

Hydrographic Measurements of a Tidal Cycle Upstream of the Glasgow Tidal Weir

49th Marine Measurement Forum

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Motivation

- Investigation of river Clyde's hydrographic conditions upstream of the Tidal Weir at different tides and low river flows as part of the River Clyde Scoping Study
- Improving the Clyde's water quality
- Investigating on how well the Tidal Weir is represented in the 3d model



Background Information

04/05/2011 Spring Tide Time (GMT) Height (m)	25/07/2011 Neap Tide Time (GMT) Height (m)	29/09/2011 Spring Tide Time (GMT) Height (m)
00:47 3.3	00:07 1.1	00:54 3.8
06:04 0.4	06:51 2.8	06:20 -0.1
13:08 3.2	13:10 0.9	13:29 3.5
18:24 0.4	19:22 2.9	18:47 0.1
Background flow: 9 m ³ /s	Background flow: 17 m ³ /s	Background flow: 29 m ³ /s

- Tidal Weir operators maintain a water level of 4.16 m upstream of Tidal Weir
- Tidal Weir is an underflow tidal sluice
- Time difference between tides (high/ low) in Greenock and Tidal Weir is 28 min
- Background flow: River gauge Daldowie

Measurements

Location: Clydesdale ARC & Clyde ARC rowing club boat house

Hydrographic cross-sections 80 m upstream of the Tidal Weir by the OceanMet and Hydrology Units of SEPA

ADCP x-sections with 2 MHz RDI StreamPro & 3 MHz Sontek S5:

- Current speeds & directions
- Total flux pos.: flow downstream
- Total flux neg.: flow upstream

YSI 6600 CTD measurements
(depth profiles at 3 locations):

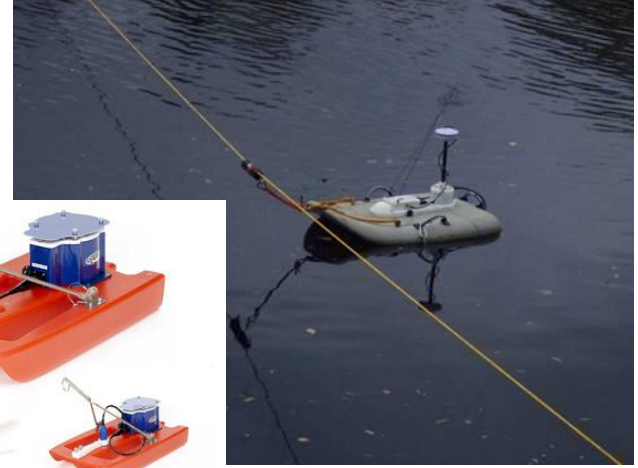
- Salinity
- Temperature
- Oxygen

CastAway YSI CTD measurements
(depth profiles at 3 locations):

- Salinity
- Temperature



ADCP Setup: Sontek S5; RDI StreamPro



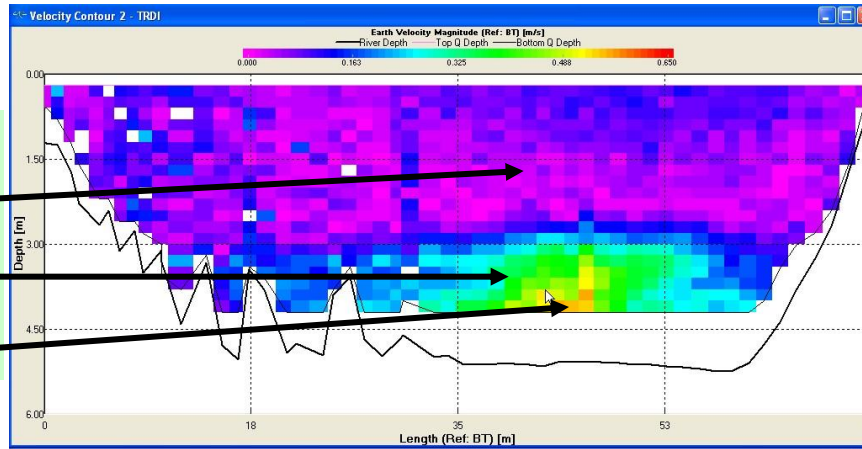
ADCP 4/5/2011: 30 min before high tide

Velocity Magnitude:

