Post-Glacial Deltas in the Region of the Great Bend of the Wabash River

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Abstract

Short-length, steep-gradient intermittent streams from three small drainage basins terminate in sand and gravel deltas in the Wabash River near Lafayette and West Lafayette, Indiana. The cause and effect of each delta was examined, as well as its influence on the environmental geology of the area. The small streams originate in ground-moraine uplands and flow across outwash into the Wabash River. The deltas were formed in two phases: the first accumulated slowly with little change in the river, and the second developed rapidly after urbanization of the area and resulted in an offset of the river channel. These deltas are part of a zone of similar landforms in the region of the "Great Bend of the Wabash." Environmental impact ranges from negligible to potentially harmful. The most severe instances involve loss of farmland and possible erosion of an abandoned landfill.

Introduction

This paper describes three deltaic accumulations in the Wabash River and their influence on the environmental geology of Lafayette and West Lafayette, Tippecanoe County, Indiana. Each delta is located where a short-length, steep-gradient tributary reaches local base level at the Wabash River. These dendritic tributaries have incised into Wisconsinan-age outwash terraces and ground moraine by normal erosional processes after cessation of glacial and glacio-fluvial deposition about 10,000 years ago.

The three deltas, their drainage basins, and the generalized surficial geology of the two-city area are depicted in Figure 1. Two drainage basins are located inside or adjacent to city limits, whereas the third appears located well beyond those political boundaries. However, this is not the case as urbanization has now encroached onto the headwaters of that drainage basin.

The overall view of the surficial geology for the study area (Fig. 1) shows a broad, evenly-undulating ground moraine dissected by a valley of large dimensions, now filled in part with great quantities of outwash sand and gravel. This valley is occupied by the Wabash River. The floodplain alluvium is a thin veneer of sand-silt-clay deposits of Holocene age.

This paper presents for the first time, specific physiographic place names that allow more descriptive detail for landscape features than was previously available in the Greater Lafayette area (Fig. 1). These designators were developed during an environmental geology analysis which considered, among other environmental concerns, the relationships of the three delta areas (4). These place names are particularly useful in delineating irregularly shaped landforms within the rectilinear Congressional Land Survey. Although topography is not shown in Figure 1, two distinct levels of partly-dissected outwash deposits represent former stages of the stream that drained the melting ice sheets. The upper level (Purdue Terrace and Wea Outwash Plain) and lower level

