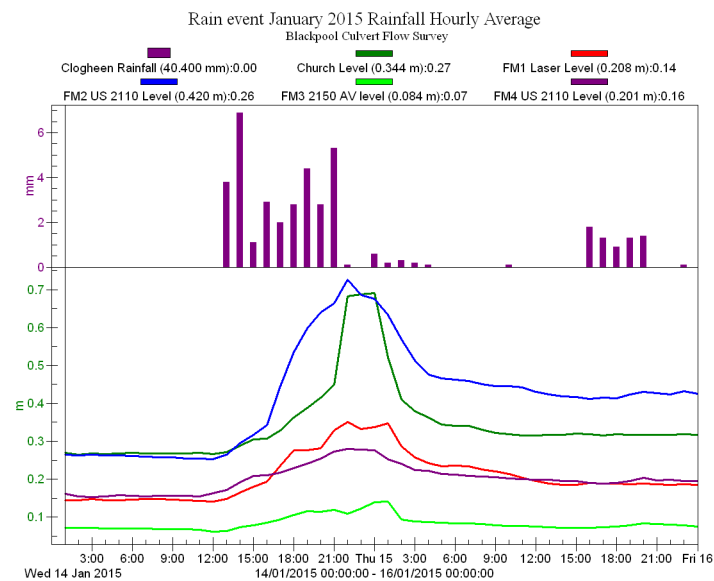


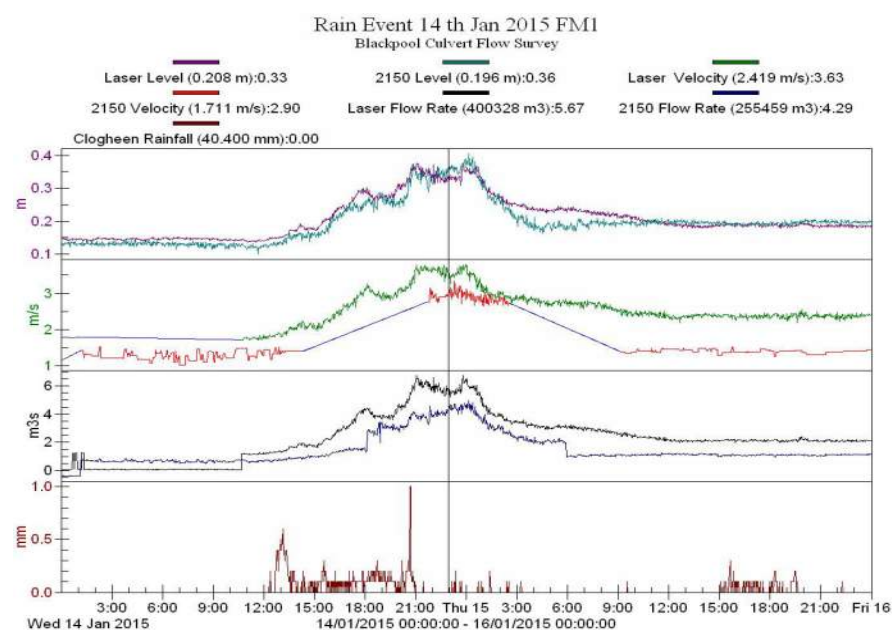
Figure 4 : Rainfall and levels during 14th January Rain event- (hourly average)



FM1: Rain Event 14th January Bride River - Laser and 2150 AV Loggers

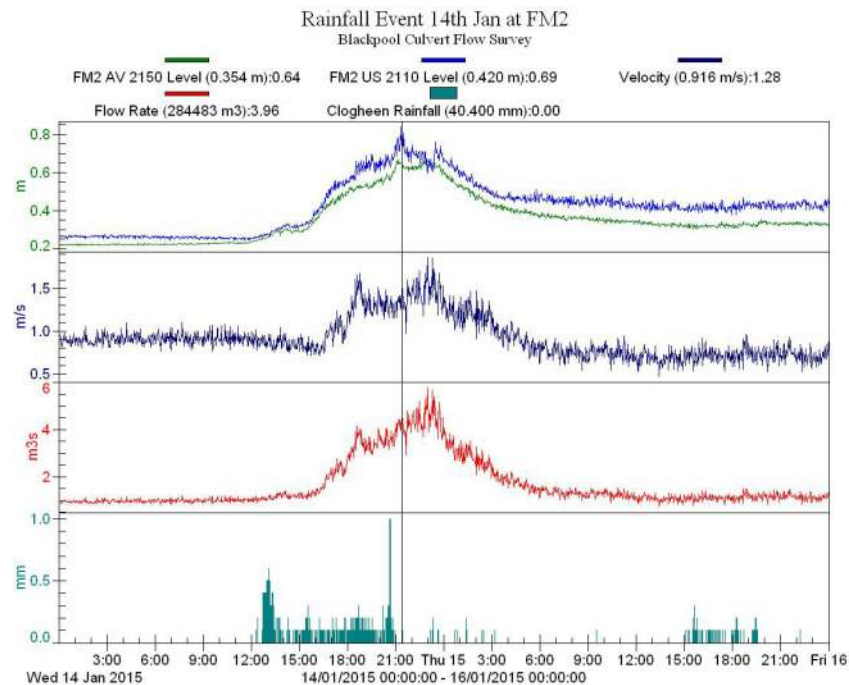
Both Laser and 2150 AV show a peak level of 0.34 meters approx. The 2150 velocity data locked out during the increase but kicked in at the peak level for a period. However the Laser worked better and this is used as the benchmark for calculating an accurate flow at FM1 , (Bride River). The max flow recorded by the Laser logger was 6 m³/Sec approx.

Fig 5: Rain Event 14th January at FM1- Level Velocity and Flows



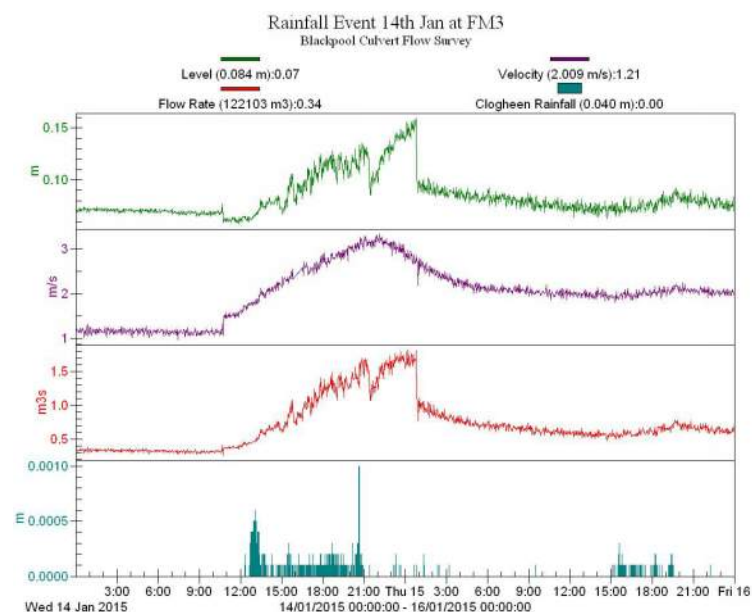
FM2: Rain Event 14th January Old Brewery Line – Ultrasonic 2110 Logger (US) and 2150 AV

Fig 6: Rain Event 14th January at FM2- Level, Velocity and Flows



FM3: Limerick Road Upstream- 2150 AV Logger

Fig 7: Rain Event 14th January at FM3- Level Velocity and Flows



FM4: Limerick Road Downstream – New 2110 Ultrasonic Logger:

At FM4 we recorded levels with the newly fitted Ultrasonic Flow logger which is placed 3 meters upstream of the old 2150 AV position. We used an equation derived from previous level ,velocity data to convert levels to velocities and subsequently to flows in order to provide an estimate of the flow rates at FM4. This is used for flow balancing calculations.

Fig 8: Rain Event 14th January at FM4- Level calculated Velocity and calculated Flows

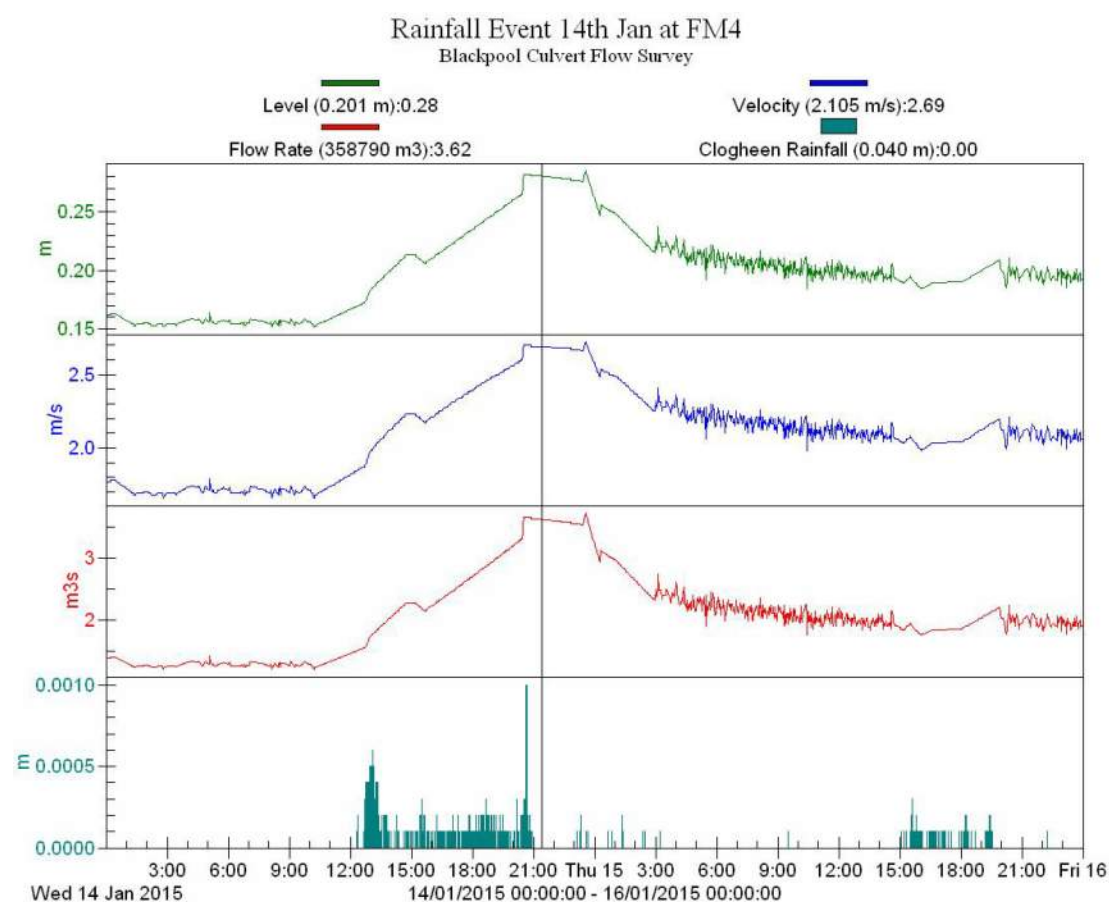
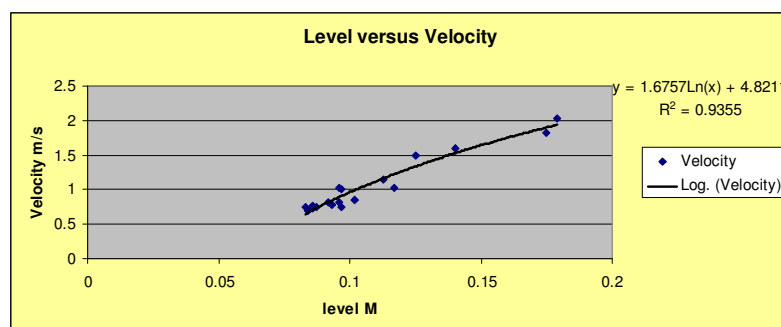


Fig 9: Level to velocity Algorithm used for FM4:



Flow Balancing for Rain Event 14th January 2014:

Flows at FM4 are derived from the ultrasonic level logger using an algorithm created from previous level velocity data. FM2 is a natural channel but for flow calculating purposes we assume a rectangular channel with an even floor level.

Fig 10: Rain Event 14th January Flow Calculation Summary Graph

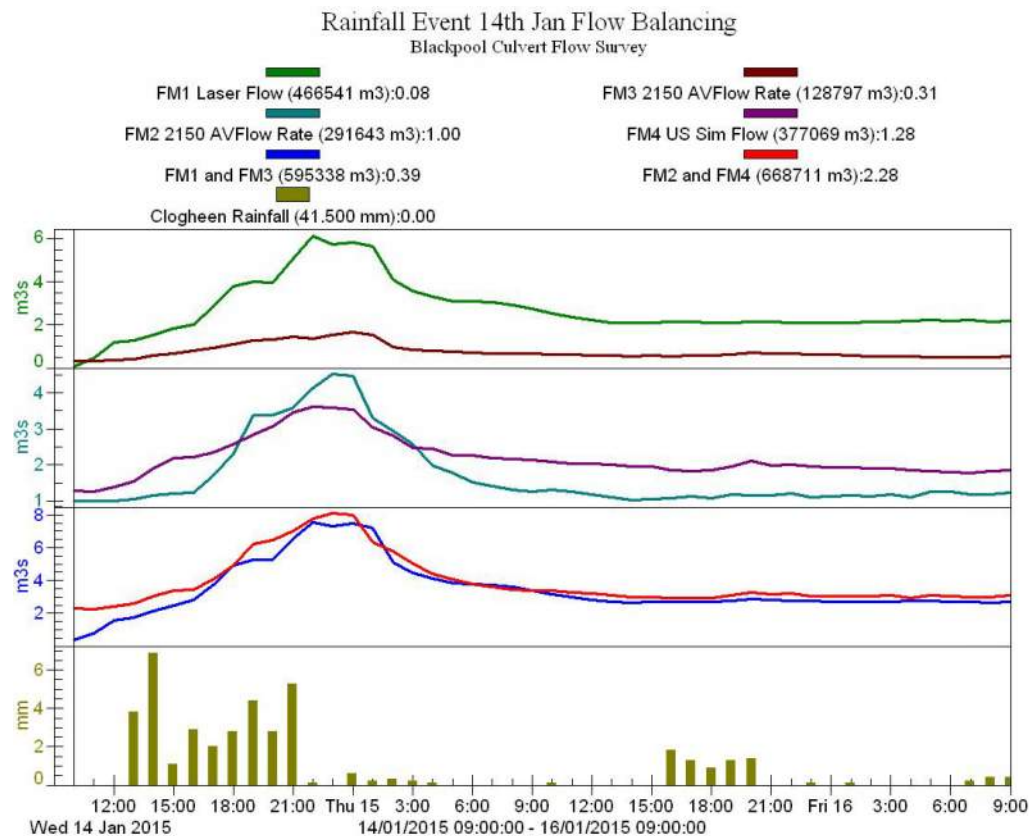


Fig 11: Flow totals and Percentage distribution during 14th Jan Rain Event

Site Name	FM1 Laser Flow	FM2 4th Nov	Flow Monitor 3.	FM4 stack 190115		
Label	FM1 Laser Flow Rate	FM2 2150 AV Flow	Fm3 2150 AV Flow	FM4 2150 AV Flow	FM1+FM3	FM2+FM4
Units	m3	m3	m3	m3	m3	m3
25/01/2015 00:00	278606	191315	78467.2	210932	357073	402247
26/01/2015 00:00	187935	100328	50329.7	166137	238265	266464
Totals	466541	291643	128796.9	377069	595338	668711
%	78.37%	48.99%	21.63%	63.34%		

Flow totals calculated with a combined over read on FM 2+FM4 of 12.32%
Our calculations arrive at 37.49 % of the FM1 Bride River flow crossing bifurcation to FM4.

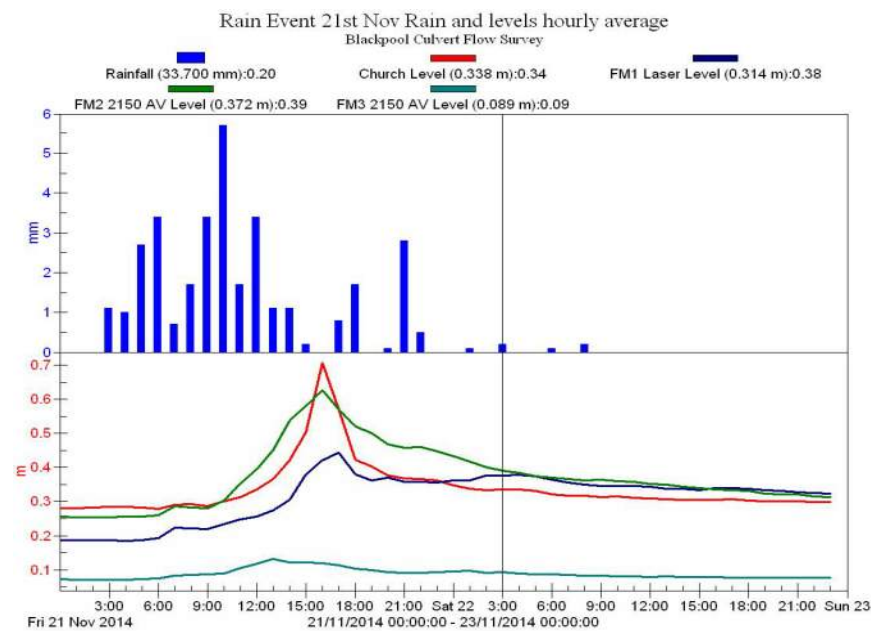
Fig 12: Flow M3 and percentages crossing Bifurcation during 14th Jan rain event

Crossing Bifurcation from FM1 to FM4		174898	37.49%
over-estimation at FM2+FM4		73373	12.32%

Rainfall Event 21st November 2014

A significant rain event occurred on the 21st November. This was a week after the 13/14th rain events and a wet month overall and levels were still elevated prior to the event. Unfortunately on analyses it turns out there was issues with clogging on both rain gauges at White Church and Clogheen during the event. Hourly rainfall data acquired from Met Eireann for Cork Airport is used for analyzing the event. Also entry into the culvert at this time was not possible. The FM4 flow logger 2150 AV flow logger was not producing good data so flows are studied for FM1, FM2 and FM3 only and flows are derived for FM4 by subtraction.

