Columbia Environmental Research Center

Ecological Dynamics of Wetlands at Lisbon Bottom, Big Muddy National Fish and Wildlife Refuge, Missouri

Final Report to
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U.S. Department of the Interior
U.S. Geological Survey

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Introduction

Before the late 1800's, a shifting, braided channel with abundant unvegetated sandbars and extensive flood- plain connectivity characterized the Missouri River. The shifting channel provided a wide variety of hydraulic environments, including a substantial amount of shallow, slow water. Historically, this natural fluvial regime resulted in a large quantity of connected and non-connected off-channel water bodies. Within the last century and continuing to the present, the channel of the Lower Missouri River (downstream from Sioux City, Iowa) has been trained into a fast, deep, single-thread channel (fig. 1A). Intensive physical modification of the Missouri River for navigation, flood control, and power generation has resulted in dramatic changes to the river corridor. At present, artificially created habitats such as wing dikes, revetments, and levees concentrate the flow to help maintain a deep navigation channel, while disconnecting it from the flood plain. In addition, reservoir regulation of the Missouri River has substantially changed the annual hydrograph (fig. 1B), sediment loads, temperature regime, and nutrient budgets. Collectively, these physical changes have drastically altered the hydrological and ecological function of the Missouri River system. Today, the river largely consists of high velocity habitats with deep water, and low-flow backwaters that are lacking in shallow water depths and connectivity. Shallow sandbars and flooded wetland habitats that are frequently connected are now rare.

Flooding in the 1990's also caused dramatic changes in flood-plain habitats of the Lower Missouri River. These changes have inhibited continued agricultural use in many areas, making lands available for

