

# Merthyr Tydfil to Merthyr Vale - Depth and Velocity

Main Report

September 2010  
Environment Agency Wales

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September 2010

Environment Agency Wales

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Rivers House, St Mellons Business Park, St Mellons, Cardiff CF3 0EY

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# Executive Summary

Mott MacDonald was appointed in September 2009 to undertake a 2D flood risk modelling and mapping study of the River Taff from Merthyr Tydfil to Merthyr Vale. The client is the Environment Agency Wales. The project is operating to the Strategic Flood Risk Management Framework 2 (SFRM2) guidelines and specifications.

Aberfan and Merthyr Vale have been identified as flood risk hot spot areas by the Environment Agency Wales. This study has been commissioned to get a better understanding of flood risk in these areas in particular with respect to the onset of flooding and flood hazard.

As defined in the brief, the aim of this study is:

*To produce a 1D/2D model of the study area to investigate the defended and undefended situation over a range of flood events.*

Based on the findings of the Inception Report and subsequent discussions with the Environment Agency Wales a methodology for the Main Stage was agreed which has been followed to provide the deliverables of this study. This Report is the culmination of the Main Stage of this project and describes the hydrological and hydraulic modelling, the flood risk mapping including hazard mapping and the derivation of trigger levels for the hot spot areas.

- Chapter 1 gives a brief introduction to the study area, the objectives of this study and the adopted approach.
- Chapter 2 summarises the findings of the Inception report regarding the hydrometric data together with more details relevant to the selected calibration events.
- Chapter 3 gives an overview of the survey data used for this study.
- Chapter 4 describes the details of the hydrological modelling such as the derivation and calibration of the ReFH catchment models, the estimation of the design peak flows and the development of the design hydrographs.
- Chapter 5 gives the findings of the development and calibration of the hydraulic models.
- Chapter 6 describes the final design models and gives details of the design model runs. The flood maps are discussed.
- Chapter 7 covers the identification of flood threshold levels and their respective trigger levels at upstream gauging stations.
- Chapter 8 finishes the report with a number of recommendations.

# 1. Introduction

## 1.1 Introduction

Mott MacDonald was appointed in September 2009 to undertake a 2D flood risk modelling and mapping study of the River Taff from Merthyr Tydfil to Merthyr Vale. The client is the Environment Agency Wales. The project is operating to the Strategic Flood Risk Management Framework 2 (SFRM2) guidelines and specifications.

## 1.2 Project Background

Historically, flooding has occurred in this area and has affected communities and interrupted communications. Flood Risk Mapping has previously been carried out to indicate which areas are most affected by rising water levels from the River Taff.

Following on from this indicative Flood Risk Mapping, further detailed modelling of the flood risk in key areas has been envisaged by the Environment Agency Wales to complement the existing information. 2D modelling techniques allow a more in-depth analysis of flood risk, not only in terms of flood extent but also in terms of flood hazard.

The area has been the subject of a number of previous flood risk modelling and mapping studies. During these studies 1D models of the River Taff have been developed and refined; the existing Flood Forecasting model will be the starting point for the present modelling study. Further details of previous studies are given in Chapter 2 of the Inception Report.

Aberfan and Merthyr Vale have been identified as flood risk hot spot areas by the Environment Agency Wales. This study has been commissioned to gain a better understanding of flood risk in these areas, in particular with respect to the onset of flooding and flood hazard.

## 1.3 Objectives and Main Tasks

The objectives of this study as stated in the Brief are:

- To identify areas potentially at risk from flooding from the River Taff;
- to produce maps of flood extents, depth, velocity and hazard; and
- to identify trigger levels at Merthyr Tydfil and Merthyr Vale level gauges connected to flooding thresholds in the Aberfan and Merthyr Vale area.

The key tasks are summarised below:

- Determine what existing modelling data of the catchment is available and can be used in the 2D mapping study.
- Determine what new data has become available since previous modelling studies in the catchment were completed.
- Conduct an initial review of previous hydrological modelling carried out in the catchment to determine what further hydrological work needs to be undertaken for the new 2D modelling.
- ~~Conduct a review of existing topographic information and determine what further work is required.~~
- Collect additional information as identified, including on-site survey work if required.

- Produce a 1D and a 1D-2D model of the study area to accurately model the channel and floodplain for the 5yr, 10yr, 15yr, 20yr, 50yr, 75yr, 100yr, 100yr+20% for climate change, 200yr and 1000yr design events under the defended scenario.
- Produce a 1D and 2D model of the study area to accurately model the channel and floodplain for 100yr and 1000yr design events under the undefended scenario.
- Produce channel and floodplain water level, velocity and depth information for all modelled design events to produce hazard maps of the 2D domain.
- Produce flood outlines for all modelled design events (defended and undefended).
- Determine the Areas Benefiting from Defences for the 100yr event.
- Determine trigger levels for flood thresholds at Aberfan and Merthyr Vale.

## 1.4 Catchment description

The River Taff originates in the Brecon Beacons, south of Pen-Y-Fan as two tributaries, the Taff Fechan and the Taff Fawr. Both tributaries flow southwards through the Brecon Beacons to Merthyr Tydfil, where they join to form the River Taff. This catchment totals approximately 183km<sup>2</sup>. The Taff then flows southwards to Cardiff and finally drains into Cardiff Bay and the Severn Estuary.

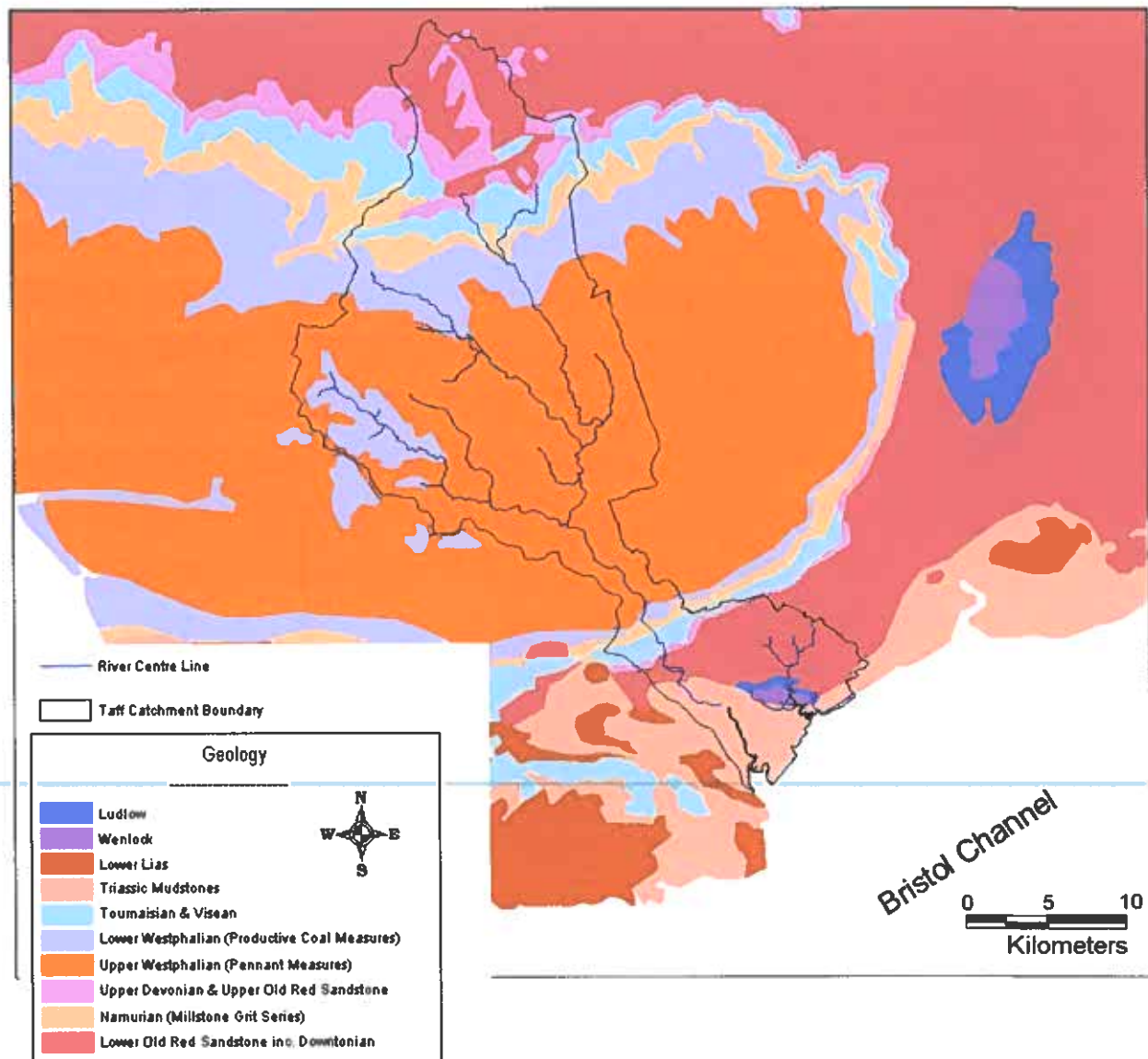
The Taff has an average gradient of 1:100 from its source to the Severn Estuary. The steep, mountainous upper catchment and urbanised valley floors result in a flashy catchment, with the river levels rising very rapidly in response to heavy rainfall.