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PROCEEDINGS OF THE INDIANA ACADEMY OF SCIENCE FOR 1976
VOL. 86—1977

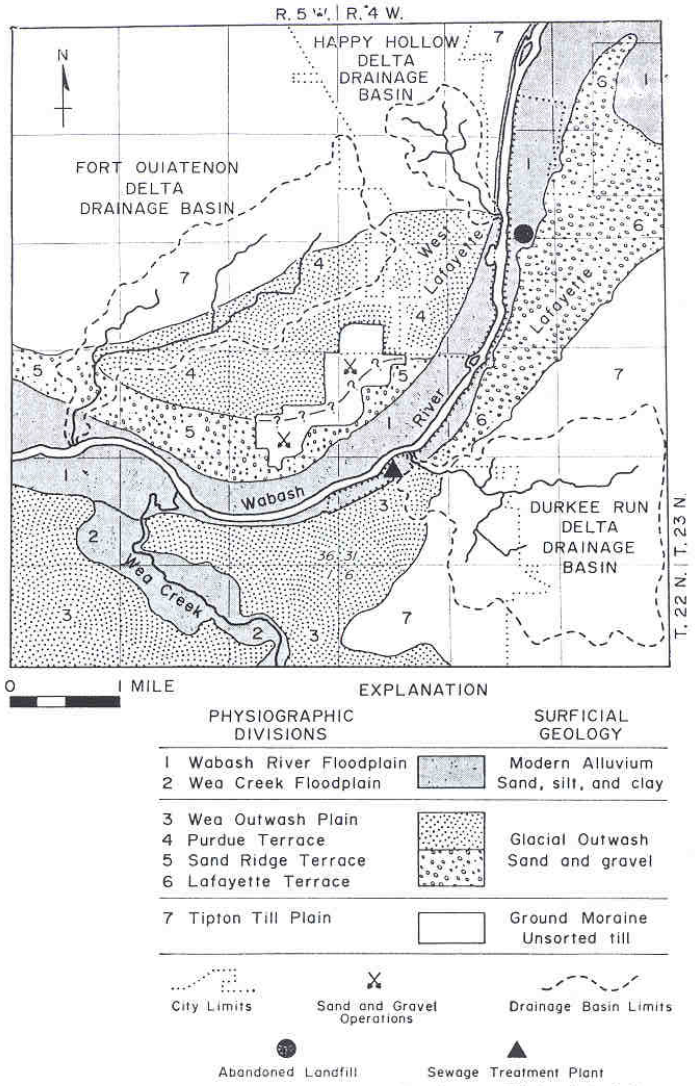

FIGURE 1. *Map showing physiographic areas, surficial geology, and limits of the drainage basins.*

(Lafayette Terrace and Sand Ridge Terrace) correspond to the Shelbyville and Maumee Terrace levels, respectively, as discussed by Thornbury (5).

Discussion of the Problem

Located along a six-mile reach of the Wabash River, the Happy Hollow, Durkee Run, and Fort Ouiatenon Deltas are terminal features of small-size tributaries whose long profiles, drainage basin size and average gradient are shown in Figure 2. These small drainageways originate on the Tipton Till Plain and have downcut through two levels of outwash materials bordering the Wabash River. For comparison, Wea Creek, whose long profile and statistics are also shown in Figure 2, flows across a landscape with identical physiographic conditions and terminates in a similar delta, yet affects the Wabash River to a much lesser degree than do the other streams. The significance of this difference will be discussed subsequently.

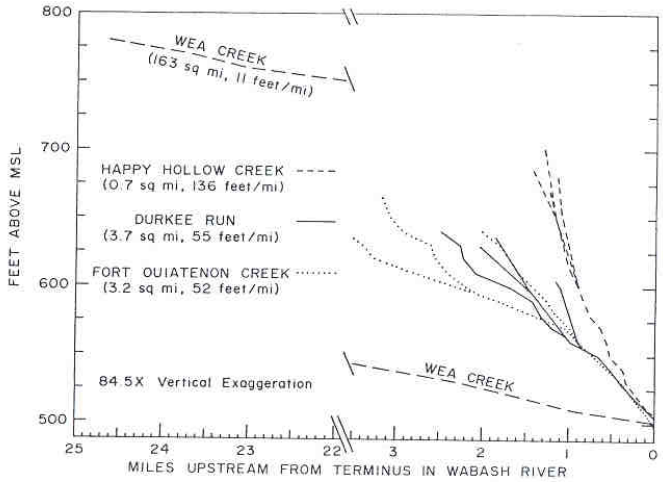

FIGURE 2. *Long profiles and drainage basin statistics for the streams terminating in deltas.*

During low water stages of the Wabash River, the deltas are seen to consist of two parts. The main body of each appears as a smooth, arcuate deposit of sand and gravel, covered with typical floodplain forest vegetation (willows, cottonwoods, and silver maples) and rising 2 to 5 feet above the river's surface. Near the upstream end of each main accumulation, an irregularly shaped secondary delta juts outward into the channel. These portions of the deltas consist also of sand and gravel (perhaps of somewhat coarser grain size than the main delta),

but are devoid of vegetation except for pioneer species which take hold on the "new land" during extended low water stages. These secondary deltas are less than two feet above the lowest seasonal water levels and are easily inundated by minor fluctuations in the river. Figure 3 shows the outlines of the two portions of each delta and the channel contours opposite the delta. The secondary part of the Fort Ouiatenon Delta is not shown because it was submerged by a 1.7-foot rise of the Wabash River just prior to stream channel mapping.[1] However, some indication of its extent is shown by the channel contours. For each delta the bathymetric contours demonstrate the constriction of the upstream cross-section owing to the progradation of the secondary delta and development of a scour pool on the outside of the delta-influenced bend. Also shown in Figure 3 is the interpreted position of the Wabash River channel prior to offset by delta construction.

