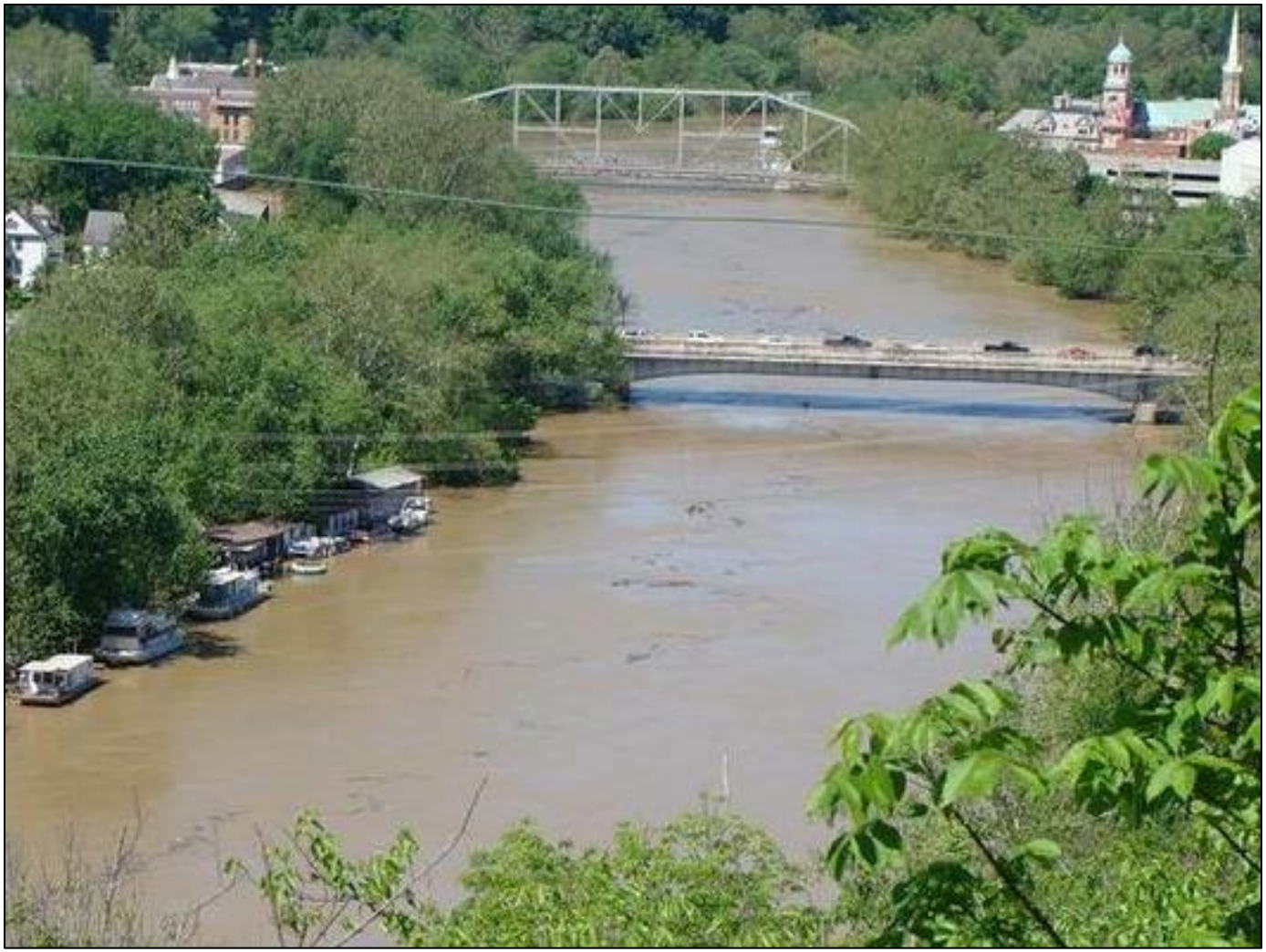
Kentucky Flood Inundation Projects:



USGS
science for a changing world

By: Jeremiah Lant, Hydrologist, USGS

Outline

- Completed and current flood inundation projects
- General overview of the project objectives and process involved in a flood inundation project
- Detailed look at the projects
- Live demo of USGS Web Mapping Application
- Questions

USGS

Hopkinsville, Kentucky

- Local Stakeholder:
  - **Dave Herndon**, Planning Services Coordinator, Community and Development Services, City of Hopkinsville Kentucky.
- Technical Partners:
  - **Mike Griffin**, USGS
  - **Jeremiah Lant**, USGS
    - jlant@usgs.gov
    - (502) 493-1949
- National Weather Service Coordinator:
  - **Kris Lander**, NWS
    - kris.lander@noaa.gov
    - (816) 268-3124
- Approximate Timeline:
  - **January 2012 –> December 2012**

USGS

Frankfort, Kentucky

- Local Stakeholder:
  - **Deron Rambo**, Director of Emergency Management for the City of Frankfort at the Office of Emergency Management.
- Technical Partners:
  - **Mike Griffin**, USGS
  - **Jeremiah Lant**, USGS
    - jlant@usgs.gov
    - (502) 493-1949
- National Weather Service Coordinator:
  - **Kris Lander**, NWS
    - kris.lander@noaa.gov
    - (816) 268-3124
- Approximate Timeline:
  - **July 2012 –> June 2013**

USGS

General Project Objectives

- **Develop** detailed libraries of flood inundation maps for a particular reach of river.
  - *The flood inundation maps show estimates of the areal extent and the depth of flooding in the floodplain corresponding to selected water levels (stages) at a USGS streamgage.*

- **Use** the flood inundation maps in conjunction with the National Weather Service (NWS) Advanced Hydrologic Prediction Service flood warning system to show predicted areas of flood inundation.

- **Provide** online portals for the public to view USGS flood inundation study information and interact with the flood inundation map libraries.

- **The flood-inundation maps, along with online information regarding current stages from USGS streamgage and forecasted stages from the NWS, provide emergency management and local residents with critical information for flood response activities.**

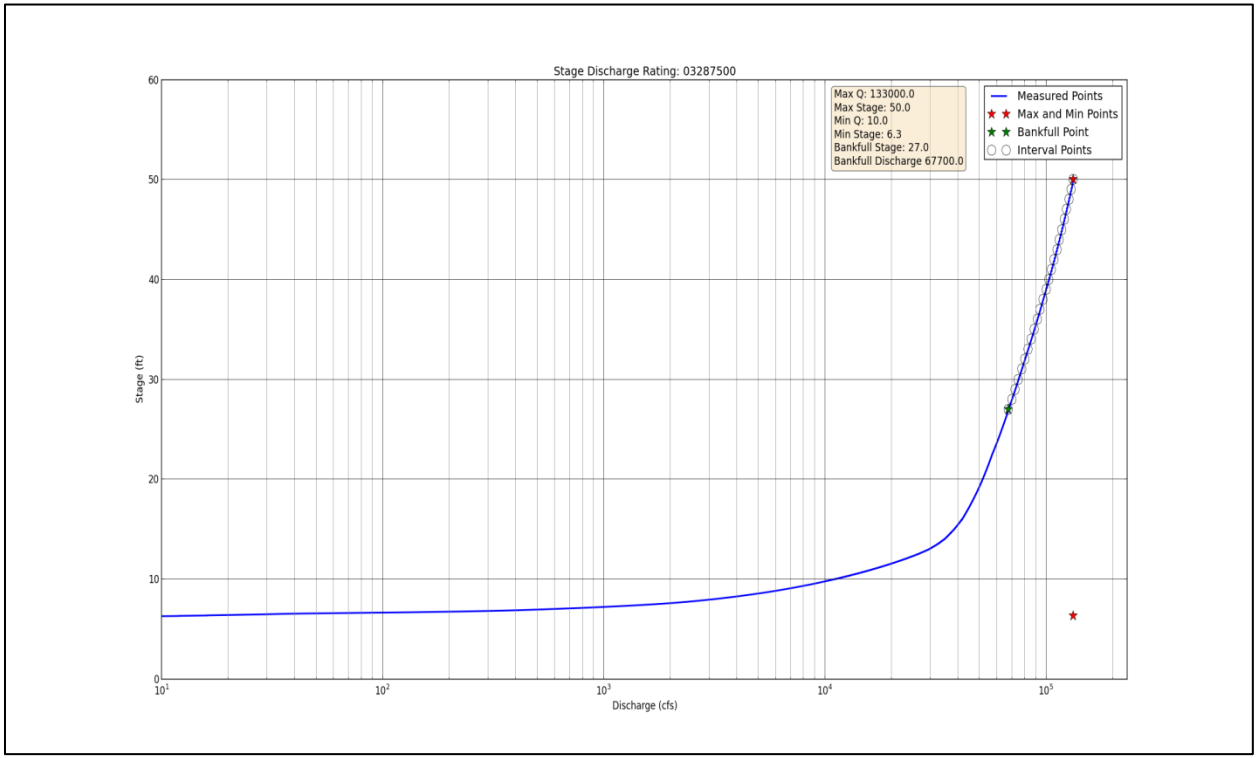
USGS

Project Phases

- **Phase 1** – Project Scoping and Planning
  - Site selection, modeling approach, and data collection
- **Phase 2A** – Hydraulic Analyses
  - Build and calibrate hydraulic model
- **Phase 2B** – Mapping
  - Create and submit map products to NWS and USGS Flood Inundation Mapping Program (FIMI)
- **Phase 3** – FIMI and AHPS Web Implementation
  - Put maps on the Internet

USGS

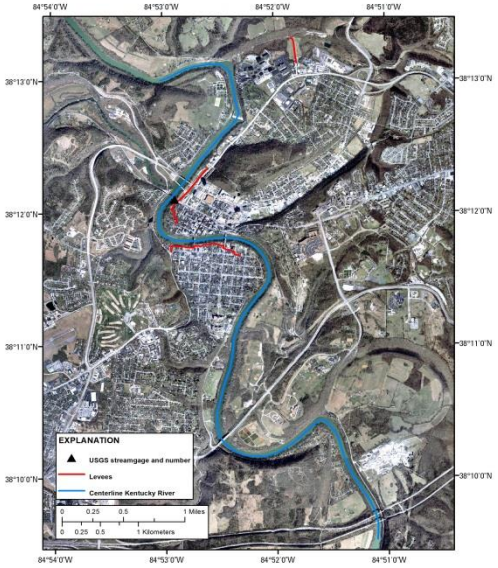
General Project Process: Phase 1 – USGS Data