Within the upper catchment there are a series of water supply reservoirs, the largest being the Llwynon Reservoir on the Taff Fawr supplying water to Cardiff, and the Ponsticill on the Taff Fechan supplying water to Merthyr Tydfil. These regulate flow downstream, by storing water in the winter, with potential to reduce flood discharges, (depending on initial reservoir level), and maintaining flows in the summer, through compensation releases.

The coal resources within the catchment have led to substantial industrialisation in the area. The catchment as a whole is affected by significant historic mine workings and mine-water discharges, and industrial abstractions and discharges. For the same reasons, the groundwater flow regime has been affected by the creation of a network of shafts and adits. As a result of the relief of the catchment, most of the villages and transportation routes are concentrated along a narrow corridor following the line of the river valley.

The River Taff rises in the Old Red Sandstones and Carboniferous Limestone of the Brecon Beacons, and then flows through an area underlain by coal measures for much of its course. Further downstream, the geology is mudstone with significant alluvium deposits in the valleys. Figure 1.1 illustrates the geology of the catchment. Although the Carboniferous Limestone is recognised as a major aquifer, and the Coal Measures and Triassic strata are minor aquifers with local importance, the contribution of groundwater is modest to even low flows. Thus, river levels fall quite rapidly in dry periods.

Figure 1.1: Geology of the River Taff Catchment



Source: Environment Agency Wales, Processed by MM

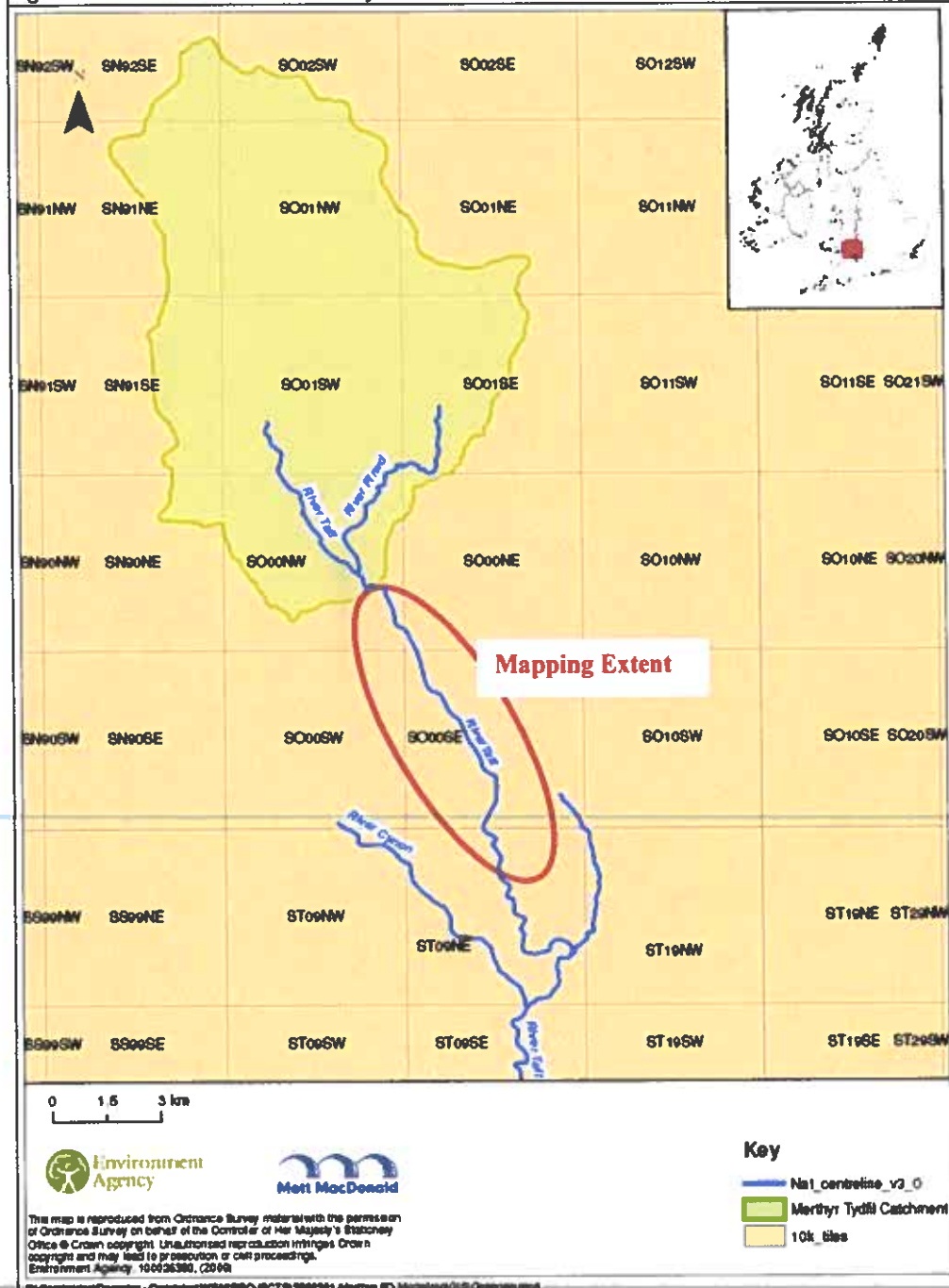
## 1.5 Modelling Extent

Figure 1.2 shows the study area together with the area specified for Flood Risk Mapping.

The reach of the River Taff for which Flood Risk Mapping is required extends from the gauge at Merthyr Tydfil (NGR 304308 206814) to downstream of Aberfan (NGR 307660 199050).

The main catchment draining into the River Taff at Merthyr Tydfil is also shown in Figure 1.2.

Figure 1.2: Overview of Study Area



Source: Environment Agency Wales, Processed by MM

## 2. Hydrometric Data

### 2.1 Overview

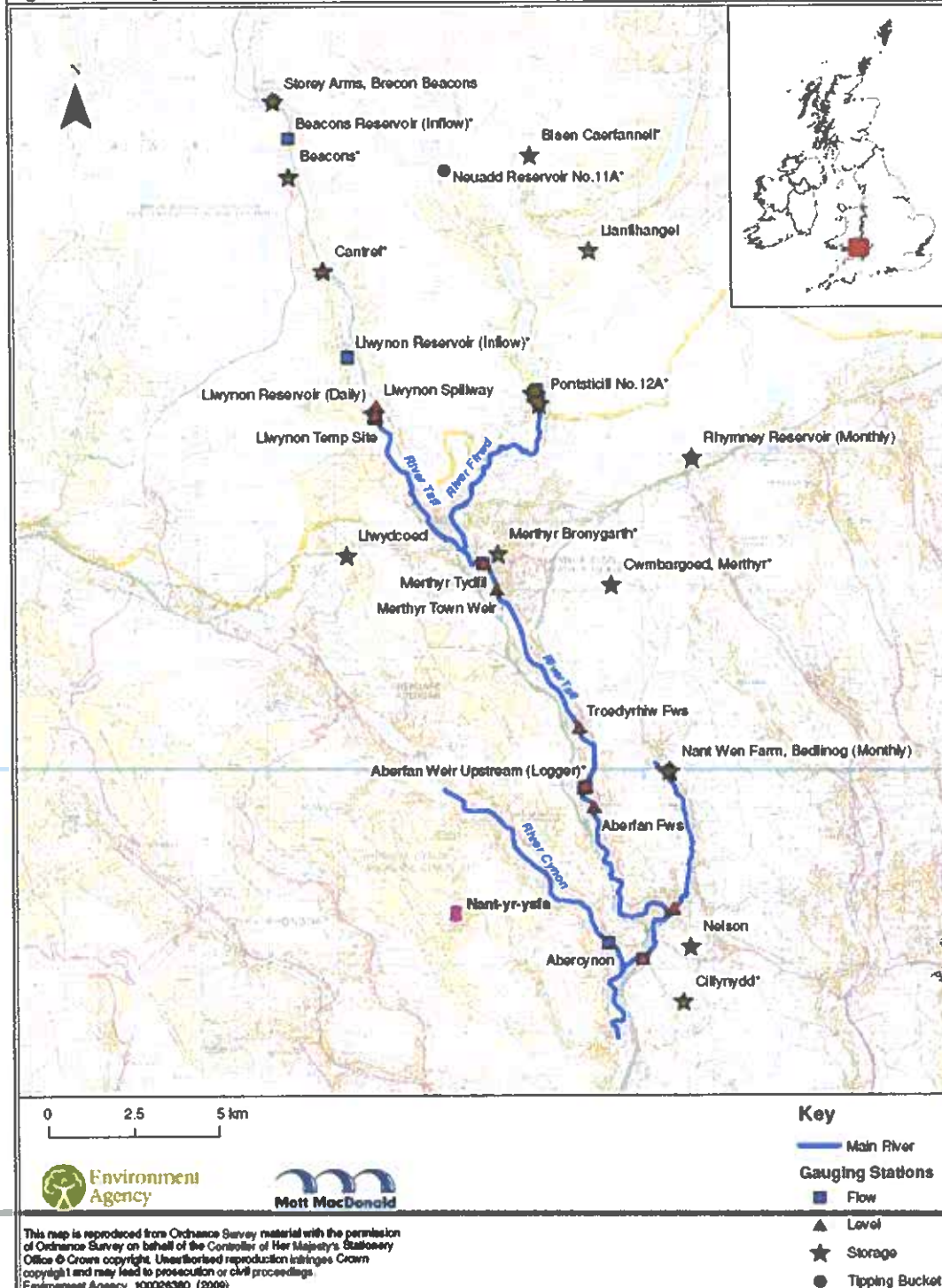
Hydrometric data for the study was made available by the Environment Agency Wales. For each gauge the complete record was provided. During the Inception Phase, the data was processed and assessed for quality and consistency.

