A PROPOSAL SUBMITTED TO:
City of Lee's Summit, Missouri

Precipitation-Based Flood Mapping and Data Analytics for the City of Lee's Summit, Missouri

Flooding in Lee's Summit on April 29, 2022, near SE Brentwood Drive and East Langsford.

U.S. Geological Survey
Central Midwest Water Science Center

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CENTRAL MIDWEST WATER SCIENCE CENTER

Summary

The City of Lee's Summit, Missouri, a southeastern suburb of the greater Kansas City, Missouri, metropolitan area, has an estimated population of 101,108 and covers an area of around 65 square miles. The city of Lee's Summit has identified developed areas that are prone to flooding along Cedar Creek and the East Fork Little Blue River. These areas are either currently developed or have the high potential for future development and any future flooding poses a significant risk to the infrastructure and people inhabiting these at-risk areas. The city of Lee's Summit seeks solutions in understanding the causes of flooding and increasing readiness to potential flash flooding along these identified streams. The primary objectives of the proposed study are (a) monitor these streams using both telemetered and non-telemetered stage sensors, (b) gather observed precipitation data from the City of Lee's Summit's potentially planned precipitation gages along with forecast information by the National Weather Service (NWS), (c) develop and calibrate hydrologic and hydraulic models of select basins that will be used to develop value-added inundation map libraries that will be used for both regulatory and risk management purposes. These inundation map libraries will consist of a variety of antecedent soil moisture conditions and will also account for any projected future change in precipitation frequencies due to climate change.

Field data collection and surveys throughout 2024 will consist of installing one telemetered Fit-For-Purpose (FFP) USGS stream gage and 5 non-telemetered submersible water level loggers throughout select basins, along with field surveys conducted to assist with aerial lidar data used for the development of hydrologic and hydraulic models. Proposed deliverables include a USGS Scientific Investigations Report, a USGS Data Release, and a model archive accompanying a web-based decision-support tool.

Background/Introduction

The City of Lee's Summit, Missouri, has experienced historical flooding --not limited to road overtopping-- and regulatory concerns from substantial damage and potential encroaching development. In addition, it is anticipated that continued development and regulatory concerns will affect the southern portion of Lee's Summit. Cedar Creek and East Fork Little Blue River are the waterways of greatest concern for flooding. Cedar Creek is the largest stream within the city limits that contributes to road overtopping at Chipman road and poses a flood risk to adjacent pedestrian traffic. The East Fork Little Blue River has a higher population density than other waterways within the City of Lee's Summit, reflecting rental properties within the floodplain and anticipated substantial damage outcomes.

Problem

Given the effects of flash flooding due to climate change and increasing development, appropriate communication and messaging is needed to local business, residents, and city officials that convey flood risk, including the protection of life and property. Additionally, products are needed to support regulatory management and administration involving future permitting and compliance, as well as informed decisions regarding future base capital improvement cost expenditures.

Objectives and Scope

The overall objective of this study is to provide a decision support product that conveys flood-risk information and meets regulatory needs for the City of Lee's Summit, Missouri. The overall objective is fulfilled by the following detailed study objectives:

1. Data collection to develop the foundation for communication and product integrity
   a. Install, operate, and maintain one Fit-For-Purpose (FFP) telemetered stage platform (fig 1). This stage platform will serve as a real-time river observation for the City of Lee's Summit and its citizens on their largest river with the purpose to provide a stage-threshold exceedance notification. This is a non-standard USGS stage gaging platform reflecting limited quality assurance standards.
   b. Install, operate, and maintain 5 non-telemetered stage sensors in the East Fork Little Blue River basin (fig 1).
   c. Coordinate and ingest furnished precipitation gage data by the city.

2. Development and calibration of hydrologic and hydraulic models for the East Fork Little Blue River basin to produce:
   a. Deterministic static inundation map libraries attributed with hydraulic parameters depth, velocity, and water-surface elevation conveying risk along with regulatory analytics including first floor elevations, critical infrastructure, and loss estimation.
   b. Probabilistic static inundation map libraries with attributed content defined in (a.) for the existing1-percent base regulatory flood as compared to the future 1-percent flood for a 30- and 50-year projection utilizing climate-based precipitation.

3. Ingestion of observed data by the City of Lee's Summit's precipitation gage(s) along with forecast information by National Weather Service (NWS) for station KXLT (Lee's Summit Municipal Airport, fig 1) facilitated through a dynamic data pull, ingesting 1-hour Quantitative Precipitation Forecasts (QPF) into a web-based decision-support tool.

