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The residence time of intensively managed agricultural landscapes

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Much of the agricultural landscape across the Midwestern United States is intensively managed through numerous surface and subsurface drainage improvements, and the growing extraction of groundwater resources. The relatively recent glaciation of the North Central region means that the landscape is less dissected and hydrologically connected than older till areas. Low topographic gradients and underlying dense till which restricts vertical water movement, as well as kettle depressions, have led to poorly drained soils and extensive wetlands within the landscape. Large areas of this land could only be farmed once the excess water was removed through artificial surface and subsurface drainage. Conventional wisdom in the region maintains that subsurface tile drainage reduces the occurrence of peak flow events by increasing soil water storage capacity. At the watershed scale, this view does not take into account the coincident increase in surface drainage and reduction in residence time in surface depressions. This paper explores to what degree water management and irrigation has changed surface and subsurface water storage and residence time over the last century and how this has impacted flow duration throughout the Wabash River system in Indiana, USA. The effects of subsurface tile drains, wetlands and aquifer storage are explicitly represented within the Variable Infiltration Capacity (VIC) macroscale hydrology model. We maintain a focus on the entire Wabash River, a river system of historic importance that is also representative of many similar areas in the till plain region of the agricultural Midwest, which contribute to water quality and flood dynamics of the Mississippi river system. By lowering the water table, surface and subsurface drainage improvements have increased the subsurface storage capacity at the beginning of rain events, but this is overwhelmed by the decrease in surface storage capacity for intermediate to large events, decreasing the current residence time of water relative to pre-settlement conditions.