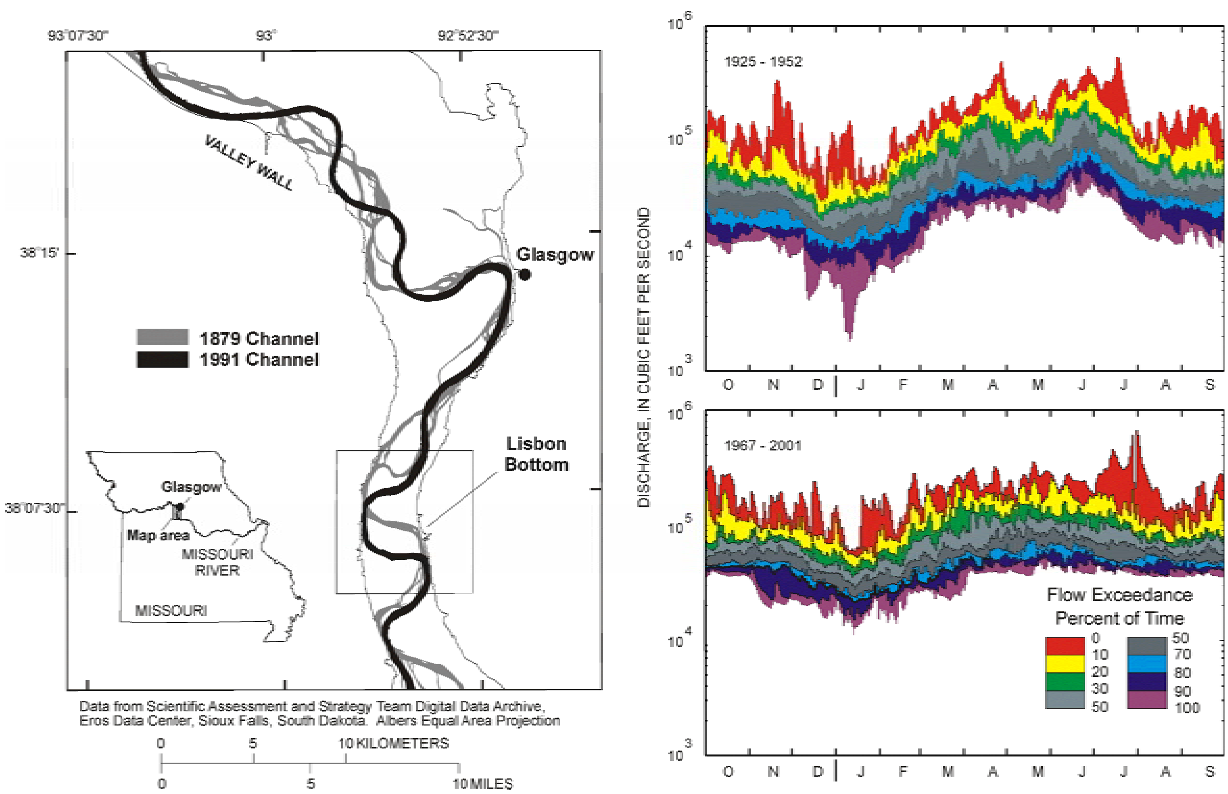


Figure 1. Typical changes in Lower Missouri River. **A.** Channel changes in Grand-Osage sediment, 1879-1991. **B.** Hydrologic changes at Boonville, Missouri pre- and post-regulation

purchase by government agencies. These lands are serving as rehabilitation areas where existing levee breaks have allowed flood-plain landscapes to be directly or indirectly shaped by natural riverine processes such as flood-pulses, scouring, sedimentation, and changes in vegetation. To date, more than 28,000 ha of flood-plain lands in the Lower Missouri corridor have been purchased by state and federal agencies, and some areas are being allowed to revert back toward a more natural or historical state. One parcel included in the land acquired by the U.S. Fish and Wildlife Service (USFWS) Big Muddy National Fish and Wildlife Refuge is Lisbon Bottom, which is approximately 875 ha in size, and is situated at a large bend in the Lower Missouri River about 5 km south of Glasgow, Missouri (river mile[1] 213-218, fig. 2). Here, additional flooding since 1993 has created a new chute and a hydrologically diverse complex of permanent and ephemeral wetlands.

