Foreword – The role of sediment transport in river dynamics is essential to evaluating the impacts of large magnitude events [1]. A long-term analysis of a river’s dynamics, is required to reasonably assess the quantity of sediment mobilized over the entire flow regime. However, there is a dearth of in-situ sediment transport data available for rivers around the world with even fewer studies obtaining observations during large magnitude events to authenticate the accuracy of event-based transport simulations [2]. The objective is to develop representative sediment transport models of Mimico Creek river (Southern Ontario, Canada), that has undergone intensive event-based sediment transport sampling and inter-event bed material particle tracking over a three-year period [3]. A HEC-RAS model was developed for the study reach and calibrated to a series of discharge events where in-situ bedload sampling occurred. Both step-wise discharge and unsteady flow simulations were evaluated to compare sediment transport rates for a range of transport models which included the Meyer-Peter-Muller [4] and the Wilcock-Crowe [5]. Calibration designs were developed to estimate sediment discharge in Mimico Creek. The results of the calibrated model were used to calculate the mean travel distance of bed material using the expression for the volumetric rate of bed material transport. Results from the modelling exercise found mean travel distances were similar and in some cases larger than those observed from field measurements, considering both mobile and immobile particles.

Study site – The study focuses on a 2.1 km reach of Mimico Creek (66.3 km²) in southern Ontario, Canada. The majority of the watershed is urbanized with remaining areas zoned as industrial or transportation (airport). Immediately upstream of the study reach, the channel flows within a concrete trapezoidal channel (0.5 km) before transitioning into a gravel-bed channel at the beginning of the reach study. Complete bed material routing is observed throughout the concrete channel section.

July 8th, 2013: a precipitation event occurred generating a flood exceeding the 100-year return period [6]. Pre and post erosion surveys along the 2.1 km reach combined with in-situ and inter-event sediment transport studies and a proximal hydrometric monitoring station afforded a unique opportunity to evaluate the performance of various sediment transport models applicable to gravel-bed rivers for flashy high magnitude events.

Sediment transport measurement and sediment transport modelling and mean bed material travel distance:

• Bedload sampling was conducted during recurrent floods using the modified single width increment method with 0.076m Hillley-Smith samplers between 2012 and 2013 [3].
• Sampling of the coarse particle transport were conducted using tracer particles embedded with RFID (radio frequency identification) tags between 2011 and 2013 [3].

Wilcock-Crowe transport model [5]:

\[
W_i = \left(1 - \frac{1}{g} \cdot q_{bi} \cdot (F_i \cdot u_o^2)\right)
\]

Meyer-Peter Müller transport model [4]:

\[
Q_b = V_b \cdot D_b \cdot W_i \left(1 - P \right)
\]

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>(Q_{mm} ) (m³/s)</th>
<th>(Q_{bm} ) (tones/day)</th>
<th>(Q_{bb} ) (step-wise discharge) (ton/day)</th>
<th>(Q_{mm} ) (unsteady flow) (ton/day)</th>
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Estimation of mean travel distance of bed material:

• The results of the calibrated HEC-RAS model were used to estimate the mean travel distance \(L_m\) of bed material. \(L_m\) is the mean tracer survey transport distance of event-based particles (including immobile particles), \(L_{mm}\) is the mean tracer survey transport distance of event-based particles (considering only mobile particles).
• \(L_m\) varied widely compared to calculated mean field distances. For the 2nd flash event, the simulated (step-wise discharge) \(L_m\) is similar to \(L_{mm}\).
• No relationships were found between \(L_{mm}\) (and \(L_m\)) and peak discharge \(Q_{mm}\) [3]. The same situation is visible in simulation results, where there is no monotone function relating \(Q_{mm}\) and \(L_m\).

Conclusions – This study employed the Meyer-Peter-Wilcock and Crowe models within the HEC-RAS modelling framework to evaluate the representativeness of event-based estimates of sediment transport and bed material transport distances. Results were compared to three-year (2011-2013) field sampling campaign where in-situ bedload and inter-event particle tracking had occurred. Results showed that the Wilcock and Crowe transport model represented the poorly graded gravel bed channel conditions over the range of flows inventoried. Mean bed material transport distances using the Wilcock and Crowe model [0.12 m < \(L < 5.7\) m and 0.11 m < \(L < 6\) m, considering respectively step-wise discharge and unsteady flow simulations] compared relatively well with field observations [0.1 m < \(L < 3.5\) m] and in some instances overestimated travel distances. Findings from this study reinforce the importance of accounting for different transport estimates. The Wilcock and Crowe models account for bulk inter-particle interactions (e.g. hiding and sand-gravel transport-dependent flow) and the armor layering effects [11]. These could not be accounted for using the Meyer-Peter-Müller equation, which could not be correlated to the field conditions and bed material gradation. The comparison of simulated transport distances against available field observations also provides another mechanism to validate appropriate transport equations; particularly where in-situ bedload sampling may not be available.

References: