Mapping Potential Flood Extents in Eastern Kansas

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DEM = Digital Elevation Model
“Floodplain Mapping” can mean many things:

Who has to buy flood insurance?

*FEMA “100-year” floodplains are estimated using hydrodynamic models*
“Floodplain Mapping” can mean many things:

**River Valley Identification:**
Extracting the historic floodplain as a map feature

**New Method:**
*FLDPLN (“floodplain”) Model*
“Floodplain Mapping” can mean many things:

Detailed “Depth to Flood” (Flood Risk) Mapping

FLDPLN Model
“Floodplain Mapping” can mean many things:

Flood Extent Estimation (Example 1)
“Floodplain Mapping” can mean many things:

June 13, 2008

Flooding on the Cedar River crested more than 11 ft above the historic record in Cedar Rapids, Iowa

Flood Extent Estimation (Example 2)
Segmented Library of Inundation Extents (SLIE) Coverage

Federally Declared Disaster Area Due to Flooding in Summer 2007
KARS Inundation Map Library Coverage Area
GIS-PB 2008 coverage  GIS-PB 2009 expansion
This floodplain database (called a Segmented Library of Inundation Extents, or SLIE) was developed for 339 stream segments in eastern Kansas.

Using stage information from gages and observers, the SLIE is used to produce current and predicted flood extents during severe flooding to improve situational awareness for disaster response personnel.

Website: http://www.kars.ku.edu/geodata/maps/depth-flood-eastern-kansas/
Also available as a web mapping service for ArcMap and Google Earth (KML)

www.kars.ku.edu
Proposed SLIE Expansion Area (KHS Regions 2 & 5)
Major Project Tasks

- 10-m USGS NED elevation data were obtained for eastern Kansas in early 2008 (pre-LiDAR)

- DEM preparation & pre-processing:
  - Digitize missing lakes (to improve landscape representation)
  - Create dam outflow paths (so that lakes are not treated as “sinks”)
  - Integrate levee data (to improve modeling accuracy; NEKS only)

- Obtain USGS and NWS gage database (apply positional corrections using NAIP imagery and gage location information; USGS-NWS datum QA)

- Use the KBS FLDPLN model to develop the **Segmented Library of Inundation Extents (SLIE)** database covering 339 eastern Kansas river segments (to use for real-time inundation extent estimation and prediction during severe flood events)

- Create prototype website (application and mapping service)
Missing Lakes in Eastern Kansas

Using the 2005 Kansas land cover map, all lakes in eastern Kansas with surface area greater than 500,000 m² (123.55 ac) were identified and cross-referenced for inclusion in the DEM.

17 lakes in the eastern Kansas study area were not present in the DEM, including large reservoirs such as El Dorado, Hillsdale, and Wolf Creek.

Using NAIP imagery for guidance, the DEM was modified to include representation of these missing lakes.
Digitizing missing lakes in the 10-m NED

What’s wrong with this picture?

John Redmond
Same 10-m NED data, shown in *hillshade relief* format

*Wolf Creek Reservoir is nowhere to be found...*
There’s Wolf Creek Reservoir
Modified DEM - Wolf Creek Reservoir added using GIS

Coffey County Lake filled during 1979-1982!
Modified DEM - Wolf Creek Reservoir added using GIS

Artificially filled at KBS in 2008...
Eastern Kansas Lakes Requiring Outflow Path Creation

Using data from the National Inventory of Dams, 147 of the largest lakes in eastern Kansas were identified.

Through site-by-site inspection of the DEM, 40 lakes required outflow modification.

This action, which created a lake-level drainage path through the dam directed toward the primary outflow channel, was necessary for hydrologic pre-processing (sink filling).
**Eastern Kansas Levee Data**

**RED** indicates levees that are part of the *National Levee Database* (NLD). These data have z-values (source: KC USACE). *The DEM was modified to include representation of these levees.*

**GREEN** indicates levees that are not part of the NLD. They have been identified using high resolution imagery, and have no z-values (source: Tulsa USACE). *These levees were not used for DEM modification.*
USGS and NWS Gage Data QAQC

134 USGS and NWS stream gages are located in the eastern Kansas study area.

All gage locations were examined for positional accuracy using NAIP imagery and other gage location information. Most gage positions required at least minor adjustment.