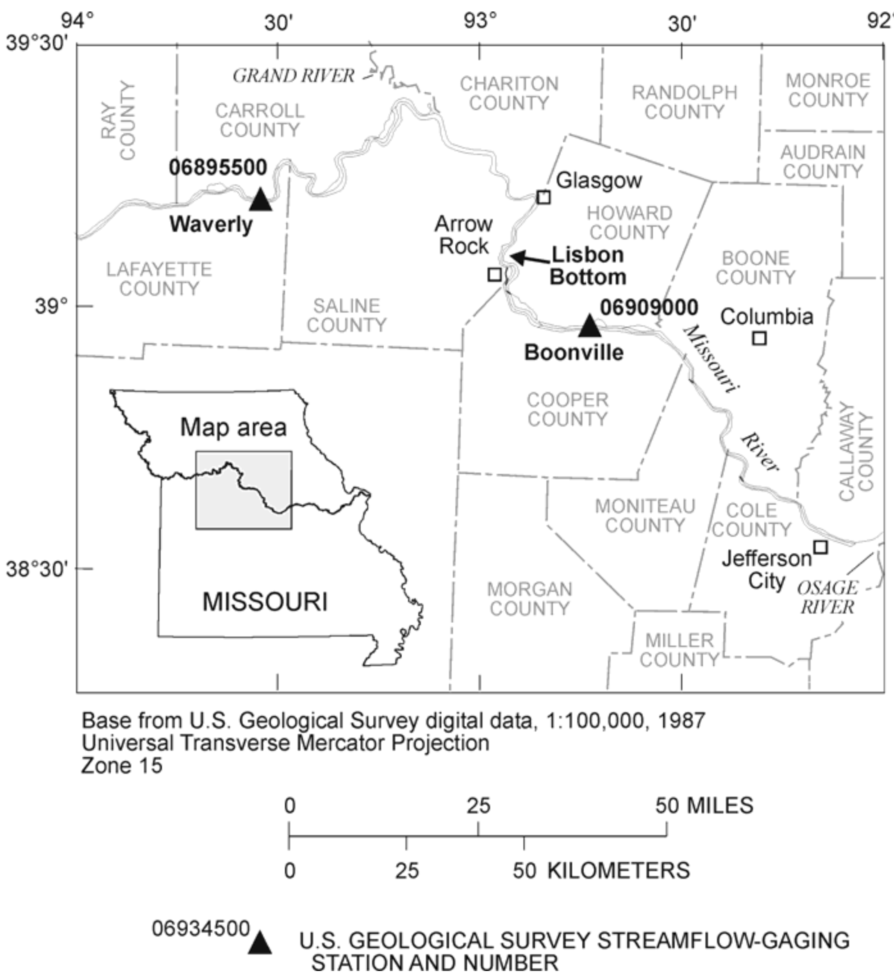


Figure 2. Location of Lisbon Bottom and nearby stream gages on the Lower Missouri River.

[1] River miles are the long-established addressing system for distances on the Missouri River. River miles increase upstream from 0 at the junction of the Missouri and Mississippi rivers at St. Louis. A mile is equal to 1.6 kilometers.

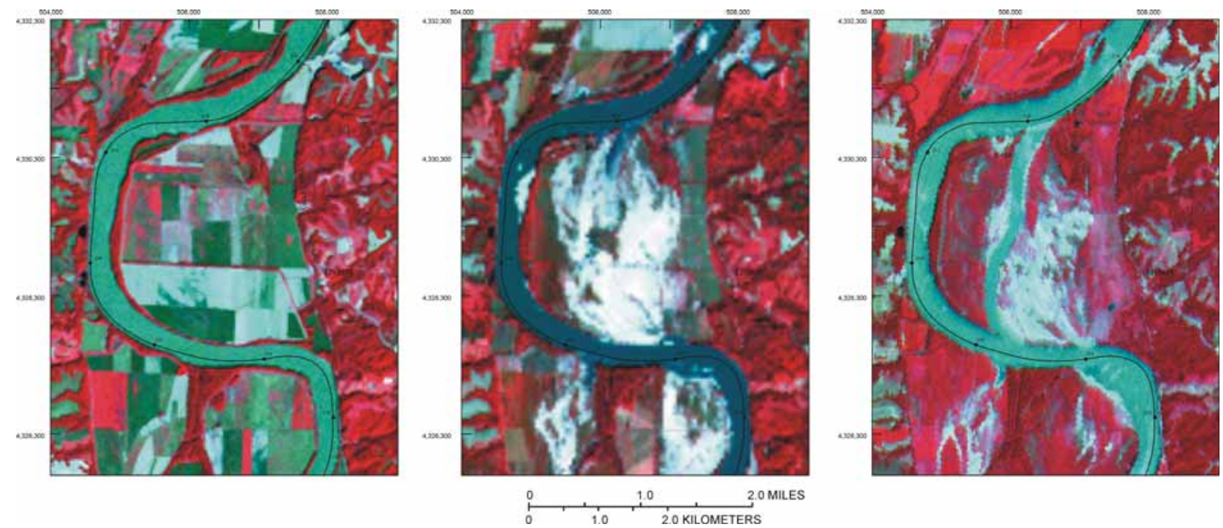
Habitat alterations over the last 50 years have led to significant changes in the quality and quantity of habitat available for fish and wildlife resources. Until the floods within the last decade, the biota within the lower river corridor had been poorly studied. Basin-wide changes have been correlated with significant declines in native species including fishes (for example, pallid sturgeon, lake sturgeon, and sicklefin chub) and birds (for example, piping plover and least tern). However, many declines in biota have not been adequately quantified, in particular those at smaller spatial and temporal scales. There is a lack of information concerning cause/effect relationships linking biological measurements to the hydrologic factors that are responsible for creating and maintaining these habitats. Moreover, there is a general lack of information available to compare the relative value of habitats in the existing navigation channel and agricultural lands with those of more natural reaches. Efforts to rehabilitate the Missouri River depend on developing quantitative understanding of management links, for example, how can changes in flow management regimes and river-corridor topography affect the availability, relative contribution, and productivity of flood-plain habitats? And if habitat is provided, how do riverine biota respond? Because hydrologic and geomorphic dynamics are the primary factors responsible for structuring the river corridor, the links must be established at a scale at which these factors can be quantified so that future management of flood-plain habitats can be based on the relationships between biological responses and changes in physical characteristics.

