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Flood Risk at Labadie Bottoms, Franklin County, Missouri

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Abstract. Flood risk at Labadie Bottoms, Missouri can be estimated with reasonable certitude from historical evidence gathered at proximal, long-term gaging stations on the lower Missouri River. The agricultural levee at Labadie Bottoms has been overtopped at river flows above approximately 540,000 cubic feet per second (cfs). Flows at or above this magnitude have occurred on the lower Missouri River six times since 1929, or approximately once every 14 years.

Regional Setting

Labadie Bottoms comprises about ten square miles of farmland and wetland in the Missouri River floodplain, situated immediately south of the Missouri River. The river has a normal width of about 1300 feet in this area, and meanders within a broad, two-mile wide floodplain bounded by steep bluffs that can be more than 300 ft. high (USGS, 1972). Labadie Bottoms is underlain by soft alluvial sediments with a thickness of about 110 feet, situated above Ordovician dolostone and sandstone units (Emmett and Jeffery, 1968; Harrison, 1997). The alluvial aquifer is highly permeable so the water table adjusts to be within about ±10 feet of the fluctuating river level (see USGS, 2010).

Labadie Bottoms is protected from moderate flooding by a nonfederal, agricultural levee with a crest elevation of about 480 ft. MSL (AmerenUE, 2009). Nevertheless, most of the bottom is situated within the FEMA 100-year regulatory floodplain (FEMA, 1984), and this expectation of flooding has been repeatedly realized, most recently in 1993 (Fig. 1). Moreover, river stages for given flows have progressively increased along the lower Missouri River during the last century (Fig. 2), in part because of the progressive isolation of floodplains from the river due to levee construction (GAO, 1995; Criss and Shock, 2001).

Determination of Flood Levels

Flood levels at Labadie Bottoms have been calculated for different flow magnitudes by the Army Corps of Engineers (USACE, 2004). Table 1 compares calculated flood levels for Labadie Bottoms (RM 58) and the nearby gaging station at Washington, Missouri (RM 68.2), only ten river miles upstream. No major tributaries join the Missouri River between these sites, nor for a considerable distance upstream. Consequently, river flows for given recurrence intervals ranging from 2 to 500 years at Labadie, Washington, and Herman, Missouri (RM 97.9) are all within ±1000 cfs of each other. Note that the water surface elevations calculated by USACE are 8.0 to 9.1 feet higher at Washington than at Labadie.

Table 1. Calculated Stages for Given River Flows at Washington and Labadie

Recurrence Interval, years	Flow, x 1000 cfs	Stage at Washington#	Stage at Labadie#	Stage Difference, ft.
500	832±1	496.3 ft	487.3 ft	9.0
200	742±1	494.7	485.7	9.0
100	673±1	493.5	484.4	9.1
50	605±1	492.1	483.1	9.0
10	440±1	487.9	479.9*	8.0
5	364±1	486.6	477.7*	8.9
2	249±1	480.2	471.5*	8.7

Stages calculated by USACE (2004, 2010), in feet relative to Mean Sea Level (MSL), for Washington (RM 68.2) and Labadie (RM 58).
*too high

Historical Flood Records

The proposed, 400-acre coal-ash landfill site is situated in bottomlands within the FEMA "100-year" regulatory floodplain (FEMA, 1984). These bottomlands have elevations ranging from 465 and 470 ft. above MSL (USGS, 1972), while the base "100-year" flood in this area would have a water surface elevation of 480 ft according to FEMA (1984), or 484.4 ft according to USACE (Table 1). Inundation of Labadie Bottoms occurred in 1986 and 1993 (Table 2; Fig. 1), which suggests that the USACE estimate is more correct.

Water levels for the largest floods of record have been compiled for Washington (NWS, 2010), and a long-term record of both flow and river stage is available for Herman (USGS, 2010). The corresponding flood levels at Labadie can be estimated by assuming a 9 foot difference from the stages measured at Washington. The 1993 estimate matches the actual 1993 flood level reported by AmerenUE (2009), which generally supports the accuracy of the estimates provided in Table 2 for the most significant, recent floods.

According to AmerenUE (2009), the agricultural levee at Labadie Bottoms has a crest elevation of 480 feet MSL. The calculations by USACE (Table 1) indicate that this levee should be overtopped for flows above 445,000 cfs. Instead, the historical record suggests that flows above about 540,000 cfs are required to overtop this levee (Table 2), so the USACE has estimated stages at Labadie for small flows. In particular, the 1973, 1994 and 1995 floods did not overtop the levee (AmerenUE, 2009). Several factors could explain why the 1986 flow overtopped the levee when the slightly higher flow in 1995 did not.

Table 1 indicates that the Missouri River is higher than most of Labadie Bottoms for even a "2-year" flow. Upward percolation of groundwater to the surface commonly occurs during such times. This effect increases the risk of contamination of surface waters and groundwater by contact with landfill waste.

Federal regulators assert that certified levees legally "remove" bottomlands from the natural, geomorphic floodplains. This reasoning has proven highly problematic for the St. Louis area, where levees protecting the large populations of Metro East have been recently "decertified" (e.g., FEMA 2010). Bottomlands are clearly an integral part of the natural floodplain, and levees cannot change this geologic reality on the permanent basis necessary for waste storage.