Channel contours downstream from the Happy Hollow Delta show a channel bar, in consequence of which a quarter-mile section of the Wabash River appears almost braided at low flow stages. This decrease in the river's ability to transport sediment is also observed downstream of the Durkee Run Delta. This is interpreted as an increase in bed load as a result of bank erosion and scour opposite the deltas. An additional change in sediment transport characteristics is represented by the fine sand and silt that covers the upper surface of each main delta. This change from the coarse, granular texture of the underlying materials suggests that the bulk of the main delta acts as a point bar (*i.e.*, reduces velocity on the inside of a river bend) at high water stages, a condition reinforced by the presence of vegetation which further reduces stream velocity and promotes rapid deposition.

A review of the historical airphoto coverage (1929-1975) shows similarities and differences concerning the three deltas and the attendant offset of the Wabash River. For all sites, the tree-covered main delta is visible on the earliest photographic record, and little or no change in outline has occurred to the present. At each location, the secondary delta apparently was already established at the time of the earliest photos. However, the extent and rate of river offset opposite delta progradation varies considerably for the sites as a function of time. Across from the Happy Hollow Delta, bank offset has been noticeable only since the early 1950's, whereas there has been little or no measureable change in the channel outline opposite Durkee Run Delta since the time of the first photographic record. Lateral migration opposite the Fort Ouiatenon Delta, although observable on the earliest photos, has been accelerating since the 1950's.

In the Happy Hollow and Durkee Run drainage basins, the photo record displays the dramatic shift from agricultural to urban conditions with the passing years. The increase in sediment yield into the streams during this land use change has been counteracted, to a minor degree, by an increase in forest cover in these two drainage basins. The present extent of forest in these areas is the greatest since the first

[1] Drainage of an artificial lake for inspection purposes raised the river level above its previous low flow.

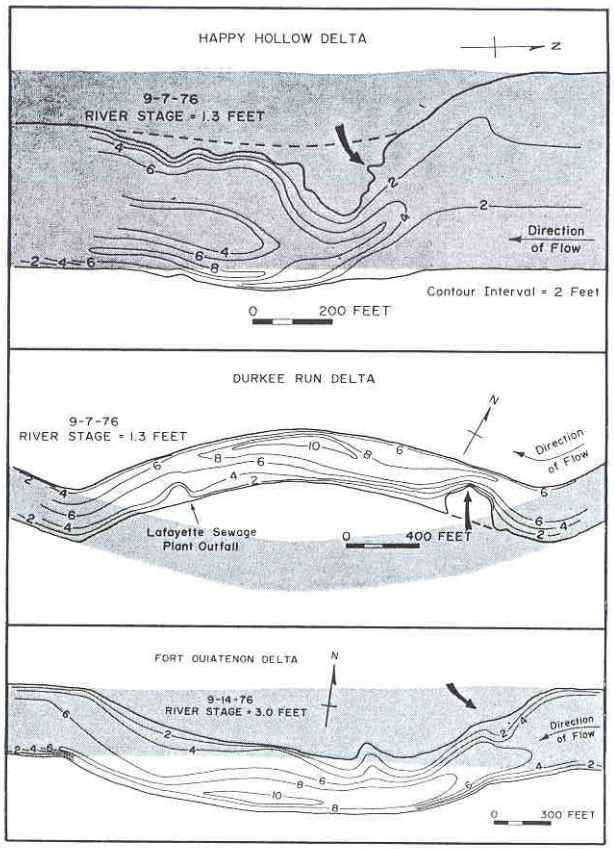

FIGURE 3. *Channel contours opposite the deltas. Dashed line separates main and secondary deltas. Bold arrow indicates position of outlet for the tributary streams. Tinted area approximates the interpreted river channel prior to delta accumulation and offset.*

days of white settlement. Dos Santos and Miles (1) reported that urbanization within the Happy Hollow drainage basin has reached its maximum extent and future sediment yields are expected to significantly decrease. Within the Fort Ouiatenon Delta drainage basin, the actual area converted from agricultural to residential/commercial usage has

been rather minimal; however, building has occurred on the steep slopes marking the transition from the Purdue Terrace to the Tipton Till Plain uplands. Thus this sloping land, which represents a minor portion of the drainage basin, has had a proportionately greater effect on erosion and stream deposition.

