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INSIGHTS INTO THE ORIGIN AND CHARACTERISTICS OF THE SEDIMENTATION PROCESS AT MULTI_BARREL CULVERTS IN IOWA

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Self-cleaning culvert designs can prevent formation of sediment deposits at multi-box culverts using the hydraulic power of the stream.

BACKGROUND

The present study is an integral part of a broader study focused on the design and implementation of self-cleaning culverts, i.e., configurations that prevent the formation of sediment deposits after culvert construction or cleaning. Sediment deposition at culverts is influenced by many factors, including the size and characteristics of material of which the channel is composed, the hydraulic characteristics generated under different hydrology events, the culvert geometry design, channel transition design, and the vegetation around the channel. The multitude of combinations produced by this set of variables makes the investigation of practical situations a complex undertaking.

In addition to the considerations above, the field and analytical observations have revealed complexities of the flow and sediment transport through culverts that further increase the dimensions of the investigation. The flow complexities investigated in this study entail: flow non-uniformity in the areas of transition to and from the culvert, flow unsteadiness due to the flood wave propagation through the channel, and the asynchronous correlation between the flow and sediment hydrographs resulting from storm events. To date, the literature contains no systematic studies on sediment transport through multi-box culverts or investigations on the adverse effects of sediment deposition. Similarly, there is limited knowledge about the non-uniform, unsteady sediment transport in channels of variable geometry. Furthermore, there are few readily useable (inexpensive and practical) numerical models that can reliably simulate flow and sediment transport in such complex situations.

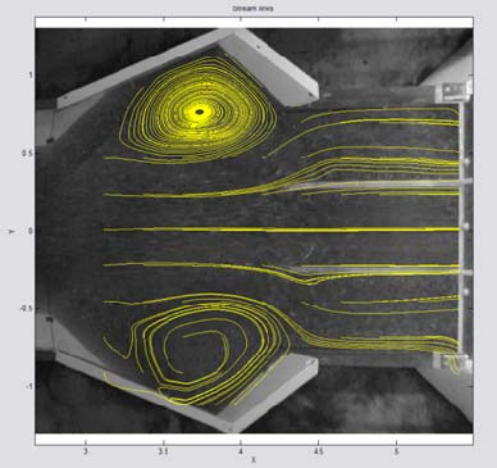
OBJECTIVES

The main objective of this research is to understand the mechanics of flow and sedimentation processes at multi-box culverts to support the design and implementation of self-cleaning systems that flush out sediment deposits using the power of drainage flows. The research entailed field observations, laboratory experiments, and numerical simulations.

OUTCOMES

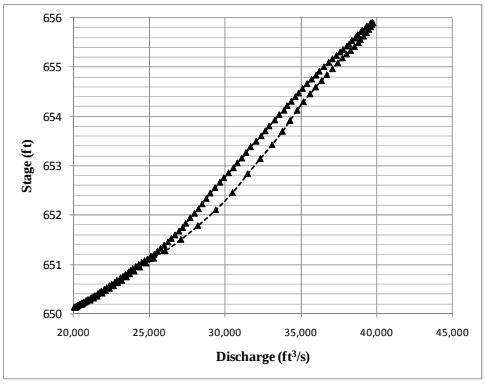
The research substantiated with evidence that the sedimentation at culverts is affected by three flow complexities.

A. The first complexity relates to the **change in flow geometry from the undisturbed cross section of the stream** (usually trapezoidal) **to the geometry of the multi-box culvert**.



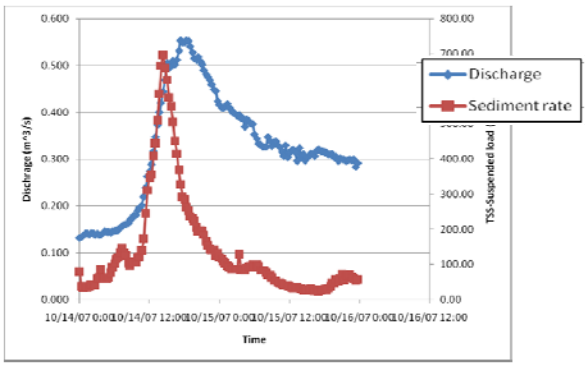
This change in geometry occurs twice at the culvert sites: an expansion exists upstream the culvert, and a contraction to the original cross section shape occurs downstream the culver. The transitions at culvert produce a three-dimensional non-uniform flow behavior gradually varying in space, as the flow moves downstream.

B. The second complexity is the **flows unsteadiness** during the propagation of the runoff through the river.



For monitoring purposes, the open-channel steady flow is described with a one-to-one relationship between river stage and discharge (a.k.a. rating curve). For unsteady flows (e.g., large storm) this relationship is not valid. The relationship carries the memory of the flow unsteadiness and becomes a loop curve instead.

C. An additional complexity is related to the fact that the **sediment and flow hydrographs in rivers are not in phase**: the peak of sediment hydrograph arrives before or after the peak of discharge depending on local conditions.



IMPLEMENTATION

The insights garnered by the present study represent essential knowledge that will be further used to formulate guidelines to retrofit existing culverts and to improve the design specifications in order to ensure that culverts do not require intervention after construction or cleaning.