Fig 13: Rain Event 21st November 2014 Rainfall and Levels- hourly averaged

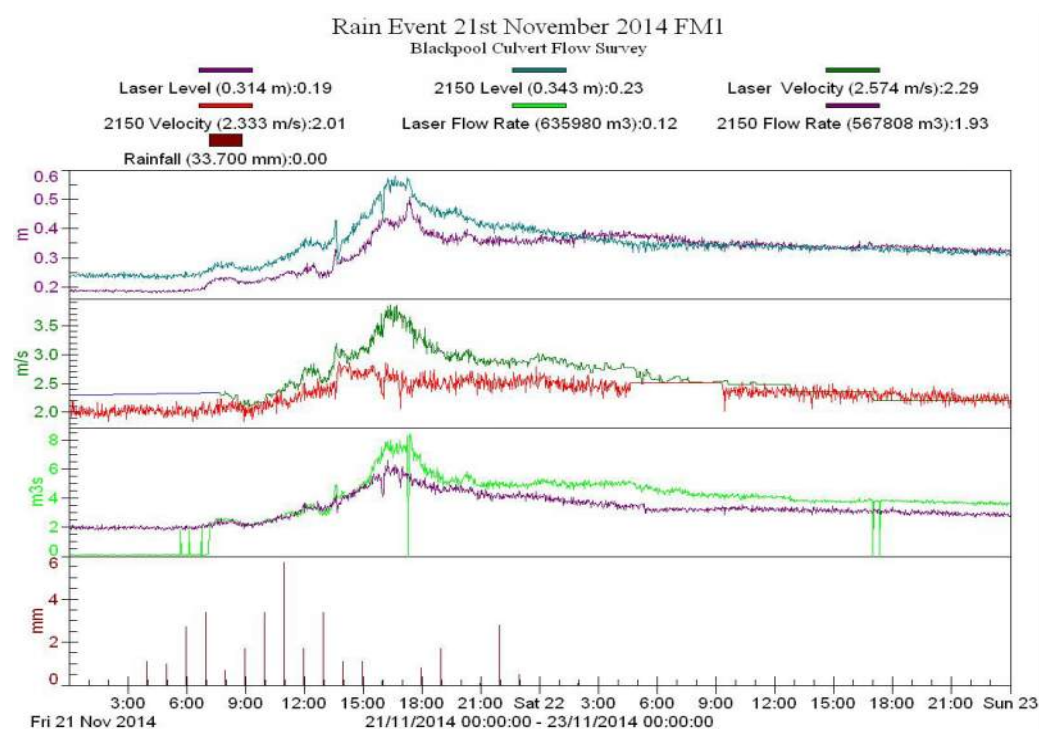


33.7mm of rainfall was recorded at Cork Airport during the event. The peak church level was 0.7 meters approx. The peak level at FM2 old brewery line was 0.6 meters.

FM1: Rain Event 21st November Bride River - Laser and 2150 AV Loggers:

Figure 14 compare levels velocities and flows of the Laser and 2150 at FM1. It is suspected that the 2150 AV logger was fouled as we were not able to get in to clean it. The Laser flow logger has constantly provided good scatter profiles and is not prone to ragging or fouling, thus is used once again as our benchmark for recording flows entering the culvert from the Bride River. A brief peak velocity of 3.72 m/s with equivalent flow rate of 7.72 m³/sec was recorded by the Laser flow logger.

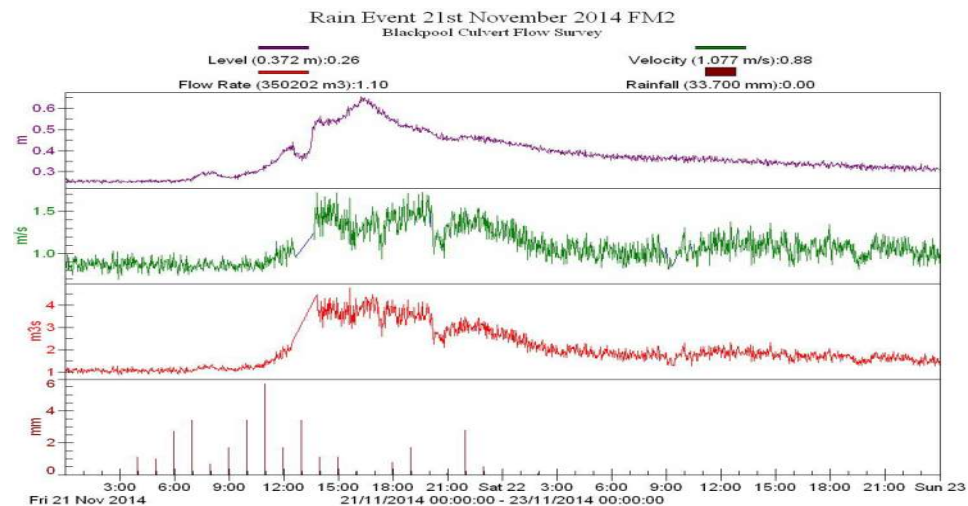
Fig 14: Rain Event 21st November at FM1- Level Velocity and Flows



FM2: Rain Event 21st November - Old Brewery Line – Ultrasonic 2110 Logger (US) and 2150 AV

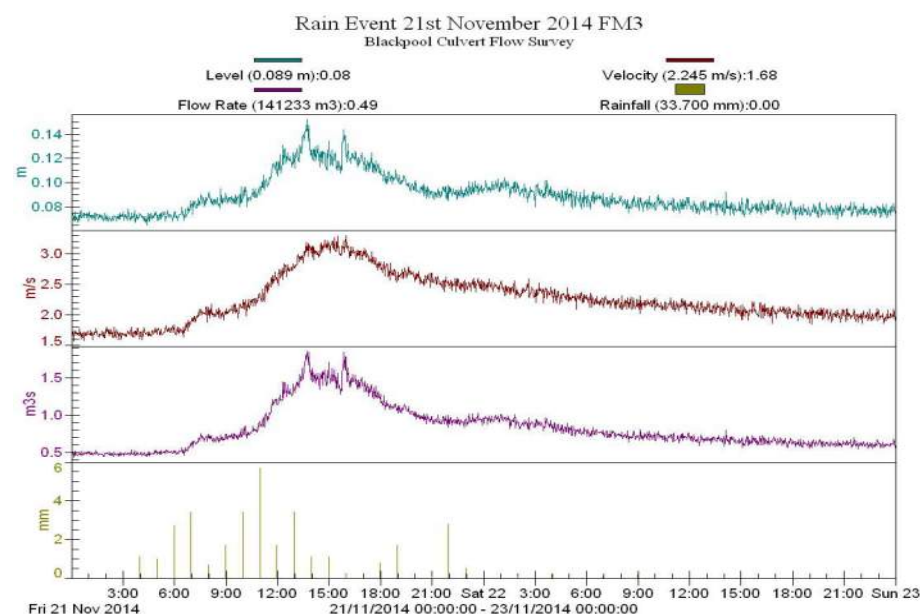
Figure 15 shows the level velocity and estimate flow at FM2- old brewery line. A peak level of 0.63 Meters and peak flow estimates of 4 m³/sec

Fig 14: Rain Event 21st November at FM2- Level, Velocity and Flows



FM3: Rain Event 21st November– 2150 AV Logger

Fig 15: Rain Event 21st November at FM2- Level, Velocity and Flows

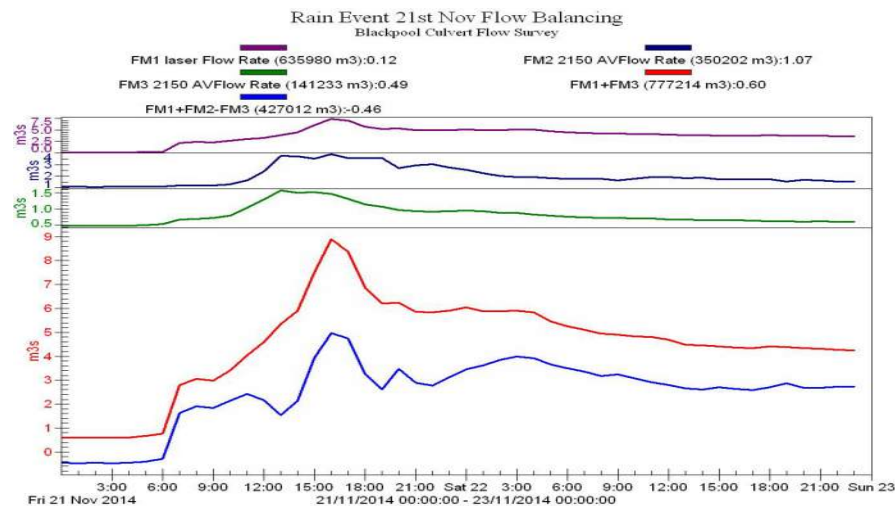


Calculated Flow Balancing for Rain Event 21st November:

In the absence of good data at FM4 flow is balanced using best estimates at FM2 and subtraction of FM1 + FM3. Using this method the following data was derived.

In figure 16 below the blue trend is the derived expected flow in FM4 channel during the rain event.

Fig 16: Rainfall Event 21st November Flow balancing trend graph



The breakdown of flows and percentage calculate as seen in table in Fig 17 below;

Figure 17th Rain event 21st November – breakdown of calculated totals and percentages

Site Name	FM1 Laser Flow	FM2 4th Nov	Flow Monitor 3.	FM4 stack 190115		
Label	FM1 Laser Flow Rate	FM2 2150 AV Flow	Fm3 2150 AV Flow	FM1 +FM3	FM4: (FM1+FM3-FM2)	FM2+FM4
Units	m3	m3	m3	m3	m3	m3
21/11/2014 00:00	274723	193578	79050	353773	160195	402247
22/11/2014 00:00	361258	156624	62183	423441	266817	266464
Totals	635981	350202	141233.4	777214	427012	668711
%	81.83%	45.06%	18.17%		54.94%	

Flow across bifurcation from FM1 bride River to FM4 during the rain events calculates as in figure 18 with this process.

Fig 18: Estimated Flow M3 and percentages crossing Bifurcation during 21st Nov rain event

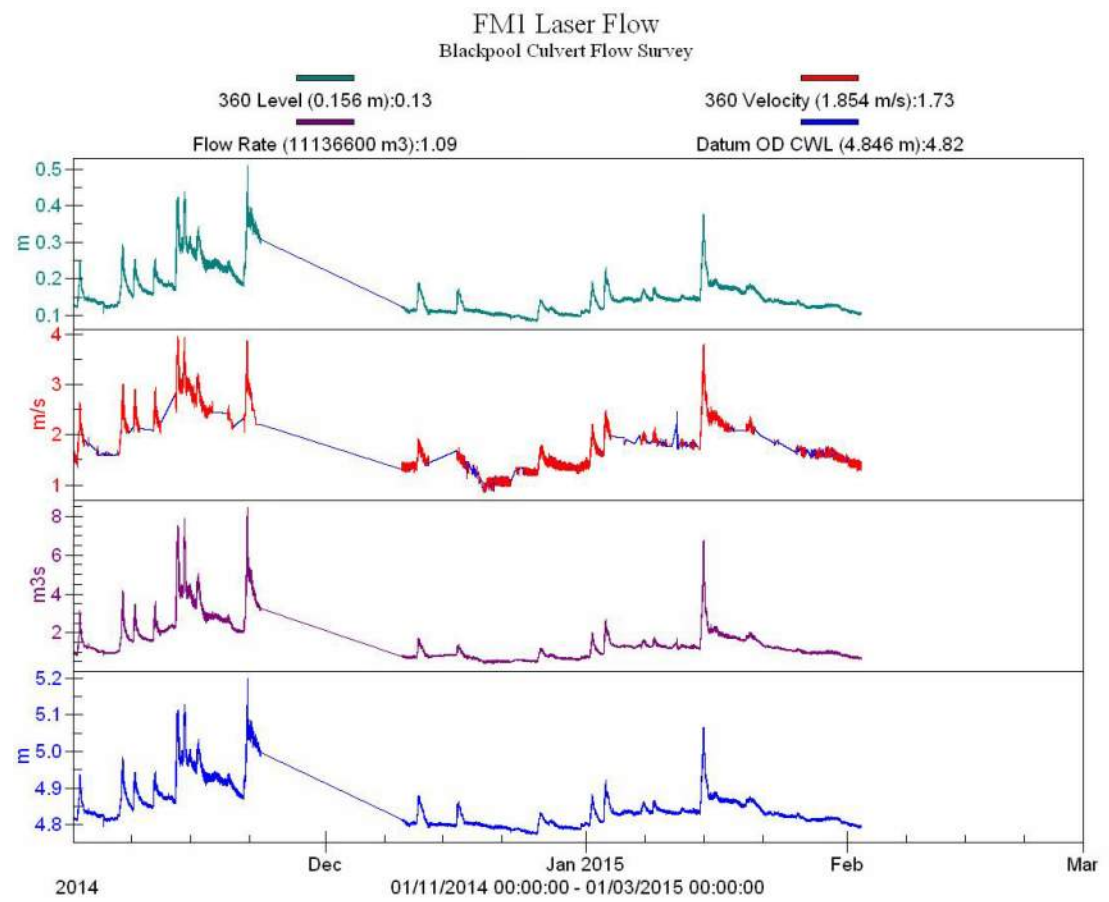
Crossing Bifurcation from FM1 to FM4		285779	44.94%
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General Report for each site for November December and January:

Laser Flow Logger at FM1

Every time the levels have increased the Laser flow logger reads and provides good data with very good level to velocity correlation. Ideally it would have been better to have 4 of these Laser loggers to avoid the issues with ragging, one at each channel, but unfortunately this option was not available. At low flows the velocity can cut out and reach zero but it has been easy to edit these events from the data, (red trend), and create a good overall flow conversion. Data is missing for a period between ends of November to 9th December due to battery failure during a period when we were not able to get into the culvert. Fortunately no significant events were missed. Figure 19th shows the recorded data between November and December including datum levels.

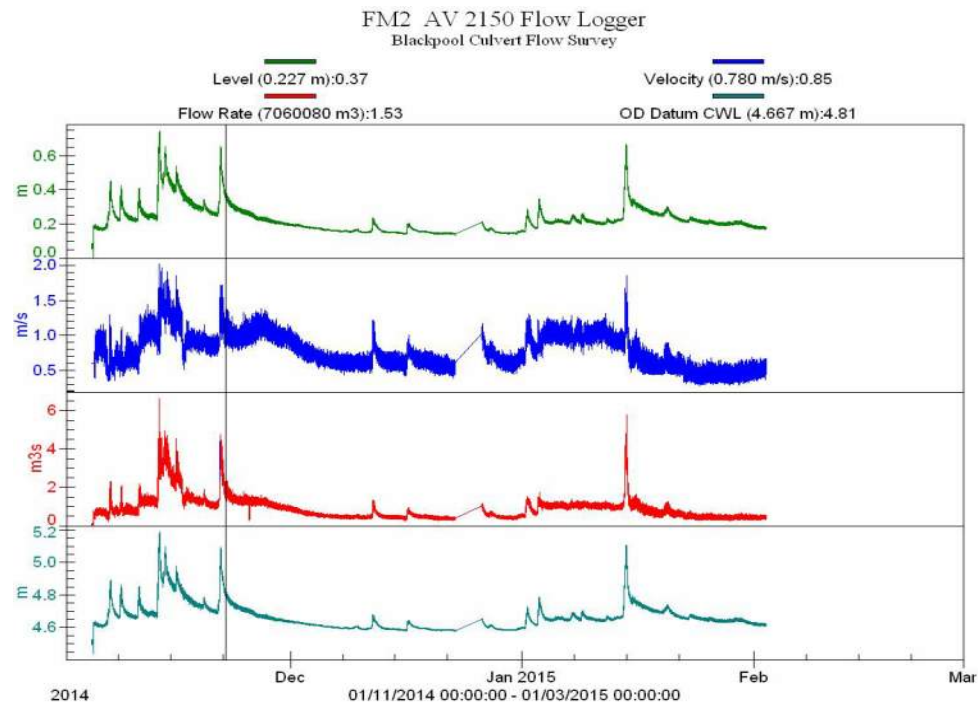
Fig 19th Laser Flow Logger complete recorded data Nov Dec Jan



2150 AV Logger and relocated 2110 Ultrasonic at FM2- Brewery channel

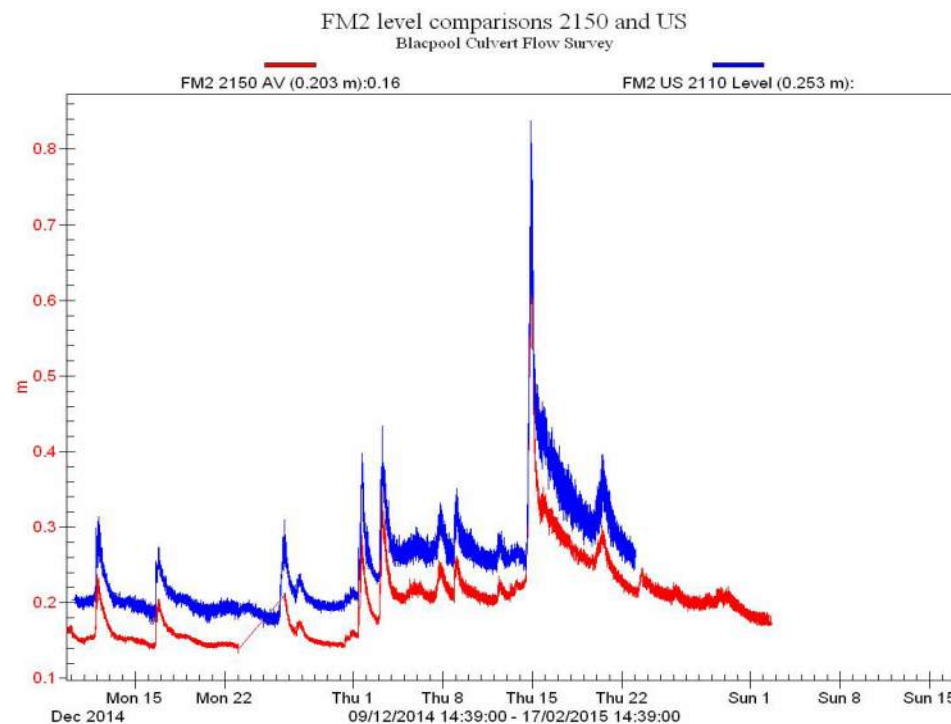
Despite the uneven floored channel and varied and sometimes turbulent conditions in the FM 2 brewery line, the 2150 AV logger generally has worked well as can be seen in Figure 20. All main rain events were recorded. Flows are estimations based on a standard 4 meter rectangular culvert.

Fig 20 FM2 2150 AV Flow Logger complete recorded data Nov Dec Jan



On the 9th December the Ultrasonic level logger in the culvert was moved as requested to the FM2 channel. This was installed in the channel 3 meters upstream of the 2150 V logger, as this was a suitable mounting point in the ceiling, and the flow was less turbulent at this point. The levels followed the same trends closely although the ultrasonic levels in general are higher as seen in figure 21. For flow calculations we used the 2150 AV logger level and velocity.