Environmental impact adjacent to the deltas is as varied as is their recent erosional history. Across the river and slightly downstream from the Happy Hollow Delta, a sanitary landfill was previously operated near the base of the Lafayette Terrace (see Fig. 1). Although operation ceased in early 1972, materials placed in the landfill are subject to exposure and removal during high water stages of the Wabash River. This is a consequence of the river offset opposite the Happy Hollow Delta which has removed a portion of the natural levee, allowing access to the landfill site and the adjacent floodplain. In contrast, no adverse impact has occurred opposite the Durkee Run Delta because this area is devoted to minor agriculture or vacant, fallow land. In fact, there is a harmonious land use on the main portion of the Durkee Run Delta, which is the site of the Lafayette sewage treatment plant. Surrounded by man-made levees, this site is well removed from the erosion on the opposite bank. At the Fort Ouiatenon Delta the Wabash River offset has resulted in the loss of some five or six acres of regularly-tilled farmland. An additional expense to the landowners at this site involved the excavation of a new drainage ditch. This was done to prevent severe erosion along a natural waterway ending at that portion of the river bank suffering rapid offset. If uncontrolled, such erosion would have denied access to an additional 20 or more acres of land and rendered them useless for crop production.

Based on field observations and historical airphotos, the following general account is offered as a history of formation for each of the deltas. After 1) the last glacial stage had deposited the local ground moraine, 2) meltwaters of the northward-receding ice mass had accumulated, reworked, and then dissected outwash sand and gravel into two major terrace levels, and 3) the climate began a trend towards present-day conditions, normal stream erosion commenced on the escarpments of the local terraces and the Tipton Till Plain. Rapid runoff from the small-size, steep-gradient drainages was thus established, leading to delta formation in the present-day Wabash River. Because of minimal sediment yields from vegetated slopes under pristine environmental conditions, the normal flow of the Wabash was able to accommodate the deltaic input and remove the excess. Thus no significant deflection of the river channel would have occurred. During this period, delta sediments shifted downstream from the initial outlet site and formed the large crescent-shaped areas visible today (main delta formation).

Since the coming of the white man to the area, there has been a shift in land use, climaxed by maximum agricultural tillage about 1920 (although decreasing steadily ever since) and a tremendous residential/urban expansion, starting in the 1940's and continuing to the present. These terrain disturbances sufficiently increased runoff volumes and erosion, resulting in deposition of the smaller, secondary deltas now

seen prograding into the Wabash River channel. With establishment of these newer sedimentary deposits, the river was unable to transport the sediments and began to deflect around them. The redirected river current began to erode the alluvial banks opposite the secondary deltas, culminating in the present offsets across from the Happy Hollow and Fort Ouiatenon Deltas. In contrast, the progradation of the secondary Durkee Run Delta appears to have had little or no effect in initiating further erosion because the present offset at that site is nearly identical to that observed in the earliest photo record. Hence it can be predicted that a more-or-less naturally stabilized channel will develop. Periodically it may be subjected to new bank-caving and lateral migration, accompanied by rapid attenuation of the sinuosity of the induced offsets. The Wabash River seems unable to establish free meanders in response to the offsets.