We have suggested in the Inception Report using events for the model calibration which cover periods previously used for the calibration of other models such as the Flood Forecasting Model (FF model) together with a number of more recent events. These have been finalised following the submission of the Inception Report. The selected events include the two largest floods recorded which had occurred in 1998 and 2008, and three events of a smaller magnitude.

Data recorded during the selected events have been further assessed to ensure their suitability for model calibration purposes and to gain an understanding of the catchment hydrology. This includes the impact of the reservoirs on flood peaks, the contribution of flow from the various sub-catchments and the attenuation of flow.

Figure 2.1 shows the hydrometric network in the study area.

Figure 2.1: Hydrometric Network



Source: Environment Agency Wales, Processed by MM

## 2.2 Calibration and Verification Events

### 2.2.1 Selected Events

Table 2.1 summarises the five events for the calibration and verification of the model agreed with the Environment Agency Wales (EA Wales).

We suggested in the Inception Report four events for calibration including two events previously used for the calibration of the Taff FF Model and two more recent events. A fifth event was added following a suggestion by the EA Wales.

Data availability varies for the selected events. There is very little data available for calibration during Event 1. For subsequent events more data is available, and flow and level records are available at a number of gauges for the other calibration events. Two events in 2008 have been suggested for use as they benefit from the improved data availability.

Although there is relatively little hydrometric data available for Event 1 this event has remained included as it is the largest event recorded. Some calibration data including water levels is, however, available (WS ATKINS (2000): Aberfan and Merthyr Vale Flood Alleviation Scheme Engineering Feasibility, 2000 [4]). All flood defences have been built following the devastating flood in October 1998. Event 1 would therefore need to be calibrated using the undefended scenario.

Table 2.1: Summary Selected Calibration and Verification Events

| Event              | Start                | End                  | Comment                      | Peak flow at Merthyr Tydfil (m <sup>3</sup> /s) | Comment                 |
|--------------------|----------------------|----------------------|------------------------------|-------------------------------------------------|-------------------------|
| 1 – October 1998   | 20 Oct 1998<br>00:15 | 29 Oct 1998<br>23:45 | Little data for calibration  | 258, largest recorded                           | Recommended by EA Wales |
| 2 – February 2002  | 31 Jan 2002<br>00:15 | 3 Feb 2002<br>23:45  | Limited data for calibration | 121                                             | Used for Taff FF Model  |
| 3 – October 2004   | 19 Oct 2004<br>00:15 | 26 Oct 2004<br>23:45 |                              | 95                                              |                         |
| 4 – January 2008   | 12 Jan 2008<br>00:15 | 16 Jan 2008<br>23:45 |                              | 87                                              | New                     |
| 5 – September 2008 | 3 Sep 2008<br>00:15  | 8 Sep 2008<br>23:45  |                              | 212, second largest recorded                    |                         |

Source: MM

### 2.2.2 Event Rainfall

#### 2.2.2.1 Individual TBR 15 min Records

Following the initial assessment of the rainfall records during the Inception Phase, a more detailed analysis of the 15 min TBR rainfall records has been carried out for the selected calibration events.

The availability of 15 min rainfall records is summarised in Table 2.2.

For Event 1 and Event 2 a rainfall profile is only available at Llywnon TBR gauge. This gauge is located in the upper part of the catchment and does not represent the rainfall across the catchment. Other gauges

such as daily storage gauges have been used to derive rainfall profiles for these events. Details are given in Section 2.2.2.2.

For the other three events, rainfall profiles are available at four TBR gauges. These are distributed across the catchment and represent well the spatial variability. They are considered suitable for the determination of the catchment rainfall.

For Event 5, a 15 min catchment rainfall based on HYRAD records has been made available. A comparison of the TBR rainfall in the upper catchment to Merthyr Tydfil and the HYRAD rainfall is shown in Figure A.1. All three cumulative records show a steep rise in rainfall representing the rainfall which caused the flooding further downstream in the catchment. The TBR gauge at Storey Arms shows the highest rainfall, whereas the rainfall recorded at the Llwynon Reservoir is slightly below the HYRAD catchment rainfall. Figure A.1 also shows that the recorder at Storey Arms gauge stopped working on 5 October. Although the majority of the rainfall had fallen at the time the recorder stopped, part of the event rainfall was not recorded. The missing data (5 Sep 2008 12:15 – 29 Sep 2008 17:15) has been infilled based on the HYRAD rainfall profile, and a factor representing the ratio between the rainfall event totals at the two gauges prior to the failure of the recorder.

Table 2.2: Summary of Availability of 15 Min TBR Rainfall Records for the Selected Calibration Events

| Event | Llwynon | Nant Wen | Rhymney | Storey Arms     |
|-------|---------|----------|---------|-----------------|
| 1     | ✓       | -        | -       | -               |
| 2     | ✓       | -        | -       | -               |
| 3     | ✓       | ✓        | ✓       | ✓               |
| 4     | ✓       | ✓        | ✓       | ✓               |
| 5     | ✓       | ✓        | ✓       | Partly/infilled |

Source: MM

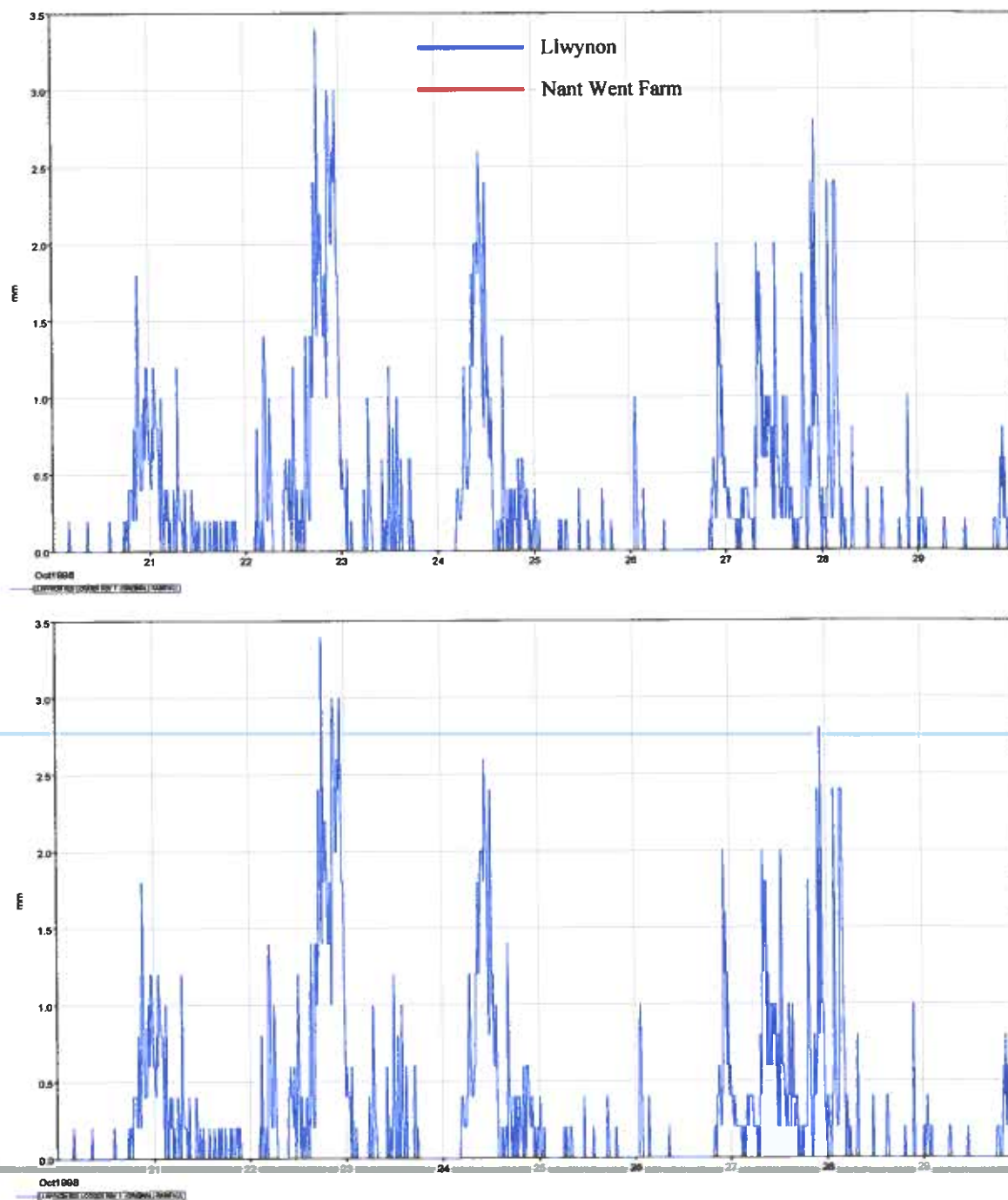
Table 2.3 summarises the rainfall totals for the calibration events at each individual gauge. The totals show the expected spatial variation in rainfall across the catchment.