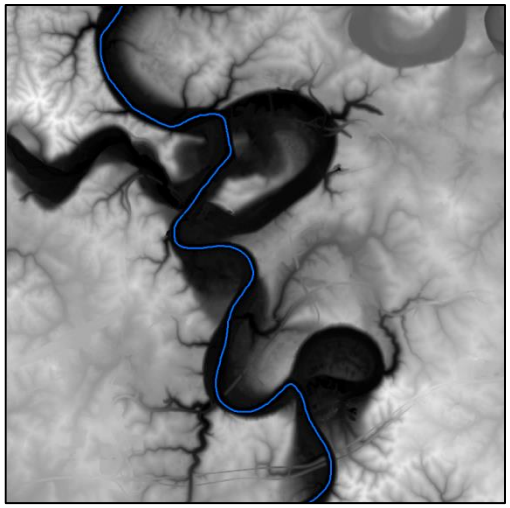
USGS

General Project Process: Phase 1 and 2

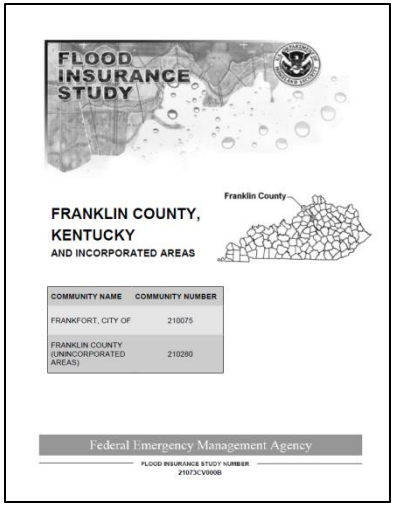
Study Area



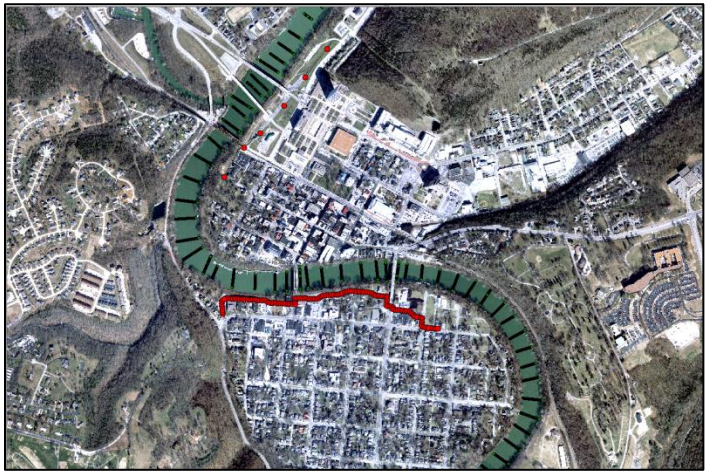
Digital Terrain/Elevation Model



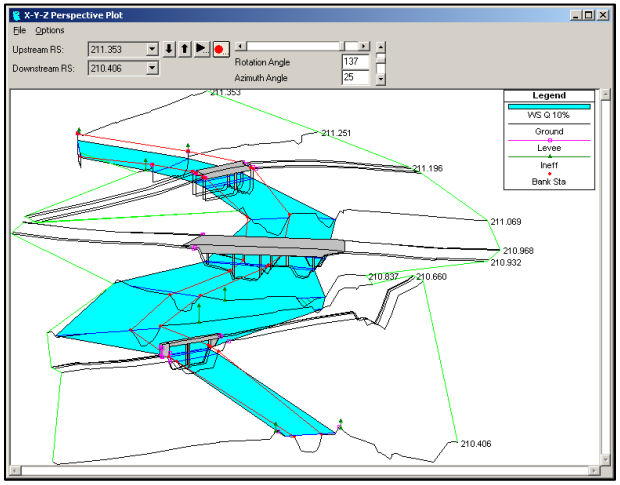
FEMA Flood Insurance Study



Bathymetry and/or survey data

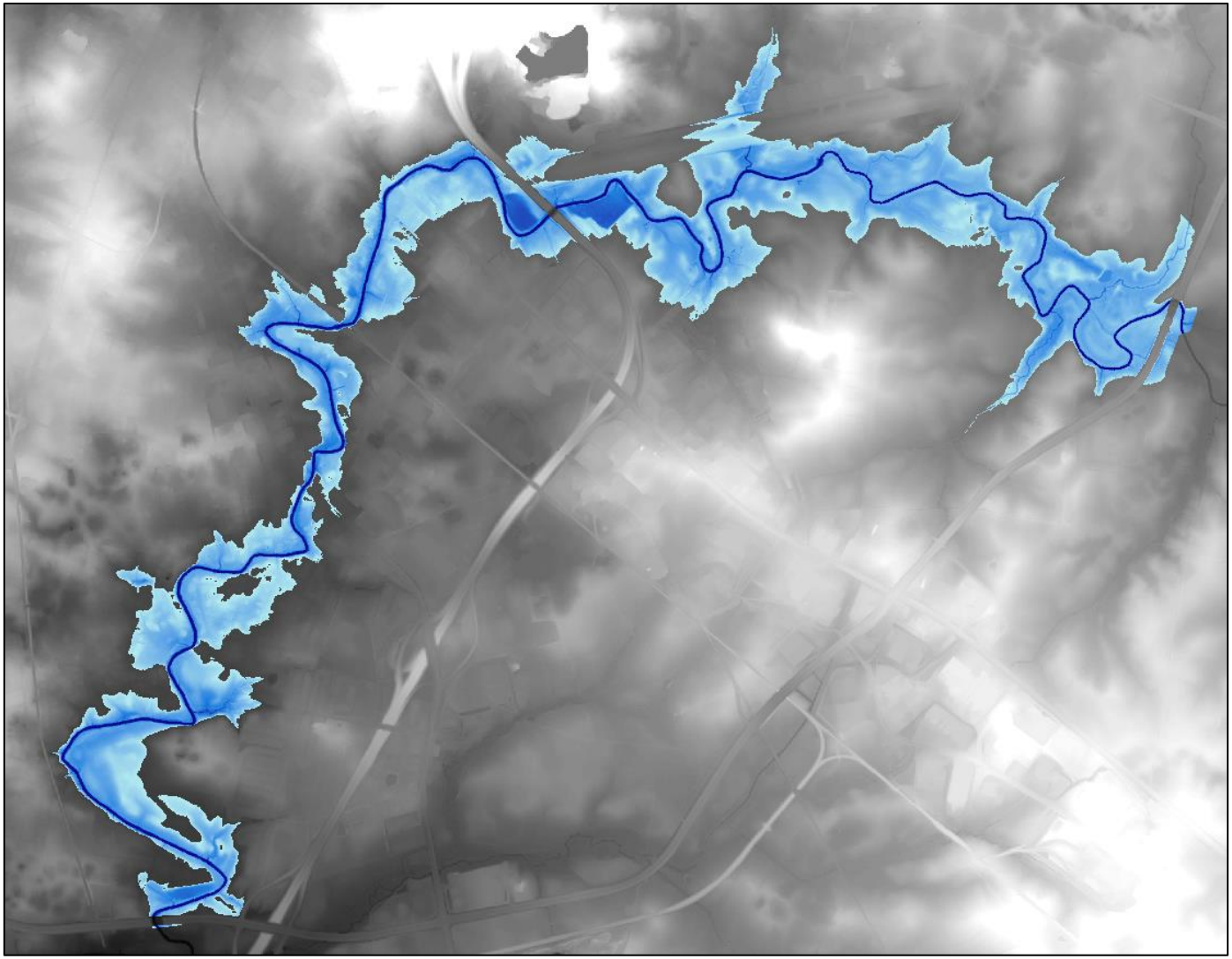


Hydraulic Model



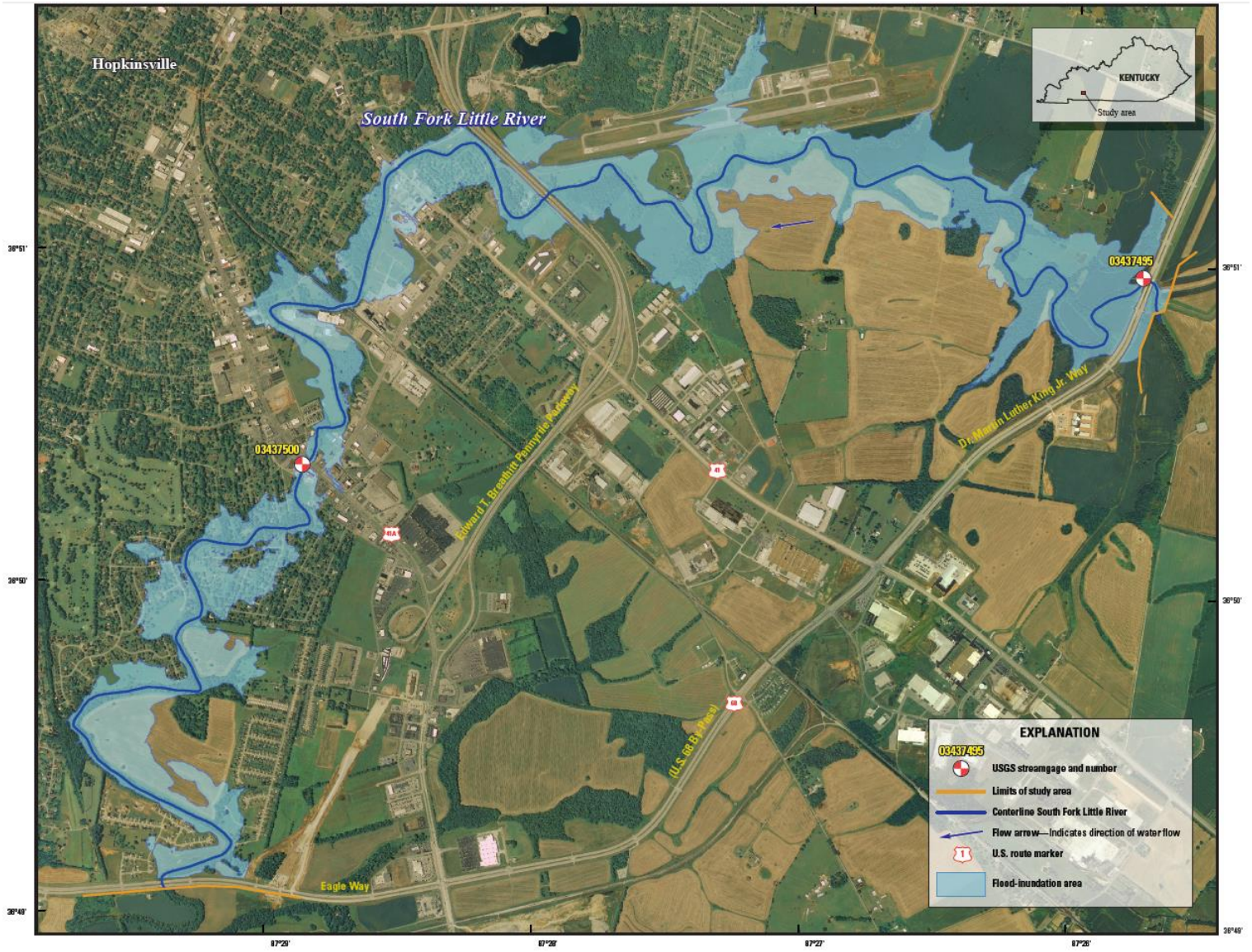
USGS

Sample Flood Inundation Map



USGS

Sample Flood Inundation Map

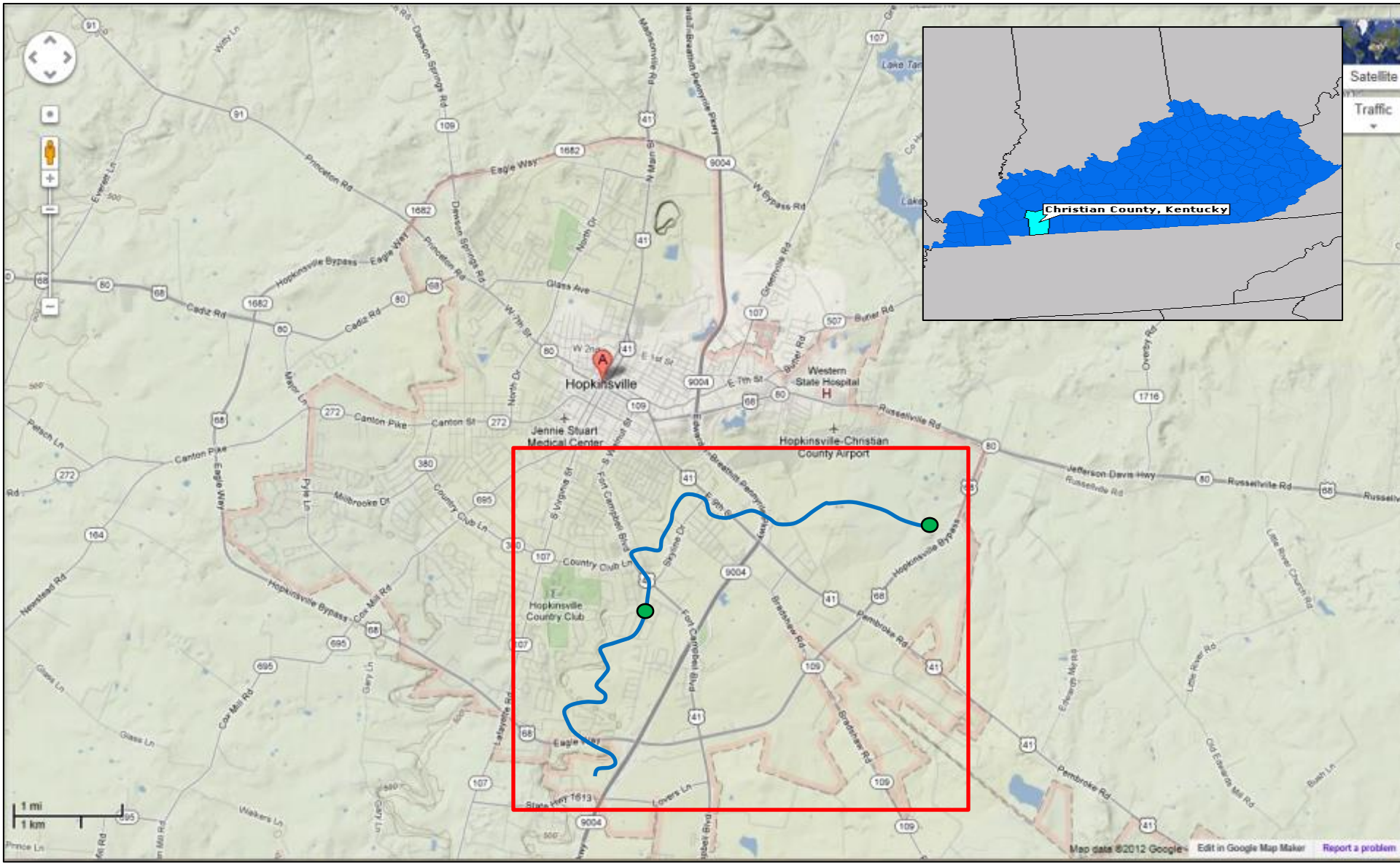


USGS

Flood Inundation Project: Hopkinsville, KY

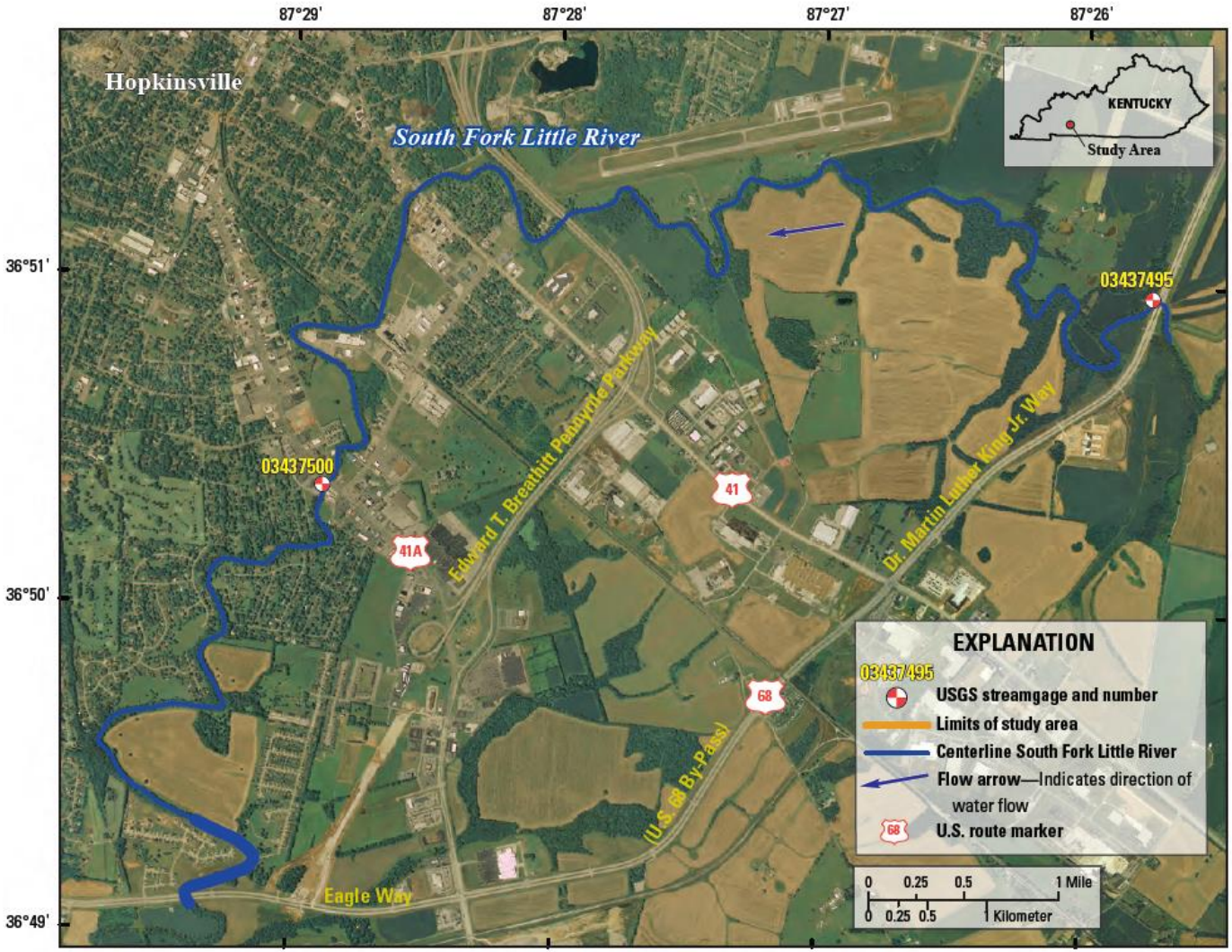
USGS

Phase 1: Study Area – South Fork Little River



USGS

Phase 1: Study Area – South Fork Little River



Projection: Lambert Conformal Conic
State Plane Coordinate System, Kentucky, FIPS, 1600
North American Datum of 1983 (NAD83)
Orthophotography from National Agriculture Imagery Program, 2006

USGS

Phase 1: Modeling Approach

	Stage (ft.)	Elevation (ft.) NAVD88
Highest Inundation Stage:	21.0	541.0
Major Flood Stage:	20.0	540.0
Moderate Flood Stage:	17.0	537.0
Flood Stage:	15.0	535.0
Action Stage:	13.0	533.0
Lowest Inundation Stage:	10.0	530.0
Gage 0 Datum:	0.0	520.0

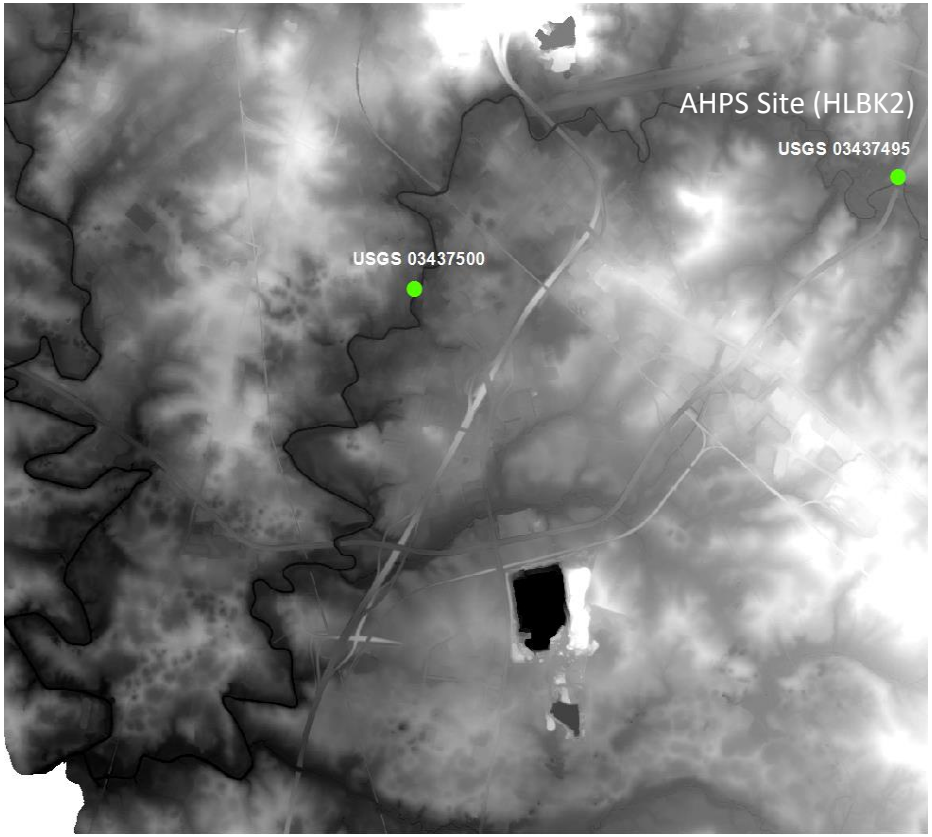
Mapping Interval (ft): 1.0

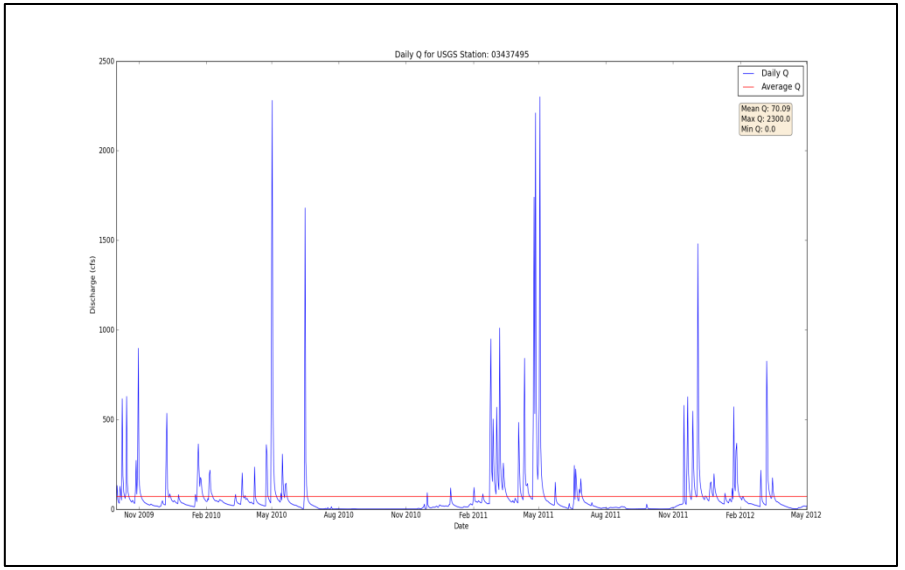
List of Modeled Stages (ft): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 21.5*

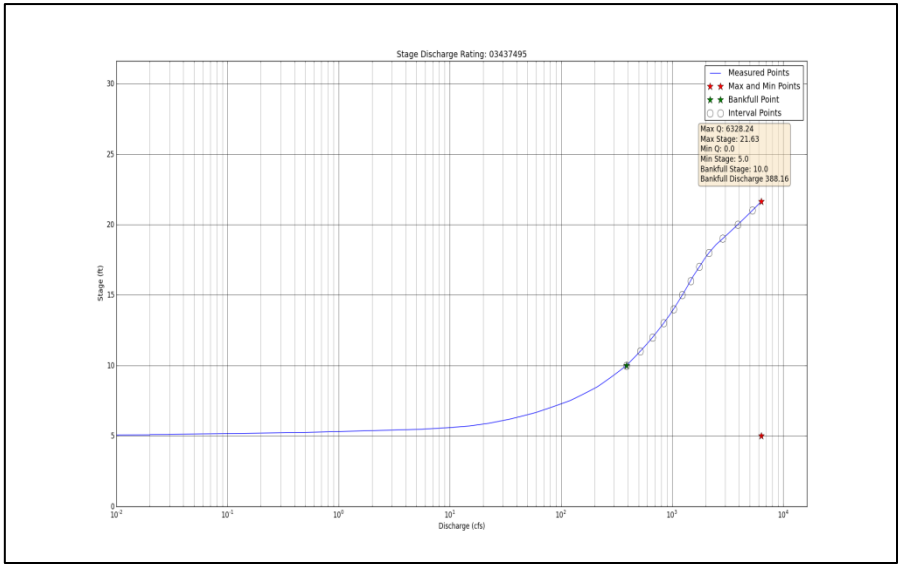
* 21.5 which corresponds to the 1.0-percent annual exceedance probability defined by FEMA at the USGS streamgage at South Fork Little River Highway 68 By-Pass at Hopkinsville, Kentucky (station no. 03437495).