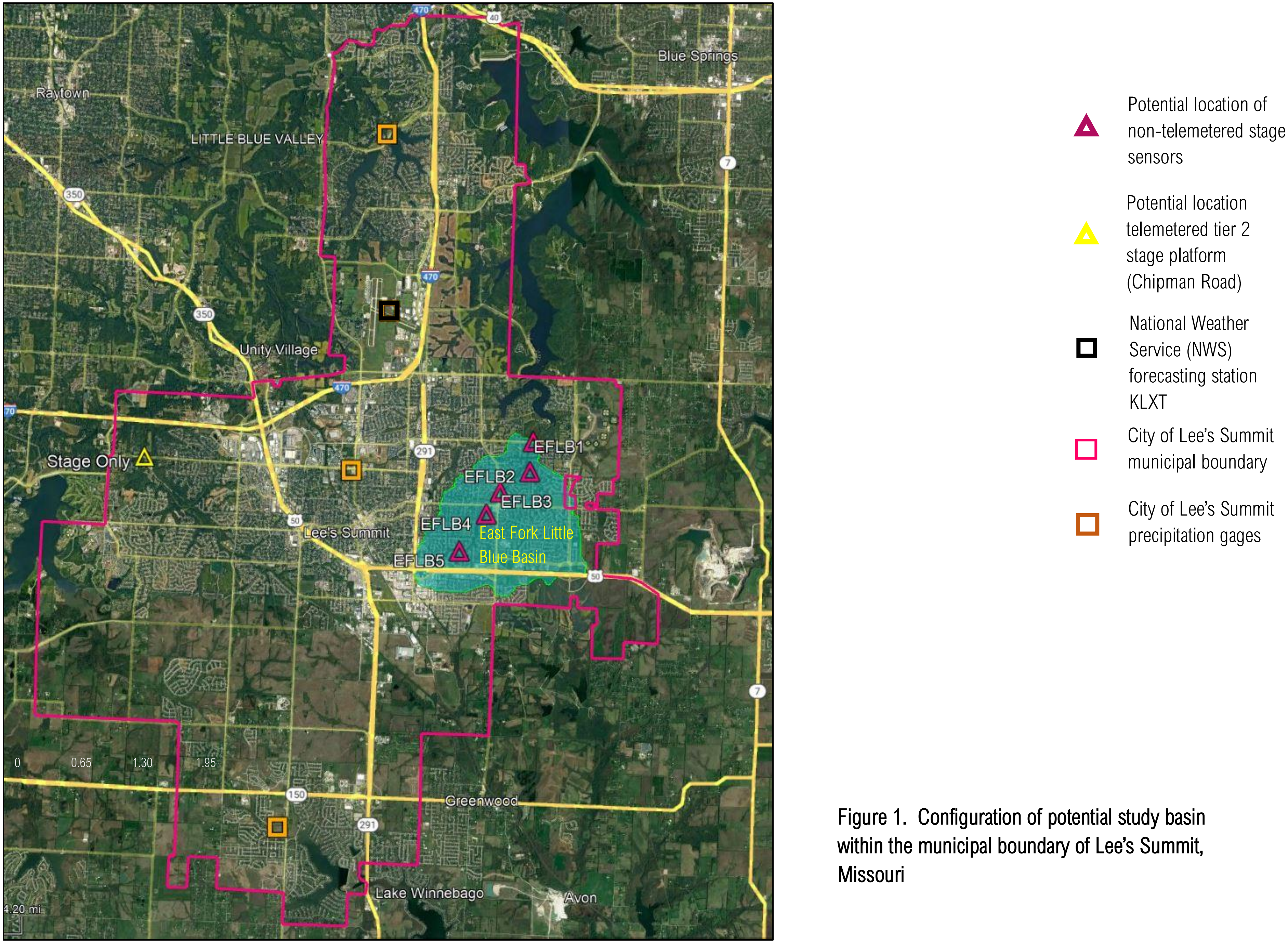


Figure 1. Configuration of potential study basin within the municipal boundary of Lee's Summit, Missouri

Relevance and Benefits

Communities throughout the United States are challenged with messaging and managing flood risk, ensuring safety, and administering appropriate management standards to assure resiliency in the wake of estimated future climate impacts. Frequency and intensity of flooding (opposed to the number of moderate floods) as a result of extreme precipitation events (fig. 2) may continue to increase given additional moisture into the atmosphere owing to evaporation from warmer temperatures (Brunner, Swain, et. al., 2021). Managing flood risk involves the ability to manage an impending disaster, addressing elements of planning, response, and mitigation. A decision support tool provided by this study will address these elements as well as a foundation for compliance with operational and disaster management benefits realized by the City of Lee's Summit, not limited to:

1. Emergency response plan support with operational and coordination capability to protect lives and property in a timely and effective manner.
2. Mitigation planning support to decrease repetitive losses, financial hardship or potential loss of life with the potential to leverage future grant opportunities.
3. Promotion of communication and management within the regulatory floodplain.
4. Support of informed decisions regarding future base capital improvement cost expenditures through cited benefit-cost evaluation
5. Identification of quantitative change in design-storm magnitudes from climate-based hydrology for design planning of stormwater infrastructure.

U.S. Geological Survey water mission goals addressed by this study include contribution toward the advancement of hydrologic monitoring networks, prediction of changes in the quantity of water resources in response to land use changes and addressing the anticipation of response of water-related emergencies (flooding) (Evenson et.al., 2013). The methods and products developed in this study, therefore, will provide benefits to the residents and managers of the city of Lee's Summit and to the USGS.

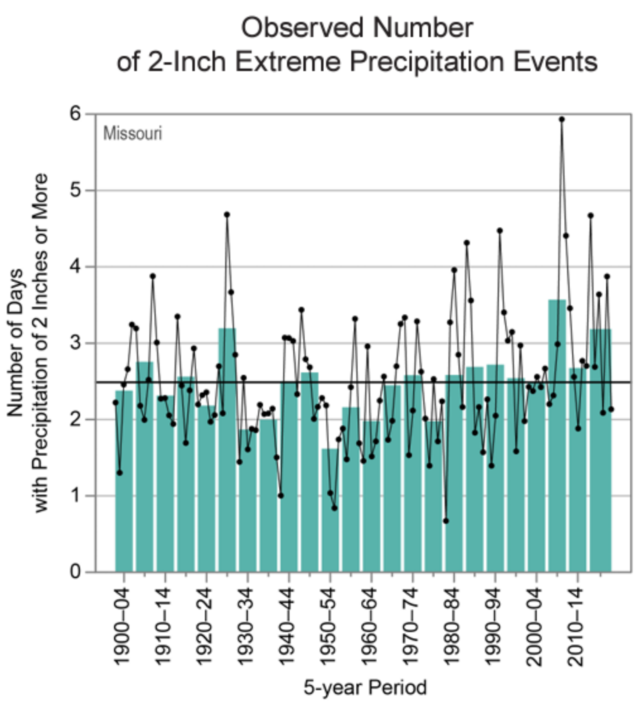


Figure 2. Temporal change in the number of extreme precipitation events in Missouri (Frankson and others, 2022).