Figure 2.2 to Figure 2.6 show the rainfall profiles recorded at each gauge.

Table 2.3: TBR and HYRAD Rainfall Totals for the Selected Calibration Events

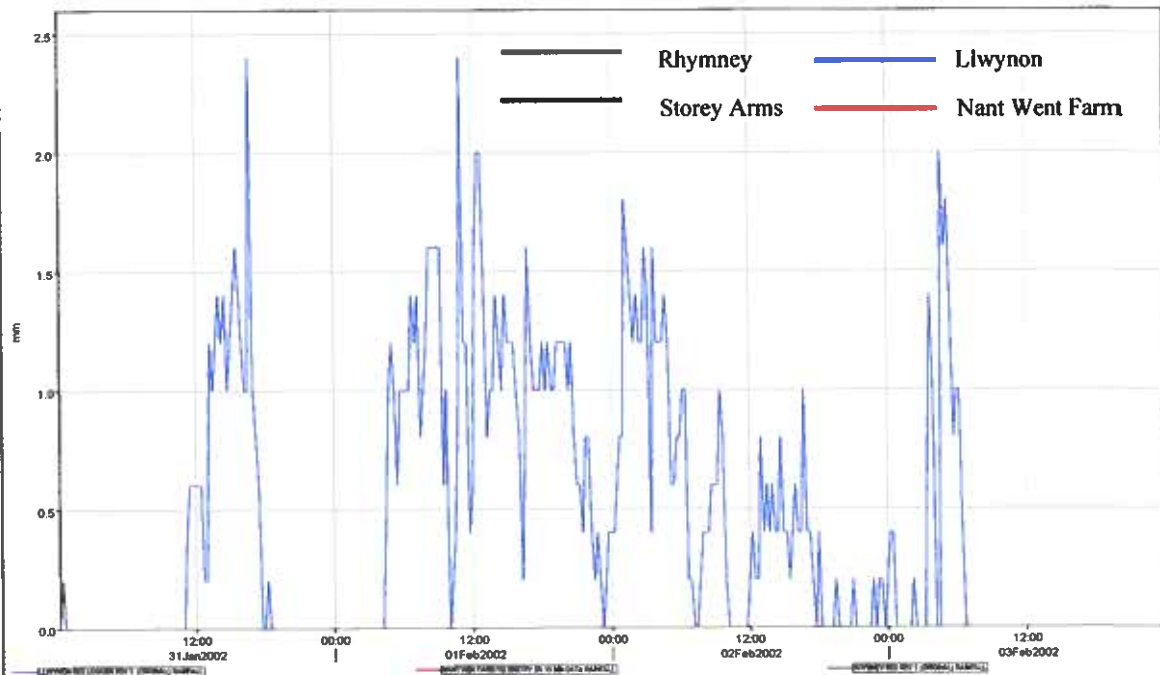
| Event         | HYRAD<br>Catchment at<br>Merthyr Tydfil | Llwynon | Nant Wen | Rhymney | Storey Arms |
|---------------|-----------------------------------------|---------|----------|---------|-------------|
| Rainfall (mm) |                                         |         |          |         |             |
| 1             | -                                       | 266     | -        | -       | -           |
| 2             | -                                       | 164     | -        | -       | -           |
| 3             | -                                       | 147     | 30       | 152     | 163         |
| 4             | -                                       | 81      | 90       | 86      | 124         |
| 5             | 119                                     | 122     | 119      | 119     | 128         |