USGS

Phase 1: Data Collection

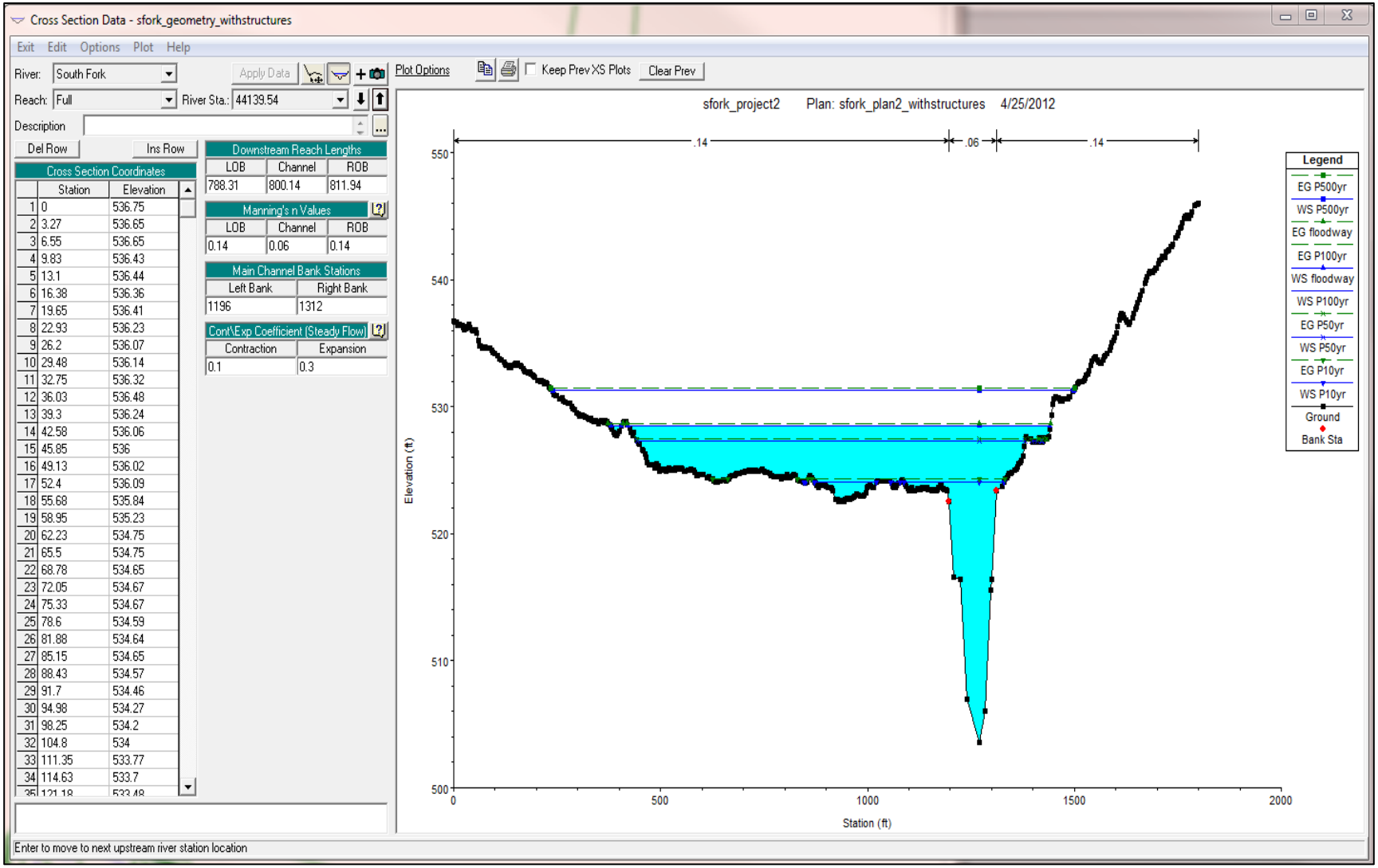






USGS

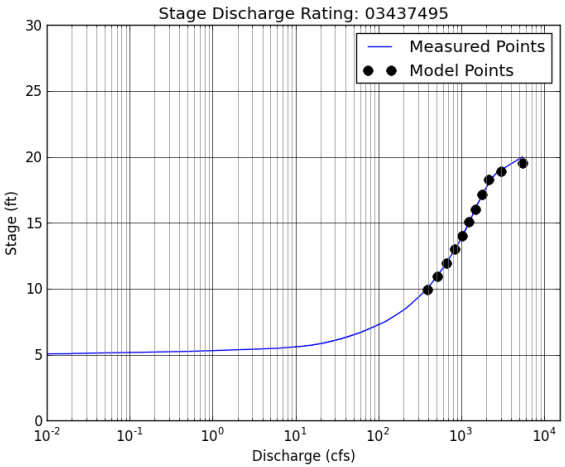
Phase 2A: Hydraulic Modeling



USGS

Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation

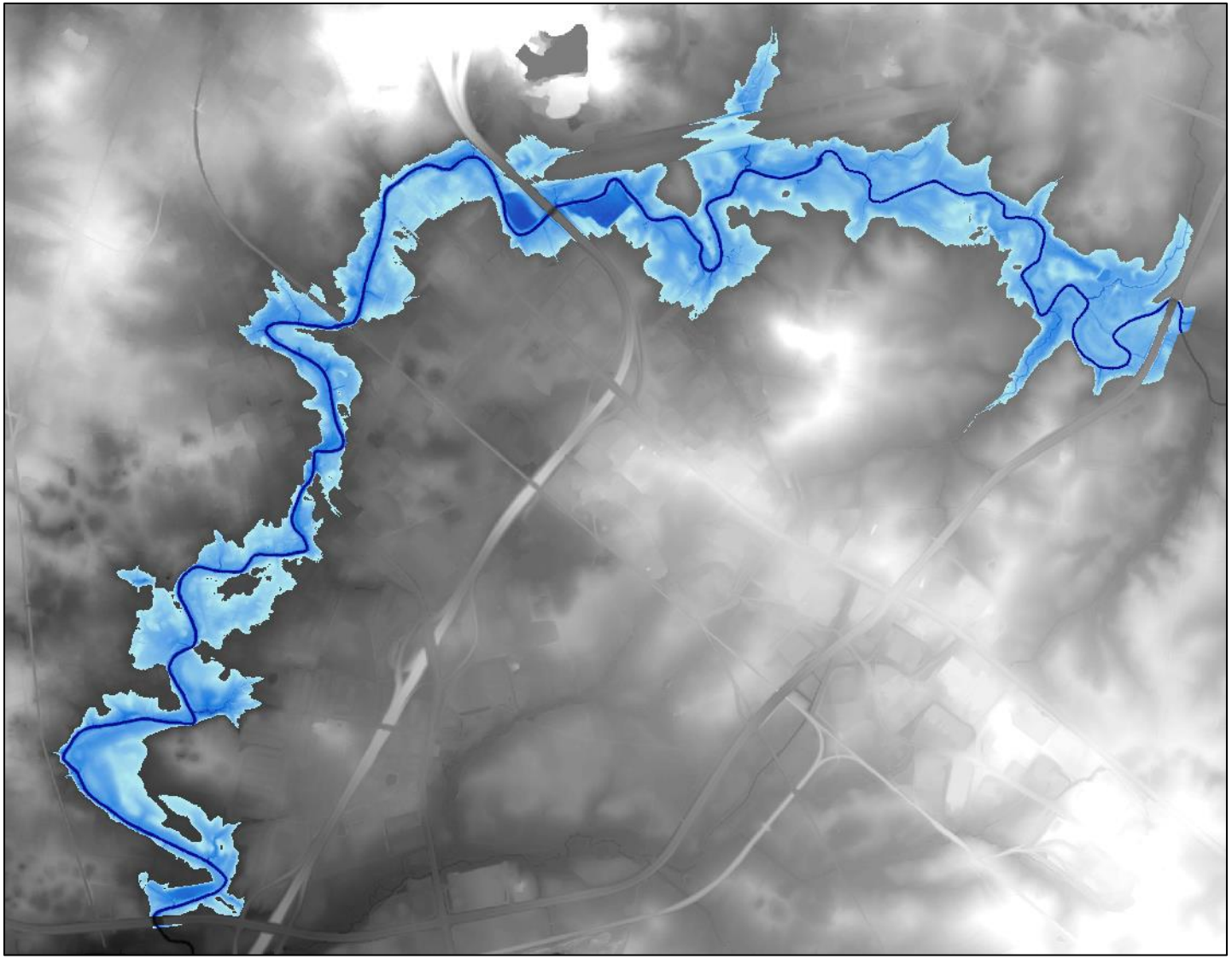


- 2) Multiple Recent Flood Events

Date	USGS streamgage (station number)	Peak water-surface elevation (ft)	Model water-surface elevation (ft)	Elevation difference (ft)
June 21, 2011	03437495	531.94	531.92	-0.02
	03437500	526.30	526.27	-0.03
November 21, 2011	03437495	535.17	535.19	+0.02
	03437500	528.21	529.15	+0.94
December 5, 2011	03437495	537.89	538.14	+0.25
	03437500	532.39	532.42	+0.03