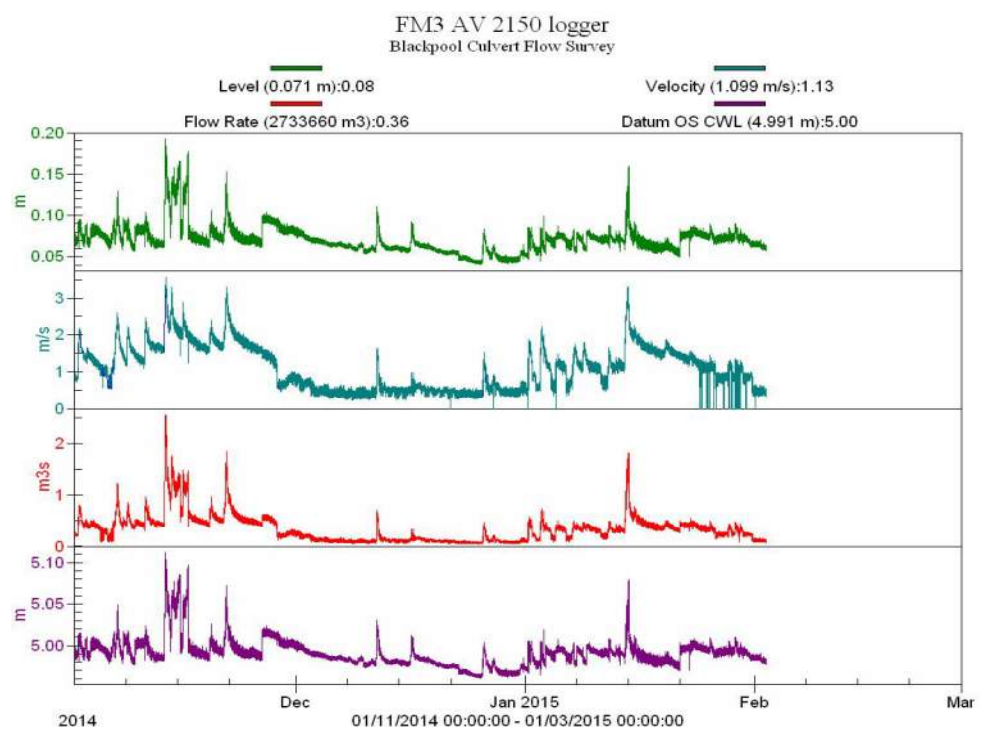
Fig 21: 2110 Ultrasonic, (US), Level Logger compared to 2150 AV logger



2150 AV Logger at FM3: Limerick Road –Upstream:

In general data at FM3 was good despite the low levels and high velocities which are not ideal for measurement. Certain flow conditions however seemed to create a wave in front of the probe which seemed to come and go. This resulted in occasional step up and down in levels particularly at lower flows which created doubt about the accuracy of the flow measurement. However, the trend during rain events was typically elevated levels and velocities as expected, so we are reasonably confident that the more important rain event data should be accurate. Figure 22 shows the level, velocity flow, and datum trend for November, December and January.

Fig 22 FM3 2150 AV Flow Logger complete recorded data Nov Dec Jan



2150 AV Logger and new 2110 Ultrasonic Flow Logger at FM4-Downstream Limerick Road.

Data from the 2150 AV logger at FM4 was often disappointing and not unusable despite changing the probe and meter earlier in the survey. It was not during the culvert entry on the 19th January when it was raining, that a considerable quantity of water was pouring down on the logger through cracks in the manhole cover. While it was always difficult to maintain good data at this site due to ragging and turbulence issues, since the middle of November we had an additional issue of drift on the level measurement rendering this data not usable, which effected the rain event of 21st November in particular. It is suspected now after witnessing conditions the logger was exposed to in the rain, that desiccant within the logger may have been wet which effected the automatic atmospheric compensation over the last few months. As previous results at this site had been disappointing, JBA requested we install an ultrasonic level logger at this site. This was installed back on the 9th December and we have been using this data since, although the varied and occasionally turbulent conditions have resulted in some noisy data at times, although the trend can be clearly identified. As we are determined to try and get some additional velocity data we have fitted a complete new logger 2150 AV logger at FM4 on the 22nd January in the hope that we might get one good event before the survey is complete.

Since the new 2150 logger has been installed result look much better. Figure 23 shows the recent comparisons between the new ultrasonic 2110 level logger and the new 2150 V logger. The Ultrasonic probe is 3 meters upstream of the 2150 AV probe. These levels we be rechecked during the next visit as it is difficult to take accurate levels in the turbulent conditions.

Fig 23: Recent Level comparison at FM4 between new 2150 AV and new 2110 Ultrasonic

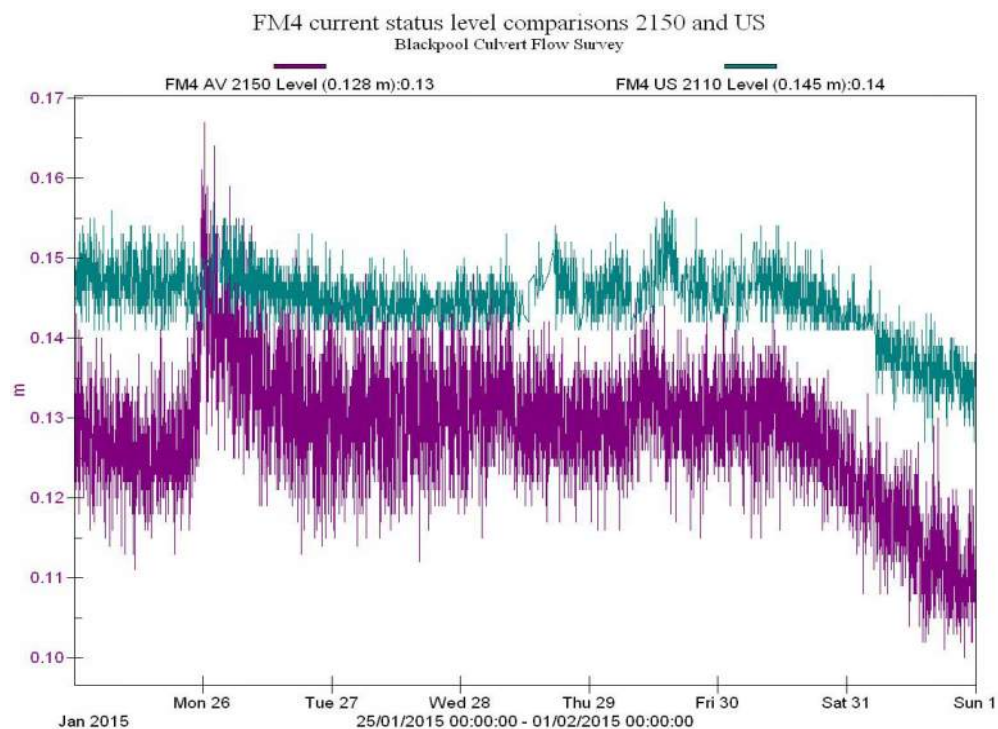
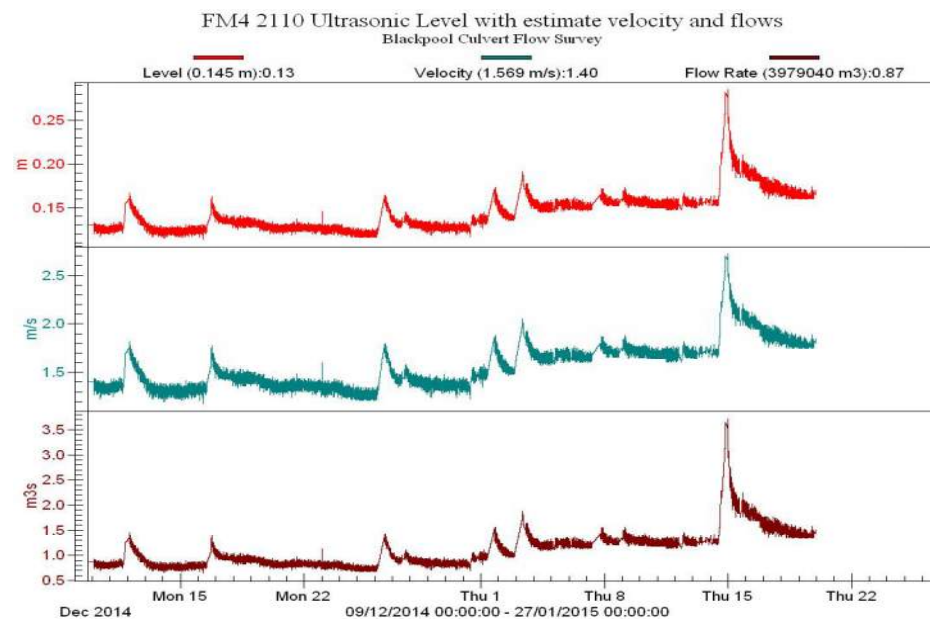


Figure 24 shows the new 2110 ultrasonic level logger data installed in December. It also includes the estimated velocity and flows based on previous algorithms calculated.

Fig 24: FM4 new ultrasonic 2110 level logger Level data and derived velocity and flow

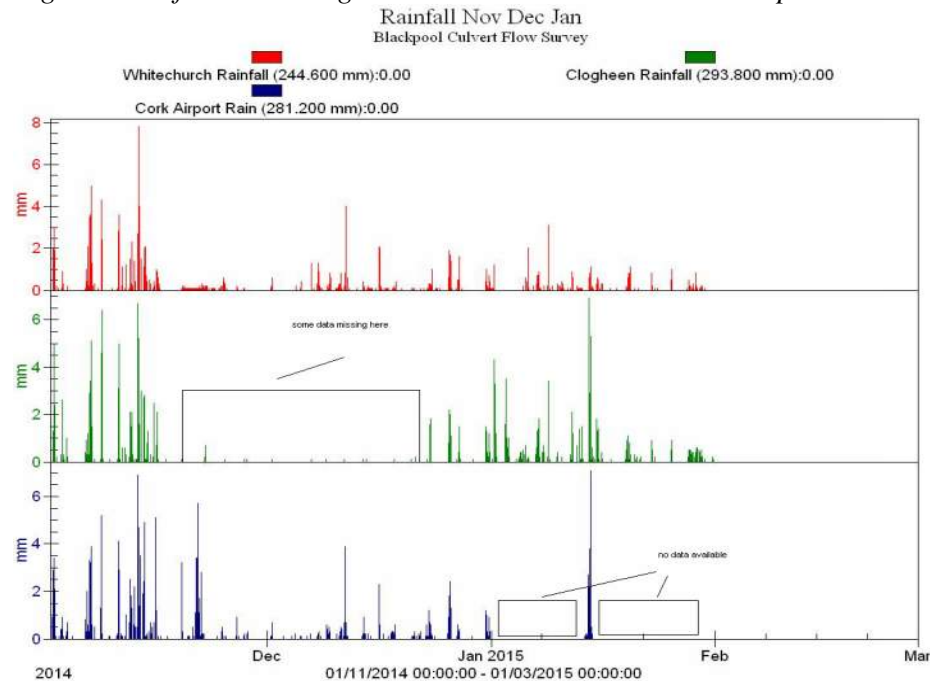


Rainfall Data:

Generally the rain gauges worked well but in the autumn and winter months we encountered regular issues of clogging of the funnel which resulted in some missing data. This issue could occur very quickly so it was difficult to maintain. Unfortunately we missed the event on the 21st November and we rely on Cork Airport hourly data for this event. In the 14th January event the Clogheen Rainfall data was good. At the start of the event it was noted that White church was clogged and this was rectified after but data was not used because the first few hours were missing. Going forward we are considering installing a third rain gauge to provide more data security.

Figure 25 below displays the rainfall data over the last 3 months

Fig: 25 Rainfall data Clogheen White Church and Cork Airport Nov Dec Jan



Current Situation in the Culvert:

At present we have dry conditions in the culvert, Flow calculations of our most recent data at the end of January confirms good flow balancing providing some confidence in previous calculations.

Fig26: Recent Dry weather flows in culvert with flow balancing

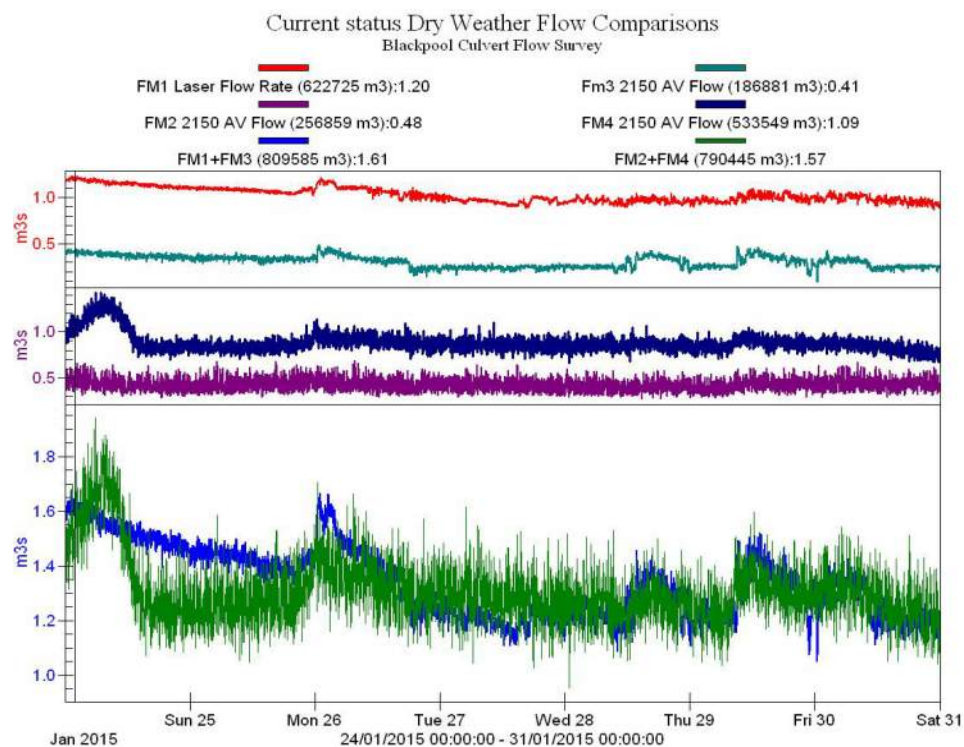


Figure 27 below displays the calculated totals between 25th and 31st of January with flow balancing percentages

Fig 27: Flow totals between the 25th and 31st January with flow balancing and percentages

Site Name	FM1 Laser Flow	FM2 4th Nov	Flow Monitor 3.	FM4 stack 190115		
Label	FM1 Laser Flow Rate	FM2 2150 AV Flow	Fm3 2150 AV Flow	FM4 2150 AV Flow	FM1+FM3	FM2+FM4
Units	m3	m3	m3	m3	m3	m3
25/01/2015 00:00	99595.2	37289.6	32911.1	86976.8	132506	124266
26/01/2015 00:00	93288	37168.4	29527.2	72738.8	122815	109907
27/01/2015 00:00	93019.7	37281.7	27816.8	78394.8	120837	115677
28/01/2015 00:00	83298.3	36309.3	20969.5	74459.5	104268	110769
29/01/2015 00:00	83282.9	35026.7	25229.9	73834.3	108513	108861
30/01/2015 00:00	85706.4	36135.5	26574.4	75288.6	112281	111424
31/01/2015 00:00	84534.8	37647.6	23852	71856.1	108387	109504
Totals	622725.3	256858.8	186880.9	533548.9	809607	790408
%	76.92%	31.73%	23.08%	65.90%		

These recent calculations would indicate that 58.75% of the Bride River flow entering the culvert at FM1 is crossing the bifurcation to FM4- Limerick Road in relatively dry weather conditions. This is significantly higher than calculations during wet weather which has calculated between 29 and 45 % of flow crossing the bifurcation for the three most recent rain events analyzed. This percentage has increased over the three analyzed rain events which could be due to the additional debris gathering at the entrance at FM2 – old brewery channel.

Fig 28: Flow crossing bifurcation from FM1 to FM4 in January dry weather analyses.

Crossing Bifurcation from FM1 to FM4		365866.5	58.75%
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Blackpool Culvert- Data Analyses and Rainfall Events Nov Dec Jan

Fig 29: recent spot check levels.

date **22/12/2014**

Spot Level checks

Meter	Level	Time	on logger	adjustment	comment
FM1 2150 AV	0.11	23:48	0.1	-0.01	
FM1 Laser	0.1	23:40	0.1	0	
FM2 2150 AV	0.16	n/a	0.167	0.007	
FM2 2110 US	0.18	n/a	0.19	0.01	
FM3 2150 AV	0.06	n/a	0.055	-0.005	
FM4 2150 AV	0.14	00:31	0.098	-0.042	this rectified later
FM4 2110 US	0.14	n/a	0.123	-0.017	

date **19/01/2015**

Spot Level checks

Meter	Level	Time	on logger	adjustment	comment
FM1 2150 AV	0.16 to 0.17	23:40	0.174	0.009	high and turbulent
FM1 Laser	0.14 to 0.15	23:46	0.174	0.029	high and turbulent
FM2 2150 AV	0.27	12:50	0.296	0.026	high and turbulent
FM2 2110 US	0.27	n/a	0.317	0.047	high and turbulent
FM3 2150 AV	0.06	n/a	0.064	0.004	high and turbulent
FM4 2150 AV	0.17 to 0.24	00:20	0.175	0.055	wave at probe
FM4 2110 US	0.15 to 0.16	n/a	0.175	0.02	high and turbulent

date **22/01/2015**

Spot Level checks

Meter	Level	Time	on logger	adjustment	comment
FM1 2150 AV	0.15 to 0.17	23:18	0.123	-0.037	some ragging
FM1 Laser	0.14 to 0.17	23:20	0.141	-0.014	moving level
FM2 2150 AV	0.24 to 0.26	23:21	0.256	0.006	moving level
FM2 2110 US	0.26 to 0.28	23:22	0.24	-0.03	moving level
FM3 2150 AV	0.1 to 0.12	n/a	0.08	-0.03	wave in front of probe
FM4 2150 AV	0.2 to 0.22	23:24	0.117	-0.093	to be confirmed on next entry
FM4 2110 US	0.18 to 0.2	23:26	0.147	-0.048	to be confirmed on next entry

This report was compiled by Finbarr O Riordan Water Technology Ltd.

Blackpool Flow Survey:

Summary Report on Rainfall event April 25th Friday evening

Significant rain shower started at 7 pm approx with level increase in culvert recorded at 8 pm approx.

Rain recorded over next 10 hours was as follows:

(editing; 3 x rain gauges adjusted time by one hour for summer time)

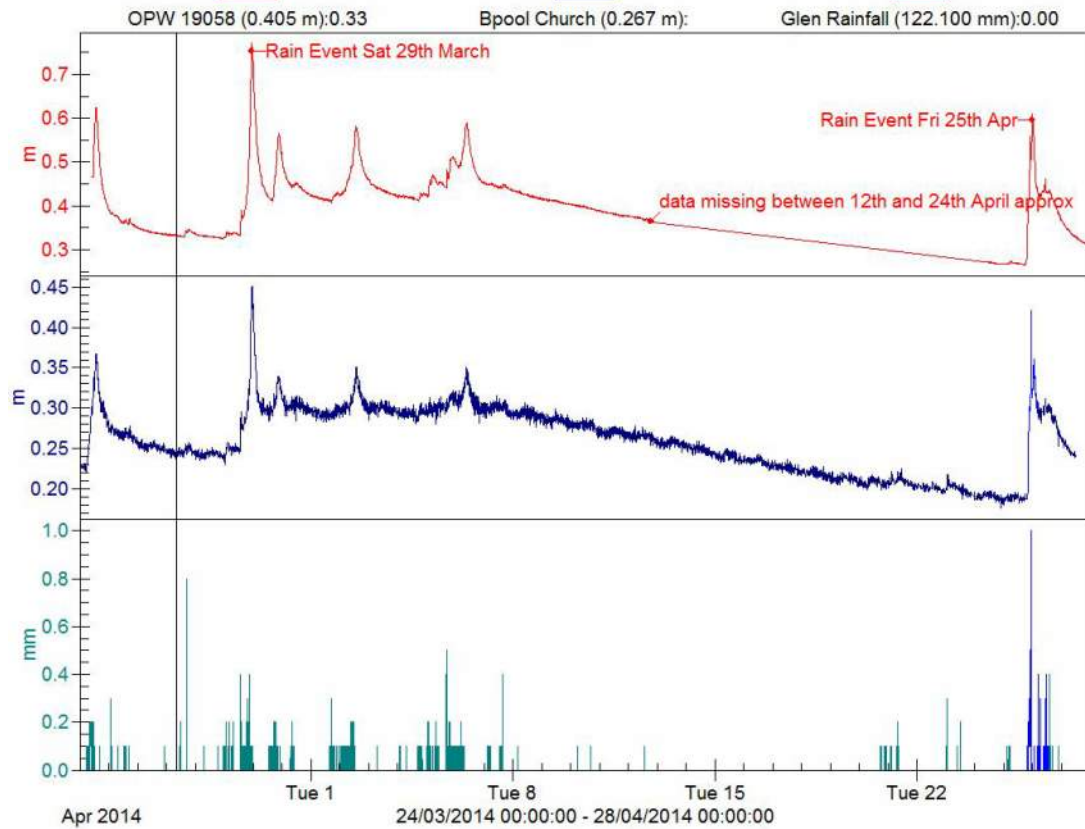
	Glen River RG 5.	Clogheen RG 4.	White Church RG 1.
	Rainfall	Rainfall	Rainfall
	Glen Rainfall	Clogheen Rainfall	Whitechurch Rainfall
	mm	mm	mm
25/04/2014 18:00	0	0	0
25/04/2014 19:00	1.7	0.8	2.2
25/04/2014 20:00	5	4.3	5.2
25/04/2014 21:00	5.4	4.3	6.5
25/04/2014 22:00	7.1	3.9	9.9
25/04/2014 23:00	0	0.1	0.1
26/04/2014 00:00	0.1	0	0
26/04/2014 01:00	0	0	0
26/04/2014 02:00	0	0.1	0
26/04/2014 03:00	0	0.2	0.2
Totals	19.3	13.7	24.1

Note that this rain event was after a period of relatively dry weather and levels were low in Bride River prior to this. The following graph of both OPW 9058 gauge and level logger installed at Blackpool bridge at start of survey work shows that higher event occurred back in March 29th when the water levels were higher due to significant rain previous.

(no editing)

Blackpool

Level Loggers March April 2014



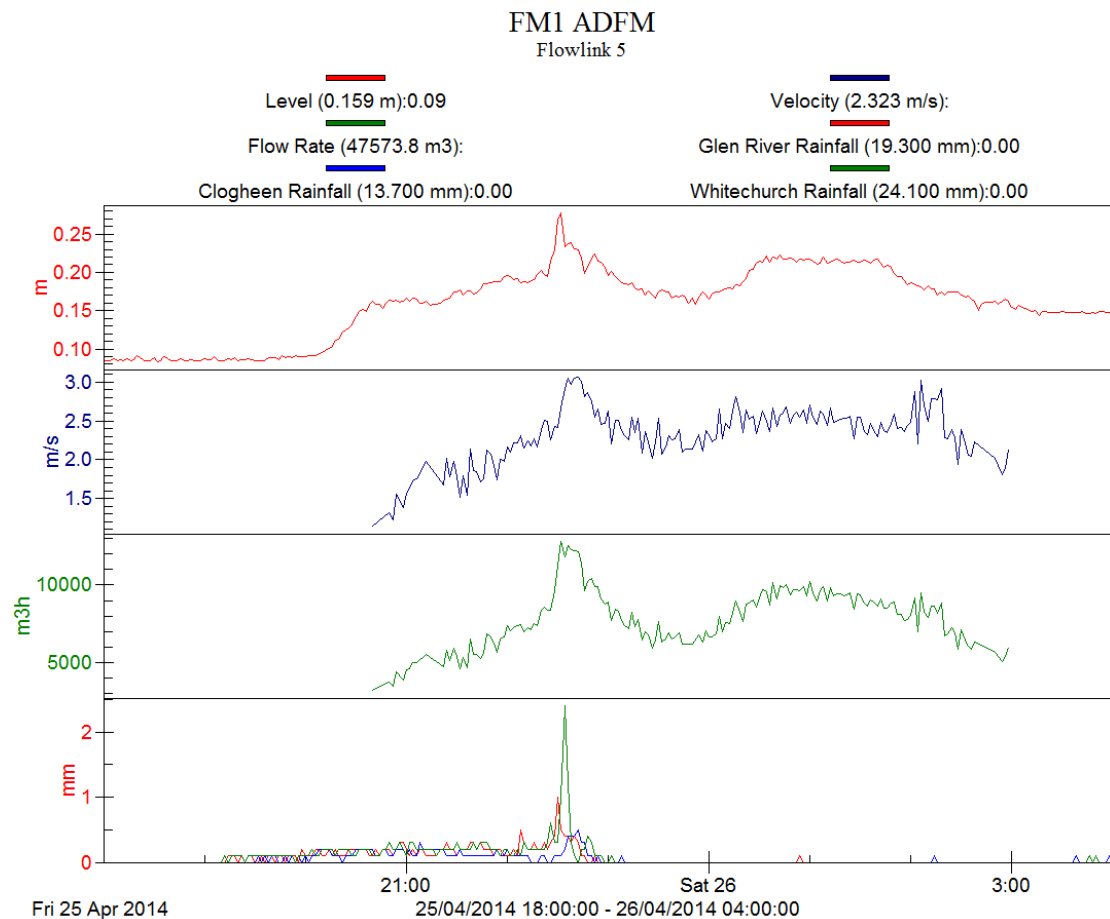
The ADFM velocity profiler set up at FM1 picked up the event. The velocity readings kicked in as expected when the level went above 0.16 metres approx.

max velocity recorded : 3m/s on ADFM at 10:32 pm

max level on ADFM : 0.268 metres at 10:32 pm

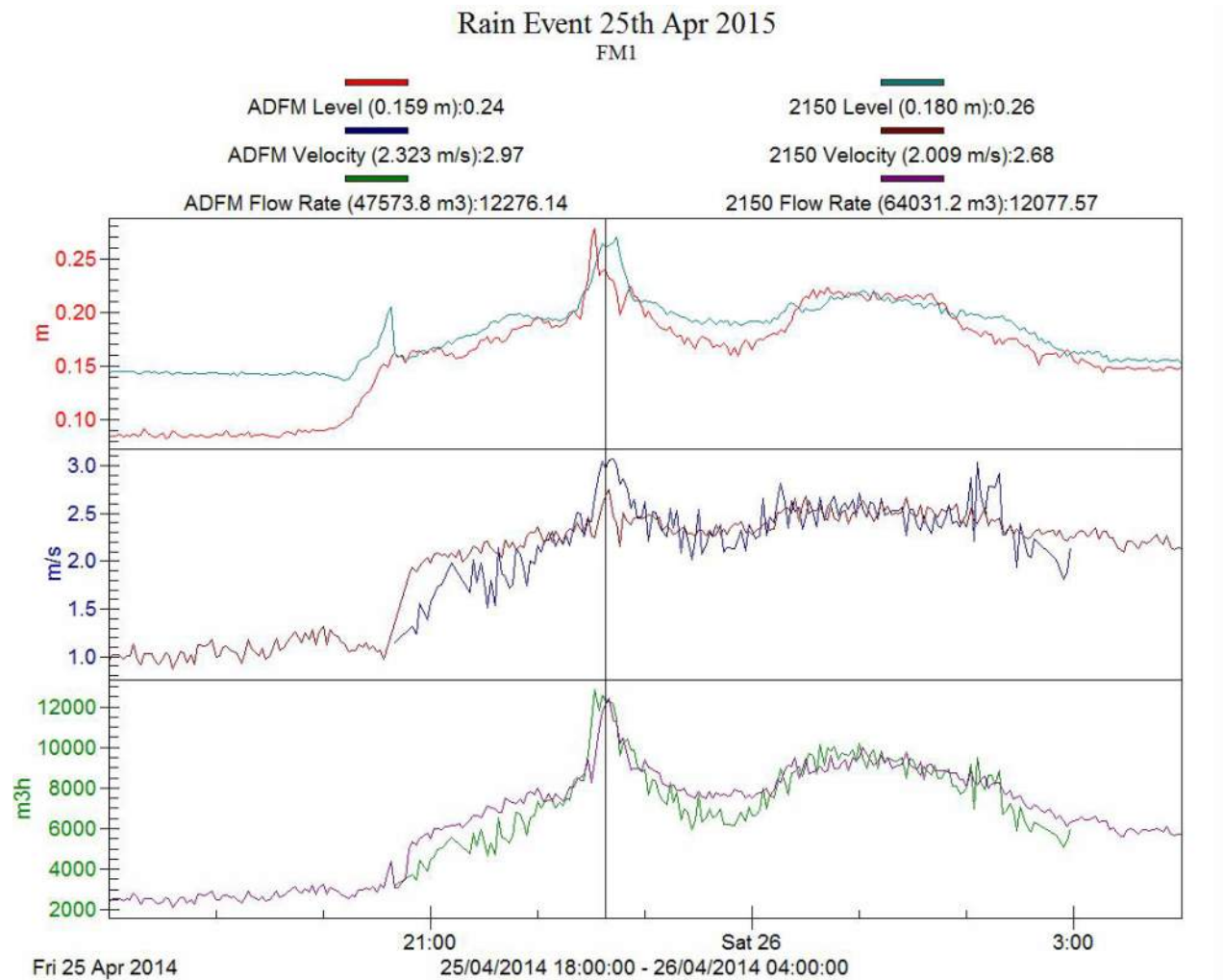
max flow: : 12,564 m³/hr at 10:32 pm

(no editing of ADFM, rain gauges time adjusted by one hour for summertime)

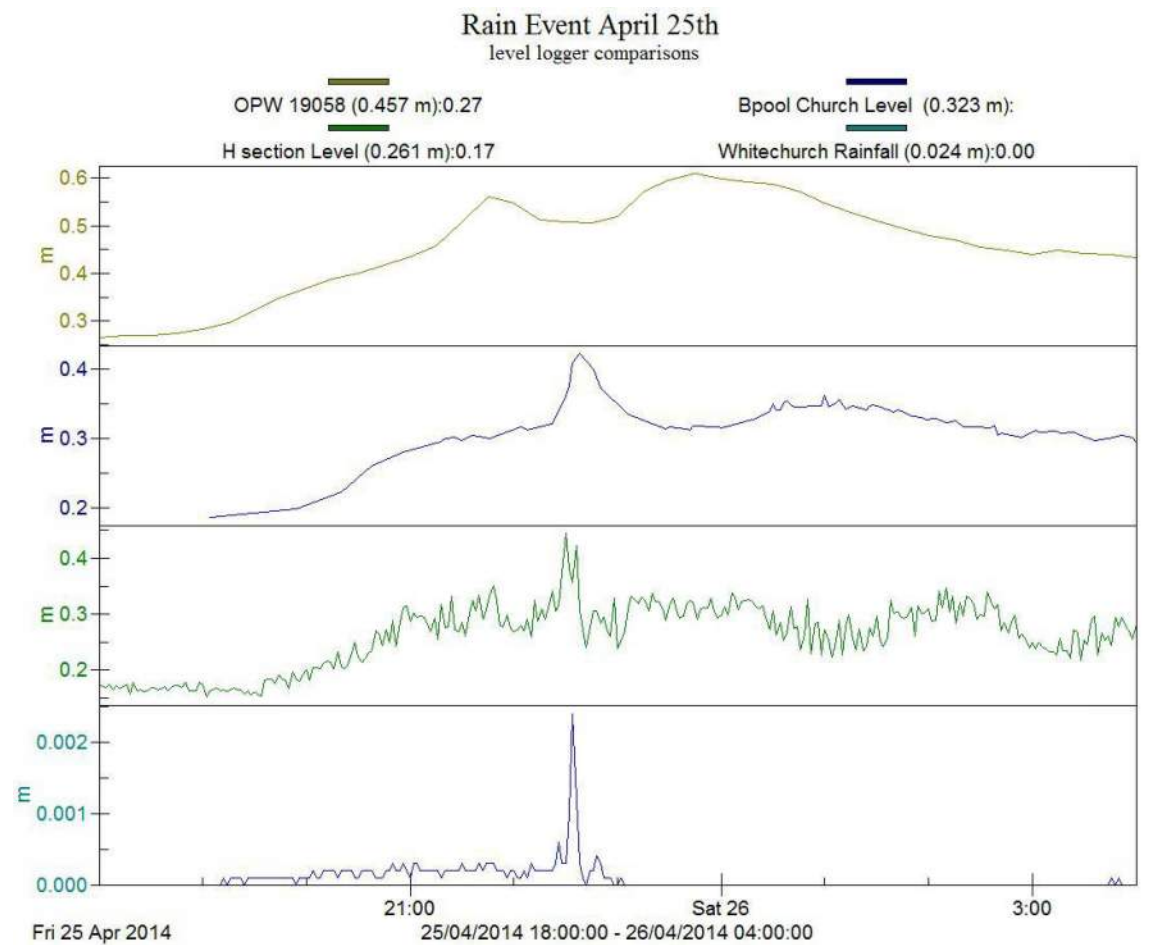


The 2150 Area Velocity Logger is installed adjacent to the ADFM at FM1 and it also picked up the event and correlated well to the ADFM.

(no editing)



3 level loggers are compared in the following graph



max level recorded at OPW 19058 was 0.609 metres at 11:45 pm

max level recorded at Blackpool Church was 0.42 at 22:38

max level recorded in H section in Culvert was 0.361 at 22:30

(editing: WTL H section level logger and rain gauge time adjusted by one hour for summer time)

FM2- Brewery Channel:

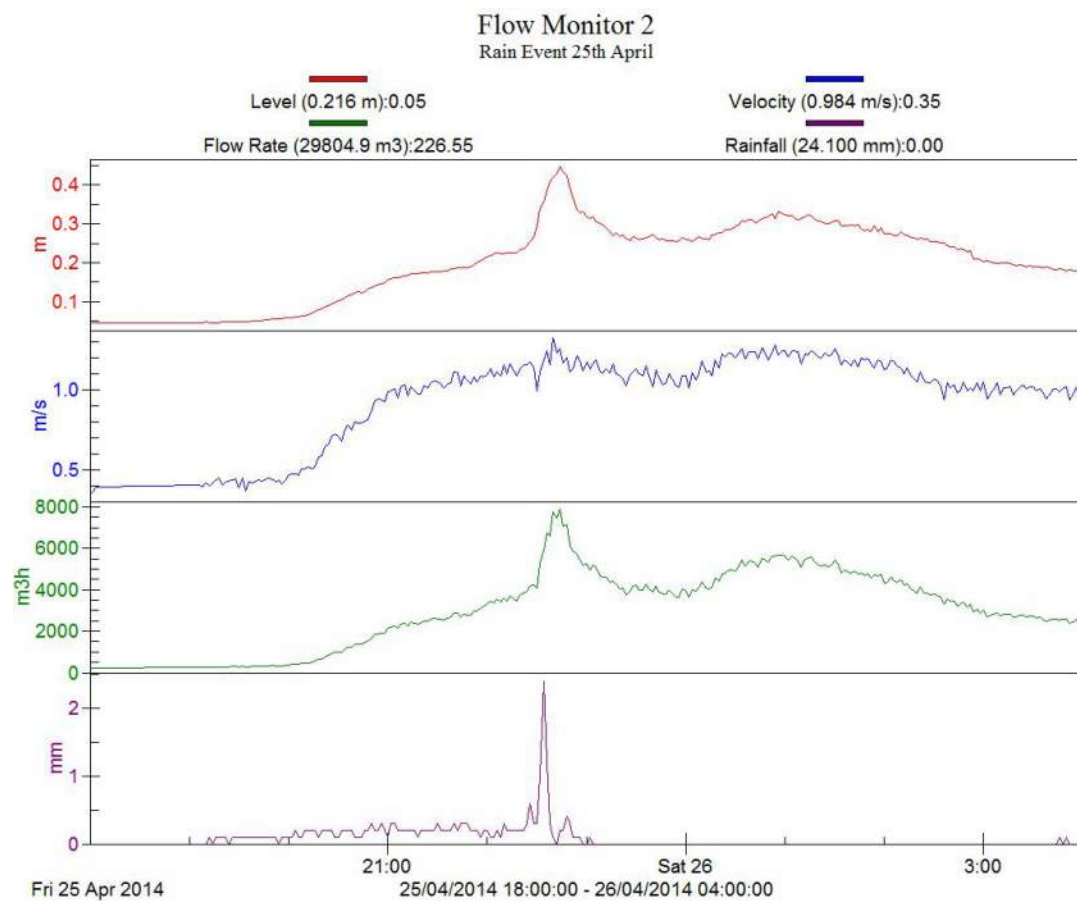
Event was picked up well at FM2 Brewery Channel:

Max level 0.447 metres at 10:40 pm

max velocity 1.32 m/s at 10:40 pm

Derived flow data may be unreliable due to uneven channel floor at measuring point.

(editing: one hour correction for summer time)



FM3- Upstream culvert N20

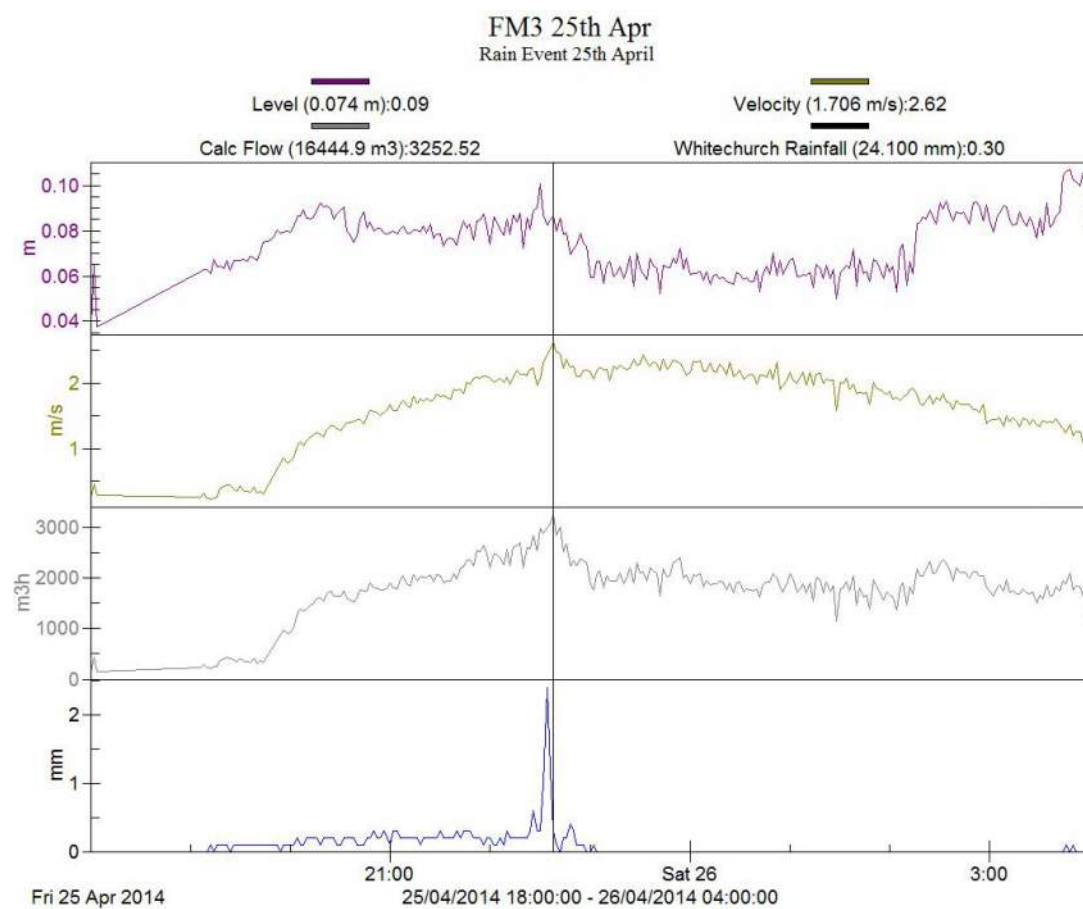
The event was picked up at FM3 with a good velocity profile , however some of the level data appears somewhat erratic. This could be due to some debris catching on the probe temporarily.

max level of 0.074 at 10:30 pm

Max velocity of 2.52 m/s at 10:36 pm

derived max flow rate 3,073 m³/hr at 10:36pm

(editing: level adjusted to reference during profiling on 23rd , flow derived from adjusted level, one hour time correction for summer time).