General Objectives and Study Approach

The general objectives of this project are to:

- Quantify spatial and temporal distribution of biota in aquatic habitats of Lisbon Bottom in relation to changes in hydrological variables that are associated with the spring flooding regime.
- Document biological responses as they relate to habitat dynamics.
- Analyze and interpret these results to provide managers with biological information necessary to develop management strategies for Lisbon Bottom and other tracts of the Big Muddy National Fish and Wildlife Refuge.

Lisbon Bottom is being managed by the USFWS in a passive manner, in other words, with a regime that allows the landscape to be formed by natural flooding and vegetative succession (fig. 3). Although still affected by flow regulation and the requirement to maintain navigation in the main channel, Lisbon Bottom is representative of many high-sinuosity portions of the Lower Missouri River, and provides an important case study to evaluate passive, least-cost approaches to river-corridor ecosystem management. The presence of existing levee breaks from the 1990s floods, and the naturally formed secondary chute (fig. 3) have re-established a dynamic connection to the Missouri River at this location. With a close proximity to the U.S. Geological Survey (USGS), Columbia Environmental Research Center and to long-term stream gages, Lisbon Bottom presents the opportunity to study ecosystem processes and dynamic geomorphology in a setting that more closely mimics the natural riverine system than any other site on the Lower Missouri River.



A **B** **C**

Figure 3. False color images of Lisbon Bottom showing extensive changes to land cover from 1992 to 1997. Red colors are indicative of vegetative cover; the more intense the color, the greater the biomass. The bright white in B. and C. represents sand deposits. From October 1994 to August 1997, much of Lisbon Bottom became more vegetated, despite the floods of May 1995 and June 1996. The difference in the color of the river between A., C. and B. is related to sediment load which is higher in A. and C. **A.** Pre-flood Thematic Mapper image September 24, 1992, Boonville discharge = 66,000 cfs. **B.** SPOT image October 11, 1994, Boonville discharge = 46,700 cfs. **C.** SPOT image, August 23, 1997, Boonville discharge = 91,100 cfs. Imagery courtesy of Washington University.

Wetland classification schemes represent one reference point for designing biological research studies within standing water bodies, and allow scientists to stratify sampling regimes. Cowardin and others (1979) provides the most complete, broad-scale descriptions, and under this system the wetlands at Lisbon would be classified as palustrine of either the forested, emergent or scrub-shrub types. However, the wetlands at Lisbon could not be adequately classified before the beginning of this study because the water source, permanence, and vegetation types were unknown and had not been surveyed. We expected the wetlands at Lisbon would represent a diverse continuum of these conditions, and recognized that the importance of each of these variables may not be equal for each animal group we studied. Galat and others (1998) provided a more specific categorization of different wetland types in the Lower Missouri River flood plain, which include: 1) remnants, or aged shallow wetlands surrounded by mature trees; 2) oxbows, created by channel cutoffs from tributary streams or the Missouri River mainstem, 3) scour holes, created by scouring when levees broke during the recent floods, and 4) ephemeral or temporary wetlands which consist of shallow depressions with early successional plants, including moist-soil vegetation and woody shrubs. At present, Lisbon Bottom contains wetlands that fall under all of these categories except for oxbows. Some wetlands represent either transitions between categories, and may actually change types over time, or fall under different categories from year to year. Therefore, each of the chapters in this report may use a different breakdown of wetland types for analysis and interpretation.

The studies presented as chapters below have been designed to provide an understanding of the links between biologic responses and hydrologic dynamics. This report provides biological, physical and chemical aspects of conditions at Lisbon Bottom—including surface water, limnology, and community dynamics of benthic invertebrates, zooplankton, fish, and waterbirds. The results encompass late winter, pre-flood, flood, and post-flood conditions, as well as pre- and post-periods of waterfowl migration and flood-plain spawning or dispersal of fishes. The biological components of the study represent a chronology of changes in conditions observed throughout the study period from March through July 1999; hydrologic components cover two periods during June 1999–October 2001 (fig. 4). Biological and hydrologic components sampled a wide range of hydrologic conditions, from typical late fall low flows to floods with 2–10 year recurrence intervals. Notably, the study components were carried out at the end of a relatively wet 10-year period when the Lower Missouri River experienced as many as 18 individual floods exceeding the 2-year magnitude (fig. 4).

