard areas reduced by levees are considered at risk from levee failure.

3.3.3 Previous Occurrences

There are 13 dam incidents reported in Kentucky in the National Performance Dam Program Incident Database[8] between 1973 and 1998, none of which occurred in Fayette County. The Association of State Dam Safety Officials identified 10 dam incidents in Kentucky between 1981 and 2021[9]. None of these events occurred in Fayette County.

The 2015 UK Hazard Mitigation Plan identifies three dam failure incidents that occurred in counties with outlying UK campuses. The events occurred in December 1981 in Harlan County, in 1993 in Boone County (Treasure Lake Dam) and on October 11, 2000, in Martin County (Massey Dam). The 1981 Harlan County dam failure resulted in a fatality. The Massey dam failure released over 300 million gallons of slurry and toxic coal ash. The EPA collected its largest fine ever at the time under its wastewater permit program. Both the December 1981 Harlan County dam failure and the 2000 Massey failure were from coal waste impoundments. No known impacts to UK or its facilities occurred from these events.

Through a search of available news articles and communication with university staff, no occurrences of levee failure impacting the university were identified. While the university has not reported any claims or impacts, dam or levee failure has the potential to be catastrophic.

3.3.4 Extent

Dam failure can be measured in terms of loss of life or property. Due to the limited number of historic events, the extent of dam failure on UK's main campus is difficult to determine, as no deaths or property damage have been reported; however, loss of life and property due to dam failure is possible. When a dam fails, an excess amount of water is suddenly let loose downstream, destroying anything in its path.

Levee failure results in the life and property behind the levee being unprotected from flooding impacts. Unless there is flooding, the life and property behind the levee are mostly likely not at immediate risk from the levee failing; however, when flooding occurs, the areas behind a failed levee may experience unexpected or more severe flooding.

Many dams and levees are built for flood protection and usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If a larger flood occurs, the dam may be overtopped.

If during the overtopping the dam fails or is washed out, the water behind it is released and becomes a flash flood. Failed dams and levees can create floods that have catastrophic impacts to life and property because of the tremendous energy of the released water.

[7] From "Levees of Kentucky", National Levee Database, https://levees.sec.usace.army.mil/#/
[8] From "Dam Incident Database", National Performance of Dams Program, http://npdp.stanford.edu/dam_incidents
[9] From "Dam Incident Database Search", Association of State Dam Safety Officials, https://damsafety.org/Incidents

3.3.5 Probability

With no reported events potentially impacting the campus, dam failure and levee failure are not a common occurrence on UK's main campus.

The probability of dam and levee failure could increase with changing climate conditions. Increases in precipitation, especially in the frequency and intensity of extreme events, could increase the probability of failure or overtopping. Warmer temperatures may negate some of the flooding effects of increased precipitation but may also result in more snow falling than rain.

Considering the above, a probability of possible (one to 10 percent annual chance) was assigned to the dam failure hazard.

3.3.6 Vulnerability Assessment

All current and future buildings, infrastructure and populations within dam inundation zones are considered at risk of dam failure, including critical facilities. No dollar losses are reported as a result of dam failure on UK's main campus or outlying campuses. The Kentucky Division of Water has developed inundation maps for high hazard potential dams (HHPDs) regulated by the Kentucky Division Water[10]. Dams regulated by the U.S. Army Corps of Engineers, the Division of Mine Reclamation and Enforcement or other federal and state agencies are not included in the maps. For the vulnerability assessment, an intersection analysis was performed to identify UK buildings within HHPD mapped inundation zones. This analysis does not include dams classified as significant hazard potential dams or low hazard potential dams, as inundation areas were not available.

Buildings, infrastructure and populations with reduced flood risk due to levees are considered at risk of levee failure. No dollar losses are reported due to levee failure on UK's main campus or outlying campuses. For FEMA accredited levees, the areas with reduced flood risk due to the levee are mapped. For the vulnerability assessment, an intersection analysis was performed to identify university buildings within the reduced flood risk areas or within 500 feet of reduced flood risk areas.

Main Campus

No main campus buildings were identified within the HHPD inundation zones as a result of the intersection analysis. While there are six HHPDs in Fayette County, none of their inundation areas are shown to impact the campus as shown in **Figure 3-5**. Additionally, a buffer analysis was run to check if any campus facilities fell within 500 feet of an inundation zone. No facilities were found to intersect with a HHPD inundation zone. The inundation zones show the water flowing away from campus in the case of dam failure for all six HHPDs.

While not managed by UK, damage to infrastructure located within inundation areas could impact the campus through power outages or water contamination. Further, access to campus could be impacted in the event that highways (such as KY-4 and U.S. 60), local roads, railroads or bridges are inundated during a dam failure event and deemed impassible.

All populations within dam inundation areas are considered at-risk of dam failure. This includes populations who reside in inundation areas, as well as populations in the inundation area for work or recreation.

[10] See "Dam Inundation Area Viewer", Kentucky Division of Water, https://kygis.maps.arcgis.com/apps/webappviewer/index.html?id=a4b89b6d79434adc9a4d3b0c9d644019

Students or employees of UK that live off campus may be impacted by dam failure in Fayette County. Several residential areas are shown in inundation zones. Dam failure can result in injuries and loss of life and result in the need for evacuations.

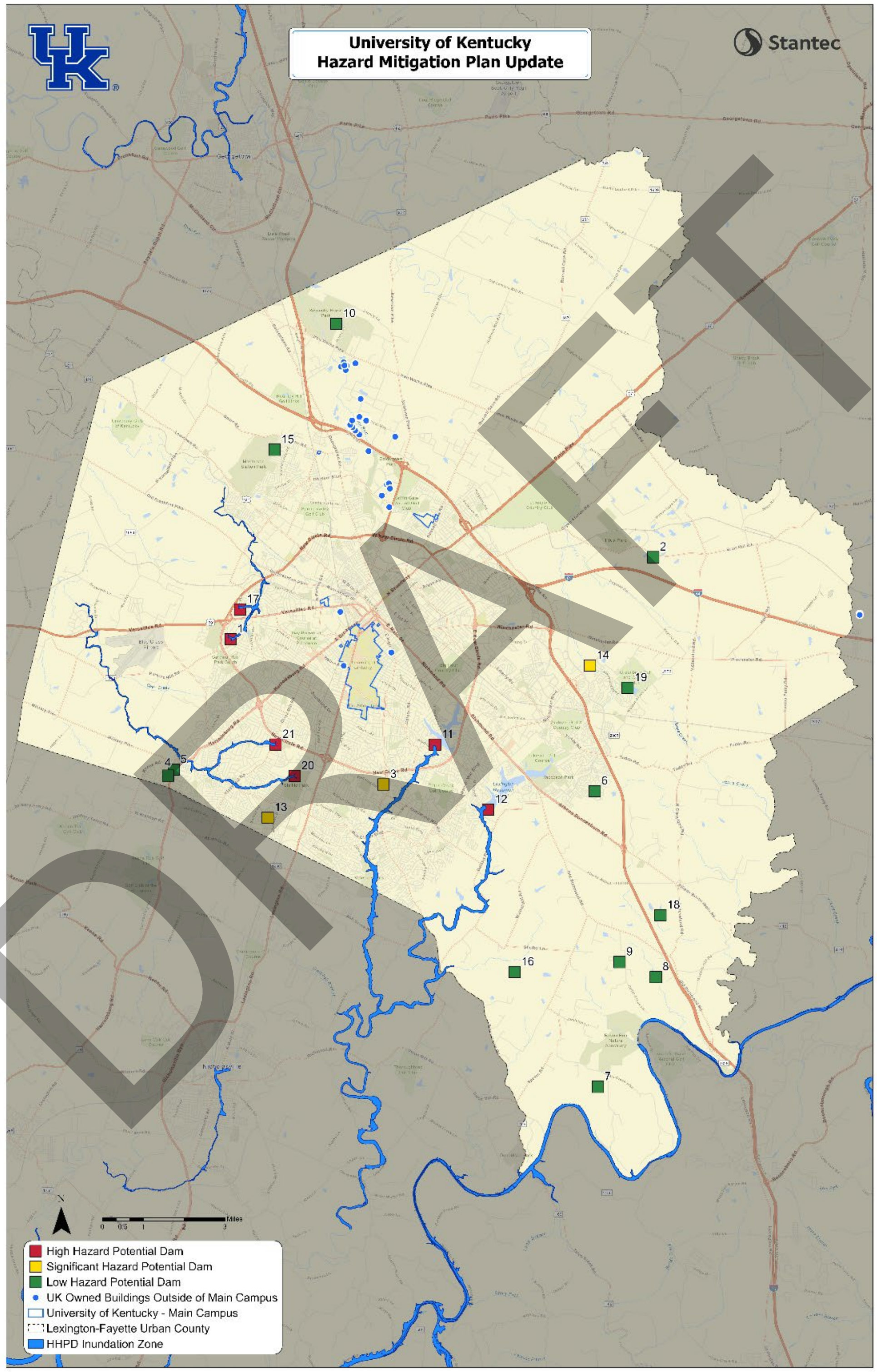


Figure 3-4: Fayette County HHPD Inundation Zones

There are no levees within Fayette County. Therefore, no facilities at UK's Main Campus intersect with reduced flood risk areas.

Outlying Campuses and 4-H Facilities

UK facilities in Fayette County outside the campus were also analyzed in relation to HHPD inundation zones. No facilities were found to intersect with a HHPD inundation zone. Additionally, a buffer analysis was run to check if any campus facilities fell within 500 feet of an inundation zone. No facilities were found to intersect with a HHPD inundation zone.

Throughout the engagement process, the university expressed concern with the proximity of two outlying campuses to dams. The Lake Cumberland 4-H Camp in Nancy, Kentucky is along the Cumberland River. Southwest of the camp is the Wolf Creek Dam, one of the largest dams in the United States and separates the Cumberland River and Lake Cumberland. In 2007, water levels had to be lowered over fear of dam failure and the dam was given a safety classification rating of one (almost certain to fail, immediately to within a few years without intervention)[11]. The dam was repaired in 2013 and the dam has a rating of 3 (significantly inadequate, or the combination of life, economic or environmental consequences where the probability of failure is moderate to high). In 2019, heavy rains and flooding caused the U.S. Army Corps of Engineers to release excess water due to dam failure concerns. This led to flooding downstream. The U.S. Army Corps of Engineers developed a flood inundation map in 2019 that has inundation zones for several release scenarios[12]. The location of the Lake Cumberland 4-H Camp was compared to the worst-case scenario of a 100,000 cfs release. The campus lies upstream of the dam; therefore, it is not shown to be within the inundation zone. The location of the camp was superimposed on the U.S. Army Corps of Engineers map as shown in **Figure 3-6**.

[11] See "'You live here, you worry': Lake Cumberland levels raise fears of dam break, despite reassurances", *Courier Journal*, Chris Kennings (2019), https://www.courier-journal.com/story/news/2019/02/26/kentucky-lake-cumberland-high-water-levels-from-flooding-rain/2983258002/

[12] From "February 2019 Wolf Creek Dam Inundation Map", U.S. Army Corps of Engineers (2019), https://www.arcgis.com/apps/View/index.html?appid=1e23f5a8f38e4addb9fe3bb9b46154a5

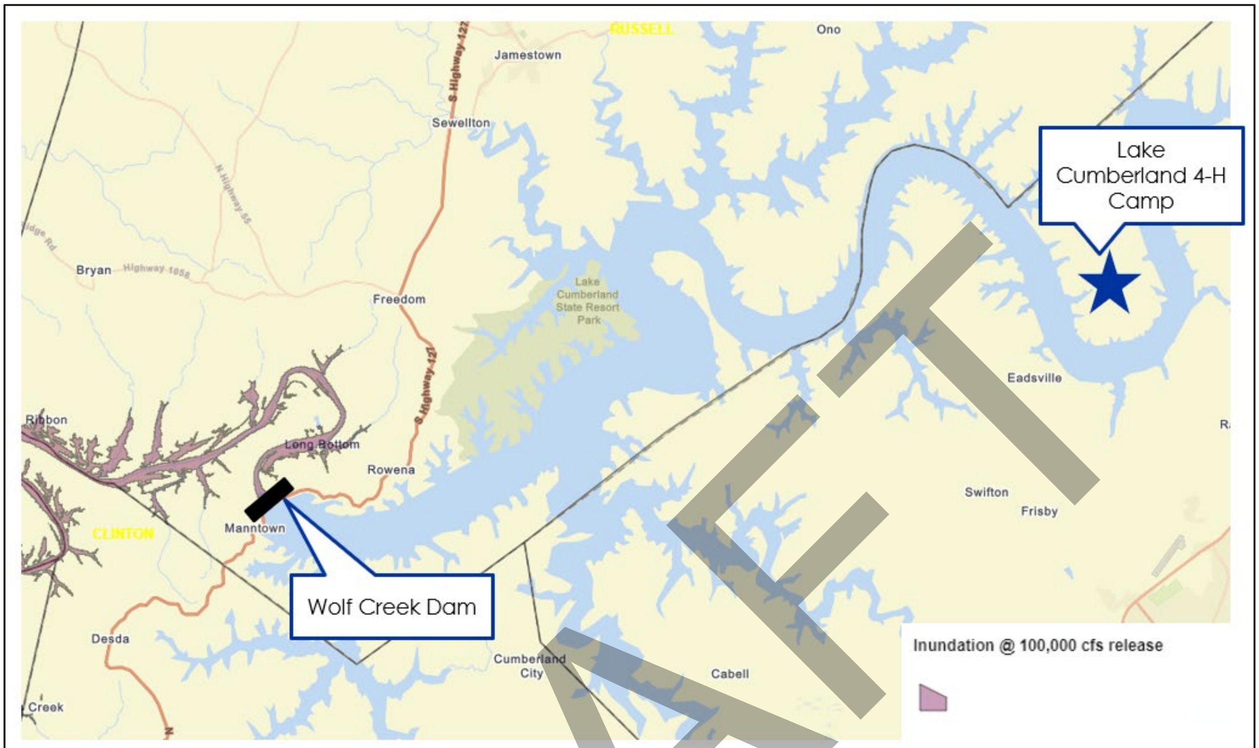


Figure 3-5: Wolf Creek Dam 100,000 cfs Release

The North Central 4-H Camp in Carlisle, Kentucky lies in proximity of two earthen dams, the Lake Carnico (Middle) Dam and the Lake Carnico Dam as shown in **Figure 3-7**. The Lake Carnico (Middle) Dam is classified as having significant hazard potential and is assessed to be in satisfactory condition. Inundation maps are not available for the Lake Carnico (Middle) Dam since it is not a HHPD. The Lake Carnico Dam is classified as an HHPD and is assessed to be in poor condition. Since it is classified as a HHPD, inundation zones are available for the dam and shown on the map. The camp is upstream of the dam and therefore is not shown to be in the inundation zone.

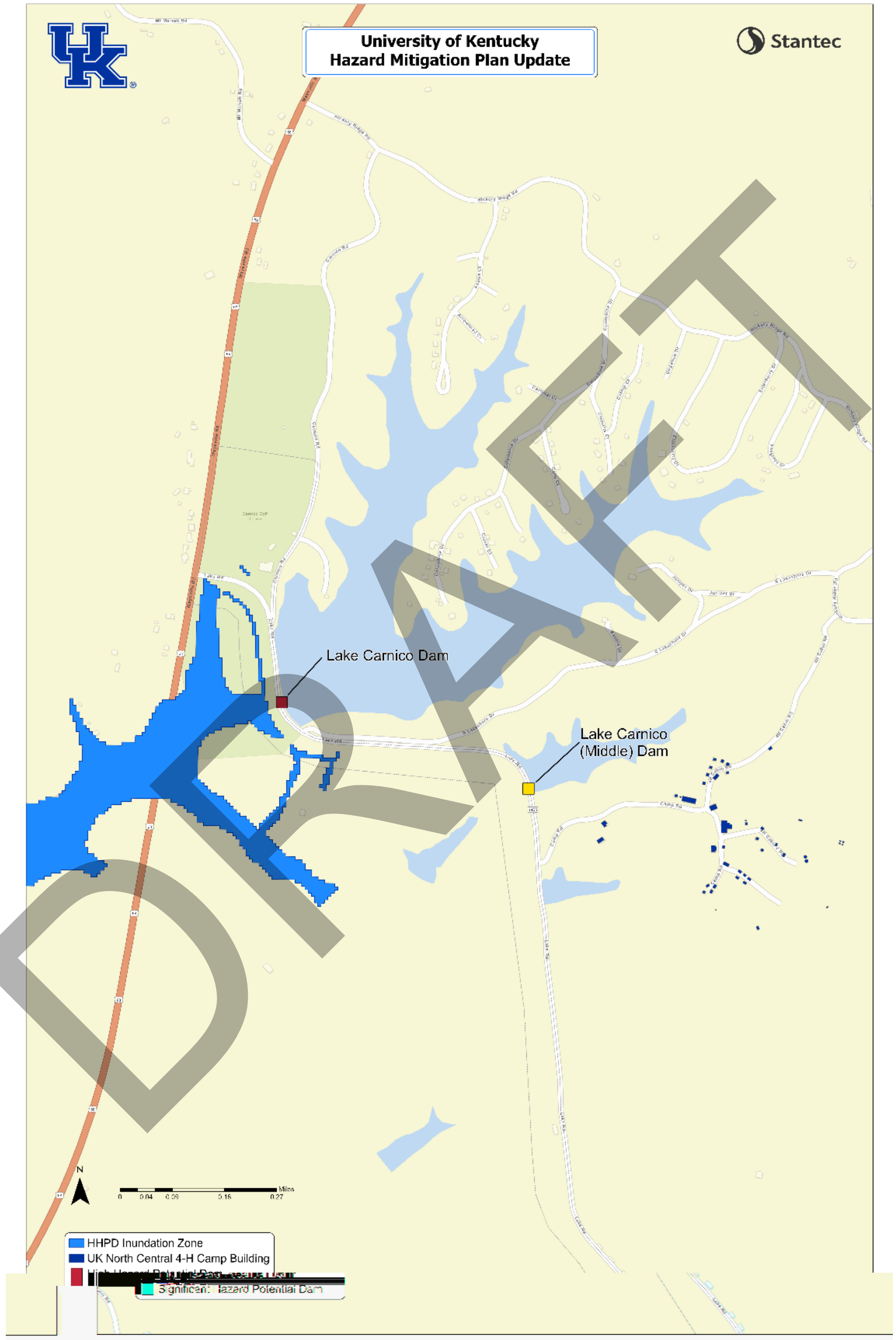


Figure 3-6: Dam Locations Near the North Central 4-H Camp

There are levees in Campbell County, Kenton County and McCracken County where UK has outlying facilities. All levees identified within Campbell County, Kenton County and McCracken County are FEMA accredited. None of UK's facilities intersect with reduced flood risk areas or fall within 500 feet of a reduced flood risk area. Therefore, they are not directly in an area that is protected from flooding by a levee.

While not managed by the university, damage to infrastructure located within inundation areas or reduced flood risk areas could impact outlying facilities through power outages, water contamination or road blockages. Students and staff may live and work in areas that are in dam inundation zones or protected by levees off campus. Dam or levee failure can result in injuries, evacuations and loss of life which could impact university personnel.

Climate change can have many indirect impacts on dam and levee failure. The cause of most dam failures is flooding from prolonged periods of rainfall. In the planning area, increased precipitation and increases in extreme precipitation events can increase the likelihood of dam failure due to increased flooding or inadequate spillway capacity. Warmer temperatures resulting in decreased snow accumulations and more snow falling as rain could have a similar effect. Levees are designed to manage a specific amount of floodwater. When the capacity of a levee is reached, it can fail due to overtopping or breaching. Increased precipitation can increase the likelihood of floodwater exceeding the levee design.

Many dams, including the ones analyzed for this plan, were constructed 30 or more years ago and were originally designed based on climate conditions effective at the time of construction. The average age of a dam in Fayette County based on the NID is approximately 46 years old. There are 5 dams over 70 years old and 10 dams over 30 years old. According to the National Levee Database, the average age of a levee in Kentucky is 52 years old. In Campbell County, Kenton County and McCracken County, the average ages of the levees are 56, 67 and 73 years, respectively. As a best practice, dam and levee upgrades and renewals should consider climate change; such actions are typically addressed in a management plan and are out of the scope of this plan.

3.4 Drought

3.4.1 Description

Drought is defined by the National Drought Mitigation Center as "a protracted period of deficient precipitation resulting in extensive damage to crops, resulting in loss of yield." Beyond its effects on the agricultural industry, periods of drought impact the natural environment, local and regional economies, human health and drinking water supplies. Although sometimes considered a rare and random event, drought is a normal, recurrent feature of climate. Climatic factors such as high temperatures, high wind and low relative humidity are often associated with drought.

However, drought occurs in virtually all climatic zones, varying significantly from one region to another and can be defined according to meteorological, hydrological, agricultural, socioeconomic or ecological criteria, as categorized in **Table 3-9**.

Table 3-8: Drought Classifications

Drought Classification	Description
Meteorological Drought	The degree of dryness or departure of actual precipitation from an expected average or normal amount based on monthly, seasonal or annual time scales. (Dry weather patterns dominate an area; can begin and end rapidly.)
Hydrological Drought	The effects of precipitation shortfalls on stream flows and reservoir, lake and groundwater levels. (Low water supply is evident; conditions take longer to develop and then recover.)
Agricultural Drought	Soil moisture deficiencies relative to water demands of plant life, usually crops. (Crops significantly affected.)
Socioeconomic Drought	The effect of demands for water exceeding the supply because of a weather-related supply shortfall.
Ecological Drought	A prolonged and widespread deficit in naturally available water supplies — including changes in natural and managed hydrology — that creates multiple stresses across ecosystems.

Droughts result from the complex interplay of weather patterns, geography, urban development, agricultural practices and land use. Because drought impacts accumulate slowly, it is often difficult to discern the distinct beginning and end of a drought. Drought severity depends on moisture deficiency, duration and the size and location of the affected area. Even during a drought there may be one or two months with above average precipitation totals. These wet months do not necessarily signal the end of a drought and may not have a major impact on moisture deficits. Droughts can be short, lasting just a few months, or they can persist for several years before regional climate conditions return to normal. While drought conditions can occur at any time throughout the year, the most apparent time is during the summer months. Nationally, drought impacts often exceed $1 billion due in part to the sheer size of the areas affected.

Research supports that climate change will have significant impacts on drought frequency and intensity, which will vary by region. Higher temperatures lead to increased evaporation rates, including more loss of moisture through soil and plant leaves.

Even in regions where precipitation does not decrease, increases in surface evaporation will lead to more rapid drying of soil if not offset by other changing factors, such as reduced wind speed or humidity. As soil dries out, a larger proportion of the sun’s incoming heat will go toward heating soil and adjacent air rather than evaporating moisture, resulting in hotter temperatures and drier conditions. In Kentucky, climate change is expected to increase the frequency and severity of drought and extreme rainfall events.

Increased evaporation is expected to offset the increased amount of annual rainfall, resulting in less water recharging the area's surface and ground water supplies. Further, climate change may result in more rainfall occurring during extreme events separated by longer dry periods. In general droughts are expected to be longer. Additionally, drought, paired with increased extreme heat events, may result in tree mortality in the state's forested areas.

The U.S. Drought Monitor[13] is designed to provide an easily understandable overview of weekly drought conditions throughout the United States. The U.S. Drought Monitor uses five drought intensity categories, D0 through D4, to identify areas of drought. These categories are shown in **Table 3-10.**

Table 3-9: U.S. Drought Monitor drought categories

D0	**Abnormally Dry**	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	**Moderate Drought**	Some damage to crops, pastures; streams, reservoirs or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	**Severe Drought**	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	**Extreme Drought**	Major crop/pasture losses; widespread water shortages or restrictions
D4	**Exceptional Drought**	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams and wells creating water emergencies

3.4.2 Location

Drought is a regional meteorological event without geographic or political boundaries. Drought may impact several areas at once for different lengths of time and with varying severity. An analysis of previous drought occurrences in the latest update to the CK-EHMP indicates that all regions of Kentucky experience drought at nearly the same recurrence rate, with central Kentucky being slightly more likely to experience a drought than other areas. In summary, UK's entire main campus and outlying facilities are all exposed to drought risk.

[13] The U.S. Drought Monitor is produced through a partnership between the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration (https://droughtmonitor.unl.edu).

3.4.3 Previous Occurrences

To understand the conditions of past drought, it can be helpful to understand the typical precipitation received each year. Lexington, Kentucky experiences an annual average of 45.2 inches of rainfall and 13 inches of snowfall[14]. Monthly averages are shown in **Figure 3-8**.

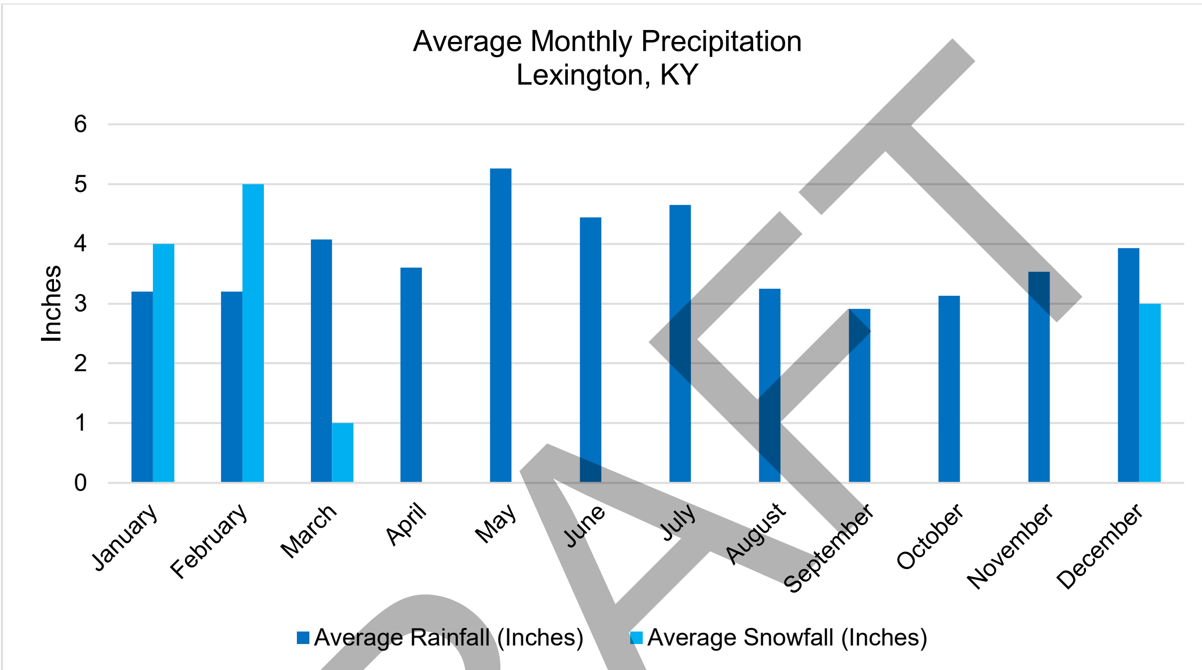


Figure 3-7: Average Precipitation and Snowfall by Month in Lexington

Data regarding drought previous occurrences was collected from several sources, including university claims data, the U.S. Drought Monitor, the 2015 UK Hazard Mitigation Plan, the CK-EHMP 2018 and the Palmer Drought Severity Index (PDSI).

The U.S. Drought Monitor was used to ascertain historical drought levels for Fayette County[15]. **Figure 3-9** and **Table 3-11** illustrate drought events recorded by the U.S. Drought Monitor service for Fayette County, KY from 2002 to 2022. Drought Categories D0 through D3 are included, as Fayette County did not experience a period of D4 Exceptional Drought during this time. 2007 is the only year with recorded instances of D3 Extreme Drought.

[14] From "Climate Lexington-Kentucky", U.S. Climate Data, https://www.usclimatedata.com/climate/lexington/kentucky/united-states/usky1079
[15] From "Conditions for Lexington, KY (Fayette County)", National Integrated Drought Information System, https://www.drought.gov/location/Fayette%20County%2C%20Kentucky

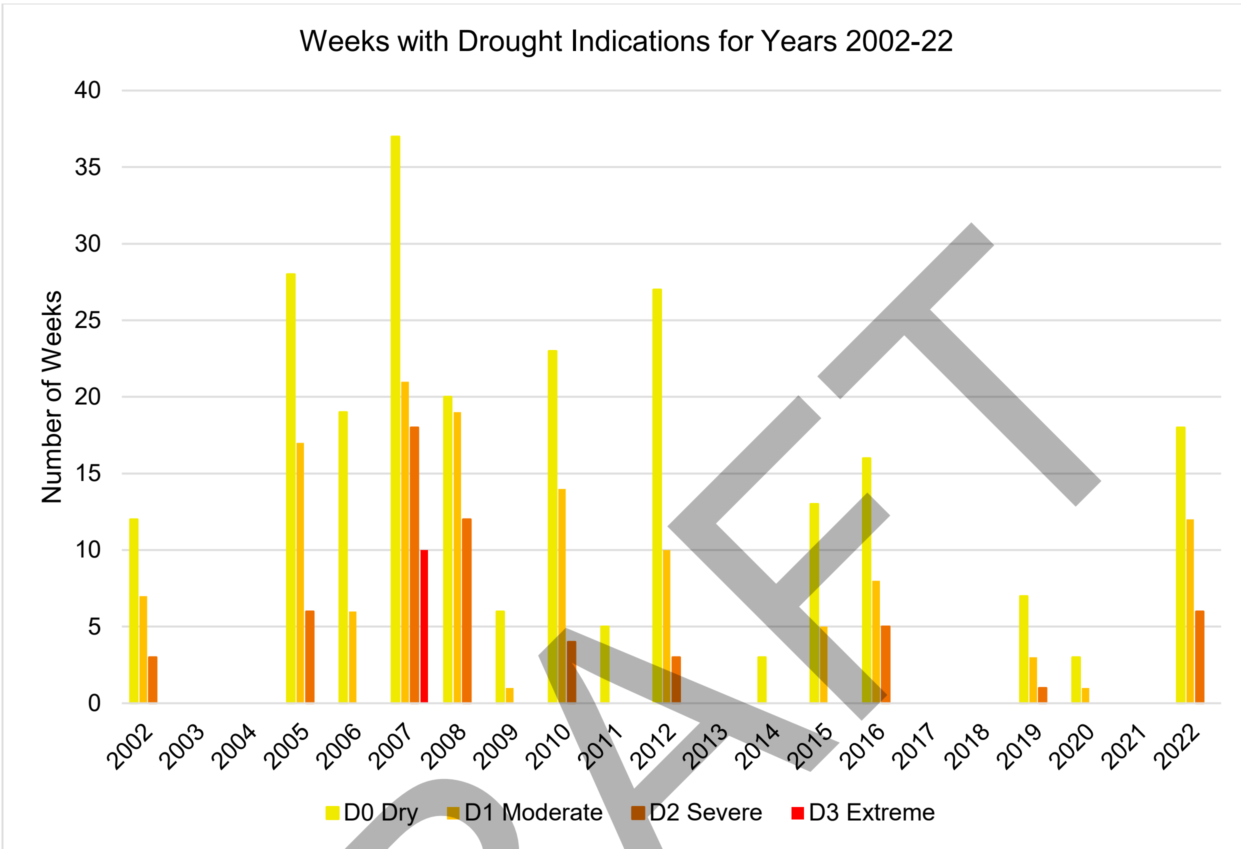


Figure 3-8: Fayette County Weeks in Drought, 2002-22

Table 3-10: Fayette County Weeks in Drought, 2002-22

Year	D0 Abnormally Dry	D1 Moderate	D2 Severe	D3 Extreme
2002	12	7	3	0
2003	0	0	0	0
2004	0	0	0	0
2005	28	17	6	0
2006	19	6	0	0
2007	37	21	18	10
2008	20	19	12	0
2009	6	1	0	0
2010	23	14	4	0
2011	5	0	0	0
2012	27	10	3	0
2013	0	0	0	0
2014	3	0	0	0
2015	13	5	0	0
2016	16	8	5	0
2017	0	0	0	0
2018	0	0	0	0
2019	7	3	1	0
2020	3	1	0	0
2021	0	0	0	0
2022	18	12	6	0

Data from the last twenty years indicate a wide variation in drought conditions in Fayette County impacting the university campus. Fourteen of 20 years reported some level of drought conditions. Nine years recorded severe drought conditions and in 2007 there were ten weeks of recorded extreme drought conditions. The driest weather was between 2005 and 2008, with 2007 showing the worst drought conditions.

UK has not recorded any damage from drought events on its main campus. Fayette County, through the *2018 Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* recorded approximately $9,500 in damages from drought events since 1960.

The Palmer Drought Severity Index (PDSI) is a standardized index based on a simplified soil water balance and estimates relative soil moisture conditions[16].

[16] See "U.S. Gridded Palmer Drought Severity Index (PDSI) from gridMET", NIDIS, https://www.drought.gov/data-maps-tools/us-gridded-palmer-drought-severity-index-pdsi-gridmet

The PDSI magnitude corresponds to the severity of the departure from normal conditions. A value less than negative 4 corresponds to an extreme drought. **Figure 3-10** shows the PDSI for the entire state of Kentucky since 1895[17].

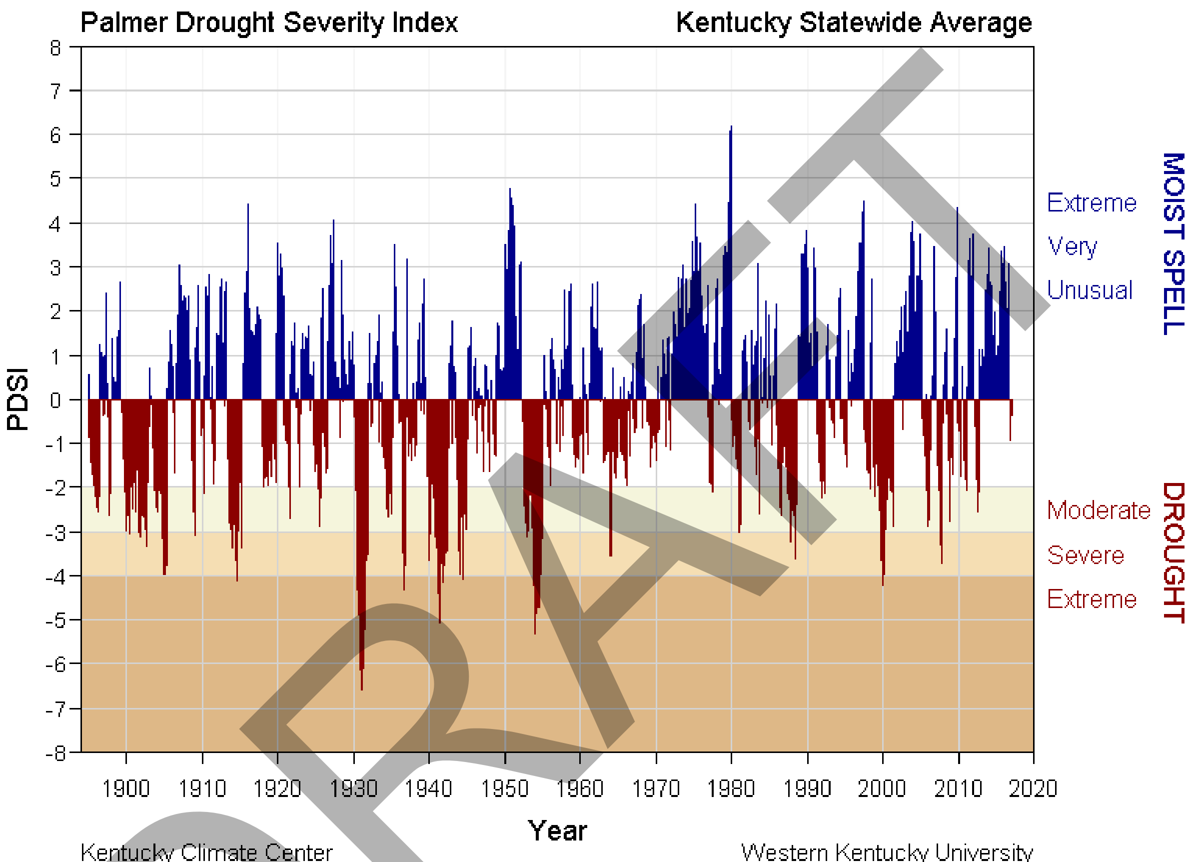


Figure 3-9: Statewide PDSI for Kentucky, 1895-2020.

3.4.4 Extent

Extent can be defined by the highest drought monitor category: exceptional drought. Fayette County does not have recorded weeks with exceptional drought; however, in 2007 the county experienced 10 weeks of extreme drought. Multiple weeks of extreme drought has the potential to cause hundreds of thousands of dollars in losses in agricultural research at UK's facilities.

[17] From "Historical Perspectives", Kentucky Climate Center, http://www.kyclimate.org/drought-historical-perspective.html

3.4.5 Probability

Drought is most likely to occur during summer months, when high temperatures increase the amount of surface evaporation. Exact probability of drought is difficult to quantify given the limited reporting period of the U.S. Drought Monitor (21 years: 2002-22). Drought conditions were reported in 15 of the 21 years for Fayette County, where UK's main campus is located. This equates to a rate of drought presence of approximately 70 percent annually.

The *Fourth National Climate Assessment* includes Kentucky in its study of the southeast[18]. The assessment states that "climate change is expected to intensify the hydrologic cycle and increase the frequency and severity of extreme events like drought and heavy rainfall". Based on historic frequency and projected future conditions, the probability of future drought occurrences is likely (between 10 and 90 percent annual probability). However, the probability of extreme of exceptional drought is possible (between one and 10 percent annual probability).

3.4.6 Vulnerability Assessment

All UK campuses are vulnerable to drought, including all current and future buildings, critical facilities, infrastructure and populations. The atmospheric nature of drought and lack of specific boundaries make it difficult to quantify drought conditions. Most drought impacts, however, are not structural but societal in nature. A drought's impact on society results from the interplay between a natural event and the demand people place on water supply.

Surface water levels in lakes, impoundments and reservoirs can drop dramatically during drought. Groundwater supply can also be impacted. During periods of drought in Kentucky, some activities which rely heavily on water use may be significantly impacted. These activities include agriculture, tourism, wildlife protection, municipal water usage, recreation and electric power generation. UK has not recorded historic damage or effects of drought events in the past.

Drought has minimal impact on structures but can impact the functionality of the building if the water supply is disrupted. Structural issues could occur if drought impacts building foundations or footings. Drought is expected to have minimal impacts on infrastructure. Green infrastructure, such as green stormwater infrastructure, may incur minor damage during drought occurrences if plants cannot resist drought.

As drought is a slow developing hazard, it is unlikely to have significant impacts on life safety and is not expected to result in warnings or evacuation. Drought occurrences may result in restrictions on water use. In the extreme event of drought-related water shortages, availability of water for firefighting may be impacted.

Drought has the potential to impact public health by reducing the quality and amount of available drinking water. In general, even a severe drought is unlikely to have detrimental impacts on the health and safety of a community.

Economically constrained households may face difficulty paying for water if a drought causes rate hikes introduced to spur conservation. Economically constrained households may also face challenges in the event food prices rise due to drought, both locally and in areas from where food is grown.

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[18] From "Chapter 19: Southeast", *Fourth National Climate Assessment*, https://nca2018.globalchange.gov/chapter/19/

As an agricultural research university, UK maintains valuable agriculture fields and livestock for research and education. The *2018 Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* analyzes USDA Crop Insurance Indemnity Payments to map a general pattern of agriculture drought susceptibility across the state as shown in **Figure 3-11.** Based on this map, drought risk is generally uniform across most of western and central Kentucky, and all UK campuses and facilities in these areas are exposed to the same level of risk. Robinson Forest Campus in Clayhole and Center of Excellence in Rural Health in Hazard have slightly less exposure to drought as the risk decreases toward the eastern portion of the state.

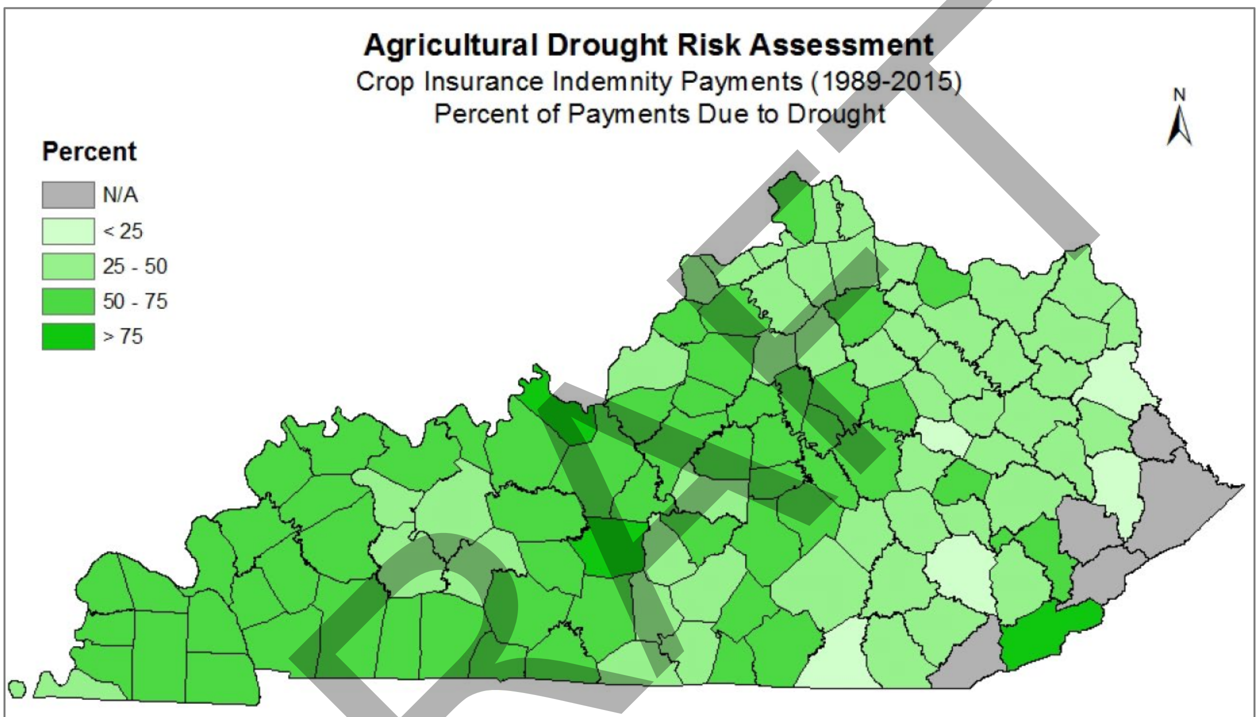

Figure 3-10: Drought Risk Assessment (Kentucky Enhanced Hazard Mitigation Plan)

Drought can cause crop failure and pasture losses. Decreased water availability for agriculture can cause significant declines in crops and livestock productivity[19]. In 2012, a severe drought impacted 80 percent of agricultural land in the U.S. causing two-thirds of its counties to be declared disaster areas. Surface water and groundwater supplies may decline increasing the cost to access water for irrigation. Drought is frequently accompanied by extreme heat as discussed in the **3.6 Extreme Heat** profile. Drought and extreme heat can expand the presence of pests and diseases that affect crops and livestock. Some crops are more drought resistant than others. Most specialty crops require a higher amount of water and present a higher risk for economic loss from drought. The cost of drought averages over $6 billion a year in the United States. Drought can cause extreme economic impacts to the agricultural industry which is one of the largest industries in the United States.

[19] See "US Crops and Livestock in Drought", NDIS, https://www.drought.gov/sectors/agriculture#:~:text=The%20depletion%20of%20water%20availability,forage%20irrigation%20and%20watering%20livestock.

In 2015, U.S. farms contributed $136.7 billion to the economy with other agriculture and food related sections contributing an additional $855 billion. In 2015, Kentucky's agriculture industry generated direct and indirect economic impacts of $46.6 billion[20].

Droughts and dry weather can also increase susceptibility to wildfire. Certain locations on the main UK campus that are heavily landscaped, or branch campus facilities in more rural locations could be exposed to a greater fire hazard during drought events. Wildfire risk is discussed in the **3.9 Wildfire** profile**.**

Research in the *Fourth National Climate Assessment* predicts generally warmer winters in Kentucky, wetter springs with potential for more flooding and generally hotter temperatures during the summer growing season, potentially causing more droughts. Current predictions indicate an increase in extreme events such extreme periods of drought followed by heavy rainfall and flooding[21].

3.5 Earthquake

3.5.1 Description

Earthquakes are defined as the sudden release of strain (or displacement of rock) in the earth's crust, resulting in waves of shaking that radiate from the earthquake source (epicenter). They may result from crustal strain, volcanism, landslides or the collapse of caverns. Earthquakes occur without warning and can affect hundreds of thousands of square miles. Their intensity ranges from very minor (shaking not detected by humans without instruments) to very violent (catastrophic in nature). Damages follow this intensity ranging from minor to catastrophic.

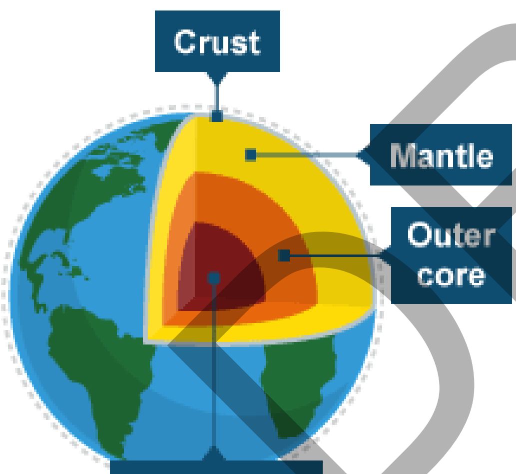

Figure 3-11: Earth's Sub Layers

To understand the nature of earthquakes, the composition of the earth must be explored. The earth is made up of four major layers and several sub layers: a solid inner core, a liquid outer core, a semi-molten mantle and the rocky crust (the thin outermost layer of the earth). These are shown in **Figure 3-12.** The upper portion of the mantle combined with the crust forms the lithosphere. This area is susceptible to fractures and is referred to as a shell. The lithosphere breaks up into large slabs, known as tectonic plates. This area is where earthquakes occur.

There are approximately twelve major plates and several dozen more minor plates on the Earth's crust, as shown in **Figure 3-13:** Plates are regions of the crust that continually move over the mantle. Areas where these plates meet, grind past each other, dive under each other, or spread apart, are called plate boundaries. Most earthquakes are caused by the release of stresses accumulated due to the sudden displacement of rock along opposing plates in the Earth's crust. The location below the earth's surface where the earthquake starts is known as the hypocenter or focus. The point on the earth's surface directly above the focus is the epicenter.

[20] See "Kentucky Department of Agriculture", NASDA, https://www.nasda.org/state-department/kentucky-department-of-agriculture/
[21] Fourth National Climate Assessment (2018). Chapter 19: Southeast Region. Retrieved from Southeast - Fourth National Climate Assessment (globalchange.gov).

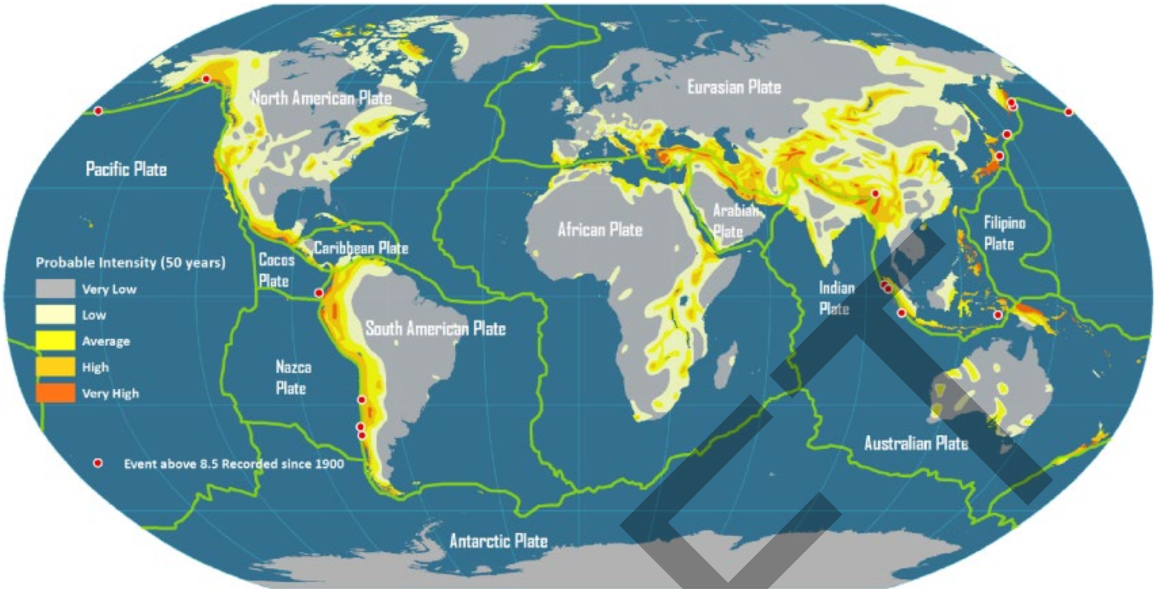

Figure 3-12: Global Plate Tectonics and Seismic Activity

The greatest hazard potential for earthquakes exists in highly populated areas, because these areas tend to have a greater number of tall buildings that are more vulnerable to seismic impact. Buildings and infrastructure built before the 1960s are also generally more susceptible to seismic movement than newer construction.

Most property damage and earthquake-related deaths are caused by failure and collapse of structures due to ground shaking. The amount of damage depends on the intensity and duration of the shaking, distance from the epicenter and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides) and liquefaction, in which ground soil loses the ability to resist shear and flows like quicksand. In the case of liquefaction, anything relying on the substrata (the layer of rock and soil beneath the ground) for support can shift, tilt, rupture or collapse.

The greatest earthquake threat in the United States is along tectonic plate boundaries and seismic fault lines located in the central and western states; however, the eastern United States faces moderate risk to less frequent, less intense earthquake events. **Figure 3-14** shows relative seismic risk for the United States[22].

[22] United States Geological Survey. (2018). 2018 National Seismic Hazard Long-term Model. Retrieved on March 3, 2023 from Seismic Hazard Model, Maps, and Site-Specific Data | U.S. Geological Survey (usgs.gov).

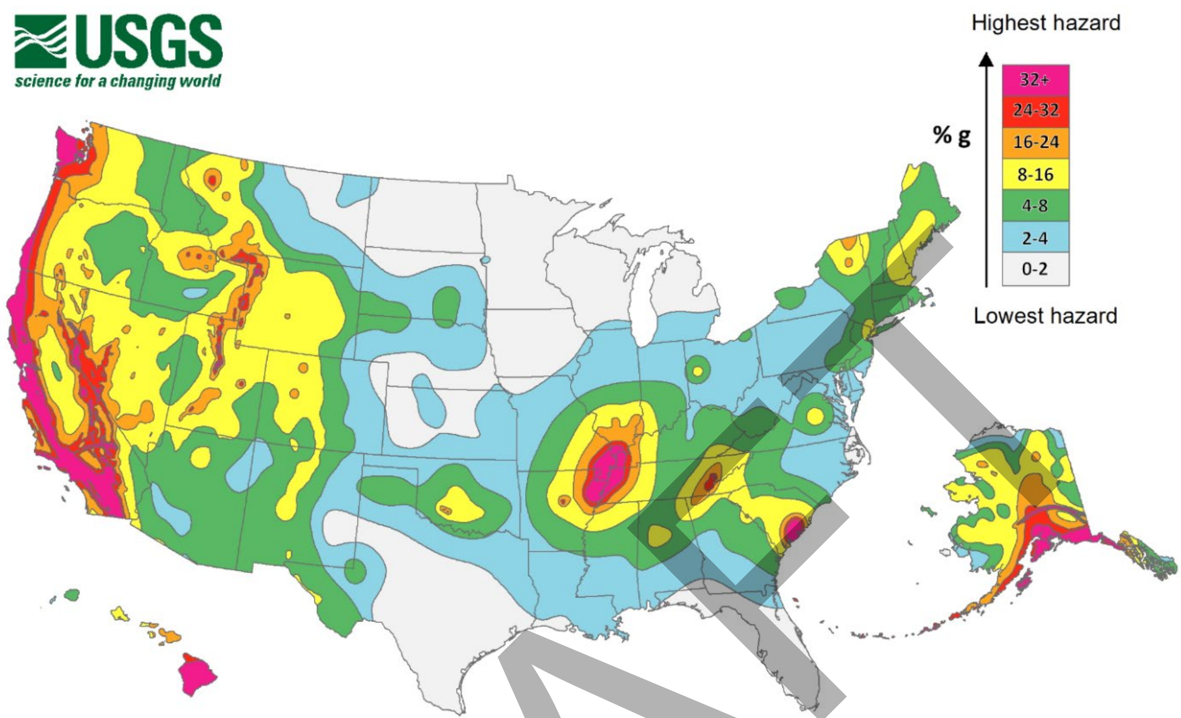

Figure 3-13: 2018 USGS Long-Term Seismic Hazard Map

Earthquake magnitude is measured using the Richter Scale (**Table 3-12**), an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. Each unit increase in magnitude on the Richter Scale corresponds to a 10-fold increase in wave amplitude or a 32-fold increase in energy. Beginning in 2002, the USGS began using Moment Magnitude as the preferred measure of magnitude for all USGS earthquakes greater than magnitude 3.5.

Moment Magnitude also has a scale, but no instrument is used to measure it. Instead, factors such as the distance the earthquake travels, the area of the fault and land that was displaced (also known as “slip”) are used to measure moment magnitude. **Table 3-13** shows the Moment Magnitude Scale.

Table 3-11: Richter Scale

RICHTER MAGNITUDES	EARTHQUAKE EFFECTS
<3.5	Generally, not felt, but recorded
3.5 - 5.4	Often felt, but rarely causes damage
5.4 - 6.0	At most slight damage to well-designed buildings, can cause major damage to poorly constructed buildings over small regions

6.1 - 6.9	Can be destructive in areas up to about 100 kilometers across where people live
7.0 - 7.9	Major earthquake; can cause serious damage over larger areas
8 or >	Great earthquake; can cause serious damage in areas several hundred kilometers across

Table 3-12: Moment Magnitude Scale

SCALE VALUES	EARTHQUAKE EFFECTS
<3.5	Very weak; unlikely to be felt
3.5 - 5.4	Generally, felt; rarely causes damage
5.4 - 6.0	Will not cause damage to well-designed buildings; will damage poorly designed ones
6.1 - 6.9	Considered a "major earthquake" that causes a lot of damage
7.0 - 7.9	Large and destructive earthquake that can destroy large cities
8 or >	Large and destructive earthquake that can destroy large cities

Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using Roman numerals, ranging from "I" corresponding to imperceptible (instrumental) events to "XII" for catastrophic (total destruction). A detailed description of the Modified Mercalli Intensity Scale of earthquake intensity and its correspondence to the Richter Scale is given in **Table 3-14** and **Table 3-15** compares the Richter scale magnitudes and MMI magnitudes for several well-known historic earthquakes in the U.S.

Table 3-13: Modified Mercalli Intensity Scale for Earthquakes

SCALE	INTENSITY	DESCRIPTION OF EFFECTS	CORRESPONDING RICHTER MAGNITUDE
I	**INSTRUMENTAL**	Detected only on seismographs.	
II	**FEEBLE**	Some people feel it.	< 4.2
III	**SLIGHT**	Felt by people resting; like a truck rumbling by.	
IV	**MODERATE**	Felt by people walking.	
V	**SLIGHTLY STRONG**	Sleepers awake; church bells ring.	< 4.8
VI	**STRONG**	Trees sway: suspended objects swing, objects fall off shelves.	< 5.4
VII	**VERY STRONG**	Mild alarm; walls crack; plaster falls.	< 6.1
VIII	**DESTRUCTIVE**	Moving cars uncontrollably; masonry fractures, poorly constructed buildings damaged.	

SCALE	INTENSITY	DESCRIPTION OF EFFECTS	CORRESPONDING RICHTER MAGNITUDE
IX	RUINOUS	Some houses collapse; ground cracks; pipes break open.	< 6.9
X	DISASTROUS	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread.	< 7.3
XI	VERY DISASTROUS	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards.	< 8.1
XII	CATASTROPHIC	Total destruction: trees fall; ground rises and falls in waves.	> 8.1

Table 3-14: Richter vs. Moment Magnitude Values

Earthquake	Richter Scale	Moment Magnitude
New Madrid, MO 1812	8.7	8.1
San Francisco, CA 1906	8.3	7.7
Prince William, AK 1964	8.4	9.2
Northridge, CA 1994	6.4	6.7

3.5.2 Location

Earthquakes can be felt and cause damage hundreds of miles from a fault or event epicenter. Seismic zones are used to describe an area where earthquakes tend to focus[23]. Kentucky is affected by earthquakes from several seismic zones, including the New Madrid Seismic Zone, the Wabash Valley Seismic Zones and the Eastern Tennessee Seismic Zone, as shown in **Figure 3-15**. The Paducah campus is the only UK campus or 4-H camp located in one of the seismic zones; however, these seismic zones produce earthquakes that have the potential impact facilities in western, south-central or eastern Kentucky.

[23] USGS. What is a seismic zone, or seismic hazard zone? Retrieved from What is a seismic zone, or seismic hazard zone? | U.S. Geological Survey (usgs.gov).

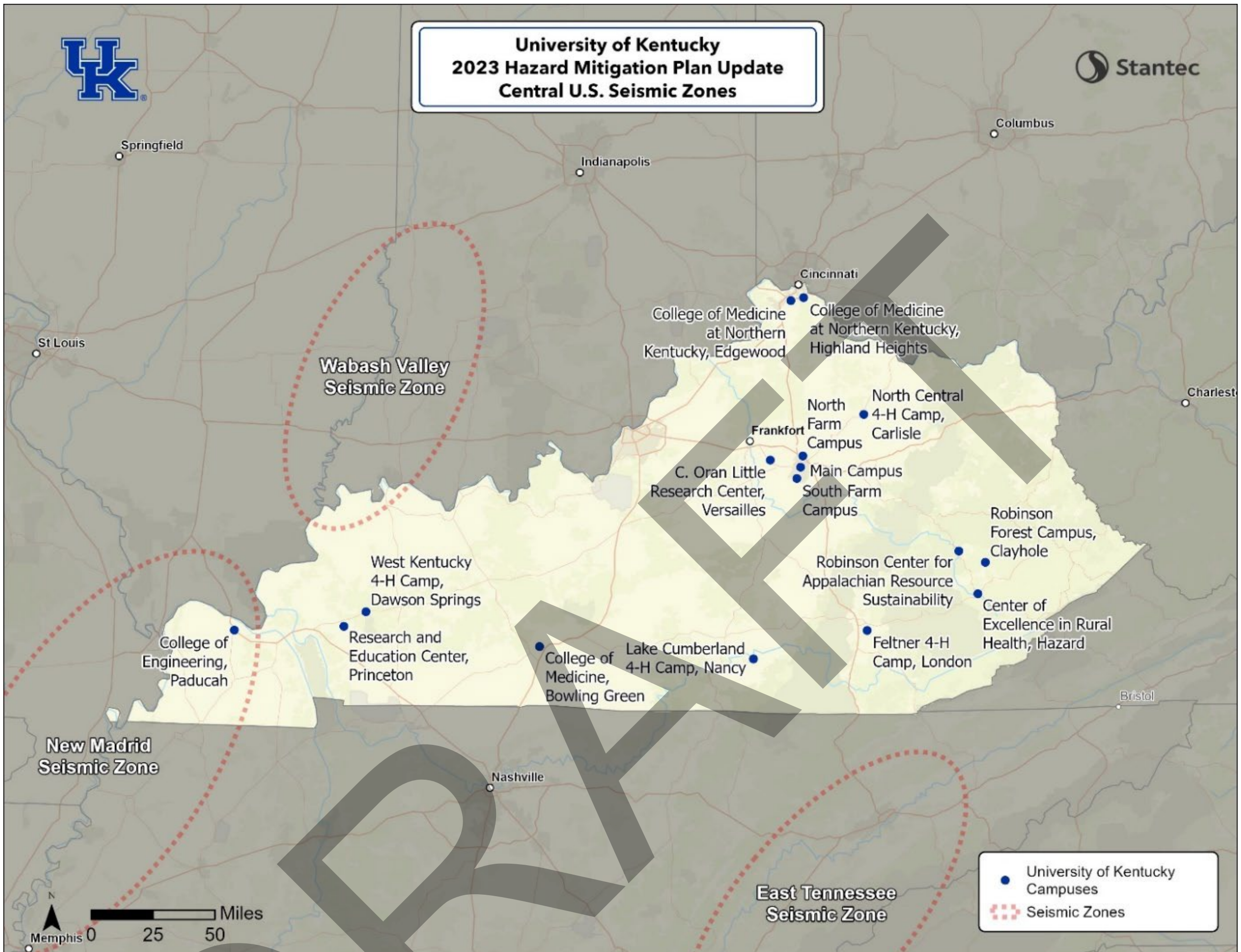

Figure 3-14: Central U.S. Seismic Zones

Fault zones, or areas where several faults are spaced close together, can also be used to determine where earthquakes may occur that would impact the university. Fault zones in the region are shown below in **Figure 3-16.** There is a small Class B fault area located southeast of Lexington indicating geologic evidence of a fault or Quaternary deformation, yet not strong enough to classify as a Class A fault area. The Class B area is of note because of previous earthquakes that originated in the area east of Lexington. All the other fault areas shown in **Figure 3-16** are classified as Class A fault areas. A Class A fault area has geologic evidence of a Quaternary fault of tectonic origin and is a potential source of significant earthquakes. The fault areas found in the western portion of the state are associated with the New Madrid and Wabash Valley Seismic Zones, which are much more active fault areas.

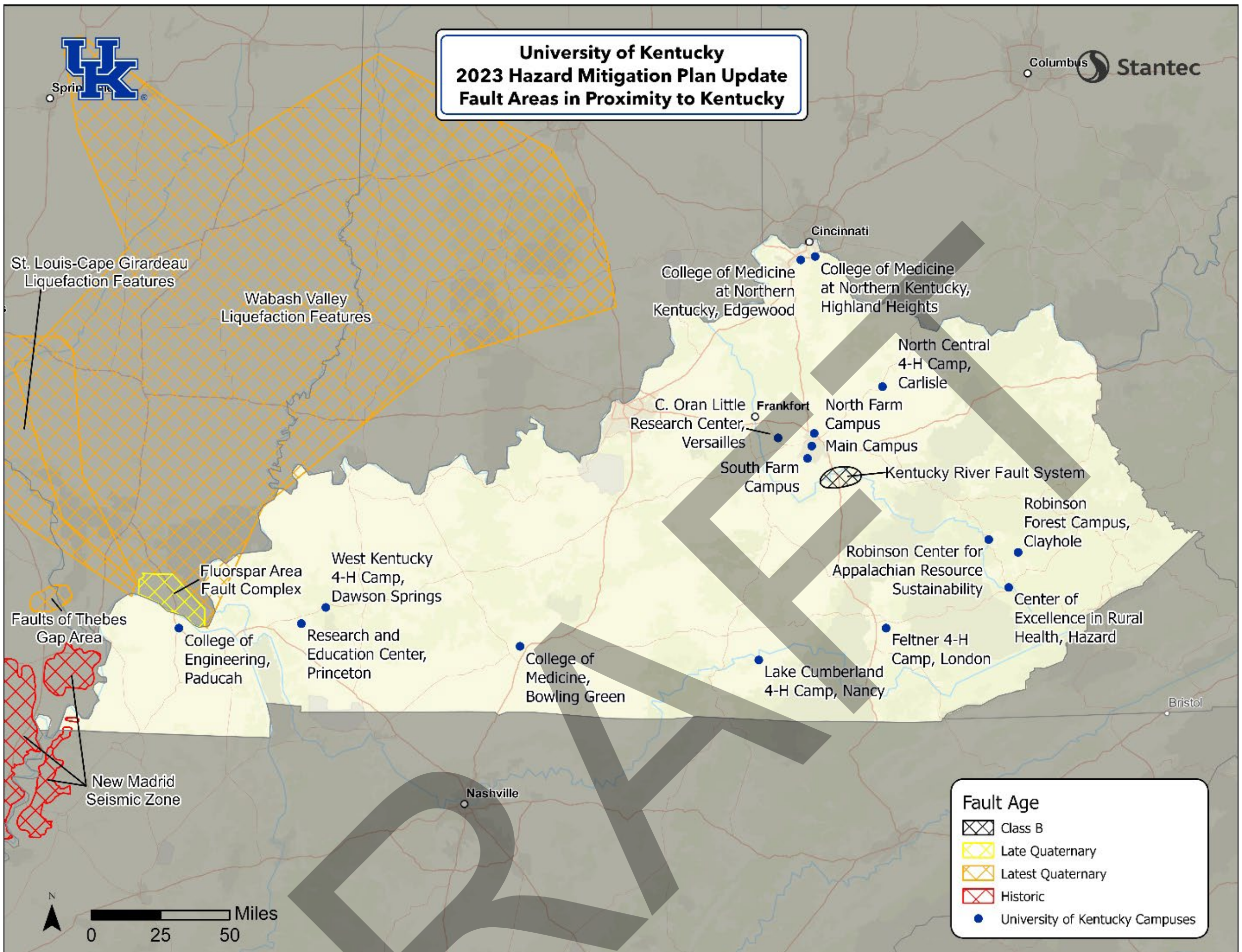

Figure 3-15: Fault Areas in Proximity to Kentucky

The extent of damage caused by an earthquake is highly dependent on where the epicenter of the earthquake is located and the strength of the quake. Damage from an earthquake can be caused by a surface rupture, a large open crevice on the surface caused by an active fault; however, most earthquakes that impact Kentucky do not result from an active fault. The Reelfoot Fault in the extreme western portion (part of the New Madrid Seismic Zone) is the only active fault identified in the commonwealth. Strong ground movement and shaking is the more common source of damage caused by an earthquake. The intensity of ground motion at a location primarily depends on its distance from the epicenter of the earthquake and its magnitude.

Additionally, soft sediments along river valleys tend to amplify ground motion caused by an earthquake. **Figure 3-17** shows a map created by the Kentucky Geological Society illustrating the amplification potential of soils within the Commonwealth. As shown in the map, the soils of western Kentucky and along a number of river valleys throughout the rest of the Commonwealth are prone to low and moderate amplification. Soft and sandy soils can also be liquefied by strong ground motion in a process known as liquefaction. Liquefaction can cause damage by destabilizing building foundations and other structures, such as bridges.

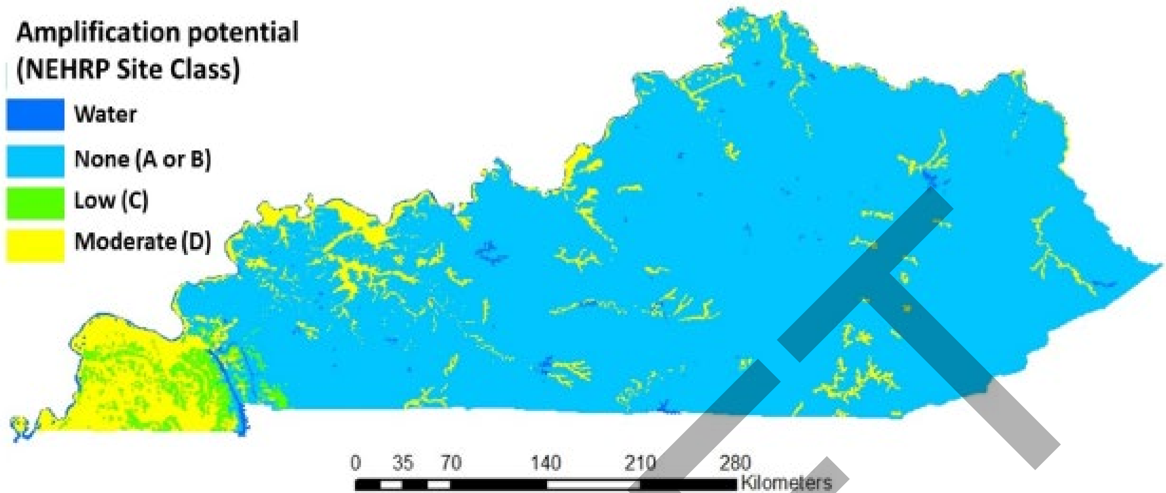

Figure 3-16: Amplification Potential of Soils in Kentucky

Based on the amplification potential in Kentucky, liquefaction is not a concern for most of the state. However, the College of Engineering's Paducah campus is in an area of low to moderate amplification potential. Additionally, the university's facilities located along the Ohio River may be located in low or moderate amplification potential areas. This would potentially impact the College of Medicine's Edgewood and Highland Heights campuses and UK Health's newly acquired King's Daughters Hospital in Ashland.

3.5.3 Previous Occurrences

As previously stated, the New Madrid Seismic Zone, the Wabash Valley Seismic Zones and the Eastern Tennessee Seismic Zone all have produced earthquakes that impacted Kentucky. The most impactful earthquake event to impact the commonwealth was a series of events that occurred in the New Madrid Seismic Zone from December 1811 to February 1812. During this timeframe, at least three significant earthquakes occurred. These events are the largest earthquakes to occur in the continental U.S. east of the Rocky Mountains to date[24]. The earthquake with the greatest impact that originated in Kentucky occurred near Sharpsburg, Kentucky in 1980, about 30 miles northeast of Lexington. This quake, a 5.2 magnitude earthquake, caused a shaking intensity of 4.9 on the MMI scale in Lexington. This is rated as slightly strong shaking on the MMI scale, and there were no reports of significant damage to any of UK's property.

The USGS maintains the ANSS Comprehensive Earthquake Catalog, which is the combination of several earthquake datasets. The resulting Earthquake Catalog is a fairly comprehensive record of earthquakes from around the world. This Earthquake Catalog was used to find earthquake events that have occurred since 1900 within 300 miles of a UK campus or outlying facility, shown in **Figure 3-18**.

[24] U.S.G.S. (2012). Largest Earthquakes in the United States. Retrieved on February 28, 2023 from Largest Earthquakes in the United States (archive.org)

The largest earthquake since 1900 to occur within 300 miles of a UK campus happened in 1937 near Sidney, Ohio, located in western Ohio. However, most of the previous occurrences happened in the 3 seismic zones mentioned above (shown in **Figure 3-16**).

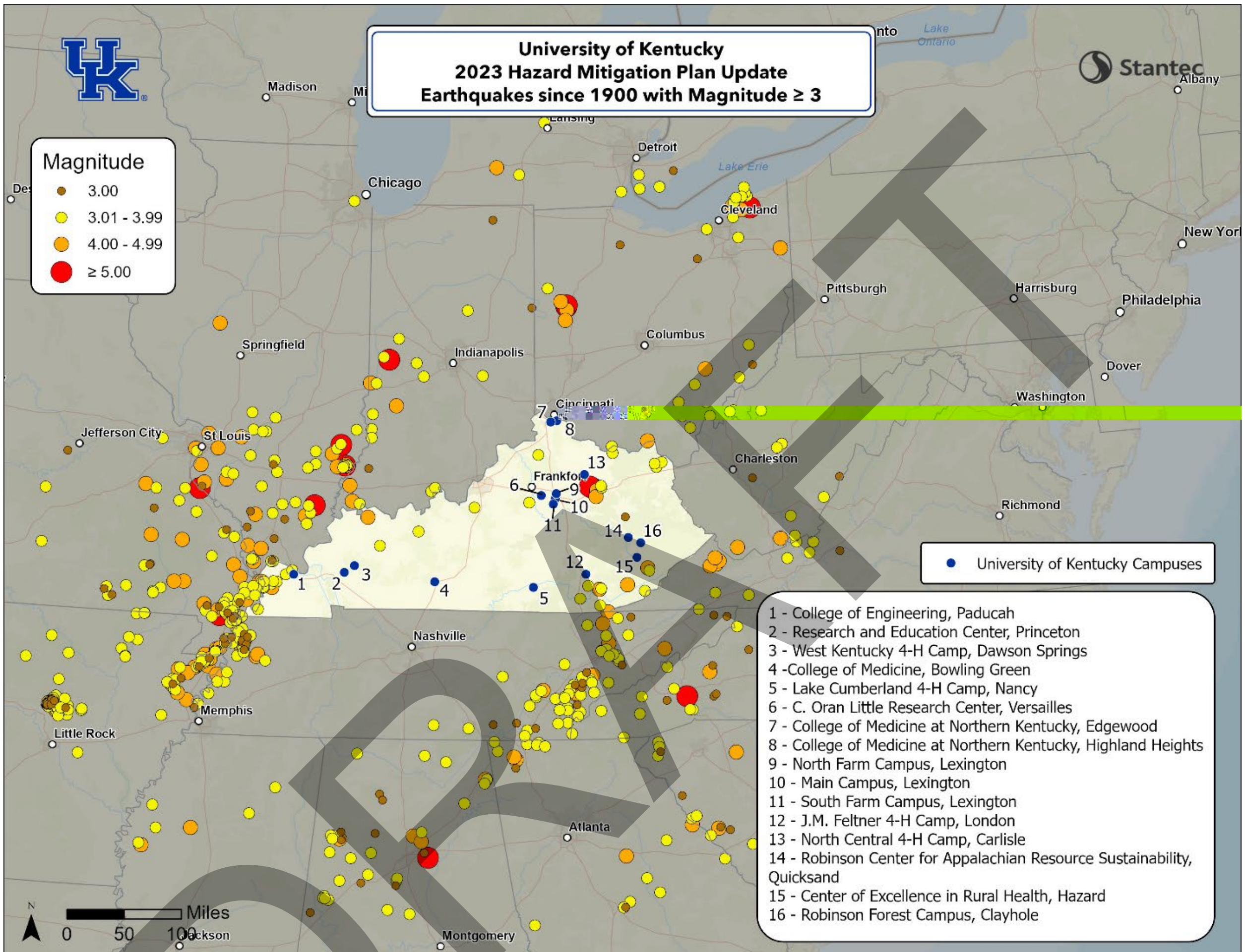

Figure 3-17: Previous Earthquakes Since 1900 with a Magnitude ≥ 3

Table 3-16 provides a breakdown of previous earthquake occurrences by UK facility, including the total number of earthquakes that have occurred within 50 miles of each campus or camp since 1900. The table also includes the date of the most recent earthquake within 50 miles of each campus or camp.