Approach

Four tasks will be accomplished to complete the objectives of this study. These tasks are (1) data collection and monitoring, (2) basin hydrology modeling, (3) hydraulic modeling, (4) web-based decision support tool development and reporting. A general timeline for completion of these tasks is provided in the Timeline and Budget section of this proposal.

Task 1. Data collection and Monitoring

Time series and geospatial data are required for development, calibration, and subsequent simulations for predictive outcomes of hydrologic and hydraulic models. Time series data include (but are not limited to):

- Installation, operation, and maintenance of a Fit-For-Purpose (FFP) stage-only gaging platform over Cedar Creek near or at Chipman Road, disseminated by way of the National Water Information System (NWIS) web with site specific QA and Data Management plan, or disseminated by way of the USGS Short Term Network (STN) with similar quality assurance and data management.
- Acquisition of stage time series and select discrete discharge measurements at 5 non-telemetered stage sensors within the East Fork Little Blue basin illustrated in figure 1 for moderate or high flow events that occur during the study. Operation of non-telemetered sensors will occur during the study through the third quarter of FY2025.
- Precipitation acquisition and analysis from the Advanced Hydrologic Prediction Service (AHPS) and Multi-Radar/Multi-Sensor System (MRMS) project from the NWS.
- NWIS web hosting and web scraping of observed precipitation data provided by the City of Lee's Summit precipitation gage network (figure 1).
- Web scraping of forecasted precipitation text products (fig 2a) and analysis from the National Blend of Models for 1-hour QPF data from the NWS.

Geospatial data will include (but is not limited to):

- 2020 lidar furnished by the National Resource Conservation Service (NRCS) and Federal Emergency Management Agency (FEMA).
    - Use of Global Navigation Satellite Systems (GNSS) techniques and methods (Rydlund and Densmore, 2012) to capture location and elevation information not defined from available lidar for the East Fork Little Blue basin. Survey information not limited to channel bathymetry, infrastructure, floodplain, transportation, and detention/retention storage.
        - Datum protocols and establishment (Rydlund and Noll, 2017) for non-telemetered stage sensor locations.
        - Identification and preservation of high-water marks (Koenig and others, 2016) for any potential moderate and/or high flow events that occur during the study.
- As-built / design plans for pertinent infrastructure.
- National Land Cover Dataset (NLCD) land cover data
- National Agriculture Imagery Program (NAIP); and
- Next-Generation Radar (NEXRAD) Hydrologic Rainfall Analysis Project (HRAP) grid data.

Sediment and soils data will include:

- Soil Survey Geographic (SSURGO) database (NRCS, 2019)

Task 2. Basin Hydrology Modeling

Analysis conducted within the East Fork Little Blue River basin will utilize the Hydrologic Engineering Center (HEC)-River Analysis System (RAS). Precipitation and infiltration will be modeled using HEC-RAS rain on grid, a precipitation modeling component within HEC-RAS or Hydrologic Engineering Center (HEC)-Hydrologic Modeling System (HMS) model, a process-based, semi-distributed water-balance model designed to predict the effects of management decisions on water, sediment, and water-quality (i.e., nutrients) (Scharffenberg, 2018). The modeling program that is used for this project scope will be determined by USGS during the project period. Modeled processes for this effort include, but are not limited to, event surface runoff, base flow, and channel transmission losses, which can be simulated in the model and are determined by process-related parameter values. Simulated waters aggregated within their corresponding sub-basins are allocated to the sub-basin reach and exit a sub-basin via outlet points on the stream network that define the sub-basin. The outlet point for the select basin is represented by the non-telemetered EFLB1 at Scruggs Road (East Fork Little Blue) (fig 1). Select discharge measurements will be used along with stage hydrographs to support model calibration.

Model outputs include streamflow for the sub-basin outlet, including the delineated basin outlet, at variable timesteps from sub-daily to annual. Many mathematical model options exist within HEC-RAS rain on grid to determine precipitation losses (interception and storage), methods of transforming excess precipitation to streamflow, and the addition and rate of change of baseflow. Modification of these model options allows for the control of antecedent storm conditions such that simulated event hydrographs can be preceded by dry, normal or wet starting conditions (USACE, 2020). Dry, normal and wet soil-moisture antecedent conditions will be simulated to account for a conservative range of possible hydrologic responses from the basin. A constant estimated baseflow condition will precede all simulated events.

Frequency (recurrence) of storm events will be used to define inputs to hydrologic analysis over a range of select durations derived from National Oceanic Atmospheric Administration (NOAA) Atlas 14 Volume 8 (Perica and others, 2013). Atlas 14 intensity and depths will be used in support of full duration observed storm events from the local precipitation gaging network in the City of Lee's Summit. Distribution for non-observed Atlas 14 storm events will use a known rainfall distribution method (Huff Quartile, Pilgrim-Cordery, SCS Type II, etc.) that is determined to be ideal for this study area. Boundary conditions or forcings to hydraulic models produced by HEC-RAS will be represented by a combination of various frequency, duration and resulting accumulation precipitation inputs from observed events and Atlas 14 that will drive notable (deterministic) flood impacts. Annual-maximum series (AMS), Full Duration (FDS) and partial-duration series (PDS) precipitation amounts will be evaluated for appropriate use given event frequency.