Figure 2.2: TBR Rainfall – Event 1



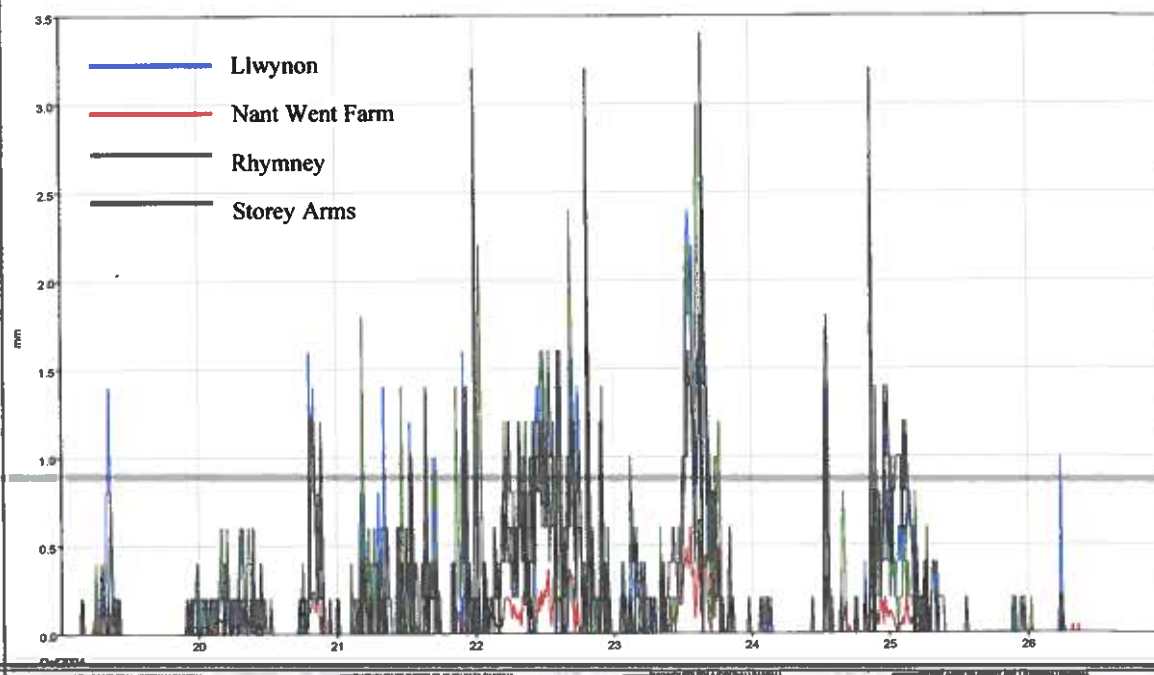
Source: Environment Agency Wales, WISKI

Figure 2.3: TBR Rainfall – Event 2



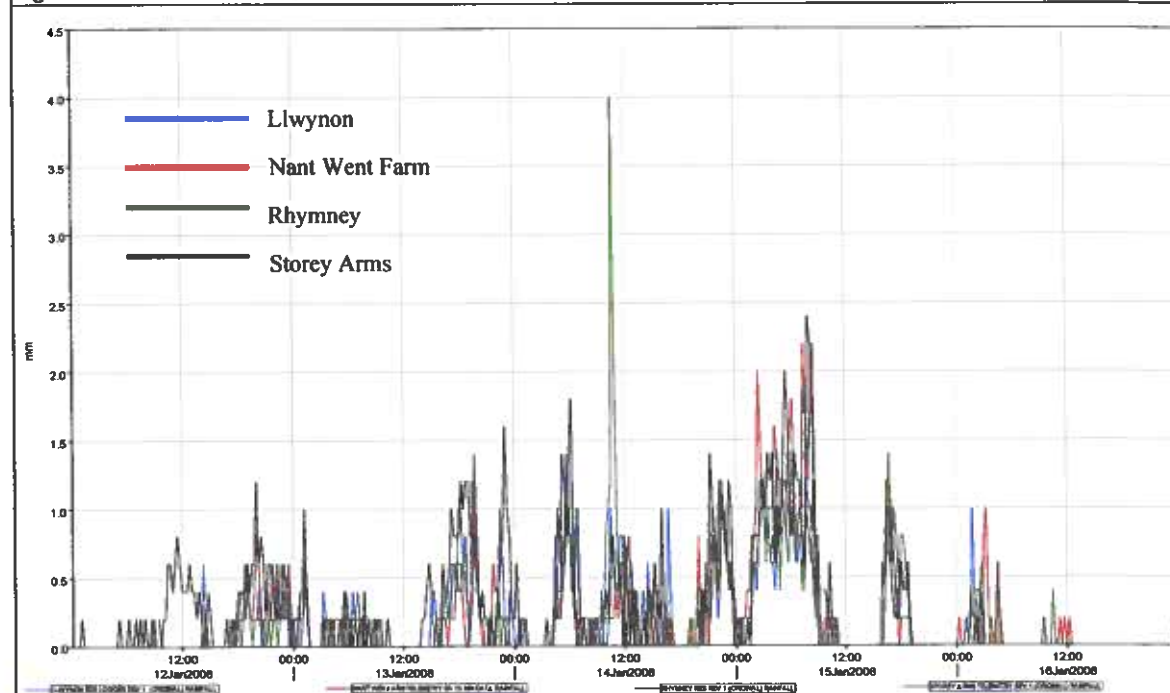
Source: Environment Agency Wales, WSKI

Figure 2.4: TBR Rainfall – Event 3



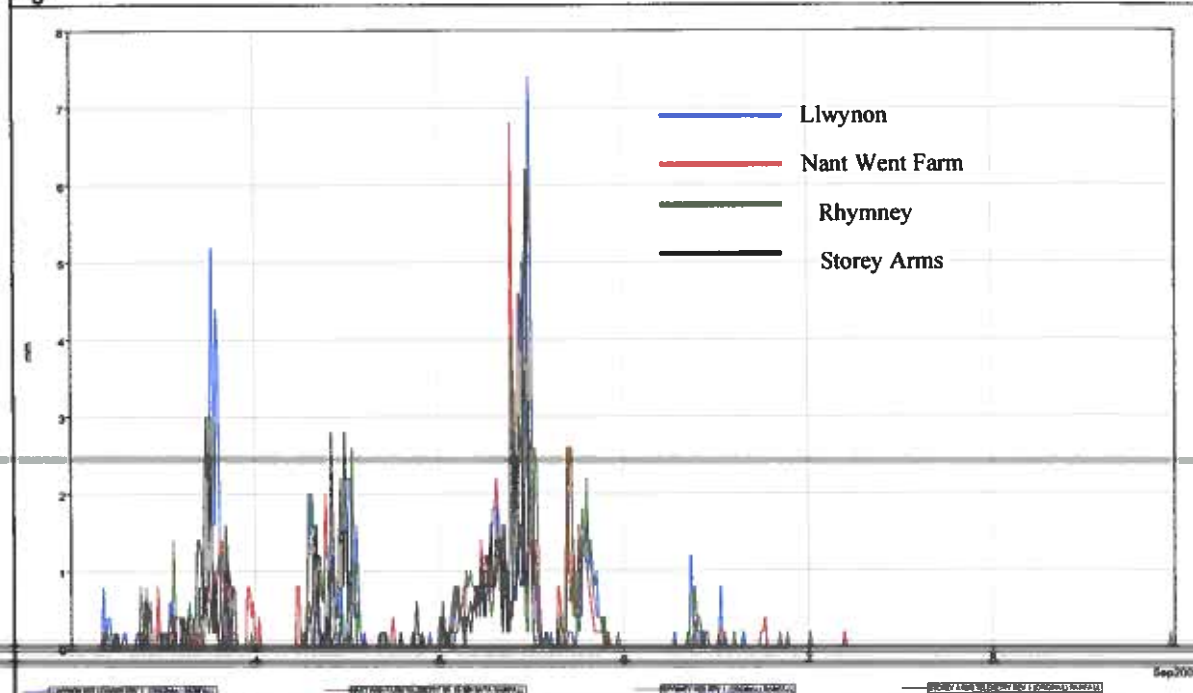
Source: Environment Agency Wales, WSKI

Figure 2.5: TBR Rainfall – Event 4



Source: Environment Agency Wales, WISKI

Figure 2.6: TBR Rainfall – Event 5



Source: Environment Agency Wales, WISKI; gaps infilled by MM

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### 2.2.2.2 Daily Storage Gauges

Rainfall records at a number of storage gauges are also available. Their locations are shown in Figure 2.1.

Although the records received from the EA Wales were labelled as daily rainfall, their recording appears to be irregular and often do not provide daily rainfall profiles. However, for events where 15 min records are generally not available, these totals have been used to derive 15 min profiles by scaling the available profile (at Llwynon) according to the ratio of the respective event totals. This approach has been used for Event 1 and Event 2, both lacking of TBR records. A summary of the details is given in Table 2.4.

Table 2.5 summarises the rainfall totals for the calibration events at each individual gauge.

Table 2.4: Summary of Rainfall Profile Transfer to Storage Gauge Locations

| Table Heading Left                       | Event 1 | Event 2 |
|------------------------------------------|---------|---------|
| Donor Profile                            | Llwynon | Llwynon |
| Ratio Event totals at Llwycoed           | 0.97    | 1.33    |
| Ratio Event totals at Pontsticill        | 1.10    | 1.08    |
| Ratio Event totals at Beacons            | 1.30    | 1.03    |
| Ratio Event totals at Merthyr Bronygarth | 0.79    | 0.93    |
| Nant-yr-Ysfa                             | 0.53    | 0.82    |

Source: MM

Table 2.5: Rainfall Totals for Event 1 and Event 2 at the Storage Gauges

| Event         | Llwycoed | Pontsticill | Beacons | Merthyr Bronygarth | Nant-yr-Ysfa |
|---------------|----------|-------------|---------|--------------------|--------------|
| Rainfall (mm) |          |             |         |                    |              |
| 1             | 258      | 293         | 348     | 212                | 141          |
| 2             | 218      | 177         | 169     | 152                | 135          |

Source: MM

### 2.2.2.3 Catchment Rainfall

In order to derive catchment rainfall for the sub-catchments the location of the gauges together with their data availability had to be considered.

For Event 1 and Event 2 the gauges listed below have been used to derive rainfall profiles across the catchment. Where daily storage gauges had to be used, the 15 min profiles recorded at Llwynon have been transferred by applying a scaling factor based on a comparison of the daily totals at the TBR gauge and the storage gauge.

- Llwynon,
- Llwydcoed,
- Pontsticill,
- Beacons,
- Merthyr Bronygarth,
- Nant-yr-Ysfa

For Event 3 to Event 5 the following four TBR gauges have been used to derive the catchment rainfall profiles:

- Storey Arms,
- Llwynon,
- Rhymney,
- Nant Wen Farm.

Weighting factors for each gauge have been derived using the Thiessen Polygon Method. Figure 2.7 shows the Thiessen polygons together with the sub-catchment boundaries for Event 1 and Event 2. Figure 2.8 shows the same information for Event 3 to Event 5. The individual weighting factors are summarised in Table 2.6 and Table 2.7.

Rainfall profiles for each event have been derived for all 12 sub-catchments. The event totals are summarised in Table 2.8.

**Table 2.6: Thiessen Weighting Factors for Catchment Rainfall – Event 1 and Event 2**

| Catchments             | Rain gauge station |           |                   |                    |              |             | Grand Total |
|------------------------|--------------------|-----------|-------------------|--------------------|--------------|-------------|-------------|
|                        | Brecons            | Llwydcoed | Llwynon Reservoir | Merthyr Bronygarth | Nant-yr-ysfa | Pontsticill |             |
| <b>Aberfan</b>         | 0.0%               | 0.0%      | 0.0%              | 25.4%              | 74.6%        | 0.0%        | 100.0%      |
| <b>Bargoed</b>         | 0.0%               | 0.0%      | 0.0%              | 50.9%              | 49.1%        | 0.0%        | 100.0%      |
| <b>Ditch</b>           | 0.0%               | 0.0%      | 0.0%              | 100.0%             | 0.0%         | 0.0%        | 100.0%      |
| <b>Fiddlers</b>        | 0.0%               | 0.0%      | 0.0%              | 0.0%               | 100.0%       | 0.0%        | 100.0%      |
| <b>Llwynon Lat</b>     | 0.0%               | 43.5%     | 47.0%             | 9.5%               | 0.0%         | 0.0%        | 100.0%      |
| <b>Llwynon</b>         | 58.6%              | 0.0%      | 39.4%             | 0.0%               | 0.0%         | 2.0%        | 100.0%      |
| <b>Merthyr Town</b>    | 0.0%               | 0.0%      | 0.0%              | 64.5%              | 0.0%         | 35.5%       | 100.0%      |
| <b>Nant Morlais</b>    | 0.0%               | 0.0%      | 0.0%              | 97.2%              | 0.0%         | 2.8%        | 100.0%      |
| <b>Pontsticill</b>     | 34.9%              | 0.0%      | 0.8%              | 0.0%               | 0.0%         | 64.3%       | 100.0%      |
| <b>Pontsticill Lat</b> | 0.0%               | 0.0%      | 20.6%             | 26.1%              | 0.0%         | 53.4%       | 100.0%      |
| <b>Taff Bargoed</b>    | 0.0%               | 0.0%      | 0.0%              | 0.0%               | 100.0%       | 0.0%        | 100.0%      |
| <b>Troedyrhiw</b>      | 0.0%               | 4.4%      | 0.0%              | 94.9%              | 0.7%         | 0.0%        | 100.0%      |

Source: MM

Table 2.7: Thiessen Weighting Factors for Catchment Rainfall – Events 3 to 5

| Catchment              | Rain Gauge station         |                                     |                      |                                         | Total  |
|------------------------|----------------------------|-------------------------------------|----------------------|-----------------------------------------|--------|
|                        | Llwynon Reservoir (Logger) | Nant Wen Farm, Bedlinog (Telemetry) | Rhymney Res (Logger) | Storey Arms, Brecon Beacons (Telemetry) |        |
| <b>Aberfan</b>         | --                         | 100.0%                              | --                   | --                                      | 100.0% |
| <b>Bargoed</b>         | --                         | 87.9%                               | 12.1%                | --                                      | 100.0% |
| <b>Ditch</b>           | --                         | 100.0%                              | --                   | --                                      | 100.0% |
| <b>Fiddlers</b>        | --                         | 100.0%                              | --                   | --                                      | 100.0% |
| <b>Llwynon</b>         | 53.3%                      | --                                  | --                   | 46.7%                                   | 100.0% |
| <b>Llwynon Lat</b>     | 100.0%                     | --                                  | --                   | --                                      | 100.0% |
| <b>Merthyr Town</b>    | 9.7%                       | --                                  | 90.3%                | --                                      | 100.0% |
| <b>Nant Morlais</b>    | 91.0%                      | --                                  | 9.0%                 | --                                      | 100.0% |
| <b>Pontsticill</b>     | 42.7%                      | --                                  | 24.0%                | 33.2%                                   | 100.0% |
| <b>Pontsticill Lat</b> | 85.6%                      | --                                  | 14.4%                | --                                      | 100.0% |
| <b>Taff Bargoed</b>    | --                         | 100.0%                              | --                   | --                                      | 100.0% |
| <b>Troedyrhiw</b>      | 29.6%                      | 60.3%                               | 10.1%                | --                                      | 100.0% |