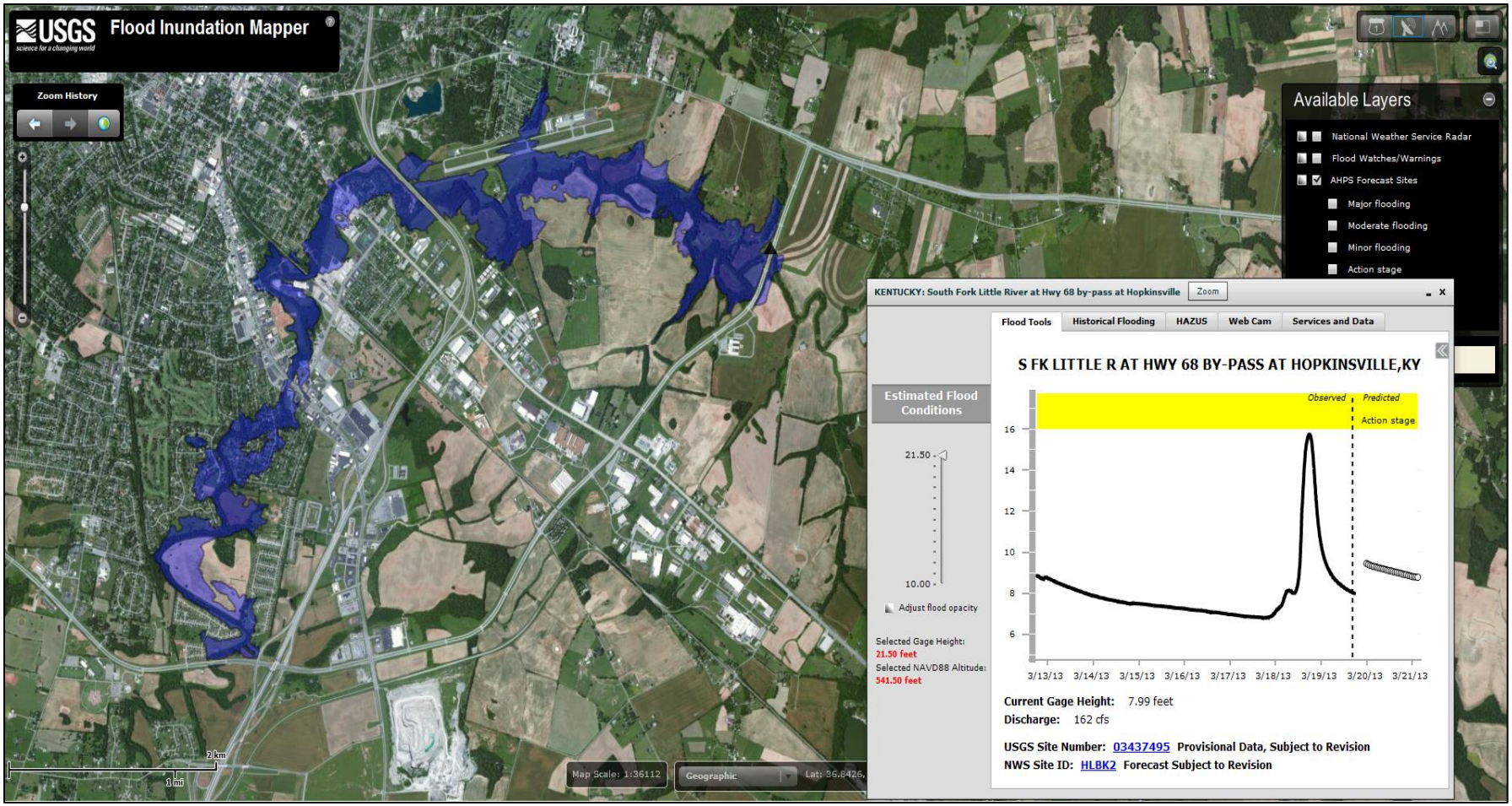
USGS

Phase 2B: Mapping



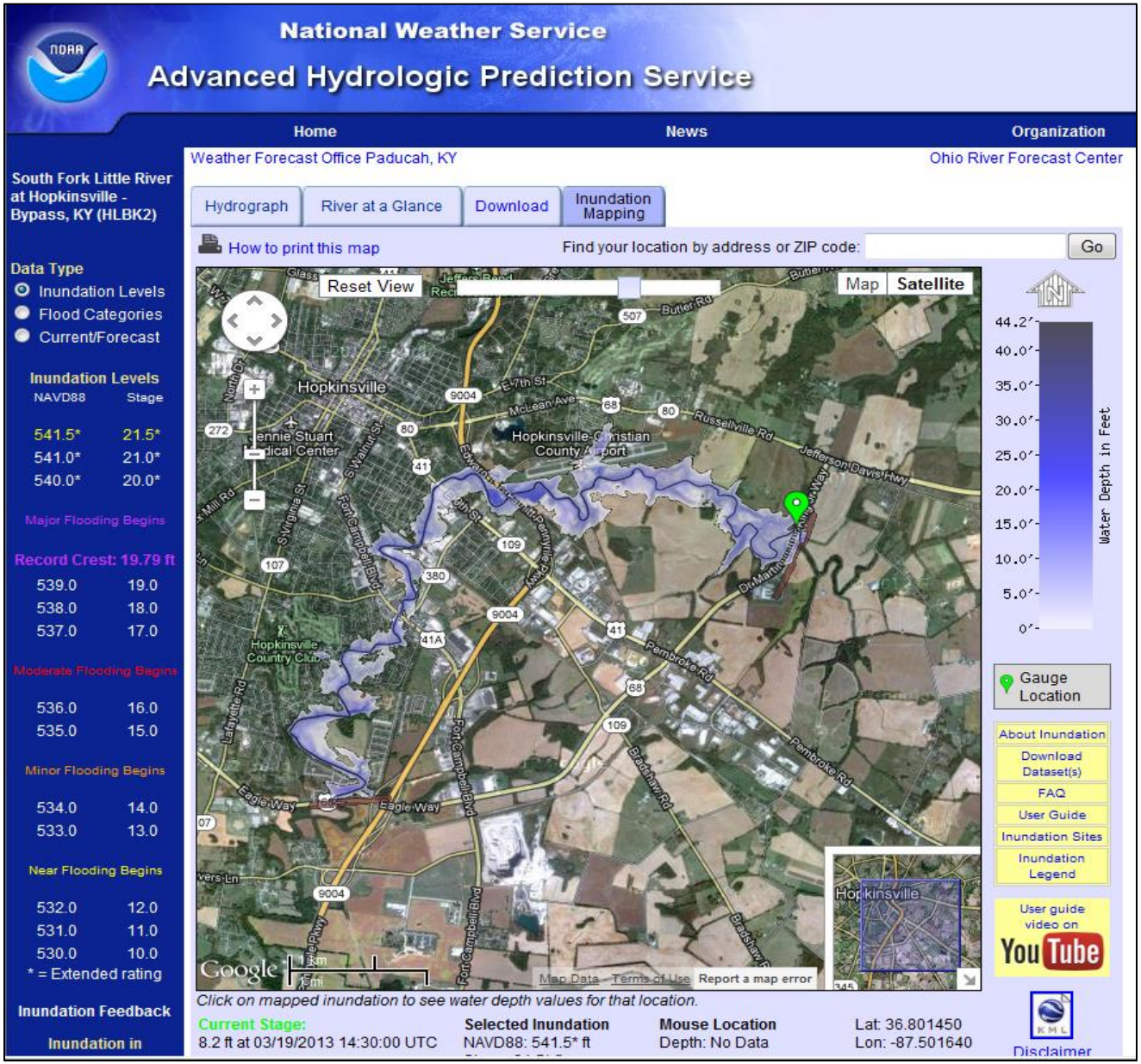
USGS

Phase 3: Web Implementation



USGS

Phase 3: Web Implementation

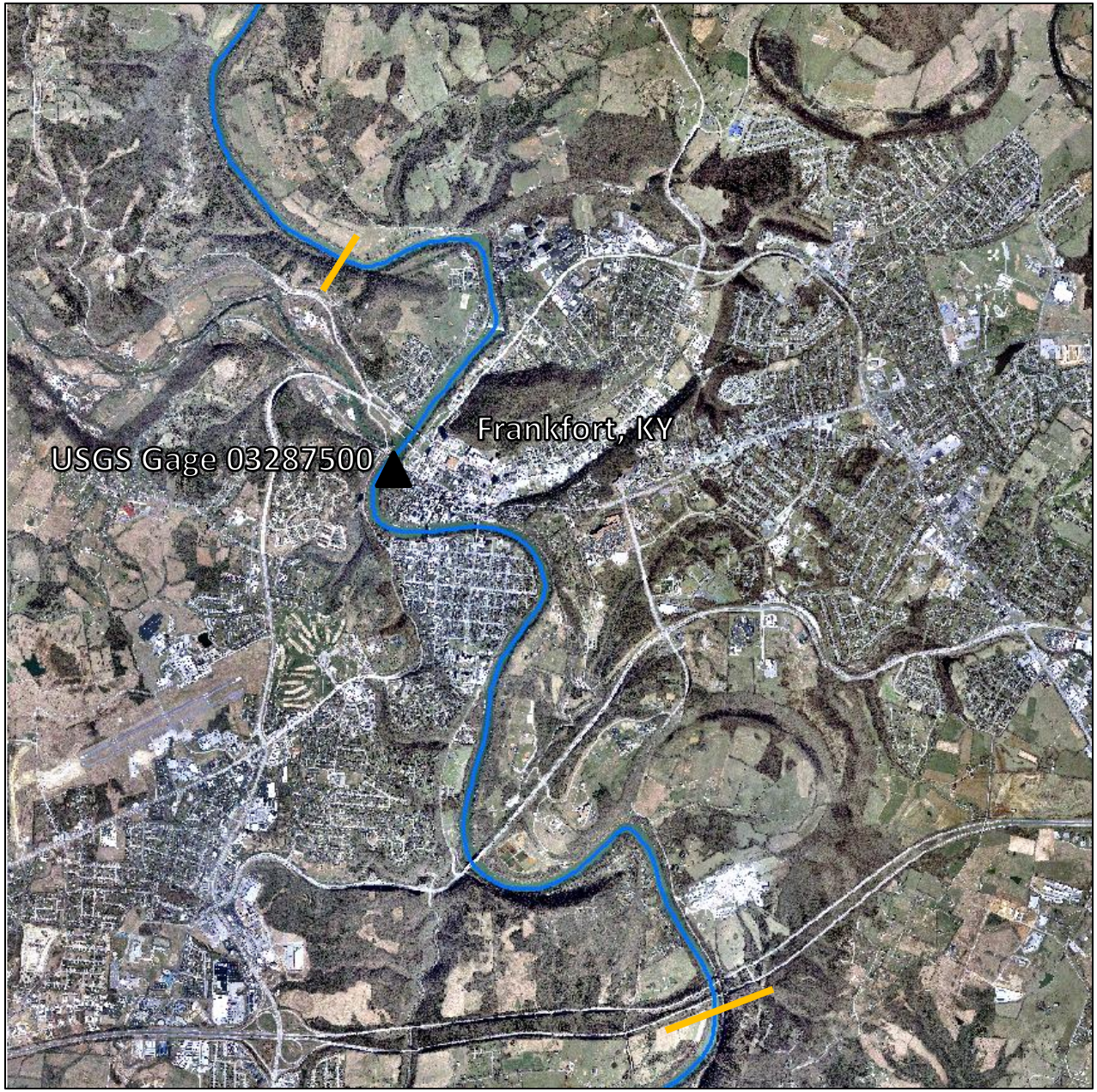


USGS

Flood Inundation Project: Frankfort, KY

USGS

Phase 1: Study Area – Kentucky River

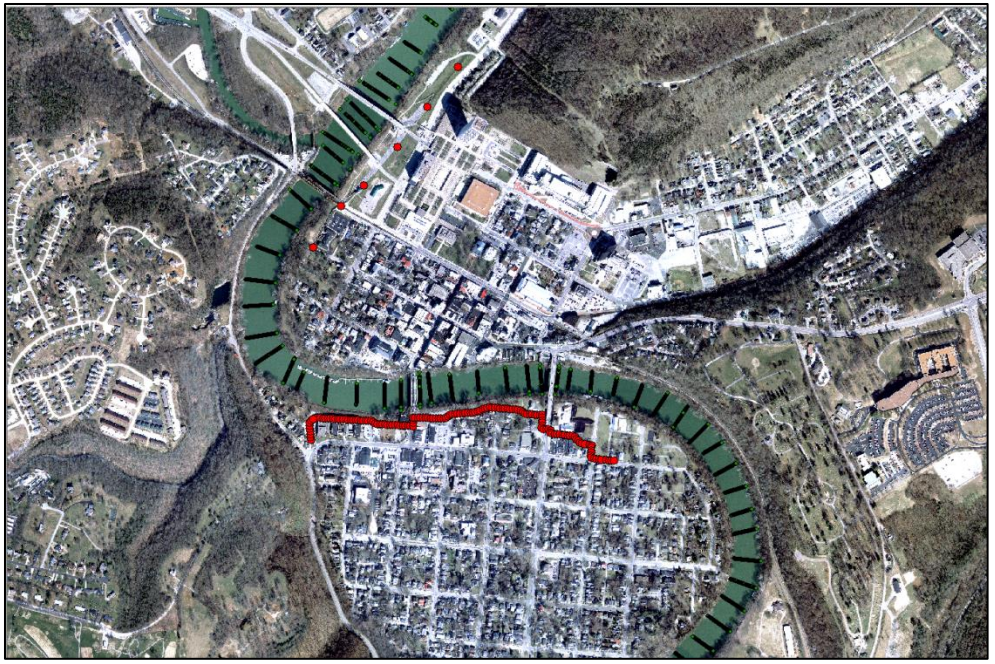


USGS

Phase 1: Data Collection
USGS Kentucky Water Science Center Bathymetry Data

Raw bathymetry data

Processed bathymetry data and NLD data



Hydraulic model built includes the bathymetry data collected by the USGS Kentucky Water Science Center along with levee data from the Army Corps of Engineers National Levee Database for the south and north Frankfort, KY levees.

USGS

Phase 1: Modeling Approach

	Stage (ft.)	Elevation (ft.) NAVD88
Highest inundation Stage:	52	513.58
Major Flood Stage:	40	501.58
Moderate Flood Stage:	35	496.58
Flood Stage:	31	492.58
Action Stage:	29	490.58
Lowest inundation Stage:	27	488.58
Gage 0 Datum:	0	461.58

Mapping Interval (ft): 1.0

List of Modeled Stages (ft): 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52

FEMA Elevations for 10, 2, 1, 0.2 % Flood: 10% = 496.0 ft, 2% = 503.0 ft, 1% = 508.0 ft, 0.2% = 510.0 ft

USGS

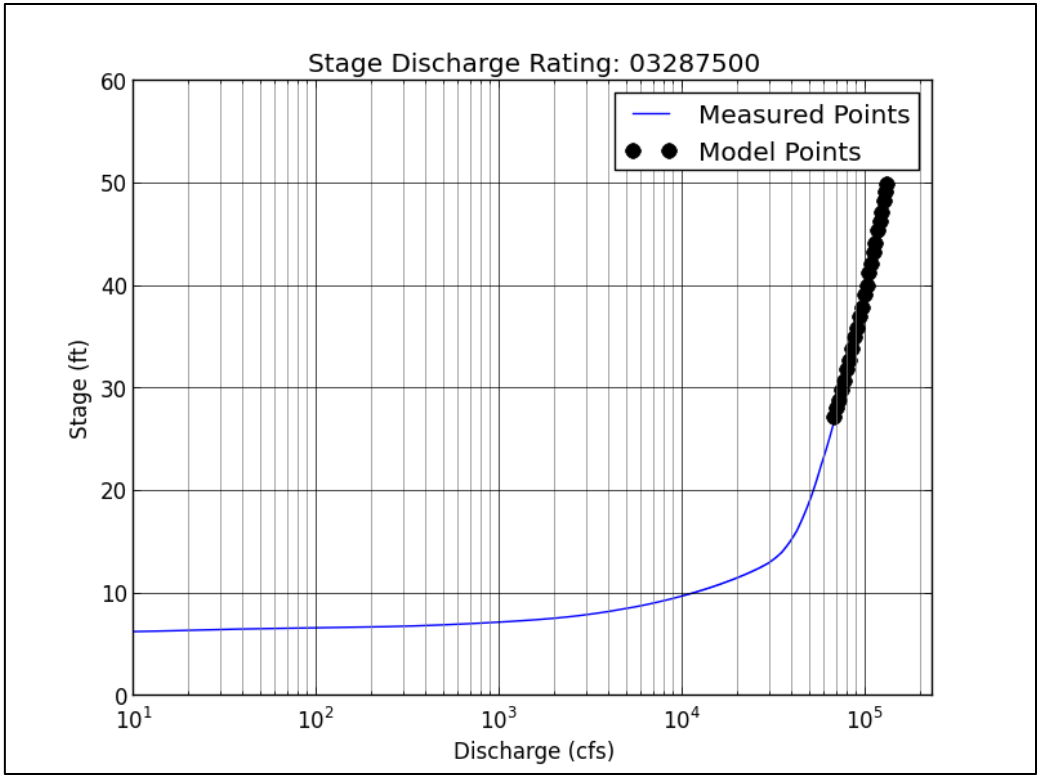
Phase 1: Modeling Approach

- **Levee Approach**:
  - NLD shows South Frankfort LFPP Segment is designed for 100-year event with 2-ft of freeboard. Construction from Sept '93 to Dec '96.
  - NLD shows North Frankfort LFPP Segment is designed for 100-year event with 2-ft of freeboard. Construction from March '68 to Sep '70.
  - Structures will be modeled with the following considerations:
    - 1. Upon overtopping the landward side of the levee fills completely
    - 2. Steady-state modeling assumptions will be employed
    - 3. The levee will remain structurally intact
- **Bridge Approach**:
  - A bridge will be considered overtopped once the water surface elevation equals the respective low steel elevation.

USGS

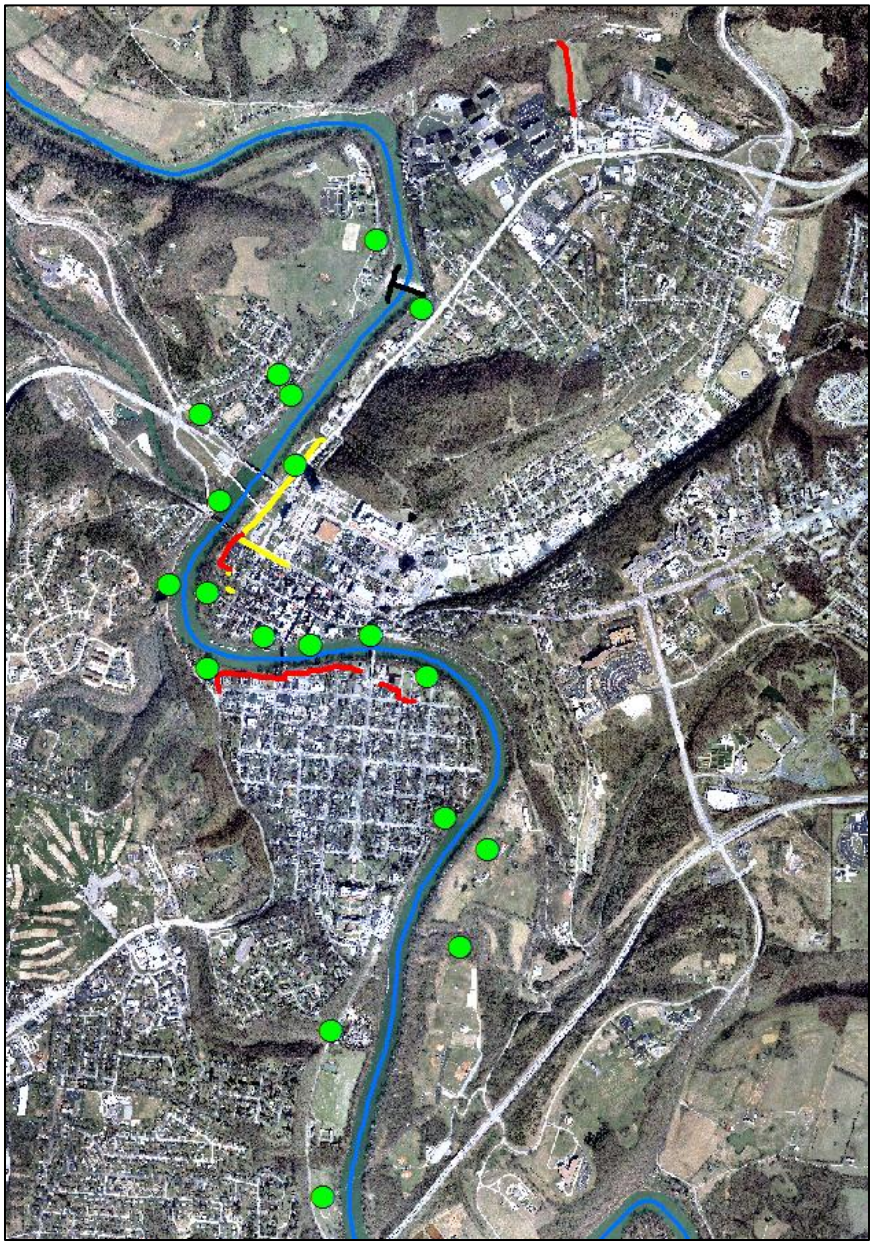
Phase 2A: Model Calibration – Stage Discharge Rating

- Hydraulic model was calibrated to the most recent USGS stage discharge rating at the USGS gage 03287500 Kentucky River at Lock 4 at Frankfort, KY.
- 24 water surface profiles were used in model calibration ranging from 27 to 50 ft. of stage.
- The model's 24 water surface profiles are within +- 0.5 ft. of the established USGS stage discharge rating which meets the criteria set by the NWS.



USGS

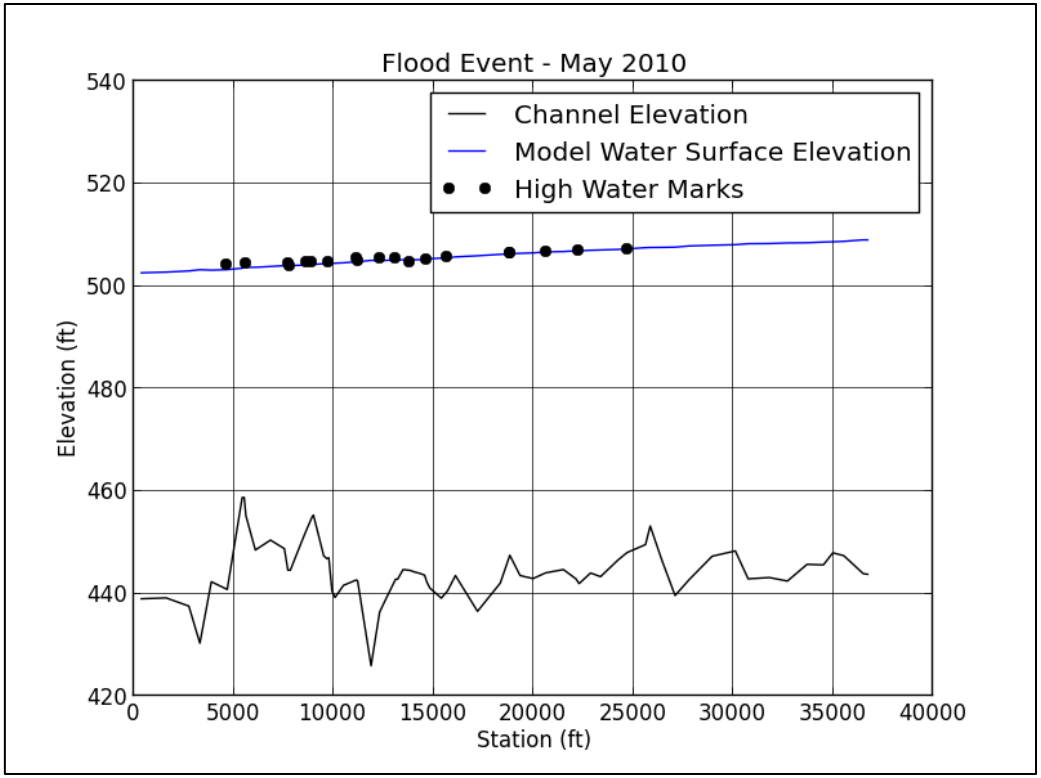
Phase 2A: USGS Collected High Water Marks for the May 2010 Flood



USGS

Phase 2A: Model Calibration – May 2010 Flood Event

- Hydraulic model was calibrated to a recent flood event that occurred in May 2010.
- The USGS Kentucky Water Science Center measured 19 high water marks from the May 2010 flood. These 19 high water marks were used in model calibration.
- The model's the water surface profile for the May 2010 flood event is within +- 1.0 ft. of the measured high water marks which meets the criteria set by the NWS.

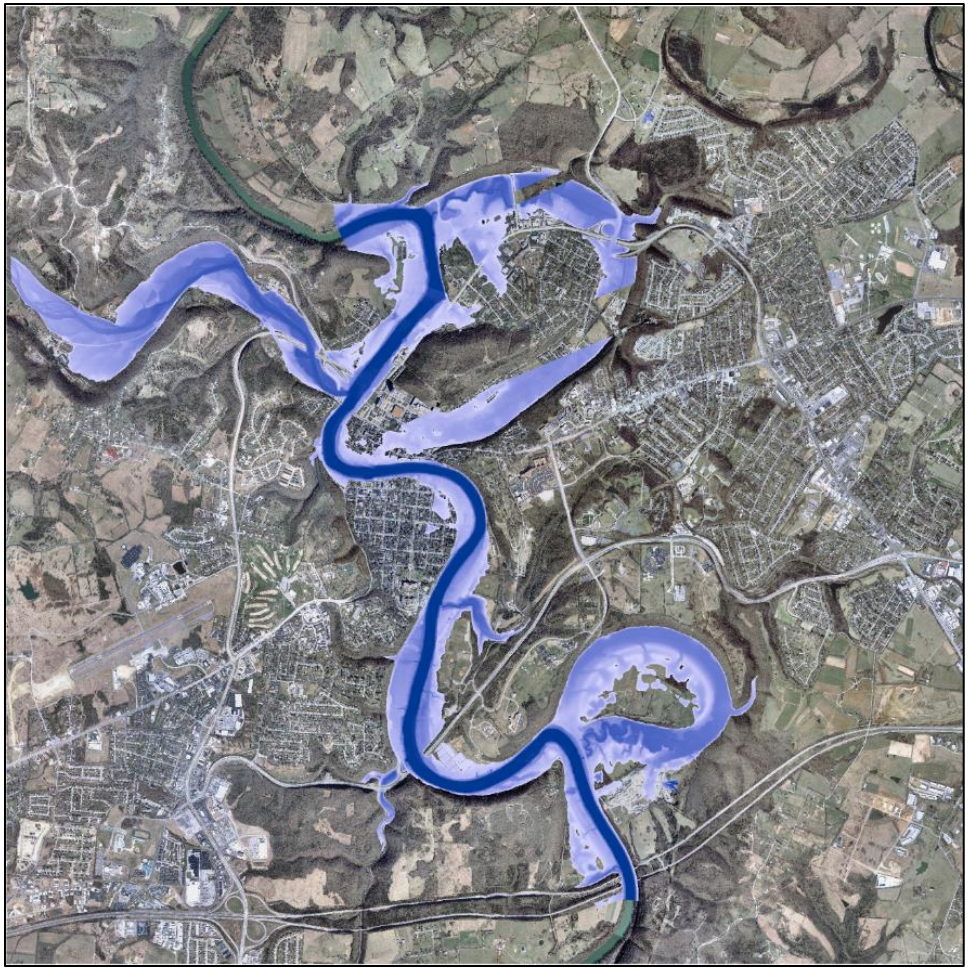


USGS

Initial Unedited Depth Grids

- The following slides show some of the initial results (26 depth grids) from the calibrated model.
- The depth grids range from the lowest inundation stage of 27 ft. and increase by a 1 ft. mapping interval to the highest inundation stage where the levees are completely overtopped at 52 ft.
- These maps will require some editing to eliminate wetted areas that are disconnected from the main stem and to properly represent bridge overtopping when it actually occurs.
- These initial maps require the review and approval of the local stakeholder to identify if these initial maps, to the best of their knowledge, properly show the flooding conditions at each respective stage.