Future conditions modeling uses historical data that are assumed to represent a stationary process. Climate change introduces nonstationary risks such as sea level and temperature rise, and changes in timing and distribution of precipitation, snowpack, and snowmelt. Failure to account for such nonstationary risks may compromise the operational characteristics of existing and future infrastructure (NCHRP, 2019). The National Cooperative Highway Research Program (Transportation Research Board) Project 15-61 provides documentation and a "roadmap" to utilize technical topics related to the need for the incorporation of climate science projections into inland hydrology design and analysis (NCHRP, 2019). The NCHRP document will serve as the foundation to evaluate 30- and 50-year precipitation projections by way of adaptation tools used by the transportation industry that involve climate data processing through the Coupled Model Intercomparison Project (CMIP). Climate drivers will incorporate carbon emissions scenarios or Representative Concentration Pathways (RCPs) for both RCP4.5 and RCP8.5 to provide a sufficient range for comparisons that ultimately reflect future-conditions precipitation frequency estimates as shown in table 1 (*1-percent precipitation probability for both 6- and 24-hour storm durations over a range of dry, normal, and wet antecedent moisture conditions*).

	Deterministic Conditions*		Existing Conditions		Future Conditions							
	NOAA Atlas 14 Point Precipitation Frequency		Storm Duration		RCP4.5 - 30 yr		RCP4.5 - 50 yr		RCP8.5 - 30 yr		RCP8.5 - 50 yr	
					Storm Duration		Storm Duration		Storm Duration		Storm Duration	
	Lee's Summit - Accumulation		6-hour	24-hour	6-hour	24-hour	6-hour	24-hour	6-hour	24-hour	6-hour	24-hour
Antecedent Moisture Condition	Frequency	Duration	Recurrence Interval (t-year)		Recurrence Interval (t-year)		Recurrence Interval (t-year)		Recurrence Interval (t-year)		Recurrence Interval (t-year)	
Dry	Variable*	Variable*	100	100	100	100	100	100	100	100	100	100
Normal	Variable*	Variable*	100	100	100	100	100	100	100	100	100	100
Wet	Variable*	Variable*	100	100	100	100	100	100	100	100	100	100

*Combination of various frequency, duration, and resulting accumulation precipitation representing notable flood impacts

National Oceanic Atmospheric Administration (NOAA) ATLAS 14 Point Precipitation Freqeuncy Estimates for Lee's Summit, Missouri

