Measuring the flow in a small irregular river using LS-PIV
Contents

• Definition of LS-PIV
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Definition of LS-PIV

• Non-intrusive approach used to measure the 2-D velocity field on the water surface.
Definition of LS-PIV

• There are 3 types:
  – Large-scale Particle Image Velocimetry (LS-PIV)
  – Space-tome Image Velocimetry (ST-IV)
  – Controlled-surface Wave Image Velocimetry (CS-WIV)
The challenge

- Can we determine the discharge by simply looking at the patterns on the water surface?

\[ k = \frac{U_d}{U_s} \]

\[ \frac{U(z)}{U_s} = \left( \frac{z}{h} \right)^{1/7} \]

\[ k = 0.875 \]
Experimental site

- “Man made” river
- Width = 5m; bank-full depth = 0.75m
Experimental site


(a) Cross section 2.

(b) Cross section 5.
Data collected

• Event 1: bank-full  \( (Q \sim 2.0 \text{ m}^3/\text{s}) \)
• Event 2: in-bank \( (Q \sim 0.34 \text{ m}^3/\text{s}) \)
• Event 3: over-bank \( (Q \sim 4.5 \text{ m}^3/\text{s}) \)
Data collected
• How does the position of maximum velocity vary with lateral distance?
ADCP & ADV data – cs 2

(a) Inbank - 18/8/08
(b) Bankfull - 16/1/08
(c) Overbank - 10/2/09
ADCP & ADV data – cs 5

(a) Inbank - 18/8/08

(b) Bankfull - 16/1/08

(c) Overbank - 10/2/09
Velocity vectors for cs 5

(a) Secondary flow vectors

(b) Near surface velocities
Secondary flow – cs 2
Surface velocity
Relationship between $U_d / U_s$ in-bank flow

(a) Section 2.

(b) Section 5.
Relationship between $U_d / U_s$

bank-full case

(a) Section 2.

(b) Section 5.
Relationship between $U_d / U_s$ over-bank case

(a) Section 2.  
(b) Section 5.
Average value of $U_d / U_s$

<table>
<thead>
<tr>
<th>Event</th>
<th>Cross section 2</th>
<th>Cross section 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbank (18/8/2008)</td>
<td>0.397</td>
<td>1.175</td>
</tr>
<tr>
<td>Bankfull (16/01/2008)</td>
<td>0.862</td>
<td>1.028</td>
</tr>
<tr>
<td>Overbank (10/2/2009)</td>
<td>0.989</td>
<td>1.066</td>
</tr>
</tbody>
</table>

(c.f. 0.875)
Quantifying the effect of second flow on $U_d / U_s$
Quantifying the effect of second flow on $U_d / U_s$

- Assume channel can be discretized in linear elements.

$$\Gamma = \frac{\partial}{\partial y} \left[ H \rho \ (UV)_d \right]$$
Secondary flow vs. k
Conclusions

• The ratio of the depth averaged velocity to the surface velocity (k) can vary significantly between cross sections.

• k varies with Q and is highly dependent on the structure of the local velocity field.

• For practical purposes, a value of k=1.0 is not an unreasonable starting point for discharge estimation, providing that a cross section is chosen where there is significant mixing.
Roughness distributions
Roughness distributions