Sample initial unedited depth grid

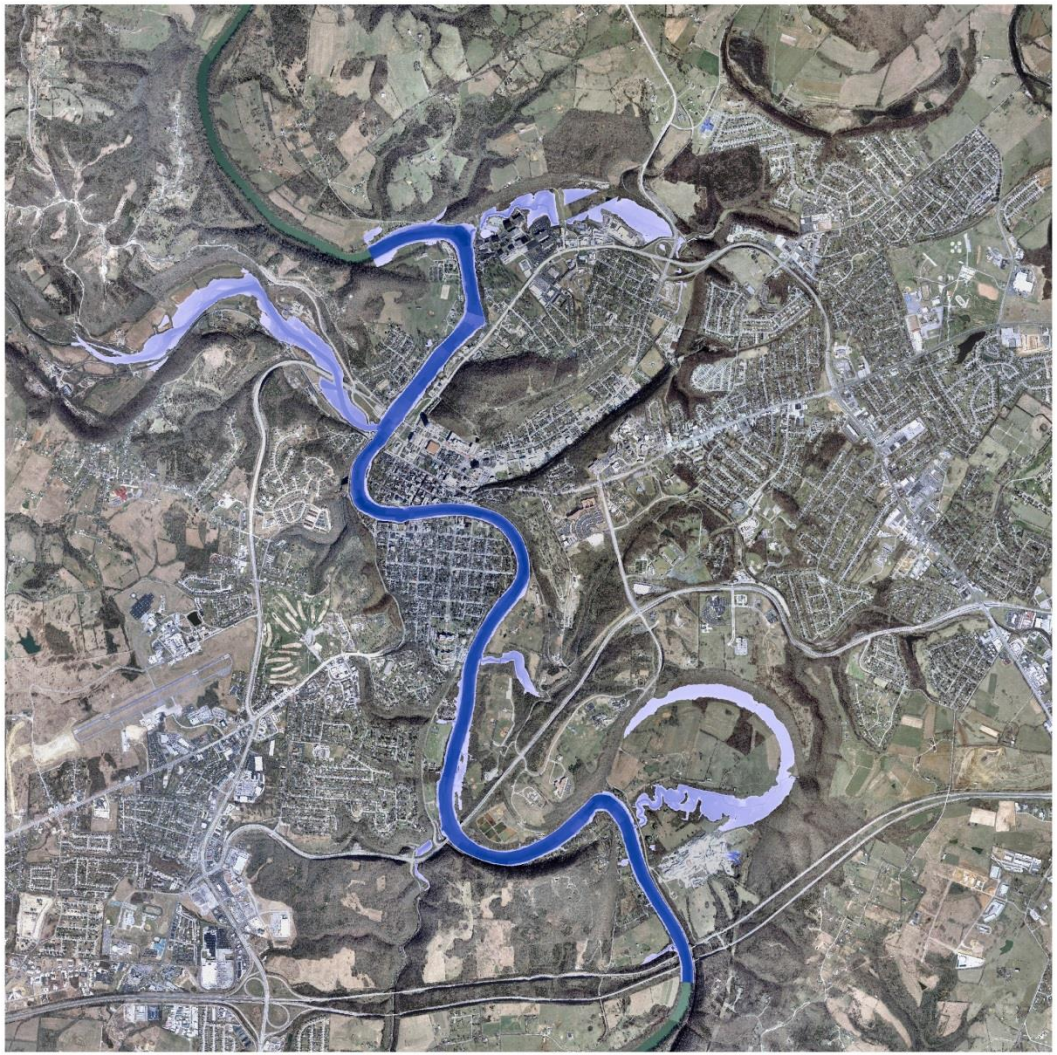


USGS

Stage 27 ft.

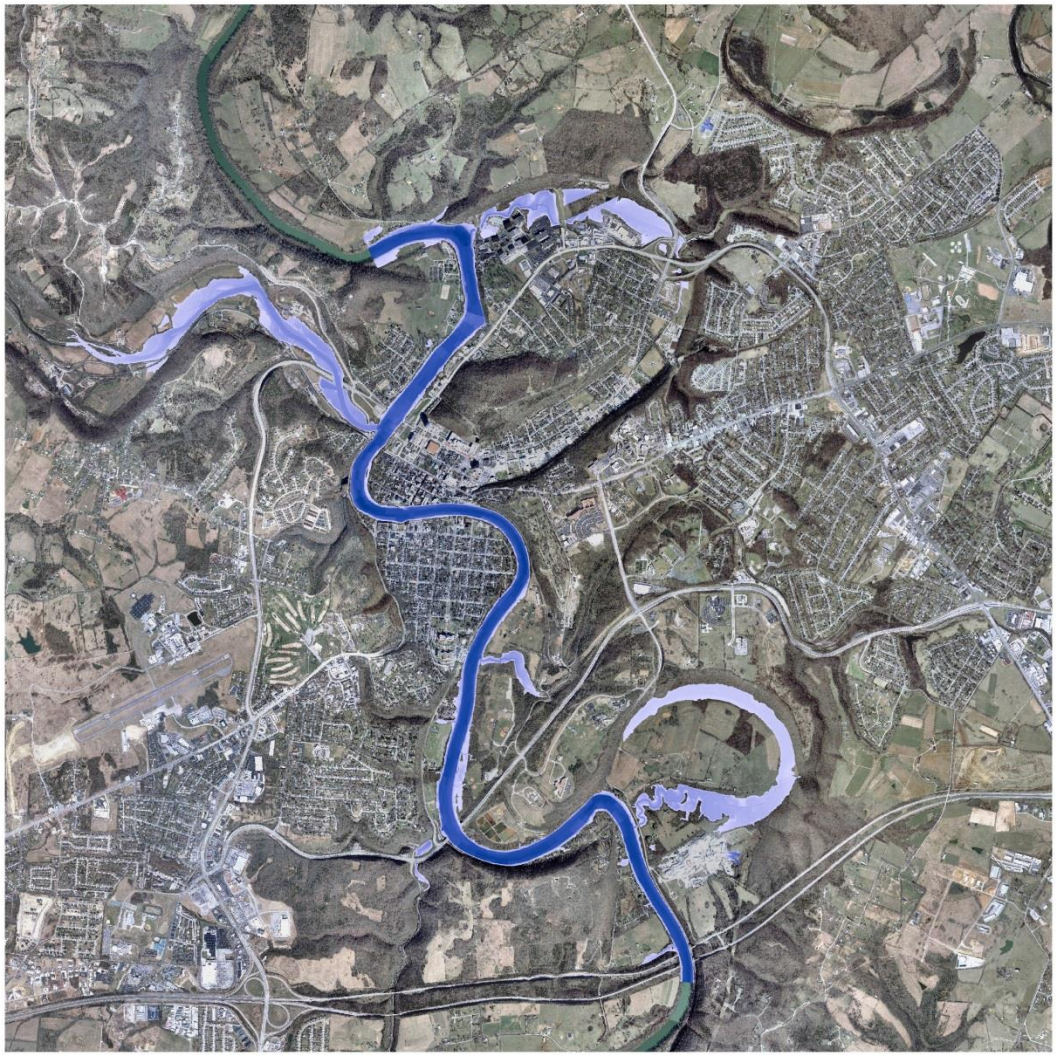
USGS

Stage 28 ft.



USGS

Stage 29 ft.



USGS

Stage 30 ft.

USGS

Stage 31 ft.

USGS

Stage 32 ft.

USGS

Stage 33 ft.

USGS

Stage 34 ft.

USGS

Stage 35 ft.

USGS

Stage 36 ft.

USGS

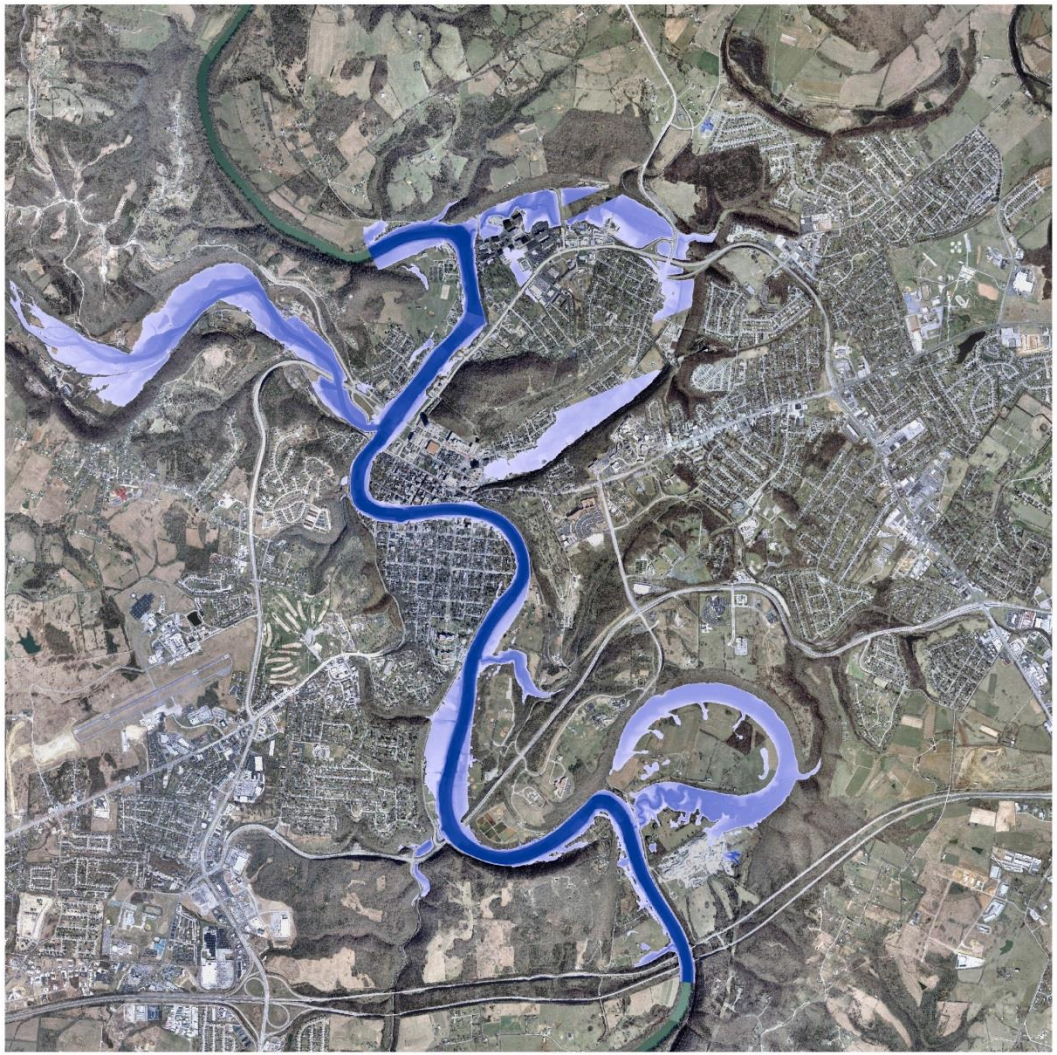
Stage 37 ft.

USGS

Stage 38 ft.

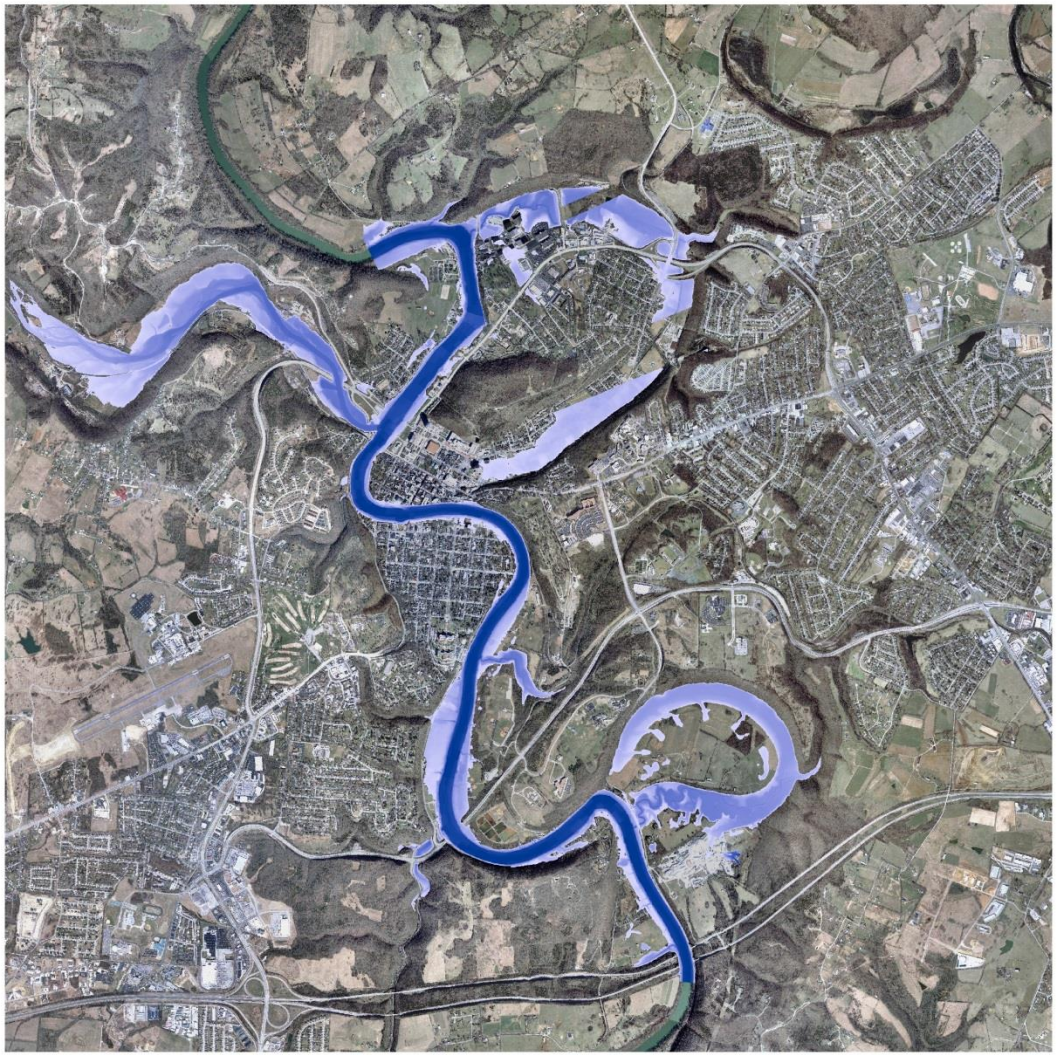
USGS

Stage 39 ft.



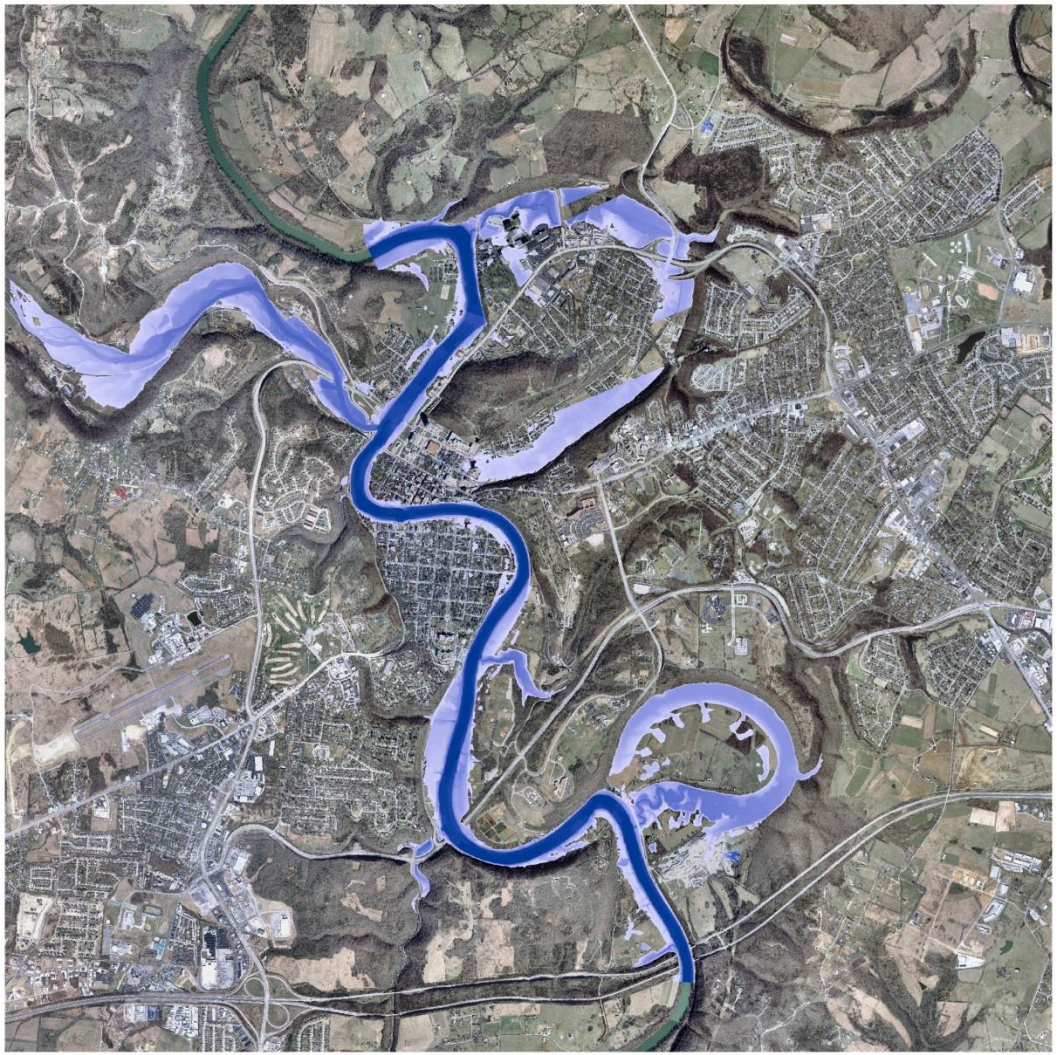
USGS

Stage 40 ft.