max.: 0.03 m/s

about 0.36 m/s

max.: 0.55 m/s

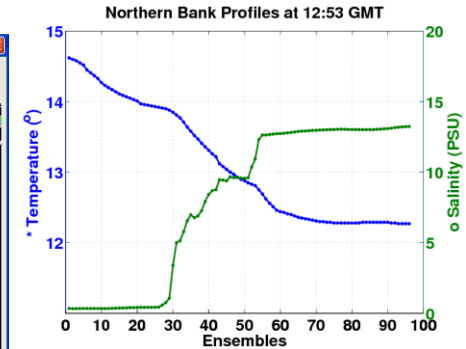
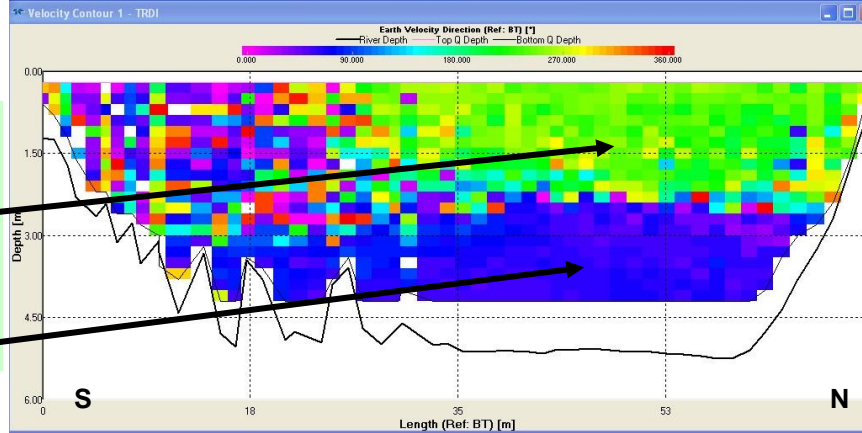


Velocity Direction:

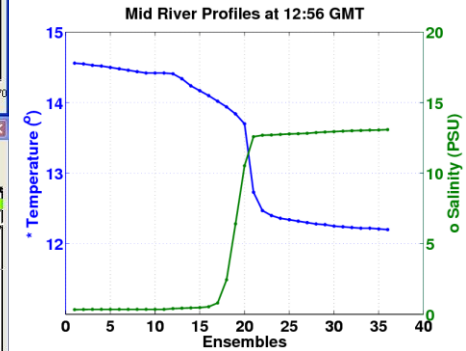
around 230° ~

W-SW

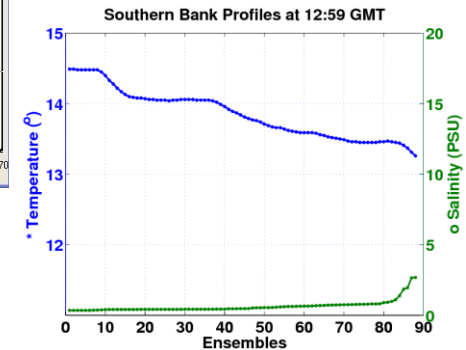
around 65° ~ E-NE



12:53 GMT



12:56 GMT



12:59 GMT

- Data averaged over 10 ensembles
- Flooding Tide; Transect at 13:07 GMT,
- Total Flux: -16.60 m³/s => general flow upstream
- Upper water column flow downstream; lower water column flow upstream
- Tidal Weir gates open at the bottom