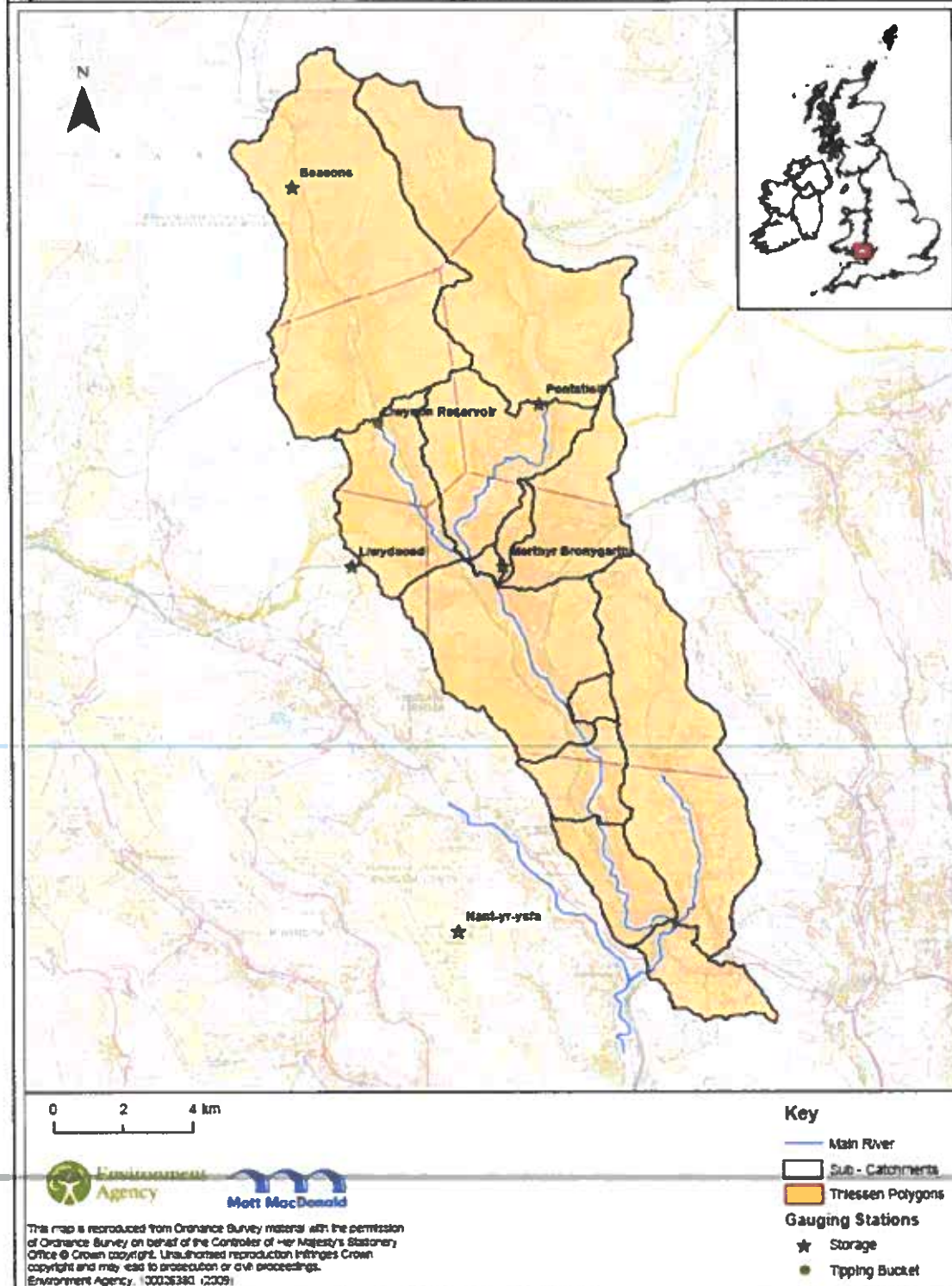
Source: MM

Table 2.8: Catchment Rainfall Totals – Event 1 to 5

| Sub-catchment          | Rainfall (mm) |         |         |         |         |
|------------------------|---------------|---------|---------|---------|---------|
|                        | Event 1       | Event 2 | Event 3 | Event 4 | Event 5 |
| <b>Aberfan</b>         | 159           | 140     | 30      | 90      | 119     |
| <b>Bargoed</b>         | 177           | 144     | 45      | 90      | 119     |
| <b>Ditch</b>           | 212           | 152     | 30      | 90      | 119     |
| <b>Fiddlers</b>        | 141           | 135     | 30      | 90      | 119     |
| <b>Llwynon</b>         | 258           | 167     | 147     | 81      | 122     |
| <b>Llwynon Lat</b>     | 314           | 186     | 154     | 101     | 105     |
| <b>Merthyr Town</b>    | 241           | 161     | 152     | 85      | 120     |
| <b>Nant Morlais</b>    | 214           | 153     | 147     | 81      | 122     |
| <b>Pontsticill</b>     | 331           | 174     | 153     | 96      | 109     |
| <b>Pontsticill Lat</b> | 267           | 168     | 147     | 82      | 122     |
| <b>Taff Bargoed</b>    | 141           | 135     | 30      | 90      | 119     |
| <b>Troedyrhiw</b>      | 222           | 155     | 77      | 87      | 120     |

Source: MM

Figure 2.7: Sub-catchments and Thiessen Polygons for Rainfall Gauges – Event 1 and 2



Source: MM

This map shows the War River catchment area in Scotland, divided into sub-catchments and Thiessen Polygons. The War River is highlighted in blue. Gauging stations are marked with black dots. The map includes a north arrow, a scale bar (0-5 km), and an inset map of Scotland. Labels include 'War River', 'Gauging Station (Topping Bucket)', 'Thiessen Polygons', and 'Sub-Catchments'. The map is reproduced from Ordnance Survey materials with permission.

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C:\DOCUME~1\fei25034\LOCALS~1\Temp\daefae7a-976f-4de6-b846-fbc85537fa08\Werthyr\_Tydfil\_FRM\_Main\_Phase-revB.doc

### 2.2.3 Event Flows

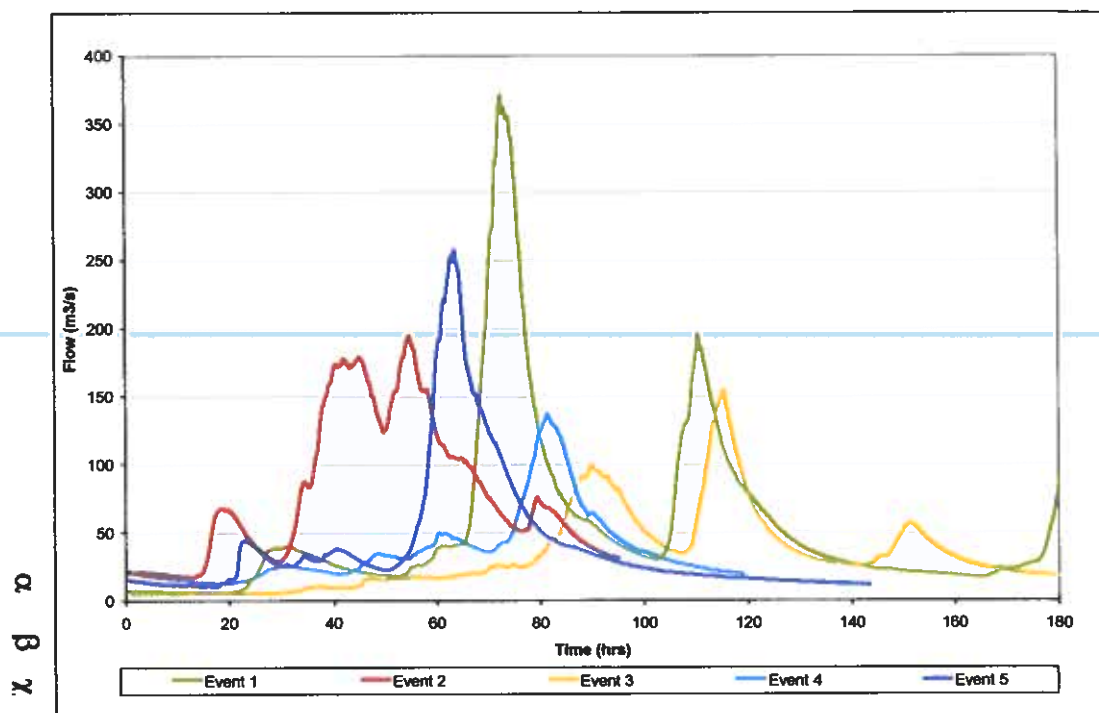
Figure 2.9 shows the flows recorded at Fiddler's Elbow during the five calibration events. The largest event in terms of peak flow was Event 1. Event 2 had a significantly lower peak flow but more volume. Event 2, 3 and 4 ranged between with hydrographs similar to Event 1 but less peak flow.

Figure 2.10 to Figure 2.14 show the flow hydrographs as received from the Environment Agency Wales for the selected calibration events.