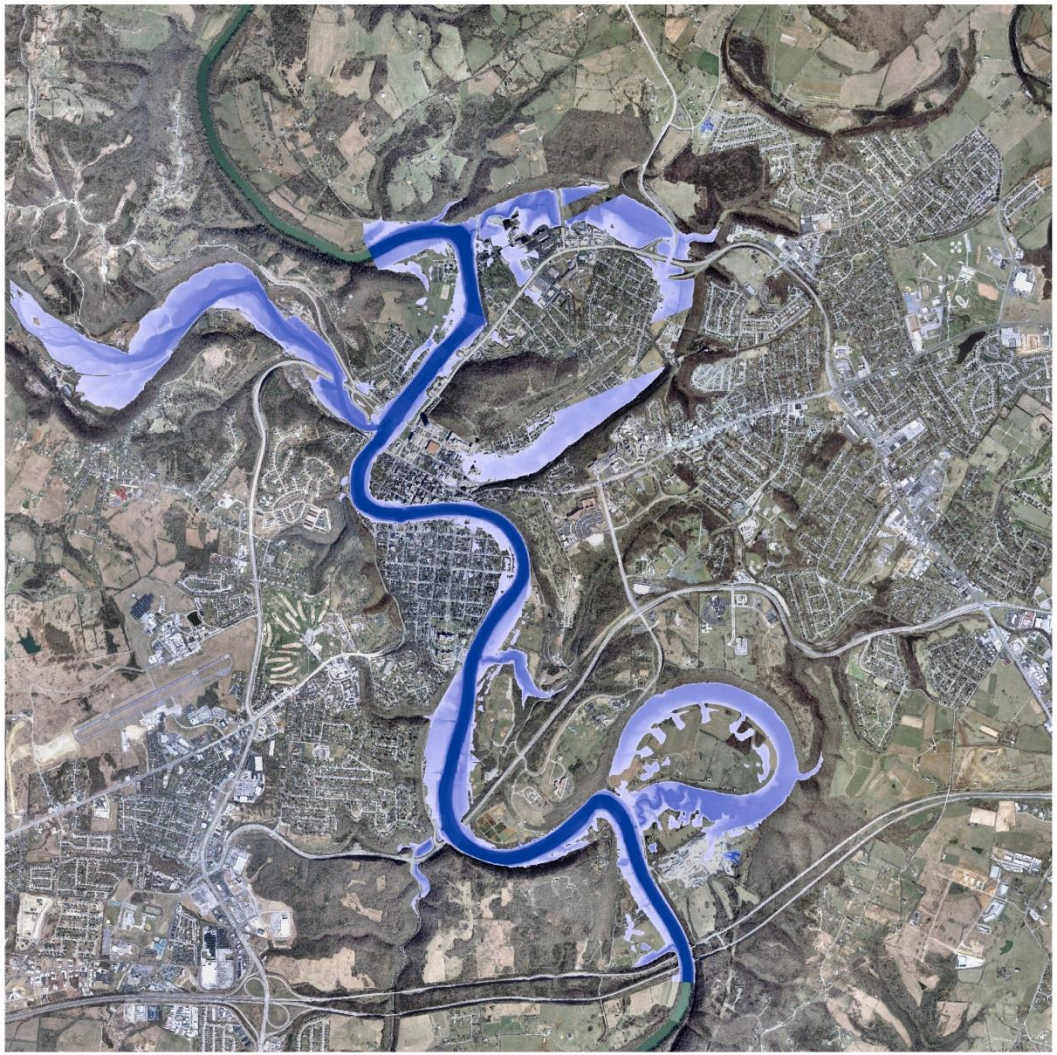
USGS

Stage 41 ft.



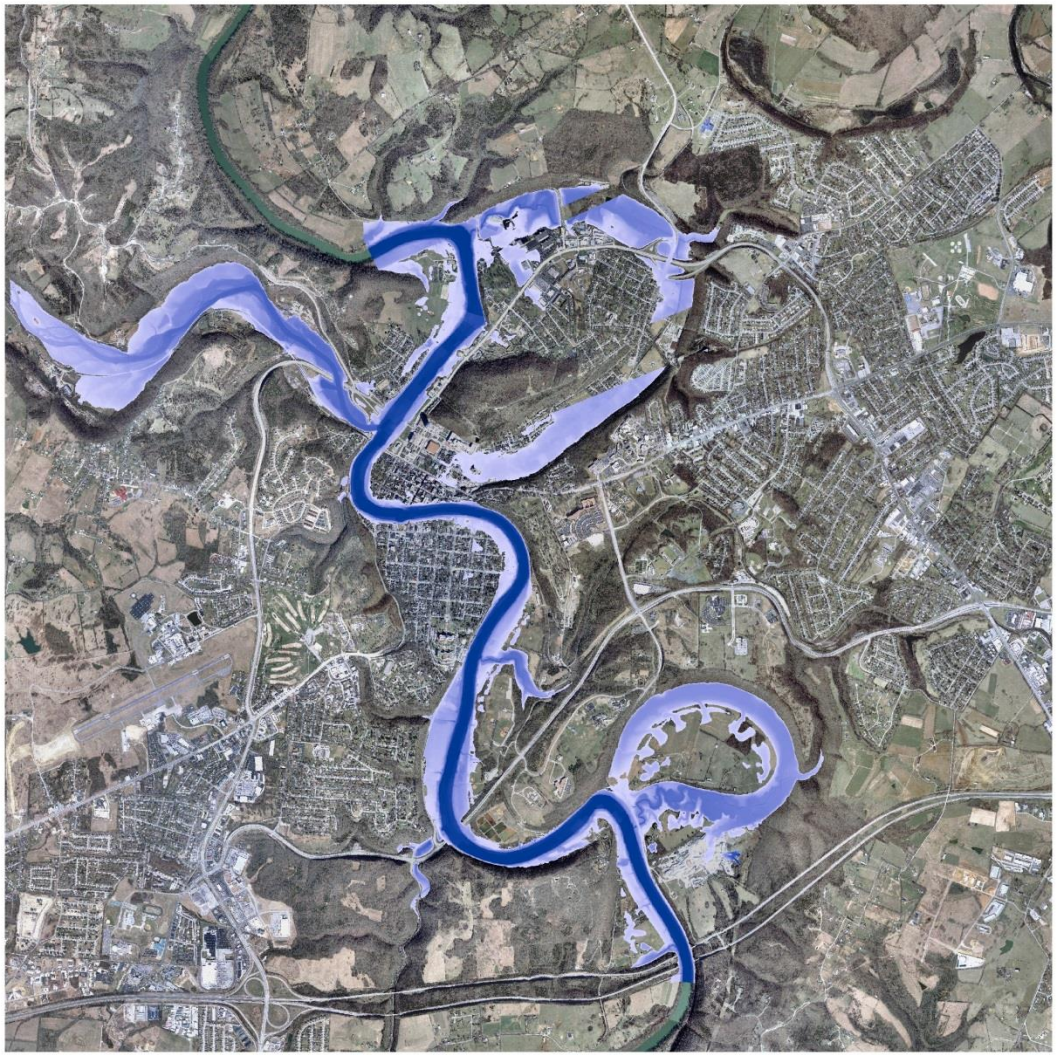
USGS

Stage 42 ft.



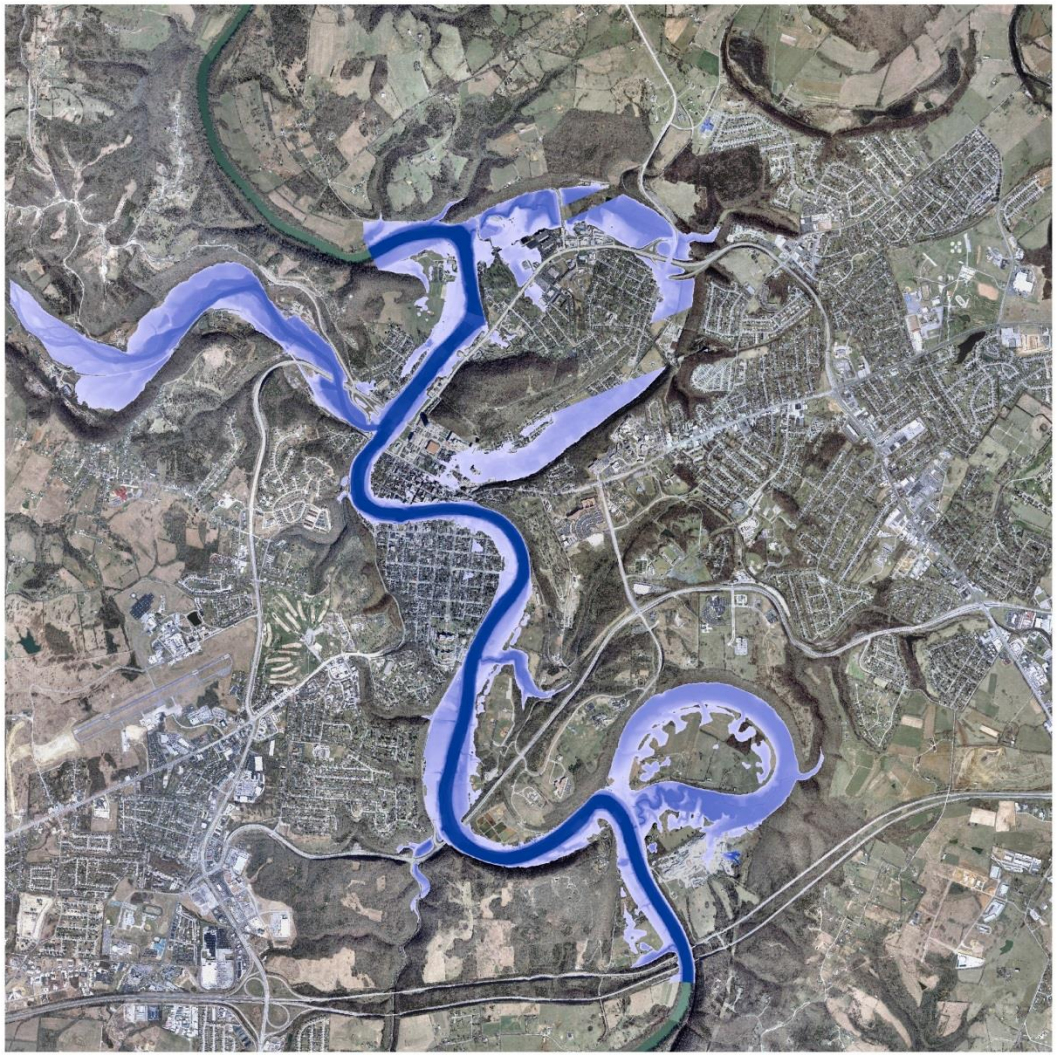
USGS

Stage 43 ft.



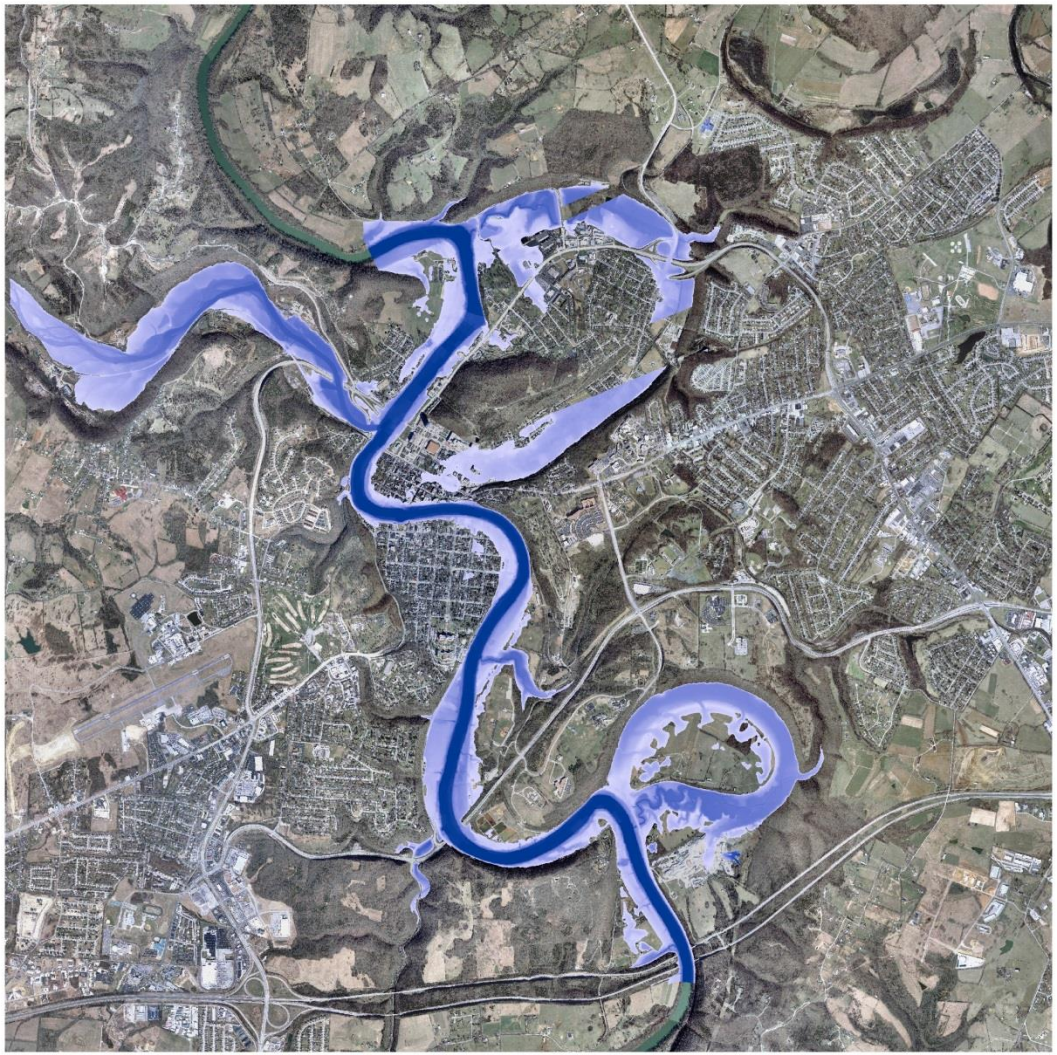
USGS

Stage 44 ft.



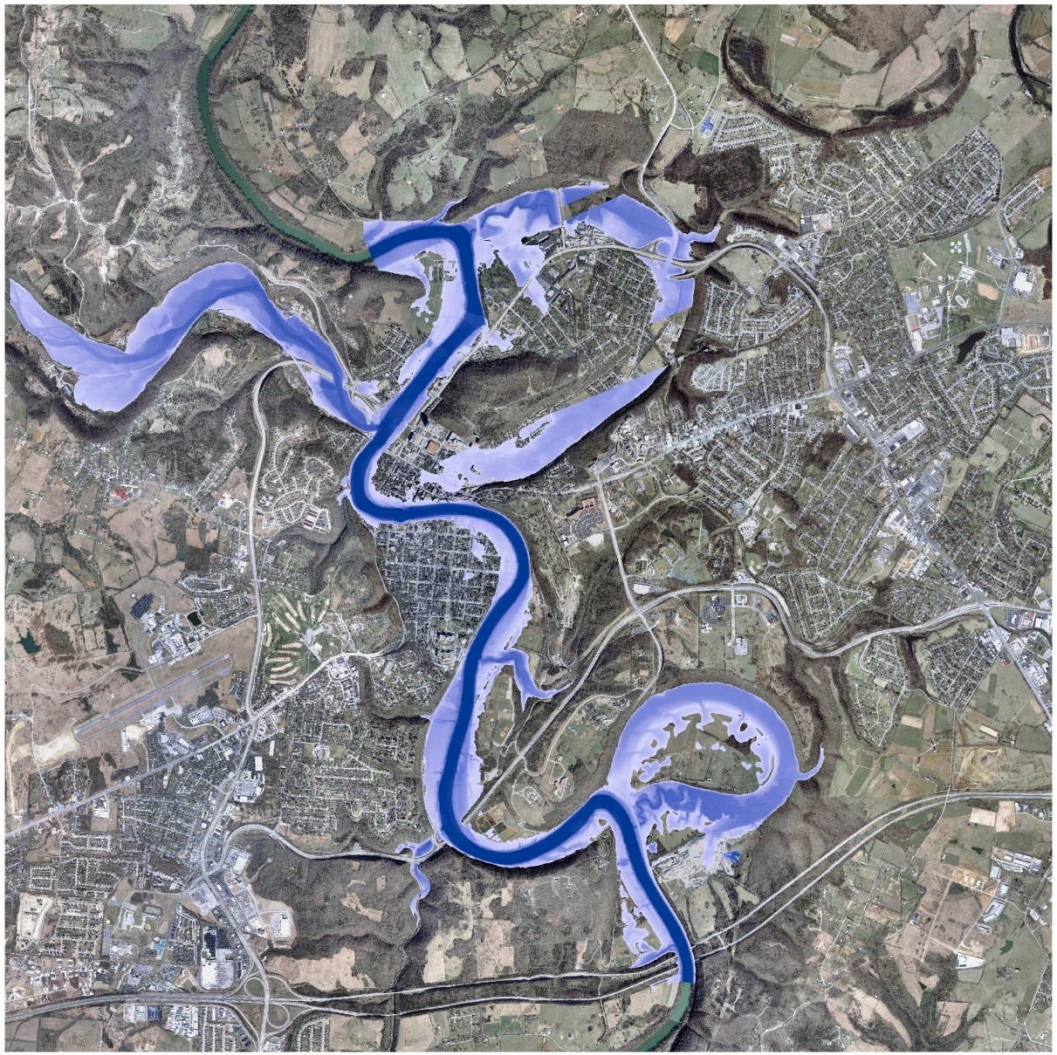
USGS

Stage 45 ft.