Table 3-15: Previous Earthquake Occurrences (Magnitude ≥ 3) within 50 miles of a UK Facility

Impacted Campus	Total Number of Previous Occurrences within 50 Miles	Date of Most Recent Earthquake
C. Oran Little Research Center	6	09/07/1988
Center of Excellence in Rural Health	8	11/10/2012
College of Engineering - Paducah	36	09/27/2019
College of Medicine - Bowling Green	1	03/23/1980
College of Medicine - Edgewood	1	06/05/1974
College of Medicine - Highland Heights	1	06/05/1974
J.M. Feltner 4-H Camp	10	01/20/2020
Lake Cumberland 4-H Camp	2	01/27/2009
Main Campus	8	09/08/1990
North Central 4-H Camp	9	12/12/2021
North Farm Campus	8	09/08/1990
Research and Education Center (Princeton Campus)	2	08/26/2003
Robinson Center for Appalachian Resource Sustainability	8	11/10/2012
Robinson Forest Campus	5	11/10/2012
South Farm Campus	8	09/08/1990
West Kentucky 4-H Camp	2	01/07/1973

3.5.4 Extent

There are several ways to measure the extent of an earthquake including magnitude and intensity experienced. The Modified Mercalli Intensity (MMI) Scale can be used to report the intensity experienced of an earthquake. The NOAA National Centers for Environmental Information has a U.S. Earthquake Intensity Database that has a record of earthquakes from 1638-1985. The data is a collection of damage and felt reports for over 23,000 U.S. earthquakes. For nearly every earthquake, the cities in the surrounding area that reported shaking provided a reported intensity (based on the MMI scale). This information was used to find earthquakes that impacted the university's campuses and facilities. **Table 3-17** provides the highest reported MMI for each campus from 1900 to 1985.

Table 3-16: Highest Reported MMI at UK's Campuses (1900-1985)

Impacted Campus	Reporting City	Highest Reported MMI	Date of Earthquake
C. Oran Little Research Center	Versailles	6	07/27/1980
Center of Excellence in Rural Health	Hazard	5	01/02/1954
College of Engineering - Paducah	Paducah	6	11/09/1968
College of Medicine - Bowling Green	Bowling Green	4	09/02/1925
College of Medicine - Edgewood	Fort Mitchell*	3	11/01/1935
College of Medicine - Highland Heights	Fort Thomas*	4	07/27/1980
J.M. Feltner 4-H Camp	London	5	01/19/1976
Lake Cumberland 4-H Camp	Nancy	4	07/27/1980
Main Campus	Lexington	6	01/19/1976
North Central 4-H Camp	Carlisle	6	07/27/1980
Research and Education Center	Princeton	4	02/02/1962
Robinson Center for Appalachian Resource Sustainability	Quicksand	4	07/27/1980
Robinson Forest Campus	Clayhole	5	07/27/1980
West Kentucky 4-H Camp	Dawson Springs	6	11/09/1968

* For the College of Medicine – Edgewood campus, Fort Mitchell was used as the reporting city. For the College of Medicine – Highland Heights campus, Fort Thomas was used as the reporting city. These were the closest cities to each campus that were included in the database.

If a repeat of the 1812 event were to occur, it is possible that UK's main campus could experience some damage and UK's properties in western Kentucky, especially in areas with softer riverine soils, could experience major damage. According to the USGS isoseismal map of the New Madrid Earthquakes of 1811-1812, Fayette County would experience very strong shaking and could sustain moderate damage. Greater extent events are possible, especially at UK's westernmost campuses.

3.5.5 Probability

The probability of significant, damaging earthquake events affecting the University varies greatly depending on the location of the campus or facility being considered. Using the NOAA's U.S. Earthquake Intensity Database, an annual probability was assigned for each campus. There was a total of 66 reported earthquakes from 1811 to 1985 that impacted cities where UK has facilities. Each campus was assigned a probability based on the number of earthquakes that were felt at each location during this timeframe. The annualized probabilities are shown in **Table 3-18.**

Table 3-17: Annualized Probability of Earthquakes Impacting UK's Campuses

Impacted Campus	Reporting City	Number of Earthquakes Reported	Annual Probability
C. Oran Little Research Center	Versailles	1	0.6%
Center of Excellence in Rural Health	Hazard	6	3.5%
College of Engineering - Paducah	Paducah	28	16.2%
College of Medicine - Bowling Green	Bowling Green	5	2.9%
College of Medicine - Edgewood	Fort Mitchell*	1	0.6%
College of Medicine - Highland Heights	Fort Thomas*	1	0.6%
J.M. Feltner 4-H Camp	London	3	1.7%
Lake Cumberland 4-H Camp	Nancy	1	0.6%
Main Campus	Lexington	9	5.2%
North Central 4-H Camp	Carlisle	2	1.2%
Research and Education Center	Princeton	4	2.3%
Robinson Center for Appalachian Resource Sustainability	Quicksand	2	1.2%
Robinson Forest Campus	Clayhole	1	0.6%
West Kentucky 4-H Camp	Dawson Springs	2	1.2%

*Fort Mitchell was used as the reporting city for the College of Medicine – Edgewood campus. For the College of Medicine – Highland Heights campus, Fort Thomas was used as the reporting city. These were the closest cities to each campus that were included in the database.

The probability of a significant, damaging earthquake at one of the university's campuses is less likely than the annual probabilities presented above. Overall. The probability assigned to the earthquake hazard for the university is possible (one to 10 percent annual chance).

3.5.6 Vulnerability Assessment

Earthquakes can be experienced in any part of Kentucky and the university has facilities spread across the commonwealth. Therefore, all of UK's buildings (including critical facilities), infrastructure and populations are considered at risk to the earthquake hazard. The level of risk at UK's various campuses is not the same, and as noted below, facilities in the southeast and western portions of the state are more likely to experience a catastrophic event. However, light to moderate damage is feasible at all of UK's campuses and outlying facilities.

A less severe earthquake may cause damage to buildings, including critical facilities, in the form of structural damage, fallen shelves and toppled furniture. This also presents a risk to building occupants; injuries are possible from items falling off shelves or walls. Damage to infrastructure is also possible in the form of minor damage to pipes, impacts to roads, bridges, railroads, dams and utility poles. Underground infrastructure, such as water and sewer systems and natural gas pipelines are especially vulnerable. A more severe earthquake will cause increased damage, resulting in more severe damage to buildings and infrastructure. Fires may result from ruptured pipes or downed power lines, which can lead to structure fires. A severe earthquake may introduce contamination into water supplies and can result in prolonged power outages. Additionally, it is worth noting that an earthquake in the western portion of the state may disrupt natural gas and petroleum pipelines that originate in that area. A severe earthquake could result in long-term impacts on the economy resulting from disruptions of bridges, rail lines, communication and utility lines, water, food and medical supply paths.

The USGS has produced seismic hazard maps used for projecting the ground shaking that may be exceeded with a two percent probability in 50 years (or a 2,500-year return period). This long-term model was last updated in 2018 and is what is typically used for national seismic safety regulations and design standards[25]. **Figure 3-19** shows this model with all of UK's campuses mapped over top.

As shown on the map, facilities located closer to the New Madrid Seismic Zone on the western edge of Kentucky are most at risk.

[25] Wang, Z., & Ormsbee, L. (2005). Comparison between probabilistic seismic hazard analysis and flood frequency analysis. *Eos, Transactions American Geophysical Union*, *86*(5), 45-52.

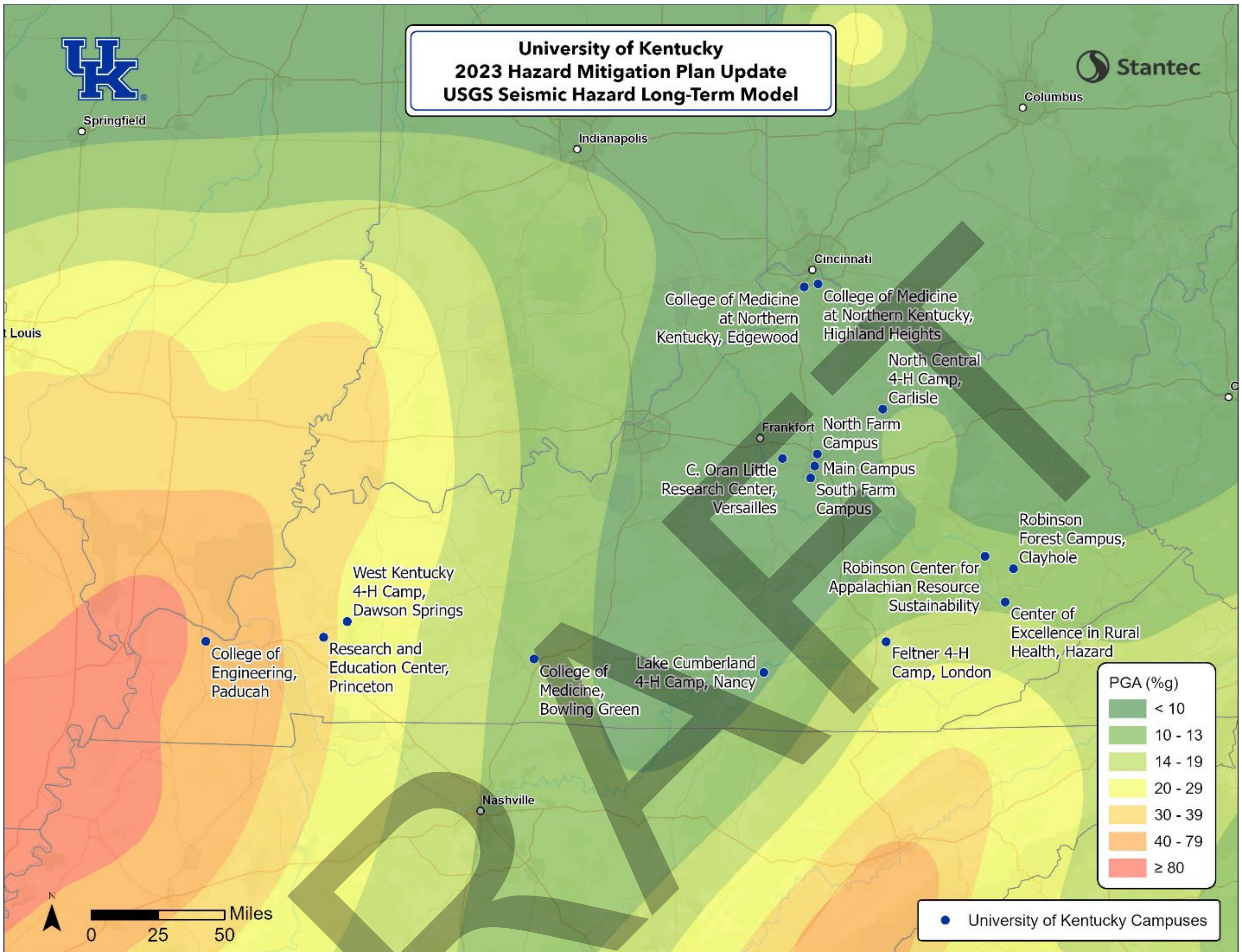

Figure 3-18: UK's Separate Campuses Overlaid on USGS Seismic Hazard Long-Term Model

Although all of UK's facilities are presented with some level of risk, those located in areas with a peak ground acceleration (PGA) greater than 10%g in the USGS's seismic hazard long-term model are considered more at risk. Three separate levels of risk were established based on the PGA values. Low earthquake risk was assigned to areas with a PGA equal to or less than 10%g, medium earthquake risk was assigned to areas with a PGA between 11-30%g, and high earthquake risk was assigned to areas with a PGA greater than 30%g. **Table 3-19** provides a breakdown of the earthquake risk level associated with each of UK's campuses or camps.

Table 3-18: Earthquake Hazard Rating by Campus

Facility Name	PGA (%g)	Earthquake Hazard Rating
College of Engineering, Paducah	60	High
Research and Education Center, Princeton	30	High
West Kentucky 4-H Camp, Dawson Springs	20	Medium
Feltner 4-H Camp, London	14	Medium
Center of Excellence in Rural Health, Hazard	12	Medium
Robinson Center for Appalachian Resource Sustainability	10	Medium
Robinson Forest Campus, Clayhole	10	Medium
College of Medicine, Bowling Green	10	Medium
Main Campus	8	Low
North Farm Campus	8	Low
South Farm Campus	8	Low
C. Oran Little Research Center, Versailles	8	Low
North Central 4-H Camp, Carlisle	8	Low
Lake Cumberland 4-H Camp, Nancy	8	Low
College of Medicine at Northern Kentucky, Edgewood	6	Low
College of Medicine at Northern Kentucky, Highland Heights	6	Low

The risk level, based on the USGS's seismic hazard long-term model, associated with each of UK's buildings are noted in **Appendix B**.

3.6 Extreme Heat

3.6.1 Description

The EPA defines an extreme heat event as "weather that is much hotter than average for a particular time and place". Essentially, any stretch of very hot weather is an extreme heat event, which may sometimes be dismissed as simply a hot spell. Extreme heat events are generally predictable along with larger weather patterns. The National Weather Service regularly tracks temperature trends and issues heat warnings well in advance of a hazardous event.

Extreme heat is characterized by temperatures that hover 10 degrees or more above the average high temperature of a region for several days to several weeks. In comparison, a heat wave may occur when temperatures hover 10 degrees or more above the average high temperature for the region and last for an extended period. The actual temperature threshold depends on norms for the region[26].

"Very hot" weather is relative to where you are located and what kinds of weather a population is accustomed to. It also depends on air temperature and relative humidity (the amount of moisture in the air). Higher humidity makes any given temperature "feel" hotter because people cannot effectively cool off by perspiring. The National Weather Service uses the Heat Index to normalize these factors and provide a consistent heat measurement. Air temperature combined with relative humidity equals the Heat Index. The example in **Figure 3-20** illustrates a Heat Index of 121 with an air temperature of 96° F and relative humidity of 65 percent — a dangerous situation. The Lexington-Fayette County Division of Emergency Management activates their extreme heat planning procedures when the Heat Index exceeds 95[27].

Temperature (°F)

Relative humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of heat disorders with prolonged exposure or strenuous activity

Caution — Extreme caution — Danger — Extreme danger

Figure 3-19: National Weather Service Heat Index

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[26] See "Extreme Heat", UW Emergency Management, https://www.washington.edu/uwem/preparedness/know-your-%20hazards/extreme-heat/

[27] From "Lexington-Fayette Urban County Extreme Heat Incident-Specific Plan", Lexington-Fayette County Emergency Weather Plan (March 2021), https://www.lexingtonky.gov/sites/default/files/2021-08/2021%20LFUCG%20Heat%20Plan.pdf

According to the Centers for Disease Control (CDC), extreme heat is more dangerous than any other weather-related hazard and sends 65,000 people to hospitals every year[28]. Between 2006 and 2015, 1,130 people died from extreme heat. In addition to causing direct harm, extreme heat exacerbates a variety of other health issues such as respiratory, cardiovascular and kidney-related diseases. Health issues associated with extreme heat can be more prevalent in the spring and early summer before people are accustomed to higher summer temperatures.

According to the CDC, the most common health impacts to a population from extreme heat include:

- **Heat Cramps:** Muscle spasms caused by a large loss of fluids and salt in the body. They can occur during strenuous outdoor activity (labor, sports) during very hot weather.
- **Heat Exhaustion:** A serious condition requiring medical attention that can occur after long exposure to extreme heat and dehydration.
- **Heat Stroke (hyperthermia):** Most often progresses from the previous heat-related conditions and occurs when the body can no longer regulate its internal temperature. Heat stroke can result in death without immediate emergency medical care.

3.6.2 Location

Extreme heat events impact large areas, and all of Fayette County is vulnerable. Extreme heat events can be especially intense in urbanized areas or "heat islands." On hot, sunny days, exposed surfaces can absorb and radiate heat, sometimes to temperatures 50 to 90 degrees Fahrenheit hotter than the air temperature. In contrast, areas with more vegetation tend to remain close to air temperatures, and trees can provide shade for people and buildings. UK campus buildings, roadways, parking lots and synthetic turf fields contribute to the urban heat island effect. Vegetation, tree cover and landscaped areas of campus can slightly mitigate the heat island effect of built areas. The urban heat island effect is visualized for different land use types in **Figure 3-21**[29].

[28] See "Climate Change and Extreme Heat", EPA (October 2016), https://www.epa.gov/sites/default/files/2016-10/documents/extreme-heat-guidebook.pdf
[29] See "Climate Change and Extreme Heat", EPA (October 2016), https://www.epa.gov/sites/default/files/2016-10/documents/extreme-heat-guidebook.pdf

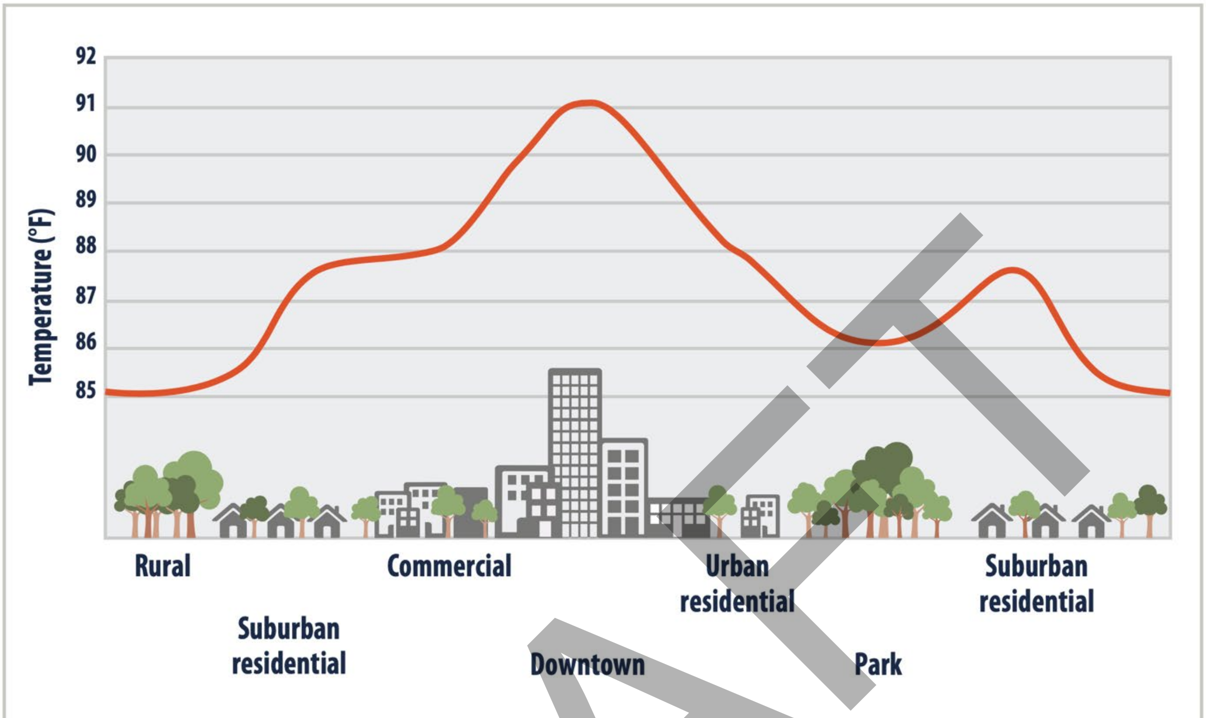

Figure 3-20: Urban Heat Island Effect Increases Local Air Temperature

3.6.3 Previous Occurrences

Data regarding previous extreme heat occurrences was collected from several sources, including stakeholder interviews, the 2015 UK Hazard Mitigation Plan, the Lexington-Fayette Urban County hazard mitigation plan, the *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* and the NOAA National Centers for Environmental Information (NCEI) Storm Events Database.

The NCEI Storm Events Database reports extreme-heat events by county; city- or campus-specific data is generally not available. Therefore, all extreme heat events reported for Fayette County are included due to the regional nature of extreme heat events and the likelihood that events impacting Fayette County also impacted the university's main campus. According to NCEI, there has been one extreme heat event in Fayette County since 1996 as shown in **Table 3-20.**

Table 3-19: NCEI Extreme Heat Occurrences in Fayette County

Date	Deaths/ Injuries	Damages (2022 Dollars)	Details
06/28/2012	0/0	$0	A 10-day heat wave began on June 28, ending on July 7. Hot temperatures, combined with moderate drought stunted area crops. On June 29, the official high temperature at Lexington Airport reached 103 degrees Fahrenheit, a record for the date and one degree shy of the all-time record high temperature for the month of June.

The current Lexington-Fayette County hazard mitigation plan and 2015 UK Hazard Mitigation Plan reference several extreme heat events that affected most of the state, including Fayette County. Those extreme heat events are summarized below.

- The "Dust Bowl" years of 1930 – 1936 saw several of the hottest summers on record in the U.S. July **1936** brought on some of the highest temperatures during that period including a record of 108°F in Fayette County. Nationally, 5,000 deaths were attributed to the heat wave. Fayette County experienced 85 days of over 90°F during 1936.
- In **1952**, there was a heat wave. While it was not as intense as other heat waves, it was long. The Kentucky Division of Forestry noted that numerous acres burned in 1952 due to a lack of precipitation.
- There were consecutive heat waves in **1990** and **1991** leading to a statewide drought in 1991.
- During the last two weeks of July in **1999**, the Midwest experienced a series of days with temperatures over 90°F. More than 232 deaths in 9 states were attributed to the heat wave. Most fatalities were elderly persons living alone in cities without or with limited air conditioning. The urban heat island effect amplified temperatures by 3 to 5°F.
- During **2007**, there were a recorded 67 days of temperatures over 90°F and 5 days reaching over 100°F. A federal disaster designation by the U.S. Department of Agriculture was declared allowing farmers in the state to seek emergency assistance, including low-interest loans to help pay for essential farm and living expenses.
- In **2010**, a heat wave lasting 7 consecutive days saw temperatures at or above 105°F. The summer was among the hottest on record. There were at least 13 heat related illnesses treated by hospitals in the Paducah area, 29 cases of heat exhaustion in the Owensboro area and seven cases in the Hopkinsville area.

3.6.4 Extent

Extreme heat extent can be defined with record highs. The record temperature in Lexington, Kentucky, where the university's main campus is located, was 108°F on July 10, 1936, and July 15, 1936[30]. The hottest temperature recorded in Kentucky was 114°F on June 28, 1930, in Greensburg, Kentucky (approximately 55 miles northeast of the Bowling Green Medical campus). Hotter events are possible in the future, especially with expected temperature increases due to climate change. In addition, the urban heat island effect can increase heat events.

[30] See "Lexington Climate", National Weather Service, https://www.weather.gov/lmk/clilex

3.6.5 Probability

The CDC has tracked the number of extreme heat days in communities for the last twenty years (2001-2021). Extreme heat days by year for Fayette County are shown in **Figure 3-22**[31]. Data is collected between May and September annually. The first 10 years of data (2001-2010) averaged 15.7 annual extreme heat days, and the second 10 years (2011-2021) averaged 25.6 annual extreme heat days.

Climate change is expected to result in increasing temperatures for all parts of the United States. According to the *Fourth National Climate Assessment*, average U.S. temperatures have increased by 1.3°F to 1.9°F since 1895, when recordkeeping began. Since 1970, temperature increases have occurred rapidly. Increases in average temperature will result in more hot weather and increasing number of extreme heat days. **Figure 3-23** illustrates temperature changes between 1991 and 2012 compared with average temperature between 1901 and 1960 (AK and HI average temperature between 1951 and 1980).

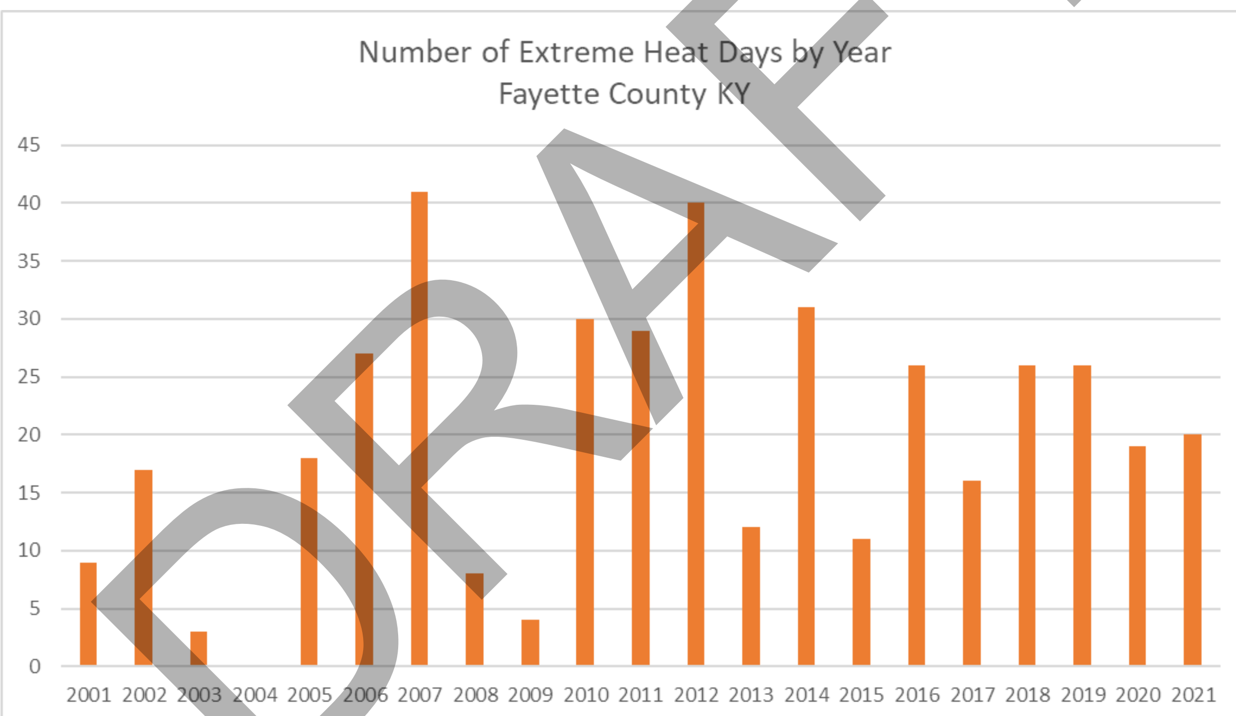

Figure 3-21: Extreme Heat Days by Year, Fayette County, KY.

[31] From "National Environmental Public Health Tracking Network", CDC, https://ephtracking.cdc.gov/

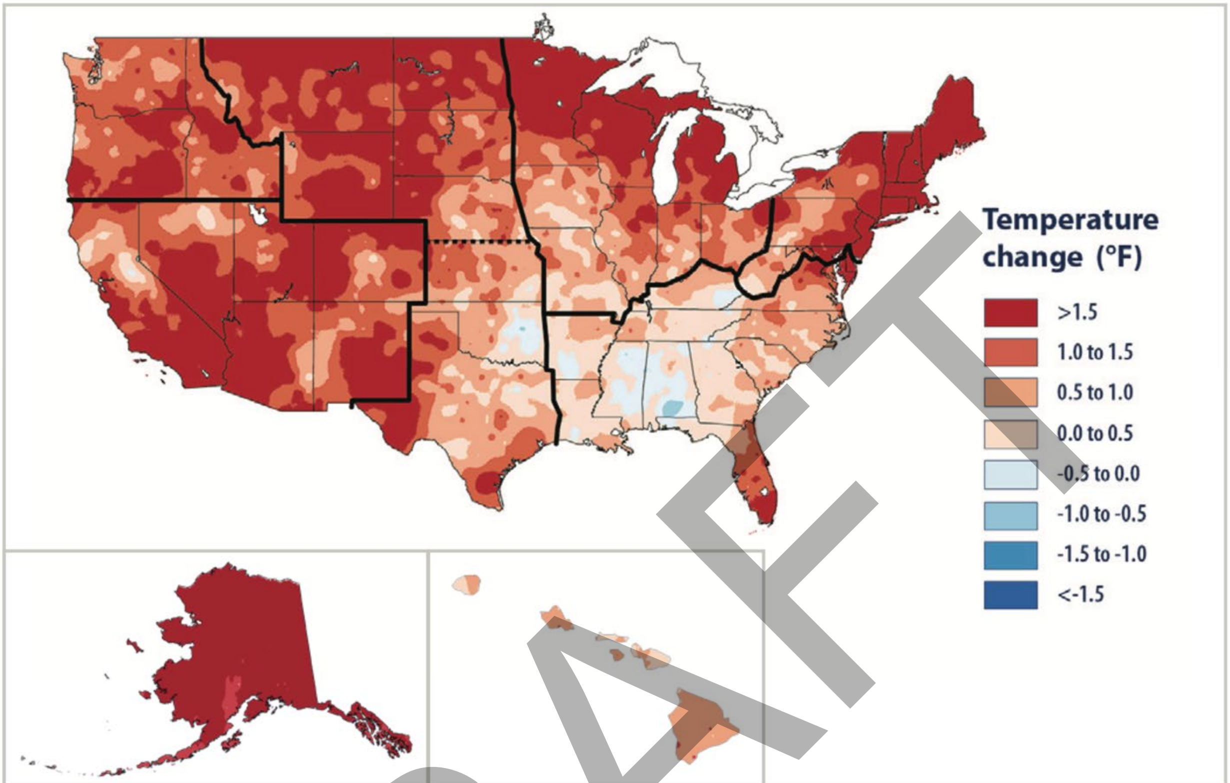

Figure 3-22: Observed U.S. Temperature Change 1991 - 2012 (EPA)

Under a higher emissions scenario (RCP8.5), Lexington-Fayette County is expected to experience 17 more days above 95°F annually by mid-century and 60 more days above 95°F by end of century[32]. The *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* references a study completed by the U.S. Army Corps of Engineers (USACE) and Ohio River Basin Alliance (ORB Alliance) that studies climate change in the Ohio River Basin, including Kentucky[33]. The study recognizes that there has been gradual warming in the Ohio River Basin since the late 1970s, and that gradual warming will continue until 2040. The study predicts temperatures may rise one degree every decade through 2099. The *Fourth National Climate Assessment* recognizes that cities across the southeast are experiencing more frequent and longer summer heat waves, which can be worsened by the urban heat island effect. The number of days with high nighttime temperatures has been increasing across the Southeast, which reduces the ability to recover from high daytime temperatures.

The entire state of Kentucky is projected to experience an increase in the number of warm nights with western Kentucky and urbanized areas seeing the greatest increase as shown in **Figure 3-24**.

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[32] See "Neighborhoods at Risk", Headwaters Economics, https://nar.headwaterseconomics.org/2100046027/explore/climate

[33] See "Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance", U.S. Army Corps of Engineers (2017), https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=339719&Lab=NRMRL

Increases in the intensity and frequency of extreme heat events will exacerbate life safety, health and public health impacts.

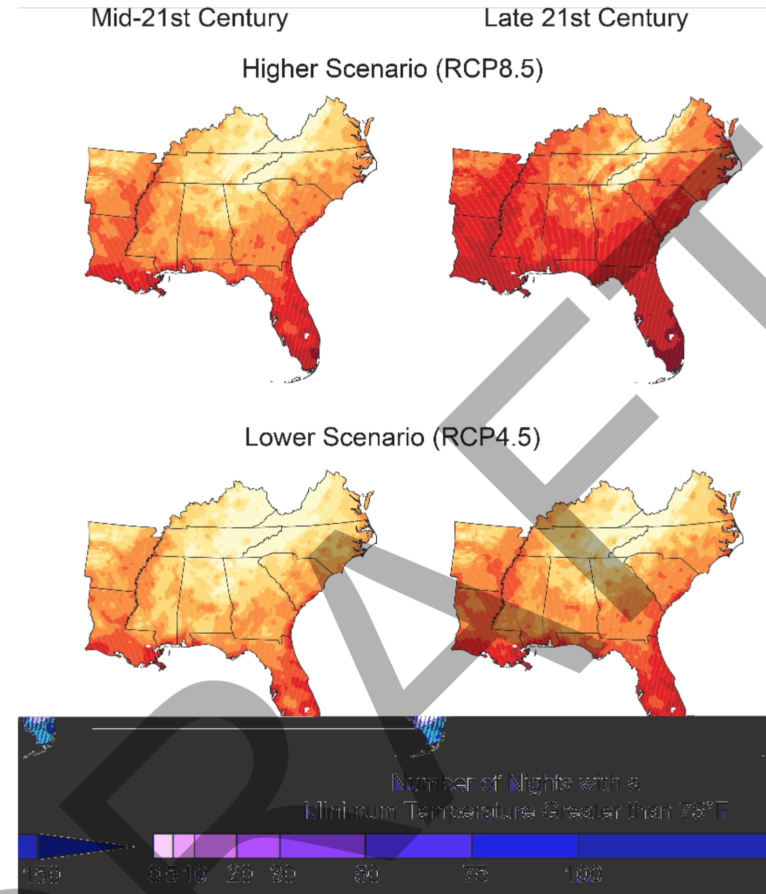

Figure 3-23: Projected Number of Warm Nights in the Southeast

With 25.6 annual extreme heat days from 2011 to 2021, Fayette County experiences approximately 2.5 extreme heat days a year. Given the number of extreme heat days a year and projected increase in the number of extreme heat days a probability of “highly likely” (greater than 90 percent annual chance) was assigned.

3.6.6 Vulnerability Assessment

All UK campuses and 4-H camps are vulnerable to extreme heat, including all current and future buildings, critical facilities, infrastructure and populations. There are no reported associated dollar losses with the extreme heat hazard in the planning area. Future damage is expected to be negligible but is possible through power outages or road buckling, for example.

Extreme heat events generally have a limited impact on buildings. However, in some rare cases extreme heat can cause structures to collapse or buckle. Further, increasing extreme heat events may require HVAC equipment to be upsized.

Extreme heat events generally have a minimal impact on infrastructure. Power consumption for air-conditioned environments could increase and thus stress utility infrastructure, resulting in blackouts. In severe cases, heat can cause railroad tracks to expand. This is referred to as a heat kink in the rail line and can result in disruptions or derailments. Heat can also cause pavement to expand and buckle.

Despite limited potential for damage, there are serious health risks to the population. Urban areas are exposed more acutely to the dangers of extreme heat due to the urban heat island effect. On campus, this would include built areas without shading, such as surface parking lots and clusters of buildings. Stadiums are also particularly vulnerable to extreme heat events, especially with the use of turf grass and rubber fill, which captures and radiates heat, as well as the "bowl" shape of the stadium, which limits air flow and breezes.

People are at risk for heat stroke or sun stroke, heat exhaustion, fatigue and dehydration. Certain groups may be more vulnerable to the effects of extreme heat. Groups particularly vulnerable to extreme heat include[34]:

- Older adults, who do not adjust as quickly to changes in temperature. They are also more likely to be on medications or have chronic illnesses that affect the body's ability to regulate its temperature. Groups of older adults on campus may include UK faculty or staff, campus visitors or patients being treated by UK HealthCare.
- Infants and children, who rely on others to keep them cool and hydrated. Like older adults, children may visit campus for special events or field trips, as residents in family-oriented on-campus housing or to be treated at UK medical facilities.
- Athletes, who may be more likely to exercise and become dehydrated during extreme heat events. The university houses many athletes (varsity, club and intramural teams) and students utilizing athletic facilities on-campus.
- Outdoor workers, such as maintenance, groundkeepers and outdoor researchers, who are more exposed to extreme heat and are more likely to become dehydrated.
- Populations who may not have air conditioning available in offices, cabins or residence halls.

Aside from the heat-induced health impacts described above, extreme heat negatively impacts air quality by increasing the amount of ground-level ozone (or smog). Worsened air quality can aggravate existing respiratory illnesses, and long-term exposure can result in decreased lung function[35]. Extreme heat can degrade water quality by heating water bodies directly or heating runoff that drains into them.

As an agricultural research university, UK maintains valuable agriculture fields and livestock for research and education. Extreme heat can lead to damage or loss of crops. Each crop has optimal temperature ranges for growth and reproduction[36]. Warming may cause shifts in crops that are typically able to grow in an area. If temperatures exceed a crop's optimum temperature, yields may decline. High temperatures can also cause soil to become drier, leading to drought.

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[34] See "About Extreme Heat", CDC (2017), https://www.cdc.gov/disasters/extremeheat/heat_guide.html
[35] From "Ground-level Ozone Basics", EPA (June 2022), https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics#effects
[36] See "Climate Impacts on Agriculture and Food Supply", EPA, https://climatechange.chicago.gov/climate-impacts/climate-impacts-agriculture-and-food-supply#:~:text=Heat%20stress%20affects%20animals%20both,threaten%20pasture%20and%20feed%20supplies.

Many weeds and pests thrive under warming temperatures, which may cause more competition with crops. Rising concentrations of carbon dioxide can also reduce the nutritional value of food crops. Extreme heat and heat stress also impact livestock. Heat stress can increase vulnerability to disease, reduce fertility and reduce milk production. Higher temperatures can also increase the prevalence of parasites and diseases that affect livestock.

During an interview with staff from the UK Martin-Gatton College of Agriculture, Food and Environment (CAFE), previous experiences and concerns with extreme heat were mentioned in reference to the 4-H camps. Due to extreme heat, there have been days where all activities were moved indoors. There are limited air-conditioned spaces at the 4-H camps, and there are no spaces that can hold everyone inside for a class. Additionally, the HVAC systems are outdated and there is limited insulation in some facilities. The department wants to redo the HVAC system at Lake Cumberland 4-H Camp due to reoccurring issues.

3.7 Extreme Cold

3.7.1 Description

"Extreme cold" extent can mean different things in terms of hazard identification. It might be associated with a winter storm or heavy snowfall, or it could happen with little to no precipitation. Generally, extreme cold events refer to a prolonged period (days) with extremely cold temperatures. According to the National Weather Service an extreme cold event can refer to a single day of extreme or record-breaking day of sub-zero temperatures. Extended or single-day extreme cold events are hazardous to people and animals and cause problems with buildings and transportation. Extreme cold and winter storm events are generally predictable, along with larger weather patterns.

"Very cold" weather is relative to where you are located and to what kinds of weather a population is accustomed. It also depends on air temperature combined with wind speed. Higher winds make any temperature "feel" colder because of the extra cooling effect moving air causes.

The National Weather Service uses the Wind Chill Index to normalize these factors and provide a more effective categorization of dangerously cold temperatures. The National Weather Service weather forecast offices routinely issue two types of alerts to warn people about dangerously low wind chill temperatures:

- A **Wind Chill Advisory** is issued when wind chill temperatures are potentially hazardous.
- A **Wind Chill Warning** is issued when wind chill temperatures are life-threatening.

The Wind Chill Index is a measure of the rate of heat loss from exposed skin caused by the combined effects of wind and cold. As the wind increases, heat is carried away from the body at a faster rate, driving down both the skin temperature and eventually the internal body temperature. Exposure to extreme wind chills can be life-threatening. **Figure 3-25** shows the NOAA Wind Chill Chart, which demonstrates the Wind Chill Index as it corresponds to various temperatures and wind speeds. For example, if the air temperature is 5°F and the wind speed is 10 miles per hour, then the wind chill would be -10°F.

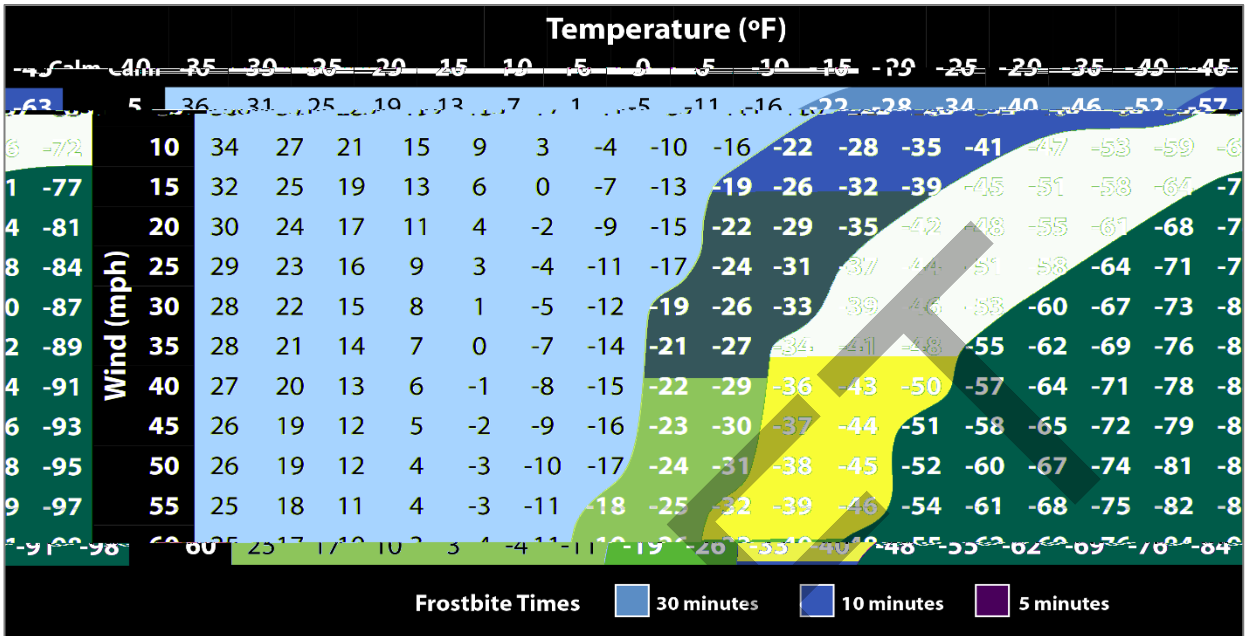

Figure 3-24: NOAA Wind Chill Index

Frostbite and hypothermia are both extreme cold-related impacts that result when individuals are exposed to extreme temperatures and wind chills, in many cases because of severe winter storms. The following describes the symptoms associated with each:

- **Frostbite** is characterized by a loss of feeling and a white or pale appearance. At a wind chill of -19°F, exposed skin can freeze in as little as 30 minutes. It can permanently damage tissue, and, in severe cases, can lead to amputation.
- **Hypothermia** occurs when the body begins to lose heat faster than it can produce it. As a result, the body's temperature begins to fall. Hypothermia is characterized by uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness and exhaustion. Left untreated, hypothermia will lead to death.

3.7.2 Location

All of Kentucky has the potential to experience extreme cold events. The main campus in Fayette County and the outlying facilities have similar exposure to the extreme cold hazard.

3.7.3 Previous Occurrences

Data about previous extreme cold occurrences was collected from several sources, including university claims data from January 2012 to October 2022, the 2015 *UK Hazard Mitigation Plan*, the *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* and the NOAA NCEI Storm Events Database.

The NCEI Storm Events Database reports extreme-cold/ windchill events by county; city- or campus-specific data is generally not available. Therefore, all extreme cold events reported for Fayette County are included.

However, due to the regional nature of extreme cold events it is likely that events impacting Fayette County likely impacted UK's main campus. According to NCEI, there have been two extreme cold events in Fayette County since 1996 as shown in **Table 3-21**.

Table 3-20: NCEI Extreme Cold Occurrences Fayette County

Date	Deaths/ Injuries	Damages (2022 Dollars)	Details
02/15/2015	2/0	$0	An arctic outbreak brought frigid air to central Kentucky, resulting in one of the heaviest snowfalls in a decade for the state and several hypothermia fatalities. Several record-low temperatures occurred early on February 20 when clear skies and calm winds and a fresh snowpack in excess of six inches led to early morning lows near 20 degrees below zero, as measured by several Kentucky Mesonet locations. The ASOS site at Lexington Airport reached -18 degrees. Ten hypothermia deaths were recorded in Kentucky during the period. In Fayette County, a woman slipped and fell in the parking lot of her apartment after leaving a friend's home. Her body was found the next morning. The coroner ruled her death to be exposure and hypothermia. In addition, a man died due to exposure in his unheated mobile home early on February 17.
01/11/2016	1/1	$0	Bitterly cold temperatures encompassed central Kentucky during the morning hours of January 11. Widespread lows were in the single digits to low teens, and Bluegrass Airport in Lexington recorded a minimum temperature of 10 degrees. A slight breeze kept wind chill values in the single digits above and below zero. A local homeless man was found unresponsive in downtown Lexington and later pronounced dead. The Fayette County Coroner's office determined alcohol and exposure to the cold leading to hypothermia contributed to his death.

The 2015 UK Hazard Mitigation Plan referenced additional extreme cold events summarized below:

- In **1994**, an intense winter storm caused record snow in Fayette County. The county came within one degree of its all-time record cold.
- In **2009**, a massive ice storm caused destruction throughout the state and included extremely cold weather. Most of the state saw temperatures below freezing and wind chill below zero degrees. Due to the extreme cold, recovery efforts were slow from lingering ice.

During winter the Ohio Valley is subject to cold snaps where temperatures can reach well below freezing. Extreme cold events are most likely to occur between November and March when UK faculty, staff and students are on campus. UK Risk Management provided claims data from January 2012 to October 2022. There were 35 claims attributed to extreme cold, costing over $1.4 million.

There were 23 buildings with extreme cold claims;20 of the buildings were located on the main campus. The claims associated with extreme cold are shown in **Table 3-22**. Most of the claims were due to frozen pipes. Additionally, the winter of 2022 – 2023 brought extreme cold temperatures to UK's main campus. There were multiple frozen water pipes that caused extensive damage across campus. Damages to student housing disrupted living arrangements for some students returning from the holiday break[37]. These claims were not included in the claims data provided.

[37] See "UK working to repair buildings impacted by burst pipes", WKYT (January 2023), https://www.wkyt.com/2023/01/02/uk-working-repair-buildings-impacted-by-burst-pipes/

Table 3-21: UK Extreme Cold Claims

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous losses ($) *
3869	Beef Unit/Intensive Rsch	-	$4,288,658	$339,793	$246,382	Not Rated	1	$23,824
5	Frank D. Peterson Service Building	Main Campus	$29,372,246	$5,043,265	$0	Poor	1	$27,290
12	Blazer Dining	Main Campus	$25,066,646	$710,201	$1,530,075	Not Rated	1	$0
14	Hilary J. Boone Center	Main Campus	$4,935,802	$515,969	$0	Not Rated	1	$35,960
17	Dickey Hall	Main Campus	$14,674,458	$1,804,872	$468,472	Poor	1	$261,160
19	Memorial Coliseum	Main Campus	$111,532,057	$2,292,632	$0	Fair	1	$12,586
27	Patterson Office Tower	Main Campus	$92,282,524	$2,660,643	$2,848,935	Poor	1	$0
56	Breckinridge Hall	Main Campus	$5,041,629	$101,171	$420,702	Poor	1	$0
96	Dorothy Enslow Combs Cancer Research Building	Main Campus	$24,461,391	$4,079,179	$2,437,299	Good	2	$9,823
200	Wethington Allied Health Building	Main Campus	$79,165,066	$6,866,590	$17,783,727	Excellent	2	$107,219
222	Kroger Field	Main Campus	$141,979,364	$627,903	$0	Not Rated	1	$16,533
223	Warren Wright Medical Plaza	Main Campus	$70,097,094	$7,479,870	$4,002,293	Fair	3	$23,122

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous losses ($) *
230	Sanders-Brown Center on Aging	Main Campus	$26,553,265	$4,069,808	$10,042,018	Fair	2	$41,840
286	ASTeCC	Main Campus	$40,117,642	$11,544,719	$5,082,012	Good	1	$44,694
293	UK Hospital - Chandler Medical Center & Hospital (Pavilion H)	Main Campus	$386,308,392	$103,697,511	$10,164,347	Not Rated	3	$23,770
298	William R. Willard Medical Education Building	Main Campus	$122,815,949	$14,483,261	$22,941,927	Poor	1	$0
305	Peter P. Bosomworth Health Sciences Research Building	Main Campus	$41,359,879	$8,225,940	$5,797,348	Excellent	2	$556,787
351	644 Maxwelton Ct	Main Campus	$531,662	$2,339	$0	Fair	1	$0
596	Lee T. Todd, Jr. Building	Main Campus	$150,646,287	$11,800,000	$28,725,168	Excellent	1	$93,698
602	Patient Care Facility (Pavilion A)	Main Campus	$713,655,650	$106,579,517	$0	Not Rated	3	$34,761
8633	UK HealthCare Good Samaritan Hospital	Main Campus	$158,161,512	$35,142,164	$90,654	Not Rated	2	$47,223
2070	CAER Laboratory 2	North Farm	$22,922,835	$0	$9,722,278	Not Rated	1	$30,701

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous losses ($) *
9306	Kitchen & Dining Hall	Robinson Forest - Clayhole	$828,470	$39,129	$0	Not Rated	1	$11,919

3.7.4 Extent

The extent of extreme cold/wind chill (i.e., severity) is defined with record lows and the NWS Wind Chill Index. The record low temperature for Fayette County is -21°F, occurring on January 24, 1963. This correlates to a frostbite exposure time of 5 – 30 minutes, depending on the wind. The record low for Kentucky is -37°F in Shelbyville on January 19, 1994. This correlates to a frostbite exposure time of 5 – 30 minutes, depending on the wind. Colder events are possible, but warming temperatures associated with climate change may result in less severe extreme cold events in the future.

3.7.5 Probability

There have been three extreme cold events reported in Fayette County since 1996.The county experiences approximately one extreme cold event every eight to nine years. However, it is likely that extreme cold events are underreported in the NCEI database. Based on the provided claims data, the university reports approximately 3.5 claims associated with extreme cold each year. Most of the claims were related to frozen pipes.

Nationally, climate change is expected to result in increasing temperatures for all parts of the country, often along with increased precipitation. Climate scientists expect that warming temperatures will result in the coldest days being less cold, which would reduce frequency of the extreme cold/wind chill hazard. Increased precipitation could complicate cold weather by bringing more ice storms. According to the *Fourth National Climate Assessment*, average U.S. temperatures have increased by 1.3°F to 1.9°F since 1895, when recordkeeping began. Since 1970, temperature has increased rapidly. Increases in average temperature results in more hot weather and an increasing number of extreme heat days**. Figure 3-26** illustrates temperature changes between 1991 and 2012 compared with average temperature between 1901 and 1960 (AK and HI average temperature between 1951 and 1980).

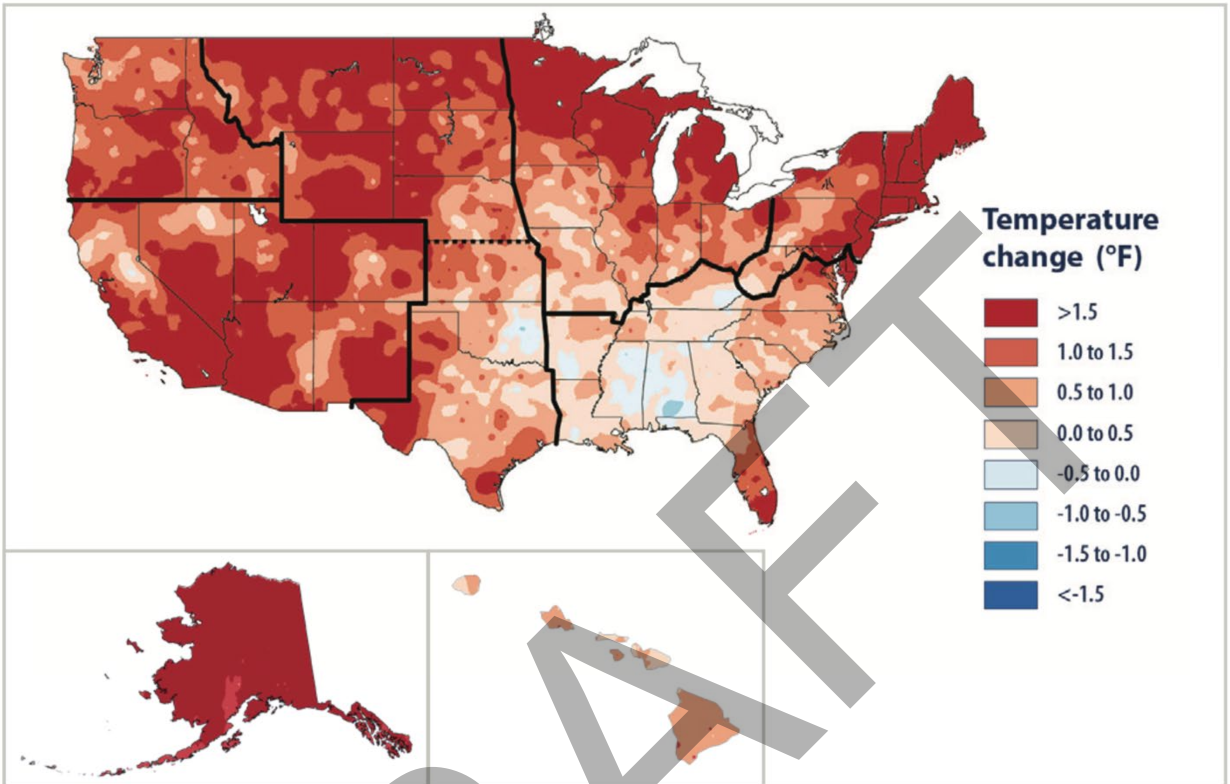

Figure 3-25: Observed U.S. Temperature Change 1991 – 2012 (EPA)

The *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* references a study completed by the U.S. Army Corps of Engineers and Ohio River Basin Alliance that studies climate change in the Ohio River Basin, including Kentucky[38]. The study recognizes that there has been gradual warming in the Ohio River Basin since the late 1970s. The gradual warming will continue until 2040, after which the study predicts temperatures may rise one degree every decade through 2099. Warming temperatures have the potential to decrease the magnitude and frequency of extreme cold events.

Trends show temperature increases on cold days growing larger farther north across the United States. Instability in atmospheric wind patterns can contribute to "polar vortex" events, bringing arctic air south into the Ohio River valley. UK should not rely on past winter weather patterns to remain stable into the future.

Based on the information available regarding historic or current events, the extreme cold/wind chill hazard was assigned a probability of likely (10 to 90 percent annual chance).

[38] See "Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance", U.S. Army Corps of Engineers (2017), https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=339719&Lab=NRMRL

3.7.6 Vulnerability Assessment

The entire UK campus and outlying facilities, including current and future buildings, populations, infrastructure and other assets, are vulnerable to extreme cold/wind chill events.

Extreme cold can result in damage to buildings, including critical facilities, typically from internal pipes freezing and bursting. Frozen water lines can interrupt water supplies and cause significant damage to buildings and property from burst pipes. With many students and personnel living and working on campus, burst pipes from freezing temperatures can lead to large operational disruptions. In the winter of 2022-2023, damages from frozen pipes at UK's main campus led to student housing disruptions. Extreme cold/wind chill can also result in damage to infrastructure, including broken water mains and stress to concrete and asphalt.

Extreme cold/wind chill can result in frostbite or hypothermia, even after only a few minutes of exposure. Certain populations, such as the elderly, young children and those without access to an adequate heat source are considered at a higher risk of experiencing the impacts of extreme cold, which could include death. Some extreme cold/wind chill events may result in advisories imploring people to remain indoors to limit exposure. Evacuations are not likely for extreme cold events. However, people may be advised to remain indoors. New students coming from warmer climates are also considered a vulnerable population as they may not be used to colder climates and may not have proper clothing and equipment. Many international students stay on campus during winter break when most of the campus is closed. These students may not be used to extreme cold and may need to walk or utilize public transportation to reach critical facilities.

Wide-scale impacts to public health from extreme cold/wind chill events are limited. Carbon monoxide-related deaths are highest during extreme cold events due to the increased use of gas-powered furnaces and alternative heating sources (e.g., generators, grills and camp stoves) inside homes and buildings[39]. The risk for fire and electric shock also increases when using alternative heating and power sources, such as space heaters.

Extreme cold events present a high risk to socially vulnerable populations. Economically constrained households are more likely to live in homes with inadequate heat (e.g., substandard or aging housing) and less able to find or even seek out a warm place. Further, such populations may have little to no financial buffers that would facilitate preparedness or mitigation actions, such as repair or insulation of homes, purchase and installation of safe heating options or the ability to afford a heating bill surge resulting from an extreme hold event. This often results in the use of improper heat sources (such as a stove), which creates further dangers like carbon monoxide poisoning. People experiencing housing insecurity also face increased risks and may struggle finding or traveling to a heating location.

As an agricultural research university, UK maintains valuable agriculture fields and livestock for research and education.

In Kentucky, most crops are not grown in the winter, when extreme cold is most common[40]. However, extreme cold during the growing season can lead to damage or loss of crops. Livestock is also impacted by extreme cold, especially when it is associated with severe winter storms.

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[39] See "Extreme Weather & Public Health", Arizona Department of Health Services, https://www.azdhs.gov/preparedness/epidemiology-disease-control/extreme-weather/index.php#cold-co-poisoning
[40] See "Kentucky Crop Timeline", Commonwealth of Kentucky, https://education.ky.gov/federal/progs/tic/Documents/KY%20Crop%20Time-line.pdf

For example, a 2013 blizzard in South Dakota resulted in the loss of approximately five percent of the region's cattle herd[41]. In these instances, livestock must be relocated to shelters and may become stressed from unfamiliar surroundings. Extreme cold can cause water sources to freeze, leaving the livestock without adequate water supply. Animals exposed to extreme storms may experience health impacts, including death from hypothermia. Young animals are more vulnerable to extreme cold and require extra care. Personnel tending to crops or livestock during extreme cold face higher exposure.

As described above, climate change has the potential to decrease the severity and frequency of extreme cold events in Kentucky. However, Kentucky is likely to continue to experience extreme cold temperatures.

3.8 Flood

3.8.1 Description

Flooding is a frequent, dangerous and costly hazard. Globally, it accounts for 44 percent of all natural disasters and 16 percent of all deaths from natural disasters[42]. In the U.S., flooding results in an average of 88 deaths annually[43]. Approximately 75 percent of presidential disaster declarations are associated with flooding[44]. Floods cause utility damage and outages, infrastructure damage (including transportation and communication systems), structural damage to buildings, crop loss, decreased land values and travel impediments.

Flooding is the most common environmental hazard due to the widespread geographical distribution of valleys and coastal areas and the population density in these areas.

The severity of a flooding event is typically determined by a combination of several major factors, including stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surfaces. Flooding events can be brought on by severe (heavy) rain. There are several types of flooding, which are presented below in **Table 3-23**.

[41] Form "Severe Cold Weather Rangeland and Livestock Considerations", Colorado State University Extension, https://extension.colostate.edu/topic-areas/agriculture/severe-cold-weather-rangeland-and-livestock-considerations/
[42] From "WMO Atlas of Mortality and Economic Losses from Weather, Climate, and Water Extremes (1970 – 2019)", World Meteorological Association (2021), https://library.wmo.int/doc_num.php?explnum_id=10989
[43] From "Thunderstorm Hazards – Flash Floods", NOAA (November 2022), https://www.noaa.gov/jetstream/thunderstorms/flood#:~:text=While%20the%20number%20of%20fatalities,for%20flood%20deaths%20is%2088.
[44] From "Flood Related Hazards", NWS, https://www.weather.gov/safety/flood-hazards

Table 3-22: Types of Flooding

Flooding Type	Description
Flash Flooding	Flash floods occur within a few minutes or hours of heavy amounts of rainfall. They destroy buildings, uproot trees and scour out new drainage channels. Heavy rains that produce flash floods can also trigger mudslides and landslides. Most flash flooding is caused by slow-moving thunderstorms, repeated thunderstorms in a local area or by heavy rains from hurricanes and tropical storms. Although flash flooding often occurs in mountainous areas, it is also common in urban centers where much of the ground is covered by impervious surfaces.
Sheet Flooding	Sheet flooding is a condition where storm water runoff forms a sheet of water to a depth of six inches or more. Sheet flooding and ponding are often found in areas where there are not clearly defined channels and the path of flooding is unpredictable. It is also more common in flat areas. Most floodplains are adjacent to streams or oceans; although almost any area can flood under the right conditions where water may accumulate.
Urban Flooding	Urban flooding is usually caused by heavy rain over a short period of time. As land is converted from fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Since sidewalks and roads are non-absorbent, rivers of water flow down streets and into storm sewers. Roads and buildings generate more runoff than forestland. Fixed drainage channels in urban areas may be unable to contain the runoff that is generated by relatively small, but intense, rainfall events. Urbanization increases runoff two to six times over what would occur on natural terrain. This high volume of water can turn parking lots into lakes, flood basements and businesses and cause lakes to form in roads where drainage is poor or overwhelmed. Urban flooding, which can include flash flooding and sheet flooding, can also occur where there has been development within stream floodplains. This is partly a result of the use of waterways for transportation purposes in earlier times. Sites adjacent to rivers and coastal inlets provided convenient places to ship and receive commodities. The price of this accessibility has increased flooding in the ensuing urban areas. Urbanization intensifies the magnitude and frequency of floods by increasing impermeable surfaces, amplifying the speed of drainage collection, reducing the carrying capacity of the land and, occasionally, overwhelming sewer systems.
Riverine Flooding	Periodic flooding of lands adjacent to non-tidal rivers and streams (known as the floodplain) is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal watercourse, some of the above-normal stream flows affect adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of a stream or river. According to USGS, the recurrence interval of a flood is defined as probability of an event in any given year (e.g., one percent annual chance). Flood magnitude increases with increasing recurrence interval.

There are several types of floodplains. These are identified areas of flood occurrence. However, not all flooding occurs in such areas. Localized urban flooding and flash flooding often occur outside of designated floodplain areas.

A **floodplain** is the land area susceptible to being inundated or flooded by water from any source (i.e., river, stream, lake, estuary, etc.). Floodplains are natural features of any river or stream. Streams that drain more than one square mile have their estimated floodplain areas mapped in most areas. The mapped floodplain areas are called the regulatory floodplain. The regulatory floodplain mapping is a result of the hydrologic (rainfall) and hydraulic (runoff) analysis of the watershed and stream.

The **regulatory floodplain** is also known as the 100-year floodplain, base flood elevation, 1.0 percent annual chance floodplain or the Special Flood Hazard Area. The 100-year floodplain is the land area that is subject to a 1.0 percent or greater chance of flooding in any given year. The term “100-year flood” is often misinterpreted. The 100-year flood does not mean that it will occur once every 100 years. A 100-year flood has a 1/100 (one percent) chance of occurring in any given year. A 100-year flood could occur two times in the same year or two years in a row. It is also possible to not have a 100-year flood event over the course of 100 years or more.

The **floodway** is the portion of the 100-year floodplain required to convey the flood event. The **flood fringe** provides flood water storage. The floodway is a high velocity area, and structures or obstructions in the floodway may be at higher risk and can increase flood heights.

While the 100-year (or base flood) is the standard most commonly used for floodplain management and regulatory purposes in the United States, the 500-year flood, also known as the 0.2 percent annual chance flood area, is the national standard for protecting critical facilities, such as hospitals and power plants (when federally funded). A 500-year flood has a 1/500 (0.2 percent) chance of occurring in any given year. It is generally deeper than a 100-year flood and covers a greater amount of area. However, it is statistically less likely to occur.

A regulatory floodplain is a Special Flood Hazard Area (SFHA) shown on a Flood Insurance Rate Map (FIRM).. FIRMs are produced by FEMA. SFHAs are delineated on the FIRMs and may be designated as Zones A, AE, AO, AH, AR V, VE, A-99. Structures located in the SFHA are highly susceptible to flooding. Structures located in the SFHA A-Zones are required by lenders to be protected by flood insurance. Anyone in a community who participates in the National Flood Insurance Program (NFIP) may voluntarily purchase flood insurance. The following SFHA zones are present on UK campuses and/or outlying facilities:

Zone A: Zone A is the flood insurance rate zone that corresponds to the 1.0 percent annual chance floodplains determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations (BFEs) or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone AE: Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains determined in the Flood Insurance Study by detailed methods. In most instances, BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

In addition to SFHA zones, Zone X is also present on UK campuses. Zone X corresponds to areas outside of the 1.0 percent annual chance flood area, areas in the 0.2 percent annual chance flood boundary and areas of minimal flood hazard.

Flooding can occur any time of year. The severity of flooding is determined by a combination of topography and physiography, ground cover, precipitation and weather patterns and recent soil moisture conditions. Flooding is also governed by the size and the nature of a stream’s watershed. A watershed is the geographic area of land where all runoff drains to a common point. Fayette County is within the Kentucky River Basin watershed.

The Lexington-Fayette Urban County Government (LFUCG) began their floodplain management program in 1972, when the community joined the NFIP. As part of that program, the county adopted the Floodplain Conservation and Protection Ordinance to regulate development in the floodplain.

Additionally, LFUCG has participated in a voluntary incentive program under the NFIP called the Community Rating System (CRS) since its inception in 1991. Under the CRS program, communities gain points for flood prevention and reduction activities, higher regulatory standards, outreach projects, stormwater and floodplain management and other mitigation activities. The more points or credit the community receives, the lower the flood insurance premium cost for the residents of Fayette County. The 2019 *Lexington-Fayette Urban County Hazard Mitigation Plan* serves as the Floodplain Management Plan under the CRS program. UK does not insure their structures under the NFIP but instead uses self-insurance.

3.8.2 Location

The Fayette County FEMA Digital Flood Insurance Rate Map (DFIRMs), which include UK's main campus, present both the 1.0-percent annual chance (100-year) floodplain and 0.2-percent annual chance (500-year) floodplain areas as shown in **Figure 3-27.** These DFIRMs became effective in 2017. As shown in the figure, there is a limited FEMA flood hazard area present on the main campus. On UK's main campus, mapped flood hazard areas are only present the grounds of the Arboretum. There are approximately 13,500 square feet on the edge of the Arboretum property that intersects with the floodplain.

However, it should be noted that flooding outside of the FEMA designated flood areas is possible on the main campus as well as at UK's other campuses and outlying facilities. There are flood hazard areas present at the North Farm, West Kentucky 4-H Camp, and Robinson Center for Appalachian Resource Sustainability (RCARS). A more severe event could easily exceed the 0.2-percent annual chance (500-year) floodplain boundaries shown. Urban flooding and sheet flooding occur throughout the planning area.

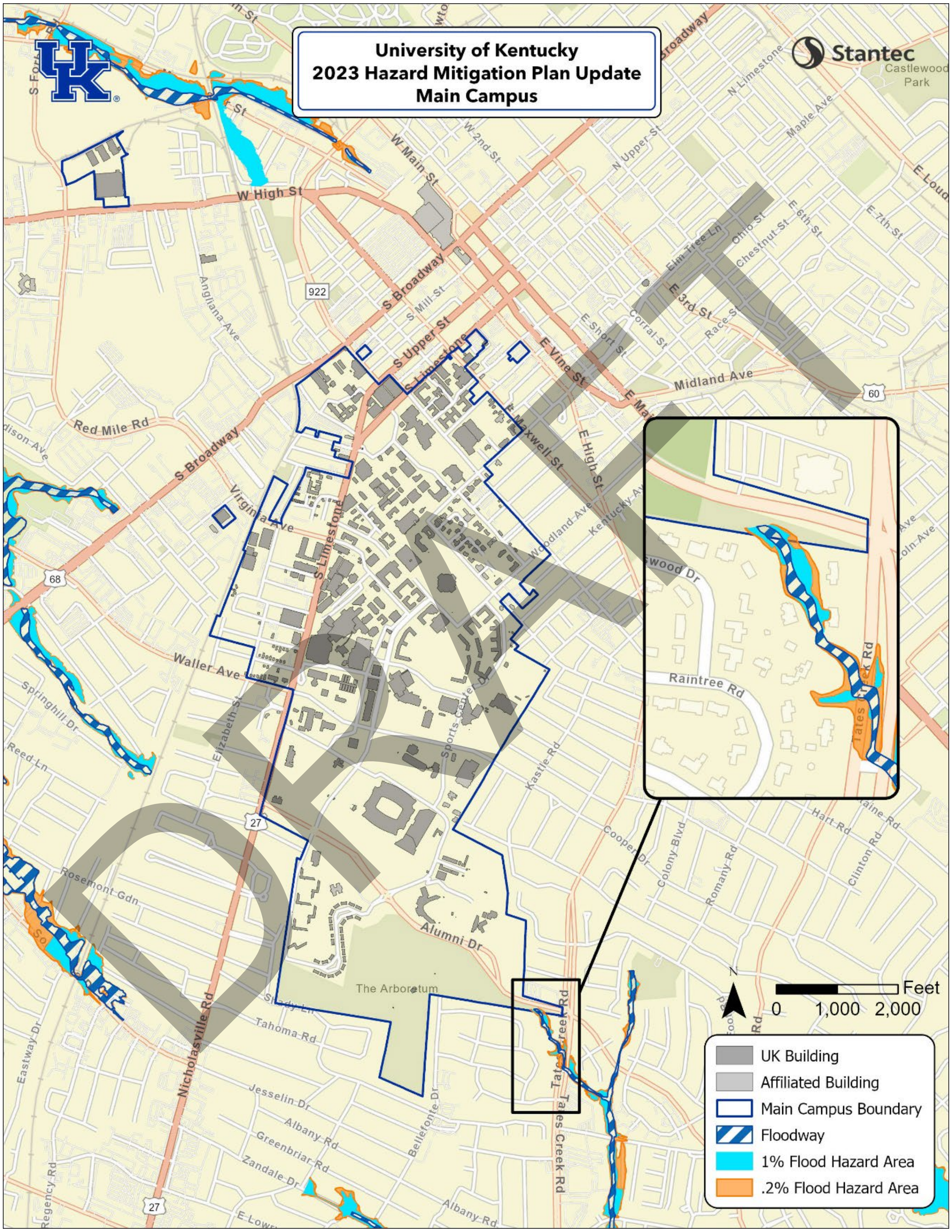

Figure 3-26: FEMA Flood Hazard Areas and UK Main Campus

3.8.3 Previous Occurrences

Data regarding flooding previous occurrences was collected from several sources, including stakeholder interviews, the 2015 *UK Hazard Mitigation Plan*, the *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan*, the NOAA NCEI Storm Events Database, Presidential Disaster Declarations and university claims data from January 2012 to October 2022. Both NCEI events and disaster declarations are made at the county level, therefore events specific to the university are not available. Fayette County has been included in nine Presidential Declarations for flooding, as shown in **Table 3-24**.

Table 3-23: Fayette County Presidential Disaster Declarations including Flooding.