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.413** (0.322-0.529)	**0.484** (0.377-0.620)	**0.600** (0.466-0.770)	**0.697** (0.539-0.899)	**0.833** (0.625-1.10)	**0.939** (0.690-1.26)	**1.05** (0.745-1.43)	**1.16** (0.794-1.62)	**1.30** (0.864-1.87)	**1.42** (0.917-2.06)
10-min	**0.605** (0.472-0.775)	**0.708** (0.552-0.907)	**0.878** (0.682-1.13)	**1.02** (0.789-1.32)	**1.22** (0.915-1.62)	**1.38** (1.01-1.84)	**1.53** (1.09-2.10)	**1.69** (1.16-2.37)	**1.91** (1.26-2.74)	**2.07** (1.34-3.01)
15-min	**0.738** (0.576-0.945)	**0.864** (0.673-1.11)	**1.07** (0.832-1.38)	**1.25** (0.962-1.60)	**1.49** (1.12-1.97)	**1.68** (1.23-2.25)	**1.87** (1.33-2.56)	**2.06** (1.42-2.89)	**2.33** (1.54-3.34)	**2.53** (1.64-3.68)
30-min	**1.02** (0.797-1.31)	**1.20** (0.937-1.54)	**1.50** (1.16-1.93)	**1.75** (1.35-2.25)	**2.09** (1.57-2.77)	**2.36** (1.73-3.16)	**2.63** (1.87-3.60)	**2.91** (1.99-4.07)	**3.27** (2.17-4.69)	**3.56** (2.30-5.17)
60-min	**1.34** (1.04-1.71)	**1.57** (1.23-2.02)	**1.96** (1.52-2.52)	**2.29** (1.77-2.96)	**2.76** (2.07-3.66)	**3.13** (2.30-4.19)	**3.50** (2.49-4.79)	**3.88** (2.67-5.45)	**4.41** (2.92-6.32)	**4.81** (3.11-6.99)
2-hr	**1.65** (1.30-2.10)	**1.94** (1.53-2.47)	**2.43** (1.90-3.09)	**2.84** (2.21-3.63)	**3.42** (2.59-4.51)	**3.89** (2.88-5.18)	**4.37** (3.14-5.94)	**4.86** (3.37-6.78)	**5.54** (3.70-7.90)	**6.06** (3.96-8.75)
3-hr	**1.87** (1.48-2.36)	**2.19** (1.73-2.78)	**2.75** (2.16-3.48)	**3.22** (2.52-4.10)	**3.90** (2.98-5.13)	**4.45** (3.32-5.92)	**5.02** (3.63-6.82)	**5.62** (3.91-7.81)	**6.44** (4.33-9.16)	**7.08** (4.64-10.2)
6-hr	**2.25** (1.79-2.82)	**2.66** (2.11-3.33)	**3.35** (2.65-4.21)	**3.96** (3.12-4.99)	**4.84** (3.72-6.33)	**5.56** (4.18-7.35)	**6.31** (4.60-8.52)	**7.11** (5.00-9.82)	**8.21** (5.58-11.6)	**9.09** (6.01-13.0)
12-hr	**2.65** (2.13-3.29)	**3.15** (2.53-3.92)	**4.02** (3.21-5.01)	**4.79** (3.81-5.99)	**5.91** (4.59-7.68)	**6.83** (5.18-8.96)	**7.79** (5.73-10.4)	**8.81** (6.25-12.1)	**10.2** (7.01-14.4)	**11.4** (7.59-16.1)
24-hr	**3.10** (2.51-3.82)	**3.69** (2.98-4.55)	**4.72** (3.80-5.83)	**5.63** (4.51-6.98)	**6.96** (5.45-8.99)	**8.06** (6.16-10.5)	**9.21** (6.83-12.3)	**10.4** (7.46-14.2)	**12.1** (8.39-17.0)	**13.5** (9.09-19.1)
2-day	**3.65** (2.98-4.46)	**4.29** (3.49-5.24)	**5.40** (4.38-6.61)	**6.38** (5.16-7.85)	**7.84** (6.19-10.0)	**9.04** (6.98-11.7)	**10.3** (7.72-13.6)	**11.7** (8.41-15.8)	**13.6** (9.45-18.8)	**15.1** (10.2-21.1)
3-day	**4.05** (3.32-4.93)	**4.69** (3.84-5.71)	**5.81** (4.74-7.09)	**6.81** (5.52-8.33)	**8.28** (6.57-10.6)	**9.50** (7.37-12.2)	**10.8** (8.11-14.2)	**12.2** (8.82-16.4)	**14.1** (9.87-19.5)	**15.6** (10.7-21.8)
4-day	**4.38** (3.60-5.31)	**5.03** (4.13-6.09)	**6.15** (5.03-7.47)	**7.15** (5.82-8.72)	**8.62** (6.86-10.9)	**9.83** (7.65-12.6)	**11.1** (8.39-14.6)	**12.5** (9.08-16.8)	**14.4** (10.1-19.8)	**15.9** (10.9-22.1)
7-day	**5.19** (4.29-6.24)	**5.87** (4.85-7.07)	**7.05** (5.81-8.51)	**8.07** (6.62-9.78)	**9.54** (7.63-12.0)	**10.7** (8.39-13.6)	**12.0** (9.08-15.5)	**13.3** (9.71-17.7)	**15.1** (10.6-20.6)	**16.5** (11.4-22.8)
10-day	**5.88** (4.88-7.04)	**6.64** (5.51-7.95)	**7.91** (6.54-9.49)	**8.98** (7.39-10.8)	**10.5** (8.41-13.1)	**11.7** (9.18-14.8)	**12.9** (9.85-16.7)	**14.2** (10.4-18.8)	**15.9** (11.3-21.7)	**17.3** (12.0-23.8)
20-day	**7.85** (6.58-9.32)	**8.87** (7.42-10.5)	**10.5** (8.76-12.5)	**11.8** (9.82-14.2)	**13.6** (11.0-16.7)	**15.0** (11.8-18.7)	**16.3** (12.5-20.8)	**17.7** (13.1-23.1)	**19.4** (13.9-26.1)	**20.7** (14.5-28.4)
30-day	**9.50** (8.00-11.2)	**10.7** (9.03-12.7)	**12.7** (10.6-15.0)	**14.3** (11.9-17.0)	**16.3** (13.2-19.8)	**17.8** (14.1-22.0)	**19.3** (14.8-24.4)	**20.7** (15.4-26.9)	**22.5** (16.1-30.1)	**23.8** (16.7-32.5)
45-day	**11.6** (9.82-13.6)	**13.1** (11.1-15.4)	**15.4** (13.0-18.2)	**17.3** (14.5-20.5)	**19.7** (15.9-23.7)	**21.4** (17.0-26.2)	**23.0** (17.7-28.8)	**24.5** (18.2-31.6)	**26.3** (18.9-34.9)	**27.5** (19.4-37.4)
60-day	**13.4** (11.4-15.7)	**15.1** (12.8-17.7)	**17.8** (15.0-20.9)	**19.8** (16.7-23.4)	**22.4** (18.2-26.9)	**24.3** (19.3-29.6)	**26.0** (20.1-32.5)	**27.5** (20.5-35.4)	**29.4** (21.2-38.8)	**30.6** (21.7-41.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Table 1. Hydrology input summary (*including* ***NOAA Atlas 14 Precipitation Frequency Data Server | U.S. Climate Resilience Toolkit***) used for basin analysis and hydraulic model boundary conditions in developing both deterministic and probabilistic static inundation map libraries. Probabilistic scenarios to be modeled are shown in yellow.

2a. Basin Hydrology Modeling Quality Assurance

Time-series data are necessary to evaluate model performance and quality assure predictive capability. Along with precipitation resources referenced in task 1, time-series data captured by non-telemetered sensors installed in task 1 as well as any potentially recovered high-water marks may be used for the duration of the proposed study. In addition, sensitivity analysis will be conducted to determine the association between independent and dependent variables to facilitate more accurate model prediction.

Statistical analysis involving *goodness-of-fit* testing is necessary and will be conducted to identify any discrepancies that may exist between observed time-series data and those that would be expected of the basin model in a normal distribution case. Essentially this testing identifies whether data are reasonable or highly unlikely and utilizes several approaches such as absolute value error statistics (root mean square error) and normalized *goodness-of-fit* statistics (Nash-Sutcliffe Efficiency coefficient) Nash, Sutcliffe, 1970, Ritter and Munoz-Carpena, 2013.