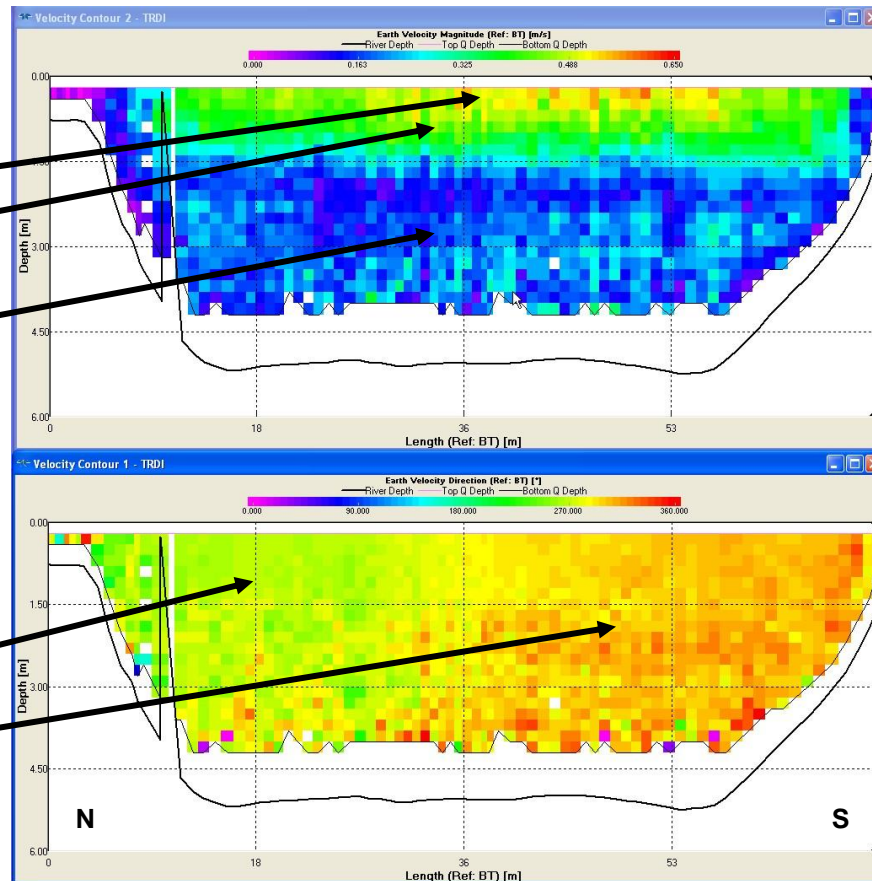
ADCP 4/5/2011: 30 min after high tide

Velocity Magnitude:

max.: 0.58 m/s
about 0.36 m/s
between 0.12 –
0.25 m/s

Velocity Direction:

around 270° ~ W
around 300° ~
W-NW



- Data averaged over 5 ensembles
- Ebbing Tide; Transect at 14:12 GMT,