Generally the flow records do not show significant gaps or inconsistencies and have been considered suitable for model calibration purposes.

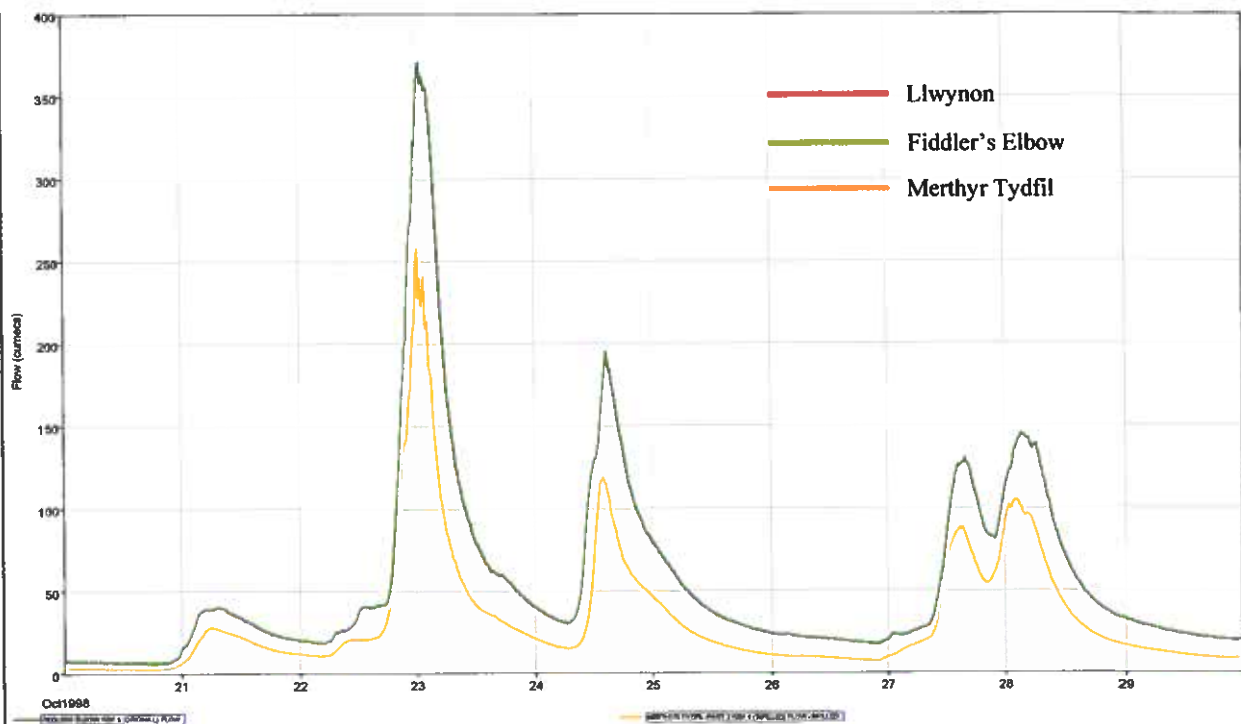
The flow hydrographs will be primarily used to calibrate the hydrological model.

Figure 2.9: Comparison of Event Flow at Fiddler Elbow



Source: EA Wales, processed by MM

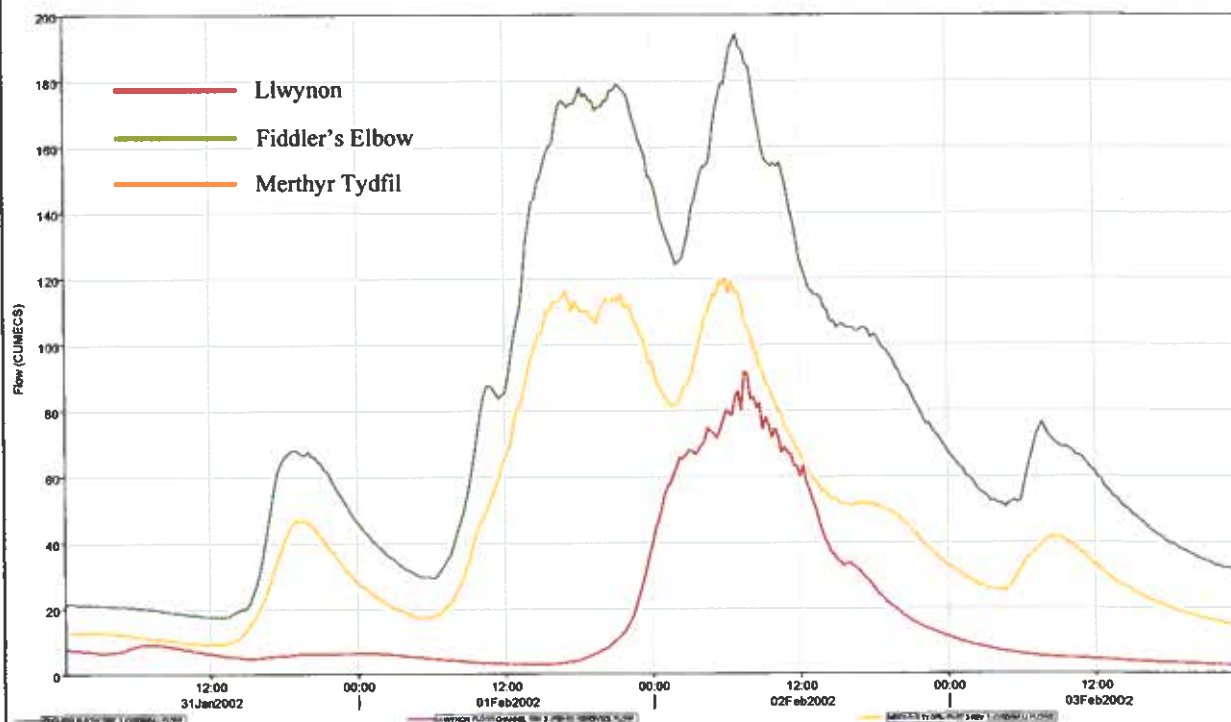
Figure 2.10: Flow – Event 1



Source: Environment Agency Wales, WISKI

Flows during Event 1 were recorded at Merthyr Tydfil and Fiddler's Elbow. More than 50% of the flow recorded at Fiddler's Elbow is contributed from the upper catchments upstream of the gauge at Merthyr.

Figure 2.11: Flow – Event 2

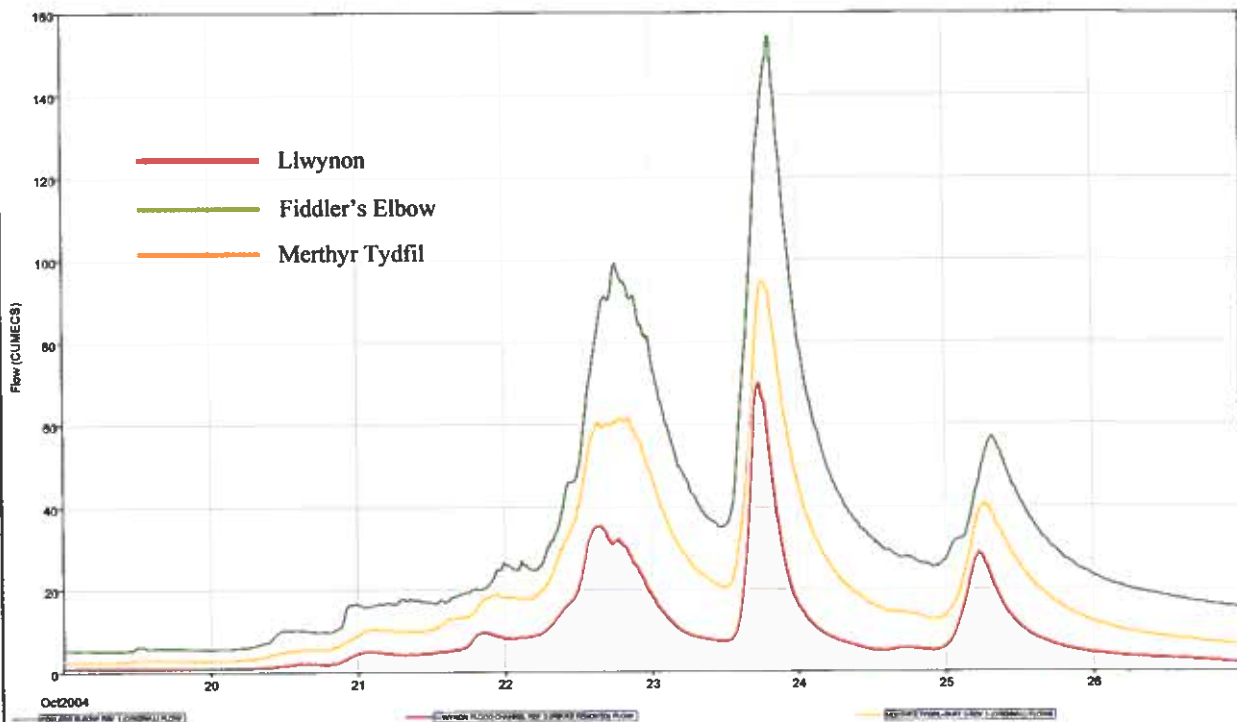


Source: Environment Agency Wales, WSKI

Flows during Event 2 were recorded at three locations: downstream of the reservoir at Llwynon, at Merthyr Tydfil and at Fiddler's Elbow. The hydrograph downstream of Llwynon Reservoir indicates that the reservoir had some storage capacity left, and a significant volume of water was stored in the reservoir thereby effectively reducing the first flood peak. However, the reservoir did not have sufficient capacity to reduce the second flood peak.