Disaster Declaration Date	Incident Period	ID	Incident Type
04/23/2021	02/27/2021 – 03/14/2021	DR4595	Severe Storms, Flooding, Landslides and Mudslides
05/11/2010	05/01/2010 – 06/01/2010	DR1912	Severe Storms, Flooding, Mudslides and Tornadoes
02/05/2009	01/26/2009 – 02/13/2009	DR1818	Severe Winter Storm and Flooding
02/21/2008	02/05/2008 – 02/06/2008	DR1746	Severe Storms, Tornadoes, Straight-line Winds and Flooding
06/10/2004	05/26/2004 – 06/18/2004	DR1523	Severe Storms, Tornadoes, Flooding and Mudslides
03/14/2003	02/15/2003 – 02/26/2003	DR1454	Flooding, Ice, Snow and Tornadoes
03/04/1997	03/01/1997 – 03/31/1997	DR1163	Severe Storms and Flooding
02/24/1989	01/13/1989 – 03/08/1989	DR821	Severe Storms and Flooding
12/12/1978	12/12/1978	DR568	Severe Storms and Flooding

The NCEI Storm Events Database reports flooding and flash flooding by county. Since 1996, there have been 44 reported flood occurrences (eight floods and 36 flash floods) in Fayette County. These records do not consider events that occurred prior to NCEI recordings (1996). Further, many events go unreported.

In Fayette County, two deaths and no injuries have been reported due to flooding. Ten of the events contained reports of property damage; one contained reports of crop damage. Significant flooding events for Fayette County are summarized in **Table 3-25**.

Table 3-24: Significant NCEI Flooding Events in Fayette County

Date	Deaths/Injuries	Damages (2022 Dollars)	Details
03/02/1997	0/0	$2,257,675 (Property)	Nine inches of rain fell in less than 24 hours. This caused widespread flooding and/or flash flooding, which resulted in numerous water-covered and closed roads, evacuations and rescues. Many homes and businesses were affected during the flooding and flash flooding. Fayette County was declared a disaster area.
07/20/1998	0/0	$2,020,953 (Crops)	East central Kentucky saw widespread flooding as three to six inches of rain fell over a three-hour time span. Numerous roads were closed due to high water, and many basements were flooded as well. More than 100 residents of mobile homes and apartments were evacuated. A few rescues were also made as motorists were trapped in high water.
09/23/2006	2/0	-	Two women were knocked down and swept away by rapidly flowing water after trying to cross a flooded intersection. Sixty intersections in town were covered by high water, some with water depths up to three or four feet. The two women were UK students.
05/02/2010	0/0	$142,576 (Property)	May 2010 experienced record or near-record two-day rainfall totals from eight to over 10 inches in many locations across central Kentucky. Major flooding occurred in at least 40 Kentucky counties, washing out roads and inundating municipal water treatment plants. Four lives were lost in Kentucky – three in vehicles and one in a home, where the resident was electrocuted in high water. Over the following days, most area rivers were flooded, including some flooding along the main stem of the Ohio River. Six to seven inches of rain across Fayette County led to area flooding in spots across the county. A major disaster was declared.
06/23/2017	0/0	-	Tropical Storm Cindy made landfall along the Gulf Coast and quickly lifted northeast toward the lower Ohio Valley. The remnants interacted with a cold front from the upper Midwest to produce widespread heavy rainfall. This led to numerous reports of flash flooding with some swift water rescues occurring as well. Multiple roads across many counties were closed due to the high water. Three river points rose into minor floods, mainly across the Bluegrass region. In addition, several strong to severe thunderstorms were tracked across the area, which brought down numerous trees and power poles. The environment also supported short spin-up tornadoes. There were two tornado touchdowns across central Kentucky.

The university provided claims data from January 2012 to October 2022. Claims data is inclusive of UK's main campus, as well as all other campuses and outlying facilities. During this time, there were 42 claims related to flooding or extreme precipitation, totaling over $320,000 in damages. Of those 42 claims, 19 included reported damage costs. The claims are shown by campus in **Table 3-26.**

Table 3-25 UK Flood Claims (January 2012 – October 2022)

Campus	No. of Flood Claims
Hazard	1
Main Campus	23
North Farm	1
RCARS	13
Robinson Forest	4

It is important to note that claims data does not include the number of damages claimed from the flood on July 27, 2022, when record-setting floods hit UK's Robinson Forest and RCARS outlying campuses. The total value for the damages from the July 2022 floods is still pending at the time of this report. The floods hit southeastern Kentucky starting on July 27, 2022. More than 35 people were killed from the flooding event. Four Robinson Forest staff members were stranded for several days with no cellphone service. Four buildings in Robinson Forest were impacted by the flooding. RCARS had 13 buildings impacted and several crop research fields lost. The damage to UK facilities is expected to cost more than $2 million. The university is exploring a variety of funding options for recovery as some of the damage is not covered by insurance.

3.8.4 Extent

UK's main campus is at a lower risk of flooding given the campus' high topographical location and limited area within the floodplain. However, the main campus is still at risk from urban flooding and flash flooding. Flood extent, or magnitude, can be measured in several ways: peak flow, stream gage height or impact (including damages). Since UK's main campus does not have stream gages present, impact was used as an indicator of extent. The most severe flood event reported for the main campus occurred on September 23, 2006.Two students were killed when they were knocked down and swept away by rapidly flowing water adjacent to UK's main campus. Sixty intersections in town were covered by high water during this event.

As extreme rainfall contributes to both riverine and urban flooding events, rainfall totals are also used as an indicator of extent. The greatest amount of rainfall reported from previous occurrences is the 1997 flood event, which saw nine inches of rainfall within a 24-hour period. A 24-hour, 100-year rain event in Fayette County is 6.69 inches of rainfall[45].

It is possible that more severe floods than those experienced in the past will impact UK's main campus and its outlying campuses and facilities.

[45] From "NOAA Atlas 14 Point Precipitation Frequency Estimates: K", NOAA, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ky

The *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* references a study completed by the United State Army Corps of Engineers (USACE) and Ohio River Basin Alliance (ORB Alliance) about climate change in the Ohio River Basin. The study recognizes that flooding events are expected to increase in several sub-basins with changing climate conditions and land use changes. The modeling shows that variability and extreme events are projected to increase, leading to more frequent flood events and droughts.

3.8.5 Probability

Based on past data, the university experiences an average of approximately four flooding claims annually: Fayette County experiences an average of approximately two flooding events annually.

The probability of flooding could increase with changing climate conditions. Projected increases in precipitation, especially in the frequency and intensity of extreme rainfall events, could increase the probability of flooding on all university campuses and 4-H camps. Warmer temperatures may negate some of the flooding effects of increased precipitation but may also result in more snow falling than rain.

Heavy rainfall events have increased in most of the southeast over the last several decades. They are projected to continue to increase in frequency. The *Fourth National Climate Assessment* shows that days with precipitation above three inches have increased in the southeast and have increased the most in recent decades as shown in **Figure 3-28**[46].

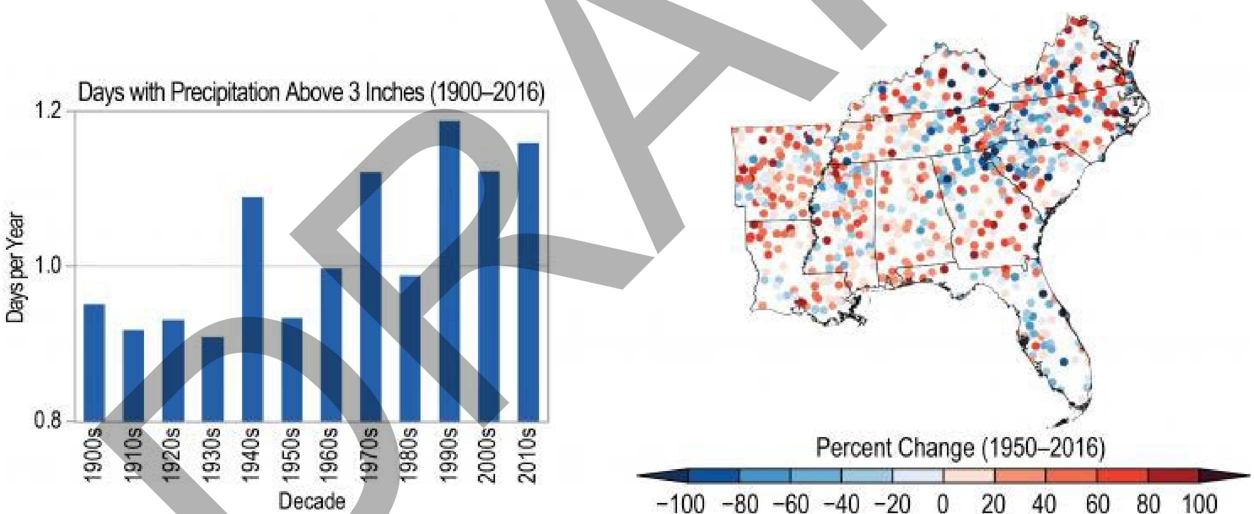

Figure 3-27: Rainfall trends in the Southeast from the Fourth National Climate Assessment

By mid-century, Fayette County is projected to experience 0.5 more days of heavy precipitation per year[47]. Heavy precipitation is more than one inch of precipitation in a day. By the end of the century, Fayette County is projected to experience 1.7 more days of heavy precipitation per year under the higher emissions scenario (RCP8.5).

[46] From "Southeast", U.S. Climate Resilience Toolkit, https://toolkit.climate.gov/regions/southeast
[47] See "Neighborhoods at Risk", Headwaters Economics, https://nar.headwaterseconomics.org/2100046027/explore/climate

Based on the above, a probability of highly likely (greater than 90 percent annual chance) was assigned.

3.8.6 Vulnerability Assessment

UK is vulnerable to many flood impacts. It is susceptible to increased flooding as the campus expands and development surrounding the campus continues in Lexington. Increased development reduces natural, permeable areas that absorb rainfall, resulting in increased stormwater runoff and localized flooding. The university has taken steps to reduce the potential for new flood damage. These efforts are discussed in the **Capability Assessment**.

Despite these steps, UK remains vulnerable to riverine and urban flooding. GIS analysis was used to determine UK buildings across all campuses located within FEMA special flood hazard areas (FEMA 1.0-percent annual chance floodplain, A and AE Zones). An examination of building and FEMA flood data shows 11 UK buildings that are within or partially within the FEMA mapped 1.0-percent annual chance floodplain (1.3 percent of all UK buildings). Further, five buildings are in the FEMA non-regulatory 0.2-percent annual chance floodplain (500-year floodplain). However, buildings outside of these areas are still at risk. In fact, several of the flood-related claims reported by Risk Management were for buildings outside of regulatory special flood hazards areas (FEMA 1.0 percent annual chance floodplain). As a result, all current and future buildings, infrastructure and populations on UK campuses are considered at risk of flooding.

Structures exposed to flooding, including critical facilities, can be severely damaged. Building contents can be lost, damaged or destroyed; structures can be compromised by floodwaters. Pressure from floodwater, especially as seepage through soil, can damage building foundations. After a flood, wooden structures may rot. The public often misunderstands the dangers presented by floodwaters. Flooding is often localized to certain parts of a community (e.g., certain roads, intersections or neighborhoods), and floodwaters can prevent normal access to buildings and facilities. This presents a danger when motorists and pedestrians attempt to traverse floodwaters. Motor vehicles and pedestrians can get swept up in flood currents, increasing the risk of drowning. Even in shallow waters, fast-moving currents can carry individuals or vehicles into deeper waters, where pressure from flowing water can prevent drivers from escaping submerged vehicles. As little as six inches of floodwater can move a vehicle, and as little as two inches can move a person. In addition, floodwaters often conceal conditions that are a danger to those on foot, including electrical wires, debris and other hazards hidden beneath the surface. In addition, roads and bridges can be weakened by flood impacts, making them unsafe for travel.

As an agricultural research university, invaluable crop research can be severely damaged or destroyed by flooding. Flooding can lead to the loss of entire crop fields as experienced at RCARS during the July 2022 floods. Flooding on farmlands can also lead to contamination, soil erosion, equipment loss, debris deposition and the spread of invasive species[48]. Livestock is also present at UK facilities for agricultural research and education. Livestock can be swept away from flood waters or may try to seek shelter outside of their confined area.

[48] See “Farming the Floodplain: Tradeoffs and Opportunities”, USDA, https://www.climatehubs.usda.gov/hubs/northeast/topic/farming-floodplain-trade-offs-and-opportunities#:~:text=Flooding%20on%20farmlands%20can%20cause,the%20spread%20of%20invasive%20species.

Livestock face several negative health impacts associated with flooding such as drinking water contamination, higher prevalence of parasites, food contamination, foot/hoof problems from standing in water and stress from unfamiliar surroundings[49].Caretakers may be unable to reach livestock for several days due to flooding impacts.

As a research institution, the university houses valuable research, expensive equipment and priceless documents on campus. Flooding has the potential to not only cause economic losses, but also to destroy rare or priceless documents such as books, maps, artwork or historical collections across the campus. UK has these types of items located throughout campus and should take precautions to safeguard these sensitive materials against flooding and other natural disasters. Damage to expensive research equipment could lead to complete loss of research abilities and loss of data. Medical equipment can also be impacted by flooding, leading to loss of use and loss of data. Patients who depend on medical equipment could face negative health impacts from loss of the equipment.

Floodwater often contains contaminants such as bacteria and chemical hazards. Flooding frequently results in combined sewer overflows, resulting in sewage in floodwaters. Individuals traversing floodwaters can contract diseases, injuries and infections.

Structures exposed to floodwaters can also present public health hazards. Damaged electrical systems, natural gas tanks and fuel storage present the risk of fire and explosions. People with asthma, allergies or breathing conditions may be at a higher risk of experiencing negative health impacts due to mold[50]. Buildings containing hazardous materials, such as medical facilities and research laboratories, are vulnerable to spills or hazardous materials releases if flooded.

To assess flood risk, a GIS-based analysis was used to estimate exposure to flood events using FEMA Digital Flood Insurance Rate Map (DFIRM) data in combination with university building and claims data. UK provided claims data from January 2012 to October 2022.

A summary of the number of UK buildings potentially exposed to flooding is presented in **Table 3-27**. The analysis does not account for building elevations.

Table 3-26: UK Facilities in FEMA Flood Hazard Areas

FEMA Flood Hazard Areas	No. of Buildings	% of Buildings
Floodway	0	0%
1.0% Annual Chance Flood	11	1.2%
0.2% Annual Chance Flood	5	1.0%
Total:	16	2.2%

Flooding can also occur outside of floodplains. University claims data was reviewed for flooding outside of floodplains. The claims data spans from January 2012 to October 2022. UK had 23 claims related to

[49] See “Flooding: Animal Health Concerns”, Texas Animal Health Commission (August 2017), https://www.tahc.texas.gov/emergency/pdf/TAHCBrochure_FloodingAnimalHealth.pdf
[50] See “Mold After a Disaster”, CDC (July 2020), https://www.cdc.gov/disasters/mold/index.html

flooding or extreme precipitation that occurred on main campus with total monetary losses at $326,743. On the main campus, 22 buildings had flooding claims. For the outlying campuses, there were six buildings outside of the floodplain with claims. The buildings are located in the Robinson Forest-Clayhole campus, the Hazard campus and the North Farm. Each of the six buildings had one reported claim and no reported losses.

At-risk buildings and their associated values are presented in **Table 3-28**, along with other attributes that may contribute to vulnerability. Buildings were determined to be at-risk if they are in a flood hazard area or have previous flood related claims. The total value (including the structure, contents and reported research values, as available) of the buildings in the floodplains is more than $2.6 million.

As mentioned previously, no buildings on the main campus are within FEMA flood hazard areas. The only UK buildings within the floodplain are in three outlying campuses. The campuses include RCARS, the North Farm and the West Kentucky 4-H Camp. These campuses were mapped, and key findings are summarized below.

RCARS

The RCARS campus has five buildings within the 1.0-percent annual chance floodplain and four buildings within the 0.2-percent annual chance floodplain. Additionally, the administration building, which is the main building for the site and houses safety equipment, is in the 0.2-percent annual chance floodplain. The RCARS campus in relation to FEMA flood hazard areas is shown in **Figure 3-29**.

North Farm

The North Farm campus contains three buildings within the 1.0 percent annual chance floodplain and one building in the 0.2 percent annual chance floodplain. The horse run-in shed is located in the 1.0 percent annual chance floodplain. The North Farm Campus in relation to the floodplains is shown in **Figure 3-30**.

West Kentucky 4-H Camp

The West Kentucky 4-H Camp contains three buildings within the 1.0 percent annual chance floodplain. The buildings are the boat house and two storage sheds. None of the buildings contain animals or hazardous materials. The West Kentucky 4-H Camp is shown in relation to the floodplains in **Figure 3-31**.

Table 3-27: UK Buildings in Flood Hazard Areas and/or with Flooding Claims

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous Losses*	Flood Hazard Areas
1	Taylor Education Building	Main Campus	$23,479,391	$1,256,753	$153,663	Fair	1	$131	No
3	Research Facility #1	Main Campus	$10,060,217	$220,969	$3,021,019	Fair	1	$8,420	No
17	Dickey Hall	Main Campus	$14,674,458	$1,804,872	$468,472	Poor	1	$20,796	No
19	Memorial Coliseum	Main Campus	$111,532,057	$2,292,632	-	Fair	1	$649	No
28	Barker Hall	Main Campus	$9,225,851	$125,041	-	Fair	1	$65	No
47	C. W. Mathews Building	Main Campus	$4,019,608	$128,607	-	Fair	1	$22,263	No
48	UK J. David Rosenberg College of Law	Main Campus	$139,666,945	$23,500,000	-	Poor	1	$144	No
51	Mineral Industries Building	Main Campus	$4,408,269	$36,043	$547,515	Fair	1	$252	No
55	Chemistry-Physics Building	Main Campus	$82,443,124	$12,669,853	$5,809,695	Poor	1	$355	No
58	Bradley Hall	Main Campus	$4,980,334	$46,231	$0	Poor	1	-	No
84	Gatehouse Roach Bldg.	Main Campus	$11,356	$500	$0	-	1	$8,251	No
107	Mining & Minerals Resources Building	Main Campus	$32,527,834	$3,610,438	$5,017,652	Fair	1	$138,158	No
125	Gamma Phi Beta	Main Campus	$2,532,132	$0	$0	-	1	$16,893	No
174	Don & Cathy Jacobs Science Building	Main Campus	-	-	-	-	1	$26	No

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous Losses*	Flood Hazard Areas
200	Wethington Allied Health Building	Main Campus	$79,165,066	$6,866,590	$17,783,727	Excellent	1	$41,474	No
254	Greg Page Apartments 12	Main Campus	$891,614	$10,000	$0	-	1	-	No
277	EJ Nutter Training Center	Main Campus	$20,514,439	$1,261,134	$1,242,133	-	1	-	No
286	ASTeCC	Main Campus	$40,117,642	$11,544,719	$5,082,012	Good	1	$74	No
305	Peter P. Bosomworth Health Sciences Research Building	Main Campus	$41,359,879	$8,225,940	$5,797,348	Excellent	1	$20,087	No
336	Thomas D Clark Building	Main Campus	$1,723,477	$15,399	$0	Fair	2	$15,524	No
596	Lee T. Todd, Jr. Building	Main Campus	$150,646,287	$11,800,000	$28,725,168	Excellent	1	$19,927	No
2401	Bailey-Stumbo Building (UK Center for Rural Health)	Hazard	$14,292,667	$805,479	$0	Not Rated	1	$0	No
3233	Horse Run in Shed	North Farm	$14,595	$0	$0	Not Rated	-	-	1%
3370	The Council of State Governments	North Farm	$7,541,939	-	$0	Not Rated	1	$0	No
3395	Entomology Research Storage	North Farm	$208,826	$0	$0	Not Rated	-	-	0.20%
3399	Entomology Storage	North Farm	$44,999	$0	$0	Not Rated	-	-	1%
7710	Storage Shed	_West Kentucky 4-H Camp	$9,305	$0	$0	Not Rated	-	-	1%

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims*	Previous Losses*	Flood Hazard Areas
7711	Storage Shed	West Kentucky 4-H Camp	$9,400	$0	$0	Not Rated	-	-	1%
7753	Boat House	West Kentucky 4-H Camp	$10,580	$0	$0	Not Rated	-	-	1%
9002	Market Shelter	RCARS	$81,086	$0	$0	Not Rated	-	-	1%
9003	Barn	RCARS	$146,137	$0	$0	Not Rated	2	$0	0.20%
9006	Plant Mechanical Center	RCARS	$291,040	$0	$0	Not Rated	2	$0	1%
9011	Storage Barn	RCARS	$179,922	$0	$0	Not Rated	-	-	0.20%
9013	Business Office	RCARS	$321,829	$0	$0	Not Rated	2	$0	0.20%
9015	Conservation Equipment Shed	RCARS	$11,014	$0	$0	Not Rated	2	$0	1%
9018	Material Storage Cage	RCARS	$38,144	$0	$0	Not Rated	2	$0	1%
9023	Administration Building	RCARS	$904,564	$148,351	$0	Not Rated	1	$0	0.20%
9303	Camp Residence	Robinson Forest – Clayhole	$118,467	-	$0	Not Rated	1	$0	No
9304	Dormitory	Robinson Forest – Clayhole	$185,662	-	$0	Not Rated	1	$0	No
9305	Faculty Dorm	Robinson Forest – Clayhole	$182,726	-	$0	Not Rated	1	$0	No
9306	Kitchen & Dining Hall	Robinson Forest – Clayhole	$828,470	$39,129	$0	Not Rated	1	$0	No

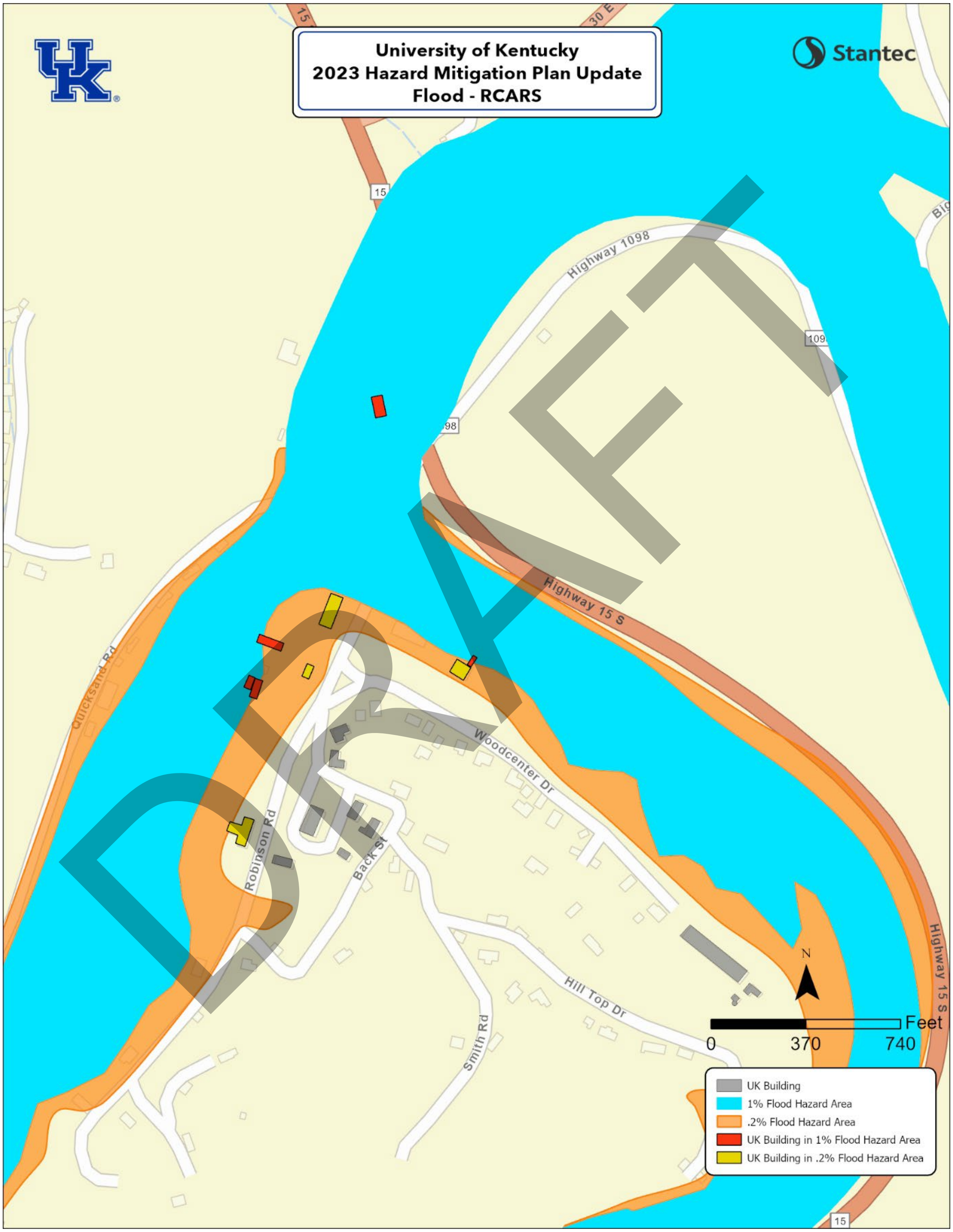

Figure 3-28: RCARS Facilities in the Flood Hazard Areas

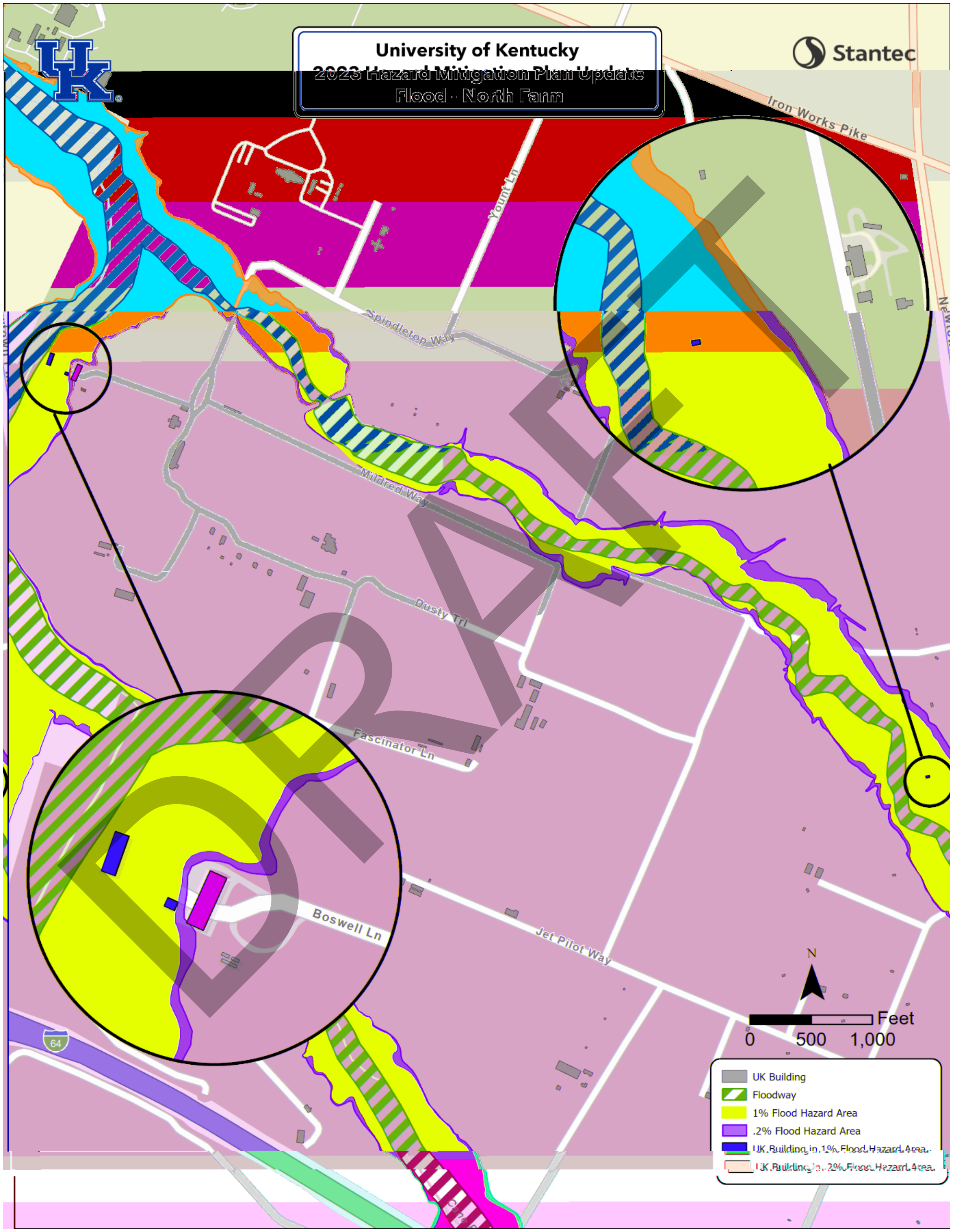

Figure 3-29: North Farm Facilities in the Flood Hazard Areas

Figure 3-30: West Kentucky 4-H Center Facilities in the Flood Hazard Areas

Climate change has the potential to increase the frequency and severity of future flood events on campus. The previously referenced study completed by USACE and the ORB Alliance recognizes that flooding events are expected to increase in the planning area. Modeling shows that variability and extreme events are projected to increase, leading to more frequent flood events and droughts.

Additionally, the annual mean streamflow is projected to increase as shown in **Figure 3-32**, which is indicative of more severe riverine flooding in the future.

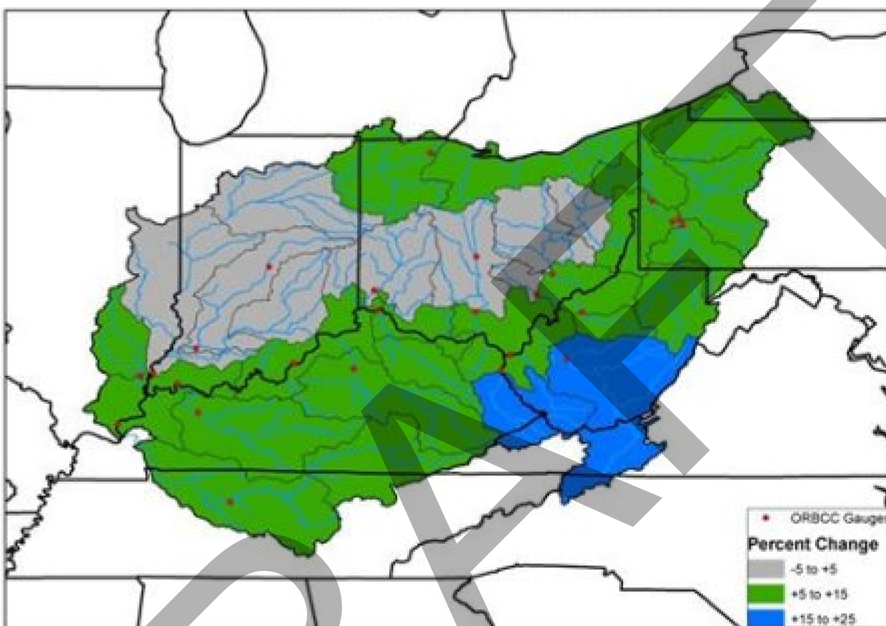

Figure 3-31: Ohio River Basin Study Forecasted Percent Change in Annual Mean Streamflow (2011-2040)

Further, as described within the *Probability* subsection of this profile, Fayette County is projected to experience increased stream flows and increased heavy precipitation days under future climate scenarios. Future flood-risk will depend upon a number of future factors: realized increases in temperature combined with realized increases in precipitation and heavy rainfall events, as well as future development trends and adopted mitigation actions.

3.9 Wildfire

3.9.1 Description

A wildfire is an unplanned fire. It includes grass fires, forest fires and scrub fires either man-made or natural in origin. There are three different classes of wildfires:

- **Surface fires** are the most common type and burn along the floor of a forest, moving slowly and killing or damaging trees.
- **Ground fires** are usually started by lightning and burn on or below the forest floor.
- **Crown fires** spread rapidly by wind and move quickly by jumping along the tops of trees.

Wildfires are a natural process that benefits the environment. Many species depend on fires to improve habitat, recycle nutrients and maintain diverse habitats. Wildfire suppression results in the curtailment of fire spread often to prevent structural loss. However, suppression can lead to more severe fires as the vegetation becomes denser.

The average forest fire kills most trees up to three to four inches in diameter in the area burned. These trees represent approximately 20 years of growth. In the case of up-slope burning under severe conditions, almost every tree is killed regardless of size or type.

When the trees are burned and everything is killed, the forest is slow to reestablish itself because of the loss of young seedlings, saplings, pole and sawtimber trees.

Leaves and other litter on the forest floor is included in fire destruction. This exposes the soil to erosive forces, allowing rainstorms to wear away the naked soil and wash silt and debris downhill, clogging the streams and damaging fertile farmlands in the valleys. Once the litter and humus (spongy layer of decaying matter) is destroyed, water flows more swiftly to the valleys and increases flood danger.

Other consequences of wildfires include the death and loss of wildlife habitats. Even when the adult animals escape, the young are left behind to perish. The heaviest wildlife loss is felt by game birds since they have ground nesting habits. Fish life also suffers because of the removal of stream shade and the loss of insects and plant food by silt and lye from wood ashes washed down from burned hillsides.

For most of the 20th century, U.S. policy called for the suppression of wildfires. However, fires benefit the ecosystem. The effects of fire can retard or accelerate the natural development of plant communities, alter species diversity and change nutrient flows. More than 100 years of suppressing fires, combined with past land-use practices, have resulted in a heavy buildup of dead vegetation, dense stands of trees, a shift to species that have not evolved and adapted to fire and occasionally an increase in non-native, fire-prone plants. Because of these conditions, today's fires tend to be larger, burn hotter and spread farther and faster, making them more severe.

Scientific analysis of the 2000 fire season identified that most burned acres were in previously logged and roadbed areas, not in road-less or wilderness areas. An August 2000 report from the Congressional Research Service that analyzed the impact of the fires in 2000 concluded that, "Timber harvesting removes the relatively large diameter wood that can be converted into wood products, but leaves behind the small material, especially twigs and needles. The concentration of these 'fine fuels' on the forest floor increases the rate of spread of wildfires."

A study of the 2020 Creek Fire in California found that fuel-reduction logging was associated with higher fire severity[51]. In 2021, Kentucky's forest sector contributed $9.09 billion in direct economic contribution[52]. Logging contributed $222 million to the Kentucky economy and 2,043 jobs.

Humans, either through negligence, accident or intentional arson, have caused approximately 90 percent of all wildfires in the last decade. Accidental and negligent acts include unattended campfires, sparks, burning debris and irresponsibly discarded cigarettes. The remaining 10 percent of fires are mostly caused by lightning or other acts of nature such as volcanic eruptions or earthquakes.

Most wildfires in Kentucky are close to the ground and do not directly kill trees[53]. However, the fire can cause openings on the base of the trees, which make the trees more susceptible to insects and disease. Additionally, wildfire can damage the quality of the tree, making it less valuable in the lumber industry.

3.9.2 Location

Forests cover approximately 12 million acres of land in Kentucky, representing 47 percent of the state's land cover. The Cumberland Plateau and the Appalachians in the eastern part of the state account for 50 percent of the state's forest cover; 25 contiguous counties having a forest cover percentage of greater than 75 percent. An Urban Tree Canopy Assessment was performed for Lexington in August 2022[54]. The assessment identified that the Urban Service Area of Lexington contains 54,648 acres of land – 23 percent has tree canopy, 33 percent has non-canopy vegetation and three percent has dry vegetation. Urbanized areas are less likely to be subject to wildfire compared to vegetated areas. Wildfire can occur throughout forested areas, shrublands and grasslands in the state, including areas in which UK campuses or 4-H camps are located.

The United States Department of Agriculture Forest Service created a website, *Wildfire Risk to Communities,* which contains mapping tools and resources to help better understand risks associated with wildfire[55]. The website contains maps of wildfire likelihood or the probability of wildfire burning in any given year. Populated areas in Kentucky have a wildfire likelihood greater than 76 percent of states in the U.S. Wildfire burn probability was mapped in relation to UK campuses and 4-H camps as shown in **Figure 3-33**. Overall, eastern Kentucky has the highest likelihood of wildfire in the state. The area of higher likelihood of wildfire includes Feltner 4-H Camp – London, Robinson Center for Appalachian Resource Sustainability (RCARS), Robinson Forest Campus – Clayhole and the Center of Excellence in Rural Health – Hazard.

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[51] From "Is "Fuel Reduction" Justified as Fire Management in Spotted Owl Habitat?", Chad Hanson (November 2021), https://www.mdpi.com/2673-6004/2/4/29
[52] See "Kentucky Forest Sector Economic Contribution", UK Martin-Gatton College of Agriculture, Food, and Environment, https://forestry.ca.uky.edu/economic-report
[53] See "Wildfires", UK Department of Forestry and Natural Resources, https://forestry.ca.uky.edu/wildfire
[54] From "Urban Tree Canopy Assessment", Lexington-Fayette Urban County Government (August 2022), https://www.lexingtonky.gov/sites/default/files/2022-10/Lexington%20KY%20-%20Tree%20Canopy%20Assessment%20Report%20-%202022.pdf
[55] From "Wildfire Risk to Communities", USDA Forest Service (2023), https://wildfirerisk.org/

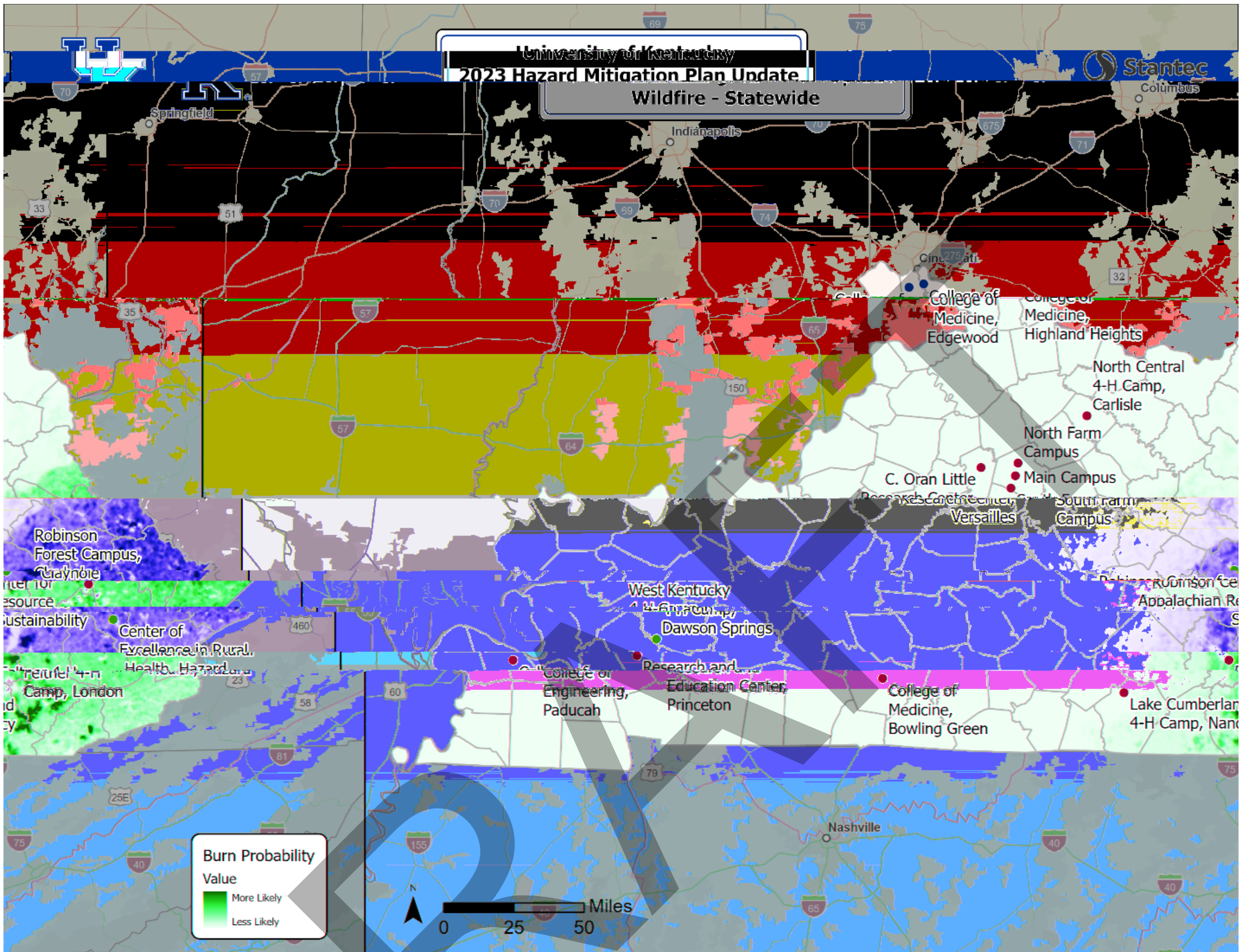

Figure 3-32: Kentucky Wildfire Burn Probability

In addition, wildfire location may be determined by investigating areas where development is near undeveloped areas. The area where urban development meets vegetated, wildfire-prone undeveloped lands is known as the Wildland Urban Interface (WUI). WUI is composed of both interface and intermix communities. In both interface and intermix communities, housing must meet or exceed a minimum density of one structure per 40 acres . Interface and intermix communities are defined by the University of Wisconsin Spatial Analysis for Conservation and Sustainability (SILVIS), which produces most of the Wildland Urban Interface data for the nation as shown below.

- **Intermix communities** are places where housing and vegetation intermingle. In intermix communities, at least 50 percent of land cover surrounding buildings is wildland vegetation. Intermix communities are in areas with more than one house per 40 acres.
- **Interface communities** are areas with housing in the vicinity of contiguous vegetation. Interface areas have more than one house per 40 acres, have less than 50 percent vegetation and are within 1.5 mi of an area (made up of one or more contiguous Census blocks) greater than 1,325 acres that is more than 75 percent vegetated. The minimum size limit ensures that areas surrounding small urban parks are not classified as interface WUI.

Examples of WUI and intermix areas are shown in **Figure 3-34**[56]. The latest WUI and intermix areas in Kentucky are shown in **Figure 3-35** from the SILVIS Lab[57]. Overall, a majority of WUI areas are in eastern Kentucky.

Source: California Department of Forestry and Fire Protection (CAL FIRE), California's Forests and Rangelands 2017 Assessment

Figure 3-33: Example of Wildland Urban Interface and Intermix Areas

56 From "California State Hazard Mitigation Plan" Cal OES (2018), https://www.caloes.ca.gov/wp-content/uploads/002-2018-SHMP_FINAL_ENTIRE-PLAN.pdf
57 See "Wildland-Urban Interface (WUI) Change 1990 – 2020", Silvis Lab University of Wisconsin-Madison, https://silvis.forest.wisc.edu/data/wui-change/

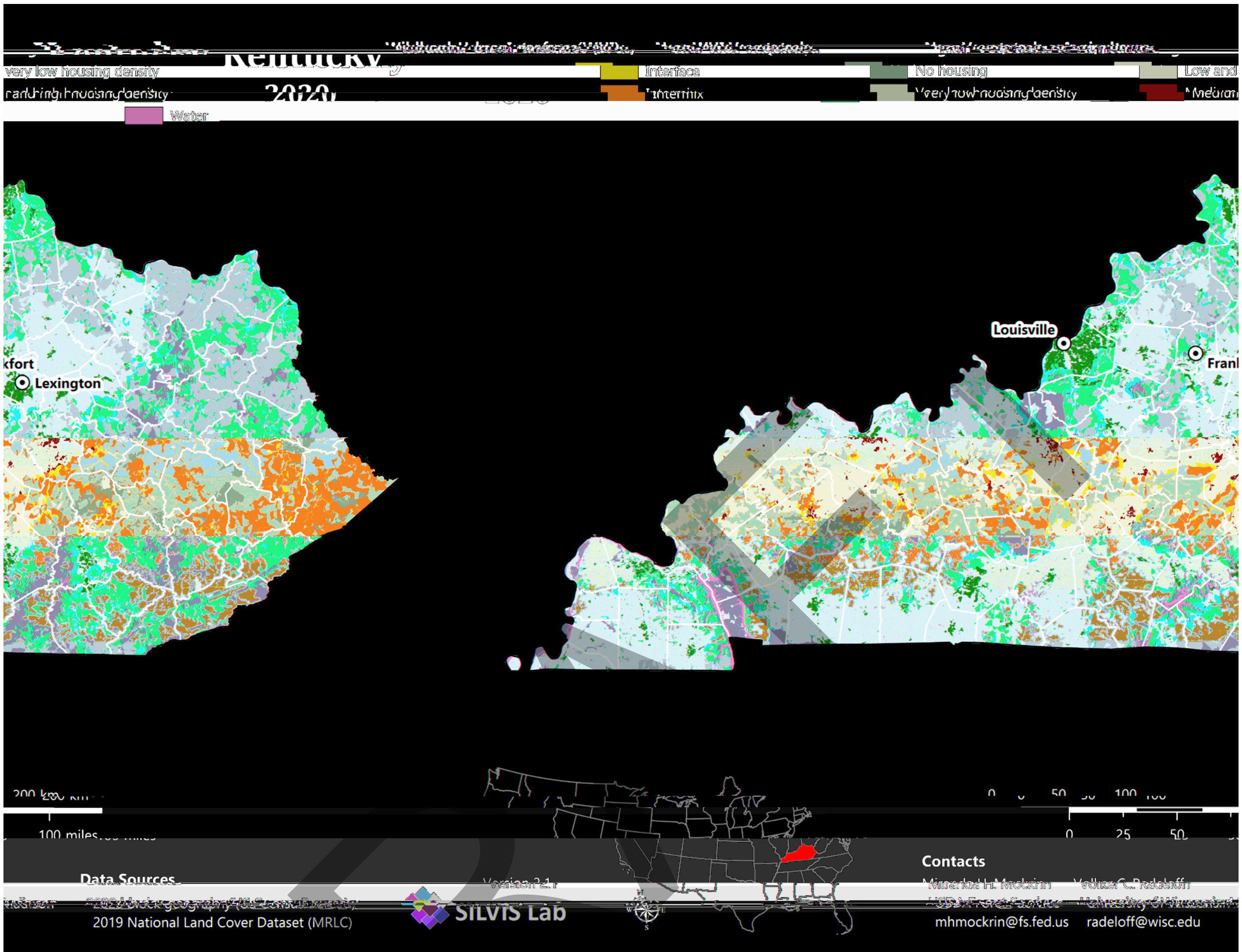

Figure 3-34: Kentucky Wildland Urban Interface

3.9.3 Previous Occurrences

Fayette County is a predominantly urban and agricultural county that has very little history of wildfire. According to the *Lexington-Fayette County Hazard Mitigation Plan*, there were three identified wildland fires in Fayette County between 2001 and 2017. The most recent wildfire to affect Fayette County was on February 21, 2017, which burned 28 acres in the southern part of the county. There are no claims from UK citing wildfire from January 2012 to October 2022.

As a part of the *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan*, wildfire events from January 1, 2013, to August 2018 were mapped as shown in **Figure 3-36**[58].

Most wildfire events took place in the eastern part of the state. The central part of the state where Fayette County is located experienced few wildfires.

[58] From "Commonwealth of Kentucky Enhanced Hazard Mitigation Plan, Risk Assessment: Wildfire", Kentucky Division of Forestry (2018)

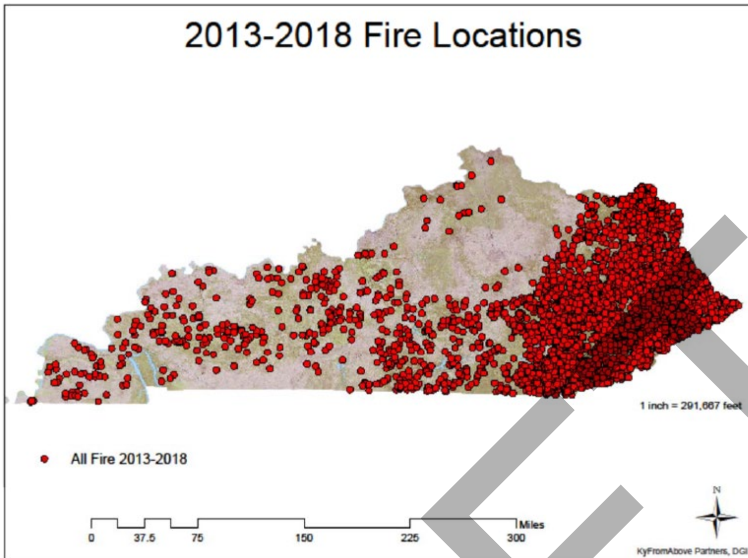

Figure 3-35: Wildfire Event Locations in Kentucky 2013 – 2018

3.9.4 Extent

The extent of wildfire can be measured by the acreage of damage. With no reported wildfires having impacted UK's campuses or 4-H camps, wildfire occurrences within the state can be used as an indicator of potential severity. The most extensive forest fire in recent history in Fayette County, where UK's main campus is located, burned 28 acres. However, more severe events are possible. On average, 30,637 acres burned each year in Kentucky between 2010 and 2019[59]. In 1987, Kentucky experienced one of its worse wildfire years on record with over 300,000 acres burned during fire season. UK campuses in eastern Kentucky are at higher exposure to wildfire. UK campuses in eastern Kentucky include Feltner 4-H Camp – London, Robinson Center for Appalachian Resource Sustainability (RCARS), Robinson Forest Campus – Clayhole, and the Center of Excellence in Rural Health – Hazard. With warming temperatures and projected increased drought occurrences stemming from climate change, future wildfires may be more severe than those experienced in the past.

3.9.5 Probability

On average, Kentucky has 1,447 forest fires each year, the Commonwealth of Kentucky is expected to experience approximately 4 forest fires every day[60]. 99 percent of all wildfires in Kentucky are caused by humans.

With three wildfires reported since 2001, Fayette County experiences approximately one wildfire every 21 years. There are two defined wildfire seasons in Kentucky: February 15 through April 30, and October 1 through December 15.

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[59] From "Ten Year Summary", KY Department of Forestry, https://eec.ky.gov/Natural-Resources/Forestry/Documents/10-Year%20Summary%20of%20Number%20of%20Fires%20and%20Acres%20Burned.pdf
[60] See "Forest Facts", KY Department of Forestry, https://eec.ky.gov/Natural-Resources/Forestry/Pages/Forest-Facts.aspx

Kentucky has two fire seasons due to the large amounts of dry material on the forest floor and lack of humidity during these two seasons. However, wildfire occurrence is possible outside of these defined fire seasons during any prolonged periods of drought. During these wildfire seasons, it is illegal to burn between 6 a.m.- 6 p.m. or within 150 feet of any woodland or brushland.

In the United States, fire suppression, combined with past land-use practices, have resulted in a heavy buildup of dead vegetation, dense stands of trees, a shift to species that have not evolved and adapted to fire, and occasionally an increase in non-native, fire-prone plants. Because of these conditions, today's fires tend to be larger, burn hotter, and spread farther and faster, making them more severe. Further, warming trends in Kentucky, along with drought occurrences projected to be longer and more intense, suggest that wildfires may become larger and more frequent in Kentucky.

Considering the lack of previous events impacting UK and its outlying facilities, the prevalence of wildfire throughout the commonwealth, and projected future impacts from climate change, a probability of possible (one to 10 percent annual chance) was assigned to the wildfire hazard. Campuses in eastern Kentucky are more likely to experience wildfire, especially campuses that interact with WUI areas.

3.9.6 Vulnerability Assessment

Wildfire impacts human life, health, and public safety as well as a loss of wildlife habitat, increased soil erosion, and degraded water quality. Wildfire also can cause utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, damaged or destroyed critical facilities, and hazardous material releases. Wildfire can cause the loss of crops, property, and other natural resources. To assess wildfire, a GIS-based analysis was used to estimate burn probability at each UK building utilizing the burn probability data from the USDA Forest Service *Wildfire Risk to Communities*[61]. The burn probability is the likelihood of wildfire burning in any given year based on fire behavior modeling across thousands of simulations of possible fire seasons. The burn probabilities were summarized into four probability ranges and used to estimate burn probability at each UK Campus. The ranges are shown in **Table 3-29**. The burn probability ranges were mapped across Kentucky as shown in **Figure 3-37**.

Table 3-28: Wildfire Burn Probability Ranges

Range ID	Probability Range
0	0 to 1 in 10,000
1	1 in 10,000 to 1 in 1,000
2	1 in 1,000 to 1 in 100
3	1 in 100 to 1 in 45
4	1 in 45 to 1 in 29

Less Likely
↓
More Likely

[61] From "Wildfire Risk to Communities", USDA Forest Service (2023), https://wildfirerisk.org/

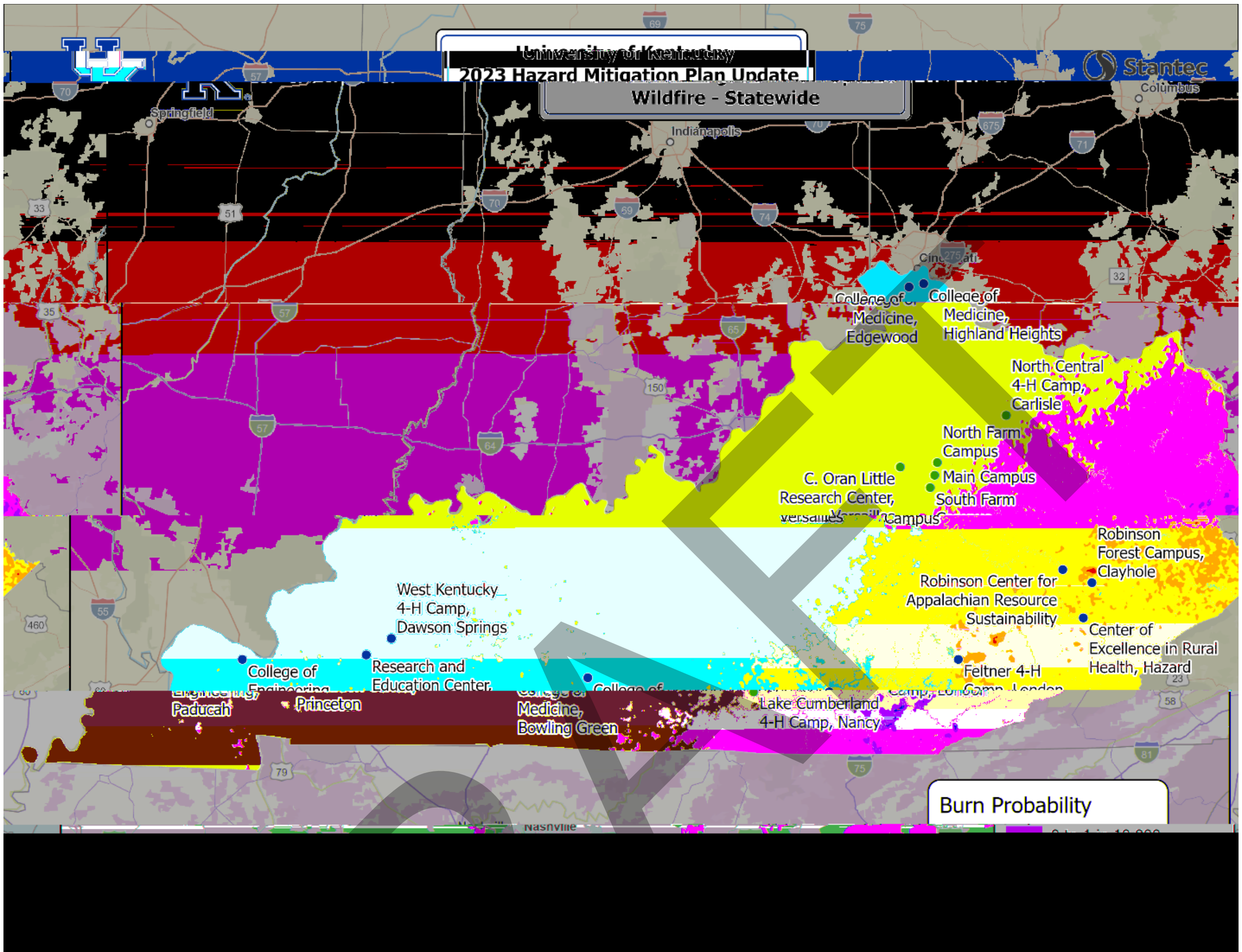

Figure 3-36: Wildfire burn probability in Kentucky per year

Of the 940 UK buildings, 91 percent are in range 0 or have a 0 to 10,000 chance of wildfire each year, indicating low probability of wildfire. The other 9 percent of UK buildings are in range one (one in 10,000 to one in 1,000 chance of wildfire each year). All the buildings located in range one are in eastern Kentucky on the campuses of Robinson Forest – Clayhole, RCARS, Feltner 4-H Camp, Hazard, or the Lake Cumberland 4-H Camp.

The highest burn probability occurred at the Pump House & Equipment Building at the Robinson Forest – Clayhole which had a burn potential of approximately one in 111. The number of buildings in range 1 are summarized by campus in **Table 3-30**. A map of Eastern Kentucky burn probability is shown in **Figure 3-38**. The burn probability by building is included in **Appendix B**.

Table 3-29: Buildings in Probability Range 1

Campus	Number of Buildings
Hazard	1
Feltner 4-H Camp	42
Lake Cumberland 4-H Camp	11
RCARS	19
Robinson Forest – Clayhole	15

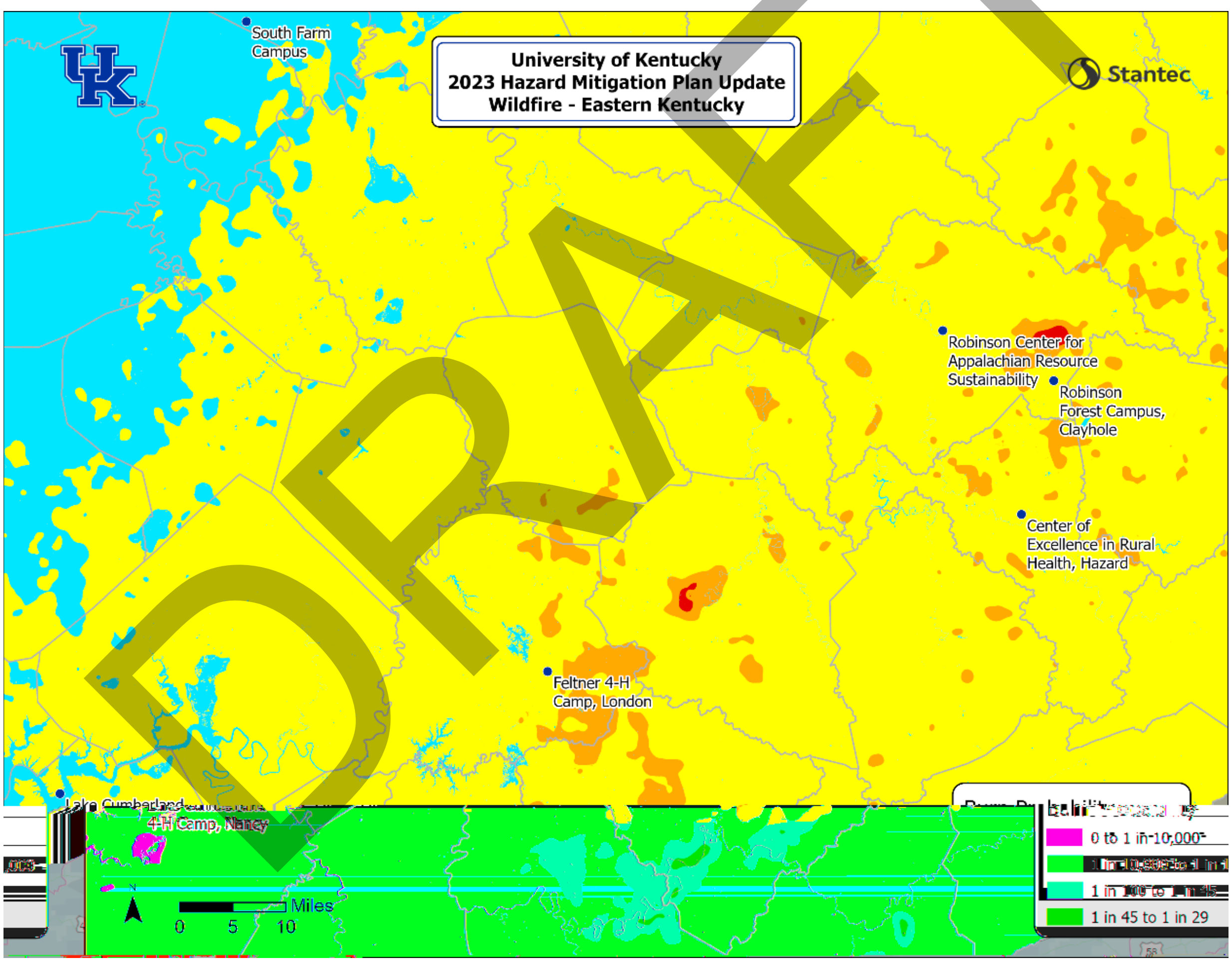

Figure 3-37: Wildfire burn probability in Eastern Kentucky per year

Wildfires can release large quantities of carbon dioxide, carbon monoxide, and particulate matter into the atmosphere. Smoke can spread over much broader areas than the area that is actively burning, negatively impacting air quality. Because smoke from wildfires is a mixture of gases and fine particles from burning trees and other plant materials, it can irritate eyes and cause damage to respiratory systems causing shortness of breath, chest pain, headaches, asthma exacerbations, coughing and death. For those with heart disease, rapid heartbeat and fatigue may be experienced more readily under smoky conditions. The World Health Organization (WHO) identifies infants, children, women who are pregnant, and older adults as being more susceptible to health impacts from ash and smoke. Emergency response workers such as firefighters face a higher exposure to wildfires and may be greatly impacted by injuries, burns and smoke inhalation.

Included in the destruction by fires are the leaves and other litter on the forest floor. This exposes the soil to erosive forces, allowing rainstorms to wear away the naked soil and wash silt and debris downhill, which will clog the streams and damage fertile farmlands in the valleys. Once the litter and humus (spongy layer of decaying matter) is destroyed, water flows more swiftly to the valleys and increases flood danger. Burned areas are subject to increased erosion, resulting in the siltation of creeks, streams and rivers. This can result in channel aggradation (wider, slower channels). Steeps slopes are also destabilized due to the burning of vegetation. Burned areas combined with heavy rain present a serious risk of landslides, rockfalls, mudflows, and debris flows. Highest risks areas are on or adjacent to steep slopes.

As an agricultural university, UK maintains several farms, forests, and large agricultural research facilities. The loss of these facilities could severely impact valuable research, educational tools, and university resources. UK maintains Robinson Forest which is over 14,800 acres in the Cumberland Plateau[62]. Robinson Forest maintains some of the most isolated forests and watersheds in eastern Kentucky. The forests are used for research by UK and other government agencies. It is used for research on forestry, forest hydrology, carbon sequestration, wildlife, and ecological relationships. Wildfire could severely impact research activities and the untouched nature of the forests.

Kentucky's wildfire risks are compounded by the state's high arson rate. The Kentucky Division of Forestry reports that 64 percent of wildfires in Kentucky were deliberately set by arsonists from 2010 to 2019[63]. For comparison, from 2010 to 2019, 0.4 percent of forest fires in Kentucky were caused by lightning.

The area of Eastern Kentucky referred to as Appalachia poses the greatest wildfire risk. This area has mountainous terrain, limited access roads and high arson occurrences which compound wildfire risk. This area is the most heavily forested area of the state and heavier fuel loading increases the risks of wildfire.

With climate change, it is expected that the weather will become more variable, and the probability of wildfires will increase. Since 2000, wildfires in the United States have burned an annual average of 7 million acres which is more than double the annual average in the 1990s (3.3 million). While the average number of wildfires has decreased, wildfires have continued to burn more acreage and at a greater intensity. Since 1960, average acreage burned by wildfires has been reported. The top five years with the largest acreage burned have occurred since 2006. The top three years are 2015, 2020, and 2017, respectively.

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[62] See "Robinson Forest", UK Martin-Gatton College of Agriculture, Food, and Environment, http://robinson-forest.ca.uky.edu/
[63] See "Ten Year Summary", Wildland Fire Management, Division of Forestry, https://eec.ky.gov/Natural-Resources/Forestry/Documents/10-Year%20Summary%20of%20Wildfire%20Causes.pdf

3.10 Hail

3.10.1 Description

Hail is precipitation in the form of irregular pellets of ice large enough to potentially cause damage. Hailstorms are a damaging outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until they develop to a sufficient weight and fall as precipitation. Hail typically takes the form of spheres or irregularly shaped masses greater than 0.75 inches in diameter. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size[64].

Hailstone size can range from just under a fifth of an inch (approximately pea-sized) to almost 4 inches (approximately melon-sized). Hailstones are categorized using the TORRO Hailstorm Intensity Scale, as shown in **Table 3-31**. Hailstone size descriptions are presented in **Table 3-32**.

Hail-related insured losses averaged between $8 billion and $14 billion per year from 2000 to 2019[65]. It damages buildings and homes by perforating holes in roofs and shingles, breaking windows and denting siding, and damages automobiles by denting panels and breaking windows. Hail rarely causes any deaths; however, several dozen people are injured each year in the United States.

Table 3-30: TORRO Hailstorm Intensity Scale

	Intensity Category	Typical Hail Diameter (in)	Probable Kinetic Energy, J-m^2	Typical Damage Impacts	Size Code
H0	Hard Hail	0.20	0-20	No damage	1
H1	Potentially Damaging	0.20 – 0.59	>20	Slight general damage to plants, crops	1-3
H2	Significant	0.39-0.79	>100	Significant damage to fruit, crops, vegetation	1-4
H3	Severe	0.79-1.18	>300	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored	2-5
H4	Severe	0.98-1.57	>500	Widespread glass damage, vehicle bodywork damage	3-6
H5	Destructive	1.18-1.97	>800	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries	4-7
H6	Destructive	1.57-2.36	-	Bodywork of grounded aircraft dented; brick walls pitted	5-8

[64] See "Severe Weather 101 – Hail", NOAA National Severe Storms Laboratory, https://www.nssl.noaa.gov/education/svrwx101/hail/
[65] From "Facts + Statistics: Hail", Insurance Information Institute, https://www.iii.org/fact-statistic/facts-statistics-hail

	Intensity Category	Typical Hail Diameter (in)	Probable Kinetic Energy, $J\text{-}m^2$	Typical Damage Impacts	Size Code
H7	Destructive	1.97-2.95	-	Severe roof damage, risk of serious injuries	6-9
H8	Destructive	2.36-3.54	-	Severe damage to multiple roof types (including sheet and metal); damage aircraft bodywork	7-10
H9	Super Hailstorms	2.95-3.94	-	Extensive structural damage (including concrete and wooden walls). Risk of severe or even fatal injuries to persons caught in the open	8-10
H10	Super Hailstorms	>3.94		Extensive structural damage (including destruction of wooden houses and damage to brick-built homes). Risk of severe or even fatal injuries to persons caught in the open	9-10

Table 3-31: Hail Size Code Descriptions

Size Codes	Diameter (in)	Relational Size
0	0.2 – 0.4	Pea
1	0.4 – 0.6	Mothball
2	0.6 – 0.8	Marble, Grape
3	0.8 – 1.2	Walnut
4	1.2 – 1.6	Pigeon's egg > Squash ball
5	1.6 – 2.0	Golf ball > Pullet's egg
6	2.0 – 2.4	Hen's egg
7	2.4 – 3.0	Tennis ball > Cricket ball
8	3.0 – 3.5	Large orange > Soft ball
9	3.5 – 3.9	Grapefruit
10	>3.9	Melon

3.10.2 Location

Hailstorms frequently accompany thunderstorms, so their locations and spatial extents coincide. It is assumed the entire UK campus and outlying facilities are uniformly exposed to severe thunderstorms; therefore, all UK campuses are equally exposed to hailstorms. Thunderstorms are discussed in more detail in the *3.13 Severe Storm Profile*. According to the National Weather Service, most of Kentucky is located in an area of the United States that receives an average of 4-6 days per year with severe hail events (see **Figure 3-39** below)[66].

66

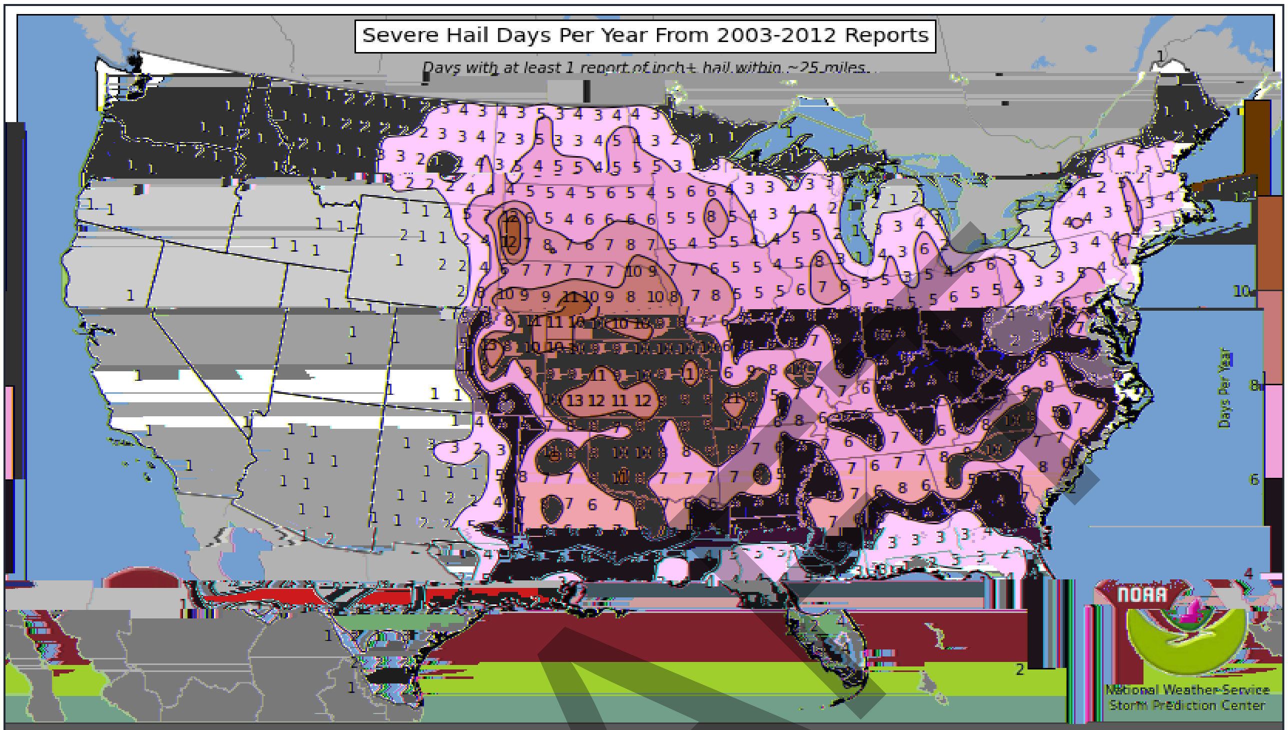

Figure 3-38: Severe Hail Days per Year in the United States

3.10.3 Previous Occurrences

The NCEI Storm Events Database reports hail information by county. Since 1955 there have been 64 reported hail occurrences in Fayette County. None of these events resulted in reported deaths, injuries, or damages. However, it is likely that hail events and associated damages to private property were not reported to NCEI. Therefore, the number of events and resulting damage is likely higher than what is indicated. Previous hail events in Fayette County are shown in **Table 3-33**.

Table 3-32: NCEI Historic Hail Events in Fayette County (1955 – 2022)

Date	Magnitude (inches)
03/04/1955	0.75
07/10/1966	4.00
07/20/1967	0.75
06/14/1969	1.00
06/24/1969	1.75
06/28/1971	2.00
04/02/1975	1.75
07/17/1975	1.75
04/21/1976	0.75
05/21/1982	1.75
05/29/1982	2.5
08/27/1983	1.00
08/27/1983	0.75
06/02/1987	1.00
06/02/1987	1.00
08/10/1992	1.00
05/10/1995	0.75
06/10/1995	1.00
06/26/1995	0.75
04/20/1996	0.75
05/05/1996	1.00
01/24/1997	0.75
03/28/1997	0.75
08/19/1999	2.00
08/24/1999	0.75
04/10/2001	0.75
05/01/2002	0.75
05/09/2003	0.75
05/15/2003	1.75
05/15/2003	0.75
06/01/2004	0.75
06/1/2004	0.88
04/22/2005	0.75
06/14/2005	0.75
04/02/2006	0.75
04/02/2006	0.75
05/25/2006	0.75
05/31/2006	0.88
05/31/2006	1.00
10/11/2006	1.00
06/05/2007	1.00
06/05/2007	1.75
06/05/2007	1.00
07/18/2007	0.75
07/18/2007	0.88
06/09/2008	0.75
06/02/2009	0.75
05/22/2011	0.88
03/15/2012	1.00
08/09/2012	1.00
05/14/2014	1.00
06/19/2014	0.88
07/27/2014	1.75
07/27/2014	1.75
04/08/2015	0.88
07/13/2015	0.75
05/01/2016	1.00
05/01/2016	1.00
04/05/2017	1.75
04/05/2017	1.00
04/05/2017	1.00
05/19/2022	1.00
05/19/2022	1.75
05/19/2022	3.00

The largest recorded magnitude hail was 4 inches in July 1966. Most of the hail magnitudes were between ¾ of an inch and 1 ¼ inches. The hail instances by magnitude are shown in **Figure 3-40**.