- Total Flux: 71.22 m³/s => fast flow downstream
- 1 of 3 Tidal Weir gates fully open

ADCP 4/5/2011: 45 min after high tide

Velocity Magnitude:

max.: 0.63 m/s

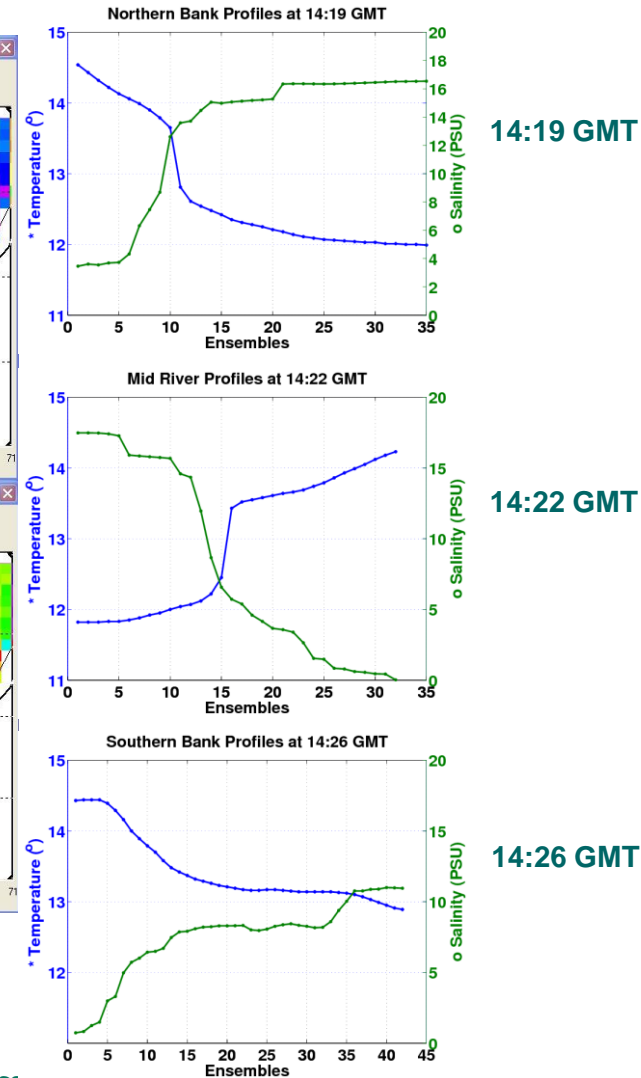
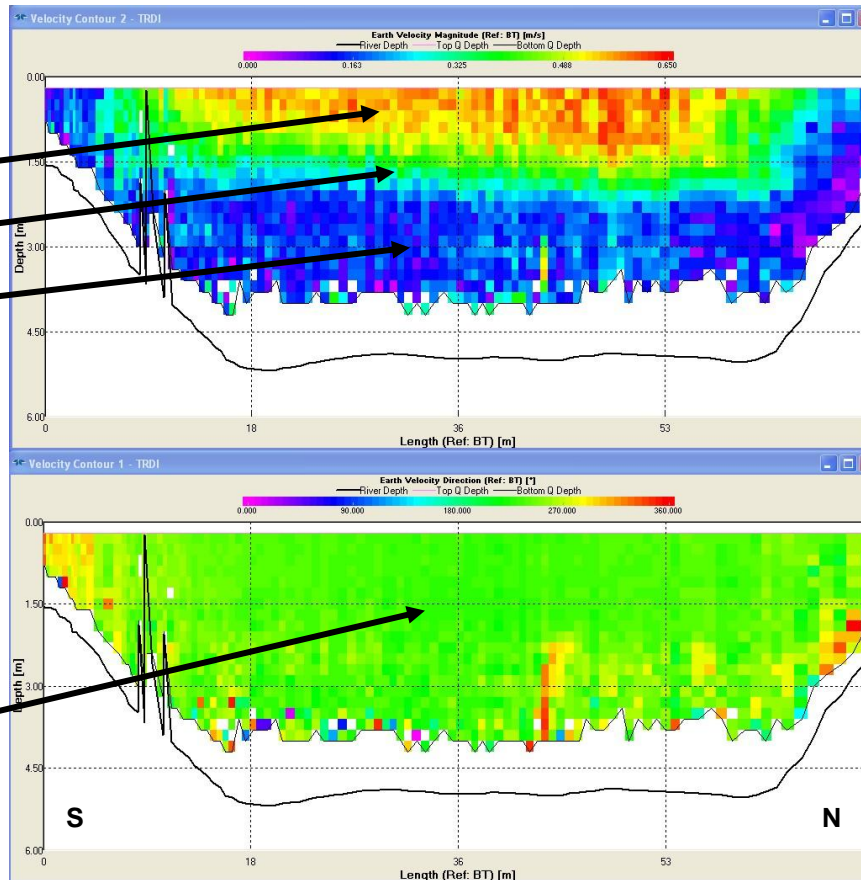
about 0.42 m/s