Task 3: Hydraulic Modeling

Hydrology time-series inputs developed from task 2 are necessary for hydraulic analysis to reveal inundation extents. A recently completed (furnished) unsteady two-dimensional Hydrologic Engineering Center (HEC) – River Analysis System (RAS) model will be used to simulate flood profiles depicting water depth, velocity, and water-surface elevations for deterministic and probabilistic static map libraries given the inputs summarized in table 1. The HEC-RAS model will perform two-dimensional hydraulic calculations for a full network of natural and constructed channels, overbank/floodplain areas, and levee protected areas (Brunner, 2016). The model accounts for channel geometry and roughness in addition to infrastructure and in-line structures (i.e., lake outlets) when estimating water surface elevations. The model output includes estimates of water-surface elevations and velocities in a channel/floodplain system for a given discharge over variable time steps.

3a. Hydraulic Modeling Quality Assurance

The two-dimensional unsteady HEC-RAS model will be calibrated using any available peak water surface data obtained from non-telemetered sensors and any historic flood heights (high-water marks) within the jurisdictional boundary, whether documented or conveyed by parole evidence. Precipitation inputs may be applied for a potential rain-on-grid approach in calibration of prior flood events.

Manual calibration consists of adjusting process-related parameter values to minimize the differences between simulated output and measured data. Model performance will be evaluated with several criteria by comparisons from observed to simulated conditions with Root Mean Square Error (RMSE). As part of the calibration process, sensitivity analysis will be conducted to determine the association between independent and dependent variables to facilitate more accurate model prediction. Adjusting parameters such as material types (manning's roughness coefficients) can be applied to evaluate model response and sensitivity that aid in providing uncertainty estimates.

Task 4: Web-Based Decision Support Tool Development and Reporting

A product is needed to convey flood-risk information and support regulatory needs with an intent to operationalize use in planning, response, and mitigation. USGS Web Informatics and Mapping (WiM) develops web-based tools ingesting model simulated features and results, infrastructure, regulatory and loss data, as well as dynamic data acquisition of telemetered gage data and forecasted text products. The web-based dashboard will offer dynamic mapping of background basin streams, topography, transportation, and residential and commercial infrastructure with the following added features and attributes (fig 3):

1. Observed precipitation data for any potentially planned precipitation gages acquired by the City of Lee's Summit.
2. Observed stage gage data near or at Chipman Road.
3. Inundation map libraries as a consequence of precipitation duration and accumulation
    a. Ability to toggle on dry, normal, and wet antecedent moisture conditions
        i. Representing a variety of simulated combinations and deterministic outcomes (fig 3)
            1. Functionality to interact with web-scraped 1-hour Quantitative Precipitation Forecast (QPF) data
            2. Functionality to evaluate observed precipitation (1.) and stage data (2.) for quality assurance.
        ii. Representing the 1-percent precipitation probability for 6- and 24-hour storm durations
            1. Differentiated with deterministic outcomes above (i.) and climate-based precipitation as summarized in table 1 for both RCP4.5 and 8.5 as well as 30- and 50-year projections.
        iii. Representing depth, velocity, and water-surface elevation data.
            1. Differentiating with first-floor elevations and any relevant critical infrastructure (fig 3a)
            2. Differentiating with census-block loss data using FEMA Hazus (fig 3b). Application of HAZUS is dependent on availability from FEMA, which may result in a delay in HAZUS deliverable availability.