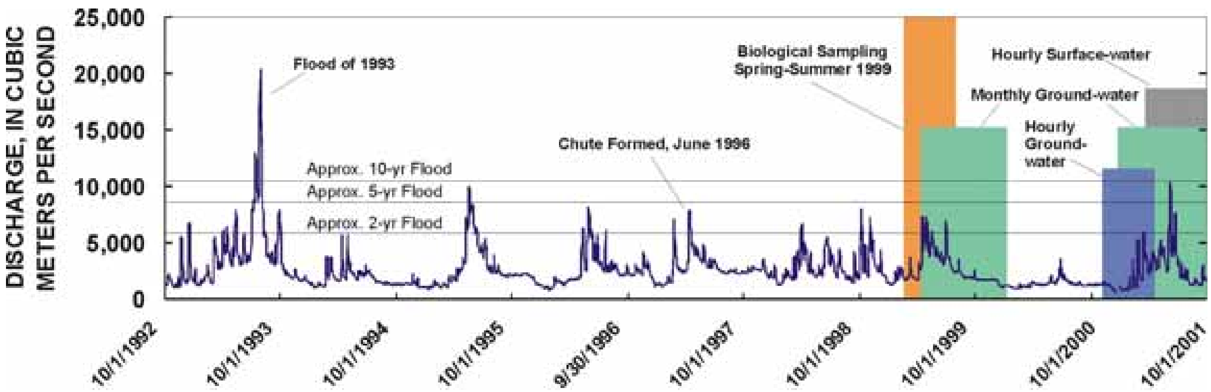


Figure 4. Daily discharges affecting Lisbon Bottom, water years 1993–2001, as measured at Boonville, Missouri, and time intervals of biological and hydrologic data collection.

Historical Background and Physical Setting

Lisbon Bottom contained mature stands of cottonwood (*Populus deltoides*) and willow (*Salix* spp.) until the late 1950's, when the forest resources were logged and the land was cleared for intensive agriculture. Row cropping covered up to 90% of the landscape (Jacobson and others, 1999) and according to aerial photographic images, the north end contained a few remnant wetlands surrounded by mature trees. These wetlands (5 and 8) (fig. 5) still exist today, and physical evidence suggests that they were used for irrigation at one time. The levee across the north end of the bottom, which protected the row crop area from flooding, had been broken and repaired eight times within the previous 20 years before the flood of 1993. The position of this levee at an outside bend of a meander in the river, and the historical propensity to flood and damage agricultural crops, made Lisbon Bottom a prime candidate for public land acquisition after the 1993 flood. Additional large floods in 1995–1997 (fig. 4) helped create a natural chute that passes through Lisbon Bottom. This channel widened and eroded laterally during high water levels in 1996–1998, and has reached a more stable configuration during the last few years. The large island resulting from this chute formation is usually inaccessible except by boat and is not included in the biological components of this study. In the spring of 2000, the U.S. Army Corps of Engineers installed a control structure at the head of the chute to regulate the percentage of flow diverted from the mainstem of the river. The chute now contains sandbars and its own secondary channels. The geomorphic evolution of the chute is documented in Jacobson and others (2001).