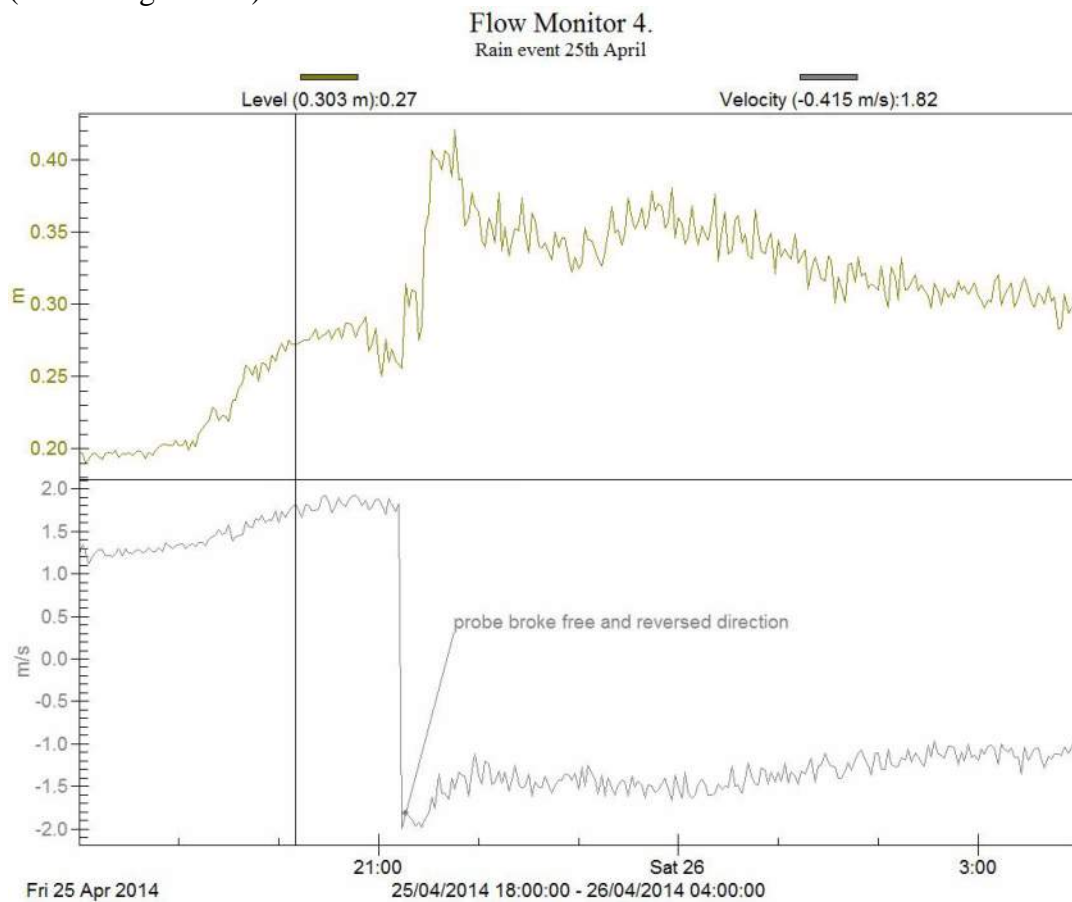


FM4 - Downstream culvert N20 :

Unfortunately it would appear that the AV probe has become dislodged and has gone into a reversed position. This may have been hit by a stone or something hard travelling at high velocity.

While editing is possible we cannot be sure of peak levels so there is probably no advantage to deriving data by reversing velocity.

(no editing of data)



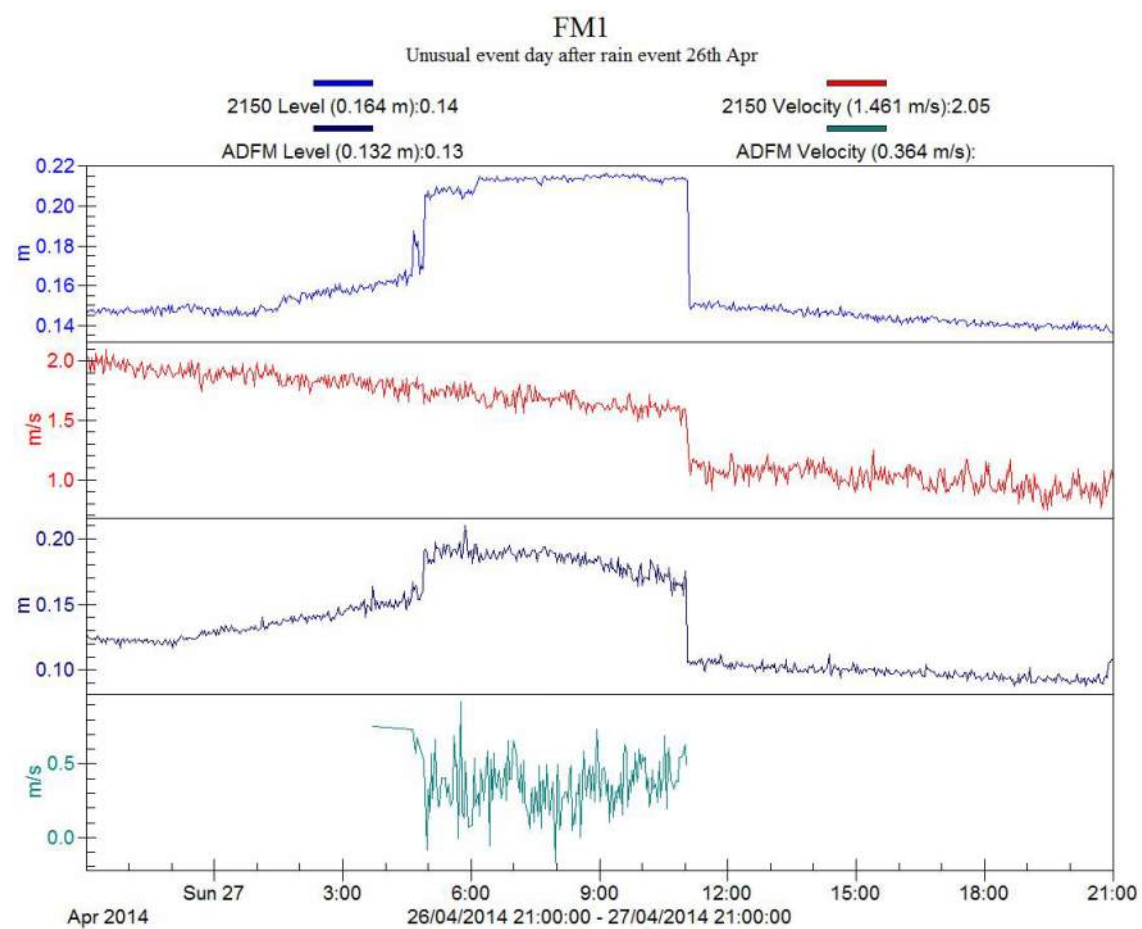
Unusual Event at FM1 after initial rain event:

An unusual event occurred at 5 am approx on the 26th the day after the rain event the previous day. A sudden level increase was recorded by both the FM1 2150 and FM1 ADFM. No other loggers recorded an increase and rainfall was negligible.

The velocities were different and it is unusual that velocity stepped down suddenly with level. ADFM only logs velocities above 0.16 metres approx.

Due to the fact that both loggers detected this indicates it was a real event.

One possible theory here is that something large came down like a branch of a tree for example and got caught in the vicinity of the probes for the period of the event and finally freed itself. If this lodged slightly upstream of the probes it could have caused a standing wave which increased level but also a critical flow section at probes maintained high velocity at 2150 side. This may have been sweeping across the channel from the ADFM side which might explain the vary velocities and also the step down when it finally moved on.



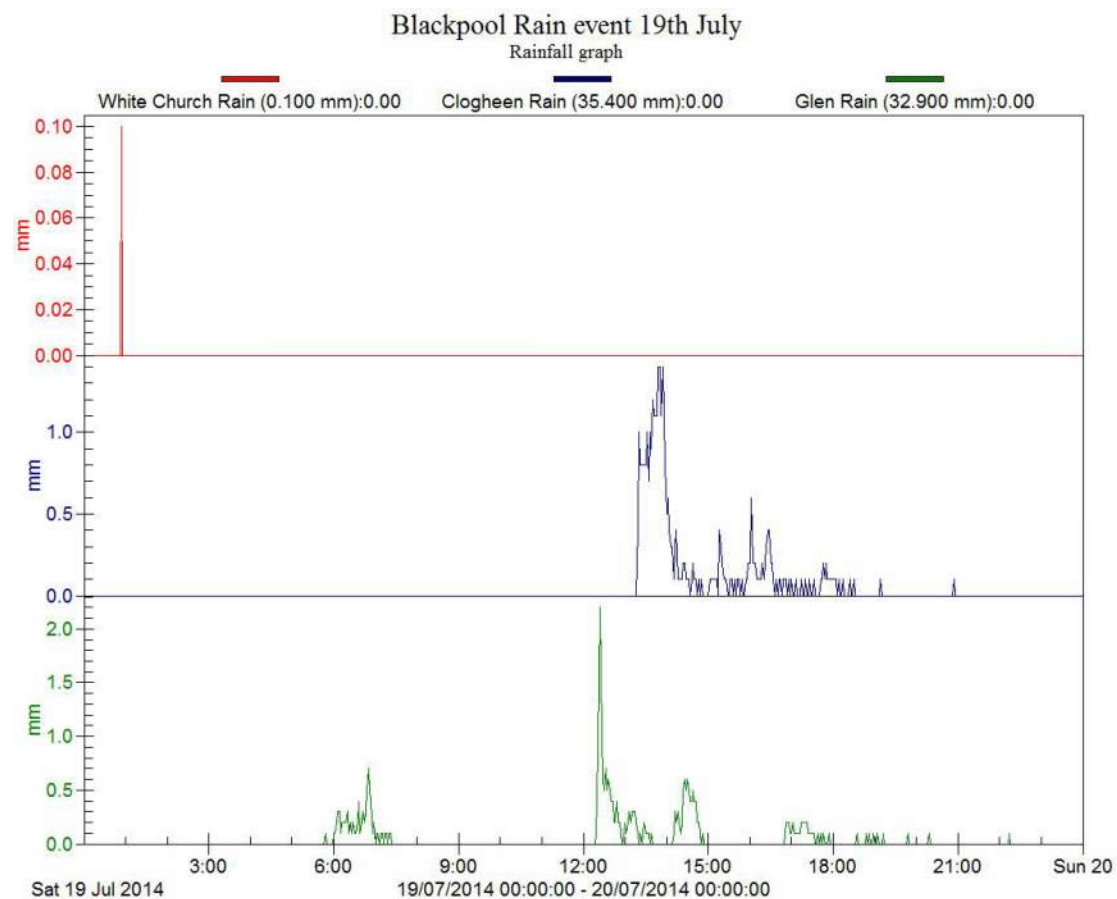
this report was compiled by Finbarr O Riordan
Water Technology Limited
30th April 2014

Blackpool Flow Survey:

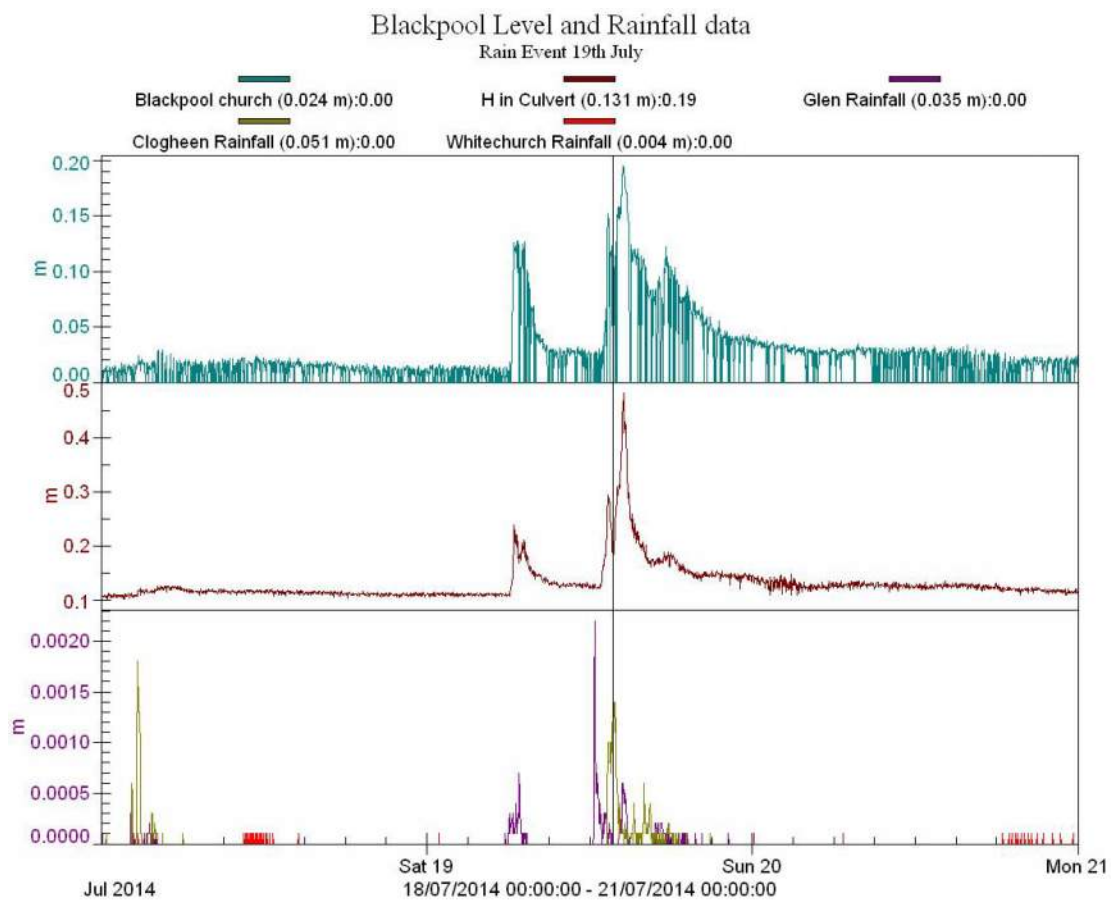
Summary Report on Rainfall Event Saturday July 19th

Significant rain shower started at around midday on Saturday 19th July and lasted until around 18:00 approx.

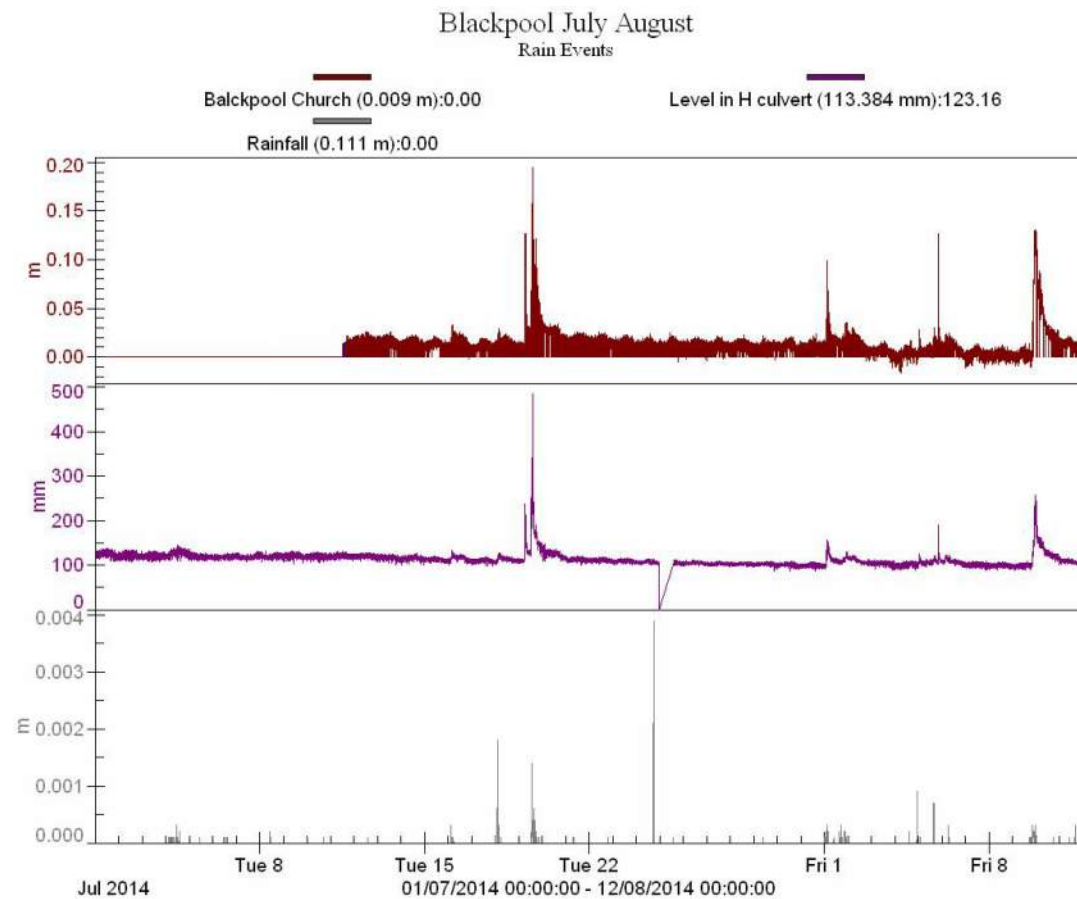
Clogheen Rain gauge read 35.4 mm while the Glen River recorded 32.9 mm. It emerged after investigating further that the Whitechurch rain gauge was not working at the time as the funnel had clogged up with leaves.