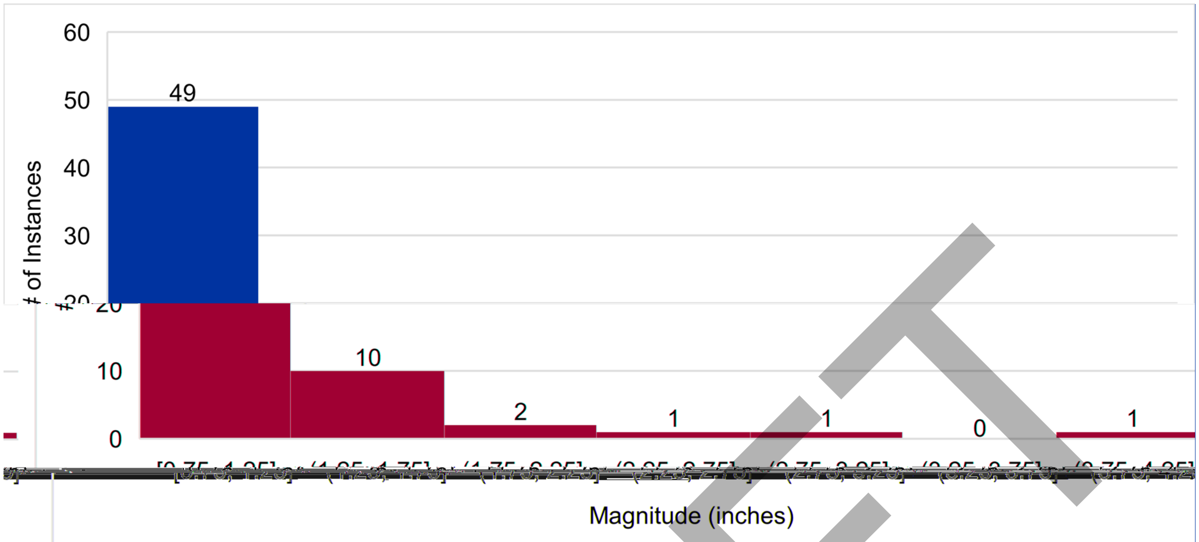

Figure 3-39: Hail Instances in Fayette County by Magnitude

Six recent hailstorms with notable damages are described below based on the *Lexington-Fayette Urban County Hazard Mitigation Plan* and local news sources[67].

- **May 19, 2022**: Strong thunderstorms produced large hail across central Kentucky. Hail sizes larger than baseballs were observed in Fayette County. Local news reported significant personal property damage to roofs and cars, but damages were not reported in NCEI[68].
- **April 5, 2017**: Severe thunderstorms developed across central Kentucky, resulting in large hail and damaging winds. The hail damaged some windows and shingles.
- **July 27, 2014:** There was widespread large hail with a magnitude the size of a golf ball. The hail damaged corn, soybean and tobacco crops at the UK Agricultural Research Farm just north of Lexington. This hail fell from a supercell that brought a destructive microburst to Lexington. Crop damage of $65,239 (2022 dollars) was reported from the hail event.
- **March 2012:** Hail approximately 2.75 inches in diameter (golf ball to tennis ball size) was seen in most regions of the state accompanying a tornadic event.
- **May 31, 2006:** A cluster of thunderstorms produced widespread tree damage, minor structural damage, heavy rains, and some large hail in the Lexington area. In the Newtown Pike area, roof damage was reported, and power lines were downed. Over east central Kentucky, trees and power lines were downed. In Greensburg, a tool shed was rolled.

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[67] Lexington-Fayette County Government. (2020). Hazard Mitigation Plan: 2020 Update. Division of Emergency Management. Retrieved on February 27, 2023 from LFUCG-Hazard-Mitigation-Plan-Approved-FEMA.pdf (bereadylexington.com)

[68] See "Baseball-size hail hits part of central Kentucky", Samantha Valentino (May 2022), WKYT, https://www.wkyt.com/2022/05/20/baseball-size-hail-hits-parts-central-kentucky/

- **June 14, 2005:** Over central Kentucky, thunderstorms developed in an unstable air mass ahead of an advancing cold front. Thunderstorm winds downed trees and power lines, along with a few instances of hail and structural damage.

3.10.4 Extent

Hail extent can be measured in terms of size, typically by diameter. According to the events reported in NCEI, the greatest extent hail reported in Fayette County was 4 inches on July 10, 1966. On the TORRO scale, this size correlates to H10. According to the TORRO scale, hailstones of this size (about the size of a melon) can cause extensive structural damage, severe injuries, and fatalities. Hail damage typically impacts personal property which is not frequently documented in NCEI data for hail. The greatest damages reported from a hail event in Fayette County is $65,239 (2022 dollars) in crop damages. It should be noted that greater extent hail is possible in Fayette County.

3.10.5 Probability

With 64 reported events in 67 years, Fayette County, where the main campus is located, experiences just under one reported hail event per year. As discussed above, it is likely that the number of events reported is lower than the number that occurred. According to NOAA data presented in **Figure 3-39**, locations within Kentucky experience an average of 4-6 hail days per year historically, indicating hail is an annual event for all UK campuses and facilities.

When possible, climate variability should be considered when determining the probability of future hazard conditions. Trends in convective storm occurrences due to climate change are subject to greater uncertainty than temperature-related trends (such as extreme heat and cold events), and research is ongoing. Because hail is an outgrowth of severe thunderstorms, trends in hail frequency and intensity are directly related to trends in thunderstorm frequency and intensity. Although studies are still being performed, a recent study cited by the *Fourth National Climate Assessment* indicates an increase in the occurrence of atmospheric conditions conducive to severe thunderstorm formation in the United States. For the Kentucky spring season, the study indicates increases of 1.2 to 2.4 days per season with severe thunderstorm environments during 2070-2099[69].

Considering the frequency of historic occurrences, the likelihood of unreported or underreported events, and climate projections for severe storm conditions, the probability of hail is highly likely (greater than 90 percent annual chance).

3.10.6 Vulnerability Assessment

Potential impacts to buildings, infrastructure, life safety, public health, populations, and the economy from the hail hazard are described below. All current and future buildings, infrastructure, and populations across all UK campuses and outlying facilities are considered at risk from hail. No dollar losses are attributed to hail events on UK campuses or 4-H camps, but future losses are possible. The National Risk Index (NRI) provides a hail risk index score, which indicates a county's hail risk relative to the rest of the United States[70]. According to the index, Fayette County has "relatively moderate" risk from hail.

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[69] "Robust increases in severe thunderstorm environmental in response to greenhouse forcing" Diffenbaugh, Scherer, & Trapp (August 20, 2013), *PNAS.*
[70] See "National Risk Index", FEMA, https://hazards.fema.gov/nri/map

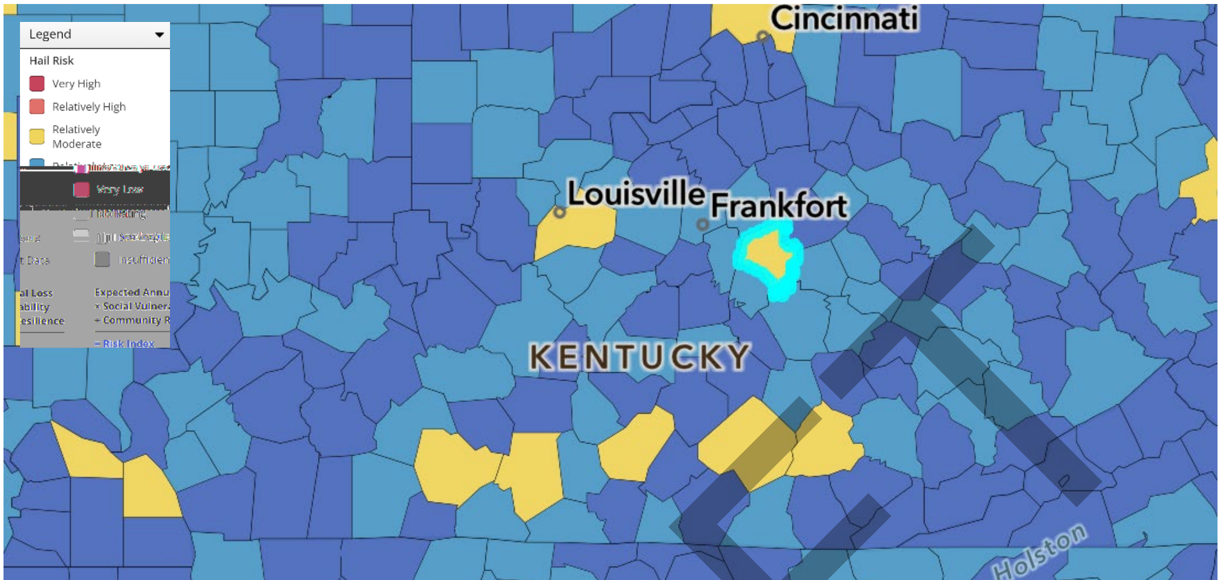

Figure 3-40: Hail Risk Index Results at a National Level

Hail can result in extensive property damage, including damage to cars, roofs, crops and landscaping. Temporary business interruptions are possible if people need to seek shelter until a hail event has passed. Hail is capable of causing damage to roofs, brick walls, and exposed glass and metal. Therefore, buildings are considered at risk of hail-related damage. Unhoused populations and populations living in substandard housing are more vulnerable to the impacts of hail events. In severe cases, hail has the potential to damage exposed infrastructure, such as roads, sidewalks, bridges, and above-ground utilities.

Further, while rare, hail can result in injuries and loss of life to persons caught in the open. UK's main campus has many people, such as students, outside throughout the day, especially during class changes, that could be exposed to hail. Further, outdoor workers at UK's outlying campuses or 4-H camps may be far from shelter when exposed to the hail hazard. Livestock at these facilities may also be injured during hail events, and crops may sustain substantial damage.

Impacts on hail intensity (extent) due to climate change are uncertain. It is unknown if future climate conditions will result in different hailstone sizes on average. Research from the National Climate Assessment indicates a projected increase in the number of days with thunderstorm environments, which could lead to an increase in the number of hail occurrences impacting UK's campuses. An increase in the frequency of events would increase the vulnerability of people, buildings, and infrastructure to hail hazard.

3.11 Karst and Sinkholes

3.11.1 Description

Karst refers to a type of topography that occurs where there are carbonate rock formations underlying the visible surface of the terrain. A karst landscape most commonly develops on limestone, but can develop on several other types of rocks, such as dolostone (magnesium carbonate or the mineral dolomite), gypsum and salt. The bedrock is millions of years old, and the karst terrain formed on them is hundreds of thousands of years old.

A karst landscape typically has closed depressions, sinkholes, sinking streams, caves, springs and underground drainage; however, karst areas vary somewhat at a regional or global scale. Geologists have adopted karst as the term for all such terrain; the term “karst” describes the whole landscape, not a single sinkhole or spring. The topography is formed by dissolution of carbonate rocks by rain and underground water.

Precipitation infiltrates into the soil and flows into the subsurface from higher elevations and generally toward a stream at a lower elevation. Weak acids found naturally in rain and soil water slowly dissolve the soluble carbonate rock, enlarging existing joints and tiny fractures within the rock. As subsurface water flow paths are enlarged over time, water movement in the aquifer changes character from one where ground water flow was initially through small, scattered openings in the rock, to one where most flow is concentrated in a few, well developed conduits. Over time, caves may form, and the ground water table may drop below the level of surface streams. Surface streams may then begin to lose water to the subsurface. As more of the surface water is diverted underground, surface streams and stream valleys become a less conspicuous feature of the land surface and are replaced by closed basins. Funnels or circular depressions called sinkholes often develop at some places in the low points of these closed basins. An illustration of karst terrain and common features are shown below in Error! Reference source not found. **Figure 3-42**[71]**.**

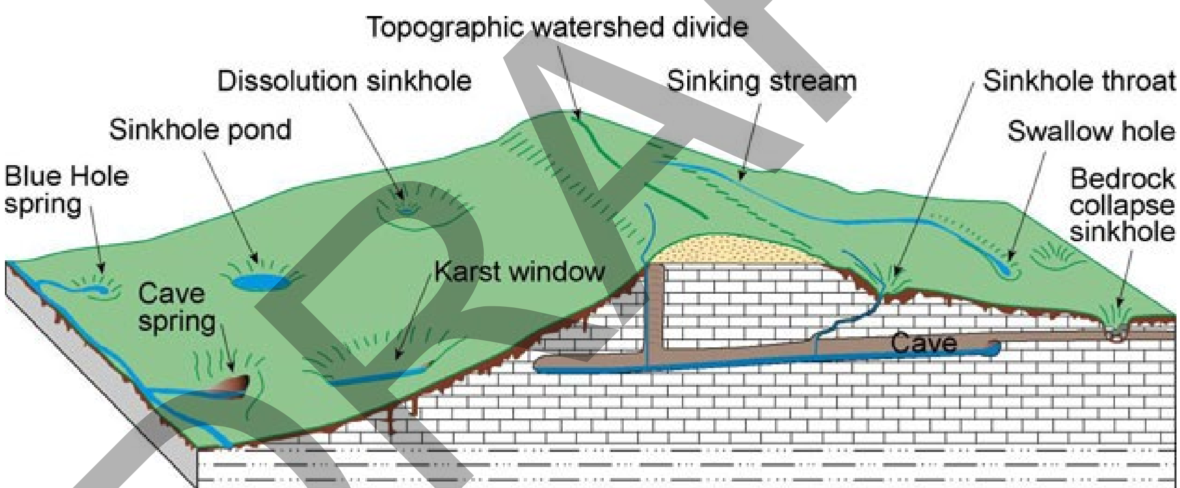

Figure 3-41: Example of Karst Terrain Features

Much of Kentucky is characterized by karst terrain. Karst attributes that may impact UK include sinkholes, high concentrations of radon, water contamination (either of the groundwater or surface water), and sinkhole flooding. These attributes are described in detail below.

[71] Karst Geology and Hydrogeology. Kentucky Energy and Environment Cabinet. Retrieved from Karst Geology - Kentucky Energy and Environment Cabinet.

Sinkholes

The most commonly encountered karst hazard is sinkholes. Naturally occurring sinkholes are formed by the processes described above, where a depression or cavern is formed as a result of dissolved carbonate rock. Human induced "sinkholes" can occur as a result of leaking water or sewer pipes and are a result of unnatural erosion, not the result of dissolved rock. This risk assessment only addresses naturally occurring sinkholes. The location of previous occurrences, extent, probability and vulnerability assessment discussed here do not apply to human-induced sinkholes.

Naturally occurring sinkholes can be broadly classified into two types: subsidence sinkholes and cover-collapse sinkholes. Subsidence sinkholes are slowly forming and caused by gradual dissolution of subsurface carbonate rock. In Kentucky, these are exemplified by broad, shallow, bowl-shaped depression. These sinkholes create the rolling hills that characterize the Bluegrass and Western Pennyroyal Regions, shown in **Figure 3-43**[72]**.** Cover-collapse sinkholes are far more dangerous and less predictable. These are the result of the sudden collapse of surface material that once covered a subsurface cave or large void caused by chemical reaction described above. Over time, the subsurface cavern that was formed grows to the point where the surface material is no longer supported, and collapses. Cover-collapse sinkholes typically have steep walls and are circular in shape, varying in diameter and depth. An example of a cover-collapse sinkhole is shown in **Figure 3-44**.

Collapses are seldom reported to any central agency. Damage to infrastructure from sinkhole flooding and cover collapse is so common in Kentucky that it is often dealt with by local authorities as a routine matter.

Figure 3-42: Subsidence Sinkhole

[72] Kentucky Emergency Management. (2018). Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan (CK-EHMP 2018). Retrieved on February 23, 2023 from Kentucky Emergency Management.

Figure 3-43: Cover-Collapse Sinkhole

High Concentrations of Radon

High concentrations of radon may be found in basements and crawl spaces of houses built on karst. The rock and sediments found in Kentucky's subsurface contain varying trace levels of uranium which releases trace amounts of radon as these materials decay. Radon is a known carcinogen and presents an environmental risk to those exposed to it at high levels or for long periods of time. According to the EPA, the average indoor radon level is about 1.3 pCi/L (picocuries per liter of air), and the average outdoor level is about 0.4 pCi/L. Homeowners should consider taking steps to reduce radon levels if testing shows levels are over 2 pCi/L in their home. If levels are over 4 pCi/L, the US, Surgeon General and EPA highly recommend taking steps to reduce these levels[73].

A 2020 study produced a statewide indoor-radon potential map for the Commonwealth of Kentucky, shown in **Figure 3-45**[74]. Structures within the yellow, brown or red areas of the map should consider testing radon levels in the lowest level of the property. However, because radon levels can vary greatly, even house to house, structures found in these areas may or may not have high levels of radon. Thankfully, short-term charcoal canister radon home test kits are quick and inexpensive to use; these can be acquired from local public health agencies or home improvement stores. It is recommended to test in winter months to provide the most accurate results.

[73] U.S. Environmental Protection Agency. (2023). Basic Radon Facts. Retrieved on February 28, 2023 from Basic Radon Facts - January 2023 (epa.gov).
[74] Haneberg, W. C., Wiggins, A., Curl, D. C., Greb, S. F., Andrews, W. M., Rademacher, K., et al. (2020). A geologically based indoor-radon potential map of Kentucky. GeoHealth, 4, e2020GH000263. https://doi.org/10.1029/2020GH000263

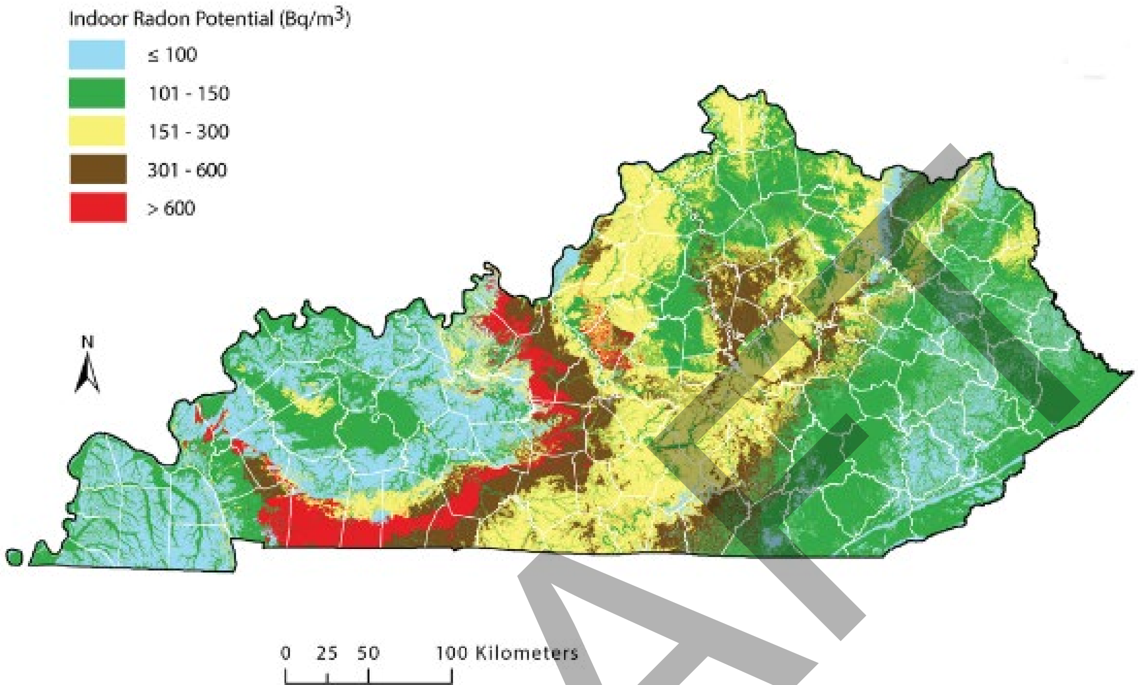

Figure 3-44: Indoor Radon Potential in Kentucky

Increased Water Contamination Risk

Because hydrology within karst terrain is often more complex than in other landscapes, this presents a risk to groundwater or surface water contamination.

Groundwater and stormwater move through underground conduits more rapidly within karst terrain, which reduces the quantity of contaminates that are filtered out relative to other groundwater systems. In Kentucky, thousands of residents get their drinking water from public suppliers located in karst areas. Additionally, thousands more get their drinking water from private wells or springs in karst areas. Water from aquifers within karst areas feed into the Commonwealth's streams and rivers, which are also a source of drinking water for many residents. Contamination within a karst aquifer can spread to surface water, presenting a public health risk. The Kentucky Division of Water has a number of programs, including the Source Water Protection Assistance Program, designed to help communities mitigate risks associated with groundwater and surface water contamination.

Sinkhole Flooding

Development that has occurred within a settled sinkhole is at risk of flooding. Of the karst related hazards presented here, sinkholes and sinkhole flooding cause the most damage to buildings.

Two common sinkhole flooding scenarios are shown in **Figure 3-46** and **Figure 3-47**[75]. In **Figure 3-46**, the underground conduit that normally drains water from a sinkhole has become blocked, causing flooding within the sinkhole. This blockage could occur at any point within the subsurface hydrology. The second common scenario, shown in **Figure 3-47**, is when flooding occurs as a result of a flow reversal. Flooding downstream produces back pressure, leading to a flow reversal within the sinkhole, causing the sinkhole to fill with water.

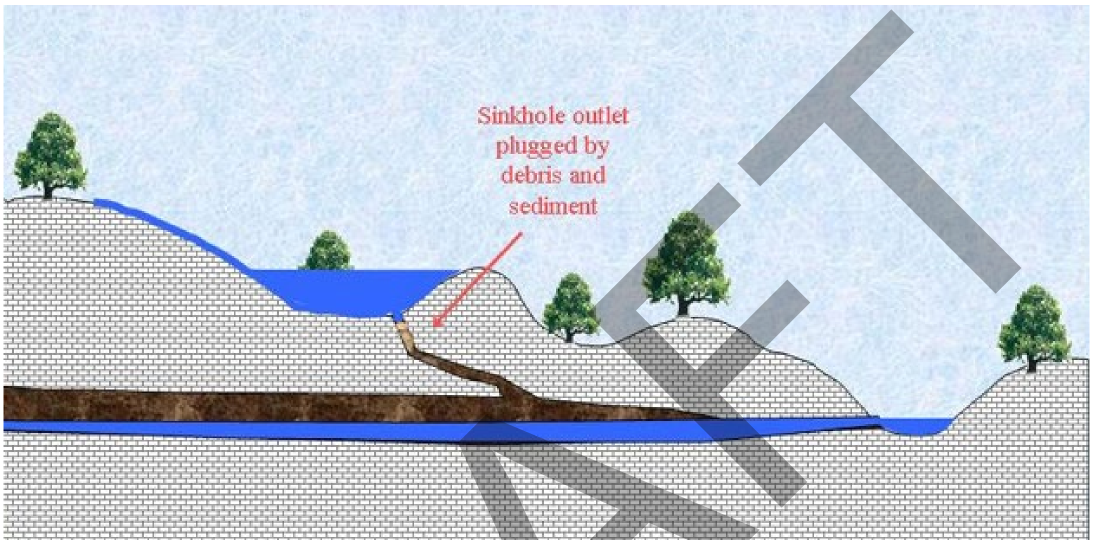

Figure 3-45: Sinkhole Flooding Caused by Debris Clog

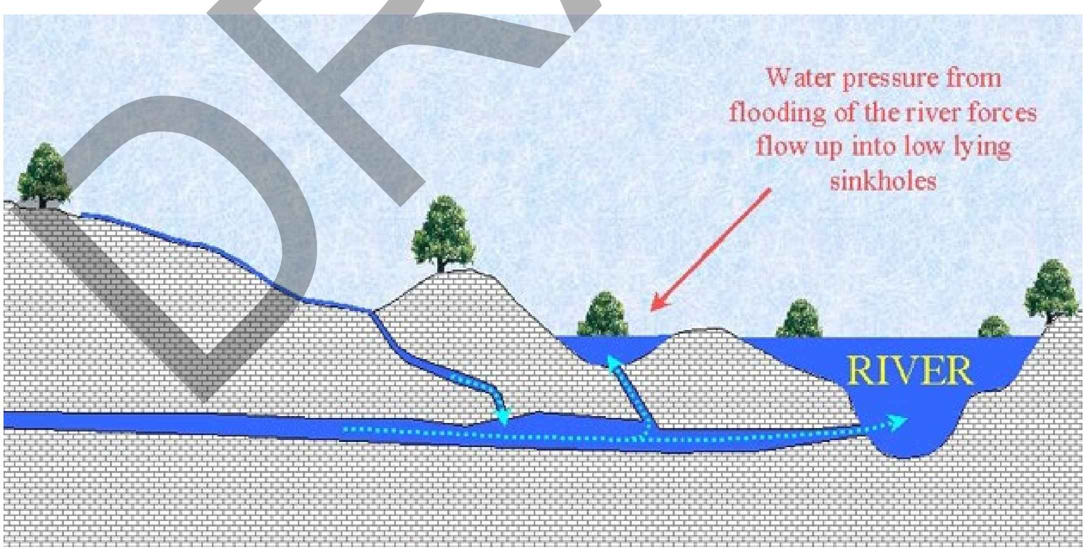

Figure 3-46: Sinkhole Flooding Caused by Flow Reversal

[75] KGS. Sinkhole Flooding. Retrieved from Karst, Kentucky Geological Survey, University of Kentucky (uky.edu).

Mine Subsidence

In Kentucky, land subsidence is often used interchangeably with mine subsidence, as abandoned subterranean mining operations are the most common cause of subsidence events. For this reason, subsidence is most likely to occur in the eastern and western coalfield regions of the state.

Kentucky coal mining has suffered more production loss due to roof collapse problems than any other coal-producing state. The geologic factors related to roof collapse commonly include faults, fractures, weak and disturbed roof strata, and rider coals (thin coals separated from the main coal seam, often by a weak shale-ridden zone).

Although the greatest number of abandoned mines runs in a belt through western Pennsylvania, eastern Kentucky, and central West Virginia, data on past occurrences isn't maintained in any single database for the Commonwealth of Kentucky.

The magnitude of mine subsidence has the potential to be quite severe in Kentucky, as evidenced in 1984 when Kentucky's legislature passed KRS 304.44-030 that established the Kentucky Mine Subsidence Insurance Fund (KMSIF). The KMSIF provides insurance coverage for structures by requiring authorized insurers to endorse the KMSIF in selling their policies to property owners and then acting as a reinsurer to those authorized companies (who have signed a reinsurance contract with KMSIF) .

The KMSIF applies to the 37 counties listed in **Table 3-34**, located primarily in eastern and western Kentucky:

Table 3-33: KMSIF Counties

KMSIF Counties				
Bell	Edmonson	Jackson	Letcher	Perry*
Boyd	Elliot	Johnson	Martin	Union
Breathitt*	Floyd	Knott	McCreary	Webster
Butler	Greenup	Knox	McLean	Whitley
Carter	Hancock	Laurel*	Morgan	Wolfe
Christian	Harlan	Lawrence	Muhlenberg	
Clay	Henderson	Lee	Ohio	
Daviess	Hopkins*	Leslie	Owsley	

* denotes County with one or more UK campuses or 4-H camps

UK has campuses and 4-H camps in these counties (noted by an "*" in Table 3-34). Because the university self-insures, the insurance ramifications of KMSIF are not relevant to UK's campuses or outlying facilities. However, the presence of the KMSIF across the county indicates that the potential for mine subsidence is a real and present risk in the identified counties. The 5 outlying campuses located in KMSIF counties are: the Robinson Center for Appalachian Resource Sustainability (RCARS, Quicksand, KY), the Robinson Forest Campus (Clayhole, KY), West Kentucky 4-H Camp (Dawson Springs, KY), J.M. Feltner 4-H Camp (London, KY), and the College of Medicine's Center of Excellence in Rural Health (Hazard, KY).

Mine subsidence occurs for one or more of the following reasons:

An underground mine's roof suddenly collapses.

"Pillars" of coal-seam left in place to support the roof of a mine weaken, soften, and suddenly crumble and collapse.

"Pillars" of coal-seam left in place to support the roof of a mine are weighted down by materials aboveground that cause the pillars to suddenly crumble and collapse.

All three mechanisms for mine subsidence described above occur suddenly and without warning. The severity of a mine subsidence event has little to do with how much earth is moved or the depth of the mine.

Each mine is different; each roof of a mine is different; each purpose of a mine is different; each placement of structure on or around a mine is different. In terms of monetary impact, a few inches of roof-break can cause as much damage to properties as more significant measurements of break or slippage. Similarly, whether the subsidence is caused by acre-feet of groundwater depletion (that had previously buoyed the mine roof) or by a few inches of differential subsidence, the impact from the varying extent can be equally damaging.

There are recent examples throughout the country where mine subsidence has had devasting impacts. In Houston, Texas, for example, millions of acre-feet of groundwater subsidence (from an aquifer system transporting water to its residents) led to land elevation within a 1,720-square-mile area lowering by one foot, creating a "subsidence bowl" that led to the roof of a mine collapsing.[76] In Benld, Illinois, the 2009 collapse of an abandoned coal mine and resulting sinking required the town's seven-year-old elementary school to be razed, despite its predecessor having sat for over 80 years in the same spot[77]. In Inez, Kentucky, a coal impoundment (dam) failure in 2000 released 250 gallons of toxic slurry into an adjacent coal mine, leading to sudden subsidence[78].

Mine subsidence can occur without warning and last only a few seconds but can have devasting consequences. The type and/or value of property, whether or not the mine was mapped (i.e., known), depth or relative shallowness of the mine, type of subsidence, and history of the mine will influence the severity of the subsidence event.

3.11.2 Location

Kentucky is one of the most well-known karst areas in the world. Much of the state's beautiful scenery, particularly the horse farms of the Inner Bluegrass, is the result of karst landscape. Approximately 55 percent of Kentucky's land area has the potential for karst, and 25 percent has well-developed karst features[79]. **Figure 3-48** shows areas with a moderate and high risk of karst development in Kentucky.

As of 2010, approximately 2.9 million people, or about 67 percent of the Commonwealth's population, live in a karst region.[80] **Figure 3-48** shows statewide karst potential based on data from KGS.

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76 Cole, Cassandra R.; Maroney, Patrick F.; & McCullough, Kathleen A. (2004). "Managing Subsidence." Journal of Insurance Issues, 27 (1), 1-21.
77 Blackford, Nathan. (2012). "A Century Later, Abandoned Coal Mines Pose Serious Risk to Property." Evansville Courier & Press. Retrieved from http://www.courierpress.com/news/local/a-century-later-abandoned-coal-mines-pose-serious-risk-to-property--photos-ep-444344530-326223051.html.
78 Kentucky Mine-Mapping Information System. (n.d.). "History." Retrieved from Kentucky Mine Mapping Information System .
79 Kentucky Geological Survey. (n.d.) Hazards: Karst. University of Kentucky. Retrieved on February 23, 2023 from Karst, Kentucky Geological Survey, University of Kentucky (uky.edu)
80 Kentucky Emergency Management. (2018). Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan (CK-EHMP 2018). Retrieved on February 23, 2023 from Kentucky Emergency Management.

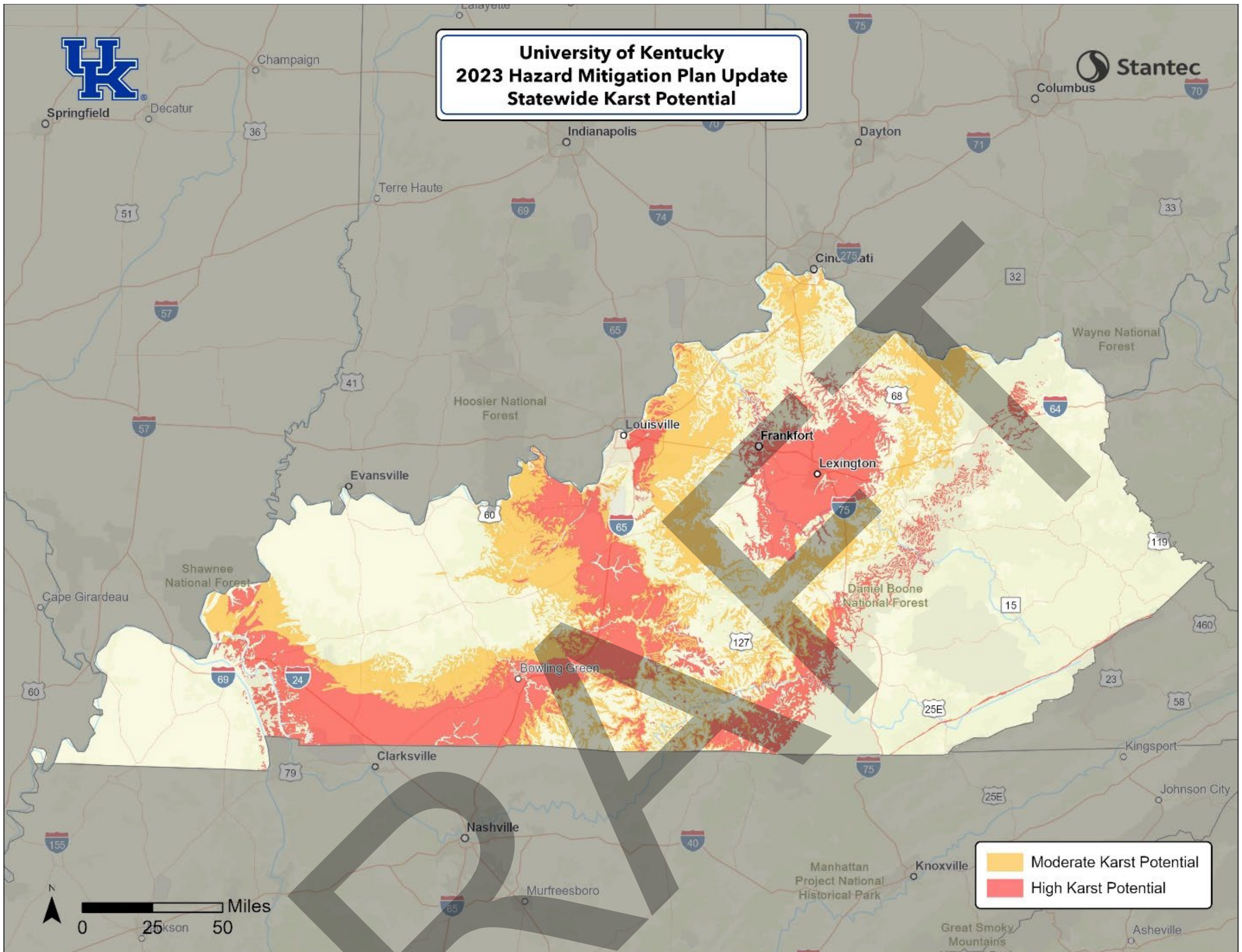

Figure 3-47: Statewide Karst Potential

3.11.3 Previous Occurrences

Several university facilities are located on karst terrain, including UK's main campus. As karst is a feature of the terrain, karst-related incidents, such as sinkholes, are used as an indication of previous events for the karst hazard. Five previous sinkhole incidents were reported by steering committee members. One of these incidents occurred in close proximity to the W.T. Young Library during its construction, resulting in a significant redesign of its foundation to account for the nearby sinkhole. The other 4 did not result in any known damages. Sinkhole occurrences across the state were mapped by KGS and provide a record of previous incidents. The sinkhole data consists of two datasets[81].

[81] Kentucky Geological Survey. (n.d.) Karst Potential Classification. Retrieved on March 29, 2023 from Karst Potential Help File (uky.edu)

The first is a dataset representing statewide sinkhole outlines which were manually digitized based on quadrangle topographic maps that were collected from 1999 through 2003.[82] The second is a dataset representing sinkhole outlines that were derived from LiDAR data. The LiDAR data was collected from 2009 to 2022 with varying collection dates for different counties.[83] **Table 3-35** provides a breakdown of the previous sinkhole data. In total there were 129,301 previous sinkholes included in both datasets throughout Kentucky.

Table 3-34: KGS Previous Sinkhole Data

Dataset	Spatial Extent	Collection Year(s)
Mapped Sinkholes	Statewide	1999-2003
LiDAR-Derived Sinkholes	Bullitt, Jefferson, and Oldham Counties	2009
LiDAR-Derived Sinkholes	Fayette, Woodford, Boyle, and Jessamine Counties	2017
LiDAR-Derived Sinkholes	Anderson, Bourbon, Franklin, Madison, Mercer, Shelby, and Scott Counties	2019
LiDAR-Derived Sinkholes	Clark, Garrard, Harrison, Montgomery, and Owen Counties	2022

Figures 3-47 through **3-53** show previous occurrences of sinkholes that are in close proximity to UK's campuses and 4-H camps specifically for the main campus, the Bowling Green campus, the Lake Cumberland 4-H Camp, the North Farm campus, the Research and Education Center, the South Farm campus, and the Little Research Center.

[82] Paylor, Randall L. et al. (2003). A GIS Sinkhole Coverage for the Karst Areas of Kentucky. Kentucky Geological Survey. Retrieved on March 29, 2023 from KGS Geologic Map Information Service (uky.edu)
[83] Kentucky Geological Survey. (2022). LiDAR_Sinkholes. Retrieved on March 29, 2023 from KGS Geologic Map Information Service (uky.edu)

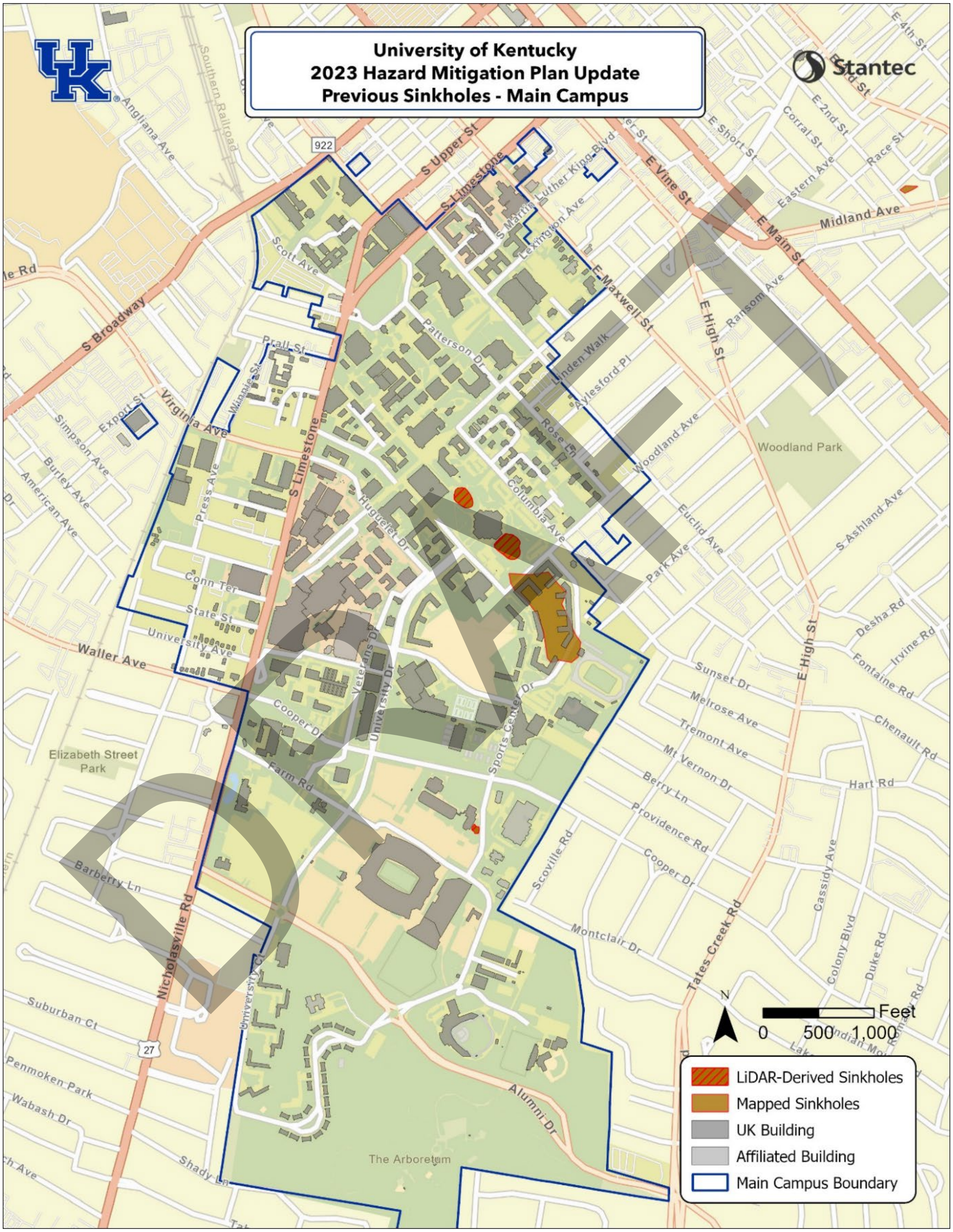

Figure 3-48: Previous Sinkholes in Proximity to the Main Campus

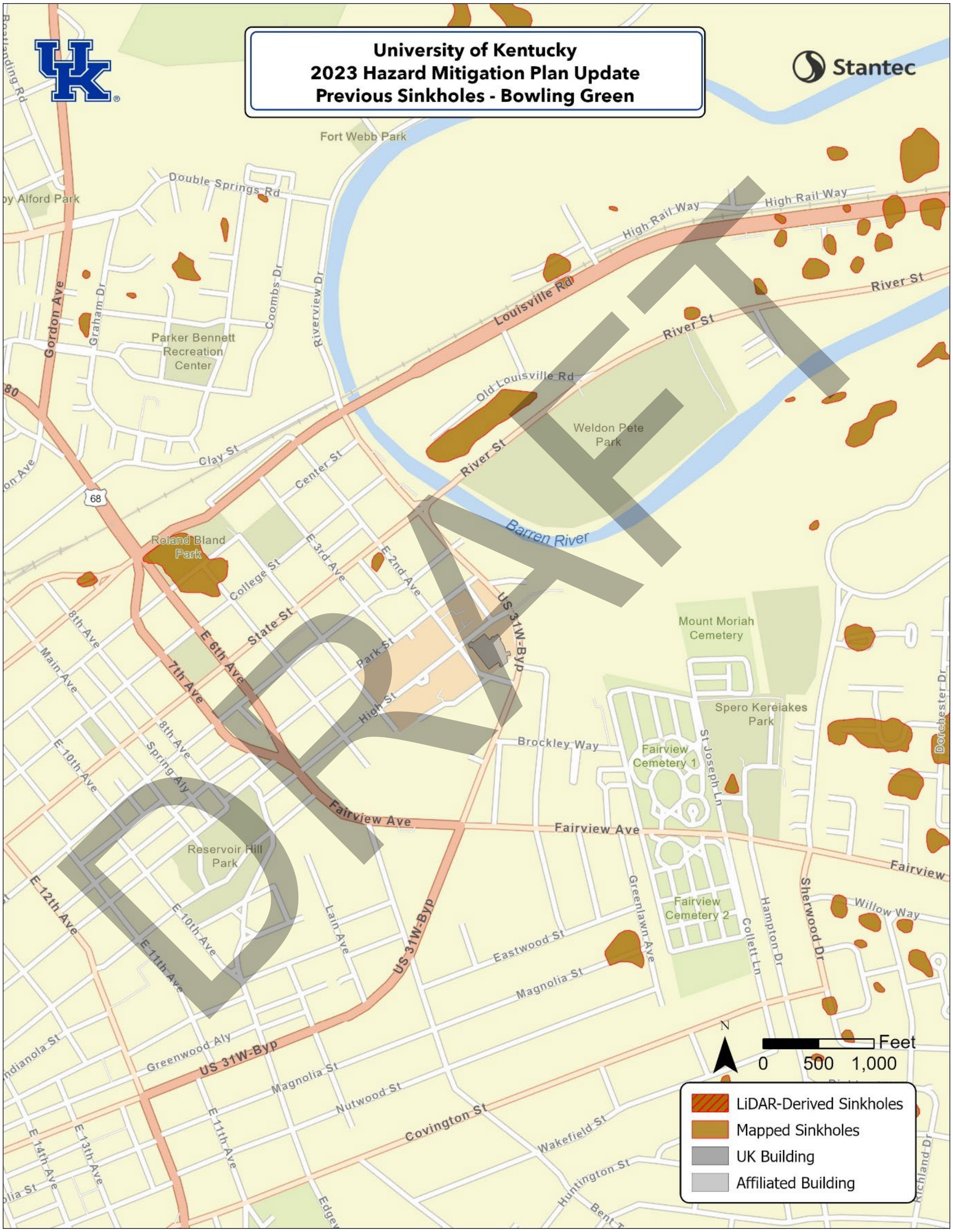

Figure 3-49: Previous Sinkholes in Proximity to the Bowling Green Campus

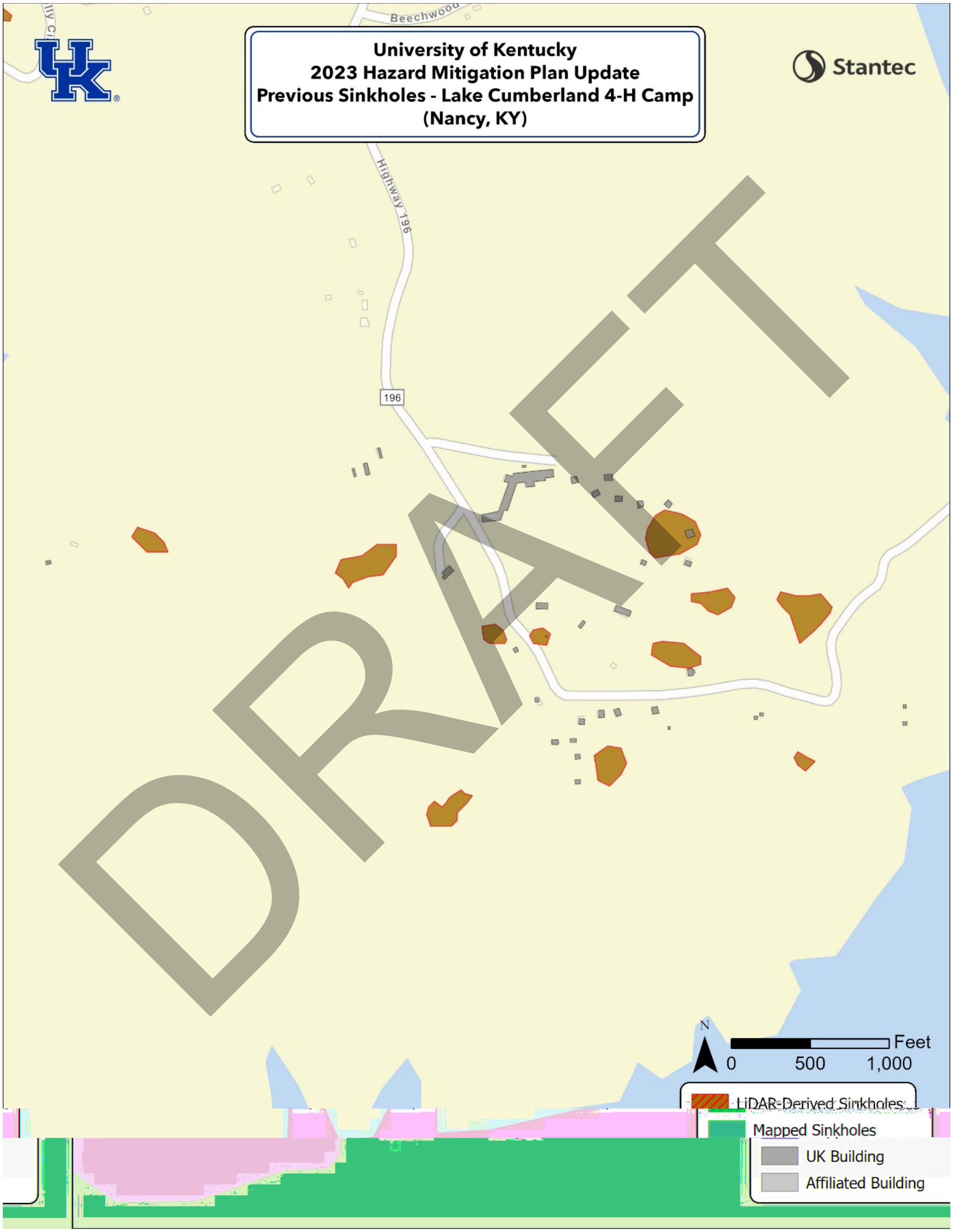

Figure 3-50: Previous Sinkholes in Proximity to the Lake Cumberland 4-H Camp

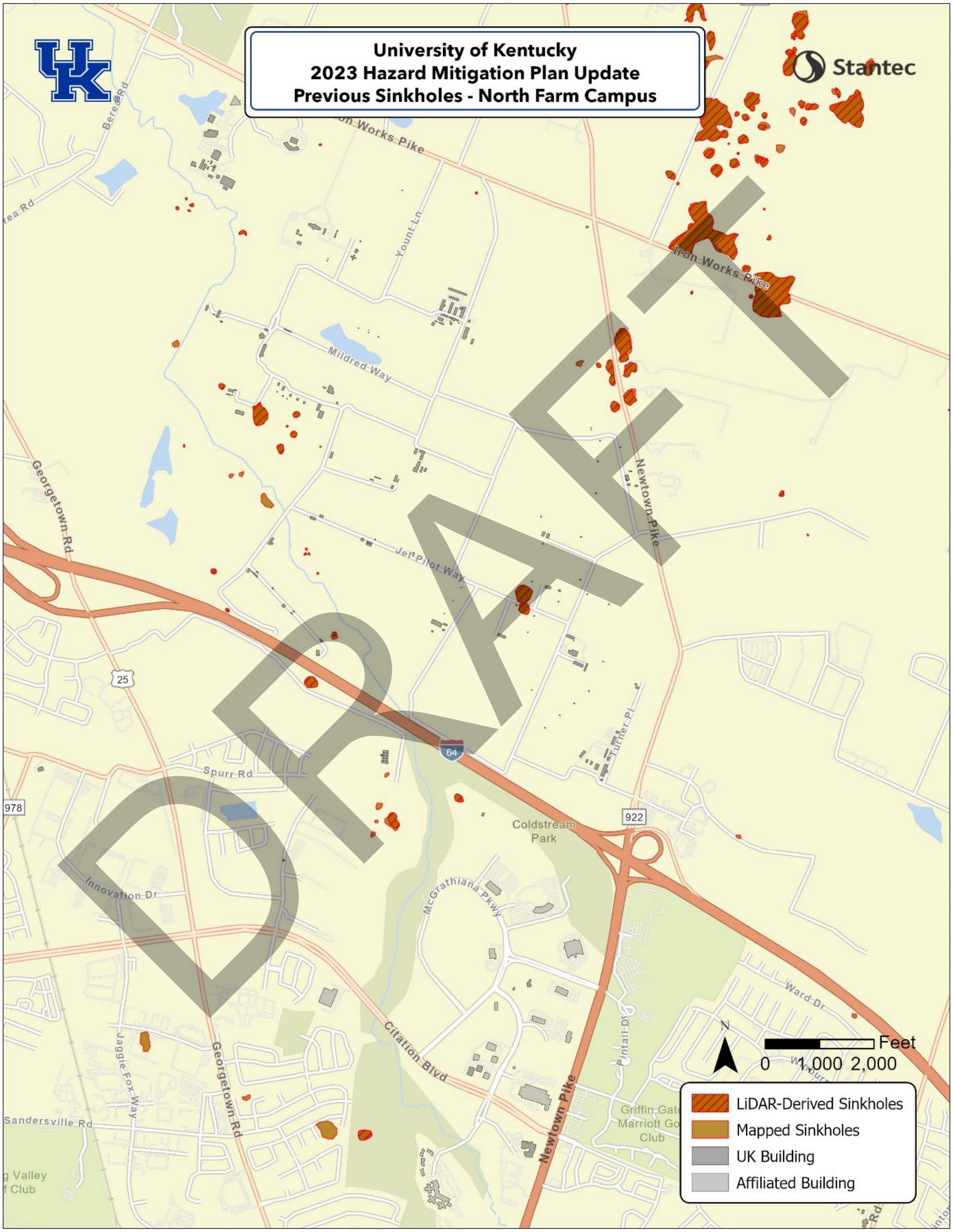

Figure 3-51: Previous Sinkholes in Proximity to the North Farm Campus

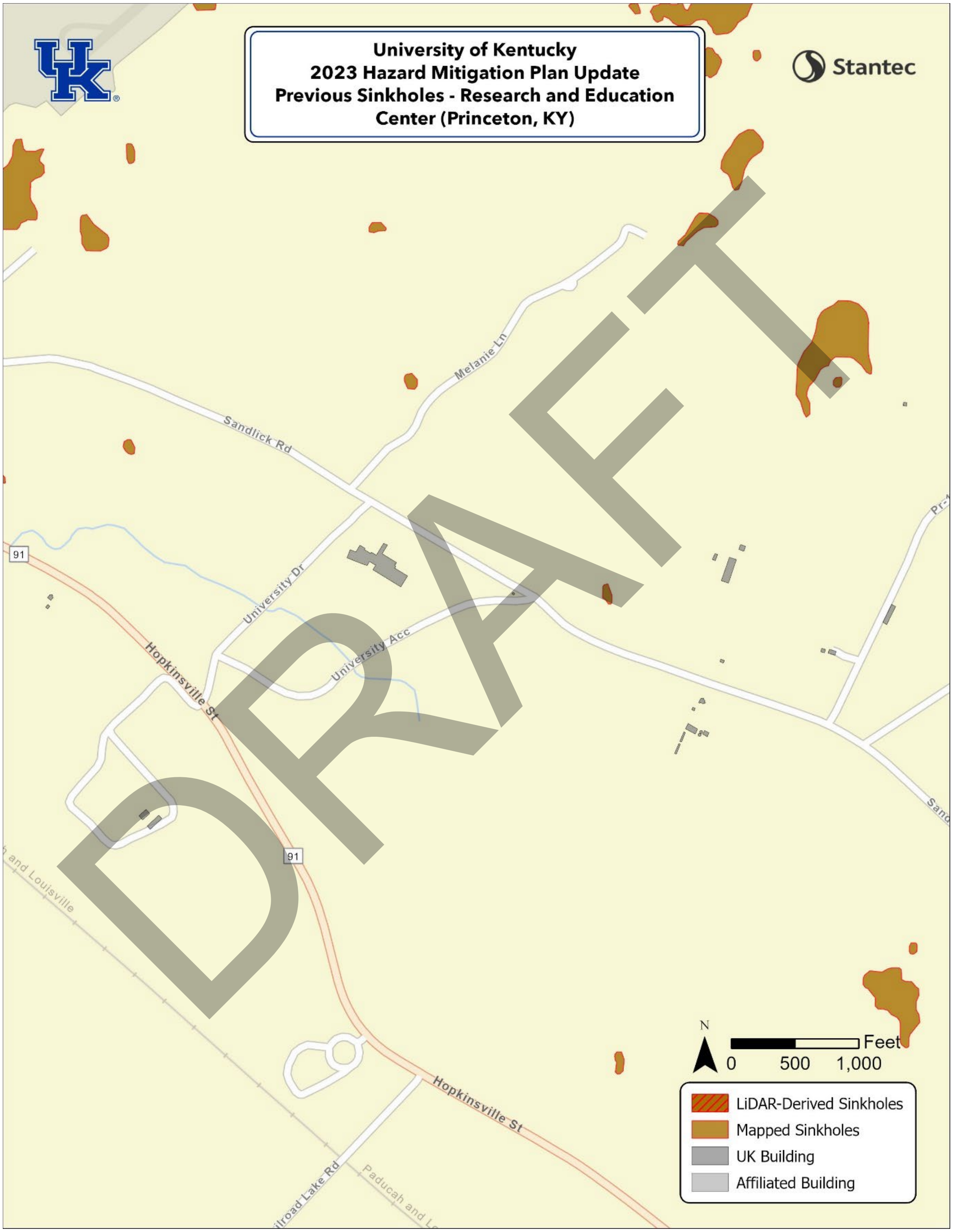

Figure 3-52: Previous Sinkholes in Proximity to the Research and Education Center

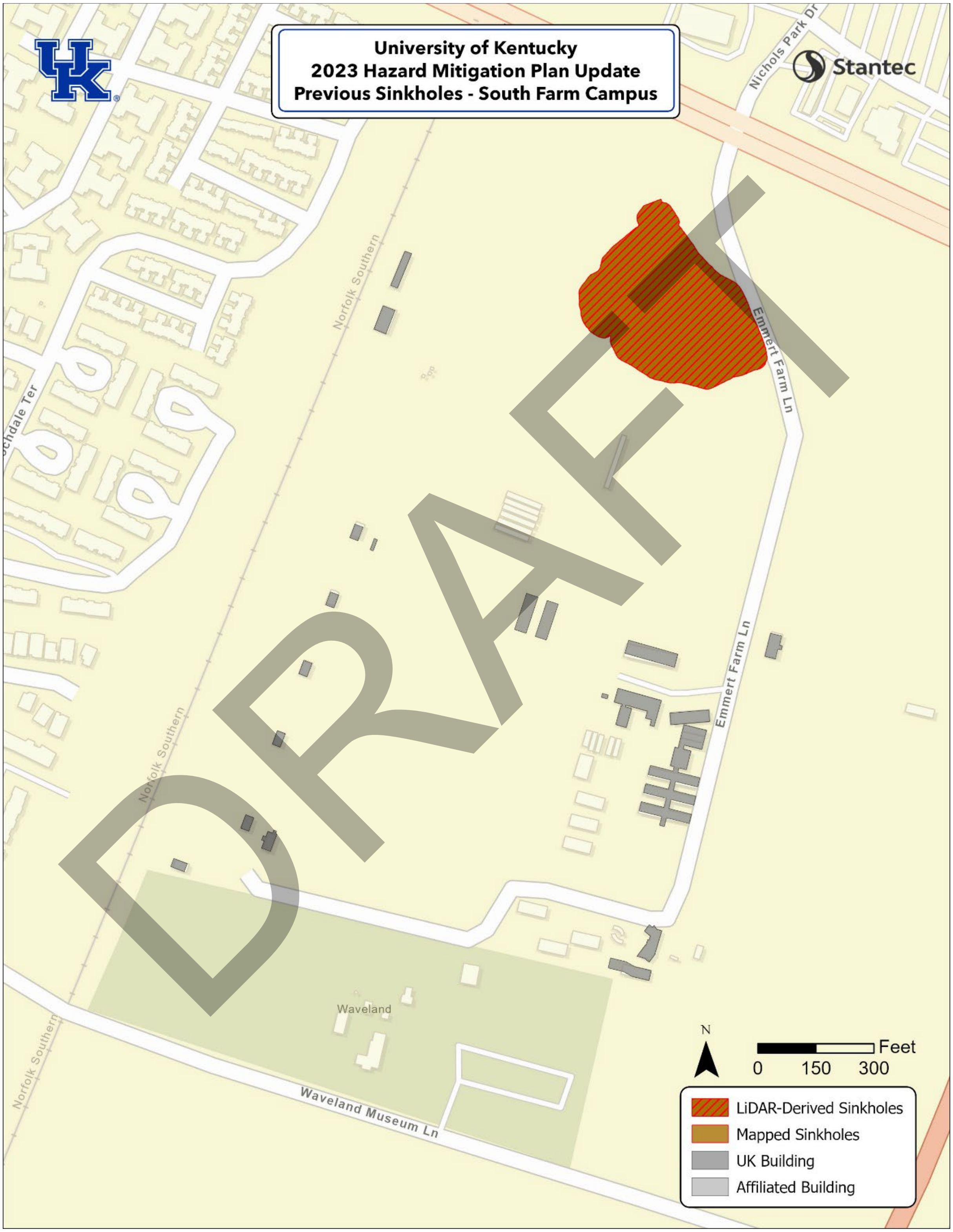

Figure 3-53: Previous Sinkholes in Proximity to the South Farm Campus

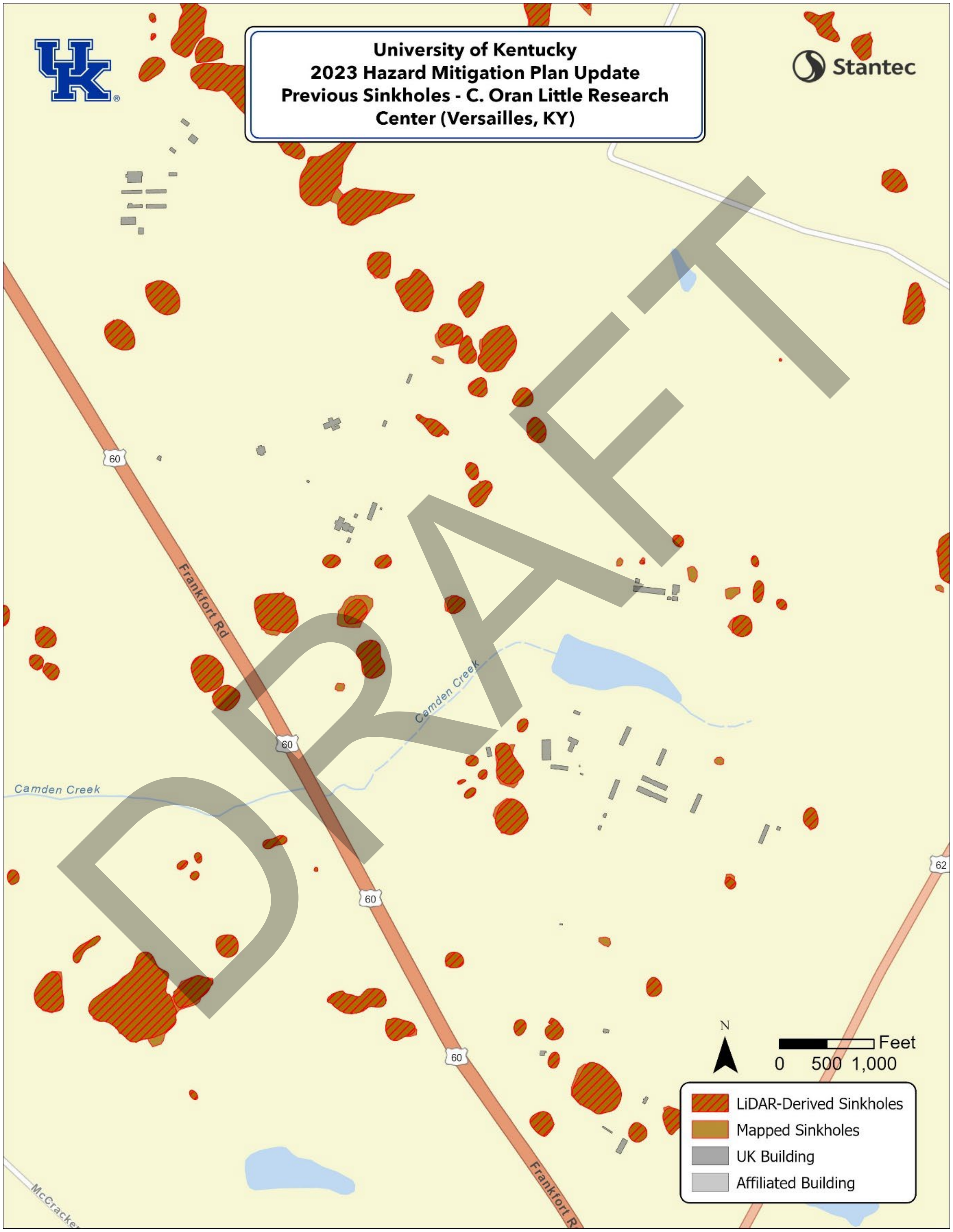

Figure 3-54: Previous Sinkholes in Proximity to the C. Oran Little Research Center

3.11.4 Extent

Karst hazards frequently damage buildings, roads, utility lines, and farm equipment. Across the Commonwealth, previous karst hazard events have killed livestock and injured people. One way to measure the extent of sinkholes is size. Sinkholes can vary greatly in size, from a couple feet to tens of feet deep and wide. When reviewing the previous sinkhole data available from KGS, 591 are within one mile of a university building. The largest sinkhole within one mile of a university building is located near the Lake Cumberland 4-H Camp (Nancy, KY) and is over 46 acres in area. The data does not indicate when this sinkhole occurred. There were no insurance claims or damages caused by sinkholes reported by the university. There was the sinkhole event mentioned in the Previous Occurrences section that caused a significant redesign of the W.T. Young Library, however no damage was caused. The largest sinkhole that previously occurred on the main campus was nearly 8 acres in size. This sinkhole can be seen in **Figure 3-49**. Again, this sinkhole likely occurred quite some time ago and the area has since been developed by UK.

Another means of measuring the extent of a sinkhole is the amount of damage caused by an event. Two of the costliest statewide sinkhole events both occurred in Bowling Green and were highly publicized. An event in February 2002 on Dishman Lane caused $1.3 million in damages. A February 12, 2014 sinkhole event at the National Corvette Museum in Bowling Green caused catastrophic damage. The 60-foot-long, 45-foot-wide, and 30-foot-deep sinkhole caused over $3.6 million in damage to the museum. Additionally, the sinkhole swallowed eight rare Corvette sports cars worth an estimated $3.4 million. It is possible that an event such as the two described above, or even more severe, has the potential to impact UK's main campus or outlying facilities.

3.11.5 Probability

Sinkhole formation can occur at any time of day, at any time of year. Evidence suggests that sinkholes are more likely to form during or after heavy rainfall, and that they may be more likely to form in May or June. But in general, they can occur anywhere there is karst terrain, at any time.

Predicting the probability of sinkhole formation is difficult based on the available data. Although KGS has a record of 129,301 previous sinkholes occurrences, there is no record of when each sinkhole occurred. On average, 24 sinkholes are reported annually to KGS. However, sinkholes are likely underreported. A KGS study published in 2018 estimates that 5,000 sinkholes occur statewide annually. Lexington-Fayette Urban County Government estimates one-to-two sinkholes occur in the county annually. In general, sinkholes are likely to occur in areas with a moderate or high karst potential, shown in **Figure 3-48**.

Reports published in 2017 and 2018 indicate that periods of drought correlate with increased occurrences of sinkholes.[84] As a result of climate change, Kentucky has experienced increased drought occurrences in recent history and this trend is expected to continue[85]. Furthermore, climate change is expected to increase extreme rainfall events, which have also been associated with increased sinkhole events. Although more research is needed to further define the relationship between climate change and sinkhole occurrences, preliminary research indicates that it will increase the number of events occurring annually.

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[84] Meng, Y. & Jis, L. (2018). Global warming causes sinkhole collapse – Case study in Florida, USA. Retrieved on February 28, 2023 from NHESSD - Global warming causes sinkhole collapse – Case study in Florida, USA (copernicus.org)

[85] Kratzenberg, J., & *, N. (2019). Drought declarations issued throughout Kentucky. Retrieved February 24, 2020 from Drought declarations issued throughout Kentucky (lanereport.com)

Given historic sinkhole occurrences, the prevalence of karst topography, and projected future conditions that may influence sinkhole formation, the probability assigned to the karst and sinkhole hazard for UK is likely (10 to 90 percent annual chance).

3.11.6 Vulnerability Assessment

Although karst hazards typically cause less damage than earthquakes or landslides, they can still have devastating effects on properties, infrastructures, and people. Karst hazards that could have an impact on university staff, students, and infrastructure include sinkholes, flooding, groundwater and surface-water contamination, and high levels of radon; with sinkholes being the most frequently encountered of these. A 2018 study estimated that the average cost of repairs caused by a cover-collapse sinkhole in Kentucky typically cost over $6,000 per event[86]. Sinkhole damage greatly depends on the location of the event; some sinkholes can just be left alone and roped off, resulting in little to no losses. According to the KGS, karst hazards produce between $500,000 to $2 million worth of damage statewide annually. The LFUCG estimates they spend at least $15,000 annually on karst hazards[87].

KGS provides geospatial data that indicates areas of moderate and high karst potential statewide. A GIS-based hazard exposure analysis was conducted to identify university facilities that are within karst hazard areas. All university property, buildings (including critical facilities), infrastructure, and populations located within moderate and high karst potential areas are considered at risk to karst hazards. **Figure 356**: shows statewide karst potential and proximity to UK's campuses. Campuses that are known to be developed on karst terrain include:

- Main campus
- College of Medicine's Bowling Green, Edgewood, and Highland Heights campuses
- Lake Cumberland 4-H Camp (Nancy, KY)
- North Farm campus
- Princeton campus – Research and Education Center
- South Farm campus
- Versailles campus – C. Oran Little Research Center

[86] Currens, James C. (2018). Characteristics of Cover-Collapse Sinkholes in Kentucky. Kentucky Geological Survey Report of Investigations. 39. https://uknowledge.uky.edu/kgs_ri/39
[87] Lexington-Fayette County Government. (2020). Hazard Mitigation Plan: 2020 Update. Division of Emergency Management. Retrieved on February 27, 2023 from LFUCG-Hazard-Mitigation-Plan-Approved-FEMA.pdf (bereadylexington.com)

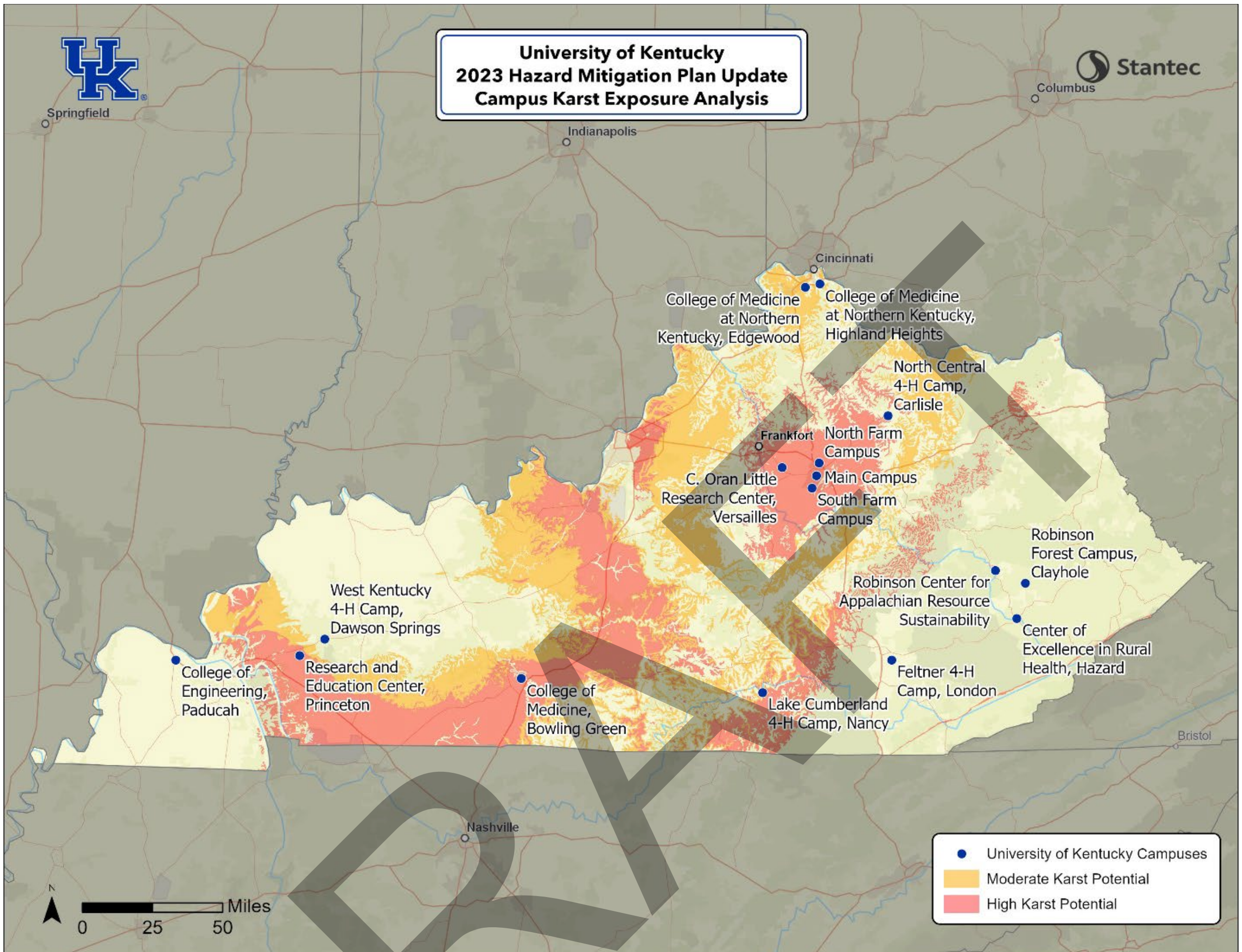

Figure 3-55: Statewide Karst Potential and UK's Campuses

Table 3-36 provides a summary of all the buildings located within karst potential areas. Karst risk for individual buildings can be found in **Appendix B.**

Table 3-35: Summary of Buildings At-Risk to Karst Hazards

Campus	Number of Impacted Buildings	Number of Buildings in Moderate Karst Potential Area	Number of Buildings in High Karst Potential Area	Number of Owned Impacted Buildings	Total of Structure Values*	Total of Content Values*	Total Research Expenditure Estimate
Main Campus (Includes Affiliated Buildings within LFUC)	426	0	426	385	$5,983,024,700	$626,290,300	$308,199,700
Bowling Green Campus	1	0	1	0	$0	$3,843,000	$0
College of Medicine Edgewood Campus	1	1	0	0	$0	$458,000	$0
College of Medicine Highland Heights Campus	1	1	0	0	$0	$3,843,000	$0
Lake Cumberland 4-H Camp	38	31	7	38	$13,731,500	$25,400	$0
North Farm Campus	204	0	204	182	$286,091,900	$25,740,700	$39,733,600
Princeton Campus	22	0	22	22	$1,513,700	$46,600	$31,600
South Farm Campus	20	0	20	20	$3,032,100	$317,800	$67,200
Versailles Campus	50	0	50	50	$27,503,200	$3,295,000	$681,200
Total	**763**	**33**	**730**	**697**	**$6,314,897,100**	**$663,859,800**	**$348,713,300**

*Totals were rounded to the nearest hundred-dollar value

The results of the exposure analysis are shown below in **Figure 3-57**: **– Figure 3-63**. These figures show where there were campus facilities in a high karst potential area. Nearly all of Fayette and Woodford Counties are high karst potential areas. As a result, the entirety of the main campus, North Farm Campus, South Farm Campus, and the C. Oran Little Research Center (Versailles Campus) are considered at high risk for karst hazards.