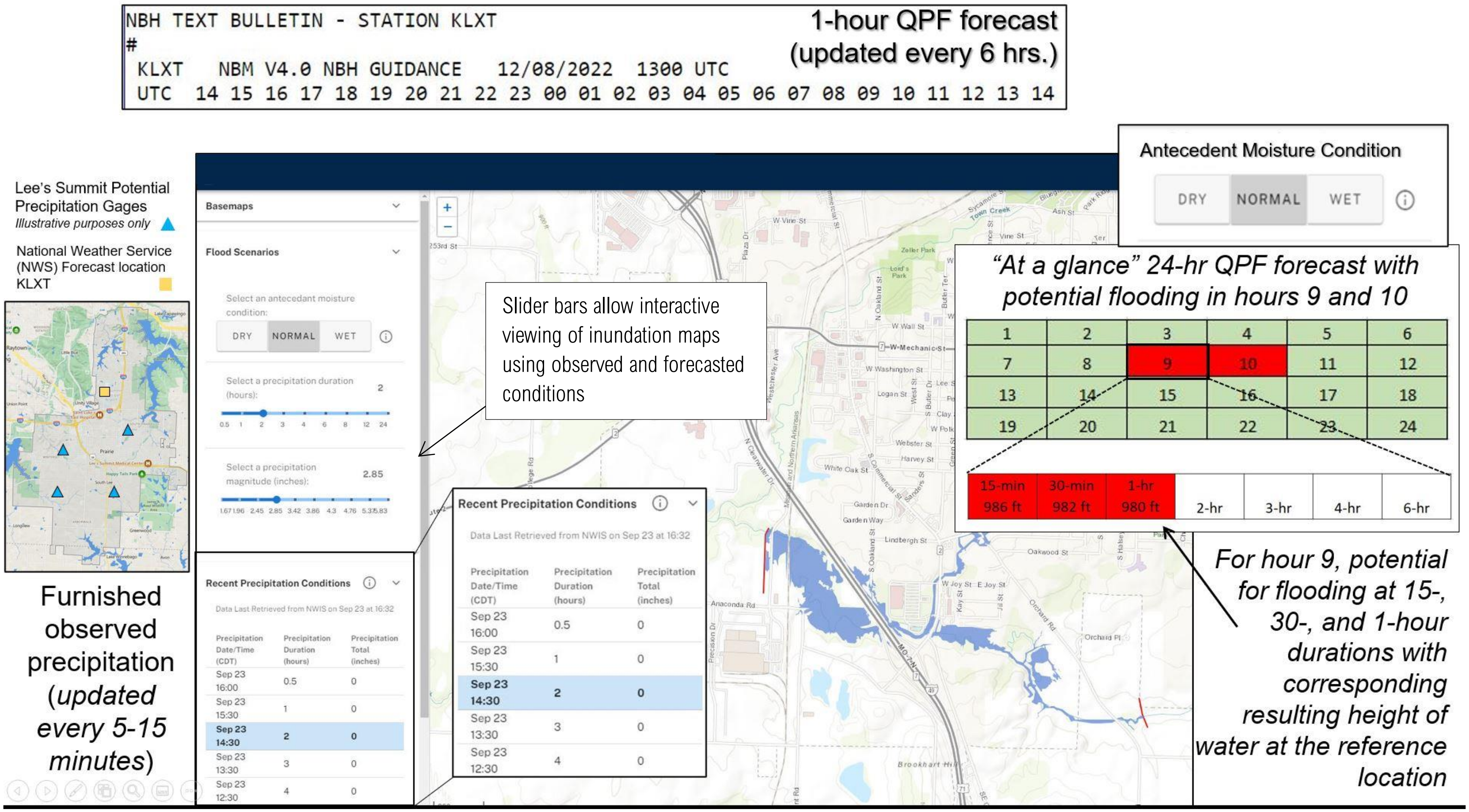
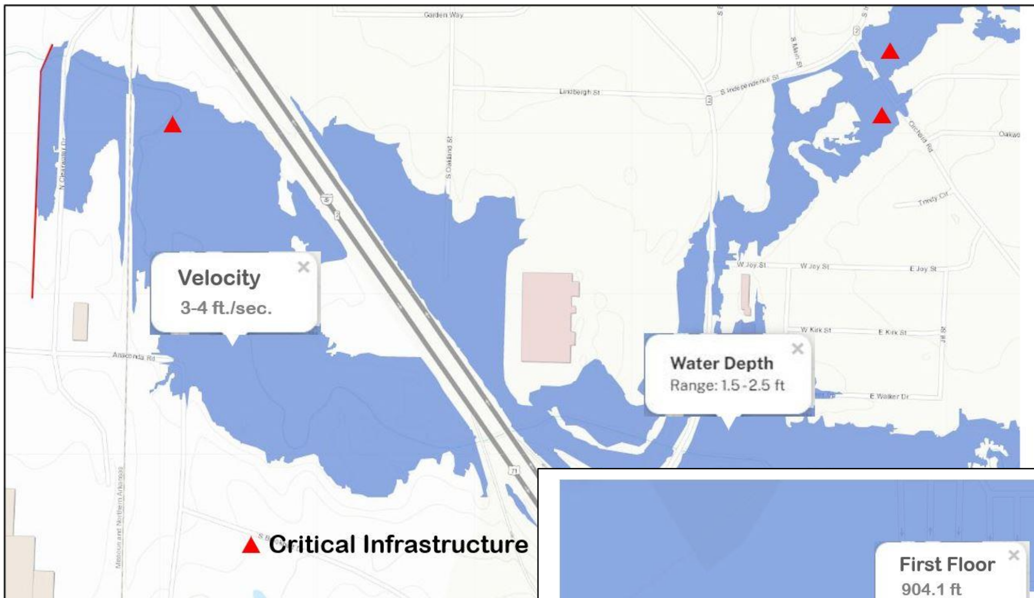


Figure 3. Example of observed conditions for precipitation identified in the lower left and ingested 1-hour Quantitative Precipitation Forecast (QPF) data interactive functionality in the upper right taken from forecast text bulletins.



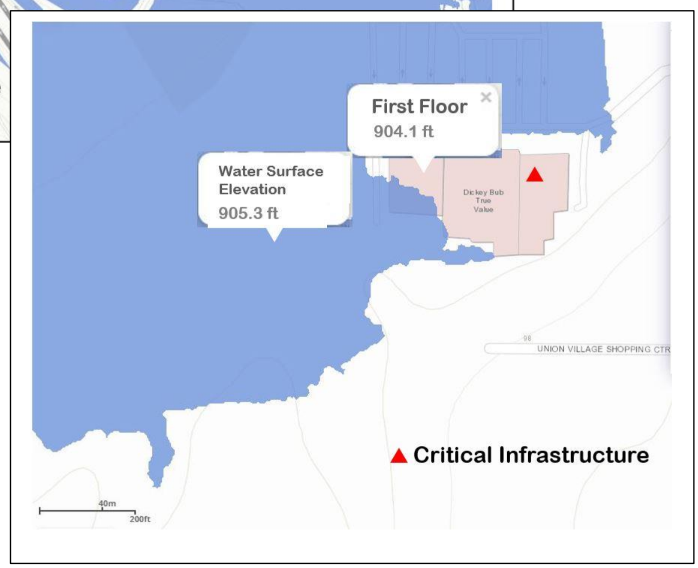
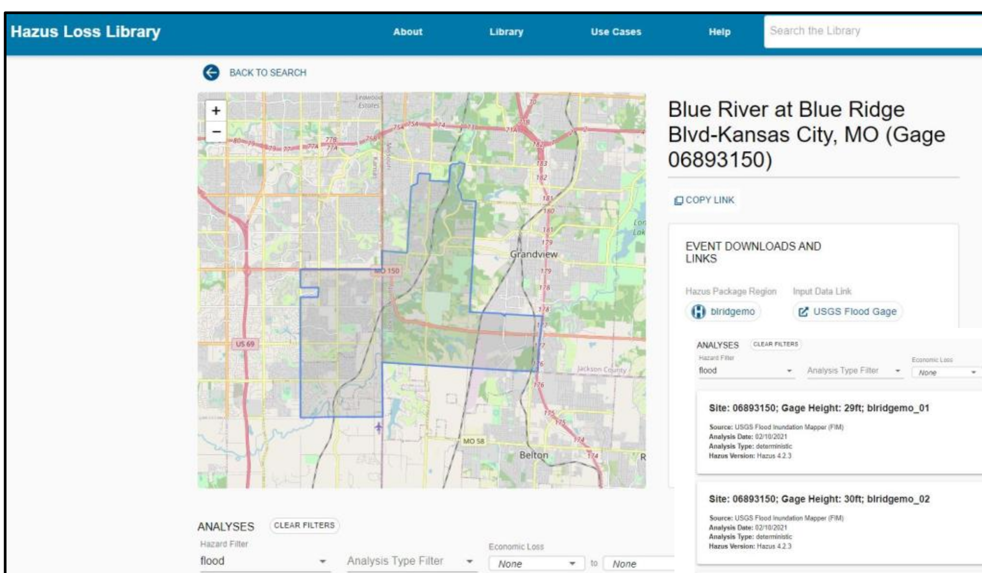