Table 2. Measured and Estimated Stages for Recent Floods at Hermann, Washington and Labadie

Date	Flow at Hermann[1] x 1000 cfs	Stage[1] at Hermann	Stage[2] at Washington	Stage[3] at Labadie, estimated	Stage[4] at Labadie	Labadie[4] Bottoms Levee Overtopped
Apr 24-5, 1973	500	515.3	487.3	478.3		No
Oct 6, 1986	549	517.4	489.7	480.7		Yes
July 31, 1993	750	518.5	492.6	483.6	483.6	Yes
Apr 13, 1994	445	513.0	NA			No
May 19, 1995	579	517.8	490.1	481.1		No

1. USGS (2010) 2. NWS (2010) 3. 9 ft difference assumed. 4. AmerenUE (2009) All stages rel. MSL.

Liquefaction Potential

East-central Missouri has significant seismic hazard due to its proximity to the new Madrid seismic zone. Floodplain deposits in the St. Louis region pose particular concern because of their potential to undergo "liquefaction" during earthquakes (Hofmann, 1995; Pierce and Baldwin, 2008; Williams et al., 2009). The mapped zone of liquefaction hazard specifically includes Labadie Bottoms (Hofmann, 1995); moreover, Labadie Bottoms is no further from New Madrid than St. Louis, and the physical character and thickness of the alluvial deposits in these areas are similar, about 105 feet at Labadie Bottoms (e.g., AmerenUE Core B-7) and about 96 to 122 feet for the Mississippi River alluvium (Miller et. al., 1974).

The process of liquefaction causes water-saturated, unconsolidated sediments to lose strength and load-bearing capacity when they are subjected to strong shaking. Liquefaction potential is particularly high during flooding, and could damage structures and cause levees to fail.

Potential earthquake hazards that could affect the proposed CCP landfill include but are not restricted to the following:

Levee failure
Sand blows causing dissemination of CCP waste
Slumping of landfill causing dissemination of CCP waste
Perforation or tearing of synthetic liner, promoting groundwater entry
Fracturing of clay liner, promoting groundwater entry
Cracking of hardened CCP ash, enhancing leachability
Landslide potential above and onto landfill

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Figure 1. Detail of Labadie Bottoms on August 19, 1993, about 3 weeks after the flood peak of July 31 on the lower Missouri River. The river had overtopped the crest of the agricultural levee by more than 3 feet, inundating the bottoms. Although the river had fallen by more than 12 feet by the date of this satellite photo, the river was still higher than most of the bottomland, mostly situated at elevations between 465 and 471 feet MSL. The diamond-shaped area near the image center includes additional levees and encompasses the power plant, which has a high floor elevation of 491 ft. This figure shows an area of approximately 6 miles by 8 miles, detailed from Landsat 5/TM Image No. 114016 (NASA, 2010).

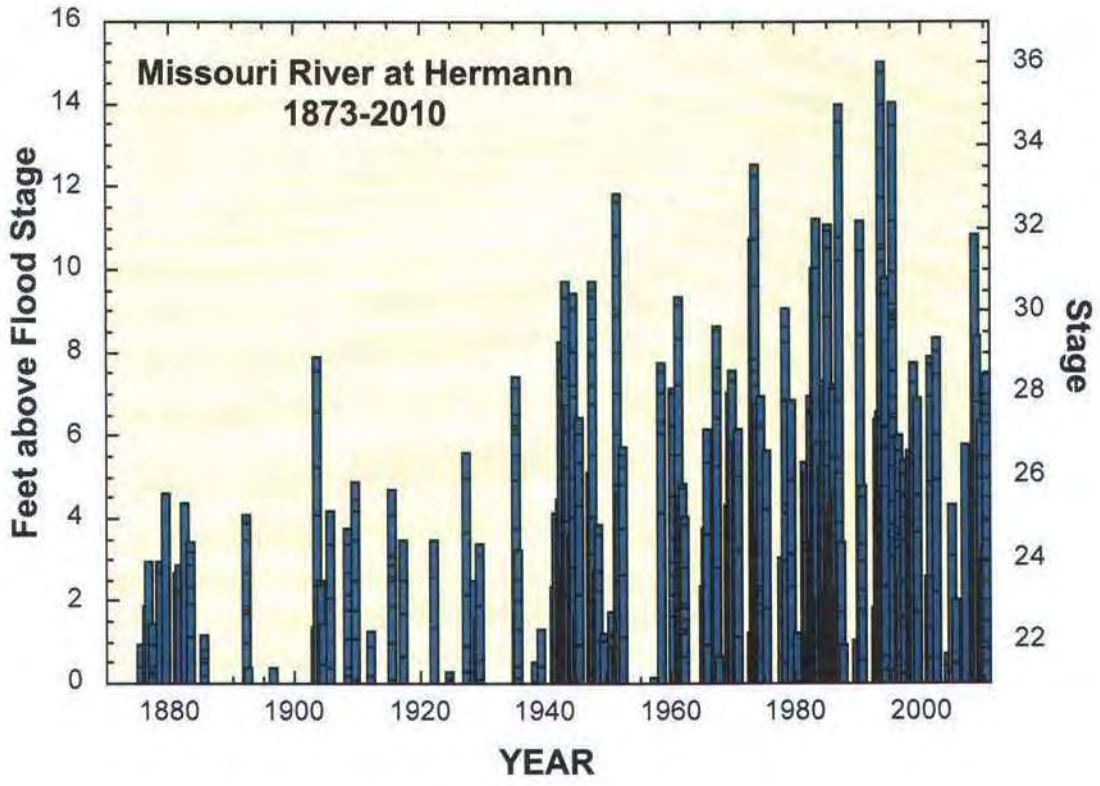

Figure 2. The stage of the Missouri River at Hermann has progressively increased since systematic records began. Daily data are available since 1873 from the USACE and the USGS (2010). Updated after Criss (2002).