A number of UK's campuses and 4-H camps are located in high or moderate karst potential areas. The College of Medicine's Bowling Green campus, an affiliated property (not owned), is in an area of high karst potential and, as mentioned in the *Extent* section of this hazard profile, is in an area known for sinkholes causing significant damage to infrastructure and buildings. Additionally, the College of Medicine's Edgewood and Highland Heights campuses, also affiliated properties, are in an area of moderate karst potential.

The Lake Cumberland 4-H Camp (Nancy, KY) is located on both high and moderate karst potential areas. And lastly, I's Research and Education Center (Princeton, KY), a UK-owned property, is located in a high karst potential area.

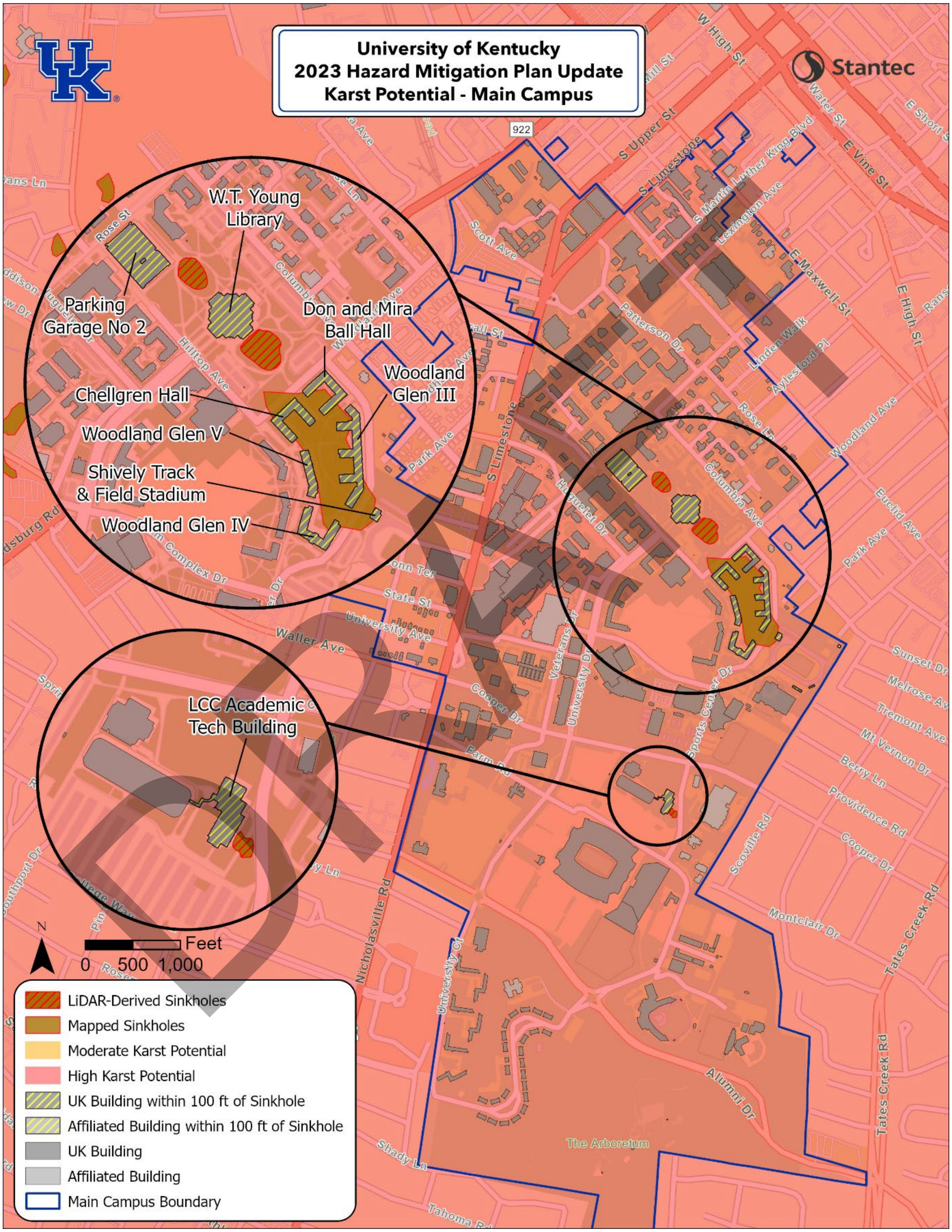

Figure 3-56: Karst Vulnerability - Main Campus

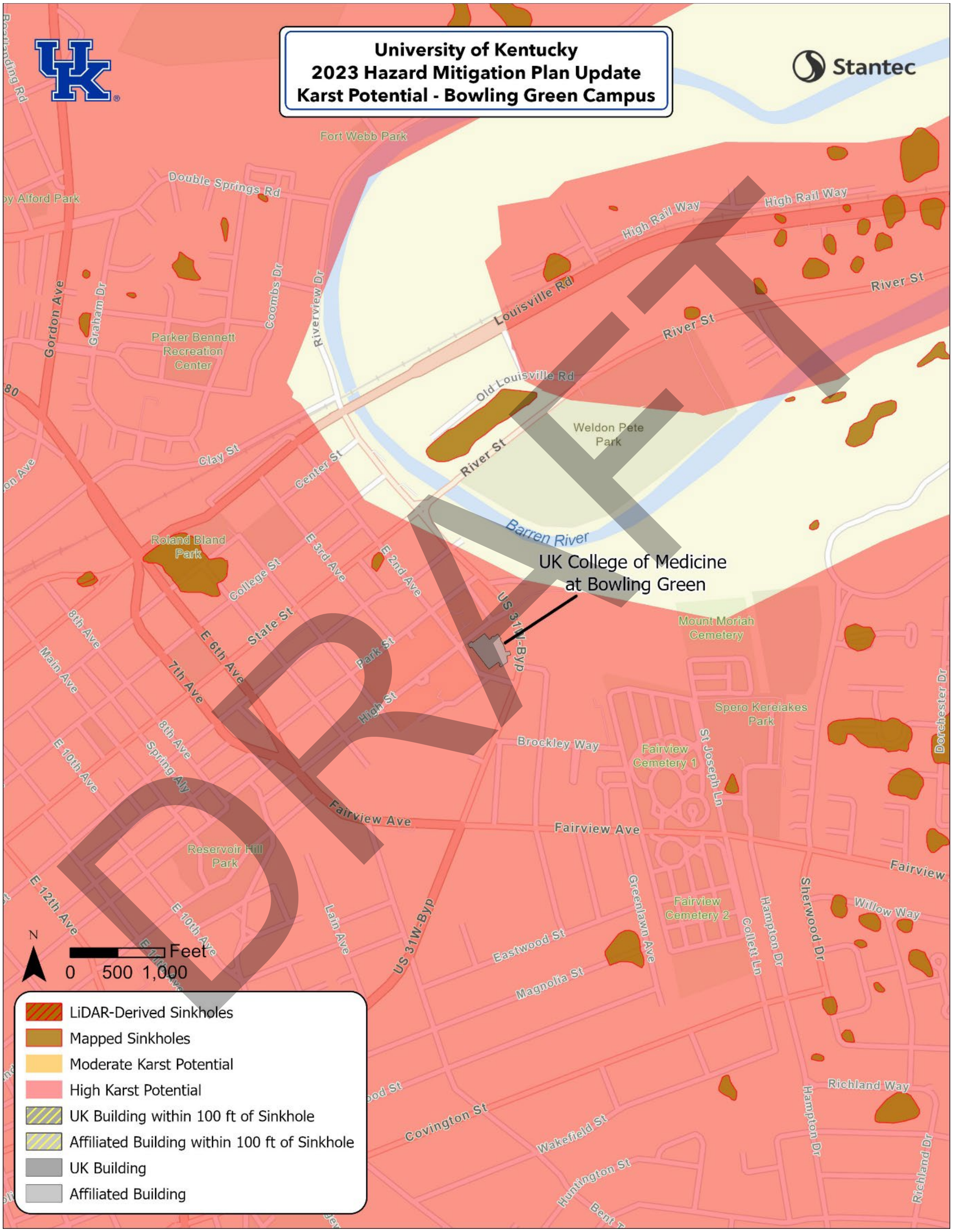

Figure 3-57: Karst Vulnerability - Bowling Green Campus

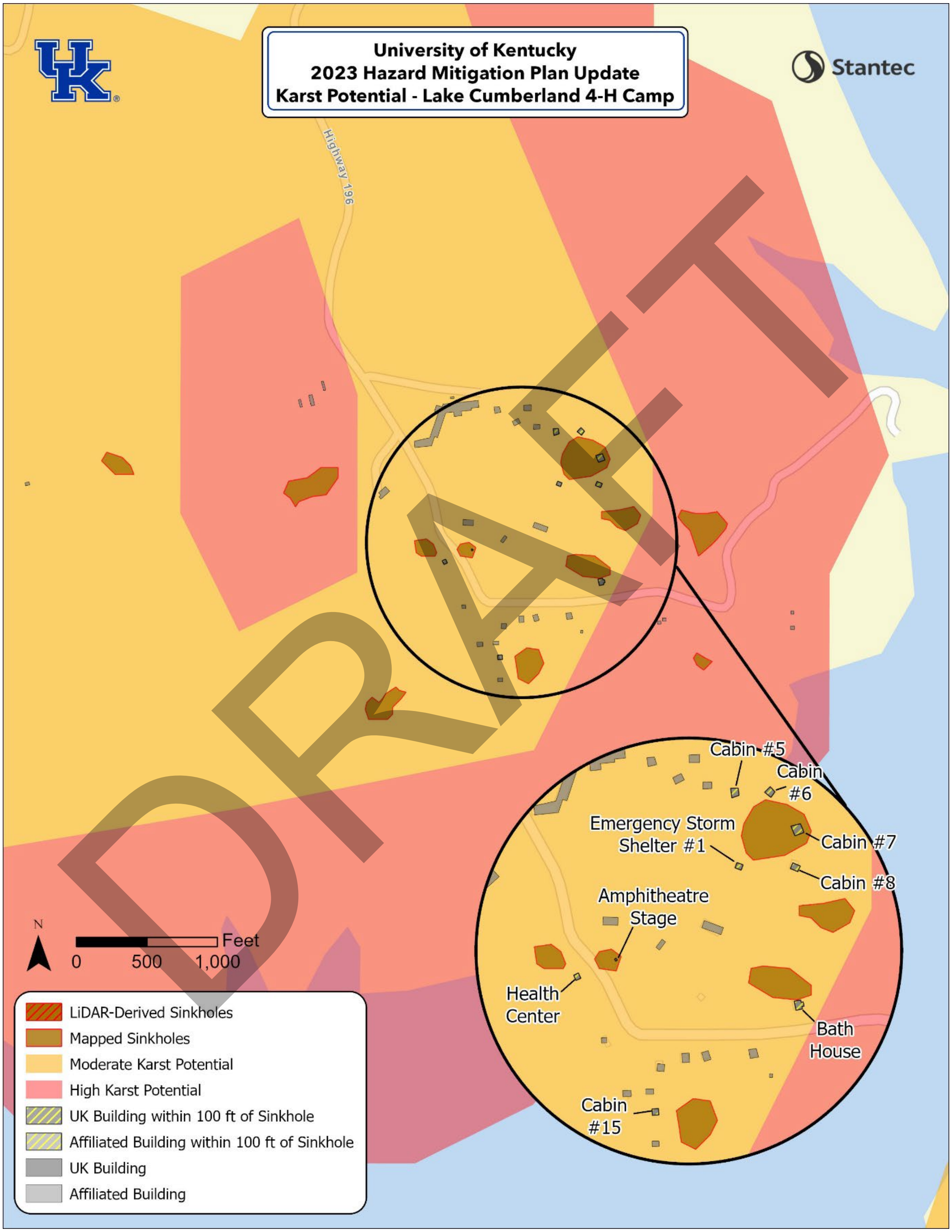

Figure 3-58: Karst Vulnerability - Lake Cumberland 4-H Camp

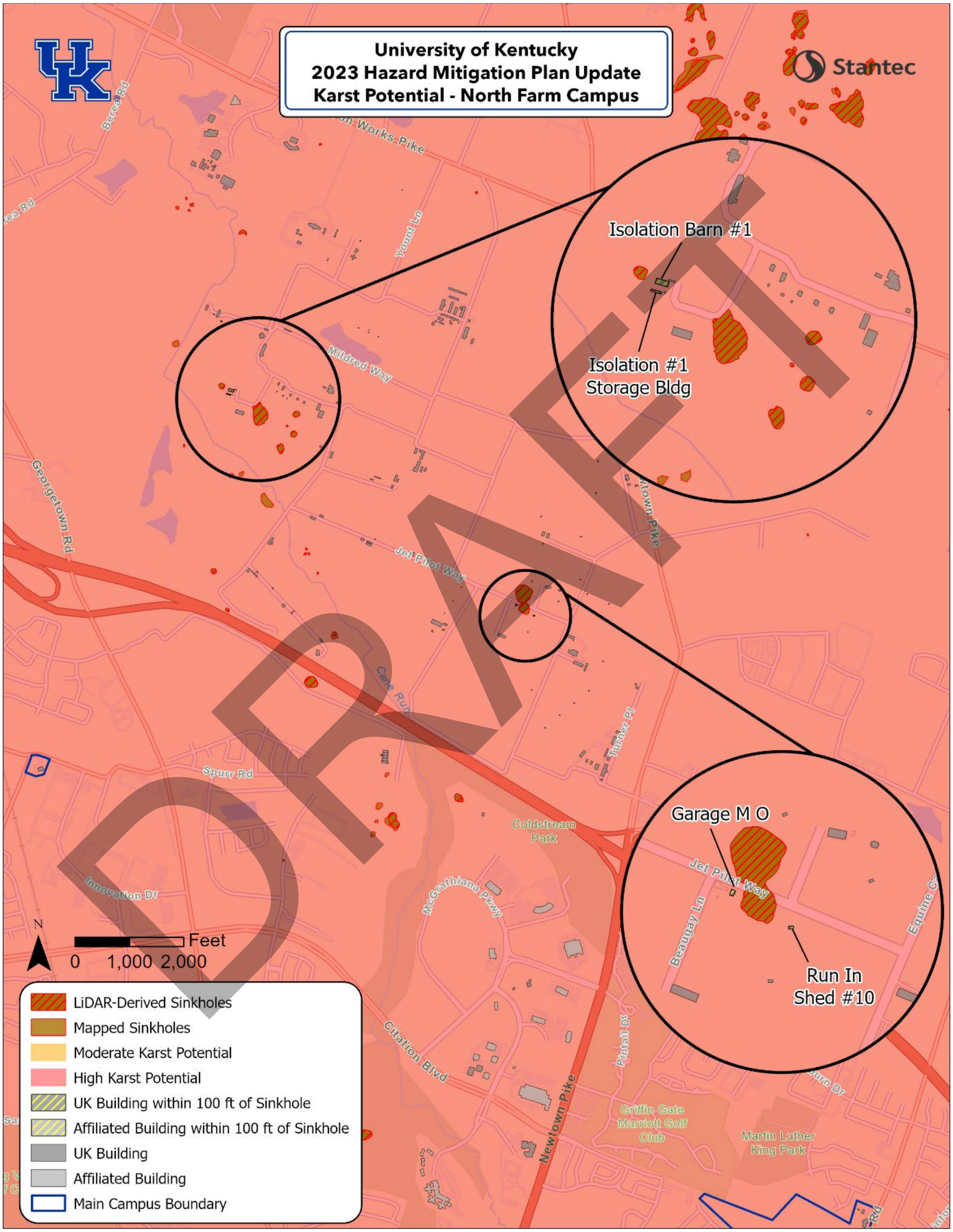

Figure 3-59: Karst Vulnerability - North Farm Campus

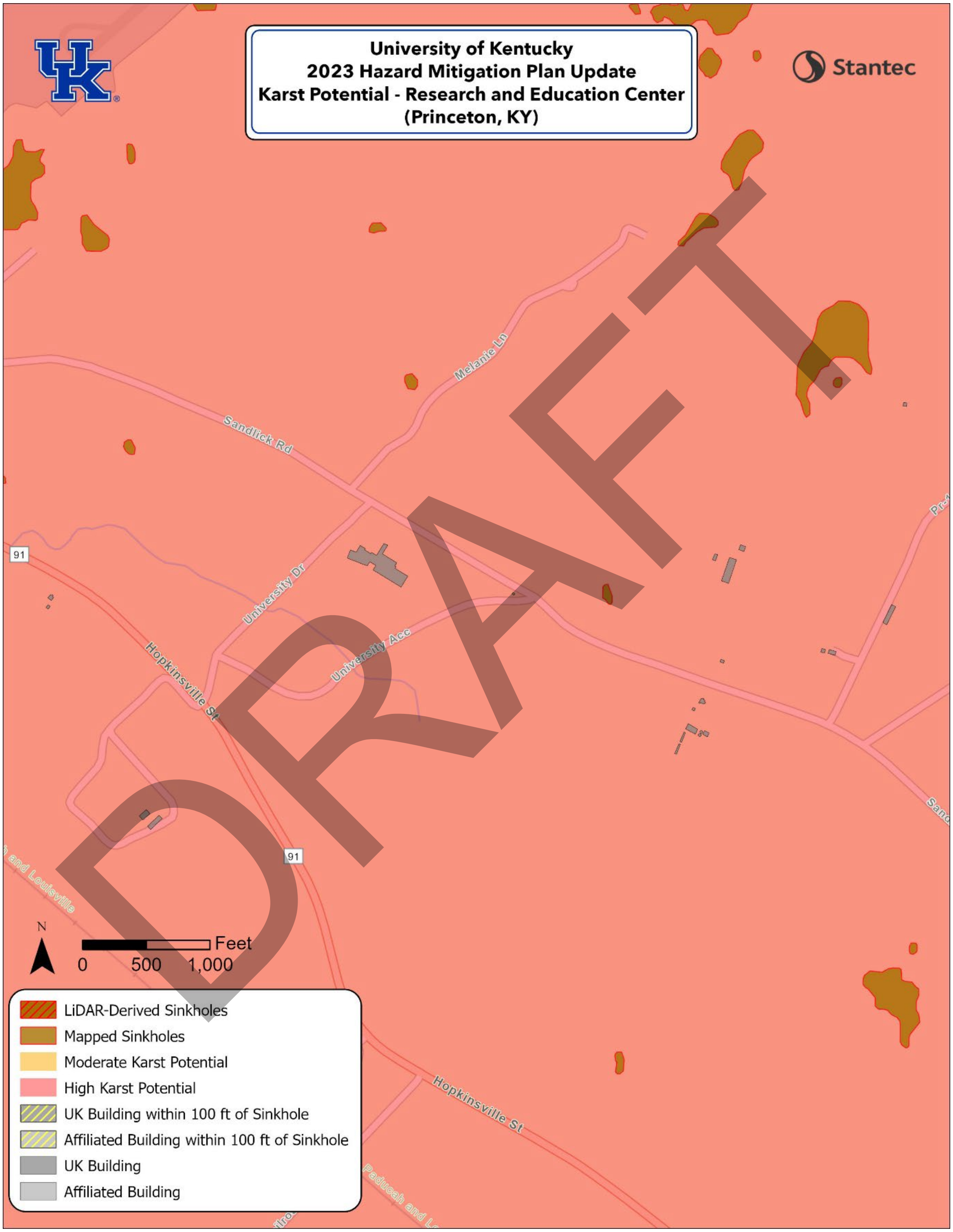

Figure 3-60: Karst Vulnerability - Research and Education Center (Princeton, KY)

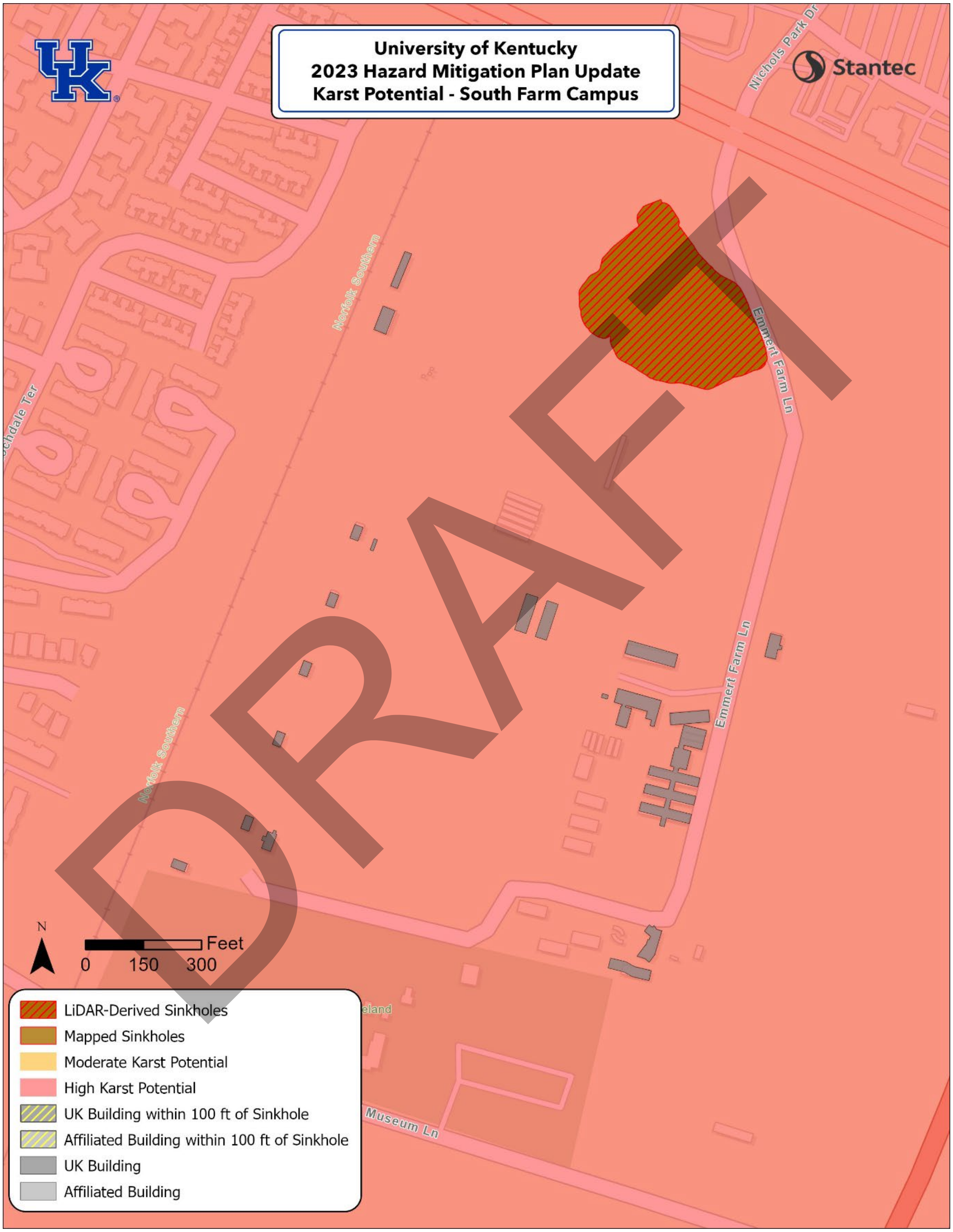

Figure 3-61: Karst Vulnerability - South Farm Campus

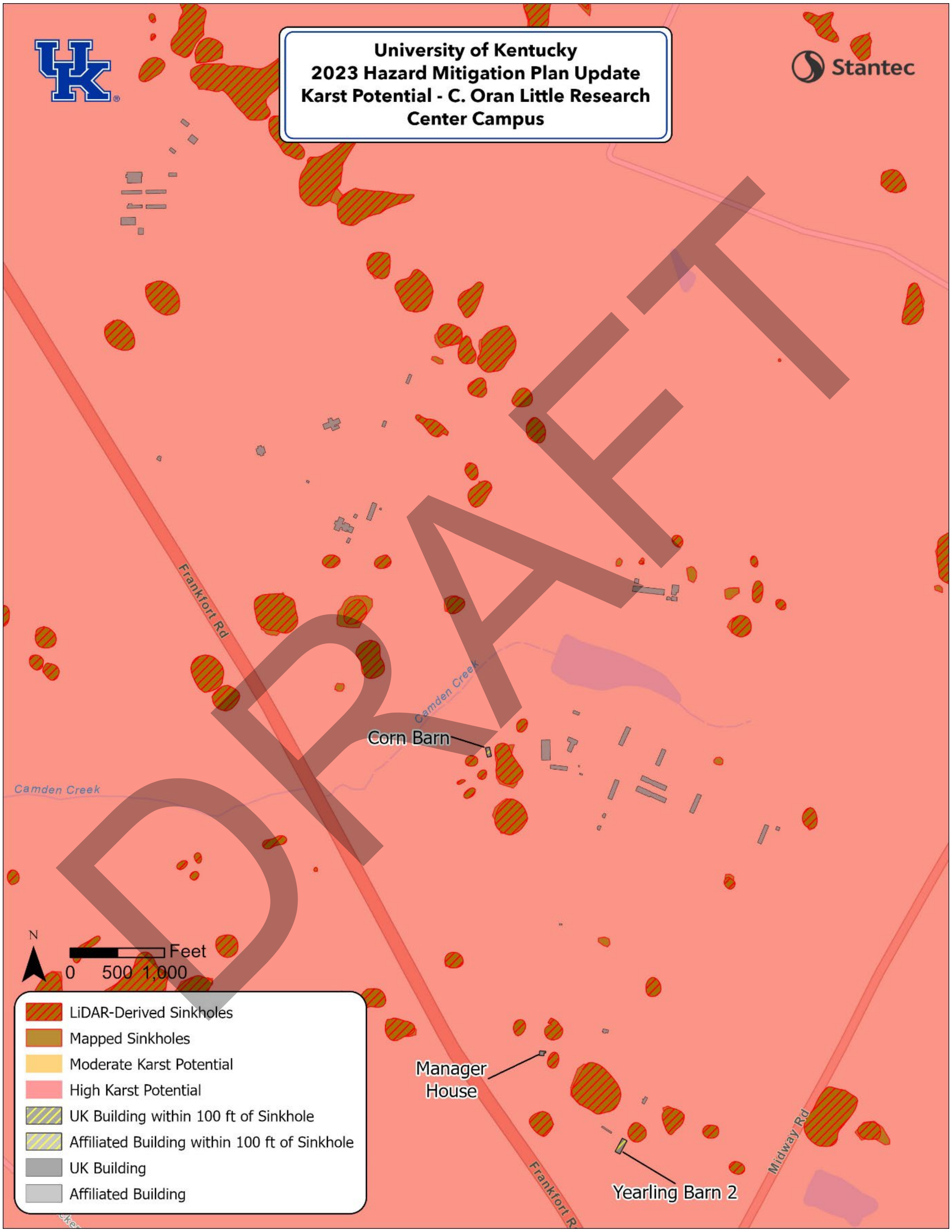

Figure 3-62: Karst Vulnerability - C. Oran Little Center (Versailles, KY)

3.12 Landslide

3.12.1 Description

A landslide is a general term for any downslope movement of rock, soil, and other debris under the influence of gravity. There are a variety of names and classifications used to identify landslides. Other terms used to identify landslides include mass movement, slope failure, and debris or mud flow. Although gravity is the driving force behind all landslides, there are a number of other contributing factors that can lead to a landslide occurring, such as vegetation, soil type, and soil saturation. There are several different types of landslides, determined by the rate of movement, the style of movement, the type of hillslope material involved, and resulting landform or deposit. The type of landslide that occurs is influenced by the rock and soil type, slope location, and the steepness of the slope. **Figure 3-64** illustrates four landslide types that are common in Kentucky, including creep landslides, translational landslides, rotational landslides, and debris flows[88]. These landslide types are further described below.

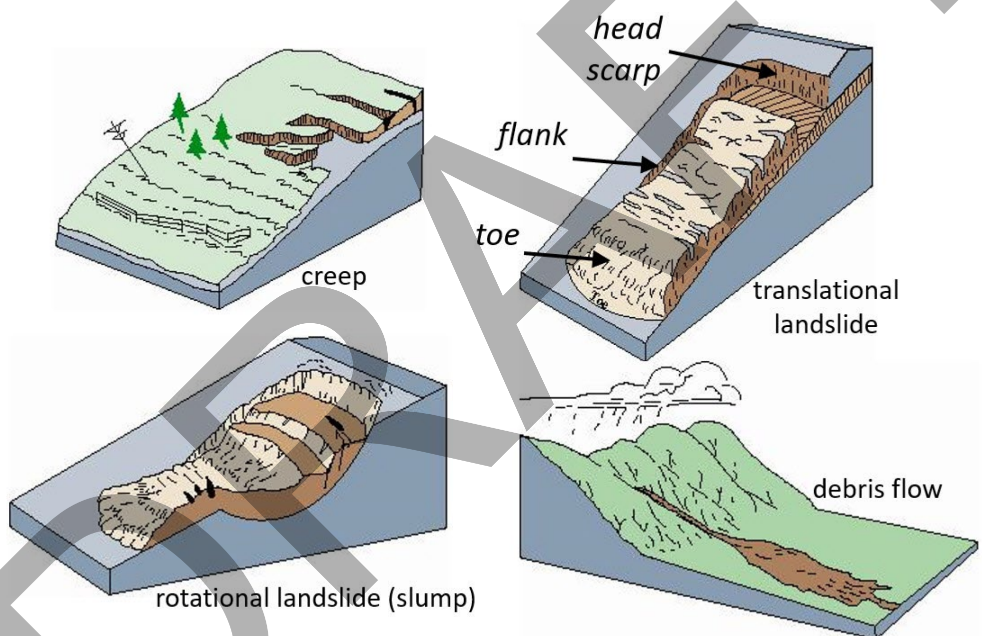

Figure 3-63: Landslides Commonly Occurring in Kentucky

A creep is the informal name for a slow, nearly imperceptible, landslide (sometimes referred to as an earthflow) where the terrain shifts downward in a more uniform fashion than other landslide types. These shifts often move at a rate of less than a foot per decade and can be hard to detect. Creep can be caused by seasonal changes in soil moisture and temperature, natural erosion processes, or human induced triggers such as leaking pipes or construction. Creep is likely the most common type of landslide and can lead to a more abrupt and catastrophic landslide event if it creates increased load on a slope that is further downhill.

[88] Kentucky Geological Survey. (n.d.) Landslide Information Map. Retrieved on March 8, 2023 from Landslide Information help file (uky.edu)

Unlike creep landslides, translational and rotational landslides are more aligned with what people normally think of when thinking of a landslide (i.e., a sudden failure where a large amount of earthen material detaches from a slope). Both types of landslides are typically caused by intense rainfall but can be triggered by earthquakes or man-made changes to the natural topography. Translational landslides tend to be more shallow than rotational landslides, with a general direction of travelling directly down the slope in an elongated shape. These commonly occur along geologic discontinuities such as faults, joints, bedding surfaces, or the contact between rock and soil. **Figure 3-65** shows an example of a translational landslide that occurred in northern Kentucky[89].

Figure 3-64: Translational Landslide in Carroll County, KY (2014)

On the contrary, rotational landslides commonly occur in homogeneous geological materials, and form more of a spoon-shaped disturbance. Rather than sliding directly down the slope, the ground gives way at a greater depth, creating a rotational effect within the slope of the hillside. **Figure 3-66** illustrates the difference in the shape of the two landslides; however, the two types of landslides can look very similar in the natural world[90].

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[89] Matt Crawford. (2015). The Kentucky Geological Survey Landslide Program: An Overview (2015 Geohazards in Transportation). Kentucky Geological Survey. Retrieved March 9, 2023 from 3_Crawford_Geohazards2015.pdf (marshall.edu)
[90] Squamish-Lillooet Regional District. (n.d.) Landslide Hazards. Public Safety Canada. Retrieved March 9, 2023 from Landslides.pdf (slrd.bc.ca)

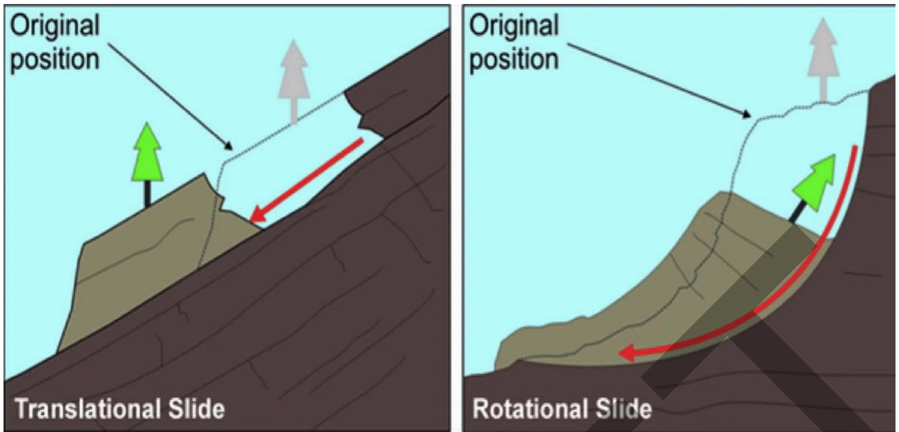

Figure 3-65: Translational Landslide vs. Rotational Landslide

A debris flow, sometimes referred to as a mudflow or "mudslide" (mudslide is an informal term), is a fast-moving, mass movement of loose soil, rock, and other debris that form a slurry that flows in an almost water-like manner downhill. The slurry can be thin and watery or thick and full of debris such as rocks, trees, or cars. A mudflow typically refers to a debris flow made up of fine-grained sediments and a high degree of fluidity (up to 60 percent water)[91]. Debris flows are typically caused by heavy rainfall or rapid snowmelt and can be triggered after only a few minutes of intense rain. Because of their highly fluid nature, debris flows can travel very quickly, up to 35 miles per hour[92].

In addition to the types of landslides described above, rockfalls are also common in Kentucky. These are characterized by an abrupt, downward movement of soil and rock that has detached from a steep or vertical slope. The falling material may break on impact or continue to bounce and/or roll down the slope, potentially knocking more material loose. These are common on very steep banks of rivers and streams or where roads cut through steep, rocky terrain. Large rocks or boulders can bounce or roll a considerable distance, potentially damaging structures or vehicles on roadways, causing injuries or fatalities. **Figure 3-67** shows a rockfall that occurred in eastern Kentucky[93].

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[91] FEMA. (n.d.) Landslide: What. U.S. Geological Survey. Retrieved on March 8, 2023 from Landslide | What (fema.gov)
[92] Highland, L.M., and Bobrowsky, Peter. (2008). The landslide handbook—A guide to understanding landslides: Reston, Virginia, U.S. Geological Survey Circular 1325, 129 p. Retrieved from USGS Circular 1325: The Landslide Handbook—A Guide to Understanding Landslides
[93] Matt Crawford. (2015). The Kentucky Geological Survey Landslide Program: An Overview (2015 Geohazards in Transportation). Kentucky Geological Survey. Retrieved March 9, 2023 from 3_Crawford_Geohazards2015.pdf (marshall.edu)

Figure 3-66: Rockfall in Breathitt County, KY (2015)

Common stresses that increase the likelihood of a landslide are erosion, earthquake shaking, excess weight from precipitation, and slope modification. Erosion from a river or stream can cut into the side of a bank and eliminate support for a hillside. Slope modification, either loading or excavating, is a human induced stress that can increase the likelihood of a landslide. Other human activities that can trigger landslides include vegetation removal, leaking pipes, or mining. Intense or long-duration rainfall is known to increase the likelihood of landslide occurrence, especially during winter and early spring months when there are no leaves on the trees. The likelihood or intensity of a landslide can be increased in areas where logging operations or a wildfire have removed large amounts of vegetation.

In general, more landslides occur in late winter and early spring when the ground is typically more saturated. Furthermore, landslide occurrences increase during years when the commonwealth receives more rainfall.

3.12.2 Location

Landslides pose a hazard in nearly every mountainous region, and landslides occur in all areas of Kentucky, including those where UK campuses and facilities are located. The USGS has developed a geospatial layer depicting landslide susceptibility at a national level. A map showing this layer paired with the location of UK's campuses is shown in **Figure 3-68**[94]**.**

[94] USGS Professional Paper 1183.

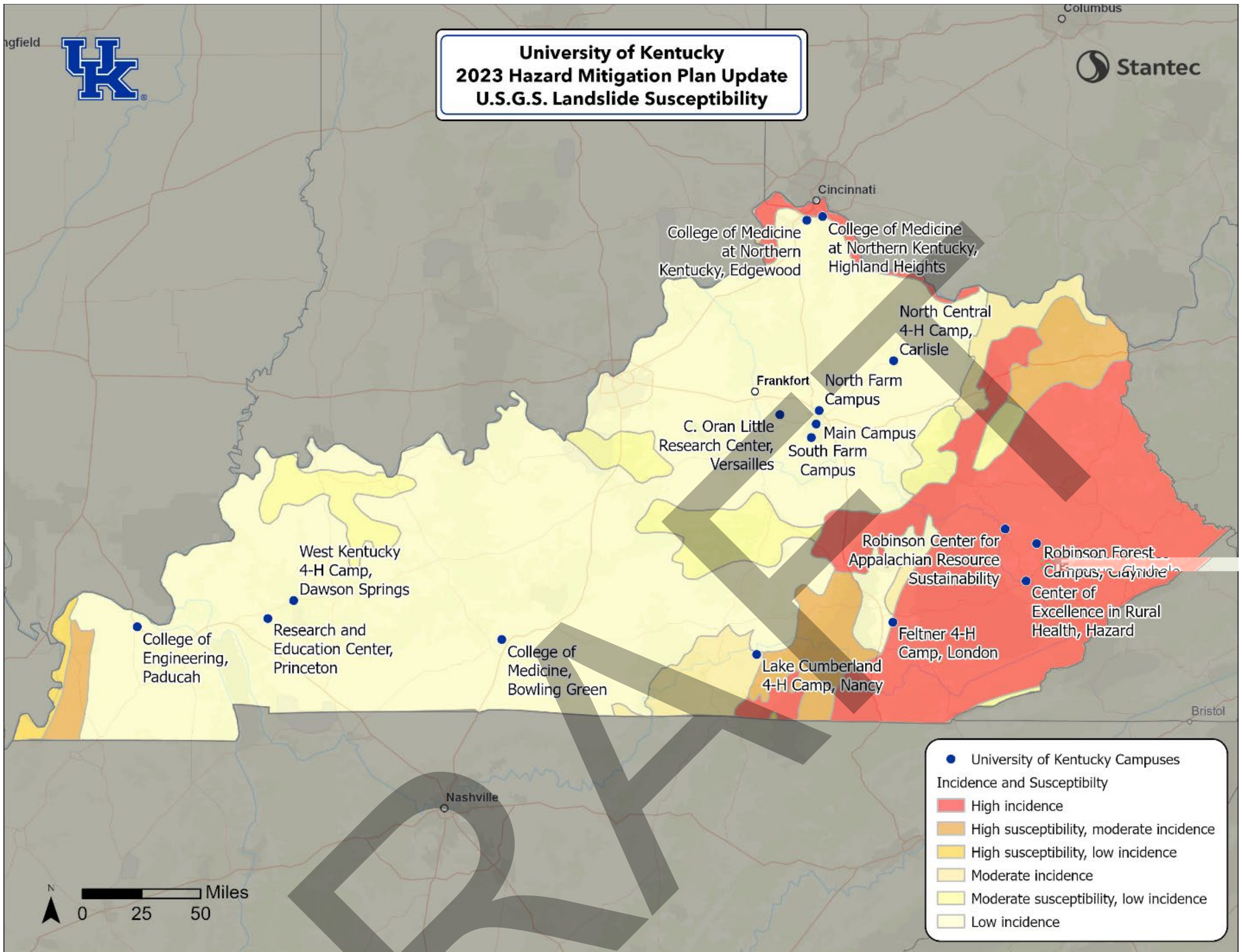


Figure 3-67: USGS Landslide Incidence and Susceptibility in Kentucky

Although landslides have occurred in all regions of the state, facilities within either the identified high incidence or high susceptibility/moderate incidence areas are most likely to be impacted by a landslide. The UK facilities that are located in these areas are: the Center of Excellence in Rural Health (Hazard Campus), the College of Medicine at Northern Kentucky, Highland Heights, the J.M. Feltner 4-H Camp (London, KY), the Robinson Center for Appalachian Resource Sustainability (RCARS), and the Robinson Forest Campus (Clayhole, KY).

3.12.3 Previous Occurrences

Landslides are a common occurrence in Kentucky, especially in eastern Kentucky. Landslide occurrences and impacts are recorded with varying levels of detail and may be compiled differently by local and state agencies. KGS, headquartered on UK's main campus, has produced a statewide landslide inventory that provides a record of previous events from a variety of sources. The landslide locations come from KGS research, state and local government agencies, input from the public, USGS, locations derived from LiDAR, and locations derived from aerial photography. The dataset is very comprehensive and contains over 19,703 landslide locations.

KGS encourages individuals to record landslide incidents by following their "Report a Landslide" procedure[95]. **Table 3-37** provides a count of the total number of landslide incidents in counties which the university has a campus.

Figure 3-69 shows the locations of all the recorded previous occurrences included in KGS's landslide inventory. Based on this dataset, the Robinson Forest Campus (Clayhole, KY) is the only UK campus or camp that has had a landslide occur within 500 feet of a building. This event, which was noted in previous iterations of UK's hazard mitigation plan, occurred on May 8-9, 2010, at the Robinson Forest Campus. The landslide occurred behind a building, with the debris flow traveling downhill and reaching the building, causing $11,503 worth of damage.

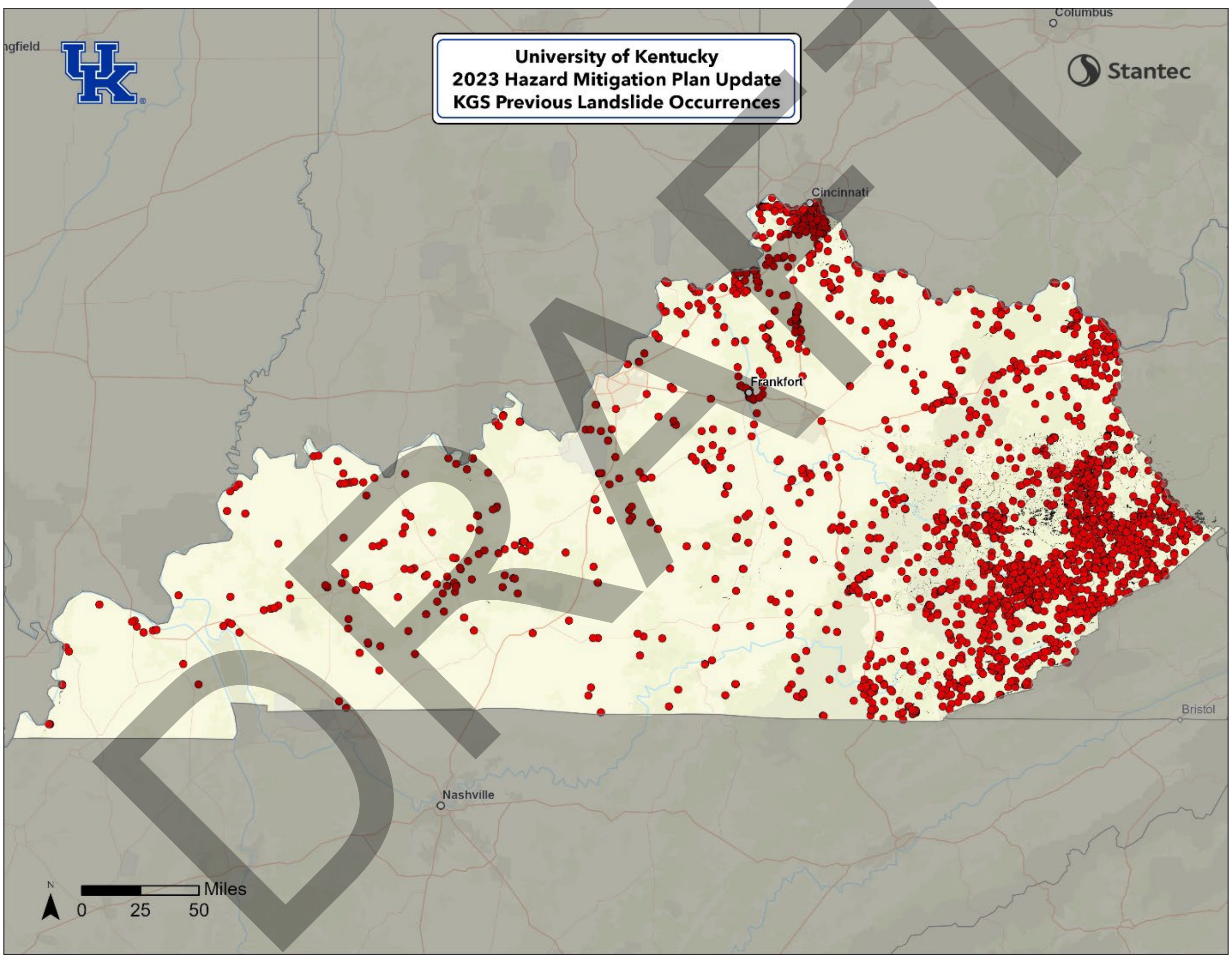


Figure 3-68: Locations for Previous Landslide Events

[95] KGS. Landslide. Retrieved from Landslide, Kentucky Geological Survey, University of Kentucky (uky.edu).

Table 3-36: Total Landslide Incidents per County for Counties that Contain a UK Campus

County Name	Campus(es) Located within the County	Total Landslide Count
Breathitt	RCARS and Robinson Forest Campus	2,273
Perry	Hazard Campus	1,244
Campbell	College of Medicine at Northern Kentucky, Highland Heights	178
Kenton	College of Medicine at Northern Kentucky, Edgewood	175
Laurel	Feltner 4-H Camp	90
Caldwell	Research and Education Center	9
Hopkins	West Kentucky 4-H Camp	8
Warren	College of Medicine, Bowling Green	8
McCracken	College of Engineering, Paducah	7
Nicholas	North Central 4-H Camp	7
Fayette	Main Campus, North Farm Campus, and South Farm Campus	2
Wayne	Lake Cumberland 4-H Camp	2
Woodford	C. Oran Little Research Center	1

Federal disaster declarations can also be a good indication of major events in which landslides were a contributing factor. Disaster declarations are made at the county level; therefore, declarations that specifically impacted UK campuses are not available. 22 major disaster declarations in which landslides were a contributing factor have been declared in counties where UK has facilities. **Table 3-38** below outlines the previous federal disaster declarations.

Table 3-37: Federal Disaster Declarations in which Landslides were a Contributing Factor

FEMA Declaration ID	Declaration Date	Impacted Counties with UK Facilities	UK Facilities in Impacted Counties
DR-846-KY	10/30/1989	Perry	Hazard Campus
DR-1454-KY	3/14/2003	Breathitt, Fayette, Nicholas, Perry, Woodford	RCARS and Robinson Forest Campus; Main Campus, North Farm Campus, and South Farm Campus; North Central 4-H Camp; Hazard Campus; C. Oran Little Research Center
DR-1471-KY	6/3/2003	Breathitt, Nicholas, Caldwell, Woodford, Hopkins, Perry	RCARS and Robinson Forest Campus; North Central 4-H Camp; Research and Education Center; C. Oran Little Research Center; West Kentucky 4-H Camp; Hazard Campus
DR-1475-KY	7/2/2003	Breathitt, Perry	RCARS and Robinson Forest Campus; Hazard Campus

FEMA Declaration ID	Declaration Date	Impacted Counties with UK Facilities	UK Facilities in Impacted Counties
DR-1523-KY	6/10/2004	Breathitt, Caldwell, Fayette, Hopkins, Laurel, Nicholas, Perry, Woodford	RCARS and Robinson Forest Campus; Research and Education Center; Main Campus, North Farm Campus, and South Farm Campus; West Kentucky 4-H Camp; Feltner 4-H Camp; North Central 4-H Camp; Hazard Campus; C. Oran Little Research Center
DR-1703-KY	05/25/2007	Perry	Hazard Campus
DR-1757-KY	05/19/2008	Hopkins, Nicholas, Woodford	West Kentucky 4-H Camp; North Central 4-H Camp; C. Oran Little Research Center
DR-1841-KY	05/29/2009	Breathitt, Perry	RCARS and Robinson Forest Campus; Hazard Campus
DR-1912-KY	5/11/2010	Fayette, Nicholas, Hopkins, Warren, Wayne, Woodford	Main Campus, North Farm Campus, and South Farm Campus; West Kentucky 4-H Camp; North Central 4-H Camp; College of Medicine, Bowling Green; Lake Cumberland 4-H Camp; C. Oran Little Research Center
DR-4216-KY	04/30/2015	Caldwell, McCracken, Perry, Wayne, Woodford	Research and Education Center; College of Engineering, Paducah; Hazard Campus; Lake Cumberland 4-H Camp; C. Oran Little Research Center
DR-4217-KY	05/01/2015	Breathitt, Nicholas, Perry, Woodford	RCARS and Robinson Forest Campus; North Central 4-H Camp; Hazard Campus; C. Oran Little Research Center
DR-4218-KY	05/12/2015	Breathitt, Nicholas	RCARS and Robinson Forest Campus; North Central 4-H Camp
DR-4239-KY	08/12/2015	Breathitt, Nicholas, Perry	RCARS and Robinson Forest Campus; North Central 4-H Camp; Hazard Campus
DR-4278-KY	08/26/2016	Caldwell, Hopkins	Research and Education Center; West Kentucky 4-H Camp
DR-4358-KY	04/12/2018	Breathitt, Perry	RCARS and Robinson Forest Campus; Hazard Campus
DR-4361-KY	04/26/2018	Caldwell, Campbell, Kenton, McCracken	Research and Education Center; College of Medicine at Northern Kentucky, Highland Heights; College of Medicine at Northern Kentucky, Edgewood; College of Engineering, Paducah
DR-4428-KY	04/17/2019	Breathitt, Campbell, Laurel, McCracken, Nicholas, Perry, Wayne	RCARS and Robinson Forest Campus; College of Medicine at Northern Kentucky, Highland Heights; Feltner 4-H Camp; College of Engineering, Paducah; North Central 4-H Camp; Hazard Campus; Lake Cumberland 4-H Camp
DR-4540-KY	04/24/2020	McCracken, Perry	College of Engineering, Paducah; Hazard Campus

FEMA Declaration ID	Declaration Date	Impacted Counties with UK Facilities	UK Facilities in Impacted Counties
DR-4592-KY	03/31/2021	Breathitt, Laurel, Nicholas, Perry, Wayne	RCARS and Robinson Forest Campus; Feltner 4-H Camp; North Central 4-H Camp; Hazard Campus; Lake Cumberland 4-H Camp
DR-4595-KY	04/23/2021	Breathitt, Fayette, Laurel, Perry, Warren, Woodford	RCARS and Robinson Forest Campus; Main Campus, North Farm Campus, and South Farm Campus; Feltner 4-H Camp; Hazard Campus; College of Medicine, Bowling Green; C. Oran Little Research Center
DR-4643-KY	02/27/2022	Breathitt	RCARS and Robinson Forest Campus
DR-4663-KY	07/29/2022	Breathitt, Perry	RCARS and Robinson Forest Campus; Hazard Campus

July 2022 Landslides

In late July 2022, record setting rainfall in the eastern part of the state led to catastrophic flooding and triggered over 1,000 landslides in the region. This included landslides in Breathitt and Perry Counties, where three university facilities are located. The Robinson Forest research forest and the Robinson Center for Appalachian Resource Sustainability (RCARS) are located in Breathitt County and the Center of Excellence in Rural Health is located in Perry County. A team of KGS geologists travelled to the area and documented new landslides that were triggered by the extreme rainfall event. They used field inspections and remote sensing to record landslide incidents. Their work focused on areas with road access, so it is likely that even more landslides occurred than were recorded. They found that the majority of the landslides triggered by this rain event were shallow translational landslides, with some instances where rotational landslides and debris flows occurred. **Figure 3-70** shows the locations of the newly documented landslides, mapped over the 4-day precipitation totals from July 26-29, 2022.

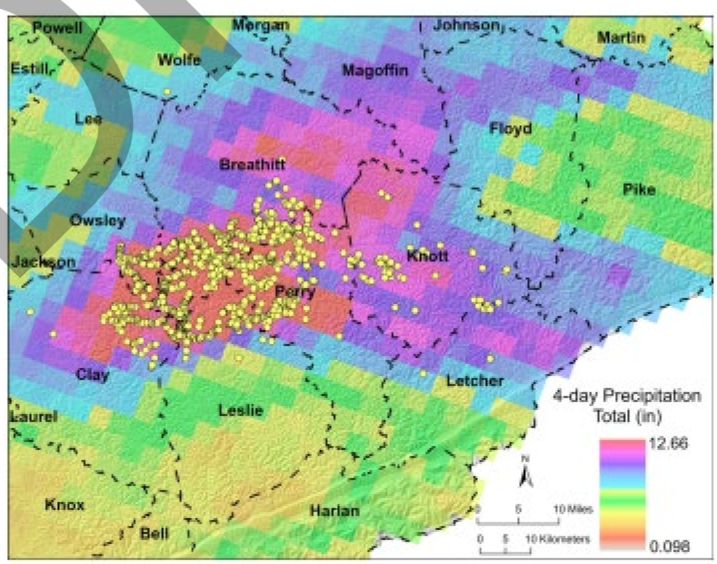


Figure 3-69: Landslides Triggered by Extreme Rainfall that Occurred in July 2022

It is worth noting that all three of the UK facilities mentioned in this area are located in valleys (referring to the buildings located at each facility; Robinson Forest is over 14,000 acres in size). None of the structures at these three locations were damaged as a result of a landslide during this event.

3.12.4 Extent

Individual landslide extent can be measured by the length of the slide, the width and depth of the failure zone, the speed of the landslide, or the amount of earthen material displaced. All of these measurements vary greatly and are situationally dependent. Further, these measurements are not frequently reported. More broadly, landslide extent can be measured by the damage caused by an event.

Landslides across Kentucky cause $10 to $20 million in direct damages annually based on conservative estimates[96]. However, based on damages reported by the Kentucky Transportation Cabinet, this number is likely even higher. The greatest extent landslide to impact a UK facility was the landslide that occurred on May 8-9, 2010, at the Robinson Forest Campus which caused $11,503 worth of damage. More severe landslide events have the potential to impact the university and its facilities, especially as extreme rainfall events increase in the future with climate change.

3.12.5 Probability

Landslides are a regular occurrence in north central and eastern Kentucky and landslides have occurred in almost every county in the state, including those with UK campuses and 4-H camps.

Statewide, there is an average of 95 landslides annually; however, as stated previously, periods with above average precipitation correspond to an increased number of landslides[97]. Kentucky has experienced a 3-12 percent increase in annual precipitation totals (depending on the area of the state) over the last 30 years[98]. This trend is expected to continue, along with increased extreme precipitation events, likely increasing the annual number of landslides in the future. Given limited previous landslide events to impact the university, as well as future conditions conducive to increased landslide activity, the landslide hazard was assigned a possible probability of (1 to 10 percent annual chance) for the university.

3.12.6 Vulnerability Assessment

Because of a lack of development, landslides that occur in rugged mountain country do not always cause damage to the built environment. It is common for losses from landslides and soil creep to occur in cities developed on gently sloping hillsides. Although a landslide may occur almost anywhere, from man-made slopes to natural, pristine ground, most slides often occur in areas that have experienced sliding in the past.

[96] Crawford, M.M. et al. (2023) Reconnaissance of Landslides and Debris Flows Associated with the July 2022 Flooding in Eastern Kentucky. Kentucky Geological Survey, ser. 13, Report of Investigations 13, 14p. Retrieved on February 23, 2023 from "Reconnaissance of Landslides and Debris Flows Associated with the July" by Matt M. Crawford, Zhenming Wang et al. (uky.edu).
[97] Kentucky Emergency Management. (2018). Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan (CK-EHMP 2018). Retrieved on February 23, 2023 from Kentucky Emergency Management.
[98] National Oceanic and Atmospheric Administration (NOAA).(2021). Decadal update from NCEI gives forecasters and public latest averages for 1991–2020. Retrieved on February 23, 2023 from NOAA Delivers New U.S. Climate Normals | News | National Centers for Environmental Information (NCEI)

Landslides are triggered by similar causes. These can be weaknesses in the rock and soil, earthquake activity, the occurrence of heavy rainfall or snowmelt, or construction activity changing some critical aspect of the geological environment. Landslides that occur following periods of heavy rain or rapid snow melt often worsen the accompanying effects of flooding.

A significant portion of the cost incurred from landslides is a result of damage to roads and other infrastructure. Additionally, public and private economic losses from landslides result from indirect cost associated with lost productivity, disruption of utility and transportation systems, reduced property values, and costs for any litigation. These indirect costs are not typically included in damage estimates.

Much of the economic loss is borne by federal, state, and local agencies responsible for disaster assistance, flood insurance, and highway maintenance and repair. Private costs involve mainly damage to land and infrastructure. A severe landslide can result in financial ruin for the property owners because landslide insurance (except for debris flow coverage) or other means of spreading the costs of damage are unavailable.

To assess the university's risk associated with landslides a GIS analysis was performed to find buildings that are located in moderate or high areas of landslide susceptibility. To complete this, an intersection analysis used UK's building footprints layer and the USGS landslide susceptibility layer (**Figure 3-68**). Any building in an area of high susceptibility, regardless of incidence rating, was counted in the High Landslide Susceptibility Area; any building in an area of moderate susceptibility, regardless of incidence rating, was counted in the Moderate Landslide Susceptibility Area. The results of the intersection are shown in **Table 3-39**.

Table 3-38: Landslide Susceptibility Analysis

Campus	Number of Impacted Buildings	Number of Buildings in Moderate Landslide Susceptibility Area	Number of Buildings in High Landslide Susceptibility Area	Number of Owned Impacted Buildings	Total of Structure Values**	Total of Content Values**	Total Research Expenditure Estimate
College of Medicine Ashland Campus*	1	0	1	1	N/A	N/A	N/A
College of Medicine at Northern Kentucky, Highland Heights Campus	1	0	1	0	$0	$3,843,000	$0
Lake Cumberland 4-H Camp	38	38	0	38	$13,731,500	$25,400	$0
Hazard Campus	1	0	1	1	$14,292,700	$805,500	$0
J.M. Feltner 4-H Camp	43	0	43	43	$5,414,100	$140,000	$0
Robinson Center for Appalachian Resource Sustainability (RCARS)	19	0	19	19	$10,836,000	$546,900	$0
Robinson Forest - Clayhole Campus	15	0	15	15	$2,847,900	$340,200	$0
Total	118	38	80	117	$47,122,200	$5,701,000	$0

*The College of Medicine Ashland Campus (King's Daughters facility) was purchased during the writing of this plan; therefore, a structure value, content value, and research expenditure estimate were not available.**Totals were rounded to the nearest hundred-dollar value.

Of the 940 building footprints spread across UK's various campuses, about 12 percent fall into a moderate or high susceptibility area (4 percent in a moderate susceptibility area, 8 percent in a high susceptibility area). The campuses that are impacted are located in the south-central, eastern, and extreme northern areas of the Commonwealth. All of the structures at the Lake Cumberland 4-H Camp, located in Nancy, KY, are located in a moderate landslide susceptibility area, shown in **Figure 3-71**. All of the structures at the College of Medicine's King's Daughters facility (Ashland, KY), the College of Medicine's Center of Excellence in Rural Health (Hazard, KY), J.M. Feltner 4-H Camp (London, KY), the Robinson Center of Appalachian Resource Sustainability (RCARS, Quicksand, KY), and the Robinson Forest campus (Clayhole, KY) are located in high landslide susceptibility areas. These are shown in **Figure 3-72** – **Figure 3-76**.