Figure 3a. Example of inundation map with data interactive functionality to click on inundation or building footprints to differentiate depth, velocity, water-surface



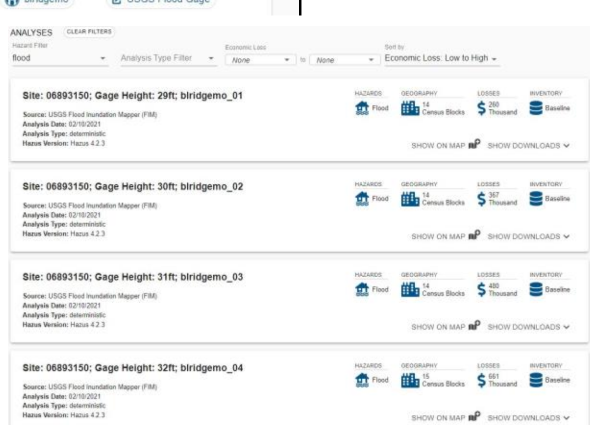


Figure 3b. Example of inundation map area tied to the nationally standardized risk-modeling loss methodology (HAZUS)

The methods used for data collection, model development, calibration, sensitivity analysis, and the results of model simulations and macro executions will be documented in a USGS Scientific Investigation Report (SIR) and accompanying Data Release and model archive. In addition, uncertainty analysis of results will be documented through model calibration and sensitivity analysis.

Quality Assurance Plan

Quality assurance (QA) measures will be followed to ensure the completeness of the information communicated during the study. The QA objectives for the collection and communication of information will:

- Withstand scientific scrutiny
- Be obtained by methods appropriate for its intended use, and
- Be representative and of known completeness and comparability.

Data used in the modeling process will be derived from reliable host sources, including the USGS National Water Information System for streamflow data, and the Natural Resources Conservation Service Geospatial Data Gateway (U.S. Department of Agriculture, 2019) for various geospatial information (such as soils and imagery). Hydrologic model outputs will be evaluated using root mean squared error (RMSE) at stage gage locations (Moriasi and others, 2007) as well as non-telemetered sensor locations. All digital data and models will be reviewed by USGS personnel to ensure proper documentation and technical standards established by the USGS Office of Quality Assurance (OQA) guidance for hydraulic modeling studies documented in OSW Technical Notes 2015.37 and 2016.25. The models and modeling results will be archived in accordance with Office of Surface Water Technical Memorandum 2015.01 (Model Archive Memo). Data collection standards as provided by USGS Techniques and Methods manuals will be upheld for GNSS surveys (Rydlund and Densmore, 2012), high-water mark collection (Koenig and others, 2016), and measured streamflow (Turnipseed and Sauer, 2010).

Policies and procedures for archiving Surface-Water data and project information are also provided in the Central Midwest Water Science Center data management plans. The project and project budget will be reviewed by USGS management on a quarterly basis to ensure project timelines are met.

Quality assurance standards for the Fit-For-Purpose (FFP) stage-gage platform will be documented within CMWSC site-specific QA plan along with appropriate data management procedures shared through the appending data management plan. FFP time series may be disseminated via NWIS web abiding by site-specific QA, articulating temporary data storage identified in the CMWSC plan or by way of the STNweb

Furnished precipitation data will be reviewed and conveyed under the term “temporary data,” subsequently available for a 60-day period as identified in SW2006.01

Deliverables

The USGS will provide quarterly progress reports to the City of Lee's Summit. The results of the modeling efforts will be published in a USGS Scientific Investigation Report (SIR). Stage hydrographs and survey data will be made available in a machine-readable electronic format accessible through the USGS Science Data Catalog and Data.gov following USGS data publication requirements. The web-based decision support tool deliverable (as described in task 4) will accompany the SIR and will be hosted by the City of Lee's Summit. Geospatial files (polygons, depth grids, velocity, etc.) will be hosted by the USGS.

Timeline and Budget

Timeline and budget based on signed agreement beginning October 1, 2023 (FY 2024).

Task	FY 2024				FY 2025			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1: Data Collection and Monitoring								
Task 2: Basin Hydrology Modeling								
Task 2a: Basin Hydrology Modeling Quality Assurance								
Task 3: Hydraulic Modeling								
Task 3a: Hydraulic Modeling Quality Assurance								
Task 4: Web-Based Decision Support Tool Development and Reporting								

	FY 2024	FY 2025	Total
City of Lee's Summit	$102,200	$104,000	$206,200
USGS	$43,800	$44,600	$88,400
Total	$146,000	$148,600	$294,600

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