about 0.2 m/s

Velocity Direction:

around $230^\circ \sim$



W-SW



- Data averaged over 5 ensembles
- Ebbing Tide; Transect at 14:19 GMT
- Total Flux: $81.59 \text{ m}^3/\text{s} \Rightarrow$ fast flow downstream
- 1 of 3 Tidal Weir gates fully open

CTD Measurements

	04/05/2011	25/07/2011	29/09/2011
Temperature (°C)	Surf:14.1-14.6 Bott: 11.8-13.1	Surf:15.9 - 20.5 Bott:16.3 - 17.2	Surf: 13.7-15.5 Bott: 13.7-14.7
Salinity	Surf: 0.30-3.46 Bott: 2.68-17.48	0.16-0.18	0.13 – 0.14
DO (mg/l)	2.7-11.3	5.9 -9.5	9.14-10.37
Oxygen Sat (%)	26-110	60 -99	88-103

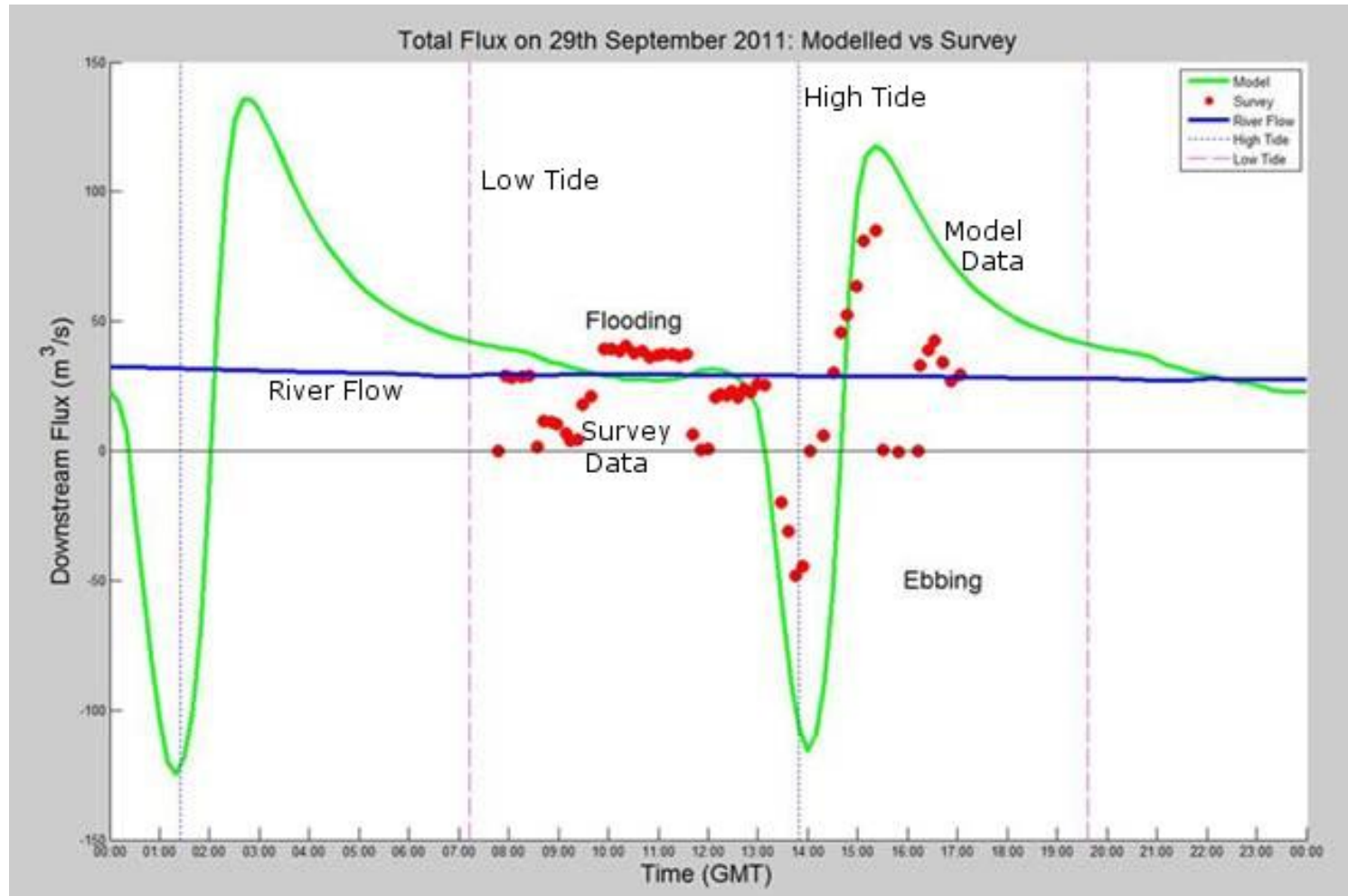
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 Survey 1 (spring tides): relatively high bottom salinities created sharp density gradient, highest values 45 min after high tide; 1 profile showed low bottom oxygen levels; oxygen levels higher than expected despite rather “dry” flow conditions
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 Survey 2 (neap tides): surface temperatures rose by 5 °C during day; no salinity detected; oxygen levels high as expected
- Survey 3 (spring tides): surface temperatures rose by 2 °C during day; no salinity detected; oxygen levels very high due to high precipitation

Flow Measurements

	04/05/2011	25/07/2011	29/09/2011
Min Downstream (m ³ /s)	5	11	3.8
Max Downstream (m ³ /s)	82	33	85
Min Upstream (m ³ /s)	-2	-	-19
Max Upstream (m ³ /s)	-16	-	-48

- Survey 1 (spring tides): low flows (12-18 m³/s) downstream before high tide; upstream flows 30 min before high tide (2 gates partially open at bottom); max downstream flows 45 min after high tide (2 gates open)
- Survey 2 (neap tides): low flows downstream throughout whole survey (11-22 m³/s); no flows upstream; gates only marginally open (~30 cm)
- Survey 3 (spring tides): varied flows before midday high tide (3-40 m³/s); high upstream flow at high tide (all gates shut); max downstream flows when all 3 gates were opened 1h 45 min after high tide

Flow – Model vs. Measurements



Conclusions

- Flow speed and direction not only dependent on tides, but also dependent on operation of Tidal Weir
- Upstream flow usually occurs during spring tides
- Highest flows upstream with $-48 \text{ m}^3/\text{s}$ measured at 3rd survey 10 min after high tide
- During neap tides flows are considerably slower (2nd survey); water levels not high enough to open gates; creating nearly stagnant conditions
- Highest flows downstream with $85 \text{ m}^3/\text{s}$ occurred 1h 45 min after high tide (3rd survey)
- Salinities (~ 17.5 ppt) only measured during 1st “dry” survey
- High oxygen levels measured in 2nd and 3rd survey are important for good water quality
- Improvements of the numerical model necessary, to represent Tidal Weir better

Thanks to

- My SEPA colleagues who were involved in the surveys
- Glasgow City Council and the Tidal Weir operators
- The Clydesdale Amateur Rowing Club
- The Clyde Amateur Rowing Club
- The Glasgow Humane Society



LIFEBOAT

Glasgow Humane Society

CHARITY No: SC001178