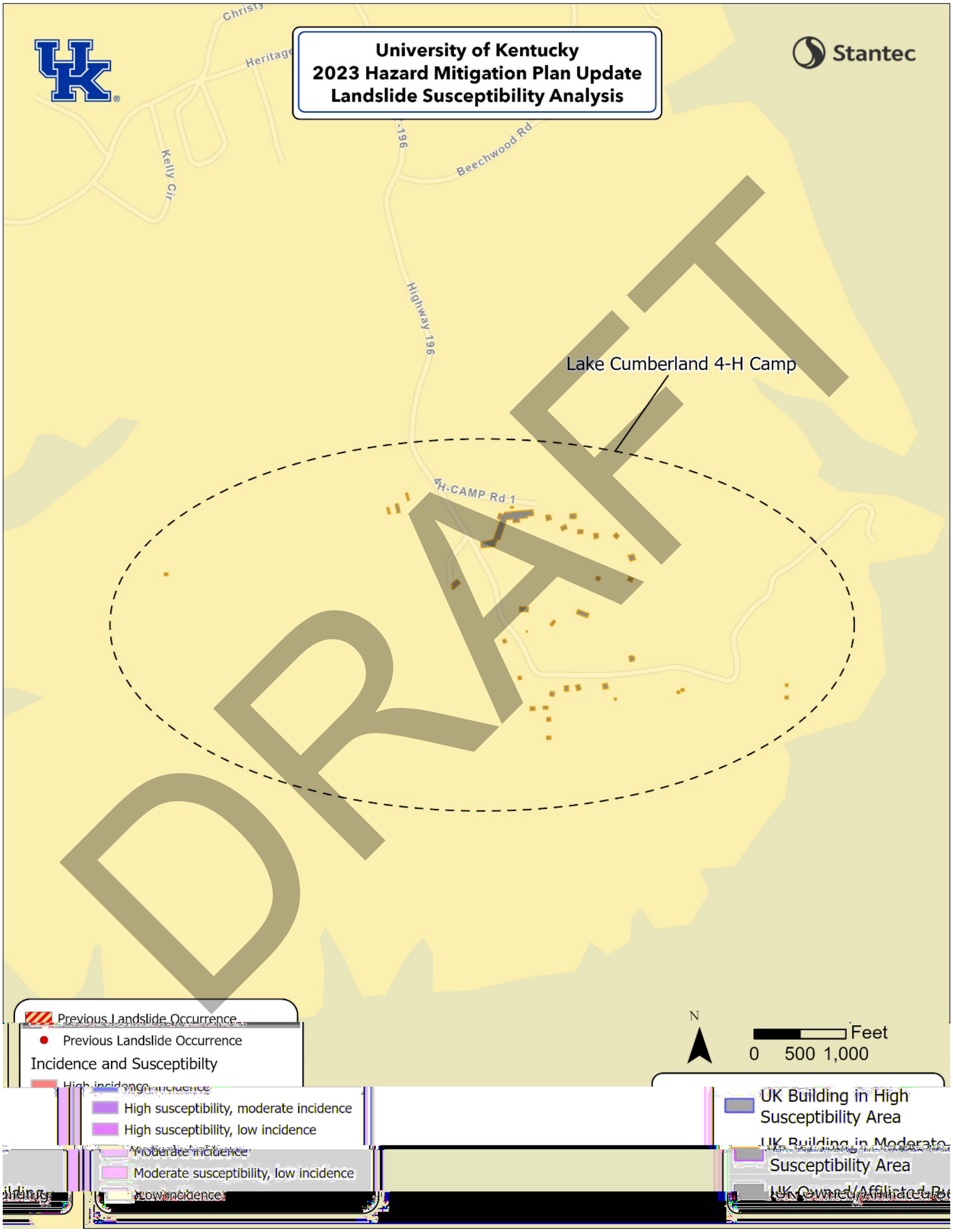


Figure 3-70: Landslide Susceptibility Analysis Results at Lake Cumberland 4-H Camp (Nancy, KY)

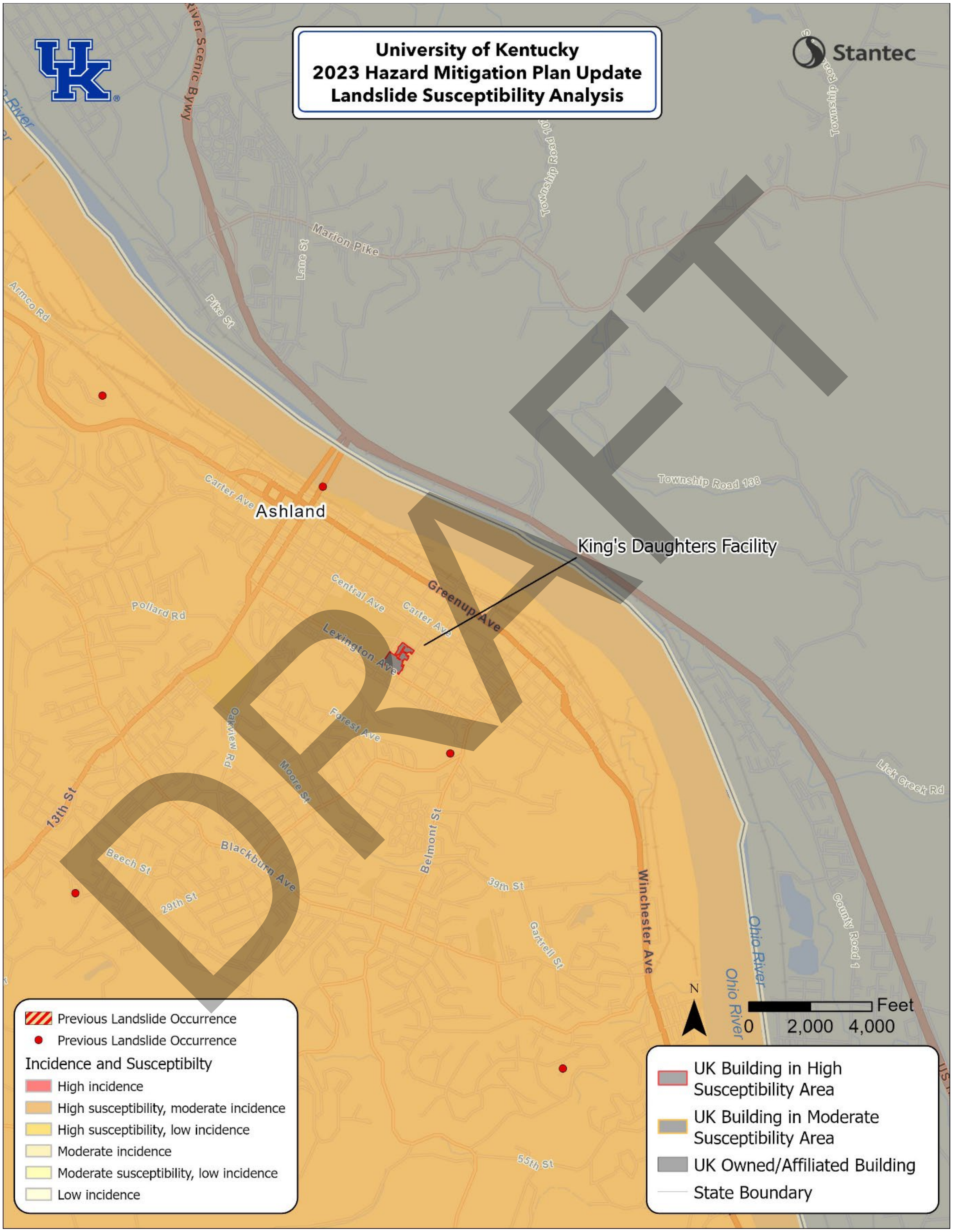


Figure 3-71: Landslide Susceptibility Analysis Results in Ashland, KY

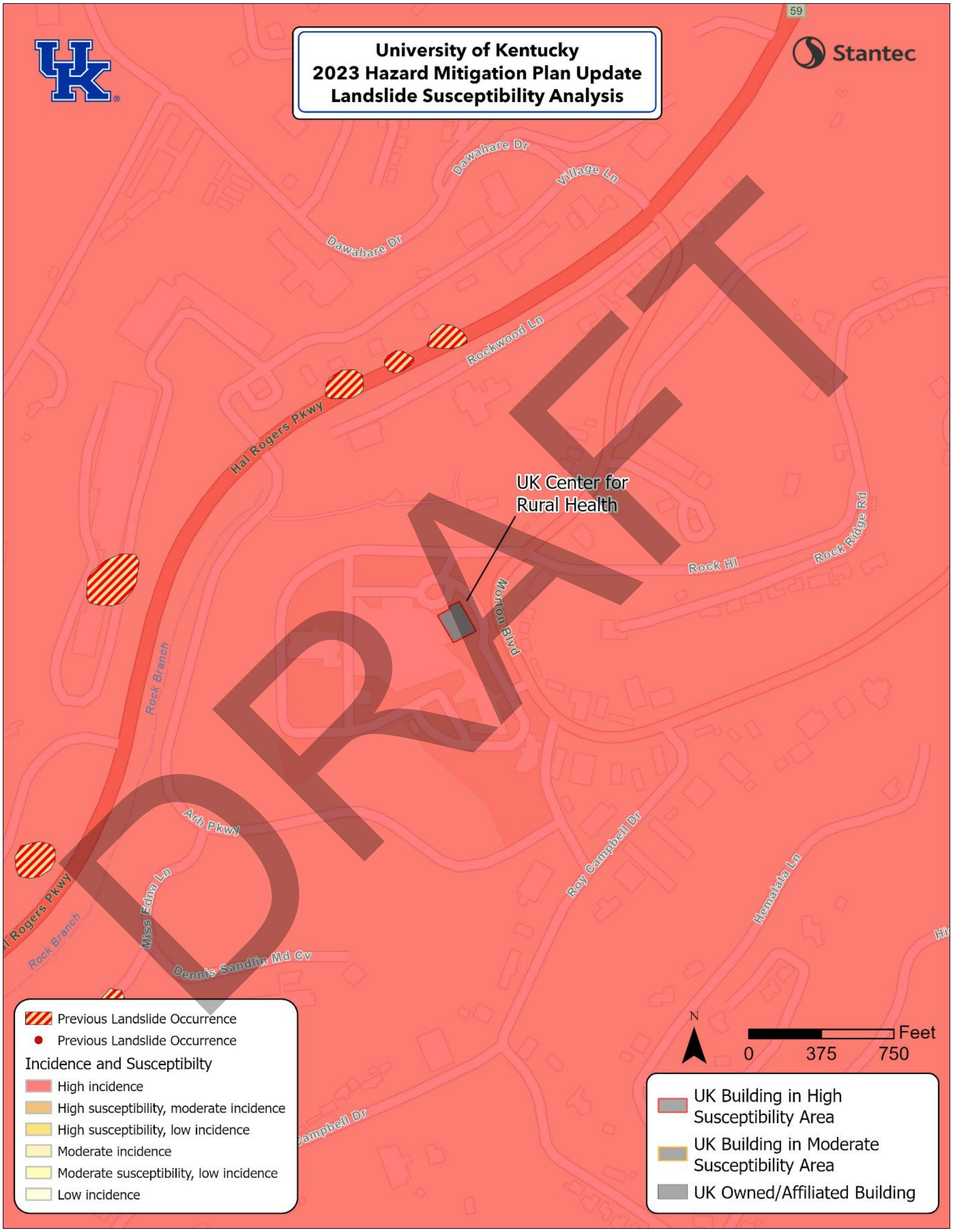


Figure 3-72: Landslide Susceptibility Analysis Results at Hazard, KY Campus

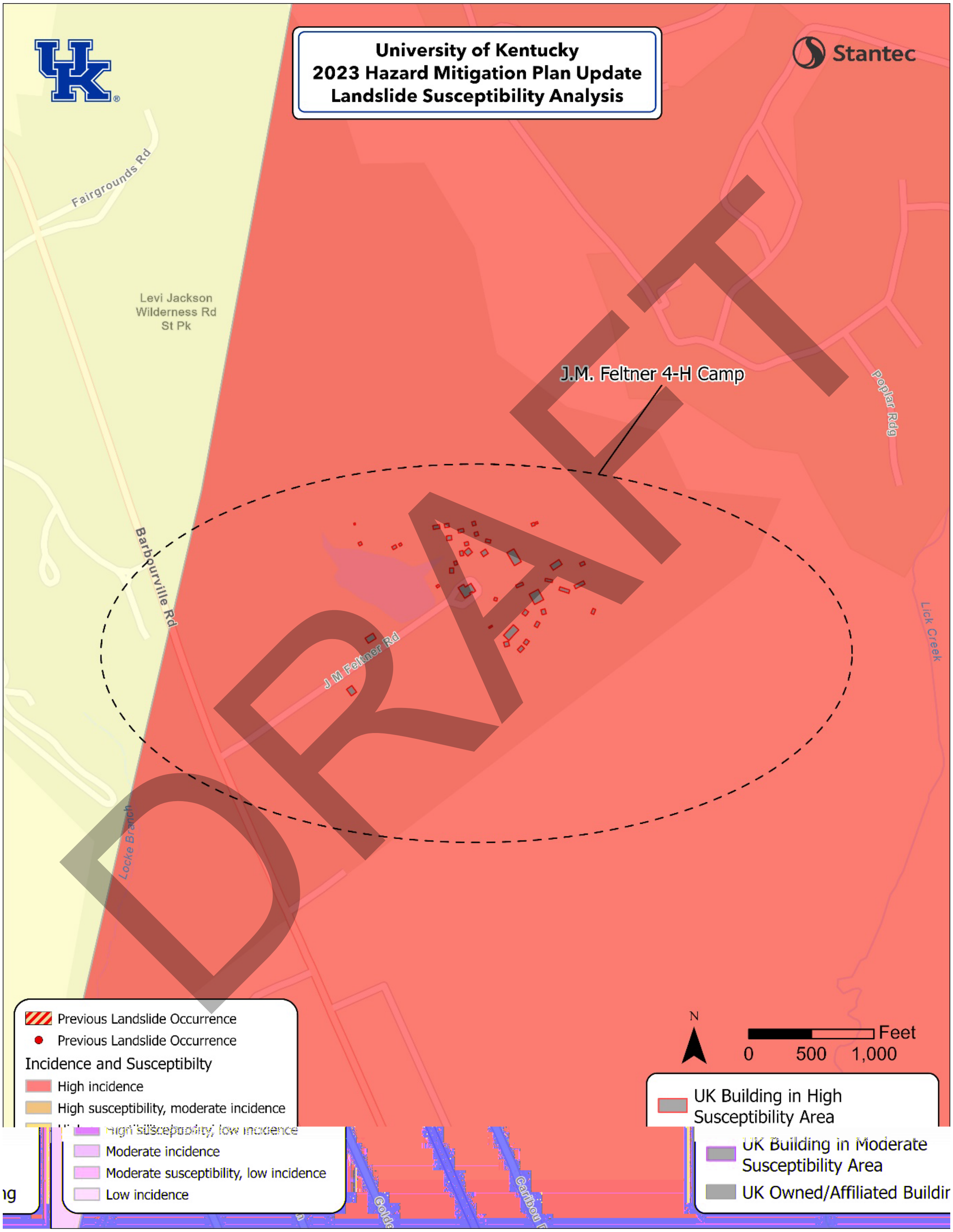


Figure 3-73: Landslide Susceptibility Analysis Results at J.M. Feltner 4-H Camp (London, KY)

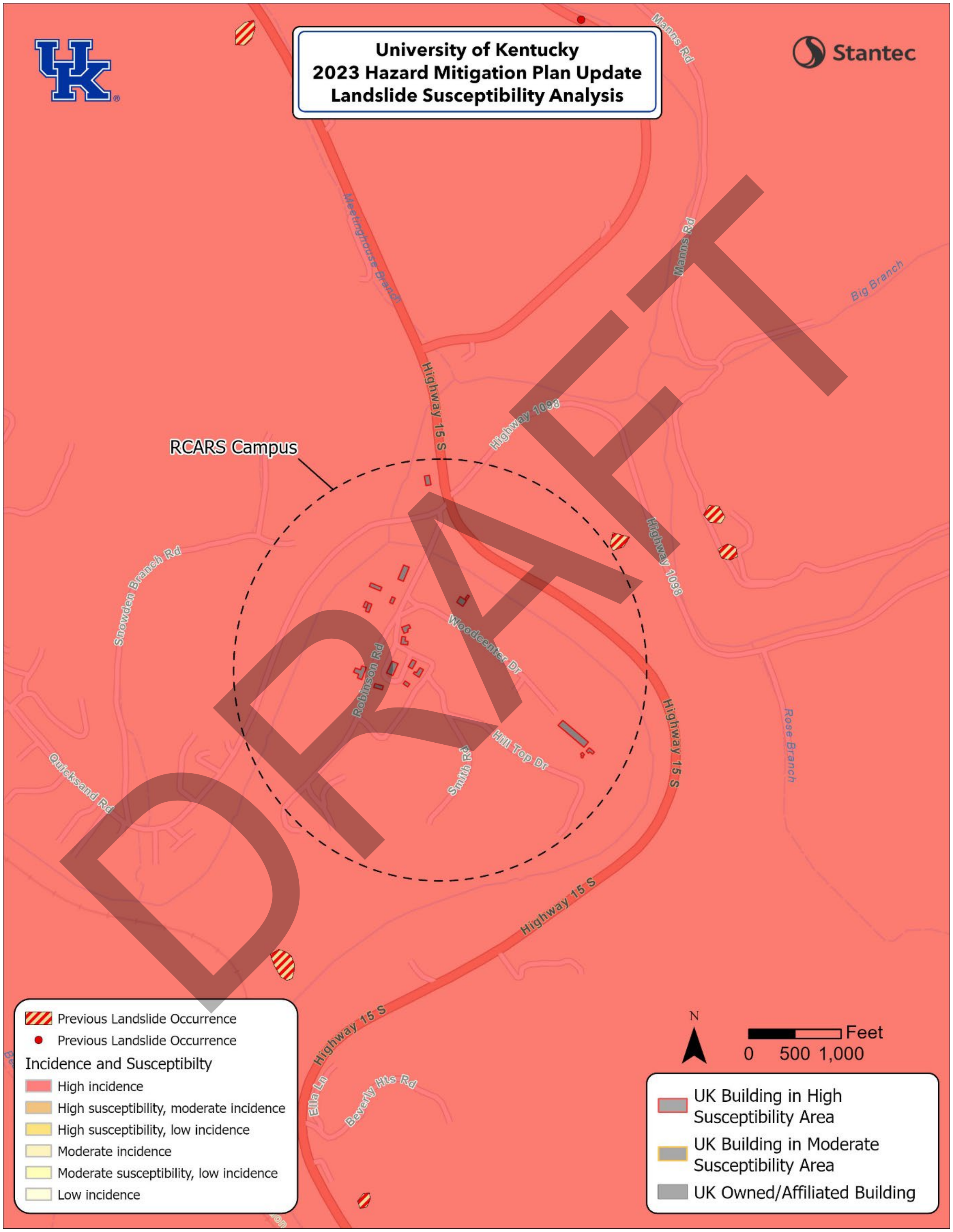


Figure 3-74: Landslide Susceptibility Analysis Results at RCARS campus (Quicksand, KY)

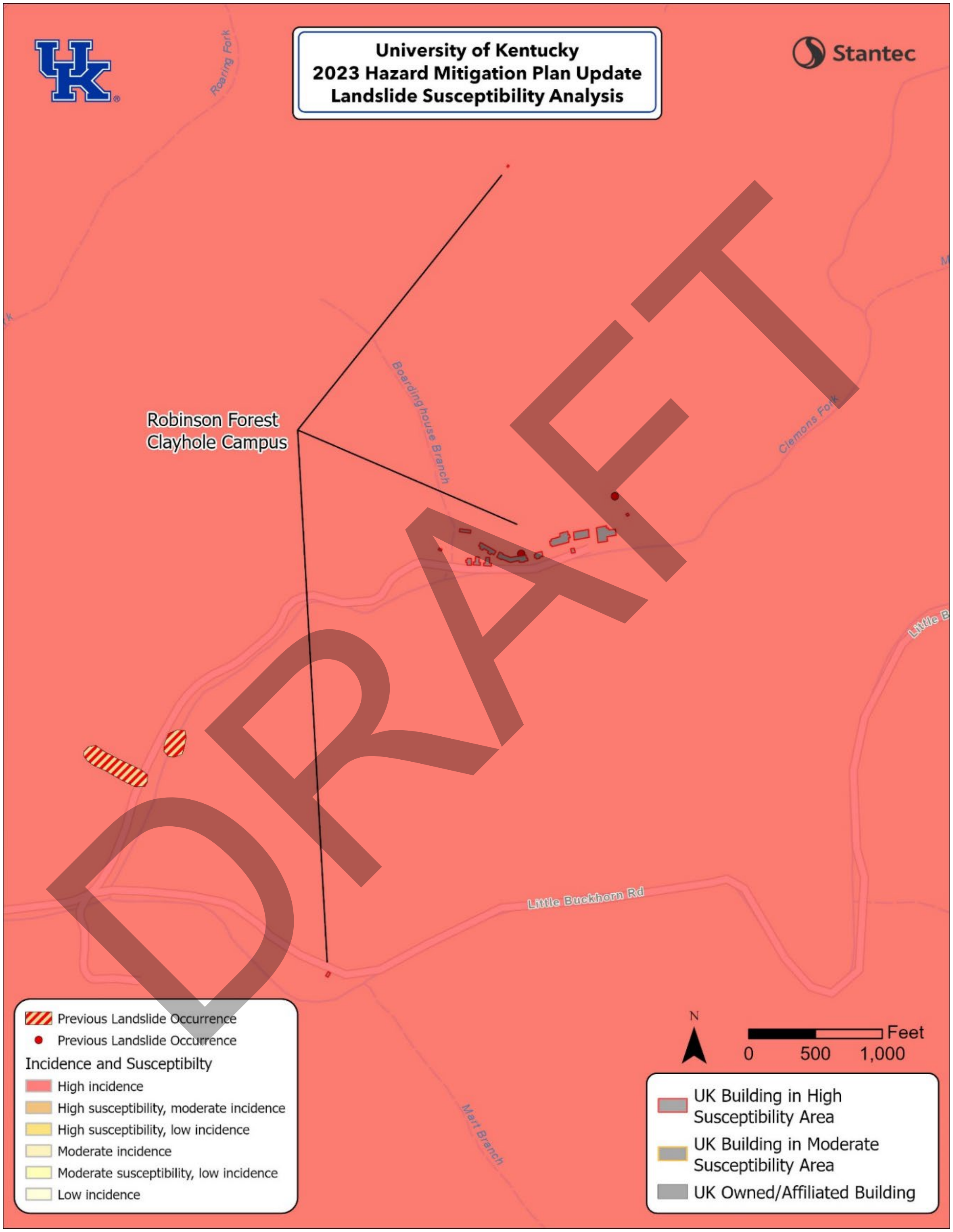
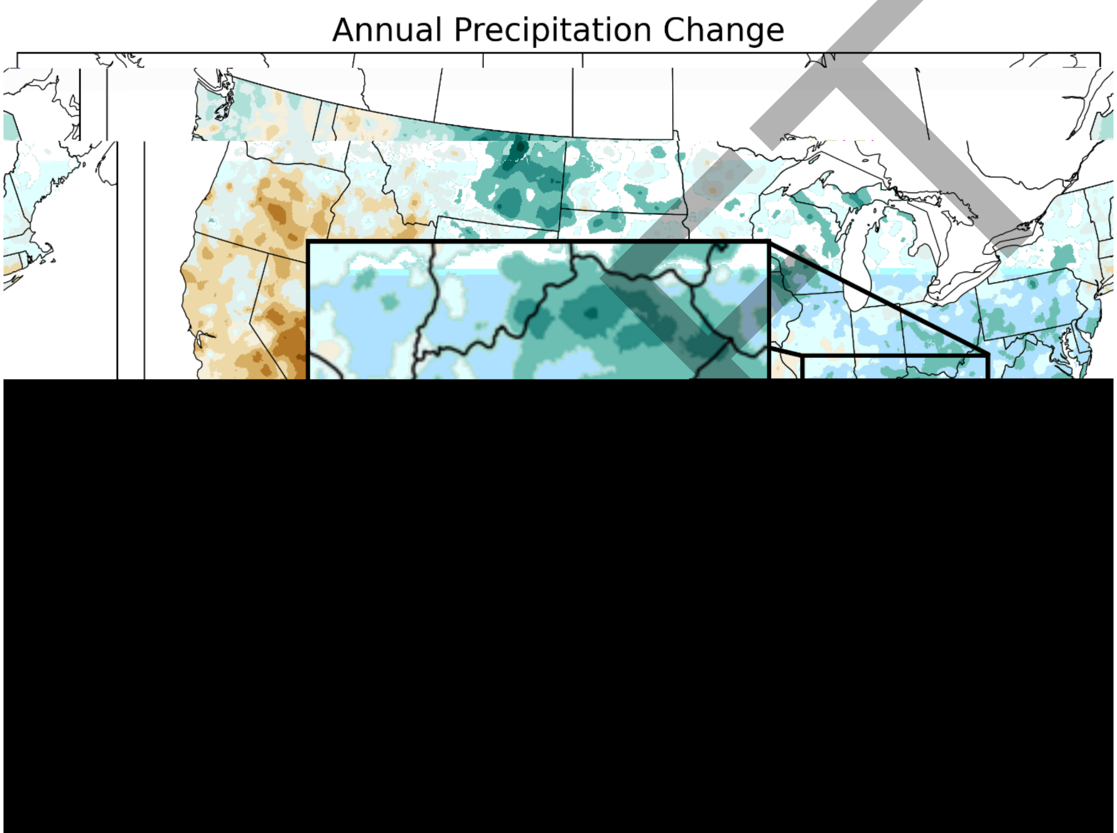


Figure 3-75: Landslide Susceptibility Analysis Results at Robinson Forest Campus (Clayhole, KY)

As previously mentioned in the *Landslide: Probability* subsection, Kentucky has experienced increased precipitation over the last 30 years. **Figure 3-77** shows the results of research included in the latest release of NOAA's U.S. Climate Normals, with Kentucky highlighted[99]. The figure shows the change in average annual precipitation over the last 30 years compared to a previous 30-year period (1981-2010). The entire state has seen an increase in annual precipitation, with the largest increases being in central and eastern Kentucky. Furthermore, the southeast U.S. has seen an increase in the annual number of extreme rainfall events (days with over 3 inches of precipitation)[100].



[redacted]

Figure 3-76: Comparing the Last 30 Years to Previous Annual Precipitation Normals

The trends of increasing annual precipitation and increasing number of extreme precipitation events are expected to continue, potentially increasing the frequency and severity of future landslide occurrences. It is also worth noting that there is already increased landslide susceptibility in areas where annual precipitation has experienced the largest increases over the last 30 years.

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[99] National Oceanic and Atmospheric Administration (NOAA).(2021). Decadal update from NCEI gives forecasters and public latest averages for 1991–2020. Retrieved on February 23, 2023 from NOAA Delivers New U.S. Climate Normals | News | National Centers for Environmental Information (NCEI)

[100] USGCRP. (2018). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds). U.S. Global Change Research Program, Washington, DC, USA, 1515. Retrieved on February 23, 2023 from Southeast - Fourth National Climate Assessment (globalchange.gov).

3.13 Severe Storm

3.13.1 Description

Storms are created when a center of low pressure develops with a system of high pressure surrounding it. This combination of opposing forces can create winds and result in the formation of storm clouds. Small, localized areas of low pressure can form from hot air rising off hot ground, resulting in smaller disturbances such as dust devils and whirlwinds. All thunderstorms contain lightning and may occur singly, in clusters, or in lines.

A thunderstorm is formed from a combination of moisture, rapidly rising warm air, and a force capable of lifting air such as a warm or cold front, a sea breeze, or a mountain. Thus, it is possible for several thunderstorms to affect one location in the course of a few hours. Some of the most severe weather occurs when a single thunderstorm affects one location for an extended period time. The NWS considers a thunderstorm as severe if it develops ¾ inch hail or 50-knot (58 mph) winds. There are four types of thunderstorms:

- ***Single Cell*** *(pulse storms).* Typically, it lasts 20-30 minutes. Pulse storms can produce severe weather elements such as downbursts, hail, some heavy rainfall, and occasionally weak tornadoes. This storm is light to moderately dangerous to the public and moderately to highly dangerous to aviation.
- ***Multicell Cluster***. These storms consist of a cluster of storms in varying stages of development. Multicell storms can produce moderate size hail, flash floods, and weak tornadoes. This storm is moderately dangerous to the public and moderately to highly dangerous to aviation.
- ***Multicell Line***. Multicell line storms consist of a line of storms with a continuous, well developed gust front at the leading edge of the line. Also known as squall lines, these storms can produce small to moderate size hail, occasional flash floods and weak tornadoes. This storm is moderately dangerous to the public and moderately to highly dangerous to aviation.
- ***Supercell***. Even though it is the rarest of storm types, the supercell is the most dangerous because of the extreme weather generated. Defined as a thunderstorm with a rotating updraft, these storms can produce strong downbursts, large hail, occasional flash floods and weak to violent tornadoes. This storm is extremely dangerous to the public and aviation.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears a“ a "bolt.” This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches a temperature approaching 50,000 degrees Fahrenheit in a split second.

The rapid heating and cooling of air near the lightning causes thunder. Flashes that do not strike the surface are called cloud flashes. They may be inside a cloud, travel from one part of a cloud to another, or from cloud to air. Overall, there are four different types of lightning:

- Cloud to sky (sprites)
- Cloud to ground
- Intra-cloud
- Inter-cloud

Straight-line wind is wind that comes out of a thunderstorm. There are several different terms commonly used for straight-line winds, including convective wind gusts, outflow, and downbursts. If these winds meet or exceed 58 miles per hour, then the storm is classified as severe by the National Weather Service. These winds are produced by the downward momentum in the downdraft region of a thunderstorm. Straight-line winds, which in extreme cases have the potential to cause wind gusts that exceed 100 miles per hour, are responsible for most thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation.

Thunderstorms are dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. While thunderstorms can occur in all regions of the United States, they are most common in the central and southern states because atmospheric conditions in those regions are ideal for generating these powerful storms.

3.13.2 Location

Severe storms have the potential to impact anywhere within Kentucky. Lightning occurs randomly; therefore, it is impossible to predict where and with what frequency it will strike. It is assumed that all university campuses and facilities are uniformly exposed to severe storms.

3.13.3 Previous Occurrences

The NCEI Storm Events Database reports thunderstorm winds by county. Since 1955, 206 thunderstorm wind events have been reported in Fayette County, where the university's main campus is located. One death and seven injuries were reported with these events. Forty-two of the 206 thunderstorm wind events had reports of property damage. Significant thunderstorm wind events (e.g., those with notable property damage, deaths, or injuries) for Fayette County are summarized in **Table 3-40**. Due to the atmospheric nature of thunderstorm events, it is assumed that events impacting the county were likely to impact the main campus. However, reported damages are not specific to UK.

Table 3-39: Significant NCEI Thunderstorm Wind Events in Fayette County

Date	Deaths/ Injuries	Property Damages (2022 Dollars)	Details
02/21/1993	0/1	$11,410,455	A severe thunderstorm and strong winds knocked over trees, blew roofs off buildings, and left thousands of people without electricity. One person was injured by flying glass in Lexington. At least 30 roads were blocked by falling trees.
05/18/1993	0/0	$114,104,550	Thunderstorm winds caused extensive damage to Hughes Aircraft. Condo and tree damage was reported around Griffin Gate in Lexington. Around six miles of straight-line wind damage occurred over northern Fayette County. Part of the roof was blown off a school.
08/09/2000	1/0	-	A man was killed in Lexington when a tree blew onto the vehicle he was driving.
07/19/2010	0/3	-	A tent was blown over at the Bluegrass Fair in Masterson Station Park. Three people were reported to be injured.
08/13/2011	0/0	-	Lexington Police reported multiple trees and power lines down across the city. Several trees were downed along Newton Pike near Lemons Mill Road. Kentucky Utilities reported that power was lost for around 19,000 customers across mostly north and western Lexington.
03/01/2017	0/0	$5,912,298	Very strong winds 50 feet off the ground hit over 10 agricultural barns causing significant damage to roofs and side panels. Several power poles were knocked over and several trees snapped and uprooted. The overall damage path extended 3 miles and had a maximum width of 1/2 mile. The duration of the thunderstorm event was approximately 3 minutes. Damage to the UK agricultural facilities was estimated to be more than 4 million dollars.
05/03/2022	0/0	-	A large tree was blown down, causing damage to a vehicle and power lines near the UK campus.

The NCEI Storm Events Database reports lightning information by county and, when the information is available, by city. Therefore, data specific to the campus was not available, and data for events reported in Fayette County were used. Thirteen lightning events were reported for Fayette County between 1996 and 2022. These events resulted in one death and four injuries. It should be noted that additional lightning events may have occurred and were not reported to NCEI; often only events with severe outcomes, such as injuries, deaths, or extensive damages, are reported. Therefore, the number of events and resulting damages are likely higher than what is indicated. Significant lightning events in Fayette County are summarized in **Table 3-41**.

Table 3-40: NCEI Significant Lightning Events Reported for Lexington

Date	Deaths/ Injuries	Property Damages (2022 Dollars)	Details
05/19/2004	0/1	-	A man was struck by lightning while working in a detached garage. He was treated and released from a local hospital.
05/25/2006	1/0	-	A woman was struck by lightning while placing yard waste in a container near her home.
06/08/2007	0/2	-	-
05/01/2010	0/0	$28,515	Multiple power outages were reported in the area due to lightning.
07/19/2010	0/0	$2,852	Lightning struck a tree and caused a fire on Innovation Drive.
05/14/2014	0/0	$38,003	Lexington media reported that lightning downed a large tree near Cross Keys Road, which fell across several power lines. This caused widespread power outages.
12/18/2016	0/0	$2,985,131	A lightning strike caused a fire in a horse barn at the Mercury Equine Center. 23 racing horses perished, and the barn was a total loss.
05/18/2018	0/0	$16,883	Four apartment units were damaged due to a lightning strike. The fire department reported that a single-family home was hit by lightning.
10/04/2018	0/1	-	A person received minor injuries from a lightning strike. The individual was evaluated and released from medical care.
03/06/2022	0/0	$50,000	A barn was struck by lightning, resulting in three horse fatalities.

In addition to the above events, claims data was provided by UK Risk Management to review from January 2012 to October 2022. There were 39 claims related to Severe Storm with a cost of approximately $1.2 million. The most expensive claim was $814,218 (2022 dollars) related to the severe storms impacting UK's North Farm on March 1, 2017. The claims related to severe storms are shown in **Table 3-42** and **Table 3-43.**

Table 3-41: UK Main Campus Severe Storm Claims

Building ID	Building Name	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims *	Previous Losses ($)*
1	Taylor Education Building	$ 23,479,391	$ 1,256,753	$ 153,663	Fair	1	$ 20,400
43	S. J. Sam Whalen Building	$ 8,347,486	$ 2,318,804	$ 1,364,961	Fair	1	$ 6,600
55	Chemistry-Physics Building	$ 82,443,124	$ 12,669,853	$ 5,809,695	Poor	1	$ 41,700
97	E. S. Good Barn	$ 5,194,941	$ 20,675	-	Good	1	$ 91,100
98	Marylou Whitney & John Hendrickson Cancer Facility for Women (Pavilion WH)	$ 33,694,928	$ 5,885,974	$ 1,342,226	Excellent	1	-
100	Haggin Hall	$ 35,252,700	$ 1,372,000	-	Excellent	1	-
107	Mining & Minerals Resources Building	$32,527,834	$ 3,610,438	$ 5,017,652	Fair	1	$ 8,000
109	Wendell & Vickie Bell Soccer Complex	-	-	-	Excellent	1	$ 3,900
$ -	Woodland Glen III	$54,553,450	$ 1,919,471	-	Not Rated	1	-
184	Agricultural Machine Research Lab	$ 508,106	$ 396,210	$ 354,617	Fair	1	$ 96,900
186	Woodland Glen IV	$ 50,726,475	$ 1,473,067	-	Not Rated	1	-

Building ID	Building Name	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims *	Previous Losses ($)*
188	Woodland Glen V	$ 19,294,814	$ 709,657	-	Not Rated	1	-
222	Kroger Field	$141,979,364	$ 627,903	-	Not Rated	3	$ 87,000
232	College of Nursing	$ 45,574,583	$ 2,403,989	$ 2,894,848	Fair	1	-
246	Greg Page Apartments 4	$ 891,218	-	-	Not Rated	1	-
284	Kentucky Clinic	$ 85,868,238	$ 1,855,011	$ 7,973,716	Excellent	1	$ 31,400
297	Dental Science Building	$ 61,588,877	$ 4,341,210	$ 4,589,758	Fair	1	-
298	William R. Willard Medical Education Building	$122,815,949	$14,483,261	$ 22,941,927	Poor	3	-
507	410 Rose Lane	$8,830,164	$ 67,219	-	Not Rated	1	$ 10,50
509	Biomedical Biological Sciences Research Building	$123,665,110	$ 15,246,416	$ 24,491,416	Excellent	1	$ 17,100
582	University Health Service	$ 38,725,864	$ 1,500,000	-	Not Rated	2	$ 5,100
596	Lee T. Todd, Jr. Building	$ 150,646,287	$ 11,800,000	$ 28,725,168	Excellent	1	$ 18,800
601	Parking Structure #8	$ 48,857,456	$ 10,000	-	Excellent	1	$ 3,500
678	Lewis Hall	-	-	-	Not Rated	1	-
9875	Vaughan Warehouse and Office	$ 8,412,143	$ 3,000,000	-	Not Rated	1	-

*Severe Storm-related claims only

Table 3-42: UK Severe Storm Claims for Outlying Campuses and 4-H Camps

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition	No. of Claims *	Previous Losses ($)*
7823	Steer Feeding Barn	Princeton - UK Research and Education Center	$ 197,920	$ 26,606	-	Not Rated	1	-
7786	West KY 4-H Camp Treatment Center	West Kentucky 4-H Camp	$ 112,932	-	-	Not Rated	1	$ 15,200
3793	Tobacco Barn #5	-	$ 332,222	$ 30,464	-	Not Rated	1	$ 1,800
3744	Swine Manure Electric Building	-	$ 1,082,163	-	-	Not Rated	1	$ 30,000
3379	Foundation Seed Proc	North Farm	$ 1,903,770	$ 131,396	$ 459,526	Not Rated	1	$ 702,400
3358	Mansion	North Farm	$ 13,984,092	$ 198,272	-	Not Rated	2	-

*Severe Storm-related claims only

3.13.4 Extent

Extent can be measured in terms of the amount of damage reported from an incident. Of the 206 days with thunderstorm winds that have been reported in NCEI, three incidents caused over one million dollars in damages at the time of the incident. The most damage from thunderstorm winds in Fayette County occurred on May 18, 1993, and caused $113,104,550 in damages (2022 dollars)[101]. The most damage from a lightning event in Fayette County occurred on May 5, 2010, and caused $28,515 in damages (2022 dollars). The most expensive claim by UK related to Severe Storm was $814,218 (2022 dollars) in 2017 when storms severely damaged several buildings at UK North Farm. However, costlier events are possible.

3.13.5 Probability

The probability of severe storms was analyzed by looking at lightning and thunderstorm trends. While seven significant lightning events have been reported over 22 years, it is known that lightning is a regular occurrence in the planning area. Lightning flash data compiled by Vaisala, Inc. with data from 2015 through 2020 shows the frequency of lightning flashes per square kilometer per year as shown in **Figure 3-78**[102]. Fayette County receives an average of 24 to 32 flashes per square kilometer per year, similar to most of Kentucky. Counties in western Kentucky are shown to experience a higher flash density than eastern Kentucky.

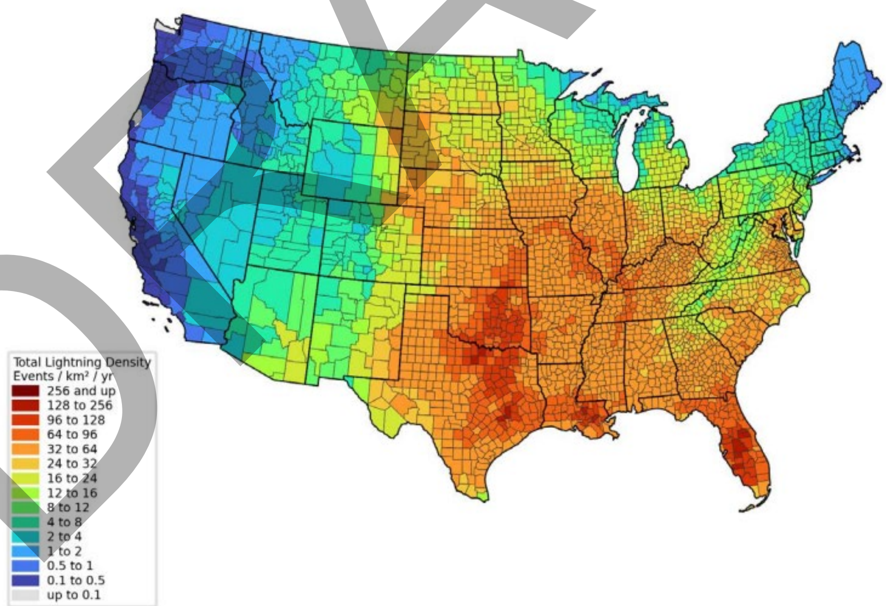

Figure 3-77: Vaisala, Inc. Average Lightning Density per Year

[101] From "Lexington-Fayette County Hazard Mitigation Plan", Lexington-Fayette County Government (2018)
[102] "Total Lightning Statistics", *2021 Annual Lightning Report*, Vaisala (2022), https://www.vaisala.com/sites/default/files/documents/WEA-MET-2021-Annual-Lightning-Report-B212465EN-A.pdf

Since 1955, 206 thunderstorm wind events have been reported in Fayette County or approximately three instances of thunderstorm winds per year. The National Weather Service tracks the number of thunderstorm days throughout the United States each year. As shown in **Figure 3-79**, most of Kentucky, including UK's main campus, experiences 45 to 54 thunderstorm days a year[103]. Southwestern Kentucky experiences 54 to 63 thunderstorm days a year. Thunderstorms are a common occurrence in the planning area.

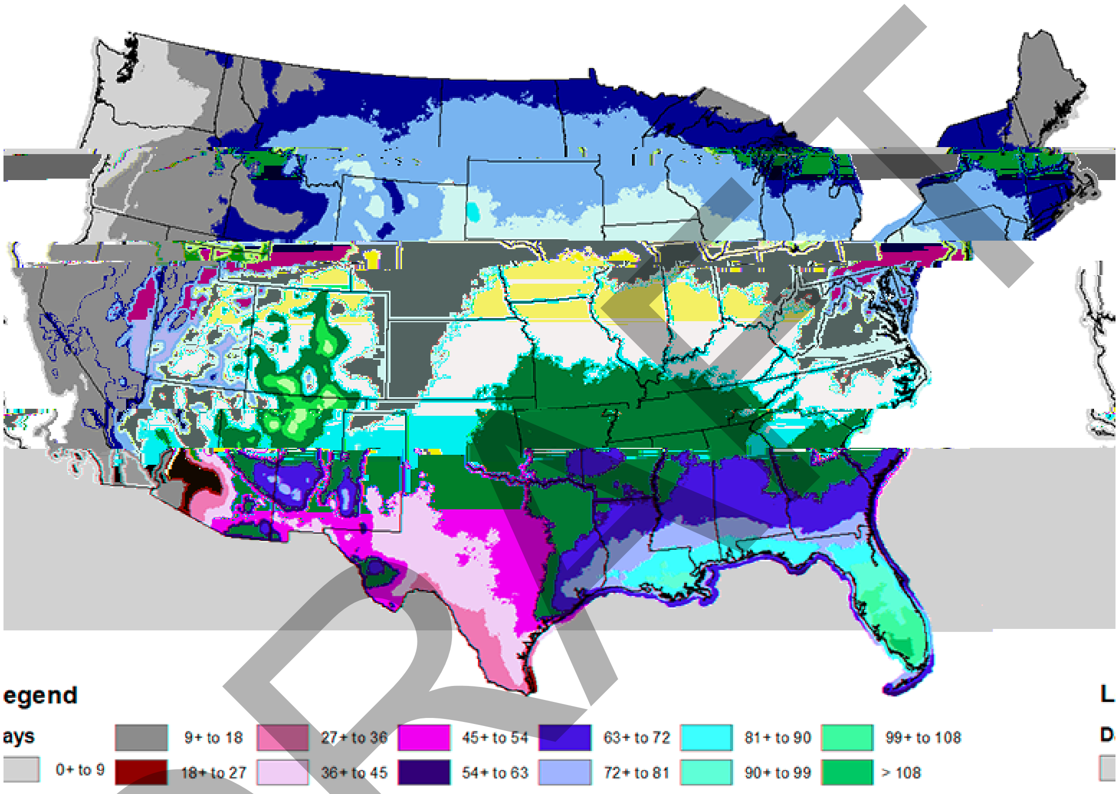

Figure 3-78: NWS Annual Mean Thunderstorm Days (1993 - 2018)

When possible, climate variability should be considered when determining the probability of future hazard conditions. Trends in convective storm occurrences due to climate change are subject to greater uncertainty than temperature-related trends (such as extreme heat and cold events), and research is ongoing. Although studies are still being performed, a recent study cited by the National Climate Assessment indicates an increase in the occurrence of atmospheric conditions conducive to severe thunderstorm formation in the United States. For the Kentucky spring season, the study indicates increases of 1.2 to 2.4 days per season with severe thunderstorm environments during 2070-2099.[104]

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[103] "Introduction to Thunderstorms", National Weather Service, https://www.weather.gov/jetstream/tstorms_intro#:~:text=The%20figure%20above%20shows%20the%20average%20number%20of,%27thunder%27%20days%20%2880%20to%20105%2B%20days%20per%20year%29.

[104] "Robust increases in severe thunderstorm environmental in response to greenhouse forcing" Diffenbaugh, Scherer, & Trapp (August 20, 2013), *PNAS.*

Another study found evidence linking warmer air temperatures to increased lightning strikes by about 12 percent per degree Celsius of warming (give or take 5 percent)[105].

By mid-century, Fayette County is projected to experience an average temperature increase by 2°F[106]. By end of century, Fayette County is projected to experience an average temperature increase by 7°F. Considering the frequency of historic occurrences, the likelihood of unreported or underreported events, local input, and climate projections for severe storm conditions, the probability of severe storms is highly likely (greater than 90 percent annual chance).

3.13.6 Vulnerability Assessment

All current and future buildings, infrastructure and populations are considered at risk to severe storm on UK's main campus and outlying facilities. Thunderstorms are dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. Severe wind associated with severe thunderstorms has the potential to blow shingles, siding, awnings, and other features off buildings. Falling trees and tree limbs can damage structures. Objects picked up by wind can be hurled through the air, damaging structures and breaking windows when contact is made. In some cases, structures can be blown off foundations. In addition, mobile or modular units (such as those installed for temporary uses) are considered at a higher risk of severe wind. Severe winds can cause damage to critical infrastructure, including communications infrastructure, utility poles, and above ground power. In addition, severe winds can result in serious life safety impacts. People outside during severe wind events may be struck by falling trees and limbs, or by objects falling off buildings or being hurled through the air.

Lightning can cause structure fires and loss of electrical equipment. Electrical systems, telecommunications equipment, and infrastructure exposed in open areas are especially vulnerable to lightning. In addition, falling limbs caused by lightning strikes to trees may damage buildings or vehicles. Lightning is one of the leading causes of weather-related fatalities. From 2013 to 2022, lightning caused an average of 23 deaths per year in the US[107]. Most lightning deaths and injuries in the United States occur in the summer months, when lightning frequency and outdoor activities reach a peak. All current and future populations on campus are considered at risk of lightning.

People who work outside or regularly engage in outdoor recreational activities are considered at a higher risk of severe storms. As an agriculture research institution, UK has students, staff and visitors that work outside regularly and are often working in remote areas. Many of the agriculture research activities take place in fields or forests that are several miles from the nearest shelter or first aid equipment.

The university has many students, faculty, and staff that primarily walk or use public transit to get around campus. Severe storms may cause road conditions that make it unsafe to run bus operations. Students waiting for the bus service or walking around campus during severe storms may face higher exposure to severe weather.

[105] "Projected increase in lightning strikes in the United States due to global warming", Romps et al. (2014), https://www.science.org/doi/10.1126/science.1259100
[106] "Neighborhoods at Risk", Headwaters Economics, https://nar.headwaterseconomics.org/2100046027/explore/climate
[107] "National Weather Service Lightning Fatalities in 2023", NWS, https://www.weather.gov/safety/lightning-fatalities

As discussed previously, recent studies have indicated the likelihood of increased days with severe thunderstorm environments with climate change[108]. Additionally, there is evidence linking warmer temperatures to increased lightning strikes[109]. An increase in the frequency of events would increase the vulnerability of populations, buildings, and infrastructure to severe storms.

3.14 Severe Winter Storm

3.14.1 Description

A winter storm is an event in which varieties of precipitation are formed that only occur at low temperatures, such as snow, sleet, freezing rain or ice. Severe winter weather typically results in a winter weather watch, warning, and/or advisory. During a severe winter weather event, one or more of the following types of weather occur:

- **Winter Storm.** A winter storm is generally defined as snow accumulation of at least eight inches in 12 or more hours, or at least six inches in six to nine hours. A winter storm can be in combination with rain, freezing rain, sleet, wind, blowing snow, or cold.
- **Heavy Snow.** A heavy snowstorm is any winter storm that produces six inches or more of snow within a 48-hour period or less. Snowstorms generally occur with the clash of different types of air masses, with differences in temperature, moisture, and pressure; specifically, when warm moist air interacts with cold dry air. Snowstorms that produce a lot of snow require an outside source of moisture, such as the Great Lakes, Gulf of Mexico, or the Atlantic Ocean.
- **Blizzard.** A blizzard is a severe snowstorm with winds in excess of 35 mph and visibility of less than a 1/4 mile for more than 3 hours.
- **Frost/Freeze**. Frost forms during freezing temperatures when the ground surface cools to a temperature colder than the dewpoint of adjacent air. When water vapor in the air above the ground surface condenses, it freezes due to low temperatures. Frost and freeze events can be detrimental when occurring outside of the expected winter season, such as early in the fall or late in the spring. These events can catch motorists off guard with slick road conditions, or damage crops and landscaping.
- **Ice Storm, Sleet, and Freezing Rain.** An ice storm is defined as a storm with significant amounts of freezing rain and is a result of warm air in between two layers of cold air. With warmer air above, falling precipitation in the form of snow melts, then becomes either super-cooled (liquid below the melting point of water) or re-freezes.

[108] “Robust increases in severe thunderstorm environmental in response to greenhouse forcing” Diffenbaugh, Scherer, & Trapp (August 20, 2013), *PNAS.*
[109] “Projected increase in lightning strikes in the United States due to global warming”, Romps et al. (2014), https://www.science.org/doi/10.1126/science.1259100

- An ice storm typically has a coating of at least ¼ inch of ice but may be up to one-half inch if winds are less than 15 mph. In the former case, super-cooled droplets can freeze on impact (freezing rain), while in the latter case, the re-frozen water particles are ice pellets (or sleet). Sleet is defined as partially frozen raindrops or refrozen snowflakes that form into small ice pellets before reaching the ground. They typically bounce when they hit the ground and do not stick to the surface. However, it does accumulate like snow, posing similar problems and has the potential to accumulate into a layer of ice on surfaces. Conversely, freezing rain usually sticks to the ground, creating a sheet of ice on the roadways and other surfaces.

As the climate changes, winter precipitation is also expected to change. With warmer temperatures, it is more likely that rain will fall in place of snow, and mixed winter precipitation (such as freezing rain) will become more likely.

Winter storms are defined differently in various parts of the country relevant to their standard weather. Two inches of snow may create serious disruptions to traffic in areas where snowfall is not expected; however, this may be considered a light dusting in regions where snowfall is typical. Therefore, there are multiple ways in which to measure a winter storm, based on snowfall, temperatures, wind speeds, societal impact, etc.

Lexington lies within the Louisville NWS Forecast Office, which defines regional standards for severe winter weather events. On average, Lexington experiences the most snowfall between December and March[110]. However, it should be noted severe winter weather is possible outside of this window, and that mild snowfall and cold temperatures may also occur outside of winter months.

In addition to precipitation associated with severe winter storms, extreme cold events, especially those caused by the combined effects of wind and cold temperatures, can occur during a severe winter storm. However, extreme cold events have been included as a separate hazard as they are not always associated with winter storms.

3.14.2 Location

It is assumed that all UK campuses and 4-H camps are uniformly exposed to the severe winter weather hazard. The *Commonwealth of Kentucky Enhanced Hazard Mitigation Plan* states, "It is safe to assume given the historic severe winter storm events suffered by Kentucky that the entire Commonwealth of Kentucky is equally vulnerable to the deleterious effects from severe winter storms and that all commonwealth assets are vulnerable equally"[111].

3.14.3 Previous Occurrences

Data regarding severe winter weather previous occurrences was collected from the NCEI Storm Events Database, FEMA Disaster Declarations, and university claims data from January 2012 to October 2022.

[110] "Lexington Climate", *NWS,* NOAA, https://www.weather.gov/lmk/clilex
[111] "Risk Assessment : Severe Winter Storms" UK-HMGP (2018), *Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan*

The NCEI Storm Events Database records winter-related weather events by county; data specific to the university is not available. Therefore, all winter weather events reported for Fayette County, where UK's main campus is located, are included. According to NCEI, there has been a total of 35 severe winter weather events in Fayette County since 1996. The occurrences by type are shown in **Table 3-44**. As winter weather is a relatively common occurrence during the planning area's winter months, it is likely that events and damage have gone unreported. Fayette County has been included in three severe winter storm Presidential Disaster Declarations as shown in **Table 3-45**[112].

Table 3-43: Severe Winter Storm Occurrences and Types in Fayette County from NCEI

Event Type	Number of Occurrences
Blizzard	0
Frost/Freeze	2
Heavy Snow	13
Ice Storm	6
Winter Storm	13
Winter Weather	1

Table 3-44: Severe Winter Storm Presidential Declarations for Fayette County

Disaster Declaration Date	Incident Period	ID	Incident Type
03/16/1994	02/09/1994 – 02/11/1994	DR-1018	Severe Storm, Freezing Rain, Sleet, Snow
01/13/1996	01/05/1996 – 01/12/1996	DR-1089	Blizzard
03/14/2003	02/15/2003 – 02/26/2003	DR-1454	Severe Winter Storm
02/05/2009	01/26/2009 – 02/13/2009	DR-1818	Winter Storm, Flooding

The 35 severe winter storm incidents reported in NCEI were reviewed for this plan update. Significant notable events are summarized in **Table 3-46.**

[112] "Declared Disasters", FEMA, https://www.fema.gov/disaster/declarations

Table 3-45: Significant Severe Winter Storm Events in Fayette County

Incident Period	Incident Type	Description
01/06/1996 – 01/07/1996	Heavy Snow	A major snowstorm hit Kentucky. Accumulation totals were from 7 to 12 inches across east central Kentucky to 7 to 16 inches across south central Kentucky to 6 to 12 inches across north central Kentucky. A major disaster was declared.
02/04/1998 – 02/06/1998	Heavy Snow	A winter storm dumped as much as 25 inches of snow on parts of Kentucky. Most of the Kentucky counties were declared states of emergency by the morning of February 5 as trees and power lines were down across a large area of the LMK County Warning Area[113] (which includes Fayette County). Roads became snow-covered, slick, hazardous and in some remote places, impassable. Over the three days, 3 people were killed and four injured across the LMK County Warning Area.
02/15/2003 – 02/16/2003	Ice Storm	The hardest-hit areas were in and around the cities of Frankfort and Lexington, where up to an inch and a quarter of ice accumulation was observed. Estimates suggest that, after the storm, nearly 125,000 residents were without power for up to five days or more. Most of the property damage was reported in the Lexington area. A great deal of the monetary damage was for cleanup and restoration of power in the days after the storm. Reported property damage cost over $31 million (inflated to 2022 dollars). A major disaster was declared.
12/23/2008 – 12/23/2008	Winter Weather	Ice accumulation on roads across the northern portions of Kentucky lead to numerous traffic accidents and several fatalities. Over $150,000 in property damage was reported (inflated to 2022 dollars).
01/27/2009 – 01/28/2009	Winter Storm	A prolonged ice and snowstorm began on January 27 and continued through January 28. Icing led to widespread tree damage and power outages. This winter storm brought the most widespread damage due to icing in recent memory across Kentucky. Over 600,000 residents lost power. Utility companies stated that this event brought the greatest number of outages from any weather event in history. The almost continuous rain or snow over a 36-hour period brought 3 to 4 inches of precipitation over a wide area and even led to some minor flooding. A major disaster was declared.

[113] NOAA National Weather Service. LMK County Warning Area. Retrieved from LMK County Warning Area (CWA) (weather.gov).

Incident Period	Incident Type	Description
02/16/2015 – 02/16/2015	Heavy Snow	This storm produced more snow across central and southern Kentucky than any other in at least a decade. A strip of heavy snow of near one foot extended across central Kentucky. At least two indirect fatalities - from heart attacks occurring while shoveling snow or trying to push out a stuck vehicle - were attributed to the snow.
11/14/2018 – 11/15/2018	Ice Storm	A cold air mass already in place combined with an anomalous low-pressure system to produce an early season freezing rain event across central Kentucky and southern Indiana. The ice on the trees, many of which still had leaves that helped to weigh them down, caused several limbs/branches to snap and some trees to fall. There were many reports of power flashes overnight as branches hit transformers. At the peak of the event, over 100,000 customers were without power in the region. One utility company serving much of central Kentucky reported that it was one of the top 10 costliest outages in its history.
03/11/2022 – 03/12/2022	Winter Storm	Plunging temperatures behind the cold front resulted in impactful snow accumulations. Heavy snowfall rates accumulated on roadways and interstates, snarling traffic, and resulting in significant societal impact.

In addition to the above events, UK Risk Management provided claims data from January 2012 to October 2022. One claim was related to Severe Winter Weather - on February 21, 2021, it was noted that an ice storm damaged a baseball foul net at Kentucky Proud Park, resulting in $14,721 in damages (inflated to 2022 dollars).

3.14.4 Extent

Severe winter weather extent can be measured in several ways, including snowfall accumulations or damages. The record snowfall in Fayette County was 13.4 inches, occurring on January 26, 1943[114]. Between 1991 and 2020, Lexington, Kentucky experienced an average of 14.5 inches of snow per year[115]. The most reported damage in Fayette County during a single winter-related weather event was over $31 million during the February 2003 Ice Storm (NCEI). After the February 2003 Ice Storm, FEMA awarded over $36 million in public assistance grants and over $9 million in individual assistance throughout Kentucky to assist with recovery[116]. Since 2012, the only severe winter weather claim reported on UK's campus was $14,721(inflated to 2022 dollars) in damages in January 2021. It should be noted that more extreme winter weather events are possible for UK's main campus and outlying campuses and 4-H camps.

114 "Snowfall Extremes", *NCEI,* NOAA (2022), https://www.ncei.noaa.gov/access/monitoring/snowfall-extremes/KY
115 "Lexington Climate", *NWS,* NOAA, https://www.weather.gov/lmk/clilex
116 "Declared Disasters", FEMA, https://www.fema.gov/disaster/declarations

3.14.5 Probability

Some type of severe winter weather is expected to impact the campus every year. It is only a matter of how severe and how many events might occur in a particular year that is difficult to predict in advance. Based on a reported 35 events in 26 years, Fayette County has historically experienced over 1.3 severe winter weather events per year. It is assumed severe winter storms impacting the county also impacted the main campus. In addition, historic climate data shows that precipitation in the planning area is increasing over time, and the frequency of heavy precipitation events is also increasing. With gradual warming and increased precipitation, it is expected that the probability of severe winter storms, heavy snow, and ice storms will increase[117]. Although warmer temperatures may lead to more rainfall in place of snowfall, precipitation could be more likely to fall as freezing rain. Based on historic occurrences and future projections, the probability assigned to the severe winter weather hazard is highly likely (greater than 90 percent annual chance).

3.14.6 Vulnerability Assessment

All current and future buildings, infrastructure, and populations are considered at risk of severe winter weather. Downed trees and branches can cause damage to buildings and other structures. The weight caused by heavy snowfall accumulation can cause roofs to collapse. In addition, ice dams can cause leaks and water damage to buildings. Ice dams occur when the bottom layer of snow or ice accumulated on a roof melts due to heat from the building, and runs off into eaves, where it refreezes. The refrozen water causes an ice dam.

Health hazards related to walking and snow removal are frequent and life-threatening. Falls, particularly to the elderly, can result in serious injury including fractures, broken bones, and shattered hips. Middle-aged and older adults are susceptible to heart attacks from shoveling snow. In addition, falling ice can become a hazard when quick warming causes ice to break and slide off building roofs and overhangs.

Dangerous driving conditions frequently occur during and shortly after severe winter storms. While vehicular accidents are often caused by the driver's lapse in judgment, the weather and its impact on roads are also a major factor. Blowing snow, whiteout conditions, ice, and slush create slippery pavement making vehicle travel less safe during and immediately following winter storms. This is a particular concern on a campus with high pedestrian traffic. University transit systems may be unable to operate safely during severe winter storms due to roadway conditions. This may limit operations and the ability of students and staff to reach resources. Additionally, critical staff may be unable to reach campus due to roadway conditions.

Severe winter weather can result in the need to cancel classes and events, discontinue university bus lines, or close airports and other businesses. In extreme cases, sheltering and evacuations may be required, especially if prolonged power outages are expected.

Power outages and/or inaccessible roads can result in limited access to food, basic supplies, and an adequate heat source. Young children and the elderly are especially at risk. Further, if the university health system or similar facilities housing vulnerable populations lose power, inhabitants may need to be evacuated to a different location to receive proper care.

[117] "Risk Assessment : Severe Winter Storms" UK-HMGP (2018), *Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan*

Many international students remain in their on-campus or off-campus residences during campus breaks with only essential staff. Some of these students may not have experienced winter weather before and may have a language barrier.

Lastly, exposure during winter weather, including students and visitors not properly dressed to withstand the cold, can result in hypothermia or frostbite. Agricultural researchers at UK may have more exposure to winter weather by working outside for long periods of time.

3.15 Tornado

3.15.1 Description

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 miles per hour to more than 300 miles per hour. The most violent tornadoes have rotating winds of 250 miles per hour or more, are capable of causing extreme destruction, and can turn normally harmless objects into deadly missiles.

Each year, an average of around 1,200 tornadoes are reported nationwide, resulting in an average of 60 deaths and 1,500 injuries. According to the NOAA Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in Oklahoma, Texas, Kansas, and Florida, respectively. The Great Plains region of the Central United States favors the development of the largest and most dangerous tornadoes, earning the designation of “Tornado Alley”. **Figure 3-80** shows tornado activity in the United States based on the number of recorded tornadoes per county from 1955 to 2014. According to the map, Fayette County experienced one to 20 recorded tornadoes over the 59-year period.

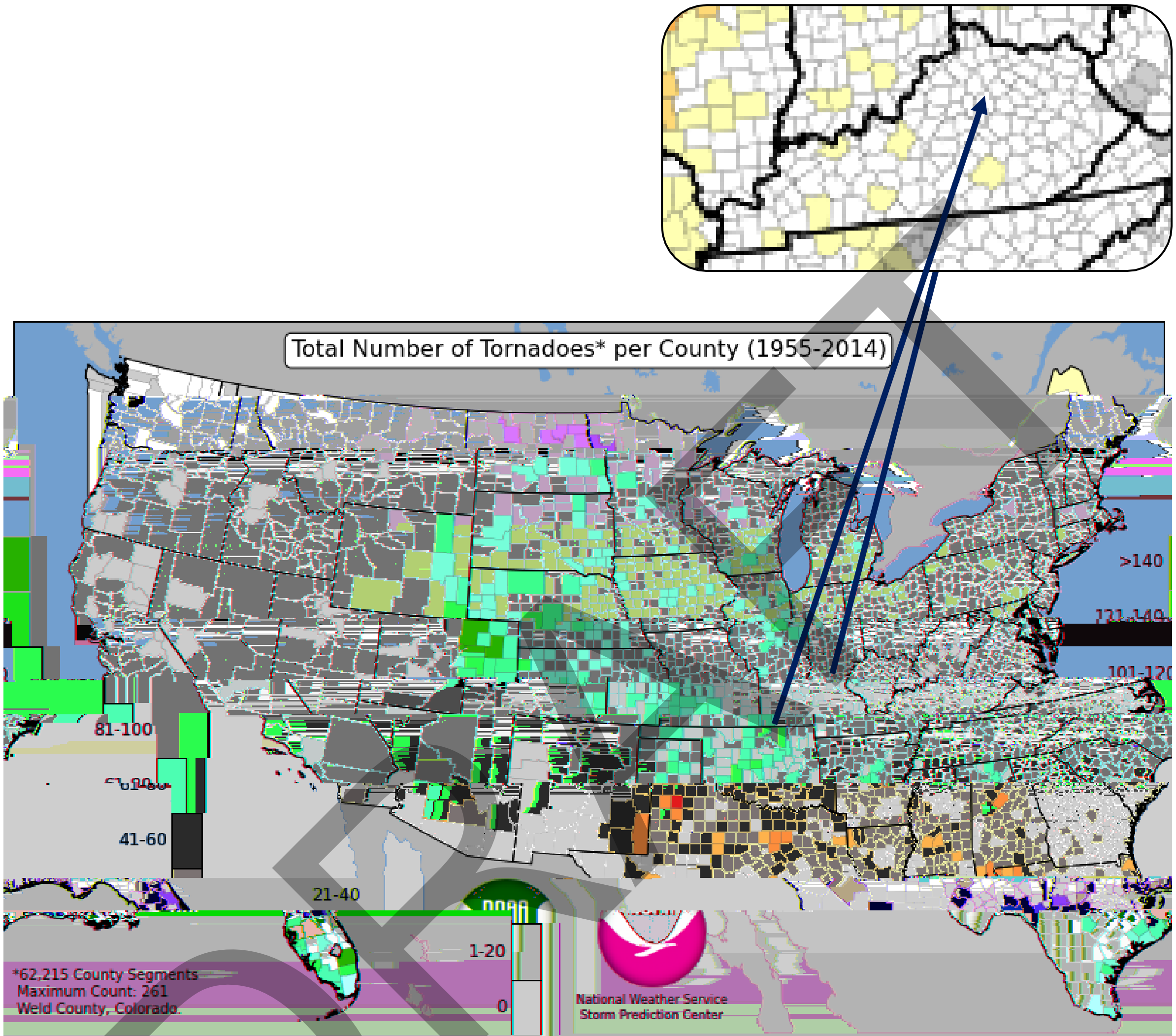

Figure 3-79: U.S. Tornado Occurrences by County

Tornadoes are most likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touchdown briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several miles long.

The destruction caused by tornadoes ranges from light to inconceivable depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damage to structures of light construction, including residential dwellings (particularly mobile homes). Tornadic magnitude is reported according to Fujita and Enhanced Fujita Scales. Tornado magnitudes prior to 2005 were determined using the traditional version of the Fujita Scale, **Table 3-47**. The Enhanced Fujita Scale, used after 2005 (**Table 3-48**), identifies six different categories of tornadoes, EF0 through EF5. Tornado magnitudes were determined in 2005 and later were determined using the Enhanced Fujita Scale.

Table 3-46: The Fujita Scale (effective prior to 2005)

F-Scale Number	Intensity	Wind Speed	Type of Damage Done
F0	GALE TORNADO	40–72 MPH	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
F1	MODERATE TORNADO	73–112 MPH	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	SIGNIFICANT TORNADO	113–157 MPH	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	SEVERE TORNADO	158–206 MPH	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	DEVASTATING TORNADO	207–260 MPH	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown, and large missiles generated.
F5	INCREDIBLE TORNADO	261–318 MPH	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete structures badly damaged.
F6	INCONCEIVABLE TORNADO	319–379 MPH	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

Table 3-47: The Enhanced Fujita Scale (effective 2005 and later)

Ef-Scale Number	Intensity Phrase	3 Second Gust	Type of Damage Done
EF0	GALE	65–85 MPH	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
EF1	MODERATE	86–110 MPH	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	SIGNIFICANT	111–135 MPH	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	SEVERE	136–165 MPH	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	DEVASTATING	166–200 MPH	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown, and large missiles generated.
EF5	INCREDIBLE	Over 200 MPH	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete structures badly damaged.

Tornado damage may include crop and property damage, power outages, environmental degradation, injury, and death. Tornadoes are known to blow off roofs, move cars and tractor trailers, and demolish homes. Typically, tornadoes cause the greatest damage to structures of light construction, such as residential homes.

In 1999, FEMA conducted an extensive damage survey of residential and non-residential buildings in Oklahoma and Kansas following an outbreak of tornadoes on May 3, 1999, which killed 49 people. The assessment found:

- The failure for many residential structures occurred when the framing wasn't secured to the foundation, or when nails were used as the primary connectors between the roof structure and the walls. A home in Kansas, for example, was lifted from its foundation. The addition of nuts to the foundation anchor bolts (connected to the wood framing) may have been all that was needed to prevent this.
- Roof geometry also played a significant role in a building's performance.
- Failure of garage doors, commercial overhead doors, residential entry doors or large windows caused a significant number of catastrophic building failures.
- Manufactured homes on permanent foundations were found to perform better than those that were not on solid foundation walls.

The National Weather Service (NWS) found from 1950 – 1991 peak months of tornado activity for Kentucky were April, May and June[118]. However, tornadoes have occurred every month and at all times of the year.

3.15.2 Location

Tornadoes have the potential to strike anywhere. Tornadoes are rarer in areas where there are lots of hills or mountains. Given the state's terrain, the mountainous eastern and southeastern regions of Kentucky will have less tornadic activity than central or western Kentucky[119]. Once a tornado touchdown occurs, it may only affect a small area or travel for miles, leaving substantial destruction in its path. Further, it is impossible to predict where and with what magnitude a tornado will strike. Therefore, it is assumed that all of UK's main campus is equally exposed to tornadoes. Outlying UK facilities in central or western Kentucky may have a higher exposure to tornadoes than located in the eastern part of the state.

3.15.3 Previous Occurrences

Main Campus

The NCEI Storm Events Database reports tornado information by county and, when the information is available, by city or by coordinate location. Since 1950, nine events have been reported in Fayette County. Two of these events occurred on UK's main campus – one in 1980 and another in 1986. No damage was identified for the university from NCEI or past news articles. Tornadoes reported in Fayette County are described in **Table 3-49.** Descriptions are provided based on the NCEI Storm Events Database[120], the NWS Tornado Climatology of Fayette County[121], and local news articles[122]. The tornado touchdown points and paths from NOAA's Severe Report Database are shown in **Figure 3-81**[123].

[118] From "Months of Peak Tornado Occurrence" NWS, https://www.weather.gov/cae/tornadobymonth.html
[119]From the section "Risk Assessment Wind: Tornadoes and Severe Thunderstorm" UK-HMGP (2018), *Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan*
[120] From "Storm Events Database" NOAA, *National Centers for Environment Information,* Storm Events Database | National Centers for Environmental Information (noaa.gov)
[121] From the website "Tornado Climatology of Fayette County" NOAA, *National Weather Service,* https://www.weather.gov/lmk/tornado_climatology_fayette
[122] From the article "The 15th Anniversary of the Masterson Station Tornado" LEX18 (2019), https://www.lex18.com/stormtracker-blog/2019/05/26/the-15th-anniversary-of-the-masterson-station-tornado/
[123] From the database "Storm Prediction Center" NOAA, https://www.spc.noaa.gov/gis/svrgis/

There were some differences between the two datasets. NCEI reported a tornado on 5/18/1995 that is shown in **Table 3-49**. The path was not included in NOAA's Severe Report Database. A tornado in 1974 was reported in NOAA's Severe Report Database (SVRGIS). **T**his tornado was not reported in the NCEI Storm Events Database.

Table 3-48: Fayette County Tornadoes from 1950 to 2022 (NCEI)

Date	Magnitude	Damages (2022 dollars)	Event Details
07/13/1956	F1	$303,399	None available
03/21/1962	F1	$273,375	None available
10/1/1977	F1	$1,359,795	None available
06/10/1980	F0	$99,977	None available
07/2/1980	F1	$999,773	None available
03/10/1986	F2	$75,197,841	Overall, 845 homes were damaged. The tornado wind speed peaked near-F3. Heavy damage was seen along Green River Court and at Pimlico Parkway. Approximately 150 families required emergency shelter. There were 20 reported injuries and no reported fatalities.
05/18/1995	F2	--	The tornado began as an F1 with wind speeds of 100 mph. The tornado blew several cars off U.S. 127 resulting in significant damage and several injuries. The tornado increased to a high end F2 with wind speeds of 145 mph when it struck West Jessamine County High School. There was extensive structural damage done to all portions of the building, along with the destruction of the tobacco barn and greenhouse. Eleven buses sustained significant damage with school children on the buses. At least 30 injuries occurred at the high school, one serious.
05/28/1996	F0	--	In the Clays Mill area and near the Copperfield sub-division, some trees were blown down and snapped off although little structural damage was done. The tornado lifted 4 miles southeast of Lexington. The supercell weakened thereafter and was overtaken by a squall-line.
05/27/2004	F3	$12,768,248	The tornado struck the Masterson Station neighborhood in the northwest side of Lexington. The tornado was on the ground for 3 miles with estimated winds up to 170 mph. The tornado damaged or destroyed over 150 homes. There were no fatalities, but 6 people were injured.

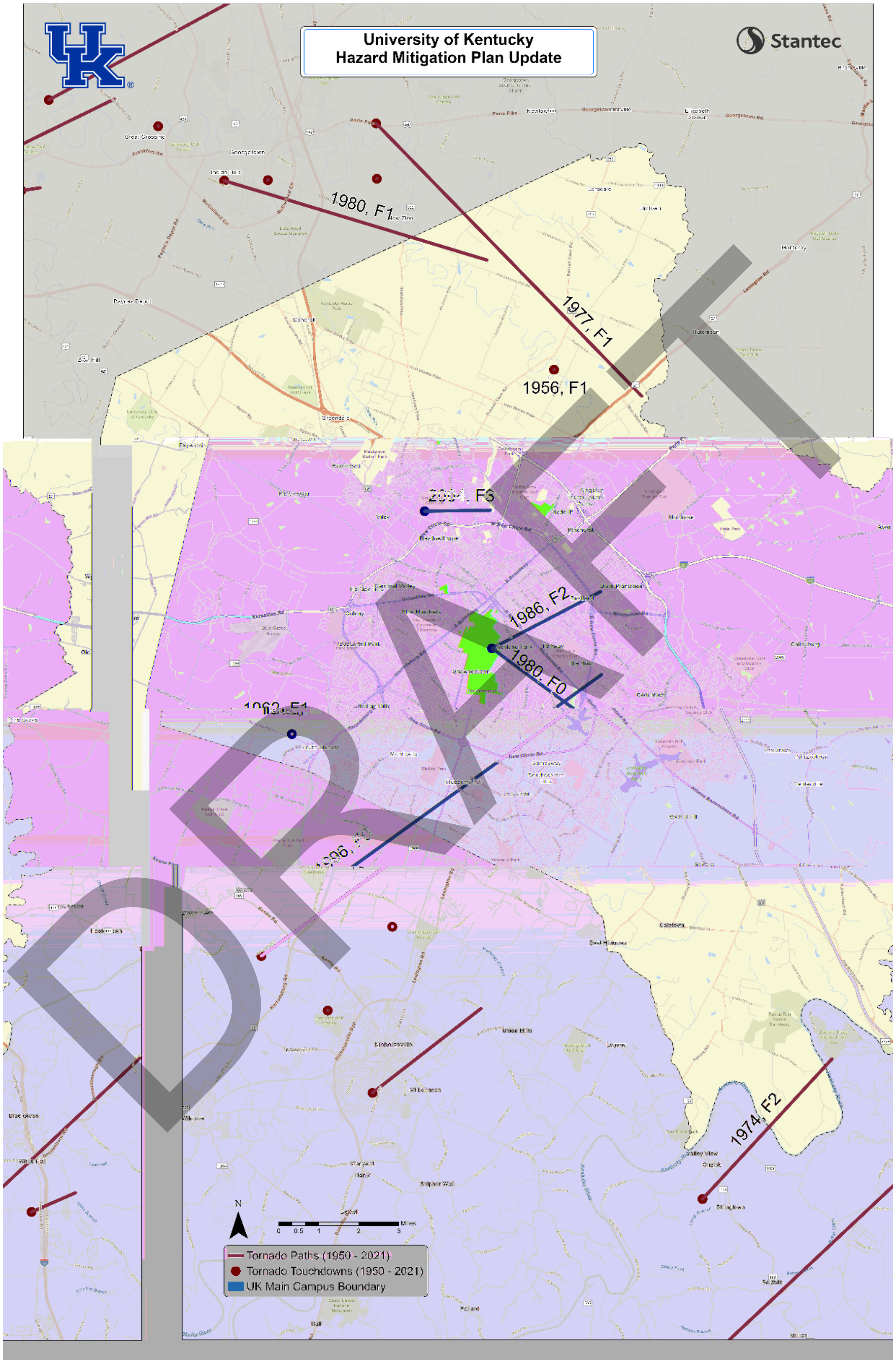

Figure 3-80: Historic Tornadoes in Fayette County 1950-2021 (SVRGIS)

Outlying Campuses and 4-H Facilities

UK Research and Education Center Tornado

The UK Research and Education Center (UKREC) took a direct hit from a tornado on December 11, 2021. UKREC is in Princeton, Kentucky. The center houses ongoing research, trainings and events. For large events such as Beef Bash, the site hosts over 500 people. The facility had recently undergone a major renovation and the addition of the UK Grain and Forage Center of Excellence which opened in 2019[124]. The UK Grain and Forage Center of Excellence before the tornado is shown in **Figure 3-82.**

Figure 3-81: UK Grain and Forage Center of Excellence

The historic EF-4 tornado started in northwest Tennessee and then crossed into Kentucky on December 11, 2021. The tornado crossed into Caldwell County where it achieved its highest rating of EF-4. A map of the tornado path is shown in **Figure 3-83.** This historic EF-4 tornado was associated with a very long-track supercell that originally formed over eastern Arkansas. The supercell produced a nearly continuous tornado damage path from northeast Arkansas, across western Tennessee, and western Kentucky. The starting point of the tornado that impacted the UKREC building was in northwest Tennessee, northwest of Union City. The average path width was a mile.

[124] From the article "Aerial Damage to the UK Grain and Forage Center of Excellence" Katie Pratt (December 12, 2021), *Grain and Forage Center of Excellence.* http://gfce.ca.uky.edu/

Figure 3-82: December 2021 Tornado Path, Princeton, KY Campus

The tornado directly hit the UKREC building destroying most of the facility. The tornado also damaged many homes within Caldwell County. In Caldwell County, there were 11 injuries and four fatalities. The UK Grain and Forage Center of Excellence following the tornado is shown in **Figure 3-84.**

Figure 3-83: UK Grain and Forage Center of Excellence Following the Tornado

Following the tornado, the center was not salvageable. UKREC employees led by the UKREC director led the recovery efforts. During an interview with the UKREC director, several notable impacts were recognized, as described below.

Some members of the community came to shelter at the facility because it was one of the newest and largest buildings in the area. The dedicated interior safe zone was one of the most impacted parts of the building.

For 13 months after the event, staff were working from temporary locations including temporary "tin can" facilities, cars, or at their homes. In January 2023, most staff returned to more permanent temporary offices on site.

The site contains almost 1,300 acres of land. Most of the facilities are congregated in one location, however people may work up to five miles away from the central buildings. There are no shelters for those performing research outside of the central area. In the summer, there are frequent thunderstorms. When there is a fast-approaching storm, depending on the location, staff do not have time to reach the central buildings. A majority of the first aid equipment is housed in the central area.

3.15.4 Extent

The greatest extent tornado to impact Fayette County was an F3 on the Fujita Scale (158–206 miles per hour). The greatest extent tornado to impact UK main campus was an F2 in 1986 on the Fujita Scale (113-157 miles per hour). The greatest extent tornado to impact any UK facility was the historic EF-4 (166-200 miles per hour) tornado that directly hit the UK Grain and Forage Center of Excellence in 2021. However, more severe events are possible. A single tornado event has the potential to be devastating to the campus and population.

3.15.5 Probability

With 9 tornados in the last 72 years, Fayette County experienced a tornado approximately every 8 years, on average. Two of the events occurring during this period impacted UK's main campus. It is possible that other unrecorded tornadoes have occurred. When considering the outlying facilities, the mountainous eastern and southeastern Kentucky will have less tornadic activity than central or western Kentucky[125].

When possible, climate variability should be considered when determining the probability of future hazard conditions. Observed trends show an increase in the number of tornado occurrences in Kentucky over the last 40 years, as detailed in the *Vulnerability Assessment* section of this profile. In projecting future conditions, trends in convective storm occurrences due to climate change are subject to greater uncertainty than temperature-related trends (such as extreme heat and cold events), and research is ongoing. Although studies are still being performed, a recent study cited by the National Climate Assessment indicates an increase in the occurrence of atmospheric conditions conducive to severe thunderstorm formation in the continental US. For the Kentucky spring season, the study indicates an increase of 1.2 to 2.4 days per season with severe thunderstorm environments during 2070-2099 compared to 1970 - 1999[126].

While it is difficult to quantify these trends in terms of future tornado occurrences, they can be considered when assigning future probability. Considering the above, a possible probability of (1 percent to 10 percent annual chance) was assigned.

3.15.6 Vulnerability Assessment

The entire UK main campus is vulnerable to tornadoes. The potential for loss of life and property damage are significant given the area's-built environment. All current and future buildings, infrastructure, and populations are considered at-risk to tornadoes, including critical facilities. Negligible dollar losses are attributed to tornado events on the main campus, but substantial future losses are possible.

Buildings located above-ground in the path of a tornado can suffer extensive damage and/or complete destruction. Although some buildings adjacent to a tornado's path can stand with little or no damage, debris hurled by the wind makes all buildings vulnerable to damage. Although all buildings are vulnerable to tornadoes, three types of structures are more likely to suffer damage:

- Mobile homes or units;
- Structures on crawlspaces (more susceptible to lift); and
- Buildings with large spans, such as airplane hangars, gymnasiums, and factories.

Schools and universities, such as UK, are a particular concern for at least two reasons:

- They have large numbers of people present including students, faculty, staff, and visitors. Community members may also seek shelter during severe weather at university facilities.

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[125]From the section "Risk Assessment Wind: Tornadoes and Severe Thunderstorm" UK-HMGP (2018), *Commonwealth of Kentucky's Enhanced Hazard Mitigation Plan*
[126] See "Robust increases in severe thunderstorm environmental in response to greenhouse forcing" Diffenbaugh, Scherer, & Trapp (August 20, 2013), *PNAS,* *https://www.pnas.org/doi/10.1073/pnas.1307758110*

- They have buildings with large span areas (open areas with high ceilings), such as gyms, atriums, and theaters.