This 19th July rain event did have the highest level recorded in July with a peak level of .48 metres in the H culvert recorded for a short period. This is comparable with levels reached last March and April in rain events although the pre-event baseline levels were higher back in March and April. Levels under the bridge at Blackpool are not comparable to previous events since the conditions have changed since the whole area was cleaned, and in general levels are now lower under the bridge.

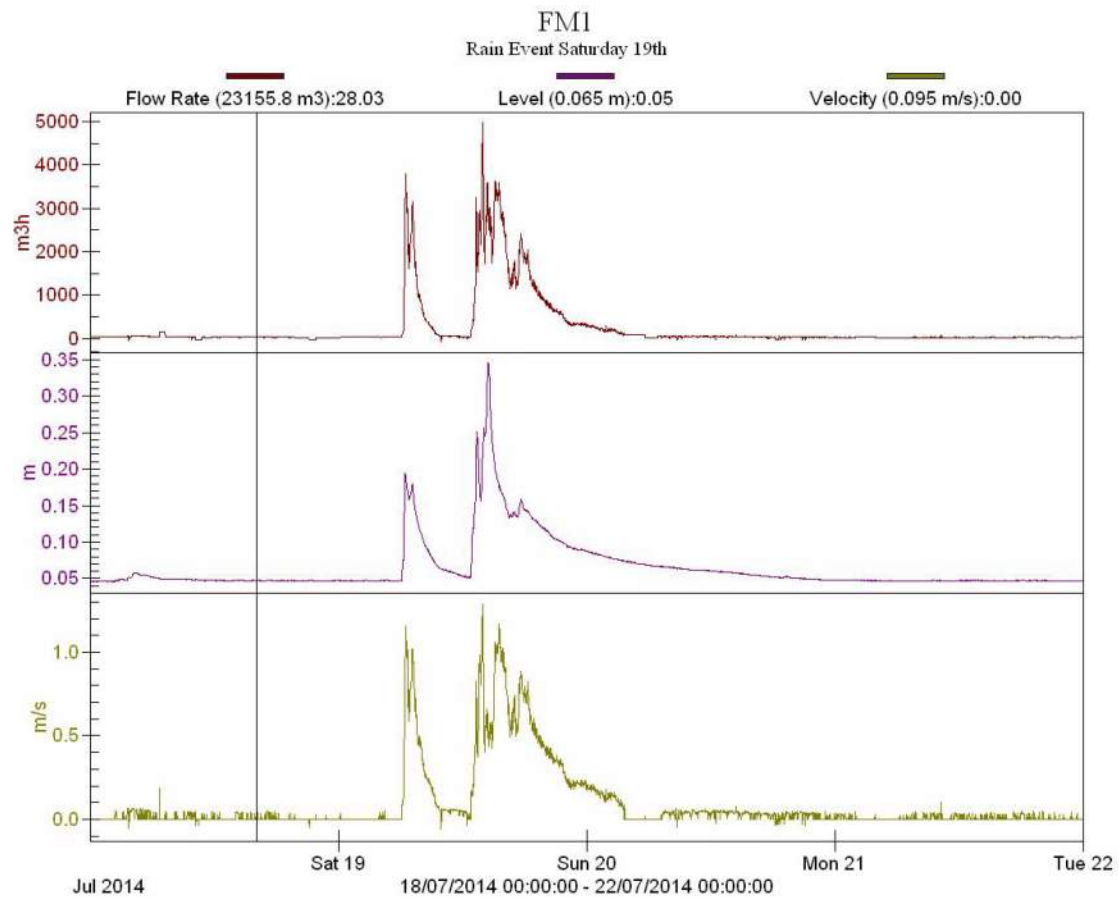


The following graph , shows the 19th July event is higher than other events in July and the start of August.

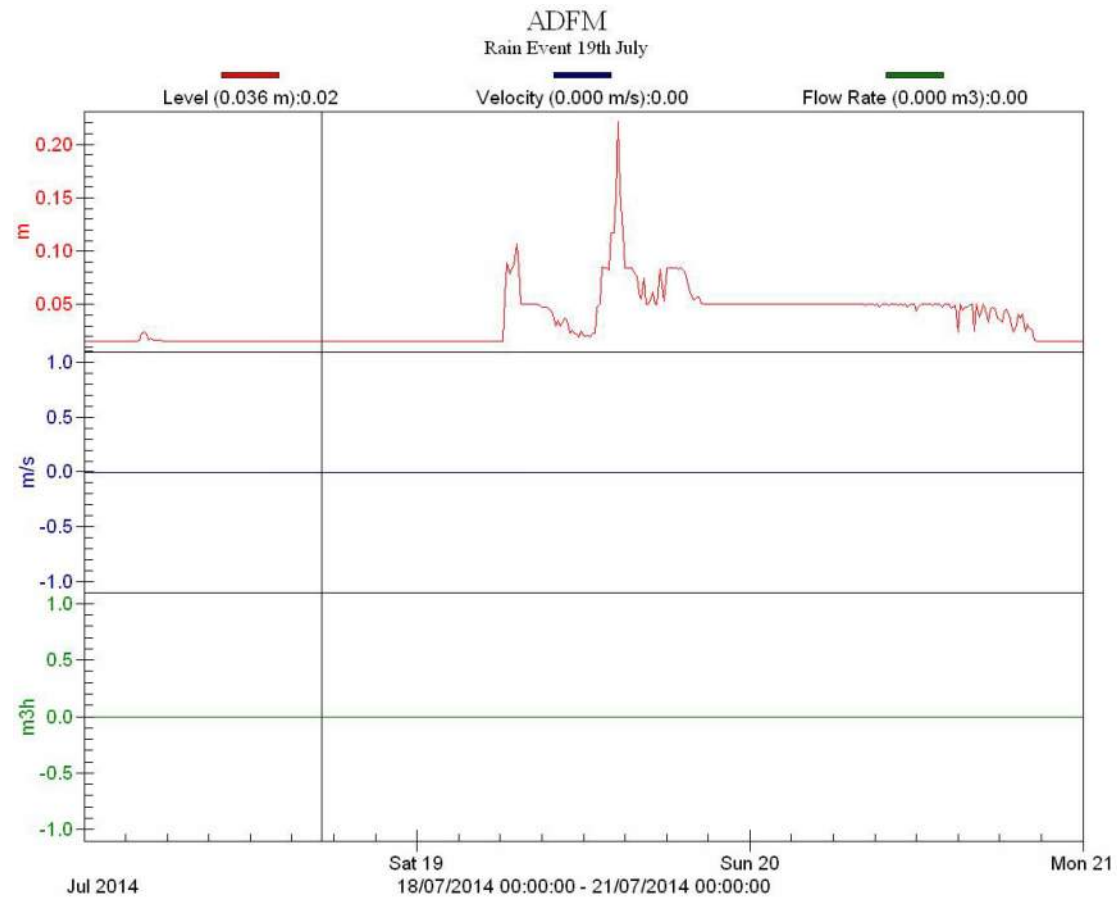


FM1 :

The event on the 2150 AV flow logger was picked up as below: While the trend looks good the velocity rate is less than expected which may indicate fouling at the front of the probe.



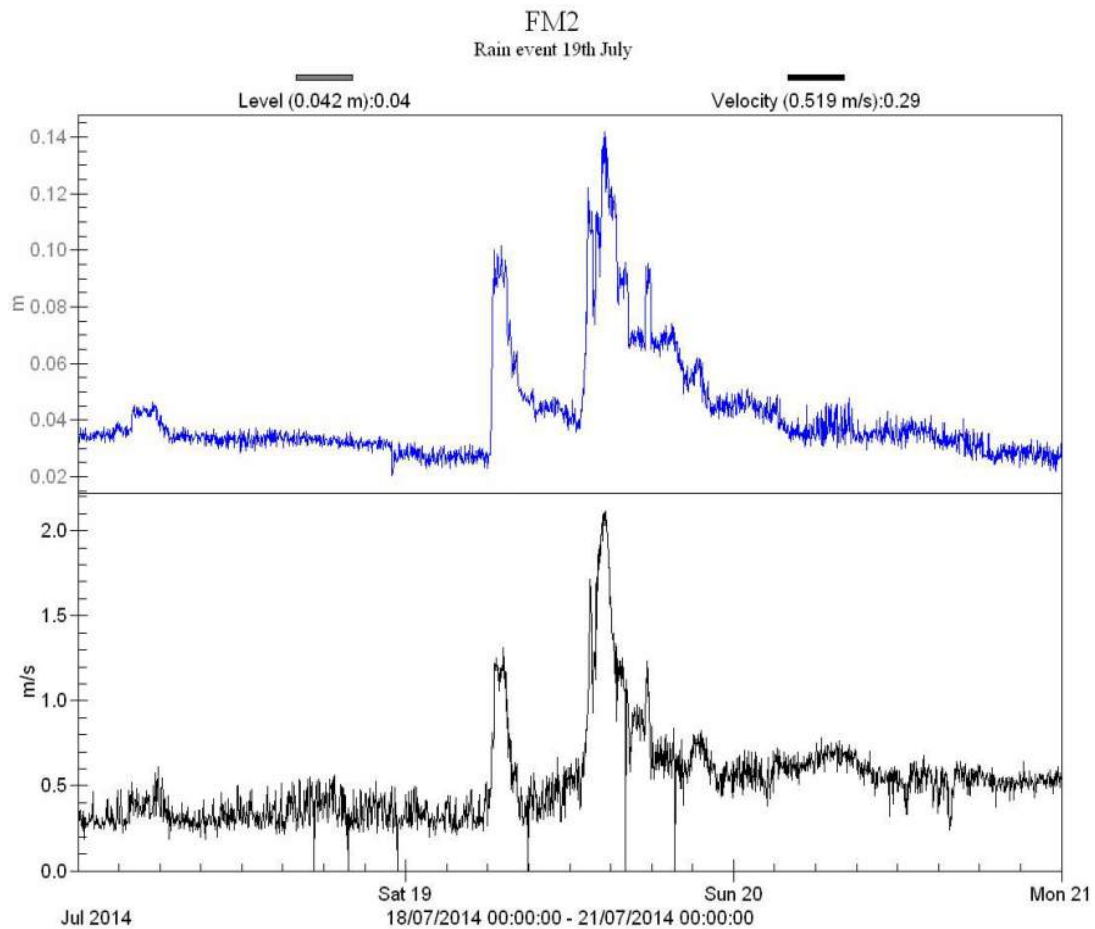
The level recorded by the ADFM logger exceeded the minimum required depth of 0.15 meters for a short period, however no velocity data started recording. It is not clear whether this was due to the fact that period was too short or whether there was some issue.



FM2: Brewery Line

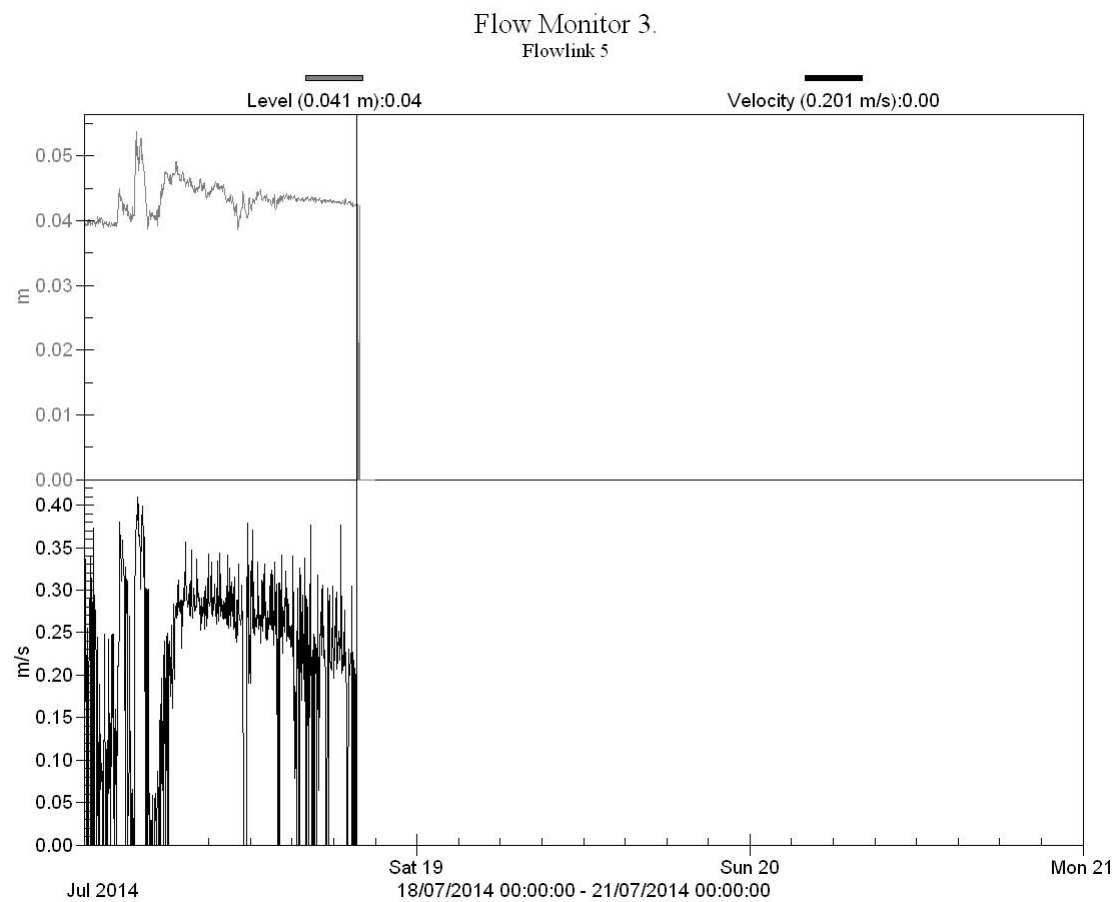
Level and velocity data recorded at FM 2 can be seen in graph below.

In general we are recommending that it is best to estimate the flow rates at FM2 by subtraction of FM1+ FM3-FM4 as the flows in the brewery channel are irregular due to the uneven floor surface.



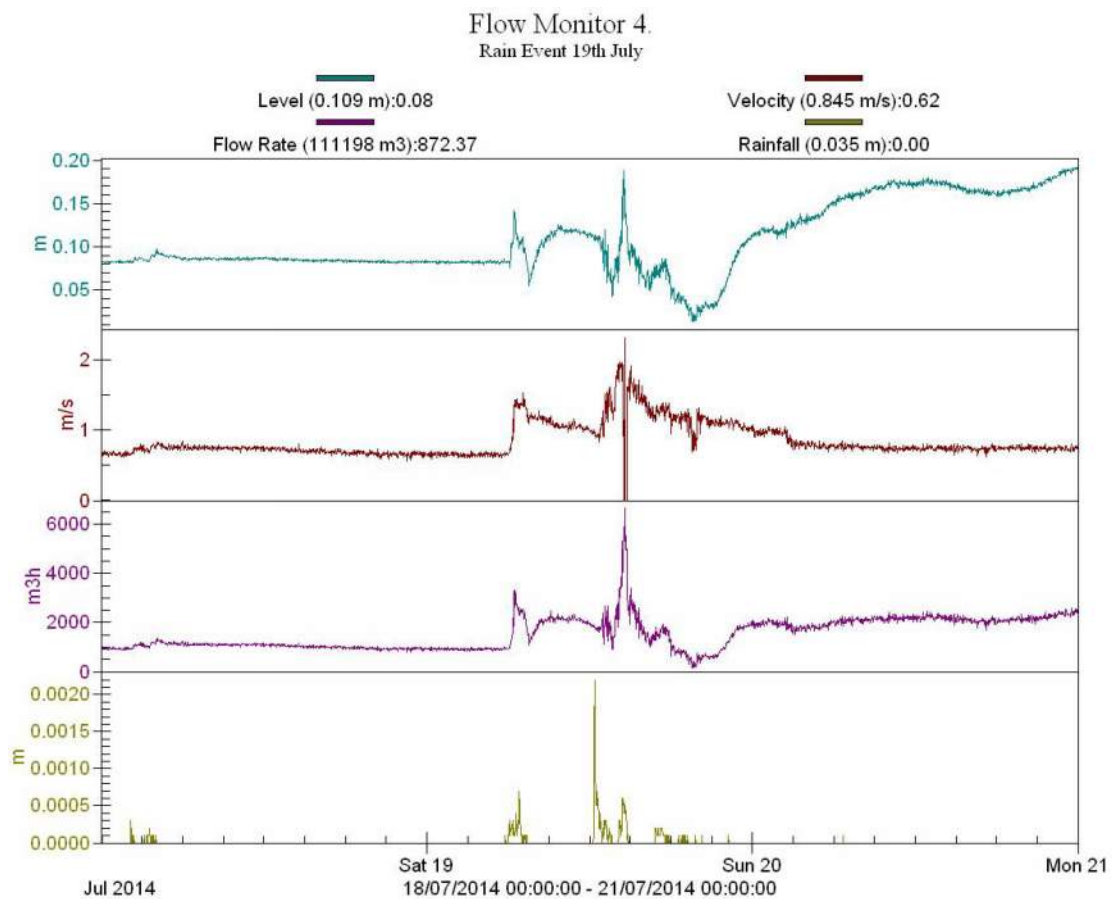
FM3- Upstream culvert N20

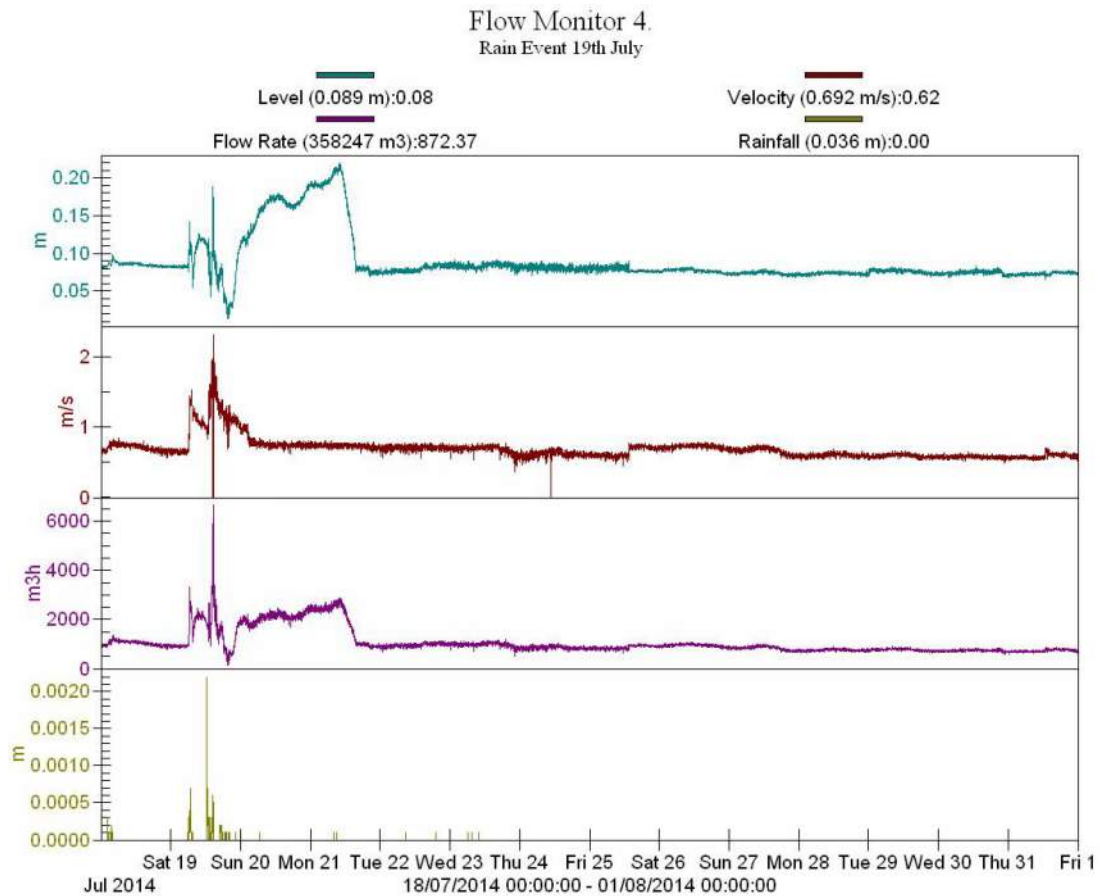
Unfortunately the battery power failed at FM3 prior to the 19th July event.