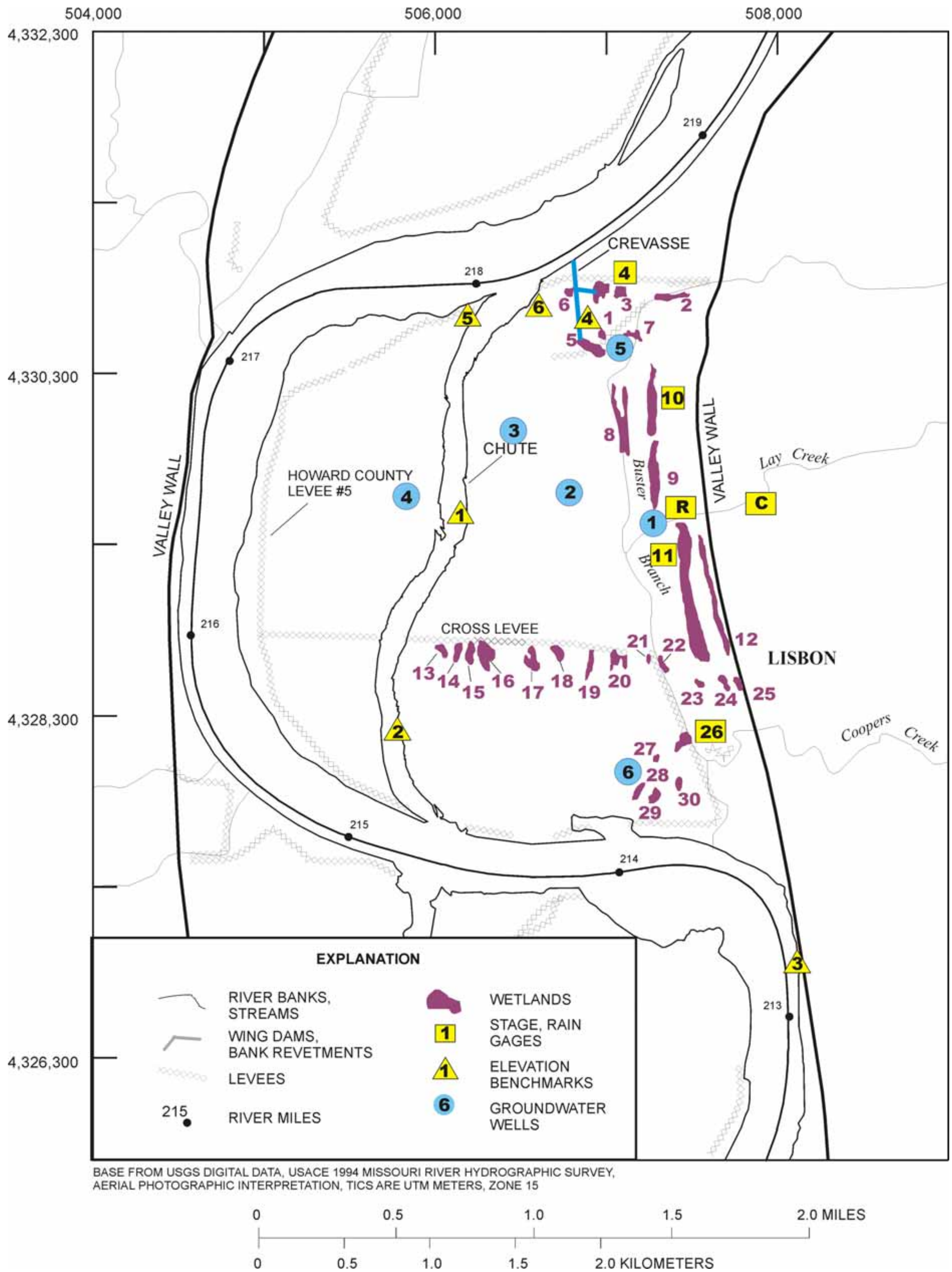


Figure 5. Map of Lisbon Bottom showing geographic features and wetlands.