Tornadoes can occur without warning, and reaction time may be short. Injuries or loss of life can result when people out in the open are in or near a tornado's path; exposed individuals can be picked by tornado winds or struck by debris. People inside structures that are impacted by tornadoes may suffer injuries or death if trapped in a collapsed building or struck by flying or falling objects. Motorists should not attempt to drive during a tornado event. The Centers for Disease Control recommend that any person in the path of a tornado find shelter or a tornado safe room immediately. Sheltering in a basement or under a sturdy object is recommended when a tornado safe room is not an option. Head injuries are a common cause of death from tornadoes; therefore, individuals should attempt to protect their heads during tornado events.

The University of Kentucky is particularly vulnerable to tornadoes given the large number of students and employees present on campus at any given moment. A parallel can be drawn to the University of Alabama, which in April 2011 experienced an EF-4 tornado that resulted in 36 fatalities, including several students and university employees. Due to damages and loss of life, the university cancelled the rest of the school year and delayed graduation.

Above-ground utilities and infrastructure are also vulnerable to tornadoes. Damage to certain exposed infrastructure, such as pipelines or septic tanks, can result in hazardous materials spills and leaks. Tornados can have devasting impacts with little warning time available; therefore, populations who are not able to quickly respond to warnings, such as those who are mobility challenged, non-English speakers, blind/sight impaired, or deaf/hard of hearing may have difficulty seeking shelter in a timely manner. The university has an emergency alert system, UK Alert, to send alerts to students, faculty, and staff during emergencies. Additionally, Fayette County Division of Emergency Management manages outdoor warning sirens throughout the county. Substantial damage could cause a reduction in university operations and/or cancelation of classes and events.

UK has facilities throughout the state. As noted in the Kentucky State Hazard Mitigation Plan, the eastern, northeastern, and southeastern parts of Kentucky are going to be far less likely to experience severe wind and tornadoes than the western end of Kentucky. Central Kentucky has moderate tornadic and severe wind activity when compared with the western part of the state. Northwestern Kentucky has high to severe exposure to winds and tornadoes.

There is still some uncertainty as to the specific link between tornadoes and changing climatic conditions, and more research is needed to understand the full impact of climate change on tornadic activity. Due to the small geographic area of tornado events, observation and modeling can be challenging. Because tornadoes are usually generated from thunderstorms, trends in tornado frequency and intensity are related to trends in thunderstorm frequency and intensity. Although studies are still being performed, a recent study cited by the National Climate Assessment indicates an increase in the occurrence of atmospheric conditions conducive to severe thunderstorm formation in the United States. For the Kentucky spring season, the study indicates an increase of 1.2 to 2.4 days per season with severe thunderstorm environments during 2070-2099[127].

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[127] See "Robust increases in severe thunderstorm environmental in response to greenhouse forcing" Diffenbaugh, Scherer, & Trapp (August 20, 2013), *PNAS.* *https://www.pnas.org/doi/10.1073/pnas.1307758110*

Another study cited by the *Fourth National Climate Assessment* highlighted that the number of days with a tornado in the U.S. have decreased; however, the number of days with multiple tornadoes has increased. This has resulted in increased variability in annual and monthly tornado trends, as well as increasing variability at the start of tornado season. Additionally, a recent study published by Northern Illinois University, in partnership with the NOAA, indicates that what is commonly referred to as "tornado alley" (e.g., Texas and the Great Plains) is shifting east, and that the frequency of tornadoes in the Southeast and Midwest regions is increasing[128]. **Figure 3-85** illustrates the study's findings of observed tornado trends over the last 40 years.

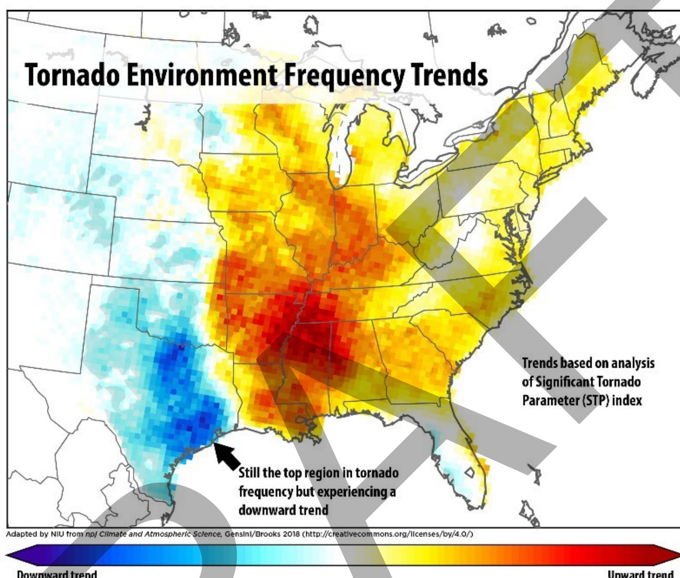

Figure 3-84: U.S. Tornado Frequency Shifting Eastward

3.16 Hazardous Materials Release

3.16.1 Description

Hazardous materials (HAZMAT) can be found in many forms and quantities that can potentially cause death; serious injury; long-lasting health effects; and damage to buildings, homes, and other property in varying degrees. Such materials are routinely used and stored in many homes and businesses and are also shipped daily on the nation's highways, railroads, waterways, and pipelines. HAZMAT incidents consist of solid, liquid, and/or gaseous contaminants that are released from fixed or mobile containers, whether by accident or by design as with an intentional terrorist attack. A HAZMAT incident can last hours to days, while some chemicals can be corrosive or otherwise damaging over longer periods of time.

In addition to the primary release, explosions and/or fires can result from a release, and contaminants can be extended beyond the initial area by persons, vehicles, water, wind, and possibly wildlife as well.

[128] From the article "Study: U.S. tornado frequency shifting eastward from Great Plains" Tom Parisi (October 17, 2018), *Northern Illinois University*. https://newsroom.niu.edu/study-u-s-tornado-frequency-shifting-eastward-from-great-plains/

The threshold for identifying fixed and mobile sources of hazardous materials is limited to general information on rail, highway, and local- and FEMA-identified fixed HAZMAT sites determined to be of greatest significance as appropriate for the purposes of this plan.

The Bureau of Transportation Statistics has reported the total number of HAZMAT incidents related to transportation systems each year from 1975 to 2022[129]. An average of approximately 16,000 HAZMAT incidents occurred each year. There was an average of 1,090 air-related, 14,097 highway-related, 815 rail-related, 29 water- related, and 10 other HAZMAT incidents.

HAZMAT incidents can also occur as a result of or in tandem with natural hazard events, such as floods, tornadoes, and earthquakes. In the case of Hurricane Floyd in September 1999, communities along the Eastern United States were faced with flooded junkyards, disturbed cemeteries, deceased livestock, floating propane tanks, uncontrolled fertilizer spills, and a variety of other environmental pollutants that caused widespread toxicological concern.

Hazardous material incidents can include the spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment of a hazardous material, but exclude:

- Any release which results in exposure to poisons solely within the workplace with respect to claims which such persons may assert against the employer of such persons
- Emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel or pipeline pumping station engine
- Release of source, byproduct, or special nuclear material from a nuclear incident
- The normal application of fertilizer

As a university, Hazardous Materials are on campus for operations, research, and medical practice. The University Environmental Quality Management Department (EQM) provides consultation and pick-up services for all UK campus and health care units to ensure safe and compliant hazardous waste management[130]. EQM runs programs focused on Hazardous Waste Management training, compliance assistance, minimization, and pick-up.

3.16.2 Location

As a result of the 1986 Emergency Planning and Community Right to Know Act (EPCRA), the Environmental Protection Agency provides public information on hazardous materials. One facet of this program is to collect information from industrial facilities on the release and transfer of certain toxic agents. This information is then reported in the Toxic Release Inventory (TRI)[131]. TRI sites indicate where such activity is occurring. There are 41 TRI sites located in Fayette County. These sites are shown in **Figure 3-86**.

[129] See “Hazardous Materials Fatalities, Injuries, Accidents, and Property Damage Data”, Bureau of Transportation Statistics (February 2024), https://www.bts.gov/content/hazardous-materials-fatalities-injuries-accidents-and-property-damage-data
[130] See “Hazardous Waste”, UK Environmental Quality Management, https://www.uky.edu/env/hazardous-waste
[131] See “TRI Search”, EPA, https://www.epa.gov/enviro/tri-search

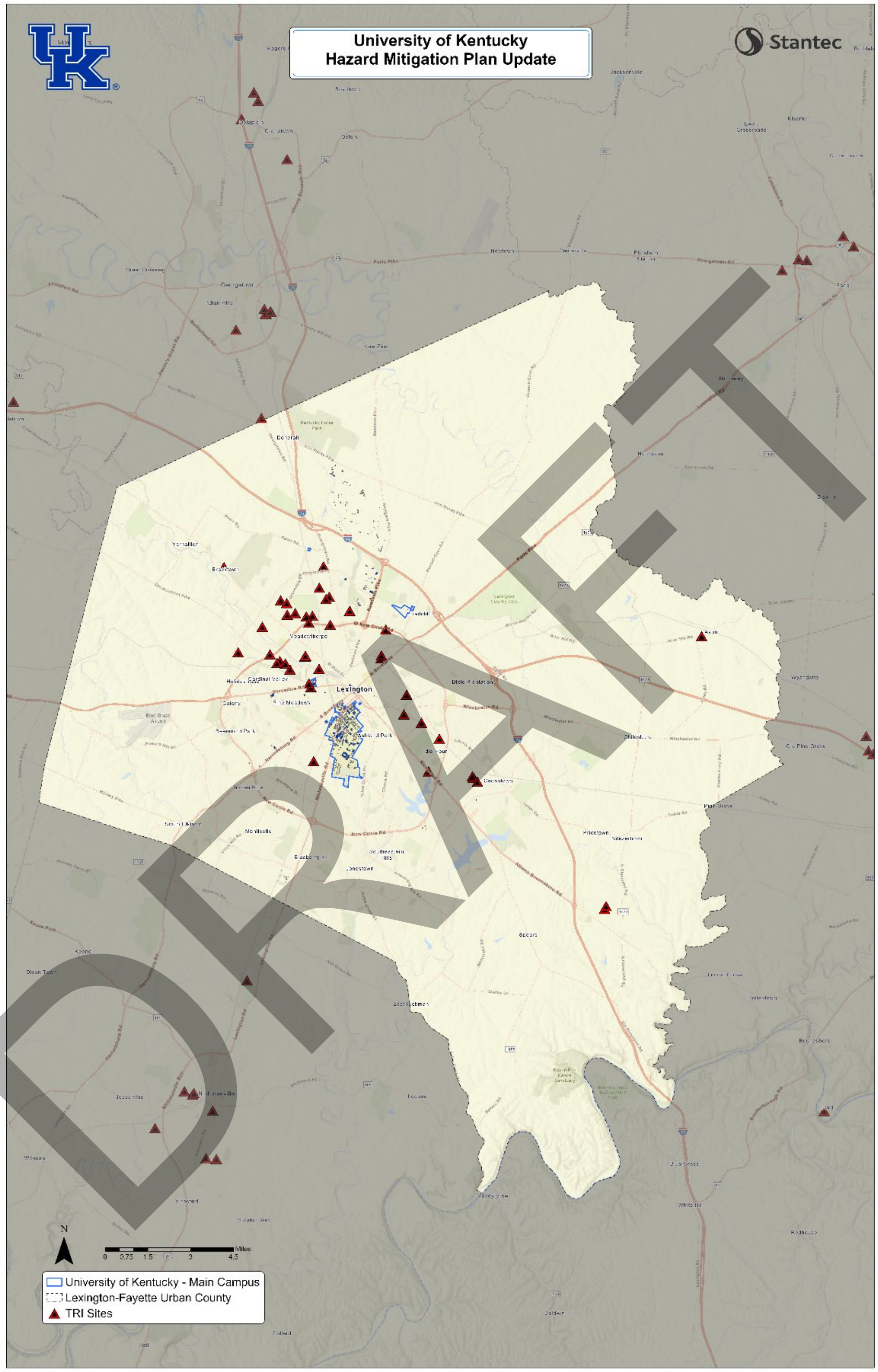

Figure 3-85: TRI Sites in Fayette County

The TRI did not include any sites on UK's campus. However, through the data collection process several buildings were noted as containing hazardous materials on the main campus. The buildings identified as HAZMAT on campus were all located on the main campus.

In addition, facilities along major roads, highways, and railroads are at an elevated risk for HAZMAT incidents due to the transport of hazardous materials. These areas are analyzed further in this hazard's *Vulnerability Assessment*.

316.3 Previous Occurrences

The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) lists mobile HAZMAT historical occurrences throughout the nation. A "serious incident" is a hazardous materials incident that involves:

- A fatality or major injury caused by the release of a hazardous material,
- The evacuation of 25 or more persons as a result of release of a hazardous material or exposure to fire,
- A release or exposure to fire which results in the closure of a major transportation artery,
- The alteration of an aircraft flight plan or operation,
- The release of radioactive materials from Type B packaging,
- The release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant, or
- The release of a bulk quantity (over 199 gallons or 882 pounds) of a hazardous material.

Prior to 2002, a hazardous materials "serious incident" was defined as follows:

- A fatality or major injury due to a hazardous material,
- Closure of a major transportation artery or facility or evacuation of six or more persons due to the presence of hazardous material, or
- A vehicle accident or derailment resulting in the release of a hazardous material.

From 2000 to 2022, 1248 mobile HAZMAT incidents have occurred in Fayette County, including 1,237 highway incidents and 11 air incidents[132]. No fatalities were reported but four incidents had reported injuries. Eight incidents are considered "serious incidents" as defined by PHSMA. Of the 1,248 reported HAZMAT incidents, 315 reported costs from damages. The serious incidents as defined by PHSMA are described in **Table 3-50**.

[132] From "Hazmat Incident Database", USDOT Pipeline and Hazardous Materials Safety Administration (November 2022), https://portal.phmsa.dot.gov/analytics/saw.dll?Portalpages&PortalPath=%2Fshared%2FPublic%20Website%20Pages%2F_portal%2FHazmat%20Incident%20Report%20Search

Table 3-49: Serious Mobile HAZMAT Incidents in Fayette County

Report Number	Date	Quantity Released (LGA* or SLB**)	Injuries/ Death	Total Damages	Mode Of Transportation	Description
I-2002101502	09/20/2002	55 LGA	0/0	$7,999	Highway	A drum was shrink wrapped on a skid along with two other drums. A forklift operator had loaded the skid of drums on the rear of an outbound trailer at the dock door. A short time later a road driver who was near the trailer noticed liquid leaking from the trailer onto the concrete trailer apron. The shift supervisor was notified, and he came with a forklift and pulled the skid off the trailer and placed it on the loading dock. The Fire Department/HAZMAT unit was notified and arrived a short time later. An emergency response team also came and cleaned up the spill and placed material in over pack drums.
I-2004010296	12/21/2003	380 LGA	0/0	$1,143	Highway	A driver pulled out of a loading dock with a riser attached to the truck.
E-2009040333	04/21/2009	50 LGA	0/0	$1,361	Highway	Improper forklift procedures by dock associate.
E-2013080279	08/12/2013	144 LGA	0/0	-	Highway	Freight tipped over in transit from the terminal to the consignee. Freight was not blocked and braced properly and was also double stacked. Terminal personnel recovered release for disposal immediately after discovery.

Report Number	Date	Quantity Released (LGA* or SLB**)	Injuries/ Death	Total Damages	Mode Of Transportation	Description
E-2014030255	01/10/2014	1173 LGA	0/0	$130,477	Highway	It was reported that a multivehicle accident caused the tractor to roll over, releasing UN2922 to the roadway and soil ditch. Due to the rollover accident, extensive damage occurred to the plastic totes that were used to transport the corrosive liquid. A replacement tanker was brought on site to carry any recovered product away from the release location. Once the product was transferred the trailer was righted and the cleanup operations took place. Absorbents and neutralizing agents were deployed, and the impacted roadway was swept up. The lanes of traffic were then allowed to flow, unimpeded. The release lasted approximately 10 hours. Diking was used to limit the migration of the release into the soil ditch. Boom and pads were used to collect some of the released material. All cleanup debris was collected and containerized for profiling and disposal. Soil was excavated once utility locations were completed.
I-2014040505	04/14/2014	0 SLB	0/0	-	Highway	A UPS unload supervisor detected a smoking package and notified a UPS designate responder. Upon arrival, the designated responder saw the package ignite. Management evacuated the building. The fire was extinguished with a fire extinguisher. Investigation after the incident showed the contents to be a motorized scooter powered by a non-spillable battery. The package did not display the appropriate markings for its contents.

Report Number	Date	Quantity Released (LGA* or SLB**)	Injuries/ Death	Total Damages	Mode Of Transportation	Description
E-2016101291	10/02/2016	363 LGA	0/0	$6,924	Highway	The driver states he got distracted by another driver while loading at MAP Lexington. The driver states his loading finished and he went to get paperwork. After retrieving paperwork, the driver started to drive off. He moved about 5 ft and heard the noise of the API head being torn off. The driver then went to the trailer and attempted to shut the internal valve. The driver left and then returned to successfully shut down the internal valve to stop the loss. Estimates that he lost between 300-500 gallons. The driver states that all the spill was contained inside the containment area. The duration of the release was approximately 60 seconds through a 4-inch aluminum pipe.
E-2018090104 (Also reported as E-2018090160)	07/05/2018	200 LGA	0/0	-	Highway	Associate did not block and/or brace freight properly for transport. Freight was crushed causing release of product.

*Liquid Gallons (LGA)

** Standard Pounds (SLB)

The EPA's TRI Toxics Trackers records releases by fixed HAZMAT sites. Between 2012 and 2021, there were 136 releases reported by 19 fixed sites in Fayette County[133]. In total, 914,995 lbs. were released during that time with 515,632 lbs. of air releases, 79 lbs. of water releases, 22,629 lbs. of land releases, and 376,655 lbs. of off-site releases. The releases are summarized by year in **Table 3-51**.

Table 3-50: TRI Releases by Year in Fayette County 2012 - 2021

Year	Sum of Releases (lbs.)	Number of Releases
2012	136,268	16
2013	152,021	16
2014	55,080	16
2015	66,371	16
2016	64,685	14
2017	61,116	13
2018	74,616	12
2019	100,679	12
2020	90,579	11
2021	113,580	10

3.16.4 Extent

The extent of hazardous materials incidents is defined by the amount of material released. According to USDOT PHMSA, the largest mobile hazardous materials incident reported in Fayette County between 2000 and 2022 was 1,173 liquid gallons (LGA) in January 2014. From the EPA's TRI Toxics Tracker, the largest fixed site release in Fayette County between 2012 and 2021 was 96,938 lbs. in 2013. HAZMAT incident extent can also be measured in terms of damages; the greatest number of damages from a single mobile incident occurred during the January 2014 incident, which reported $130,477 (2022 dollars) in damages. Damages were not included in the fixed site data. It is unknown if these events impacted the university, but a similar incident, or worse, is possible.

3.16.5 Probability

Probability is difficult to determine without a report of incidents that have specifically impacted the university, but probability can be gleaned from occurrences reported for the area. Fayette County has experienced approximately 57 PHSMA-reported mobile HAZMAT incidents per year since 2000. Fayette County has experienced approximately 14 fixed HAZMAT incidents a year between 2012 and 2021.

HAZMAT risk is also elevated by the presence of hazardous materials on campus, and by the presence of TRI sites adjacent to UK's properties. However, most events are generally cleaned up and remediated quickly.

[133] See "TRI Toxics Tracker", EPA, https://edap.epa.gov/public/extensions/TRIToxicsTracker/TRIToxicsTracker.html#continue

University officials are mindful of this possibility and take precautions to prevent such an event from occurring. Furthermore, there are detailed plans in place to respond to an occurrence and a team dedicated to managing hazardous materials on campus (Environmental Quality Management Department)[134]. However, a catastrophic event is less likely. Given the limited number of events reported at UK campuses and facilities, a probability of "possible" (1 to 10 percent annual chance) was assigned to this hazard.

3.16.6 Vulnerability Assessment

Most hazardous materials incidents that occur are contained and suppressed before destroying any property or threatening lives. However, they can have a significant negative impact. Such events can cause deaths, completely shut down facilities for a month or more and cause surrounding properties to be destroyed or suffer major damage. During a hazardous materials incident, solid, liquid, and/or gaseous contaminants may be released from fixed or mobile containers. Weather conditions will directly affect how the hazard develops. Certain chemicals may travel through the air or water, affecting a much larger area than the point of the incidence itself. Non-compliance with fire and building codes, as well as failure to maintain existing fire and containment features, can substantially increase the damage from a hazardous materials release. The duration of a hazardous materials incident can range from hours to days. Warning time is minimal to none.

To conduct the vulnerability assessment for this hazard, GIS analysis was used for fixed and mobile areas. In both scenarios, two sizes of buffers—500 and 2,500 meters—were used. These areas are assumed to respect the different levels of effect: immediate (primary) and secondary. Primary and secondary impact sites were selected based on guidance from FEMA 426, Reference Manual to Mitigate Potential Terrorist Attacks Against Buildings and engineering judgment.

For the fixed-site analysis, geo-referenced TRI sites in Kentucky, along with buffers, were used for analysis. The buffer analysis is shown for Fayette County in **Figure 3-87**. The results indicate the number of buildings at risk to HAZMAT Fixed Sites by campus as shown in **Table 3-52**. The properties of TRI Primary exposed buildings are shown in **Table 3-53.** TRI Secondary exposed buildings include 571 buildings. Given the number of TRI sites in Fayette County, the entirety of main campus is in the TRI Secondary exposure zone.

Table 3-51: UK Buildings at Risk to HAZMAT Fixed Sites in Kentucky

HAZMAT Fixed Sites		
Campus	**Primary (500 m buffer)**	**Secondary (2500 m buffer)**
Ashland	1	-
Bowling Green	1	-
Highland Heights	-	1
J.M. Feltner 4-H Camp	-	41
Main Campus	5	399
North Farm	2	55

[134] See "Hazardous Waste", UK Environmental Quality Management, https://www.uky.edu/env/hazardous-waste

HAZMAT Fixed Sites		
Campus	**Primary (500 m buffer)**	**Secondary (2500 m buffer)**
Versailles	-	7
West Kentucky 4-H Camp	-	51
Other	1	17
Total	**10**	**571**

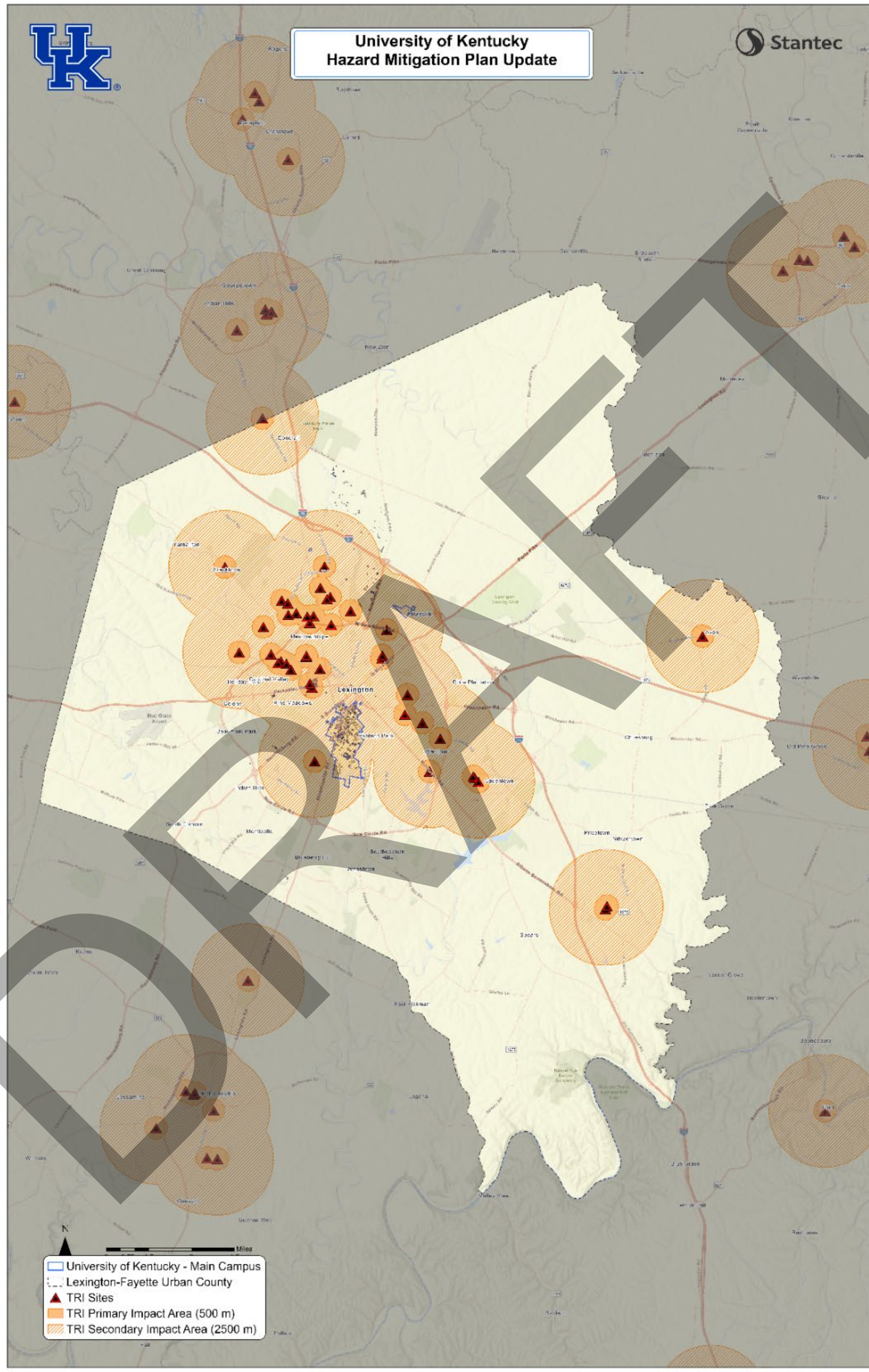

Figure 3-86: TRI Sites in Fayette County with Primary and Secondary Impact Areas

Table 3-52: UK Buildings at Risk to TRI Primary Sites (500 m buffer)

Building ID	Building Name	Campus	Building Value ($)	Content Value ($)	Research Value ($)	Building Condition
9770	UK College of Medicine at Bowling Green	Bowling Green	-	$3,842,997	-	Not Rated
-	King's Daughters Medical Center	Ashland	-	-	-	-
9881	Vaughan Warehouse #4	Main Campus	-	-	-	Not Rated
9879	Vaughan Warehouse #3	Main Campus	-	-	-	Not Rated
9882	Vaughan Warehouse #5	Main Campus	-	-	-	Not Rated
9875	Vaughan Warehouse and Office	Main Campus	$8,412,143	$3,000,000	$0	Not Rated
737	Campus Tree Upcycling Sawmill Pavilion	Main Campus	-	-	-	Not Rated
9936	Eastern State Hospital Central KY Recovery Center #1	North Farm	-	-	-	Not Rated
9921	Eastern State Hospital	North Farm	-	-	-	Not Rated
9486	Family Care Clinic	-	-	-	-	Not Rated

For the mobile analysis, the major roads (interstate highway, U.S. highway, and state highway) and railroads, where hazardous materials are primarily transported that could adversely impact people and buildings, were used for the GIS buffer analysis. The results indicate the number of buildings at risk to HAZMAT Mobile Sites by campus as shown in **Table 3-54**. The buffer analysis was performed for the entire state in relation to UK main campus and outlying campuses. **Figure 3-88** shows the major road analysis on UK's main campus. **Figure 3-89** shows the rail analysis on UK's main campus.

Table 3-53: UK Buildings at risk to HAZMAT Mobile Sites in Kentucky

Highways/Freeways		
Campus	**Primary (500 m buffer)**	**Secondary (2500 m buffer)**
Ashland	1	0
Bowling Green	1	0
Edgewood	0	1
Hazard	1	0
J.M. Feltner 4-H Camp	6	37
Lake Cumberland 4-H Camp	13	25
Main Campus	290	113
North Central 4-H Camp	14	31
North Farm	66	138
Paducah	2	0
Princeton - UK Research and Education Center	20	1
Robinson Center for Appalachian Resource Sustainability (RCARS) - Quicksand	19	0
South Farm	10	10
Versailles	0	33
West Kentucky 4-H Camp	2	49
Other	40	2
Total	**485**	**440**

Rails		
Campus	**Primary (500 m buffer)**	**Secondary (2500 m buffer)**
Ashland	0	1
Bowling Green	0	1
Edgewood	0	1
Hazard	0	1
Highland Heights	0	1

Rails		
Campus	Primary (500 m buffer)	Secondary (2500 m buffer)
J.M. Feltner 4-H Camp	0	43
Main Campus	158	246
North Farm	0	108
Paducah	0	1
Princeton - UK Research and Education Center	2	20
Robinson Center for Appalachian Resource Sustainability (RCARS) - Quicksand	0	19
South Farm	20	0
Versailles	0	14
West Kentucky 4-H Camp	0	51
Other	6	12
Total	**186**	**519**

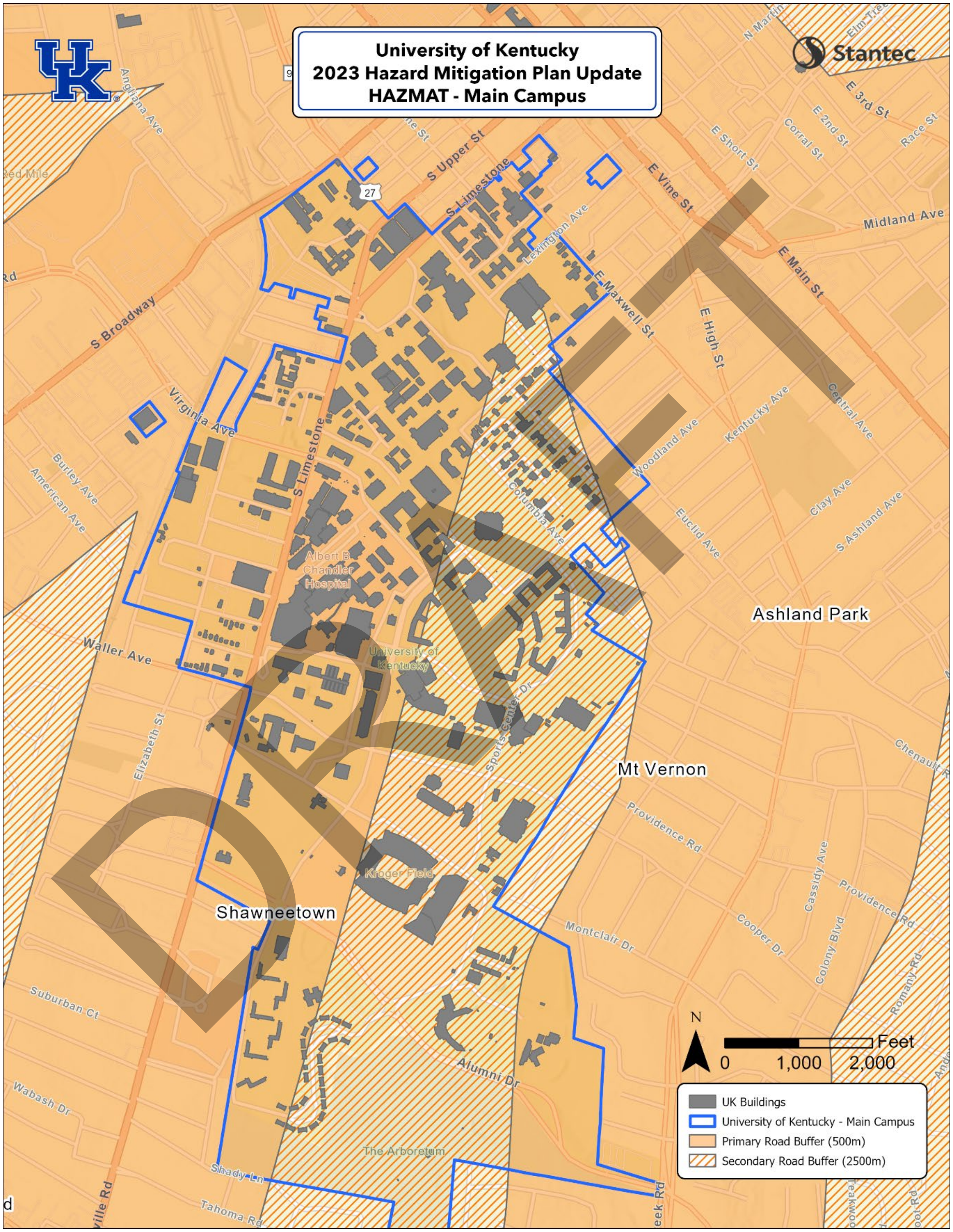

Figure 3-87: Major Road HAZMAT Buffers on UK's Main Campus

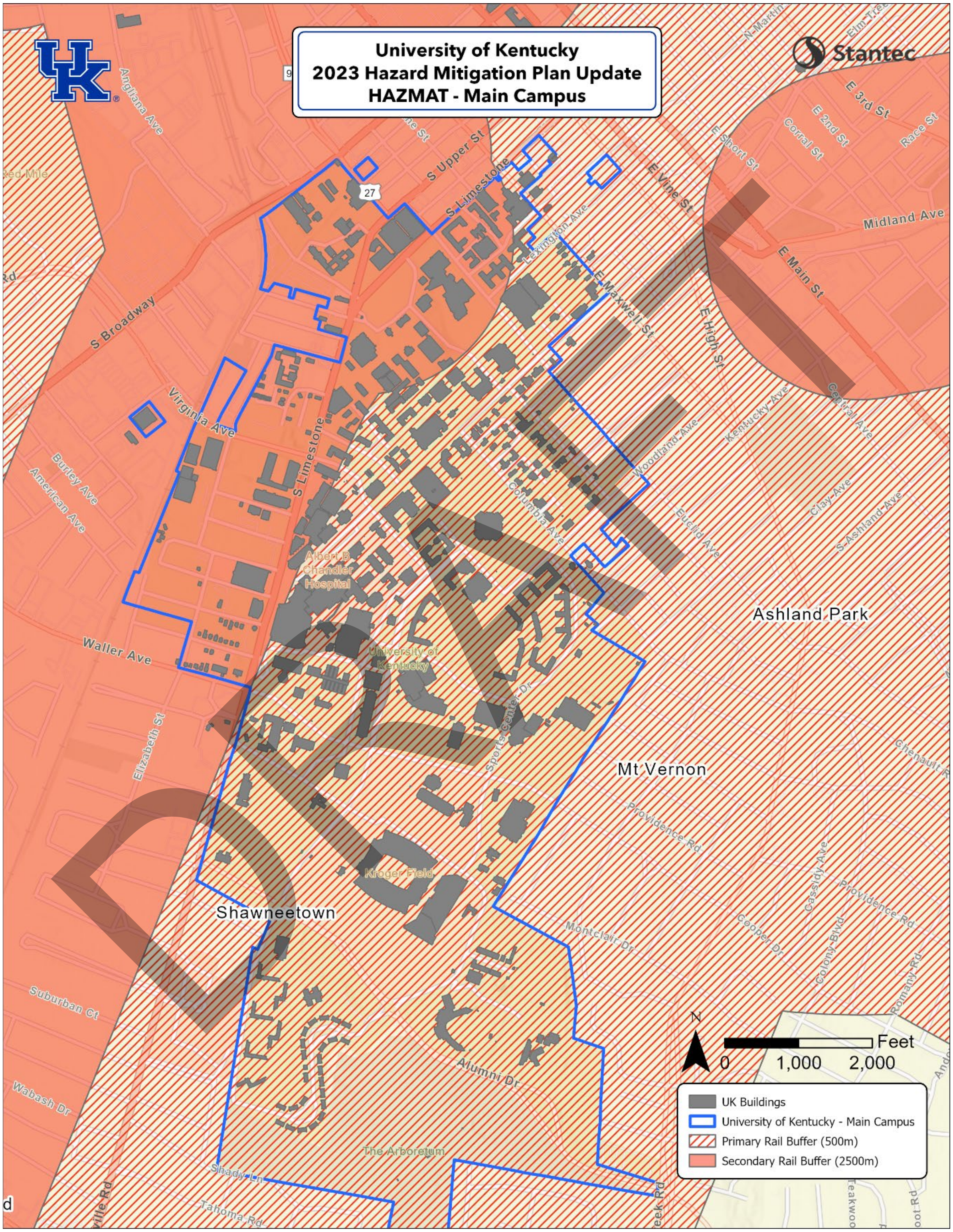

Figure 3-88: Rail HAZMAT Buffers on UK's Main Campus

Given the number of highways throughout the state and the proximity of UK facilities to highways, 925 of the 940 facilities (98 percent) were within a primary or secondary buffer zone to highways. Around 52 percent of UK buildings are in a primary buffer zone to highways and 47 percent of UK buildings are in a secondary buffer zone to highways.

A significant number of UK buildings fall into the rail primary and secondary buffer zone. Out of the 940 UK buildings, 705 buildings (75 percent) were within a primary or secondary buffer zone to rail. Around 20 percent of UK buildings are in a primary buffer zone to rail and 55 percent of UK buildings are in a secondary buffer zone to rail.

Infrastructure such as roads, bridges, railroad lines, and utilities have the potential to be impacted by hazardous materials incidents, particularly in an incident involving a corrosive material. Often, this infrastructure is used to transport hazardous materials, making them especially at-risk. HAZMAT incidents can result in injuries or fatalities when employees, responders, and civilians come in contact with hazardous materials. In certain events, people may not realize they have been exposed until symptoms are presented. HAZMAT incidents may result in the need for evacuations or sheltering in place.

HAZMAT incidents impact public health when incidents are widespread and/or long-lasting. HAZMAT incidents have the potential to contaminate drinking water sources, or to contaminate air through the release of toxic gases. One such example is Graniteville, South Carolina, where in 2005 a train derailment resulted in approximately nine deaths, 600 people seeking medical care, and the evacuation of over 5,400 people[135].

Socially vulnerable populations may be disproportionately impacted by hazardous materials releases. Within Fayette County, there are several census tracts that have high social vulnerability as defined by the CDC's Social Vulnerability Index[136]. Students, faculty, and staff associated with the University may live or work in socially vulnerable communities. Low-income neighborhoods are more likely to be located near facilities with noxious uses or adjacent to railroads or large highways. Illegal dumping of hazardous materials is also more likely to occur in low-income areas relative to high-income neighborhoods. Further, appropriate response measures for hazardous materials releases are not uniform – some events may require evacuations while others may require sheltering in place. Measures may include closing windows, sealing doors, and switching off HVAC intakes. Populations without access to information, such as internet or cellular service, or individuals with limited English proficiency may face challenges acting on response measures issued by the city of county. International students at UK may face a language barrier and are often on campus during breaks with only essential staff. In addition, the elderly or mobility challenged may struggle to evacuate or shelter in a timely manner. UK frequently has construction on campus which increases mobility challenges. Additionally, some historic buildings on campus are not ADA accessible. The deaf or hard of hearing may not hear audible evacuation orders or warnings. Once evacuated, deaf individuals or those reliant on medications or medical devices will require additional services and care considerations during response. Special accommodations for these populations must be considered in disaster planning processes. Additionally, those without health insurance may delay seeking out and receiving necessary health care services or emergency care.

Climate change is not expected to have direct impacts on hazardous materials incidents. However, HAZMAT incidents can be triggered by certain natural hazards, such as transportation accidents involving hazardous materials preempted by blinding downpours or severe winds. It is common for hazardous materials incidents (i.e., contamination) to occur as a secondary impact of flooding.

Therefore, the projected increase in extreme precipitation events in Kentucky may indicate a subsequent increase in HAZMAT incidents. Generally, if the frequency and intensity of natural hazards increases due to climate change, the frequency of HAZMAT incidents may increase as a result.

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[135] See "Collision of Norfolk Southern Freight Train 192 With Standing Norfolk Southern Local Train P22 With Subsequent Hazardous Materials Release at Graniteville, South Carolina", National Transportation Safety Board (January 2005), https://www.ntsb.gov/investigations/AccidentReports/Reports/RAR0504.pdf
[136] See "CDC/ATSDR Social Vulnerability Index (SVI)", Agency for Toxic Substances and Disease Registry, https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html

3.17 Cyber-Attack

3.17.1 Description

Cyber-attacks involve the use of computers, electronic devices, and/or the Internet to attack computer systems. There are several types of cyber-attacks, including:

- Computer viruses, which can damage infected computers
- Denial-of-service attacks, which can shut down a targeted website
- Hacking, in which sensitive information can be compromised

There are many different motives for cyber-attacks, including undermining public confidence in cyber security, vandalism, and obtaining or altering information to commit fraud, identity theft, extortion, or sabotage. For instance, confidential personal information, such as birth dates and Social Security numbers, can be sold by hackers to be used in identity theft activities. Additionally, ransomware restricts a user's access to their data and requires a user to pay the attacker prior to regaining access. A more recent cyber-attack capability is the ability to impair or destroy machinery by taking over the software that controls the machines. Cyber-attacks such as these could be used to damage critical infrastructure such as electrical grids, water treatment systems, and fuel pipelines.

Cyber-attacks can be ad-hoc or planned. Similarly, perpetrators of cyber-attacks can range from individual, amateur hackers to organized, highly skilled groups of "professional" criminals. Further, cyber-attacks can be committed by parties operating globally through the internet, making prevention, enforcement, and response challenging. **Table 3-56** describes common cybersecurity threats faced by universities[137].

Table 3-54: Common Cybersecurity Threats Faced by Universities

Type	Description
Phishing	Hackers pose as a trusted entity to trick users into providing sensitive information typically through email or social media. Hackers typically try to gather passwords to be able to login to the system as a trusted user.
Ransomware	Hackers attack the university's computer system with a type of malicious software that locates valuable data. The software holds the data and/or computer system access hostage unless the university pays the ransom sum.
SQL Injections	Hackers enter a piece of malicious code into a query box on a website such as a login page or contact form. The code allows the hacker to access and/or alter protected data.
Data Breaches	Hackers use several types of malware (software that can destroy data, affect computer performance, or allow internal access) to access valuable university data.
Outdated Technology	Many universities use outdated technology which puts them at a higher risk of more modern cybersecurity threats. Additionally, many students use their personal computers to access university systems and to perform research.

137 "Top 5 Cybersecurity Threats Facing Higher education", Fierce Education, Ashley Lukehard (July 2022), https://www.fierceeducation.com/technology/top-5-cybersecurity-threats-facing-higher-education

In context of the university, a cyber-attack is any willful criminal attack on the university's information system. Cyber-attacks have the potential to impact public safety, harm the university's critical functions and services, impair the integrity, confidentiality, and availability of information, and diminish public confidence in UK's ability to store and handle sensitive data. Cyber-attacks can have serious impacts on a university's reputation. Universities also contain expensive, cutting-edge equipment for research which may be targets to use for larger attacks.

Universities are often targets of cyber-attacks. In 2022, 44 colleges/universities were impacted by ransomware attacks[138]. The targeting of universities for cyber-attacks is likely due to the use of open networks and the large amount of data kept by higher education institutions, including personal information on students, alumni, faculty, staff, vendors, and research partners. Further, universities could be targeted for research data containing intellectual property regarding valuable or innovative products and services. While hundreds of university cyber-attacks have occurred in recent years, some notable attacks include:

- **Lincoln College.** In 2022, Lincoln College had to shut down following financial challenges due to the COVID-19 pandemic and a ransomware attack[139]. A December 2021 ransomware attack kept the college from being able to access its data including systems needed for enrollment, recruitment, and fundraising. The college faced significant enrollment shortfalls and was forced to close in May 2022.
- **University of California, San Francisco (UCSF).** In 2020, hackers attacked the university's medical school servers with ransomware[140]. To regain access to the servers, the university paid the hackers approximately $1.14 million.
- **Michigan State University.** In 2016, a database containing records of approximately 400,000 individuals, including, names, social security numbers, and university identification numbers, was breached[141]. The university offered free credit monitoring services to those potentially impacted.
- **Stanford University Hospital and Clinic.** In 2014, the health information of 20,000 hospital patients was posted on a website[142]. Following a class-action lawsuit, the case was settled at $4 million.

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[138] "No improvements: Schools were hit steadily with ransomware attacks in 2022", University Business, Michah Ward (January 2023), https://universitybusiness.com/no-improvements-schools-were-hit-steadily-with-ransomware-attacks-in-2022/#:~:text=There%20were%2045%20school%20districts,rose%20to%2058%25%20in%202022.
[139] "College Closing Another Sad Milestone for Ransomware Impact", Government Technology, Dan Lohrmann (May 2022), https://www.govtech.com/blogs/lohrmann-on-cybersecurity/college-closing-another-sad-milestone-for-ransomware-impact
[140] "UCSF pays hackers $1.1M to regain access to medical school servers", Fierce Healthcare, Heather Landi (July 2020), https://www.fiercehealthcare.com/tech/ucsf-pays-hackers-1-14m-to-regain-access-to-medical-school-servers
[141] "MSU: We won't pay hacker demanding ransom, threatening university over records", Detroit Free Press, Samuel Zwickel (June 2020), https://www.freep.com/story/news/education/2020/06/03/michigan-state-hackers-ransom-breach-records/3134361001/
[142] "Stanford Hospital, Bas agree to $4 million breach settlement", Health IT Security, Patrick Ouellette (March 2014), https://healthitsecurity.com/news/stanford-hospital-agrees-to-4-million-breach-settlement

3.17.2 Location

The entire campus and its systems are assumed to be at risk of cyber-attacks. University IT nodes, servers, and databases that store personal or sensitive information, especially those associated with the hospital, may be more likely to be targeted for a cyber-attack.

3.17.3 Previous Occurrences

As noted by officials with UK's Information Technology Services (ITS), the University's cyber systems are constantly threatened, and university personnel must constantly monitor systems to stay ahead of attacks. The university routinely manages phishing and other types of cyber intrusions.

According to news sources, two previous cyber-attacks have been identified at UK.

- An annual cybersecurity inspection by the university in 2021 identified that an unauthorized individual likely gained a copy of a College of Education database.[143] The database contains the names and email addresses of over 355,000 individuals involved with the Digital Driver's License training program. Personal information such as financial, health, or social security information were not included in the database.
- In February 2020, unidentified hackers from outside the university infiltrated UK HealthCare computer networks and installed malware to use UK's processing capabilities to mine cryptocurrency[144]. The attack led to some computer systems to slow or temporarily fail. In March 2020, the university had to reboot its computer networks causing a three-hour campus-wide network outage to mitigate the threat. An investigation into the attack found no evidence that patient or student data was compromised.

3.17.4 Extent

The severity of cyber-attacks can be measured in terms of records breached or data compromised. The 2021 College of Education breach that led to 355,000 names and emails being released was the most severe. While there was no evidence of data breach in the February 2020 UK HealthCare attack, some computer systems slowed or temporarily failed. Additionally, a three-hour campus-wide network outage was needed to mitigate the threat. It should be noted that cyber-attacks affecting more individuals are possible.

3.17.5 Probability

Due to reports from university officials, upwards trends in cyber-attacks, and the potential for attacks that have not been discovered or reported, the probability assigned to a successful cyber-attack is likely (10 to 90 percent annual chance). It should be noted that the university experiences attempted attacks routinely, however the vast majority of these are blocked prior to impacts occurring.

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[143] "UK Cyber Inspection Detects Breach, Initiates Additional Security Measures", UKNOW, Sarah Geegan (August 2021), https://uknow.uky.edu/campus-news/uk-cyber-inspection-detects-breach-initiates-additional-security-measures
[144] "Univ. of Kentucky, UK Healthcare Ends Month-Long Cyberattack", Campus Safety, Amy Rock (March 2020), https://www.campussafetymagazine.com/hospital/univ-of-kentucky-uk-healthcare-cyberattack/

3.17.6 Vulnerability Assessment

All current and future university buildings (including critical facilities), infrastructure, and populations are potentially at risk, directly and indirectly, to cyber-attacks. Universities are especially vulnerable to cyber-attacks due to the large number of users on personal devices and use of open networks. Cyber-attacks can occur on an individual (i.e., viruses and malware) or large-scale basis (i.e., hacking of university databases, taking control of critical facilities).

UK is a research university, as such has valuable research data spanning many fields that is stored on its network and on its servers. Potential cyber-attacks may be aimed at stealing information or intellectual property for personal, political, or financial gain, such as the releasing or selling of intellectual property or groundbreaking research, holding intellectual property for ransom, or destroying valuable research to further or promote a political agenda. While all academic departments and research facilities within the university are vulnerable, UK Healthcare holds additional vulnerability because it handles confidential patient information.

Further, cyber-attacks could be targeted at critical facilities and infrastructure, with the aim of harming life and property. Any software used for building or facility access control, or automated messaging, may also be at risk of cyber-attacks. Additionally, databases containing sensitive personal information, such as those associated with the admissions and alumni offices or patient medical records associated with the hospital and its clinics, as well as servers storing or backing-up valuable or confidential personal data are vulnerable to cyber-attacks.

Overall, potential impacts of cyber-attacks on the university may include:

- Permanent or temporary loss of access to data (e.g., research, course websites, patient files, administrative information)
- Loss of important research
- Monetary damages (e.g., lawsuits and other costs associated with breached personal information)
- Funds spend on investigations into attacks, providing notice and support to those affected, mitigation to parties affected (e.g., LifeLock)
- Physical damage to property (and population impacts) stemming from losing control of software associated with UK's critical infrastructure

Aside from the impacts listed above, the reputational impact on the University from a large-scale breach would be immense and may lead to people being fearful to conduct confidential research with UK. A large-scale breach could also result in difficulty recruiting students, faculty, and research partners. This would have a detrimental impact on the University, its mission, and its functionality.

3.18 Emerging Infectious Diseases

3.18.1 Description

An infectious illness outbreak is the occurrence of a disease in excess of what would normally be expected in a certain geographic area, in this case UK's campus. An outbreak may last only a few days or weeks but could also last several years. Further, a single case of a communicable disease not previously recognized in the defined area may also be recognized as an outbreak and require investigation[145]. An infectious illness outbreak is often referred to as an epidemic. An epidemic or outbreak can occur when there are sufficient numbers of a disease agent and susceptible hosts, and the agent is effectively conveyed from the source to hosts. The following mechanisms may result in an epidemic:

- An increase in the amount and/or the potency of a disease agent
- The introduction of a disease agent into a new location
- An enhanced mode of transmission, increased exposure
- A change in the susceptibility of the host to the agent
- An increase in host exposure through new portals of entry

An outbreak may occur in several different patterns, including:

- A common-source outbreak: a group of individuals are all exposed to an infectious agent or toxin from the same source (e.g., a group of patrons who all ate lettuce from a specific restaurant contract Hepatitis A)
- A propagated outbreak: a disease is transmitted by person-to-person contact, by a vehicle (e.g., needles), or by a vector (e.g., mosquito)
- A mixed outbreak: a common-source outbreak occurs and is then spread from person-to-person
- Other outbreaks: a disease is not spread by either a common source or propagated from person-to-person. This can be the result of sufficient interaction between humans and vectors (e.g., the epidemic of Lyme disease in the northeastern U.S. in the 1980s, in which the disease spread from deer to ticks to humans)

In addition to localized or regional epidemics, infectious illness outbreaks can also be pandemic in nature, meaning the outbreak occurs at the national or global level.

[145] From “Disease Outbreaks”, World Health Organization, https://www.emro.who.int/health-topics/disease-outbreaks/index.html

University campuses are recognized as being highly susceptible to infectious illnesses and outbreaks, due to living conditions (e.g., residence halls) and behaviors in which college students are in close proximity to one another (e.g., classrooms, sports teams, social gatherings). In recent years, a few notable infectious illness outbreaks on university campuses include:

- **2013-2014:** Nine students at Princeton University in New Jersey contracted serogroup B meningococcal meningitis (an infection of the brain and spinal cord that can cause brain damage and death)
- **2015-2016**: Hundreds of university students from Iowa and Illinois contracted mumps
- **2018**: About 100 students presented symptoms of a norovirus at Davenport University in Grand Rapids, Michigan. Officials decided to close the main campus for several days, which hosts 3,000 students
- **2020 - ongoing**: On March 27, 2020, a major disaster declaration was declared for the COVID-19 Pandemic response. Between 2020 and May 2021, over 700,000 COVID-19 cases were linked to American colleges and universities[146]

Emerging infectious diseases are outbreaks of previously unknown diseases, known diseases that are rapidly increasing in incidence or geographic range over the last two decades, or the persistence of infectious diseases that cannot be controlled[147]. Since the 1970s, approximately 40 infectious diseases have been discovered including COVID-19[148]. In 2007, the World Health Organization (WHO) reported that infectious diseases are emerging at a rate that has never been seen before. With the trends of increased travel, population density, and closer contact with wild animals, the potential for emerging infectious disease-causing global epidemics is a major concern.

3.18.2 Location

The entire university, including all campuses and 4-H camps, is presumed to be at-risk for emerging infectious diseases. The main campus may be at a higher risk due to a relatively high student population and the presence of a hospital. Students living in residence halls, fraternity or sorority houses, or off-campus housing may be at a higher risk for contracting infectious diseases. In addition, staff and students working at the hospital may also be at a higher risk. COVID-19 has likely had the largest overall impact on UK in recent history when considering the number of cases, deaths, educational disruptions, and societal impacts. However, more severe events are possible.

3.18.3 Previous Occurrences

The university deals with a range of infectious illnesses whether they are isolated to campus, regional, or pandemics. Some, such as the **flu**, occur every year at levels that require planning and response from the university.

[146] See “Tracking Coronavirus Cases at U.S. Colleges and Universities”, The New York Times (2021), https://www.nytimes.com/interactive/2021/us/college-covid-tracker.html
[147] From “Emerging Infectious Diseases”, Johns Hopkins Medicine, https://www.hopkinsmedicine.org/health/conditions-and-diseases/emerging-infectious-diseases
[148] From “Emerging Infectious Diseases”, Baylor College of Medicine, https://www.bcm.edu/departments/molecular-virology-and-microbiology/emerging-infections-and-biodefense/emerging-infectious-diseases

From 2008 to 2015, Kentucky had the highest rate of new **Hepatitis C Virus** (HCV) infection in the nation[149]. Most cases occurred for individuals between the ages of 18 – 24 and 25- 34.

In 2009, the university responded to the **H1N1** outbreak by implementing several public health measures and forming a planning workgroup[150]. The outbreak peaked in November 2009. UK response included vaccine clinics and public information[151].

On March 27, 2020, a major disaster declaration was declared for the **COVID-19** Pandemic response. UK moved the spring semester online following the outbreak of the pandemic. In Fall 2020, UK resumed classes on campus after developing "UK's Playbook for Reinvented Operations" to guide the return to campus while managing the risk of COVID-19[152]. Between 2020 and May 2021, over 4,000 COVID-19 cases were associated with UK[153]. As of February 2023, Fayette County has reported over 120,000 total cases and 730 deaths from COVID-19[154]. The university followed CDC guidance through information pages, guidelines and policies, symptom assessments, testing, vaccines, and other resources[155]. As the COVID-19 pandemic transitions to an endemic, UK scaled back its response following CDC Guidance.

UK HealthCare played a key role in Kentucky's response to the pandemic. During the pandemic, UK HealthCare took on many roles including treating patients with COVID-19, setting up a field hospital in case more capacity was needed, running drive-through testing clinics, providing public education about the disease, coordinating supplies and treatment with other hospitals, and leading vaccine clinics. UK HealthCare served as a leader for the state while facing other challenges such as staff safety, staff burnout, staff retention, childcare for essential staff with children, and public transportation for staff.

There are other diseases that do not have recorded occurrences on campus but have the potential to impact the university, as the university must preemptively use resources to take precautions against the disease. Examples of these diseases include Measles, which is an ongoing significant concern that has impacted several institutions of higher education. **Ebola** was of concern in 2014 due to global attention to outbreaks and UK Hospital's status as a trauma 1 center. The **Zika** virus was also a concern in 2016, especially with the large number of students and faculty traveling to impacted areas, as well as visitors on campus from impacted countries.

3.18.4 Extent

The severity of public health risks is difficult to determine given the varying impacts associated with different events. COVID-19 had the largest overall impact on UK in recent history when considering the number of cases, deaths, educational disruptions, and societal impacts. As a result of the COVID-19 pandemic, many universities, including UK, became eligible for federal grant money due to expenses and forgone revenue related to the disruption of campus activities from the pandemic156.

[149] From "State Health Assessment", Kentucky Public Health (2017), https://www.chfs.ky.gov/agencies/dph/Documents/StateHealthAssessment.pdf
[150] From "Healthcare Services ready for H1N1 rush", Laura Clark (August 2009), Kentucky Kernel, https://kykernel.com/80235/news/healthcare-services-ready-for-h1n1-rush/
[151] From "Local, national H1N1 numbers consistent", Kentucky Kernel (November 2009), https://kykernel.com/78659/news/local-national-h1n1-numbers-consistent/
[152] See "UK's Playbook for Reinvented Operations", University of Kentucky (2020), https://coronavirus.uky.edu/sites/default/files/2020-06/PLAYBOOK%20-%206:16:2020.pdf
[153] See "Tracking Coronavirus Cases at U.S. Colleges and Universities", The New York Times (2021), https://www.nytimes.com/interactive/2021/us/college-covid-tracker.html
[154] See "COVID-19 Update", Lexington-Fayette County Health Department (February 2023), https://www.lfchd.org/
[155] See "COVID-19: University of Kentucky", UK Libraries, https://libguides.uky.edu/covid19/uky
[156] From "University of Kentucky 2021 Financial Statements", University of Kentucky, https://www.uky.edu/ufs/sites/www.uky.edu.ufs/files/2021%20Consolidated%20Financial%20Statements.pdf

UK was awarded $50.2 million under the Coronavirus Response and Relief Supplemental Appropriations Act and American Rescue Plan for institutional costs and foregone revenue related to the pandemic. UK received an additional $41.4 million in federal relief funds for student emergency financial grants. These numbers represent a piece of the financial impact COVID-19 had on the University. COVID-19 also impacted enrollment numbers at the university. In fall 2020, UK saw a decrease in freshmen entering the institution by 8.5 percent and an increase in graduate enrollment by 8.3 percent. However, more severe events are possible.

3.18.5 Probability

The probability of public health emergencies impacting UK is variable, with a mix of chronic public health risks and acute outbreaks. Many public health risks occur seasonally and are ongoing, such as the common cold and influenza. Major outbreaks, such as the COVID-19 pandemic, are less common. Based on the information available regarding historic or current events, this hazard was assigned a probability of likely (10 percent to 90 percent annual chance).

3.18.6 Vulnerability Assessment

All current and future populations on UK's campus are considered at risk of infectious illnesses. Buildings and infrastructure are not typically impacted by infectious illnesses but may need to be sterilized or decontaminated in some cases. Infectious illness outbreaks can include an above average occurrence of a common disease, such as the flu, or a single case of a disease not formerly diagnosed on campus. As a university, UK has characteristics that make it vulnerable to infectious illnesses, include the close living quarters associated with residence halls and university housing, communal dining halls and bathrooms, and classrooms and libraries where large numbers of students work in close proximity to one another. These factors allow for diseases to spread quicker than they would in other settings. Further, the university receives visitors from all over the world, and has many faculty and students that travel abroad, increasing the risk of bringing a disease from another country or region back to campus.

In addition, UK's hospital system, UK HealthCare, treats patients with uncommon infectious diseases; these patients could be local, or from all over the world, as UK HealthChas many specialized facilities. To manage infectious diseases, UK follows federal and state guidelines as well as maintains all necessary accreditations. UK HealthCare also coordinates closely with the Fayette County Health Department. The capabilities of UK HealthCare discussed in more detail in the **Capability Assessment.**

An infectious illness outbreak could have severe impacts for the university. Students, faculty, and staff who contract infectious diseases could become sick or die as a result of the illness. In extreme cases, classes may have to be canceled or the University may have to implement quarantines or campus reductions in operations in order to minimize the spread of disease. During the COVID-19 pandemic, the University had to move classes online, implement quarantines, run testing facilities, and severely alter operations.

The university takes precautions against infectious illnesses. Prior to and during flu season, the university encourages students to get flu shots and promotes public awareness campaigns to self-quarantine if a student displays flu symptom.

Aside from the public health impacts described above, the reputational impact on the university from a high-profile infectious illness outbreak would be immense and may lead to people being fearful to come to campus or interact with students, staff, and facility.

Increases in temperature, precipitation, and humidity associated with climate change may all have impacts on public health. Warmer and wetter conditions create a more favorable environment for the growth and spread of some vector-borne infectious diseases, such as mosquito-borne viruses[157]. Insects also have a limited range of temperatures where they can live, which may bring new insects to the area or lead to the decline of others. Conversely, warmer and more humid weather generally weakens the spread of certain respiratory illnesses, such as influenza.

Changing climate conditions may also lead to virus mutations and adaptation leading to a rise in emerging diseases. It will also shift habitats for wildlife and livestock, bringing different animals, and their diseases, closer to humans.

[157] See "How might climate change affect the spread of viruses?", *Medical News Today*, James Kingsland (2020), https://www.medicalnewstoday.com/articles/how-might-global-warming-influence-the-spread-of-viruses

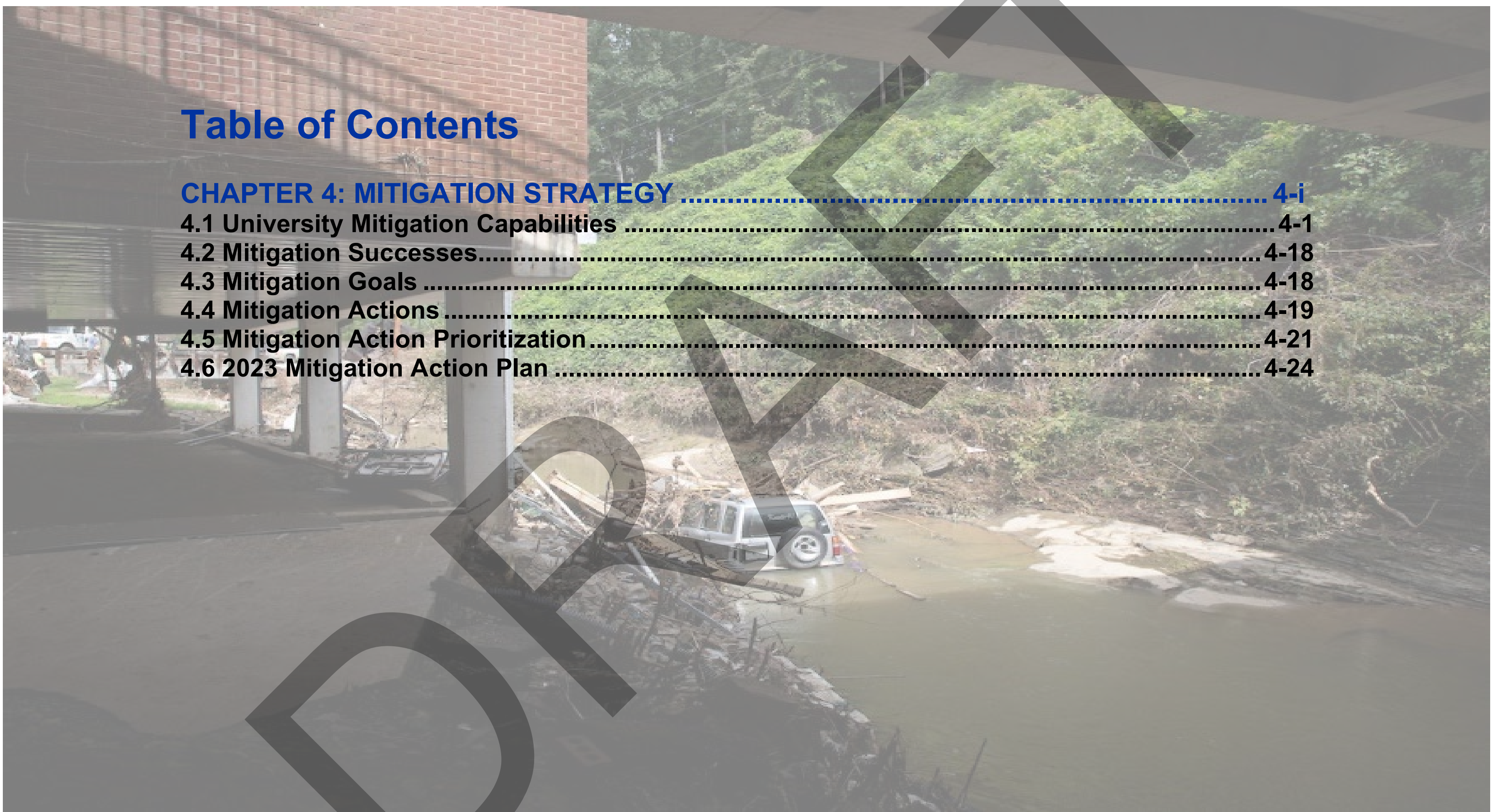

Table of Contents

Chapter 4: Mitigation Strategy

FEMA's Local Mitigation Plan requirements encourage agencies at all levels, educational institutions, local residents, businesses and the nonprofit sector to participate in the mitigation planning and implementation process. This broad public participation enables the development of mitigation actions that are supported by stakeholders and reflect the needs of the community.

The mitigation strategy update is based on marked progress from the 2016 mitigation plan, the results of the 2023 risk assessment, and lessons from experiencing three presidential declarations in a two-year period. The plan includes proactive activities, projects and programs that will help university students, faculty, staff and other stakeholders to better mitigate, prepare, respond and recover from disaster events.

The following mitigation strategy provides a comprehensive overview of the following sections:

- University Mitigation Capabilities
- Mitigation Goals
- Mitigation Actions

The intent of the mitigation strategy is to provide UK with the goals that will serve as guiding principles for future mitigation policy and project administration along with an analysis of mitigation actions deemed obtainable to meet those goals and reduce the impact of identified hazards. It is designed to be:

- Comprehensive – the development of the mitigation strategy includes a thorough review of all hazards and identifies mitigation measures intended to not only reduce the future impacts of hazards, but also to help the university achieve compatible economic, environmental, social and security goals.
- Strategic – the development of the mitigation strategy works to align proposed policies and projects with pre-identified, long-term planning goals.
- Functional – each proposed mitigation action is linked to established priorities and assigned to specific divisions, departments or individuals responsible for their implementation with target completion deadlines. When available, funding sources are identified to assist in project implementation.

4.1 University Mitigation Capabilities

The capability assessment determines the ability of UK to implement a comprehensive mitigation strategy and identifies potential opportunities for establishing or enhancing specific mitigation policies, programs or projects. As in any planning process, it is important to try to establish which goals, objectives, and/or actions are feasible based on an understanding of the organizational capacity of those departments tasked with implementation. A capability assessment helps to determine which mitigation actions are practical and likely to be implemented over time, given UK's planning and regulatory framework, level of administrative and technical support, and number of fiscal resources.

The capability assessment has three components: 1) an overview of the organizations involved with mitigation 2) an inventory of UK's relevant plans, ordinances or programs already in place and 3) an analysis of its capacity to carry them out.

Careful examination of university capabilities will detect existing gaps, shortfalls or weaknesses with ongoing university activities that could hinder proposed mitigation activities and possibly exacerbate community hazard vulnerability.

A capability assessment also highlights the positive mitigation measures already in place or being implemented by UK, that should continue to be supported and enhanced through future mitigation efforts.

The capability assessment serves as an important planning step and an integral part of an effective mitigation strategy. Coupled with the Risk Assessment, the capability assessment helps identify and target meaningful mitigation actions to incorporate in the mitigation strategy portion of this plan. Any potential shortcomings in the ability of UK to implement hazard mitigation are tied to the mitigation strategy in the form of actions selected by the planning team. It not only helps establish the goals and objectives for UK to pursue with this plan, but it also enables the goals and objectives to be realistically achievable under given local conditions. Specific recommendations for actions that will improve UK's ability to implement the hazard mitigation plan and increase resilience are offered at the conclusion of this section.

4.1.1 Conducting the Capability Assessment

The capability assessment began with completion of the capability assessment review form (form). The planning team met to review and discuss the completed Form and provided additional information.

The Form compiled information on a variety of "capability indicators" such as existing university plans, policies or programs that may impact the UK's ability to implement hazard mitigation and climate adaptation. Other indicators in the Form are related to the UK's financial, administrative and technical, education and outreach and political capabilities, such as access to budgetary and personnel resources for mitigation purposes.

In addition, the planning team members conducted interviews and conversations with key university stakeholders (Risk Management, Research, GIS, Facilities Management, Environmental Health and Safety, IT, Martin-Gatton College of Agriculture, Food and Environment, Office for Institutional Diversity, UK HealthCare and the Kentucky Climate Consortium) to determine if any policies or programs contribute to and/or hinder the UK's ability to implement hazard mitigation. Understanding general university procedures is an important consideration with respect to hazard mitigation implementation.

At a minimum, results provide an inventory of existing campus plans, policies, programs and resources that are in place or under development in addition to their overall effect on hazard loss reduction. However, the information can also serve to identify gaps, weaknesses or conflicts that the university can recast as opportunities for specific actions to be proposed as part of the mitigation strategy. The results of this capability assessment provide important information for developing an effective mitigation strategy.

It is important to consider the UK's Mission Statement in light of the capability assessment to understand the UK's footprint in the Commonwealth:

The UK is a public, land grant university dedicated to improving people's lives through excellence in education, research and creative work, service and health care. As Kentucky's flagship institution, the university plays a critical leadership role by promoting diversity, inclusion, economic development and human well-being.

The University of Kentucky:

- *Facilitates learning, informed by scholarship and research*
- *Expands knowledge through research, scholarship and creative activity*
- *Serves a global community by disseminating, sharing and applying knowledge*

The university, as the flagship institution, plays a critical leadership role for the Commonwealth by contributing to the economic development and quality of life within Kentucky's borders and beyond. The university nurtures a diverse community characterized by fairness and equal opportunity.

Not only is UK responsible to its students, faculty and staff, UK also contributes services to support economic development and quality of life in the communities of the Commonwealth and beyond.

4.1.2 UK Mitigation and Resilience Structure

The following sections provide an overview of the structure for future coordination and collaboration for implementation of the UK Hazard Mitigation Plan and response to future events. During the development of this plan, the University announced the Center for Disaster Recovery and Resilience. This office is responsible for overseeing plan implementation and collaboration with other University departments to update the plan.

Center for Disaster Recovery and Resilience: University of Kentucky Police Department (UKPD) announced in February 2023 the creation of the Center for Disaster Recovery and Resilience. The goal of this office is to serve as the designated university entity to collaborate and streamline university efforts to lessen the impact of adverse incidents to the university by developing strategic resilience and implementing mitigation actions to reduce hazards risks. To accomplish this, the center will plan and facilitate long-term recovery and mitigation from hazardous declarations that may cause an operational interruption; injury, illness or death; damage to or loss of equipment, infrastructure services or property; or functional degradation to social, economic or environmental aspects of the university**.**

The responsibilities of the office will include

- Oversee and implement the action items included in the 2023 *UK Hazard Mitigation Plan Update.*
- Establish and build stakeholder relationships.
- Identify resource programs to support ongoing operations (equipment allocations).
- Identify untapped, emerging private/public mitigation opportunities.
- Develop interlocal partnership agreements.
- Serve as a clearinghouse for UK for hazard mitigation grants.

Crisis Management and Preparedness (CMP): UK created the Division of Emergency Management in August of 2004, which was later expanded in November of 2011 to CMP. The CMP Division is a branch of the UKPD and works closely with other campus departments. The CMP mission is to coordinate and facilitate effective campus disaster preparedness, mitigation, response and recovery activities to minimize the impacts of emergencies on the campus community, facilities, and environment. The vision for CMP is to provide a disaster resilient university community. Several CMP representatives participated in the plan.

Campus Physical Plant Division (PPD): PPD serves students, faculty and staff by maintaining the campus buildings and grounds. UK's skilled craftspeople, mechanics and maintenance employees maintain facilities, repair equipment, maintain the beauty of landscaping, clean facilities and provide heating, cooling and electrical power. The mission of PPD is to provide support services for instructional, research and public service functions of UK. Support services include maintenance of facilities and grounds, utilities, minor renovations, and other related services. PPD is responsible for the repair of UK facilities as a result of natural hazard events that are covered in this plan. PPD will continue to serve as a steering committee member and mitigation planning workgroup member to participate in plan implementation.