At joint USGS-NWS gage sites, USGS and NWS datum values were cross-checked for consistency. A small number of gages had inconsistent datum values and required further inquiry.
This DEM was created using LiDAR data.

Shown is a portion of the river valley for Mud Creek in Jefferson County, Kansas.
Terrain Processing: Flow Direction

Each pixel is colored based on its flow direction.

Navigating by flow direction, every pixel has a unique exit path out of the image.

Flow direction map (gradient direction approximation)
Terrain Processing: Flow Accumulation

The flow direction map is used to estimate flow accumulation.

*flow accumulation* = catchment size
= the number of exit paths that a pixel belongs to

Flow accumulation map (channel identification)
**Terrain Processing: Stream Network**

Pixels with flow accumulation $>10^5$ pixels are colored using green or blue lines.

Mud Creek is shown in blue.
The 10-m floodplain was computed for Mud Creek using the FLDPLN model.

FLDPLN is a static, 2D hydrologic model that requires only DEM data as input.

Using simple surface flow properties, FLDPLN identifies the depth-varying floodplain in reference to the input stream network (floodwater source).
The FLDPLN ("floodplain") Model—there are two ways that point Q can be flooded by water from point P

- **Backfill Flooding**
  - Floodwater surface uphill from P

- **Spillover Flooding**
  - Floodwater surface downhill from P
Backfill Flooding—accounts for floodwater expansion due to swelling processes.
Spillover Flooding—accounts for floodwater rerouting (alternative flow path development)
PLAN VIEW illustrating backfill and spillover flooding

SPILLOVER FLOODING

BACKFILL FLOODING

Depth To Flood (DTF) Contour

flood source point

tributary channel

watershed boundary

flow divide

or

P

Q

P

Q
Let’s take a look at 10-m NED DEM near Iola (Allen County)
DTF map around Lola...
DEM “Starfish” and “Blowouts” along the Neosho River near Iola
DRG with DTF map overlaid...
Zoom in on the blowouts...

starfish

blowouts
DRG for zoom-in area...

Lone Peak

“Carrying” Contours
DRG with DTF map overlaid...
Other Applications for the FLDPLN Model
Flood scenario modeling for training exercises – HWM targeting and estimation of flood depth grid
River typing and morphology studies – valley identification and floor width estimation

- Valley floor width
- Valley top width
- Valley boundary
River valley boundary delineation –
masking for identification of floodplain wetlands
Identifying potential wetland locations & wetland boundary refinement
Assessing Wetland Hydrologic Connectivity

- DTF value extracted for each site.
- Provides a **hydrologic connectivity index** (HCl).
- HCl indicates relative frequency of connection (via floodwaters) of a floodplain location to the river.

\[ \uparrow \text{DTF} = \downarrow \text{HCl} \]
Levee Effects on Wetland Hydrologic Connectivity

- Levee data (xyz point files) obtained from KC USACE.
- Acquired as part of the National Levee Database (NLD) effort.
- Many levees are absent.
Levee Effects on Wetland Hydrologic Connectivity

30-m DEM data backdrop.
Without levee data

- FLDPLN
- No levee data.
- $\text{DTF} = \text{HCI}$
With levee data

- DTF values increased more than 4 m, indicating much less frequent reconnection to the river.

**Next Step:**
Relate stage to frequency

*Note: A non-hydrologic connectivity index, such as distance-to-stream, will not pick up levee effects.*
The Mud Creek floodplain below Lake Dabinawa is shown.

Mud Creek flows into the Kansas River north of Lawrence, KS.
Thanks for Listening…

Any Questions?