FM4 - Downstream culvert N20 :

The event was picked up FM4 however there the graph trend would indicate that there was significant fouling. Fouling remained for several days until it was cleared and levels returned to normal as seen in second graph below





Summary:

The conclusions after this event were as follows:

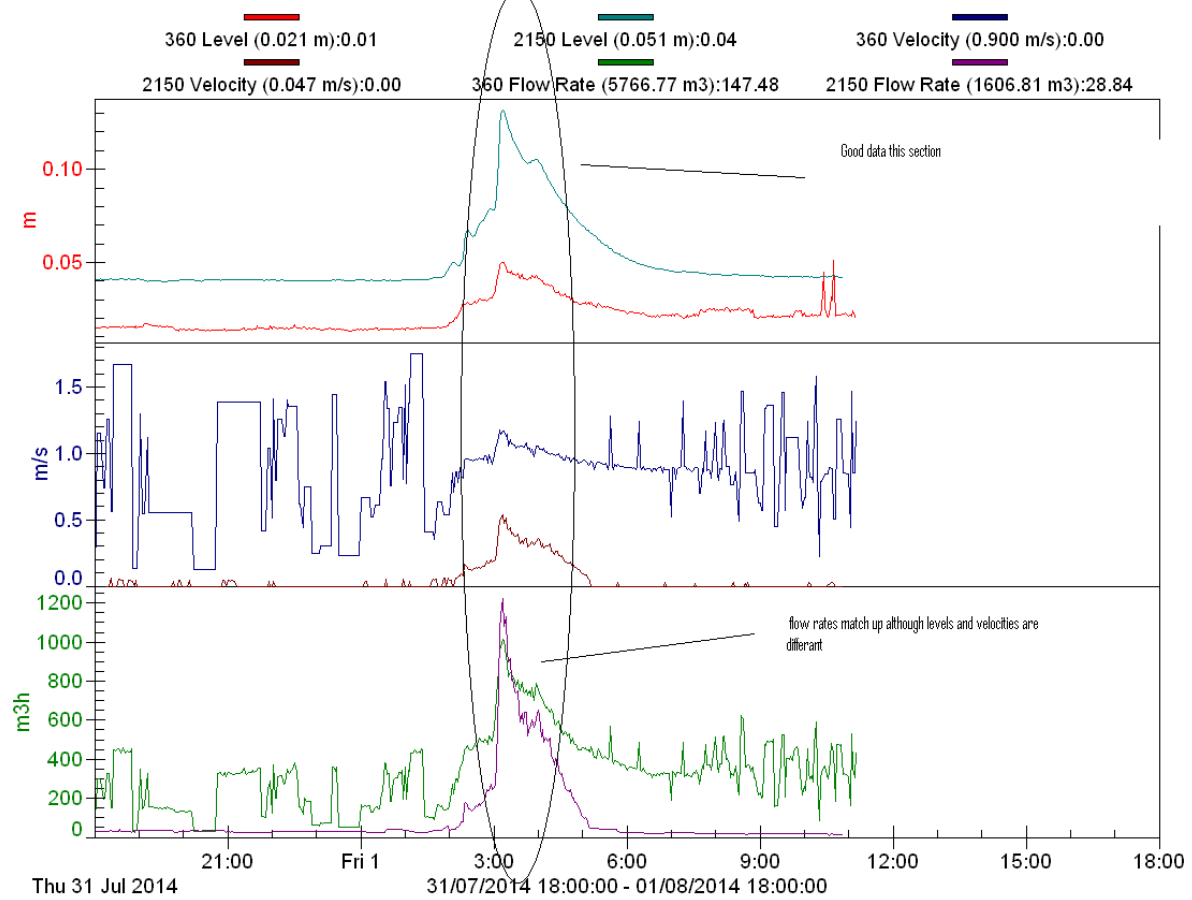
- 1/ clogging of Whitechurch Rain gauge needs to be rectified immediately
- 2/ An entry is required to clear all debris and check levels.
- 3/ ADFM needs to be removed from Culvert and tested in depths above 0.15 meters to ensure it is working correctly.

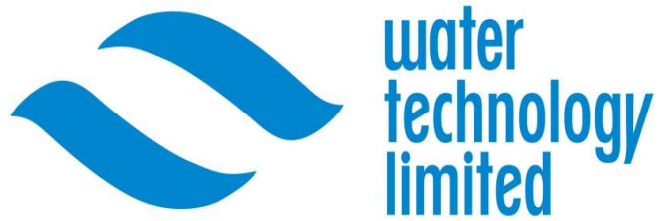
this report was compiled by Finbarr O Riordan
Water Technology Limited

360 Laser versus 2150 rain event 1st August

Flow Monitor LSR

Flowlink 5





Blackpool Flow Survey: November 2014 Report

Summary Report on two major Rain Events on 13th and 14th November 2014.

After a dry summer, October and November were wet months resulting in the water levels increasing. Levels recorded in the river Bride at Blackpool church had increased from 0.13 metres to 0.3 metres between the start of October and the 12th November with a total rainfall of 260mm recorded over this period approximately, (see Fig 3). The most significant rain event occurred on the 13th November starting at 4 am approx. A second significant event occurred that evening between the 13th and the 14th resulting in a second peak early morning on the 14th. 50mm of rainfall was logged between 13th and 14th , (see Fig 4).

Fig 1: High Flow at the Culvert Entrance at Blackpool Church the morning after second rain event on the 14th November



Levels recorded as high as 0.8 metres on the level gauge under the bridge at the church which is the highest recorded since monitoring started last March. In Fig 1 above, the photograph was taken at 10 am approx on the 14th Nov, when the levels logged under the bridge at this time would have decreased back to 0.4 metres. Thus we can assume the level at the entrance during the previous 14th Nov peak of 0.75 metres logged 4 hours prior to this could have been noticeably higher. There is a standing wave noted on left side of channel in photograph below, (Fig2)

Fig 2: Standing wave at left side of culvert Channel



Blackpool November Rain Event 13th and 14th Nov 2014

Fig 3: Rainfall and Church Level prior to Rain Event (October and up to 12th November)

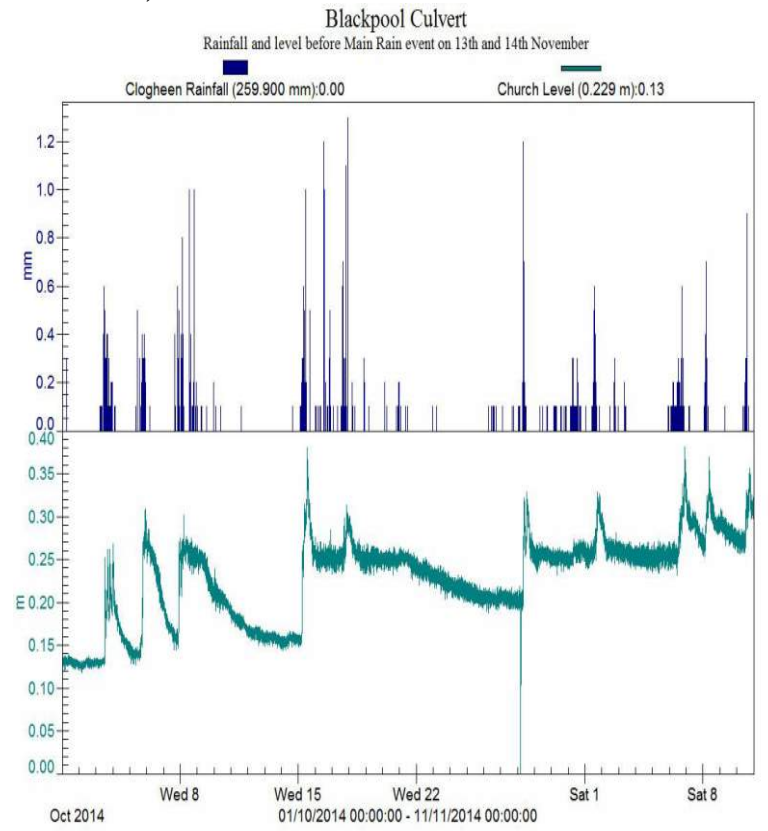
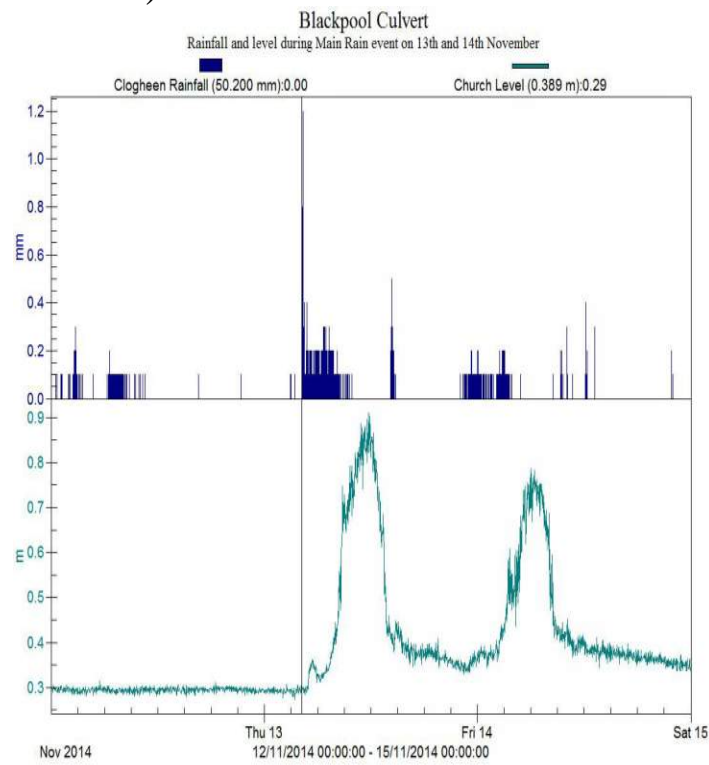


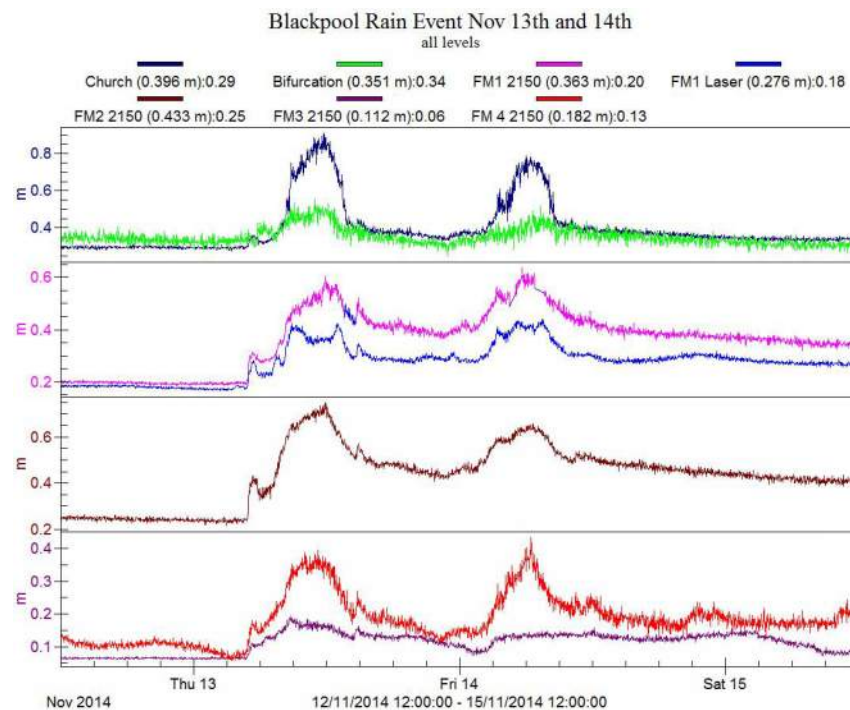
Fig 4: Rainfall and Level at Blackpool Church during Rain Event (13th and 14th November)



All Levels:

In fact levels logged during these two rain events in November were the highest recorded at all locations to date with another noticeable high level of 0.7 metres recorded in the old Brewery Line (FM2- brown line in graph).

Fig 5: All levels recorded during Rain Events on the 13th and 14th November



A peak level of 0.7 Metres was recorded at the FM1 location on the 2150 AV flow logger. However the laser flow meter which is located within a few meters of the 2150 probe recorded a peak of 0.4 metres approx. The laser is mounted directly above the centre of the culvert while the 2150 is more to the side. The data would seem to indicate that there are higher levels at this side of the channel where the 2150 probe is located, although some of this may be due to localised ragging issues or possibly a slight localised standing wave caused by the probe itself during high velocities. The pink, (2150) and blue, (laser) trend above in Fig 5 shows a slightly higher level before the events on the 2150 but a significantly higher level during the event and after. Both the 2150 AV and Laser had good level to velocity profiles with similar flow rate trends. The Laser flow meter has a particularly good level to velocity correlation and in general we have used this data as our benchmark as we can be generally confident that there are no localised debris issues at this measuring location since it is non-contact sensor.

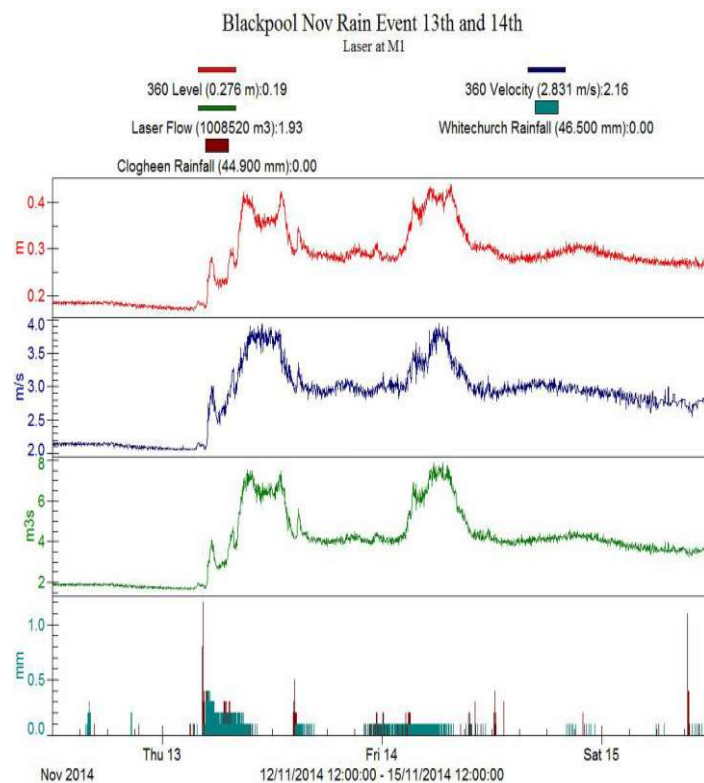
Laser Flow Logger at FM1, (Bride River culvert in from Blackpool Church):

Fig 6: laser Flow Logger at FM1



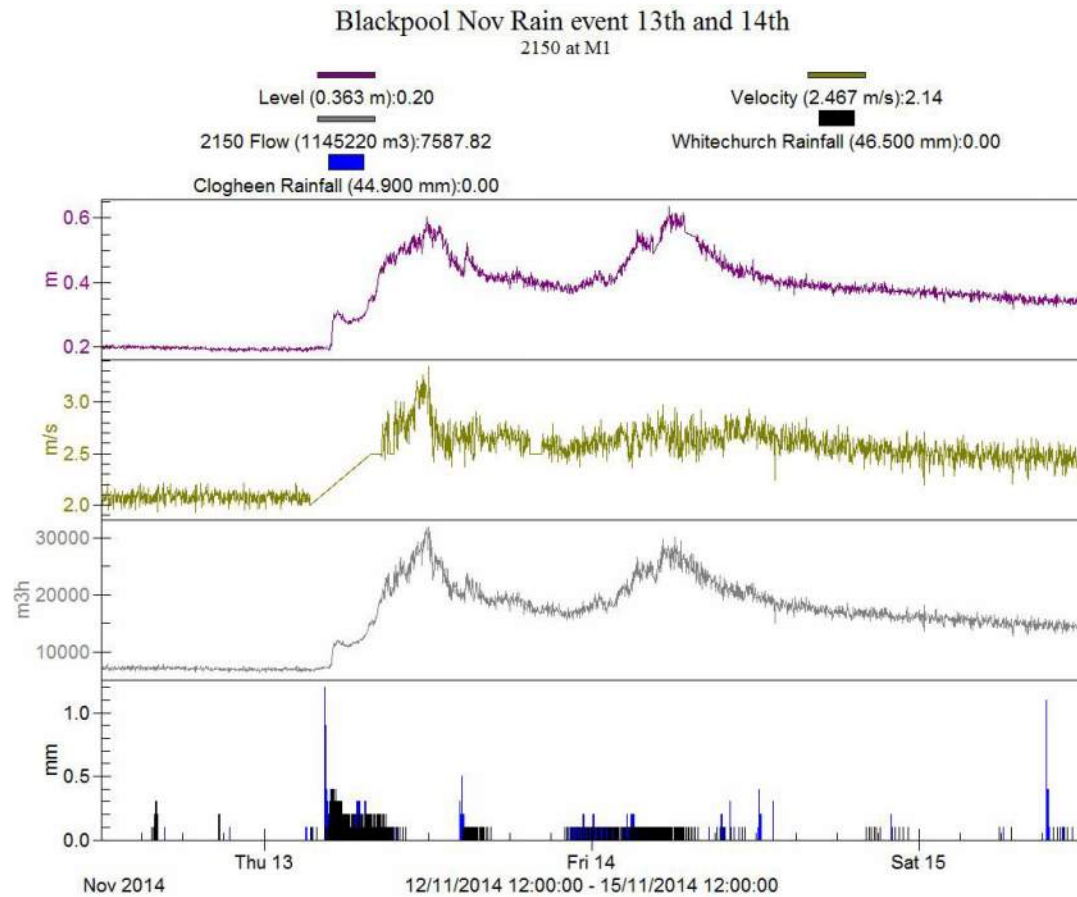
The laser flow logger recorded a peak flow of 7 M3/sec with peak velocity at 3.8 m/s during the first rain event on the 13th Nov. There is a dip in the level in the middle of the peak which may indicate channelling of higher flows to the side of the channel.