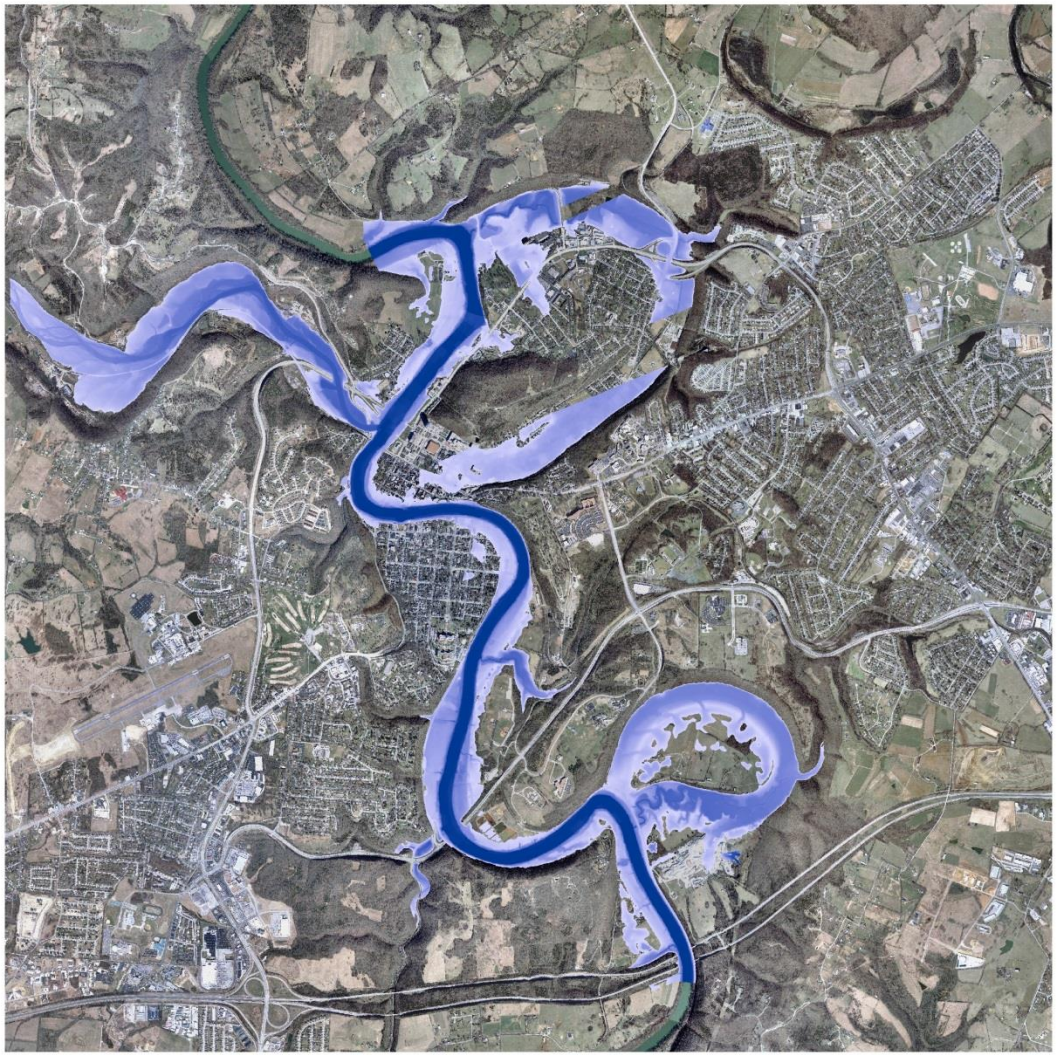
USGS

Stage 46 ft.



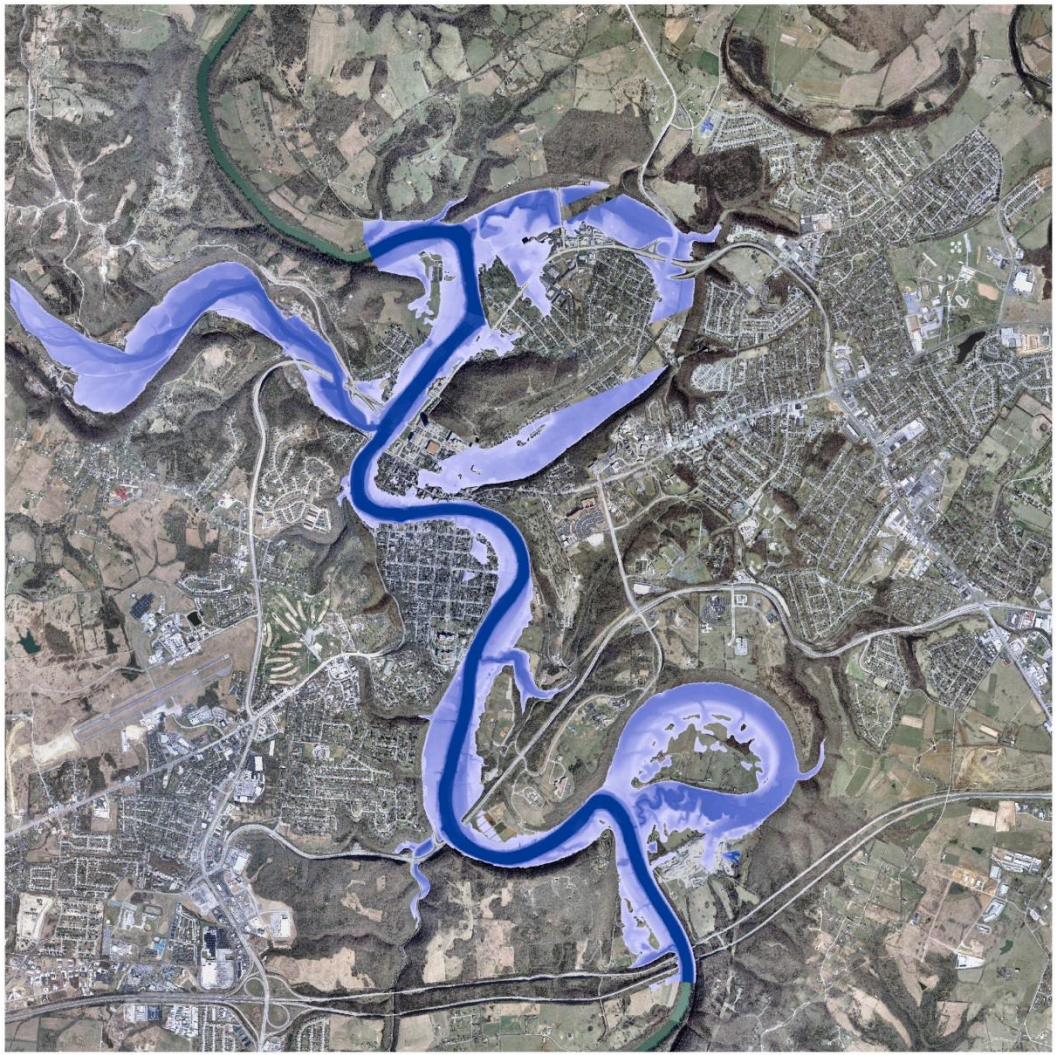
USGS

Stage 47 ft.



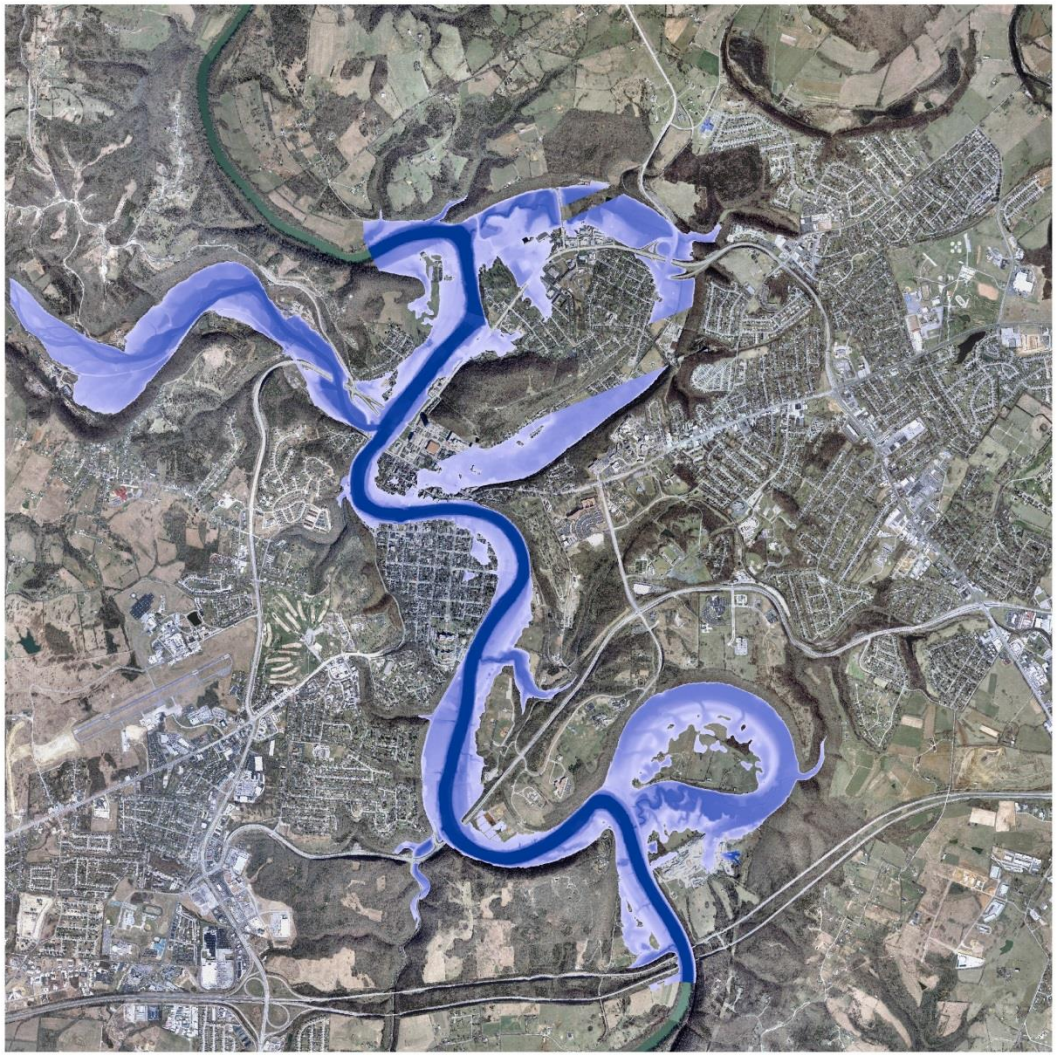
USGS

Stage 48 ft.



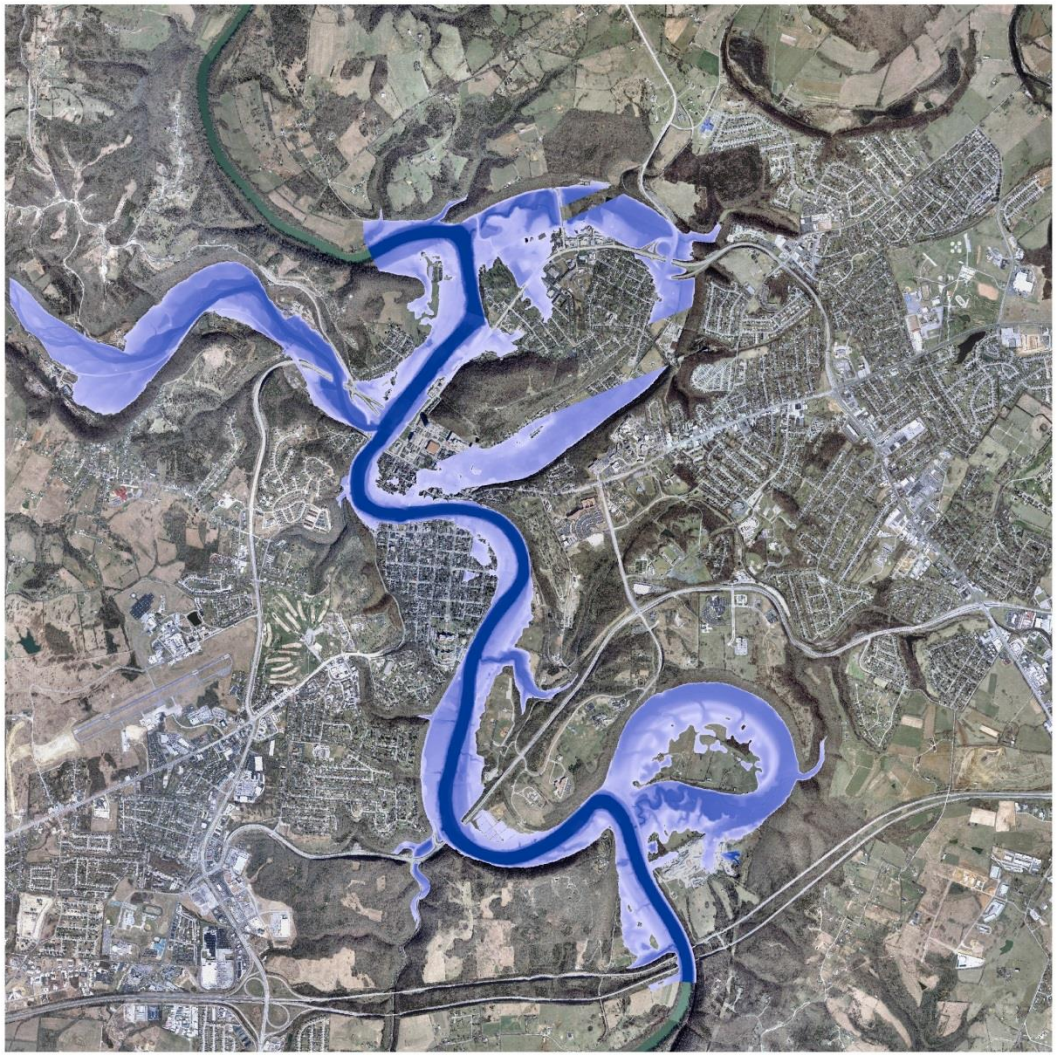
USGS

Stage 49 ft.



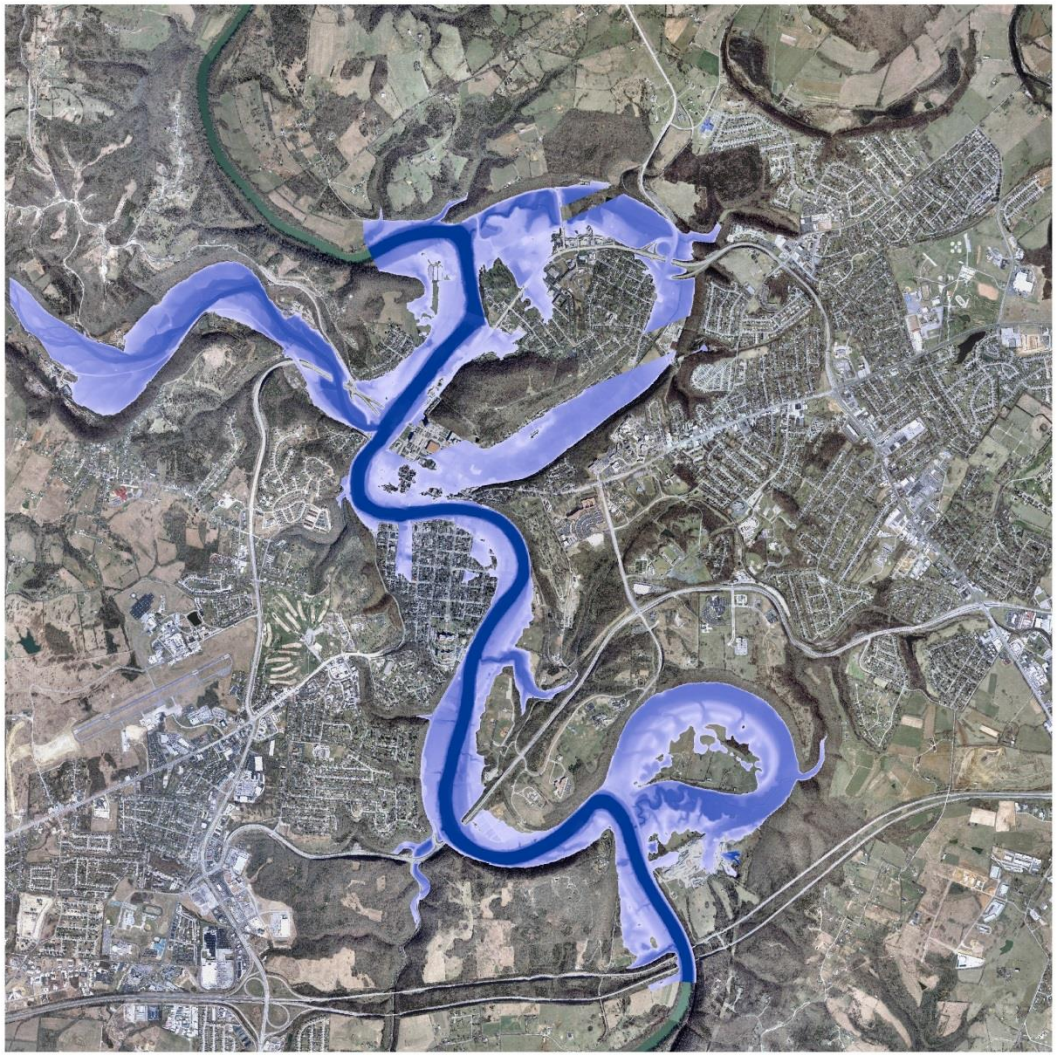
USGS

Stage 50 ft.



