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Hydrology and Earth System Sciences Discussions

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Interactive Comment

Interactive comment on "A flume experiment on the effect of constriction shape on the formation of forced pools" *by* D. M. Thompson and C. R. McCarrick

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We thank Paul Carling for taking the time to provide a thorough review of the manuscript. This reviewer has provided excellent reviews to the main author in the past, and we are excited to address his comments.

The reviewer is correct in pointing out the existing literature on scour at bridge abutments and dykes. However, there are important differences in the impact of the obstructions used in this experiment and the setups used for the other types of experiments. Bridge scour experiments usually focus on localized erosion at the bridge pier

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Interactive Discussion

Discussion Paper

where the obstruction creates a relatively small change in width of the channel. The major intent of the work is to determine the likelihood that a pier or abutment could be undermined during a flood. The resulting scour hole represents a relatively small portion of the channel width and is not a pool as strictly defined because it is less than half the channel width. The impact of backwater development is also greatly reduced, but is a major factor in pool scour with the obstructions in the flume experiments.

Scour experiments with dykes are typically conducted with features that are relatively low in elevation in comparison to channel banks. Therefore, flow often overtops the structures at the discharges important for pool scour. The author has conducted experiments on these types of designs and showed that obstructions that extend above the water surface create distinctly different scour patterns (Thompson, 2002). Furthermore, dykes are usually placed along the outside bank of meander curves, which dramatically influences backwater development and secondary flow development. Therefore, the authors did not try to directly compare results to these somewhat dissimilar conditions.

The reviewer suggests that features with longer longitudinal faces will exert more overall drag. This statement assumes that skin friction will dominate over form drag for these experimental setups. If skin friction dominates than the square and rectangular should create more drag as suggested and would have smaller pools because the system has less energy for scour. However, the square and rectangle produce the deepest pools, which show that differences in form drag dominate in these systems. In particular, variations in the angle of approach flow likely impact the size of the downstream wake and the corresponding form drag. The author completed a different flume experiment with a streamlined and none streamlined obstruction to flow that highlighted the importance of form drag relative to skin friction along the obstruction itself (Thompson, 2006). We now reference the article. The influence of the x-axis factor reflects the shape of the resultant wake zone more than differences in skin friction among obstacles.

The captions for Figure 1 and 2 were modified as requested.

We now specify that water depths were kept constant.

We agree that fully submerged and non-submerged obstacles have dramatically different impacts on scour and sediment deposition as reported in both Thompson (2002) and Thompson (2008). The shape of the obstruction was a very difficult issue to address. We were attempting to use geometries that were simplified enough to allow some repeatability with past and future studies, but we also wanted more complex shapes. We ultimately selected the six shapes used in the experiments with the hope that some general patterns in scour would emerge that could improve our understanding of more complex shapes. The similarity of some of the results of the flume experiments with the field data of entirely natural obstructions to flow from Thompson and Hoffman (2001) provide some evidence that general tendencies do exist.

Reynolds numbers do influence reattachment lengths for plane bed situations (i.e. Carling, 1989), but bed topography along the downstream of the pool rapidly comes to dominate and control reattachment points in pools. Flume experiments and computer modeling work completed by Thompson et al. (1998) show that reattachment points almost always occur at the downstream end of the pool and change with pool length. Therefore, we do not feel that standardizing by the Reynolds number is appropriate.

The authors experimented with dye tracing in the flume. Because the flume uses a recirculating flume system, small additions of dye rapidly begin to color all the water in the flume. Perhaps we should have used small amounts of dye and a photograph at the end of the experiment to estimate eddy fence locations, but we did not think of this at the time. We also chose not to use the acoustic Doppler velocimeter (adv) available in the lab because we did not want to disrupt flow patterns with the probe head. Use of an ADV also requires minimum water depths that would have negatively impact the overall design of the flume experiments.

I added one of the articles listed. However, as the article itself points out, the supercrit-

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ical conditions present in bedrock channels are rare in the alluvial systems modeled in the flume experiments in our article.

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