Capital Project Management (CPM): The mission of CPM is to serve as a liaison between the university clientele having capital construction needs, other university service units, and privately owned companies providing the necessary design, consulting and construction services.

CPM develops and coordinates UK's programmatic space requirements and reconciles those needs with available project funding to maximize the programmed space. CPM has a critical role in managing and implementing design standards of which are crucial to ensuring mitigation measures are incorporated into the construction of new facilities, including generator installation, storm shelter designations, safe room construction, and other safety standards. CPM will continue to play a key role in the implementation of mitigation measures that protect people and property during the plan maintenance process.

College of Agriculture, Food, and the Environment (CAFE): CAFE oversees programs occurring on several of UK's properties including Robinson Forest, 4-H Camps, and other research facilities in and around the Commonwealth. The research facilities include but are not limited to: Robinson Center for Appalachian Resource Sustainability (RCARS) and Robinson Forest in Eastern Kentucky and REC near Princeton. CAFE participated in two interviews to support the plan update and provided data and information related to the two presidential declarations that impacted the CAFE facilities. CAFE ensured that mitigation measures are incorporated related to its properties and programs for the next five years. CAFE will continue to document lessons learned and share with the Center for Disaster Recovery and Resilience and other university departments. CAFE will continue to participate in the plan maintenance process for action items designated for these facilities, including the installation of generators at 4-H Camps, and scheduling yearly visits by an arborist to assess tree management needs.

College of Arts and Sciences: The College of Arts and Sciences contains 32 majors, 19 departments, with more than 5,800 undergraduate and graduate students and 440 faculty. The College of Arts and Sciences will continue to be included in future workgroup meetings.

Environmental Quality Management: Environmental Quality Management is responsible for ensuring the safe and timely pick up and management of hazardous waste and various other special waste streams generated at UK by on and off-campus locations. This group provides various services regarding compliance with waste management, water, and air quality regulations. The department provides opportunities for both live and online training programs related to hazardous waste management and DOT/IATA shipping requirements. Additional services provided include responding to spills/releases on a 24-hour basis, conducting site remediation and property audits, and serving as the UK's primary resource for conducting investigations and abatement for asbestos and lead based paint. Environmental Quality Management will continue to serve on the workgroup during plan implementation.

Facilities Management[1]: Facilities Management is a service organization composed of units that plan, construct, manage, operate and maintain the physical assets (e.g., buildings, grounds and utility systems) of the university. The mission is to provide a physical environment in which staff, faculty and students can achieve excellence in teaching, learning, research and public service. Facilities Management houses Campus Physical Plant, Medical Center Physical Plant, Capital Project Management and Facilities Planning. Facilities Management will continue to serve on the workgroup during plan implementation and is also identified as a responsible department for several of the mitigation actions.

Human Resources: As an active voice in the strategic decisions that guide the university toward achieving its goals, Human Resources will deliver services and support the success of the university and the members of its community. Human Resources can play an important role in communicating with faculty and staff during the time of an emergency and dealing with the after-effects on employee

[1]See Facilities Management website, https://www.uky.edu/facilities/

benefits and pay. Human Resources participated in the plan update process and will continue to serve on the workgroup on an as needed basis.

Information Technology Services (ITS): ITS provides enterprise level services and support including student computing services, SAP support, data center operations, learning systems support and high-performance computing operations. The management team of ITS plays a crucial role in responding to disaster events. This is through ensuring connectivity for communication needs to the campus community. ITS participated in the plan update process and will serve on workgroup throughout plan implementation.

Institutional Research and Advanced Analytics (IRAA)[2]**:** IRAA utilizes state-of-the art methods and technologies to support strategic university decisions. This department analyzes institutional effectiveness, studies past trends, completes various analyses, delivers visualization and dashboards, monitors data quality and releases official institutional data to external stakeholders. For the purpose of the mitigation plan update, the planning team relied on IRAA to provide research that informed the Risk Assessment. IRAA will be a resource for plan implementation, especially for the protection of research information from damage resulting from a hazard event.

Kentucky Climate Consortium (KYCC): KYCC is an organization housed at UK and includes representatives from other Kentucky universities. KYCC supports efforts to develop rich and interdisciplinary research and teaching collaborations across the sciences, engineering, social sciences, humanities and the arts. Consortium members have extensive experience researching and teaching climate-related issues, both in and beyond Kentucky. Members are also engaged in community-oriented climate work, through nonformal educational opportunities, public lectures and more. KYCC will be invited to plan implementation workgroup meetings.

Office for Institutional Diversity (OID)[3]**:** OID serves the entire university community and supports the UK's mission to advance Kentucky as outlined in UK's strategic plan. The vice president and OID directors work across academic and non-academic units to implement ideas, collaborate on outreach and recruitment efforts and enhance student retention and achievement. OID staff provide consultation and assistance to the various colleges in developing diversity and inclusion strategies and metrics in their individual strategic plans. OID works with the Office for Institutional Research and Institutional Effectiveness to help both academic and non-academic units understand, and use data collected on students, faculty and staff, particularly as the information has implications for campus climate and inclusiveness efforts. OID will be invited to plan implementation workgroup meetings.

Office of Student Success: The Office for Student Success at UK is committed to designing and delivering student services and consists of more than 400 professional staff and faculty across more than two dozen units that engage students from the time of early college outreach to graduation and beyond.

Office of the Vice President for Student Success (OVPSS): OVPSS is the support structure through which the work of defined units is organized. OVPSS comprises central functions that serve all parts of Student Success as well as the leads of five groupings of our units referred to as Student Success Areas: Dean of Students, Enrollment Management, Student Development and Support, Student Excellence and Engagement and Student Well-Being.

Office of the Executive Vice President for Finance and Administration (EVPFA): The core purpose of EVPFA is to support and serve the university and its students, faculty, staff, alumni, fans and visitors with core values of integrity, service, team, innovation and accountability. Risk Management is housed within EVPFA and played a key role with data collection for the mitigation

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[2]See Institutional Research and Advanced Analytics, https://www.uky.edu/irads/home
[3]See Office for Institutional Diversity, https://oid.uky.edu/about-us

plan update process, including providing insurance claim information to inform the risk assessment, and identifying future mitigation action items for the next five years.

Responsibilities of Risk Management include the implementation and use of risk management processes to identify, measure and control or finance risks of loss. Risk Management is also responsible to eliminate or control practices and conditions that causes loss, assume or retain risks of loss of a predictable and non-catastrophic nature that will not adversely impact the operating budgets or financial position of the university, and transfer through contract or insurance those catastrophic risks that cannot be appropriately financed internally at an acceptable cost.

EVPFA, specifically Risk Management, will continue to participate in the plan maintenance process as a member of the workgroup.

The Tracy Farmer Institute for Sustainability and the Environment: The Tracy Farmer Institute for Sustainability and the Environment is a cross-college institute at UK under the Office of Research. The goal of the institute is to facilitate interdisciplinary efforts to support transformative new advances in a broad array of environmental and sustainability related issues, including the impact of climate change on agriculture.

Transportation Services: Transportation Services provides parking options, promotes commuting alternatives and facilitates intra-campus mobility for the UK campus community.

In 2003, the department switched from a state-funded department to an auxiliary service. The change means that Parking and Transportation Services no longer receives monies from the general fund and is self-supported. In March 2017, Parking and Transportation Services became Transportation Services. This name change was more reflective of the depth and scope of the department's offerings. The values that guide Transportation Services include:

- Innovation and Adaptability
- Transparency and Accountability
- Resource Stewardship
- Competency and Consistency
- Mutual Respect and Human Dignity
- Customer Service Excellence
- Safety and Accessibility

UK HealthCare: UK HealthCare comprises UK's hospitals and clinics and employs 9,000 people – physicians, nurses, pharmacists, researchers and other health care professionals. Facilities include Albert B. Chandler Hospital (Kentucky's only level-one trauma center), Good Samaritan Hospital, Kentucky Children's Hospital, Kings Daughters Hospital and more than 30 clinics and patient care services. The physicians and other medical professionals are trained in sophisticated medical techniques to support Kentuckians throughout the Commonwealth. There are six health care-related colleges teaching and developing the next generation of health care professionals:

- College of Dentistry
- College of Health Sciences
- College of Medicine
  - Main Campus
  - Northern Kentucky
  - Bowling Green
- College of Nursing

- College of Pharmacy
- College of Public Health

UK HealthCare performs an annual Hazard Vulnerability Assessment to identify the potential hazards and the direct and indirect effects these hazards may have on the hospital staff, patients, visitors and structure.

UK Good Samaritan Hospital[4]**:**UK Good Samaritan Hospital is an acute-care facility with 180 licensed beds. Founded in 1888, the hospital has a long tradition of providing exceptional patient care in a community-hospital atmosphere. Its acquisition in July 2007 by UK HealthCare [5]added the resources of a major health care system. With more than 600 clinical and ancillary staff and a medical staff of more than 600 physicians, UK Good Samaritan is able to offer a broad range of health care services to meet the needs of the residents of central and eastern Kentucky. All patient rooms in the hospital are single occupancy, ensuring each patient privacy and individual attention.

Utilities and Energy Management Division: As Energy Stewards for UK, the mission of the Utilities and Energy Management Division is to provide safe, reliable and resilient utility and energy services to the campus community, with a commitment to sustainability and customer service.

- Safety - Ensure safe operations for employees, system and community
- Capacity - Ability to meet load requirements
- Reliability - Uninterrupted utility services, 24/7 operation, mission critical focus
- Resiliency - Redundant systems, how quickly can the university recover, backup plans

4.1.3 Organizations Involved with Mitigation

In addition to the steering committee members, the planning team invited other local and regional organizations to participate in the plan development process. Below is a brief profile provided of each organization that participates in mitigation for the university.

American Red Cross[6] **Bluegrass Chapter:** The American Red Cross prevents and alleviates human suffering in the face of emergencies by mobilizing the power of volunteers and the generosity of donors. A UK representative serves as a board member for the Bluegrass Chapter. The Bluegrass Chapter serves the following counties: Bourbon, Boyle, Bracken, Casey, Clark, Estill, Fayette, Garrard, Harrison, Jackson, Jessamine, Laurel, Lincoln, Madison, Mason, McCreary, Mercer, Montgomery, Nicholas, Pendleton, Powell, Pulaski, Robertson, Rockcastle, Scott, Wayne, Whitley and Woodford. To accomplish future mitigation actions for education, outreach, and disaster support, UK will rely on and reach out to the American Red Cross as needed.

Bluegrass Area Development District (ADD)[7]**:** The mission of the Bluegrass ADD is to enhance the economy of communities through planning to maximize resources, projects to promote development and programs to improve the quality of life for the citizens of the region. ADDs are partners with numerous state and federal agencies, applying for and administering grants. The Bluegrass ADD serves over 800,000 residents in 17 counties and 32 cities. As a regional partner to UK the Bluegrass ADD mitigation planning initiatives may provide partnership opportunities with future policy development, education and outreach initiatives, and funding applications.

[4]See Good Samaritan Hospital, https://ukhealthcare.uky.edu/good-samaritan-hospital
[5]See Hospitals & Clinics, https://ukhealthcare.uky.edu/hospitals-clinics
[6]See American Red Cross, https://www.redcross.org/local/kentucky/about-us/locations/bluegrass-area-chapter.html
[7]See Bluegrass ADD, https://bgadd.org/planning/

Columbia Gas of Kentucky[8]: Columbia Gas is headquartered in Lexington and is an energy distributor that serves over 130,000 customers in 30 Kentucky counties, including the university. Columbia Gas served on the plan update steering committee and will continue to serve as an external partner when addressing mitigation actions pertaining to energy needs while managing disasters.

Kentucky American Water (KAW): KAW, based in Lexington, provides quality, reliable water services to portions of a 10-county region, including the university. As an external stakeholder to the mitigation plan update process, KAW provided input and will continue to be a partner in identifying future mitigation actions during the plan implementation.

Kentucky Geological Survey (KGS)[9]: The mission of KGS is to increase knowledge and understanding of the mineral, energy, and water resources, geologic hazards and geology of Kentucky for the benefit of the Commonwealth of Kentucky and the nation. KGS plays a critical role in providing geologic datasets and information that informs the Risk Assessment of the HMP. KGS will continue to serve as a resource during plan implementation for the purpose of analyzing hazard probability and providing geospatial education and information to the greater university community.

Kentucky Division of Water (KDOW): Kentucky Risk Mapping, Assessment, and Planning (Risk MAP) is a collaborative effort between KDOW and FEMA intended to better communicate flood risk across a variety of disciplines. The major tenets of Risk MAP include accurate flood hazard identification, identification of areas where major watershed changes have altered flooding characteristics resulting in the need for updated flood studies, integrating the products created through Risk MAP into regional and community hazard mitigation planning, and identifying and advancing mitigation actions that reduce flood risk in communities throughout the Commonwealth.

4.1.4 Emergency Management

Hazard mitigation is widely recognized as one of the four primary phases of emergency management. The three other phases include preparedness, response and recovery. Each phase is interconnected, as **Figure 4-1** illustrates. Opportunities to reduce potential losses through mitigation practices are often implemented before a disaster event strikes, such as flood-proofing of flood prone structures, installing back-up power sources, or enhancing security measures. Mitigation opportunities will also be presented during immediate preparedness or response activities, such as activating emergency response teams prior to severe storms, and during the long-term recovery and redevelopment process following a hazard event.

Planning for each phase is a critical part of a comprehensive emergency management program and a key to the successful implementation of hazard mitigation actions. As a result, the capability assessment will assess UK's willingness to plan and their level of technical planning proficiency.

[8]From Colombia Gas of Kentucky, https://www.columbiagasky.com/
[9]From Kentucky Geological Survey, https://www.uky.edu/KGS/

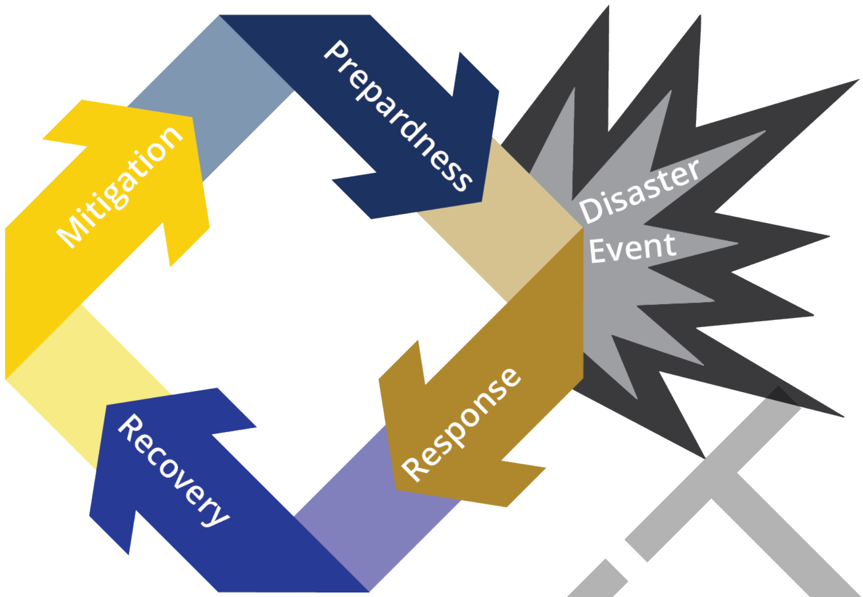

Figure 4-1: The Four Phases of Emergency Management

Building Emergency Action Plan (BEAP)**:** It is the goal of UK to have each building develop a BEAP. The BEAP is developed by all departments that occupy a building. The building emergency action plan provides guidance to occupants during an emergency situation. The information listed in each document includes disaster and crisis planning, contact information for building and floor coordinators, who take the lead in creating and updating the plan, and maps of emergency exits and evacuation gathering locations.

The disasters and emergencies included in the plan cover a wide range of scenarios including but not limited to:

- Fire
- Severe Weather
- Earthquake
- Utility Outage
- Workplace Violence/Terrorism
- Bomb Threat
- Medical Emergency

Every employee, student, visitor, etc., should become familiar with their building's plan in the event that an emergency occurs. The goal of the BEAP is to prepare everyone in advance for what may happen while they are in the building and provide information on how to react to the scenario.

Business Continuity Plan (BCP): As departments pursue academic and research excellence on campus, all UK departments and units are required to complete a BCP to prepare departments to respond to various types of operational disruptions. For this, a BCP template was created to help plan for major disasters (e.g., total loss of a building) but also less interruptions to service (e.g., the computers are down). Completion of the plan gives each department a basic continuity and recovery plan.

Campus Community Emergency Response Team (C-CERT)[10]: The UKPD offers C-CERT training for faculty and staff. The primary purpose of C-CERT is to apply established CERT curriculum, adopted by the U.S. Department of Homeland Security, to the university environment. C-CERT members receive hands-on training in basic disaster response skills, such as fire safety and suppression, light search and rescue, disaster medical operations, team organization, disaster psychology and terrorism. Using training learned in the classroom and during exercises, C-CERT members can assist others in the neighborhood or workplace following an event when professional responders are not immediately available to help.

Campus Evacuation Procedures: UK has specific evacuation procedures for building occupants when a fire alarm is activated as all occupants must evacuate the building. These procedures are practiced during regular drills.

***Commonwealth of Kentucky Hazard Mitigation Plan* (2018):** To produce the university plan update, UK relied upon data resources and guidelines set forth in the 2018 Commonwealth of Kentucky Hazard Mitigation Plan. This helps drive the way that analysis is conducted for the Risk Assessment and policy considerations when adopting new mitigation measures.

***Continuity of Operations Plan* (COOP):** Both the university and UK HealthCare have in place COOPs which are efforts within organizations to ensure the continued performance of minimum critical services during manmade, natural or technological emergencies. This is accomplished through the development of plans, comprehensive procedures, and provisions for alternate sites, personnel, resources, interoperable communications, and vital records/databases.

The purpose of the COOP is to minimize disruption to the organization. This can only be accomplished by pre-planning and by taking steps to limit any potential disruption to a predictable, acceptable period. In addition, the COOP provides for the safety and security of faculty, personnel, students, customers and visitors. This will be accomplished by maintaining emergency and security plans, conducting training, and holding exercises. University departments are responsible for their own COOP. However, UK is working on a university-wide plan.

UK HealthCare requires a COOP to ensure the continued performance of minimum essential operations, ensure survivability of critical equipment, records, and other assets, minimize business damage and losses, achieve orderly response and recovery from the incident, ensure succession of key leadership and comply with statutory requirements. This plan is a collection of resources, actions, procedures, and information that is developed, tested, and held in readiness for use in the event of a major disruption of operations. The COOP is designed to address hazards and threats.

Disaster Recovery Plan: A disaster recovery plan serves to guide the physical, social, environmental, and economic recovery and reconstruction process following a disaster. In many instances, hazard mitigation principles and practices are incorporated into local disaster recovery plans with the intent of capitalizing on opportunities to break the cycle of repetitive disaster losses. Disaster recovery plans can also lead to the preparation of disaster redevelopment programs and projects to be enacted following a hazard event. The university has not yet adopted a disaster recovery plan.

Emergency Planning and Community Right-to-Know Act: The Emergency Planning and Community Right-to-Know Act is a federal law created for community-wide planning for the storage, use and release of hazardous substances. UK maintains an active role in such local planning and the Environmental Quality Management Department coordinates the assessment of planning needs as well as the formulation of the final plans.

[10]See Campus Community Emergency Response Team, https://police.uky.edu/campus-community-emergency-response-team-ccert

***Emergency Operations Plan* (EOP):** An EOP outlines responsibilities and the means by which resources are deployed during and following an emergency or disaster.

The EOP is National Institute Management System and Incident Command System compliant, following the structure of the National Response Framework. The EOP provides guidance as to how UK conducts all-hazards response using scalable, flexible and adaptable systems to align key roles and responsibilities across the campus units. During the development of *UK Hazard Mitigation Plan Update*, the EOP is being updated with a flood emergency response plan annex and updates to the campus wide evacuation plan.

***Evacuation Plan*:** An evacuation plan provides an evacuation strategy for all or part of a jurisdiction in the event that a life safety threat or hazard occurs or is projected to occur. The evacuation plan is meant to facilitate the safe, timely and efficient evacuation of an area. An evacuation plan provides a general outline of the expected roles, responsibilities and evacuation-related response activities during an evacuation.

***Flood Emergency Response Plan*:** The university maintains a close relationship with LFUCG, which is a participant in the National Flood Insurance Program. UK is updating the EOP with a flood emergency response plan as part of the annex. A flood emergency response plan includes a risk assessment and the identification of areas that are flood prone and ways to mitigate the risk.

***UK Hazard Mitigation Plan*:** A hazard mitigation plan represents the UK's blueprint for how it intends to reduce the impact of natural and human-caused hazards on people and the built environment. The essential elements of a hazard mitigation plan include a risk assessment, capability assessment and mitigation strategy.

This plan is UK's third plan. UK participated in the development of the 2018 Commonwealth of Kentucky Enhanced Hazard Mitigation Plan and the 2019 Lexington and Fayette County Hazard Mitigation Plan.

LFUCG Floodplain Ordinance[11]: In January 2001, an amended Floodplain Conservation and Protection Ordinance went into effect regulating development in the floodplain. Under the ordinance, no construction is allowed in the floodplain (unless granted a Local Special Use Permit). In addition, all buildings must be set back 25 feet from the floodplain and two feet above the base flood elevation. The requirements also incorporate best management practices for floodplains. UK refers to the Floodplain Ordinance when major land use decisions are made.

***LFUCG Hazard Mitigation Plan*:** The 2018 LFUCG Hazard Mitigation Plan provides the framework for programs and compliance throughout the county. UK references this policy document when deciding on mitigation measures to pursue. Additionally, this plan provided vital information for the flood mitigation assessment of the UK HMP.

National Flood Insurance Compliance (NFIP): UK falls under the jurisdiction of LFUCG's floodplain regulations. LFUCG's compliance includes the adoption and enforcement of floodplain management requirements, including regulating all new and substantially improved construction in Special Flood Hazard Areas (SFHAs) and floodplain identification and mapping, including any local requests for map updates. The LFUCG Planning Office serves as the local repository for the official FEMA Flood Insurance Rate Maps (FIRM). University Design Standards: Design standards and guidelines regulate construction on the UK's campus including those elements related to natural hazard mitigation such as construction type, backup power generation, and other special considerations.

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[11]See LFUCG Floodplain Ordinance, https://library.municode.com/ky/lexington-fayette_county/codes/zoning_ordinance?nodeId=ZONING_ORDINANCE_ART19FLCOPR

UK Alert Notification System: The university utilizes an emergency notification system, UK Alert, to communicate official information during an emergency or crisis situation that disrupts normal campus operations or threatens the health or safety of members of the campus community. All UK students, staff and faculty are automatically registered in UK Alert with their official university email address. We encourage students, staff and faculty to add other contact information, such as mobile numbers and personal e-mails, to their UK Alert accounts. Parents, media, visitors and other interested parties may register for UK Alert on a voluntary self-subscription basis. Depending on the emergency and the location, an alert may be sent using all methods, or a combination of the alert methods. UK Alert uses the following methods to send immediate notifications:

- Text Messages—sent to phone numbers that have been entered by the individual user.
- Phone Calls—sent to phone numbers that have been entered by the individual user.
- Email—to all uky.edu email addresses.
- Outdoor Sirens—Blue Emergency Notification Towers are strategically placed at 26 locations across campus to provide outdoor alert tones and broadcast emergency messages. These emergency notification towers are illuminated at all times and flash when activated. The messages are pre-recorded and will provide basic information, such as "Dangerous Situation. Seek shelter immediately". More details, such as the location of the incident, will be provided in the text message, in an email and on the VoIP phones.

The alert system serves as a tool to provide emergency information to the UK community but should not be the only outlet of information. Other sources are university email announcements, UK website, local news and any other readily available news source.

Storm Ready: UK campus "Storm Ready" project is an information source for facility storm shelter locations and other storm-related information.[12]

Since 2003, UK has been officially recognized as a Storm Ready Campus by the NWS. The certification means that UK has successfully met the criteria outlined by the NWS in its nationwide program to enhance community preparedness for severe storms and weather emergencies. With assistance from LFUCG DEM, severe weather safe areas have been identified in every building on campus and flood plans with designated safe rooms are made available for every building on campus. Special weather radios have been installed in the most populated buildings and all residence halls.

Terrorism and Weapons of Mass Destruction: UK emergency response staff members have received training for any event that might disrupt normal daily activities, such as terrorism or the use of a weapon of mass destruction. UKPD attend regularly scheduled training sessions and the relevant response is incorporated into the Emergency Operations Plan.

Tornado Weather Spotter Program: UKEM and UKPD are trained as Weather Spotters through the National Weather Service (NWS). These trained people are the local eyes for the NWS and help the NWS warn the public of possible severe weather.

UK CMP Website: For all information related to UK CMP, the public can access a website containing information on UK Alert, Emergency Response Guidance, Disaster Preparedness and Planning, Severe Winter Weather, Business Continuity Planning, C-CERT, Hazard Mitigation Plan and the LiveSafe Safety App.

Vaccinations: UK has a vaccination program in response to the COVID-19 Pandemic. Currently, all students, faculty and staff are eligible to receive the bivalent COVID booster vaccine at the Gatton Student Center and UK HealthCare Locations.

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[12] From UK Campus Storm Ready Project, http://wwwagwx.ca.uky.edu/stormready/

4.1.5 University Planning Documents and Efforts

Ride Blue The University of Kentucky Bicycle Master Plan: In 2021, the university kicked off the bicycle master plan which includes a list of potential improvement locations. The potential improvements range in complexity: from simple spot location striping upgrades, to modifying existing facilities to provide greater separation from motor vehicles, all the way to innovative intersection redesigns and fully separated shared-use paths.[13]

2016 CAFE Precinct Plan: The Precinct Plan for CAFE sets forth a framework for growth over the next twenty years. The framework integrates urban design and development, landscape and placemaking, and mobility and service access. The plan is guided by environmentally sustainable principles that are at the core of the CAFE's history and mission, and seeks to flexibly accommodate the evolving academic, social, and economic demands of CAFE.

Recommendations set forward in the plan are based on the results of an extensive data-gathering process, including stakeholder interviews, facility tours and building conditions assessments, space utilization analysis, and enrollment trend analysis. Recommendations include building renovations, new facilities, and improved outdoor space.[14]

Campus Master Plan: The Master Plan was completed in 2013 and the associated map was updated in 2017. The plan includes 29 projects identified as a facility through conversations with stakeholders. The plan included "integrating sustainability in every aspect of planning". UK's statement on sustainability "recognizes the critical need to engage the university community to create policies and programs that will simultaneously advance economic vitality, ecological integrity and social equity now and into the future". The master plan created the opportunity to demonstrate leadership in this "triple bottom line" and will help to advance sustainable initiatives within several key areas. The following landscape and ecology strategies were included in the plan:

- Reduction of hard surfaces to mitigate the heat island effect
- Increase pervious surfaces to improve stormwater management and ground water recharge
- Create a new stormwater detention basin within the south campus to manage stormwater

Campus Landscape Guidance, 2015: The campus landscape design guidelines' purpose is to provide guidance to those who are responsible for the design and maintenance of the University of Kentucky campus landscape. The guidelines are intended to encourage the orderly development of the landscape in a way that serves the functional, aesthetic, ecological and management requirements of the university in a consistent way over time. The guidelines are provided to overcome the fragmentation of landscape that can accompany the incremental implementation in discrete projects separated in time and funding and staffed with different design teams. The project principles for the guidelines are focused on human connection, the experience of nature, sustainability, appropriateness, aesthetic value, use and efficient management. The plant species utilized on campus are considered in terms of appropriateness for the Bluegrass physiographic region of Kentucky, their suitability for the conditions in which they will be located, their size at the time of installation and, ultimately, how they will be protected and replaced. [15]

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[13]See "UK Bike Master Plan", https://www.uky.edu/transportation/sites/default/files/UK_BikeMasterPlan-Book_Final.pdf
[14]From CAFO Precent Plan (2016), (The University of Knetucky , 2016)
[15]See Campus Landscape Guidance, 2015., https://www.uky.edu/cpmd/sites/www.uky.edu.cpmd/files/standards/323000S01%20Campus%20Landscape%20Guidelines%202019%2004.pdf

The Campus Landscape Guidelines are intended to promote unity and consistency in the campus landscape. All future implementation projects should comply with the recommendations or suggest ways in which the guidelines could be enhanced or improved.

Climate Adaptation Plan: UK does not have a climate adaption plan, but it houses the Kentucky which supports efforts to develop rich and interdisciplinary research and teaching collaborations across the sciences, engineering, social sciences, humanities and the arts. Consortium members have extensive experience researching and teaching climate-related issues, both in and beyond Kentucky. Members are also engaged in community-oriented climate work, through nonformal educational opportunities, public lectures and more.

Crisis Relief in Situations Involving Staff and Family (C.R.I.S.I.S.) Program[16]: C.R.I.S.I.S. helps university employees who are experiencing personal hardship. This program provides temporary financial assistance in the form of a one-time payment. The program is primarily funded by staff and faculty donations. All donations are tax-deductible.

Design Standards: Design standards and guidelines regulate construction on the University's campus including those elements related to natural hazard mitigation such as construction type, backup power generation and other special considerations. UK official design standards are structured by division:

Division 00 – Procurement and Contracting Requirements Group
Division 01 – General Requirements Subgroup
Divisions 02-19 - Facility Construction Subgroup
Divisions 20-29 – Facility Services Subgroup
Divisions 30-39 – Site and Infrastructure Subgroup
Divisions 40-49 – Process Equipment Subgroup

Diversity, Equity, and Inclusion (DEI) Implementation Plan[17]**:** During the development of this plan, the university was in the process of completing the DEI Campus Plan, which will identify existing areas of concern on campus relative to institutional history and campus history, art and sculpture, civic landscapes, accessibility and other barriers to inclusion within buildings and across the campus. The planning effort will apply to the main campus, health care campus and athletics facilities. The initiative will also include an assessment of current space use on campus and will work toward a deeper understanding of different needs. The campus plan will include a vision for transforming the campus over time to create a more inclusive, equitable and barrier-free environment where everyone feels safe and supported. Representatives from Facilities Management and OID will be invited to future hazard mitigation workgroup meetings to provide updates on the DEI Implementation Plan and how it and hazard mitigation and resilience planning intersect.

Ground Water Protection Plan: The university has a Ground Water Protection Plan (GWPP) for the main campus, prepared by the UK Environmental Management Department. The GWPP identifies onsite activities that may contribute to ground water pollution and the actions taken to mitigate the risk.

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[16]See Human Resources, https://hr.uky.edu/
[17]See DEI Campus Plan, "https://dei.uky.edu/diversity-equity-and-inclusion-implementation-plan/bringing-together-many-people-one-community/dei#:~:text=The%20DEI%20Campus%20Plan%20will%20identify%20existing%20areas,main%20campus%2C%20health%20care%20campus%20and%20athletics%20facilities.

Spill Prevention, Control and Countermeasures Plan: Federal law mandates the establishment of procedures, methods and equipment for entities that manage certain quantities of oil. The Environmental Quality Management Department is responsible for coordinating the preparation of Spill Prevention, Control and Countermeasures Plans – which form an integral foundation for addressing potential releases of oil into the nearby waterways.

Stormwater and Sanitary Sewer Master Plans: The university is a Phase II program pursuant to the Kentucky Pollutant Discharge Elimination Program which regulates water quality. The KPDES permit requires post-construction best management practices, and in some instances can reduce localized flooding. There are isolated areas of flooding on the main campus. A successful flood mitigation project was implemented in 2014 at Alumni Drive and Nicholasville Road. UK also maintains a publicly available map depicting stormwater best management practices, including above ground and below ground detention. **Figure 4-2** depicts the above ground storage near the Press Avenue Garage.

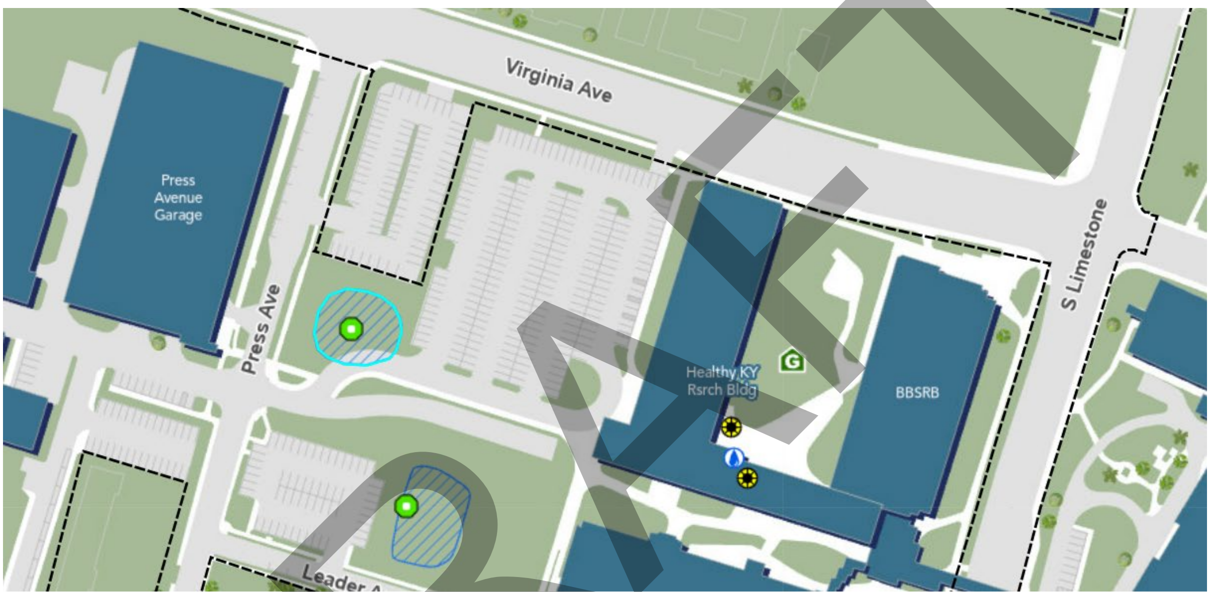

Figure 4-2 Stormwater Feature Map

UK is assessing the sewer lines on the Main Campus. The workgroup for the *UK Hazard Mitigation Plan* identified the need for stormwater and sanitary sewers master plans. These plans are included as mitigation actions.

Strategic Plan[18]: The Strategic Plan Vision Statement – "As Kentucky's indispensable institution, we transform the lives of our students and advance the Commonwealth we serve — and beyond — through our teaching and learning, diversity and inclusion, discovery, research and creativity, promotion of health, and deep community engagement."

Five principals govern the Strategic Plan: putting students first; taking care of our people; inspiring ingenuity; ensuring trust, transparency, and accountability; and bringing together many people, one community.

Sustainability Plan[19]: Sustainability was included as one of the seven core principles in the Campus Master Plan adopted in 2014 and has been an important component of planning documents adopted

[18] See Strategic Plan, https://pres.uky.edu/strategic-plan
[19] See Sustainability Plan, https://www.uky.edu/sustainability/sites/www.uky.edu.sustainability/files/UK%20Sustainability%20Strategic%20Plan.v.2.26.2019_0.pdf

since, including the Transportation Master Plan, the Campus Landscape Guidelines and the Utilities Master Plan. UK collaborated with a private sector partner in 2016 to conduct an in-depth evaluation of campus operations. The establishment of campus-wide sustainability targets was one of the key recommendations of the resulting report and served as a catalyst for development of the Sustainability Plan.

This plan encompasses the operational aspects of UK's core academic campus in Lexington, Kentucky. This includes UK Athletics, UK HealthCare, and partners in housing and dining. By the numbers, the operational areas included in this plan cover:

- More than 19 million gross square feet of building space in more than 400 buildings connected across an 800-acre campus with an urban forest of over 9,000 trees that provide a 17 percent canopy cover.
- 20 miles of roadway, 75 miles of sidewalks and 16 miles of dedicated bicycle facilities connect the campus.
- Utilities consumption of $23 million of electricity, 600 million gallons of water, and on-campus production of 1,200,000 MMBtus of steam in natural gas and coal boilers at three campus heating plants.
- More than 30,000 students, 12,000 employees and thousands of patients and visitors.
- More than a half million metric tons of greenhouse gas emissions annually.

Many colleges across campus have courses, faculty, and research programs with connections to sustainability. The Environment and Sustainability Studies (ENS), Sustainable Agriculture (SAG) and Natural Resources and Environmental Science (NRES) degree programs focus on sustainability. In addition, there are several academic entities on campus that work on the integration of sustainability with curricula and research (e.g., the Tracy Farmer Institute for Sustainability and the Environment, the Institute for Sustainable Manufacturing, the Center for Applied Energy Research and the Food Connection).

Efforts were undertaken in 2022, to update the Sustainability Plan[20]. In support of UK's mission, the vision for sustainability is two-fold:

- Ensure that the operations and activities of the university are ecologically sound, socially just and economically viable.
- Support and encourage curricula, research and creative works on critical environmental and social challenges.

This principled approach positions students, faculty and staff to be leaders for a sustainable future in the Commonwealth and beyond. The five principles defined in the Sustainability Plan are as follows:

- Make the pursuit of these goals an integral part of the UK student experience
- Decarbonize campus operations
- Become a zero-waste campus
- Model environmental Excellence
- Reinforce the university's commitment to justice, diversity, equity and inclusion

Transportation Master Plan: The Transportation Master Plan: A Strategy for Mobility and Choice was completed in 2015. The plan includes safety as a "paramount concern" and considers

[20] See Updating our Stability Plan https://wholesumky.org/?p=5023

environmental sustainability. Hilltop Ave. and Woodland Ave. were identified as streets that should be maintained as corridors for transit and service/emergency vehicles.

4.1.6 Fiscal Capability

The ability of a university to take action is closely associated with the number of fiscal resources available to implement policies and projects. This may take the form of outside grant funding awards or university-based revenue and financing. The cost of mitigation policy and project implementation varies widely. In some cases, policies are tied primarily to staff time or administrative costs associated with creation and monitoring of a given program. In other cases, direct expenses are linked to an actual project, such as installing back-up power generators or relocating structures, which can require a substantial commitment from university, state and federal funding sources. UK has made fiscal commitments to the mitigation of hazards and security of the population to date. This hazard mitigation plan provides a foundation to plan for future needs as well.

4.1.7 Political Capability

Political capabilities should be considered in designing mitigation actions to advance their adoption and implementation. UK officials have repeatedly emphasized the need and desire for a safe, secure campus, and their completion of the third hazard mitigation plan is a commitment to this effort. Dr. Eric Monday (executive vice president for finance and administration and co-executive vice president for health affairs) emphasized the importance of hazard mitigation planning through his letter see Appendix A. This has been further emphasized through the creation of the Center for Disaster Recovery and Resilience and the ongoing rebuilding efforts at the locations impacted by the recent natural disasters.

4.1.8 Conclusion on Campus Capability

A capability assessment examines university capabilities to detect any existing gaps or weaknesses within ongoing government activities that could hinder proposed mitigation activities and possibly exacerbate community hazard vulnerability. The results of the capability assessment form part of the basis for the mitigation actions, helping the university to improve its ability to mitigate and adapt to the impacts of hazards and climate change. The conclusions of the risk assessment and capability assessment serve as the foundation for the development of a meaningful mitigation strategy. During the process of identifying specific mitigation actions, the UK considered not only the level of hazard risk, but also the existing capability to minimize or eliminate that risk. The list below outlines key capabilities the university can address in the mitigation strategy.

- Disaster Recovery Plan – With the results of this plan's Risk Assessment, UK will have an improved understanding of where disasters are likely to occur and what is at risk. Preparing a plan to guide recovery and rebuilding efforts before a disaster complements the university's mission and strategic plan. Recovery will be smarter and faster with a recovery plan in place and is an investment with potentially large rewards. This plan should also address post disaster redevelopment and mitigation policies and procedures. These policies and procedures should account for the expected damage from a base flood or other disasters.
- Resilience Program – Consider resilience centers/hubs to support the university community with defined services during a hazard event.
- Biannual workgroup meetings to encourage increased communications between stakeholders, improve plan implementation and document successes, needs and capabilities.
- Invite the Office of Institutional Diversity and the Disability Resource Center to the biannual workgroup meetings to include equity considerations during plan implementation.
- Invite the Kentucky Climate Consortium to the biannual workgroup meetings to solicit input regarding climate change impacts in Kentucky.

- Document lessons learned from past events to share with the workgroup and other relevant university departments to inform future mitigation efforts.
- Consider the *UK Hazard Mitigation Plan* when developing/updating other relevant university plans.
- Update the Hazard Mitigation Database as university data is updated. This data may include research values, building values, building condition, building contents, occupancy etc.

4.2 Mitigation Successes

The university mitigation program activities summarized in this subsection demonstrate UK's ongoing efforts to mitigate the effects of hazards. Recent hazard events, including COVID, the 2021 tornado and the 2022 flooding, also led to opportunities for mitigation successes described below:

- Typical operations include enforcing current Design and Construction Standards for new university-owned development.
- UK launched incredible community efforts to stem the tide of the COVID virus. The institution spearheaded efforts to vaccinate communities and much of Kentucky, operating the largest vaccination clinic in the Commonwealth, that provided more than 250,000 doses. At its height, more than 4,000 people daily were vaccinated in a makeshift clinic established at Kroger Field — demonstrating a true university-wide effort of UK HealthCare, UK Athletics and campus. Priority was given to schoolteachers and personnel, first responders and health care workers and those with underlying health issues.
- Western Kentucky housed 246 relief workers representing 26 organizations.
- 1,245 youth and families used the university's donation system to pick-up necessities including canned food, personal hygiene items, baby formula, tools, clothes and cleaning supplies.
- CAFE successfully applied for grant funding for tornado shelters.
- Cooperative Extension Offices have emergency action plans.
- UK Wellness Department provided mental health sessions to support staff at REC and RCARS.
- Childcare was provided for staff during the COVID pandemic.
- The 2015 Tree Inventory was completed and continues to be used by UK.

4.3 Mitigation Goals

Mitigation goals represent broad statements that are consistent with the hazards identified within the plan and achieved through the implementation of more specific mitigation actions. These goals set the framework for the mitigation strategy and allow the steering committee to envision what they want to achieve over the next five-year period.

As a framework to revise and update the mitigation strategy, the planning team, workgroup and steering committee revisited the 2016 plan goals and refined them to incorporate changes and lessons learned since the last plan. Information needed for the revisions was collected during interviews, planning team meetings, steering committee meetings and workgroup sessions.

The mission of the University of Kentucky:

"…is a public, land grant university dedicated to improving people's lives through excellence in education, research and creative work, service and health care. As Kentucky's flagship institution, the university plays a critical leadership role by promoting diversity, inclusion, economic development and human well-being."

The University of Kentucky:

- *Facilitates learning, informed by scholarship and research.*
- *Expands knowledge through research, scholarship and creative activity.*
- *Serves a global community by disseminating, sharing and applying knowledge*

In keeping with this standard and promoting a proactive approach to disaster management, risk reduction, and resilience, the planning team reviewed and updated the goals for the 2023-28 plan in **Table 4-1.**

Table 4-1: Mitigation Goals

Goal Number	Goal
Goal 1	Protect lives and reduce injuries from hazards and threats
Goal 2	Protect university property, organizational information and research from hazards and threats.
Goal 3	Enhance existing or develop new university policies and practices that are designed to reduce damaging effects from hazards and threats.
Goal 4	Build stronger partnerships between government, educational institutions, businesses and the community in regard to hazard mitigation and resilience.
Goal 5	Build disaster preparedness and response through mitigation and resilience education and outreach.

4.4 Mitigation Actions

In formulating the mitigation strategy for the *UK Hazard Mitigation Plan*, a range of activities was considered to help advance the five mitigation goals, in addition to addressing any specific hazard concerns. In order to assist UK, workgroup and steering committee in developing a range of potential mitigation activities, the planning team presented the six broad categories of mitigation techniques: Prevention, Property Protection, Natural Resource Protection, Structural Projects, Emergency Services and Public Awareness and Education. Presenting mitigation activity examples under these category types helped the decision makers understand the kinds of activities addressed under a hazard mitigation plan. In addition, planning team members were encouraged to think holistically about their campus needs including both natural and non-natural hazards threats. The following provides example activities presented under each category.

4.4.1 Prevention

Preventative activities are intended to keep hazard impacts from worsening and are typically administered through programs or regulatory actions that influence the way land is developed and buildings are built. In the context of this plan, prevention measures also include security initiatives. Prevention measures are particularly effective in reducing a university's future vulnerability, especially in areas where development has not occurred, or capital improvements are not substantial. Examples of preventative activities include:

- University codes and design standards
- Building codes

- Open space preservation
- Stormwater management
- Capital improvements programming
- Security measures

4.4.2 Property Protection

Property protection activities involve the modification of existing buildings and structures to help them better withstand the forces of a hazard, or removal of the structures from hazardous locations. Examples include:

- Acquisition
- Relocation
- Building elevation
- Critical facilities protection
- Retrofitting (e.g., wind proofing, flood proofing, seismic design techniques, etc.)
- Safe rooms, shutters, shatter-resistant glass
- Insurance

4.4.3 Natural Resource Protection

Natural resource protection activities reduce the impact of natural hazards by preserving or restoring natural areas and their protective functions.

Such areas include floodplains, wetlands and steep slopes. Parks, recreation or conservation agencies and organizations often implement these protective measures.

Examples include:

- Floodplain protection
- Watershed management
- Riparian buffers
- Habitat preservation
- Erosion and sediment control
- Wetland preservation and restoration
- Slope stabilization
- Forest and vegetation management (e.g., fire resistant landscaping, fuel breaks, etc.)

4.4.4 Structural Projects

Structural mitigation activities are intended to lessen the impact of a hazard by modifying the environmental natural progression of the hazard event through construction. They are usually designed by engineers and managed or maintained by university staff. Examples include:

- Reservoirs
- Dams / levees / dikes / floodwalls
- Diversions / detention / retention
- Channel modifications

- Storm sewers

4.4.5 Emergency Services

Although not typically considered a “mitigation” technique, emergency service activities do minimize the impact of a hazard event on people and property. These commonly are actions taken immediately prior to, during, or in response to a hazard event. Examples include:

- Warning systems
- Evacuation planning and management
- Emergency response training and exercises
- Sandbagging for flood protection
- Installing temporary shutters for wind protection

4.4.6 Public Education and Awareness

Public education and awareness activities are used to advise students, university staff, residents, elected officials, business owners, potential property buyers and visitors about hazards, hazardous areas and mitigation techniques they can use to protect themselves and their property. Examples of measures to educate and inform the public include:

- Outreach projects
- Speaker series / demonstration events
- Hazard map information
- Acquisition disclosure
- Library materials
- Student educational programs
- Hazard expositions
- Social media campaigns

4.5 Mitigation Action Prioritization

During the 2022-2023 planning process the planning team, workgroup, and steering committee refined the mitigation action prioritization process. Mitigation action prioritization emphasizes the extent to which benefits are maximized, according to a review of the proposed projects and their prioritization categories. Through the scoring, the higher the number of points the higher priority the mitigation action was determined to be for UK. The prioritization process included prioritization metrics, weighting factor and scoring criteria. Six prioritization categories were selected: feasibility, equity, climate resilience, public input including project type and hazards of concern, risk reduction/benefits and costs. The weighting factor contributed to the final score and ranged between 10 to 20 percent depending on the prioritization metric. The scoring ranged from 0 to 5 for each prioritization metric as shown in **Table 4-3.**

The scoring criteria for the prioritization metrics are as follows:

- **Feasibility:** Considered whether funding was identified and the degree of ease or complexity of the proposed project implementation.

- **Climate Resilience:** Resilience is the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. The university views resilience as the ability to bounce forward, not backwards. This definition acknowledges that the climate is changing and there is a need to build the ability of students, staff, faculty, citizens, and processes to bounce forward and remain flexible.

- **University Input:** University input was solicited through a survey and data collected through the UK Police Department's website. More information regarding the survey is located in Chapter 1 Planning Process. For purposes of prioritizing actions in the mitigation strategy, the following two survey questions were incorporated into the prioritization metric.
    - The public was asked to identify and rank the types of projects that were important to them including: prevention, emergency services, natural resources protection, public education and awareness, structural projects, property protection and social cohesion projects.
    - The university community was asked to identify the hazards that are the greatest and second greatest concern to UK. Responses to these questions were prioritized as depicted in **Table 4-2.**

Table 4-2: Hazards Identified by the University Community as Greatest Threats

	Highest	Highest (2 points)	Second Highest	Total	Score
Severe Winter Storm	34	68	29	97	5
Severe Storm	31	62	30	92	5
Cyber Threats	30	60	22	82	5
Tornado	23	46	31	77	5
Emergent Infectious Disease	11	22	20	42	3
Hazardous Materials	14	28	12	40	3
Flood	6	12	7	19	3
Extreme Temperature	4	8	7	15	3
Earthquake	3	6	4	10	3
Karst/Sinkhole	2	4	4	8	3
Dam/Levee Failure	1	2	1	3	1
Drought	1	2	1	3	1
Forest Fire	0	0	0	0	0
Hailstorm	0	0	0	0	0
Landslide	0	0	0	0	0

- **Risk Reduction/Benefits:** Risk reduction includes the proactive measures a community takes to reduce the impacts of risks, including hazards on the economic, social and environmental losses avoided or benefits gained by the action.
- **Costs:** Project costs for the purpose of scoring criteria ranged from predominantly staff time to more than $500,000.

Table 4-3 provides the explanation for the project prioritization and the points for each classification.

Table 4-3: Mitigation Action Prioritization

Criteria		Weighting Factor	Scoring Criteria
1	Feasibility	20%	5 – Funding identified, easily implemented within five years 3 – Funding identified, implemented with only moderate complexity or delays 1 – Funding identified, implementation is complex and faces certain delays for implementation 0 – Not feasible, no funding identified and/or not able to be implemented
2	Climate Resilience	20%	5 – Very High (Action provides multiple benefits for climate resilience or adaptive measures) 3 – High (Action provides at least one benefit for climate resilience) 1 – Moderate (Action provides limited benefits for climate resilience) 0 – Low (Action does not provide benefits for climate resilience)
3	Public (Project type)	10%	5 – Structural Projects 5 – Public Education and Awareness 3 – Natural Resources Protection 3 – Property Protection 3 – Emergency Services 1 – Prevention
4	Public (Hazard of greatest concern)	10%	5 – Action addresses one or more hazards identified by the university community as being a high threat to the university 3 – Action addresses one or more hazards identified by the university community as being a moderate threat to the university 1 – Action addresses one or more hazards identified by the university community as being a minimal threat to the university
5	Risk Reduction/Benefits	20%	5 – Very High (Significant losses avoided and/or significant benefits with consideration to economic, social and environmental factors) 3 – High (Numerous losses avoided and/or numerous benefits with consideration to economic, social and environmental factors) 1 – Moderate (Some losses avoided, some benefits with consideration to economic, social and environmental factors) 0 – Low (No losses avoided, no public benefits with consideration to economic, social and environmental factors)
6	Costs	20%	5 – Project Costs are predominantly staff time 3 – Project Costs are estimated between $0-$100,000 1 – Project Costs are estimated between $100,001-$500,000 0 – Project Costs are estimated above $500,000

Once the actions were prioritized, the action priority was classified as Very High, High, Medium, or Low as depicted on scoring as shown in **Table 4-4** Prioritization Matrix. It should be noted that the prioritization methodology provides a mechanism for benefit-cost review, though a more detailed benefit-cost analysis is likely required for future grant applications.

Table 4-4: Prioritization Matrix

Very High	500 – 400
High	399 – 300
Medium	299 – 200
Low	199 – 0

As actions are completed and new actions are identified, the prioritizations may change based on newly identified projects and revised scoring.

4.6 2023 Mitigation Action Plan

As noted throughout this chapter the 2023 mitigation strategy section incorporated significant changes to accommodate university data and tracking needs, priorities and to create a more actionable plan.

The mitigation actions were organized by mitigation technique categories, specifically Prevention, Property Protection, Natural Resource Protection, Structural Projects, Emergency Services, Public Education and Awareness. By organizing the mitigation actions into mitigation technique categories, the broad range of mitigation action types captured within this plan becomes clear. **Table 4-5** provides a breakdown of the number mitigation actions per mitigation technique category.

Table 4-5 Mitigation Actions by Technique Categories

Technique Category	Number of Mitigations Actions
Emergency Services	8
Natural Resources Protection	1
Prevention	7
Property Protection	1
Public Education and Awareness	10
Structural Projects	7

The following key elements are captured within the mitigation plan to help UK track each action over the next five years:

- Action Number
- Action Name
- Description
- Responsible Entity
- Hazards Addressed
- Feasibility
- Climate Resilience
- Public (Project type)
- Public (Hazards of concern)
- Risk Reduction/Benefits
- Estimated Costs

- Priority
- Potential Funding Source
- Project Type
- Lead Implementer/Other Partners
- Implementation Schedule
- Comments and Status

The third and last step in designing the mitigation strategy is the development of the Mitigation Action Plan. The Mitigation Action Plan represents a comprehensive and functional plan for each action and is the most essential outcome of the mitigation planning process. The Mitigation Action Plan includes a prioritized listing of proposed hazard mitigation actions (policies and projects) for UK to complete. Each action has accompanying information, such as those departments or individuals assigned responsibility for implementation, potential funding sources, and an estimated target date for completion. The Mitigation Action Plan provides those departments or individuals responsible for implementing mitigation actions with a clear roadmap that also serves as an important tool for monitoring success or progress over time. The cohesive collection of actions listed in the Mitigation Action Plan can also serve as an easily understood menu of mitigation policies and projects for those local decision makers who want to quickly review the recommendations and proposed actions of the Plan and potentially integrate with other planning documents.

In preparing the 2023 Mitigation Action Plan, members of the UK steering committee considered the overall hazard risk and capability to mitigate the effects of hazards as recorded through the risk and capability assessment process. The adopted mitigation goals were also considered when developing each action item. **Table 4-6** describes the 2023 Hazard Mitigation Action Plan.

Table 4-6: 2023 Hazard Mitigation Action Plan

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
1	Disaster Recovery Manager	Hire Disaster Recovery Manager for the Center for Disaster Recovery and Resilience	Center for Disaster Recovery and Resilience	Multiple Hazards	100	100	50	50	60	100	460	General Fund	Prevention	None	2023
2	Center for Recovery and Resilience	The university will establish the Center for Disaster Recovery and Resilience. The goal of the Office is to serve as the designated university entity to collaborate and streamline efforts to lessen the impact of adverse incidents to the university by developing strategic resilience and implementing mitigation actions to reduce hazards risks. In order to accomplish this, the office will plan and facilitate long-term recovery from disasters and mitigation to hazard events that may cause an operational interruption; injury, illness, or death; damage to or loss or equipment, infrastructure services, or property; or functional degradation to social, economic or environmental aspects of the university.	Crisis Management and Preparedness	All Hazards	100	100	50	50	60	100	460	General Fund	Public Education and Awareness	0	2023
13	Education and Awareness	Maintain and update the hazard mitigation website and educational materials, including social media updates, with relevant information regarding ways to mitigate hazards and vulnerabilities. Encourage university participation in hazard mitigation outreach programs, including UK Alert.	UK Police Department	Multiple Hazards	100	100	50	50	60	100	460	General Fund	Public Education and Awareness	Housing, Office for Student Success, Center for Disaster Recovery and Resilience, Public Relations, and Marketing	2023-2028
16	Geospatially Identify Shut Off Valves and Other Equipment	Document and map the indoor shut off valves, fire protection, and critical equipment.	Facilities Management	Multiple Hazards	100	100	50	50	60	100	460	General Fund	Structural Projects	ITS Geospatial	2023-2025
17	Thermal Imagery Flyover	Perform thermal imagery flyover that will be used to detect steam system leaks and roof anomalies. Document thermal imagery flyover findings and perform analysis to determine locations for repairs. Identify funding and schedule to perform repairs.	Facilities Management	Multiple Hazards	100	100	50	50	60	100	460	General Fund	Prevention	ITS Geospatial	2023-2024

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
12	Personal Preparedness	Implement education and outreach programs on UK campuses focused on preparedness, including disaster kits and emergency shelters.	Crisis Management and Preparedness, Center for Recovery and Resilience	Multiple Hazards	100	60	50	50	60	100	420	General Funds (currently not budgeted), Grants	Public Education and Awareness	0	2023-2028
14	Record Disaster Management Data	Record and maintain damage and occurrence data from disasters and emergency events to support disaster recovery and hazard mitigation grant applications.	Center for Disaster Recovery and Resilience	Multiple Hazards	100	100	50	50	20	100	420	General Fund (currently not budgeted), Grants	Public Education and Awareness	Risk Management, Departments pursuing grant funding	2023-2028
21	Emergency Plans and Procedures	Develop/update emergency plans, including BEAPs, for REC, RCARS, Central Kentucky Farms and Robinson Forest. -Develop/conduct emergency procedures training for REC, RCARS, Central Kentucky Farms and Robinson Forest.	College of Agriculture, Food, and the Environment	Multiple Hazards	100	60	50	50	60	100	420	General Fund	Prevention	Crisis Management and Preparedness	2028
28	Construction Impacts	Improve university communications regarding pathways, walkways and streets impacted by construction and the alternative routes.	Facilities Management	Multiple Hazards	100	60	50	50	60	100	420	General Fund, Grants	Public Education and Awareness	Trans-portation, Disability Resource Center, Environmental Health Safety, ITS	2025
7	Tree Inventory	Maintain the data in the 2015 Tree Inventory for the main campus to maintain tree health and improve safety.	Facilities Management	Severe Storm	100	100	50	30	20	100	400	General Fund	Prevention	College of Agriculture, Risk Management	2023-2028
8	Emergency Planning	Departments will develop Business Continuity Plans (BCP) with technical support and guidance from CMP. Departments will continue to update BEAPs with Guidance from CMP.	Individual departments and Crisis Management and Preparedness	Multiple Hazards	100	60	30	50	60	100	400	General Fund	Emergency Services	Internal Audit	2023-2028
10	Campus CERT Program	Maintain Campus CERT Program and continue to coordinate with LFUCG.	Crisis Management and Preparedness	Multiple Hazards	100	60	30	50	60	100	400	General Fund	Public Education and Awareness	Human Resources, Public Relations, and Marketing	2023-2028
29	Generators at UK HealthCare Facilities	Identify needs and locations, and costs for generators at UK Healthcare Facilities for plan (including schedule) to purchase and install generators.	UK HealthCare	Multiple Hazards	60	100	30	50	60	100	400	General fund for assessment, Grants for generators	Emergency Services	Facilities Management, Procurement, EHS	2026, ongoing
15	Training for Campus Recreation Staff and Resident Advisors	Continue to train Campus Recreation staff and Resident Advisors (RAs) to respond to campus emergency events and perform drills to improve response.	Campus Housing and Residence Life	Multiple Hazards	60	100	50	50	20	100	380	General Fund	Public Education and Awareness	Housing, Office of Student Success, Campus Recreation	2023-2028

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
19	Facilities Improvements at REC at Princeton, Central Kentucky Farms, RCARS, and Robinson Forest	Develop plan, associated costs, and schedule for identification and/or strengthening/renovation of existing structures for storm shelters and emergency equipment at REC at Princeton, Central Kentucky Farms, RCARS, and Robinson Forest for storm shelters and emergency equipment. As funding allows for Robinson Forest: -Inspect bath house to assess whether it can serve as a storm shelter. -Add permanent landing lights for LZ and bury power line to helicopter pad with building improvements around LTC sawmill.	College of Agriculture, Food, and the Environment	Multiple Hazards	60	60	50	50	60	100	380	General Fund (currently not budgeted) and Grant Funding	Structural Projects	Crisis Management and Preparedness, UK Fire Marshal	2028
33	Hazard Mitigation Workgroup	Hazard Mitigation Workgroup will meet with the Center for Recovery and Resilience at least annually to discuss mitigation action status, successes, and needs to implement the 2023 plan update. -Include the Office for Institutional Diversity and Disability Resource Center in the Hazard Mitigation workgroup for inclusion and discussion regarding equity issues intersecting with hazard mitigation and recovery. -Include the Kentucky Climate Consortium regarding climate change data and efforts through the Consortium.	Center for Disaster Recovery and Resilience	All Hazards	100	60	50	50	20	100	380	General Fund	Public Education and Awareness	Other Workgroup Members	2024-2028
24	Develop New Planning Documents	Develop Family Reunification Plan.	UK Police Department	Multiple Hazards	60	60	30	50	60	100	360	General Fund	Emergency Services	Student Success, UK Police, UK HealthCare, Trans-portation, Housing, Human Resources, Office for Institutional Diversity, Public Relations	2027

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
25	Develop New Planning Documents	Develop Volunteer Management Plan.	UK Police Department	Multiple Hazards	60	60	30	50	60	100	360	General Fund	Emergency Services	Red Cross, UK HealthCare (Office of Volunteer Services), Center for Disaster Recovery and Resilience, Human Resources, Public Safety	2027
26	Develop New Planning Documents	Develop Donation Management Plan.	University Financial Services	Multiple Hazards	60	60	30	50	60	100	360	General Fund	Emergency Services	Office of Philanthropy, Environmental Health and Safety, UK HealthCare, Public Relations, Supply Center	2027
27	Resilience Hubs/Centers	Identify Main Campus locations and assess feasibility for resilience hubs/centers.	Crisis Management and Preparedness	Multiple Hazards	60	60	30	50	60	100	360	General Fund (currently not budgeted)	Emergency Services	0	2028
11	LFUCG and State HMP Participation	Participate in state committee for the Statewide Hazard Mitigation Plan and the committee for the LFUCG HMP.	Crisis Management and Preparedness	Multiple Hazards	100	100	50	50	60	0	360	General Fund	Public Education and Awareness	Center for Disaster Recovery and Resilience, Hazard Mitigation Steering Committee	2023-2025
31	Hospital Incident Command	Retrofit meeting room in Chandler Hospital for incident command center.	UK HealthCare	Multiple Hazards	20	100	30	50	60	100	360	General Fund	Emergency Services	Hospital Emergency Management, HealthCare Safety, Police Department	2028
22	Construction Drawings	Determine scope and process forward to scan paper construction drawings that pre-date requirements for electronic submittals to the university.	Facilities Management	Multiple Hazards	100	60	30	50	20	60	320	General Fund/Building Maintenance	Property Protection	ITS Geospatial	2023-2024
34	Hazard Mitigation Geodatabase	Review and update the Hazard Mitigation Geodatabase as needed over the five-year implementation period.	Facilities Management	Multiple Hazards	100	20	20	50	20	100	320	General Fund	Prevention	0	2028
9	Stormwater Master Plan and Sanitary Sewer Master Plan	Secure funding and develop a campus stormwater master plan addressing stormwater flow and volume. Secure funding and develop a sanitary sewer master plan.	Facilities Management	Flood	60	60	50	50	60	20	300	General Funds (currently not budgeted), Grants, Asset Preservation Funds	Prevention	Environmental Quality Management	2025

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
3	Generators	Identify locations with existing generators and distinguish the type of generator (partial vs. full load). Identify the location needs and whether current generators are sufficient for location needs or additional generators are required. As development occurs, determine the locations and needs for additional generators to acquire and install. This action includes buildings on the main campus (residence halls and medical facilities). Off-campus facilities are also included.	Facilities Management	All Hazards	20	60	50	50	60	20	260	General Fund/Grants funding for generators	Structural Projects	University Fire Marshal	2023-2028
5	Lightning Protection	Evaluate lightning protection needs for UK buildings and install lightning protection where needed and during whole building renewals.	Facilities Management	Severe Storm	60	60	50	50	20	20	260	Grants	Structural Projects	University Fire Marshal, CDRR	2023-2028
20	Erosion and Sediment Control Measures and Slope Stabilization Measures	For 4-H Camps: -Identify locations for and implement erosion and sediment control measures. For RCARS and Robinson Forest: -Implement slope stabilization measures	College of Agriculture, Food, and the Environment	Multiple Hazards	60	60	30	30	60	20	260	General Fund (currently not budgeted) and Grant Funding	Natural Resources Protection	0	2028

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
18	Improvements to 4-H Camps	Develop plan, associated costs, and schedule for the following improvements at 4-H Camps: -Build restrooms in 4-H cabins so campers can safely remain in cabins during severe weather. -Improve temperature control in facilities to reduce impacts of extreme weather, including mold. -Identify structures that can be used as storm shelters. -Identify structures for air conditioning to serve as alternative locations for outdoor activities during extreme heat. -Build storm shelters where needed. -Apply seismic retrofits to existing western Kentucky 4-H Camps. -Conduct forest fire fuel break restoration. -As funding and project work allows, install underground utility lines.	College of Agriculture, Food, and the Environment	Multiple Hazards	20	60	50	50	60	0	240	General Fund Grant	Structural Projects	0	2028
32	Cyber Security Education	Improve the implementation and growth for cybersecurity training across the university. The university will continue to identify ways to enhance the education for the university community (students, faculty, and staff) regarding cybersecurity and encourage participating in training, and documenting information from partners to confirm training is done.	ITS	Cyber Security	100	0	10	10	20	100	240	General Fund	Prevention	0	As needed between 2023-2028
23	Mock dorm room burn unit	Replace mock dorm room burn unit.	Environmental Health and Safety	Multiple Hazards	20	60	50	10	60	20	220	Grant Funding General Fund	Public Education and Awareness	Housing	2027
30	Mobile Response Vehicle	Explore funding source for Mobile Response Vehicle to Support Rural and Vulnerable Communities. Vehicle intended to support vaccine delivery, triage, and emergency medicine.	UK HealthCare	Multiple Hazards	20	60	30	50	60	0	220	General Fund (Currently, not budgeted)	Emergency Services	College of Public Health, Center for Health Equity Transformation, Center for Excellence in Rural Health, Procurement.	2028 and beyond

Action Item	Action Name	Action Description	Responsible Department/Office	Hazards Addressed	Feasibility	Climate Resilience	Public (Project Type)	Public (Hazard of Greatest Concern)	Risk Reduction/ Benefits	Costs	Total Prioritization	Potential Funding Source	Project Type	Other Partners	Implementation Schedule
4	Improve Karst Resilience	Conduct karst assessments on UK campuses. Monitor karst activity and require karst resilient design and construction standards for all facilities in areas susceptible to karst. Perform structural mitigation projects as needed.	Facilities Management	Karst/sinkhole	60	20	30	10	20	60	200	General Fund	Structural Projects	University Fire Marshal, Real Estate Services, UK Healthcare	2023-2028
6	New Police Department	Identify location and secure funding for new police department which will include a new EOC.	Police Department	Multiple Hazards	60	20	50	0	0	0	130	General Fund, not budgeted	Structural Projects	Facilities Management	2023-2028

Table of Contents

Chapter 5: Plan Maintenance

A routine method and schedule for maintaining the plan is necessary to implement continued risk reduction and loss avoidance. Completing the plan maintenance process will keep the university on track and serve as the basis for the 2029 plan update. The process of monitoring the plan will provide the university with the opportunity to document progress in achieving mitigation goals. The workgroup agreed that it is imperative to have stakeholder involvement for maintaining the plan to effectively incorporate the mitigation strategy into university programs and regulations.

5.1 Implementation

Each department, division, office or other partner participating in the *2023 University of Kentucky Hazard Mitigation Plan Update (UK Hazard Mitigation Plan)* is responsible for implementing specific mitigation actions as prescribed in the Mitigation Action Plan. Every proposed action listed in the Mitigation Action Plan is assigned to a specific "lead implementer" (i.e., a specific department, division, office or position) in order to assign responsibility and accountability and increase the likelihood of subsequent implementation.

In addition to the assignment of a Responsible Office/Department, an implementation time period or a specific implementation date was assigned to each mitigation action in order to assess whether actions are being implemented in a timely fashion. The university will seek internal and external funding sources to implement mitigation projects in both the pre-disaster and post-disaster environments. When applicable, potential funding sources have been identified for proposed actions listed in the Mitigation Action Plan.

Moving forward, the workgroup intends to convene as a whole, with smaller subgroups to meet as needed. A key agenda item at the biannual meetings will be to determine which actions are being implemented by members of the workgroup. Crisis Management and Preparedness and Center for Disaster Recovery and Resilience will convene the workgroup on a biannual basis and establish the subgroups to focus on implementation efforts.

5.2 Integration

The workgroup will integrate this UK Hazard Mitigation Plan into relevant university decision-making processes, plans or mechanisms, such as the campus master planning and redevelopment efforts, when appropriate.

The members of the Workgroup will remain charged with ensuring that the goals and mitigation actions of new and updated university planning documents for their departments or facilities are consistent, or do not conflict with, the goals and actions of the UK Hazard Mitigation Plan, and will not contribute to increased hazard vulnerability on campus.

Opportunities to integrate the requirements of this plan into other university planning mechanisms shall be identified through future planning efforts. Some mechanisms for integration under consideration include:

- As a supporting document for other university plans.
- For stormwater planning, continuity planning, exercises and major event programming.

- New development on campus, especially in terms of environmental concerns, security and life safety.
- Integration of UK's mitigation plan is considered on a case-by-case basis.

5.2.1 Monitoring, Evaluation and Enhancement

Periodic revisions and updates of the Hazard Mitigation Plan are required to ensure that the goals of the plan are kept current, taking into account potential changes in hazard vulnerability and mitigation priorities. In addition, revisions may be necessary to ensure that the plan is in full compliance with applicable federal and state regulations. Periodic monitoring and evaluation of the plan will also ensure that specific mitigation actions are being reviewed and carried out according to the Mitigation Action Plan.

The workgroup shall meet biannually to monitor and evaluate the progress attained and to revise, where needed, the activities set forth in the plan. The biannual meetings provide the workgroup with an opportunity to:

- Evaluate those actions that have been successful;
- Document hazard occurrences and impacts;
- Explore the possibility of documenting potential losses avoided due to the implementation of specific mitigation measures; and
- Identify any new or additional vulnerabilities that may be faced by the university and may need to be addressed through an amendment or in a future update of this plan.

In addition to biannual meetings, subgroups of the workgroup may meet more frequently to monitor and evaluate actions tasked to their specific department, office, division or facility.

5.2.2 Five-year Plan Review and Update

The plan will be thoroughly and formally reviewed by the workgroup every five years in alignment with federal regulations. This update is also used to determine whether there have been any significant changes on campus that may, in turn, necessitate changes in the types of mitigation actions proposed, goals or priorities. New development in identified hazard areas, an increased exposure to hazards, an increase or decrease in capability to address hazards and changes to federal or state legislation are examples of factors that may affect the necessary content of the plan. UK's Center for Disaster Recovery and Resilience will be responsible for reconvening the Workgroup and conducting the five-year review.

Upon completion of the review and update/amendment process, the UK Hazard Mitigation Plan will be submitted to the Kentucky State Hazard Mitigation Planner for a state-level compliance review. Final approval is obtained from the FEMA in coordination with the state. Once an "approved pending adoption" status has been issued by FEMA, the Board of Trustees and the UK president can review and formally adopt the plan via a written resolution. The university review process consists of review by the UK president, Division of Crisis Management, Center for Disaster Recovery and Resilience and the workgroup, with final approval by the UK president.

5.3 Disaster Declaration

Following a disaster declaration, the UK Hazard Mitigation Plan may be revised as necessary to reflect lessons learned, or to address specific issues and circumstances arising from the event. It will be the responsibility of the Center for Disaster Recovery and Resilience to reconvene the Workgroup and to invite the appropriate stakeholders to participate in the plan revision and update process following declared disaster events.

5.4 Plan Amendment Process

Unique circumstances, such as the availability of critical data or an omission of information or a disaster event, may necessitate a plan amendment. Upon the initiation of the amendment process, the university will forward information on the proposed change(s) to all interested parties including, but not limited to, all directly affected university divisions and departments.

5.5 Continued Public Involvement

The Center for Disaster Recovery and Resilience is dedicated to continuing public outreach and involvement in the plan and the implementation of mitigation actions. This plan was created with significant input with representation across and beyond the university and the main goal is to provide opportunities on a regular basis to facilitate continued community involvement.

Public participation is an integral component to the mitigation planning process and will continue to be essential as this plan evolves over time. In order to keep the public (i.e., campus community including staff, faculty and students) engaged over the five years, the university will regularly post information about hazards, risk and safety on university communication channels (e.g., social media and websites). These efforts are underway now and will continue over the next five years with specific content for hazard mitigation.

Other efforts to continually involve the public will be made as opportunities are presented. These efforts include:

- Advertising public meetings on university websites, social media channels, local newspapers, public bulletin boards and/or university buildings;
- Utilizing available university channels to update the university community regarding any maintenance and/or periodic review activities taking place;
- Designating willing and voluntary staff, students, faculty or community members as official members of the workgroup, as appropriate;
- Making the plan available to the public by request through the Center for Recovery and Resilience.