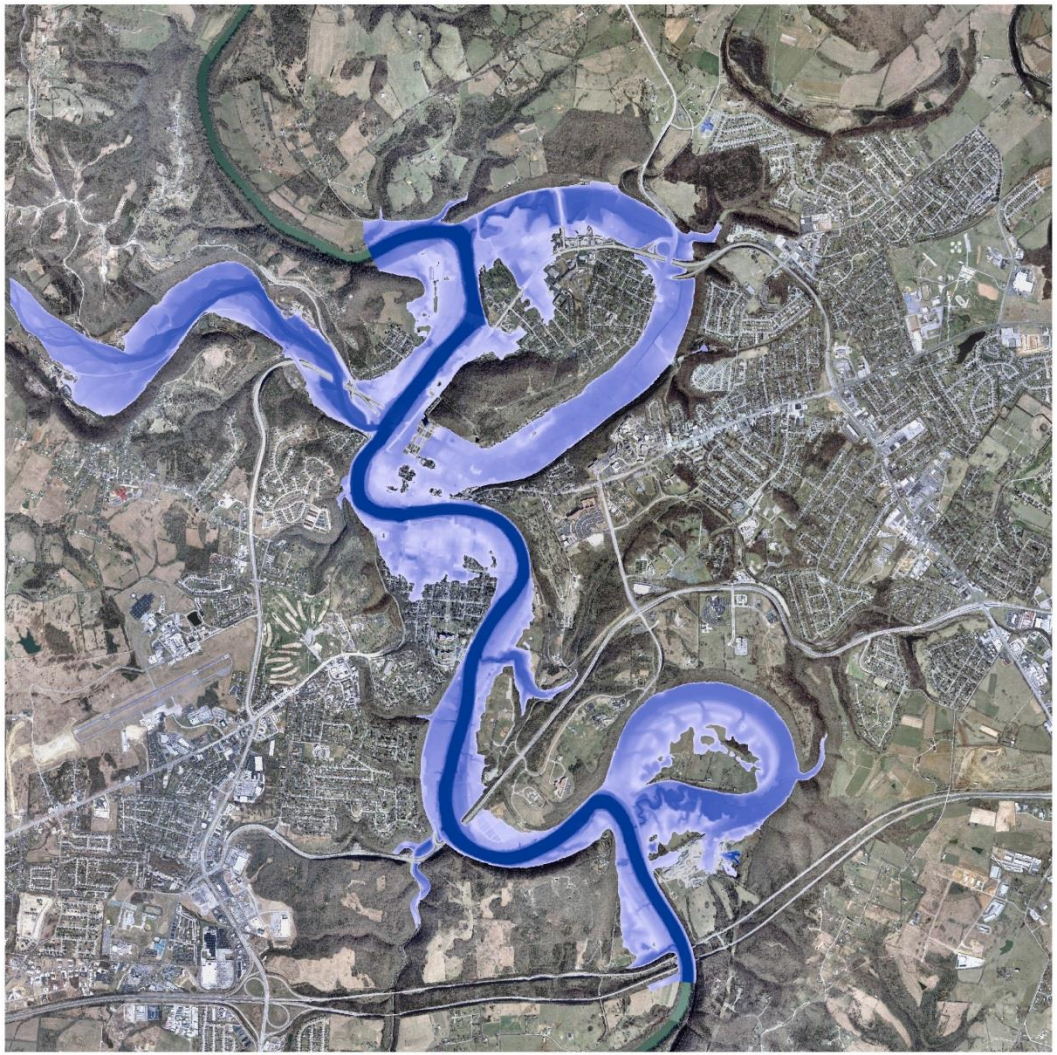
USGS

Stage 51 ft.



USGS

Stage 52 ft.



USGS

Next Steps for Frankfort, KY Flood Inundation Project

- Phase 2B – Mapping
  - Edit depth grids and polygon layers to represent realistic flooding conditions.
    - Eliminate inundated areas that are not hydraulically connected to the flow in the main stem.
    - Represent the overtopping of structures (bridges) when its respective low cord elevation is matched or exceeded by the water surface elevation in the main channel.
  - Create metadata for all depth grids, polygon layers, and supplemental data sets.
  - Submit to NWS for approval.

- Phase 3 – Web Implementation
  - Implement the depth grids, polygon layers, and supplemental data sets on the NWS AHPS mapper and the USGS FIMI mapper.

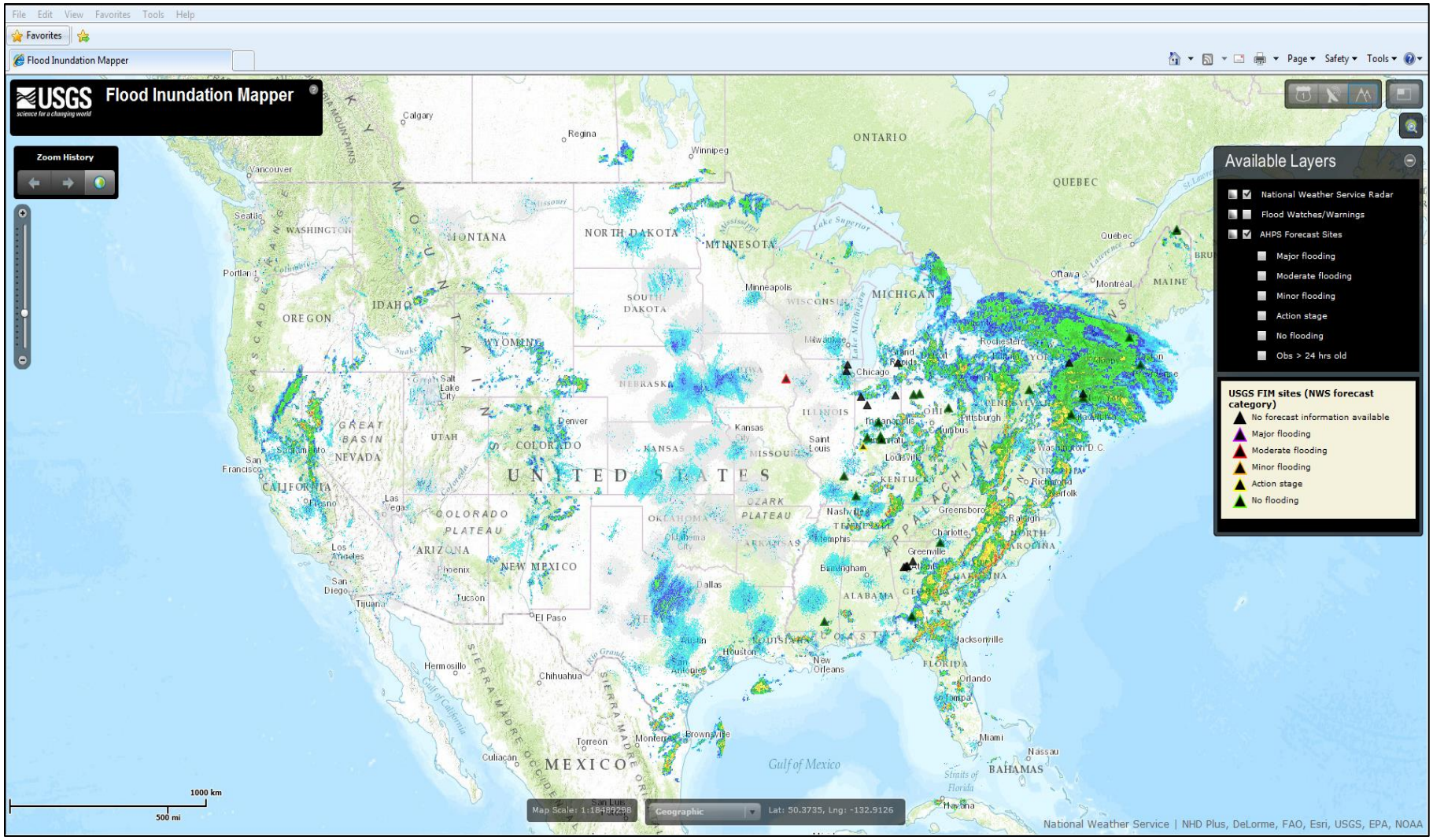
USGS

Live Demo of USGS Web Mapping Application & Important Links

- **USGS Flood Inundation Mapping Service:**
  http://water.usgs.gov/osw/flood_inundation/
- **USGS Flood Inundation Mapper:**
  http://wim.usgs.gov/FIMI/FloodInundationMapper.html
- **USGS Report (Scientific Investigations Map 3242):**
  http://pubs.usgs.gov/sim/3242/
- **NWS Advanced Hydrologic Prediction Service:**
  http://ahpsdev.enable-us.com/ahps2/inundation/inundation_google.php?wfo=pah&gage=hlbk2

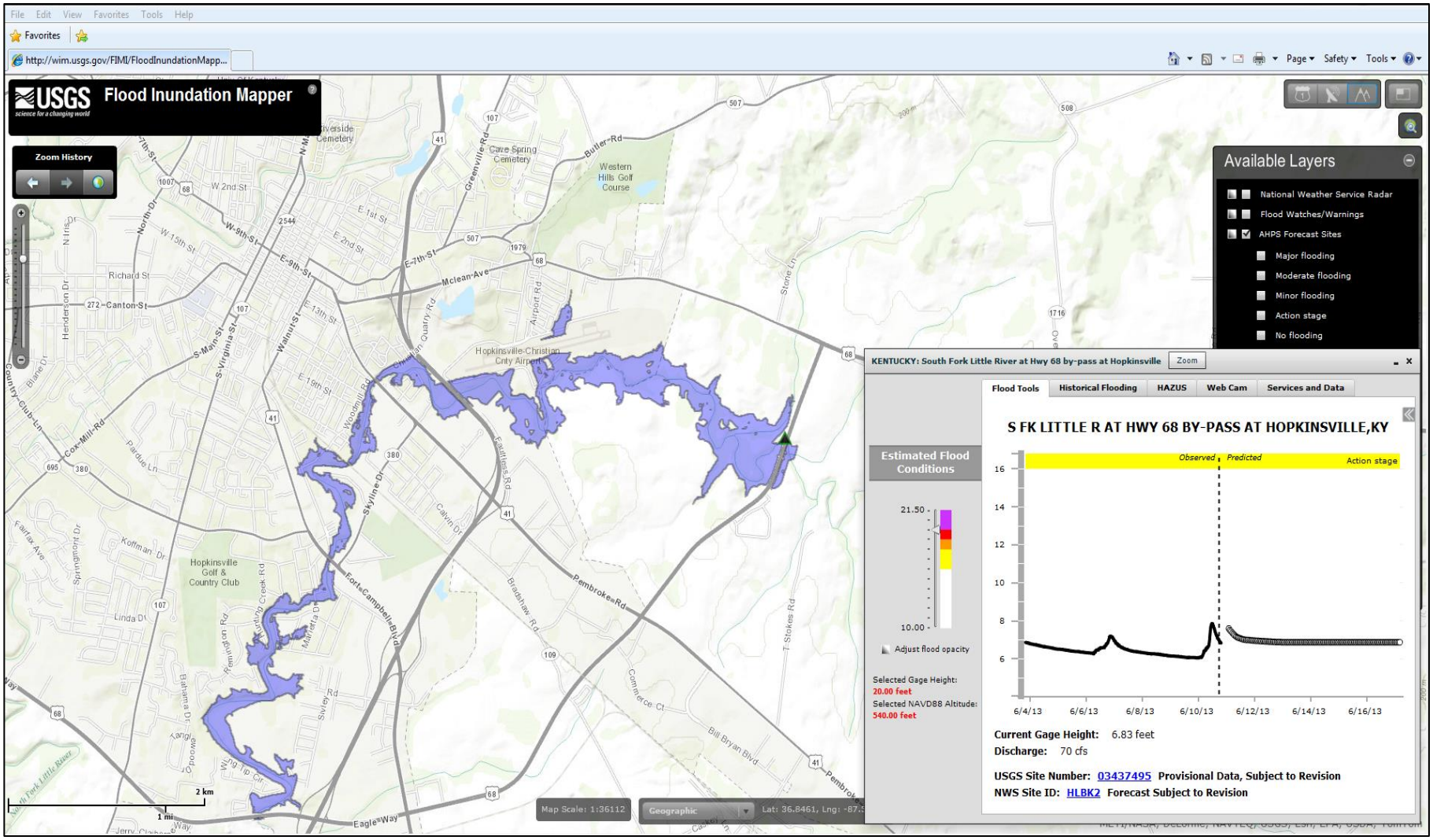
USGS

USGS Flood Inundation Mapper – Front Page

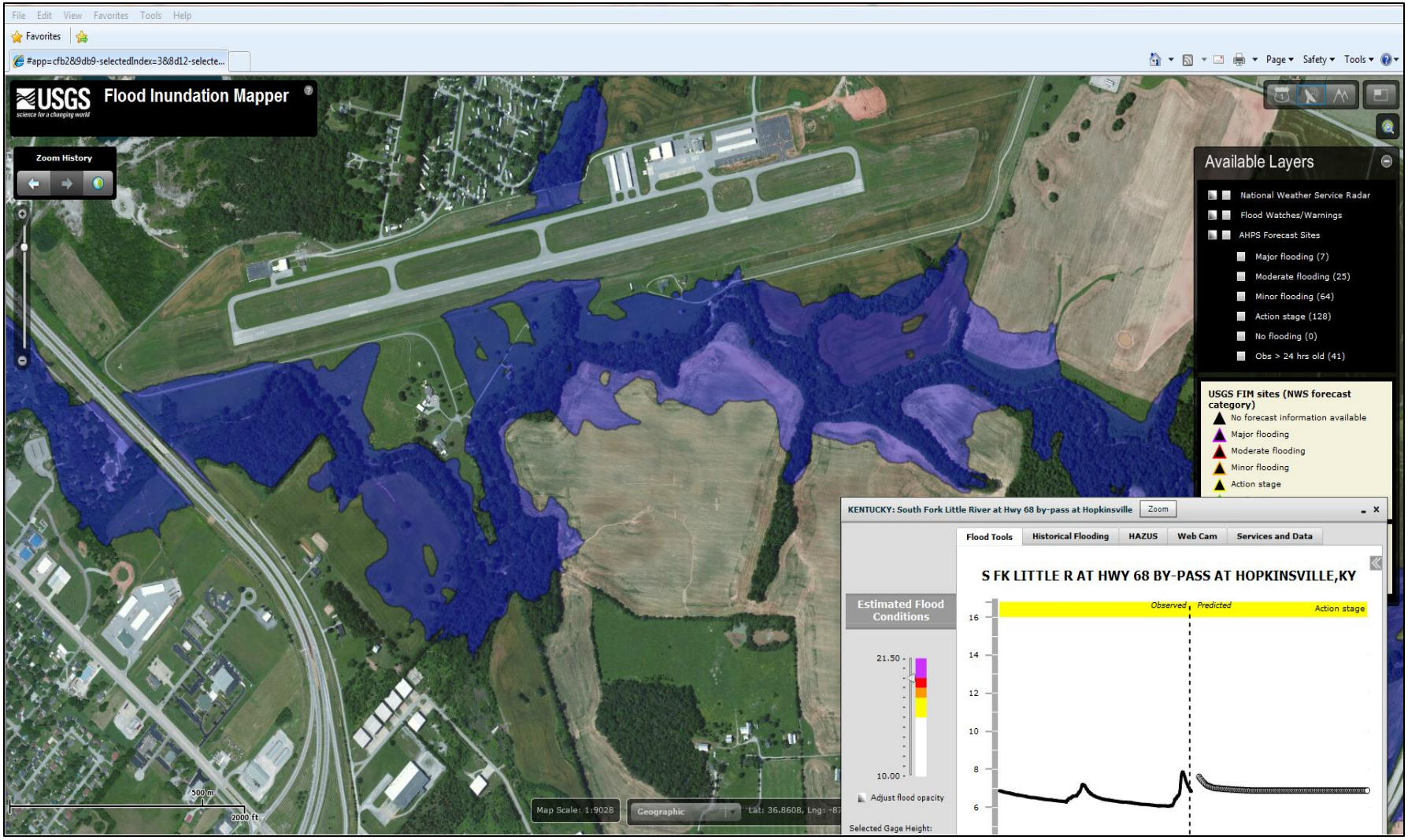


USGS

USGS Flood Inundation Mapper – Flood Tools

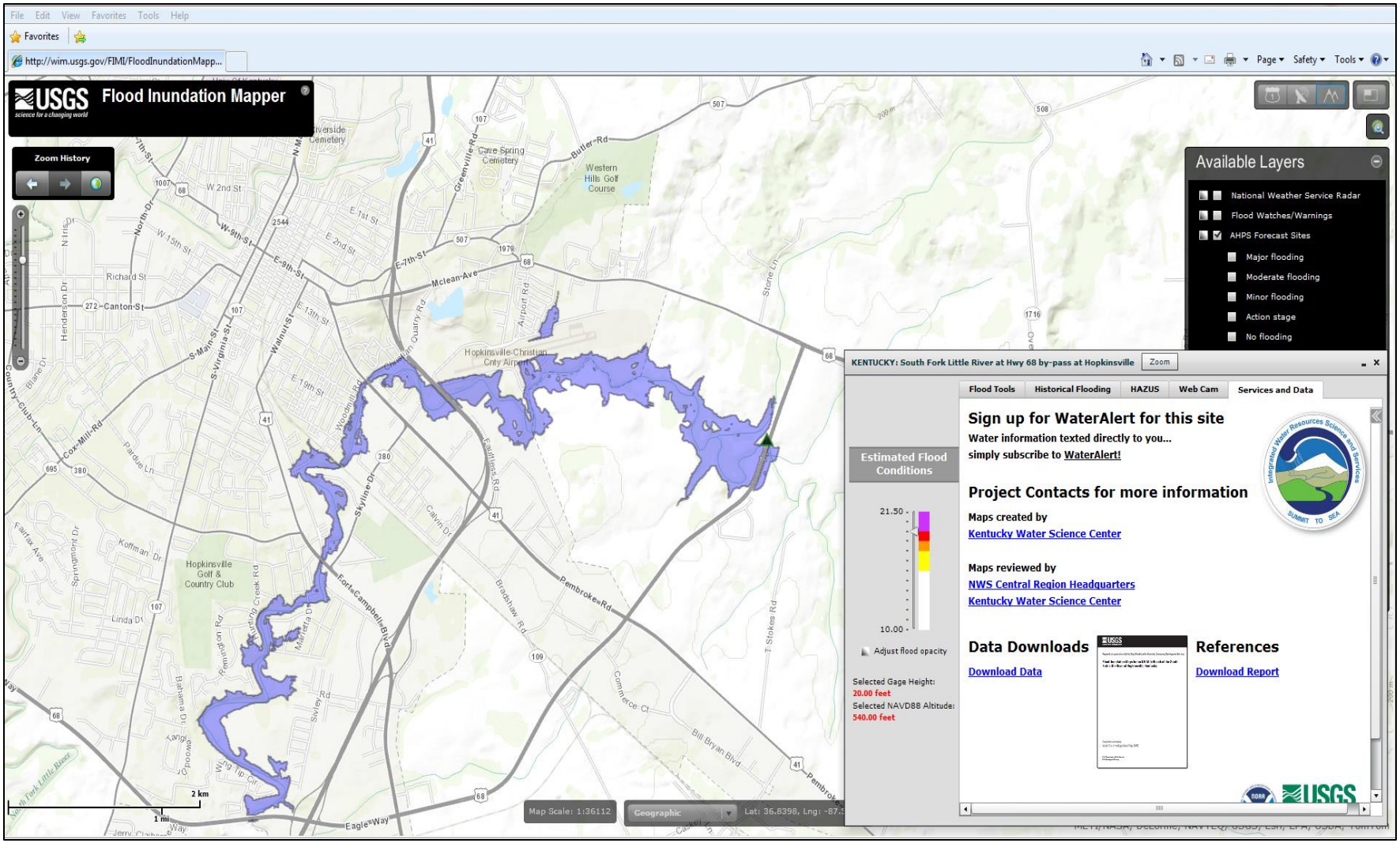


USGS Flood Inundation Mapper – Flood Tools



USGS

USGS Flood Inundation Mapper – Services and Data



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Questions?

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