In addition to large quantities of sand deposition, the 1993 flood created several connected and non-connected scours at Lisbon Bottom, including those associated with an east-west cross-levee that transects the area (fig. 5). The Missouri River Post-Flood Evaluation Project (MRPE) was initiated in late 1993 by the Missouri Department of Conservation in cooperation with the University of Missouri and included multidisciplinary studies designed to examine the effects of the 1993 flood and use of newly created habitats by different organism groups (Humburg and Burke, 1999). Three wetlands and one connected scour hole involved in the MRPE project are located at Lisbon Bottom, and included TLIS (Wetland 10 in our study), LP-1 (Wetland 7 in our study), LP-4 (Wetland 4 in our study), and S-14 (connected scour in our study). However, the area has changed dramatically since the MRPE study was completed; more flooding in 1995 and 1997 caused additional sedimentation and a surge in vegetation growth. Thick stands of cottonwood and willow in the northern portion of Lisbon Bottom slow the current and reduce scouring potential when floods cover the area. Even-aged stands of these tree species resulting from seed-bank germination after all three major floods (1993, 1995, 1997) are distinguishable from one another in both aerial photographs and on the ground, and border several of the wetlands in the northern part of the area. Sedimentation and changes in basin morphology have occurred since the 1993 flood, and can most easily be observed in Wetland 5. Sedimentation has significantly reduced the water volume in this wetland, which dried in September of 1999 for the first time since the 1993 flood.

Wetlands receiving part of their water supply from creek systems were not recognized in most definitions of flood-plain wetland types because streams entering the Missouri River flood plain have historically been diverted away from bottomland areas that are used for agriculture. This was accomplished by channelization, and by diverting stream water along secondary levees to provide more direct routes to the Missouri River mainstem while improving drainage for agricultural production. Lisbon Bottom has three separate creek systems entering it, two of which were originally diverted in this manner and one that flows into a privately owned remnant wetland along the north border (Buster Branch, fig. 5). Shortly after the Lisbon tract was purchased by the U.S. Fish and Wildlife Service in 1995, earth-moving equipment was used to construct an opening in a secondary levee to allow one of the previously diverted creeks to flow onto the flood plain. This resulted in marsh areas, an increase in moist-soil vegetation in that vicinity, and a new water connection between Wetlands 11 and 22. This surface water input changed the relative contribution of water sources, vegetation type, and permanence of some of the wetlands.

At present, the wide array of wetland types at Lisbon represent a continuum of aquatic and terrestrial plant diversity, basin morphology, permanence, and influence from various water sources. The dominant semi-aquatic emergents and moist-soil plants observed adjacent to the wetlands at Lisbon include cocklebur (*Xanthium* spp.), smartweed (*Polygonum amphibium* var. *emersum*), sedge (*Carex* spp and *Cyperus* sp.), American bulrush (*Schoenoplectus fluviatilis*), arrowhead (*Saggitaria* spp.), reeds (*Phragmites* sp.), cattail (*Typha* sp.), spikerush (*Eleocharis* spp.), and rice cutgrass (*Leersia oryzoides*). Young willow, cottonwood, and alder (*Alnus serrulata*) were the dominant woody plants along all wetland margins. Mature cottonwoods, American sycamore (*Platanus occidentalis*), and spirea (*Spiraea* spp.) are also present in some areas.

Lisbon Bottom also has two additional features that contribute significantly to the amount of surface water entering the flood plain from the river. A crevasse passes through the levee located on the north end, allowing water to enter the area during higher river levels (fig. 5). This feature supplies six different wetlands with surface water both directly (Wetlands 4 and5), and indirectly through seepage or overflow (Wetlands 2, 3, 7, and 8). During water level increases in spring, this begins to occur at river levels a few feet below flood stage. The other feature is a connected scour hole formed by a levee break on the south end of the bottom during the flood of 1993 (S-14 from the MRPE study). Even though it has undergone sedimentation, the levee breaks allow water to enter from the river by backflooding, filling Wetlands 26, 27, 28, 29, and 30 at river levels somewhat below the stage of overall flooding of Lisbon Bottom. Both of these features are important because if they did not exist, higher river stages would be required to rapidly fill the wetlands during spring flood events, and most basins would have to rely more heavily on groundwater recharge, rainfall, and creek systems for their water source. Flooding and influx of river water is required to hydrate some of the temporary wetlands at Lisbon, such as Wetland 10 that has very little creek influence and remains dry unless river flooding or significant local rainfall events occur. For more detailed information on the physical setting and hydrological characteristics associated with Lisbon Bottom, see the summaries by Jacobson and others (1999, 2001) and Chapter 1 of this report.

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