From this interpretation of the local deltaic history, a question arises about how these features relate to the regional landscape. An initial check on such deltas in adjacent areas led to an examination of topographic maps of the Wabash River area along a reach of about 150 river miles upstream and downstream from the Greater Lafayette area. Based strictly on map evidence, Figure 4 shows the distribution of deltas relative to the varying geomorphic conditions of the Wabash River valley. Morisawa (3) presented a summary of factors resulting in soil erosion; these were climate, rainfall, soil character, vegetation, geologic materials, and topography. Applying Morisawa's generalized interactions to the specific conditions of this reach of the Wabash River, it is concluded that each factor has been more or less constant for the past few centuries. However, geologic materials and topography, combined with pronounced local changes in vegetation and land use, have produced a stream reach of delta formation within the region of the "Great Bend of the Wabash" described by McBeth (2).[2] This stream reach is characterized by local relief of 150 to 200 feet and juncture with short-length, steep-gradient tributaries which head on the glacial till uplands and intermittently discharge across the locally wide outwash terraces. Upstream from this reach, available relief diminishes to generally less than 100 feet and the Wabash River tends to follow or parallel its pre-glacial channel in bedrock; there is also less outwash material. Downstream from the "bend," where the total amount of outwash is greater, the old-age characteristics of the Wabash River valley (by Davisian standards) tend towards enlargement of the drainage basins of tributary streams, thereby reducing erosion because of greater basin storage and delayed runoff. Thus the resultant diminished flow is similar to that of Wea Creek in the Greater Lafayette area. Wea Creek (see Fig. 1) drains 163 mi^2 (44 to 233 times larger than the three drainage basins studied in this report) with a rather gentle average gradient (Fig. 2). It has, since glacial times, deposited a delta at its

[2] McBeth's "Great Bend" is where the Wabash River starts to flow due south near the city of Covington, Indiana. The stream reach of delta formation for this report is that portion of the river flowing as a nearly straight line from northeast to southwest, from Logansport to Covington, although the specific physiographic conditions of this reach are typically found from Delphi to Williamsport.

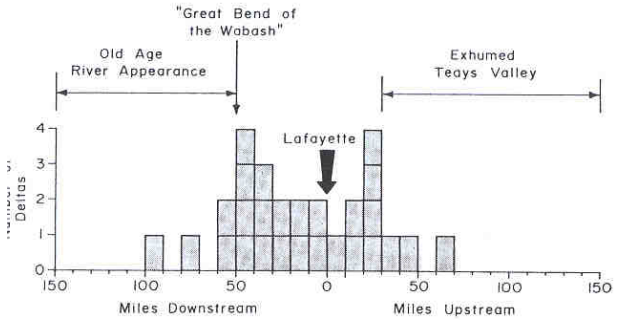

FIGURE 4. *Histogram showing the number of deltas upstream and downstream from Lafayette and the varying geomorphic conditions of the Wabash River valley.*

terminus in the Wabash River, but at a pace that has produced only a minor offset on the opposite river bank. This offset has remained nearly constant throughout the period of historical airphoto coverage.

Concluding Statement

Surface runoff is dependent not only on the quantity and rate of precipitation, but on other aspects, including topographic relief and infiltration rate of the surface layers. Stream discharge also is a function of the physical size of the drainage basin, with smaller areas showing a faster response to the same amount of precipitation. Smaller areas can also experience localized higher intensity storms. This yields, by comparison, a more delayed response for larger drainage basins. Particle size and volume of erodible material further determine the load a stream will transport as stream competence varies directly with discharge.

In this report three small drainage basins, ranging in size from 0.7 to 3.7 mi^2 (1.8 to 9.6 km^2), were examined in the Lafayette-West Lafayette area. Each drainage basin has as local base level the Wabash River, where a sand and gravel delta has been built into the channel of the larger river. These deltas are the result of intermittent, torrential streams originating on partly-urbanized, relatively-impermeable ground moraine and then flowing across abundant deposits of unconsolidated outwash sands and gravels. Each delta has two parts: a higher, vegetated area which is the main bulk of the sedimentary accumulation and a lower, non-vegetated secondary progradation extending farther into the river. In two cases, the secondary delta has initiated erosion of the opposite river bank by deflecting the current; there have also been changes in the channel characteristics. Negative environmental impact has ranged from negligible to potentially harmful, depending on prior land use.

One purpose of this report is to focus attention on the significance of landform features relative to environmental impact. In the examples

cited, the relation and consequence of small deltas and land use has been examined. Each delta is the product of natural processes, intensified in part by man's influence; the cumulative effect is negligible where there is no interference with man's activities. In the past, only through hindsight have land use problems associated with such features been recognized. Realization of the potential effects of urbanization, increased runoff, erosion, sedimentation, landfill location, *etc.*, in connection with geologic features such as these deltas, could lead to a better understanding of our physical world, allowing for management towards a better local environment in the future.

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