Fig 7: Laser Flow Logger Level velocity and flows at FM1 during Rain Events



2150 AV Flow Logger at FM1, (Bride River culvert in from Blackpool Church):

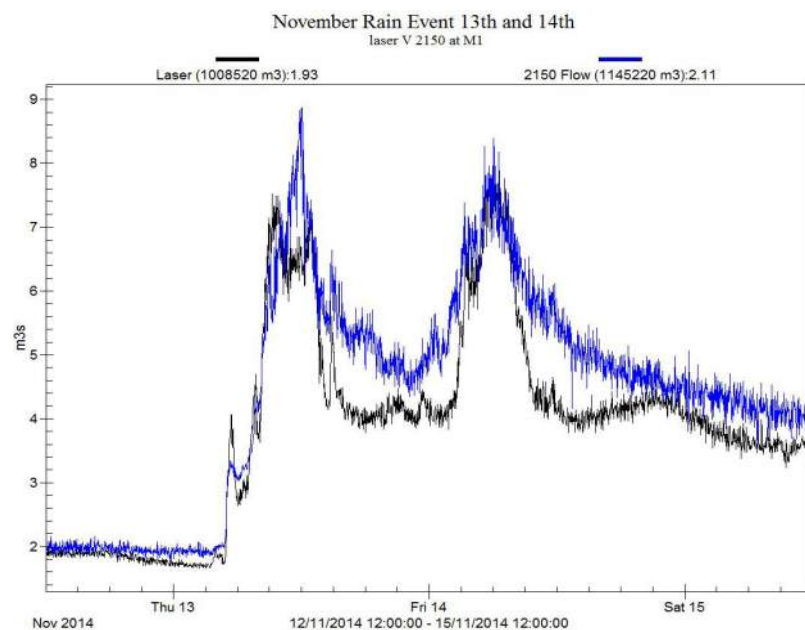
Fig 8: 2150 Flow Logger Level velocity and flows at FM1 during Rain Events



The 2150 Flow logger at FM1 recorded a higher flow peak of 8.4 m³/s during the first rain event. A section of velocity data where we assume the probe fouled or was over turbulent was corrected as seen in the graph at the start of the first rain event on the 13th Nov.

A comparison of flows between the Laser and 2150 at FM1 are seen in Fig 6 below which show a reasonable correlation at the peak flows.

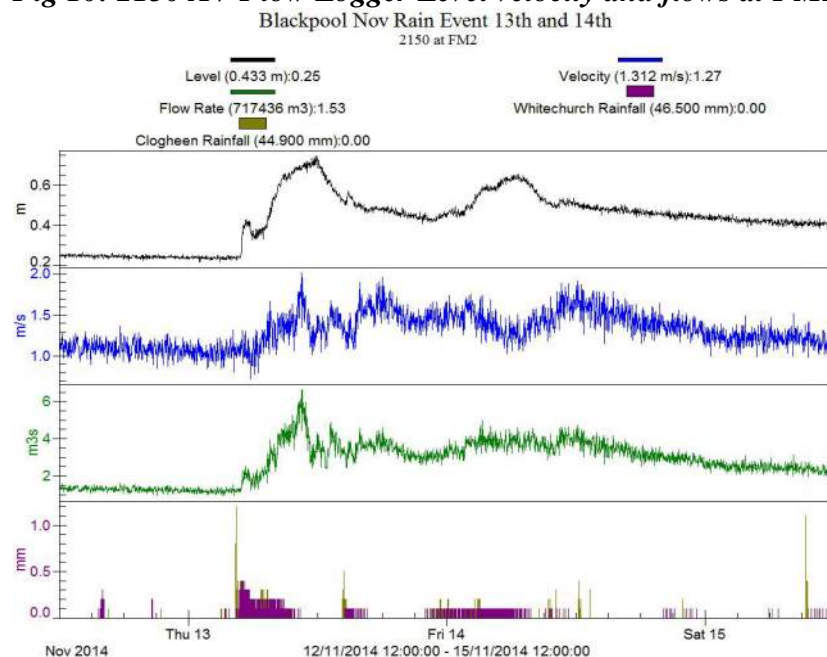
Fig 9 Comparison of flow rates between Laser and 2150AV Logger at FM1 during the two rain events



2150 AV Flow Logger at FM2 (Brewery channel):

Good quality level and velocity data was logged at FM2 with a peak level of 0.7 metres during the rain event on the 13th corresponded with a velocity of 1.9 m/s. The Brewery channel is partly natural with an uneven gravel floor which makes it difficult to estimate flows accurately. However if we assume it to be a standard rectangular channel for estimation it would calculate at a peak flow of 6 m³/sec approx.

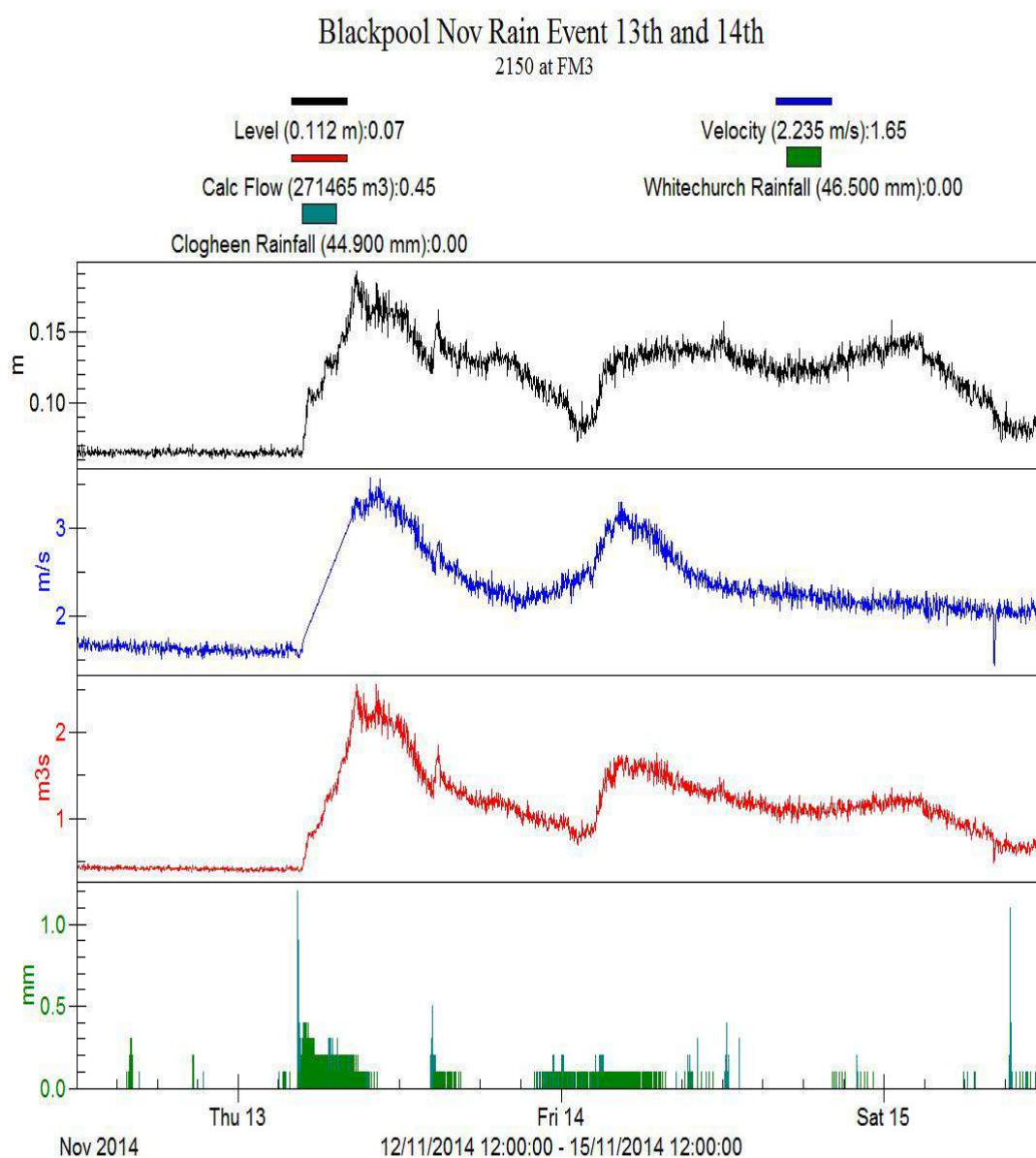
Fig 10: 2150 AV Flow Logger Level velocity and flows at FM2 during Rain Events



2150 AV Flow Logger at FM3 (Limerick Rd –Upstream):

Fig 11 shows the level velocity and data logged during the rain events measured at FM3. Data at FM3 required a small amount of correction of velocity, which appeared to not read for a few hours during the first event, most likely due to ragging. The probe had some rags on the probe when we entered the culvert later on the 16th which may have affected the quality of both level and velocity; in particular the level data was a bit erratic after the events. However, for the most part, the data looked good during the peaks themselves. A peak flow rate of 2.4 M3/Sec was recorded coinciding with a logged velocity of 3.32 M/Sec.

Fig 11: 2150 Flow logger Level, Velocity and Flow data during rain events at FM3



2150 AV Flow Logger at FM4 (Limerick Rd –Downstream):

Velocity data was not useable at FM4 due to ragging shortly into the start of the first rain event, however level data was intact. Due to the fact that all data to date would seem to indicate that flows were free flow without evidence of surcharging we concluded that we could apply a curve fit based on data analysed at FM4 during other events, to produce a reasonable virtual velocity trend. While we did not have points at the high end of the curve, in general the resultant velocity at the high levels seemed to be in line with velocities recorded in FM1 which is a similar channel. We further derived flows based on this velocity result. The resultant peak data during the first event was level 0.34 Metres, derived velocity 3 M/Sec , derived flow rate 4.84 M3/Sec

Fig 12: Virtual Velocity curve derived from manual selected points during ‘good data’ previous events.

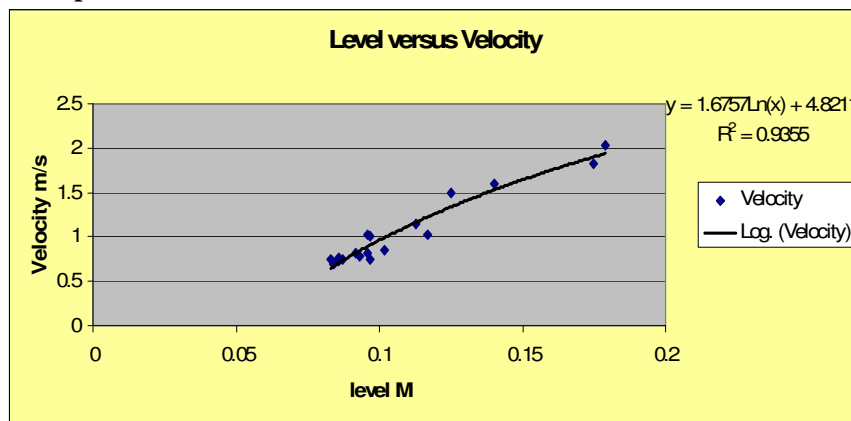
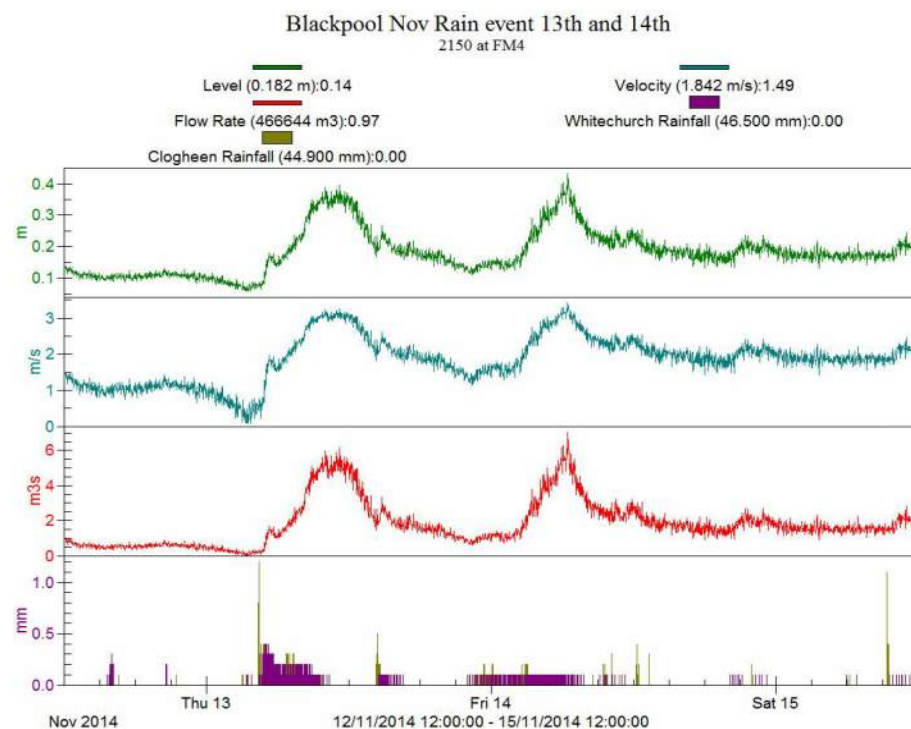


Fig 13: 2150 Flow Logger at FM4 with Level and derived Velocity and Flow data



Flow Balancing:

Fig 14 shows a graph of all flows logged during the Rain Event, noting that in the case of FM2 we are assuming a regular rectangular channel for our estimate and FM4 uses a derived velocity. Fig 15 adds the flows from FM3 and FM1 and FM4 and FM2 to consider flow balancing.

Fig 14: All Flows during Rain Event

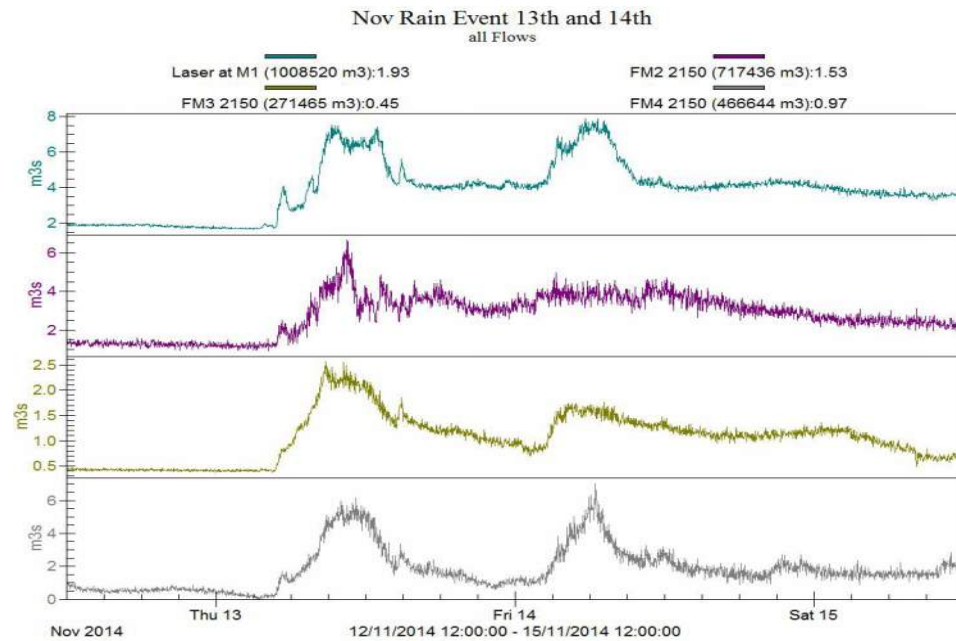
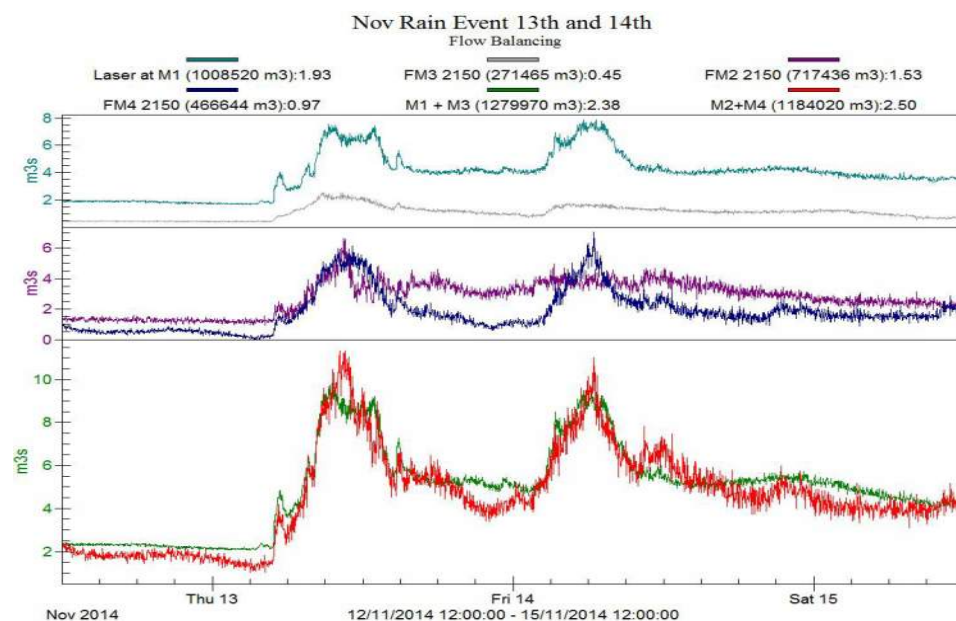


Fig 15: Flow Balancing Estimates by adding Flows



If we assume accuracy with FM1 and FM3, our derived flows at FM2 and FM4 would indicate an 8% underestimation. If we consider the total volumes the flow balancing percentages would calculate as seen in Fig 16 below.

Fig 16: Flow balancing percentages during rain event based on Total Volume FM1+FM3

	Nov 13th and 14th Rain Events					
	Total Volume Estimates					
	FM1	FM3	FM2	FM4	M1+M3	M2+M4
M3	1008520	271465	717436	466644	1279985	1184080
%	79%	21%	56%	36%	100.00%	

The flow estimates would further indicate that 71% of the flow in M1 carried out on down the M2 brewery line, while 29% cross the bifurcation to FM4.

Fig 17 below shows a picture of the bifurcation looking back towards the flow going right to left from FM1 (church culvert), to FM2 , (Brewery). This picture was taken during the entry on Sunday afternoon the 16th November at 16:00 approx.. At this time levels were still relatively high, with Church bridge level at 0.3 metres, Laser level at 0.25 Meters with velocity of 2.46 m/s. The photograph would support the conclusion that the majority of the flow is carrying on down the brewery line at high flows at present.

Fig 17th : Photograph in Bifurcation looking at FM1 to FM2 at 16:00 on Sunday 16th November



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