A large proportion of the flow recorded at Fiddler's Elbow is contributed from the upper catchments upstream of the gauge at Merthyr.

Figure 2.12: Flow – Event 3

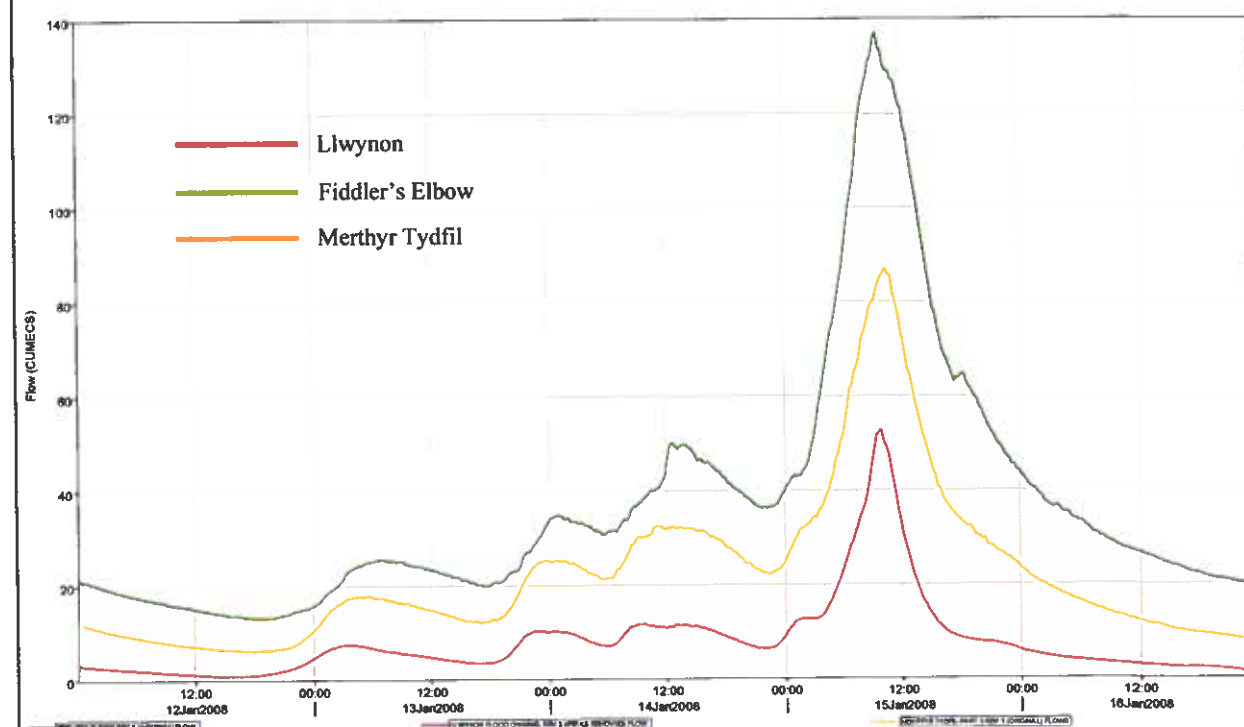


Source: Environment Agency Wales, WISKI

Flows during Event 3 were recorded at three locations: downstream of the reservoir at Llwynon, at Merthyr Tydfil and at Fiddler's Elbow. The hydrograph downstream of Llwynon Reservoir indicates that the reservoir did not have sufficient capacity to accommodate the flood volume during any of the three flood peaks. There might have been some reduction in flow during the first peak as the ratio between the flow downstream of the reservoir and at Merthyr is bigger during the first peak and is significantly lower during the subsequent peaks.

Very little rainfall was recorded at Nant Wen Farm located in the downstream part of the catchment (30 mm at Nant Wen Farm compared to 147 mm at Llwynon Reservoir). This would mean that relatively little flow recorded at Fiddler's Elbow was contributed from the downstream catchments. However, this is not supported by the flow hydrographs.

Figure 2.13: Flow – Event 4

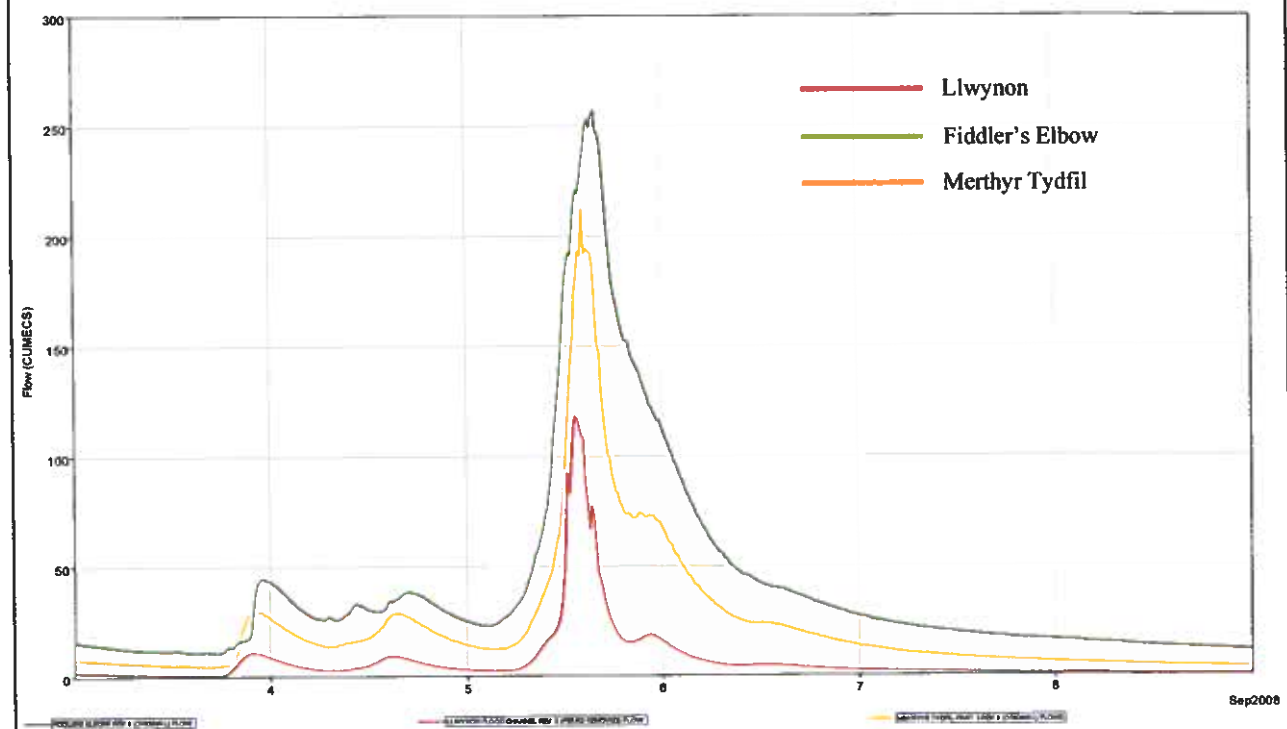


Source: Environment Agency Wales, WISKI

Flows during Event 4 were recorded at three locations: downstream of the reservoir at Llwynon, at Merthyr Tydfil and at Fiddler's Elbow. The hydrograph downstream of Llwynon Reservoir indicates that the reservoir was filled and had no capacity left to store flood waters.

The timing of the hydrographs, in particular the appearance of the main peak at Fiddler's Elbow before the flow peaks at Merthyr, points towards significant fast runoff from the downstream catchments. This is supported by the rainfall data which show an event total recorded at Nant Wen Farm (located in the downstream part of the catchment) of 90 mm, whereas at Llwynon Reservoir only 81 mm were recorded. This is a less frequently occurring pattern as it is usually the gauges located in the upper catchments of high elevation which show the highest rainfall.

Figure 2.14: Flow – Event 5



Source: Environment Agency Wales, WISKI

Flows during Event 5 were recorded at three locations: downstream of the reservoir at Llwynon, at Merthyr Tydfil and at Fiddler's Elbow. The hydrograph downstream of Llwynon Reservoir indicates that the reservoir was full at the beginning of the event. The majority of the flood volume was generated in the upper parts of the catchment. The rising of the flood and the flood peak are predominantly caused by runoff from the upper catchment, whereas the overall volume and the flow during the recession of the flood are also affected by contributions from the downstream catchments.

## 2.2.4 Water Levels

Figure 2.15 to Figure 2.19 show the water level hydrographs as received from the Environment Agency Wales for the selected calibration events.

The water level hydrographs have been used to calibrate the hydrodynamic model. Whereas flows recorded in the catchment to the gauge Fiddler's Elbow have been used for the hydrological model calibration, the calibration of the hydraulic model has focused on level gauge in the mapping reach.

Information on water levels was generally provided as stage in m. These values have been converted into water levels in mAOD by adding the datum of the respective gauge to the stage. Table 2.9 summarises the datum for each gauge as confirmed by the EA Wales which has been used for the conversion.

Contradicting values from various sources have been added as notes.

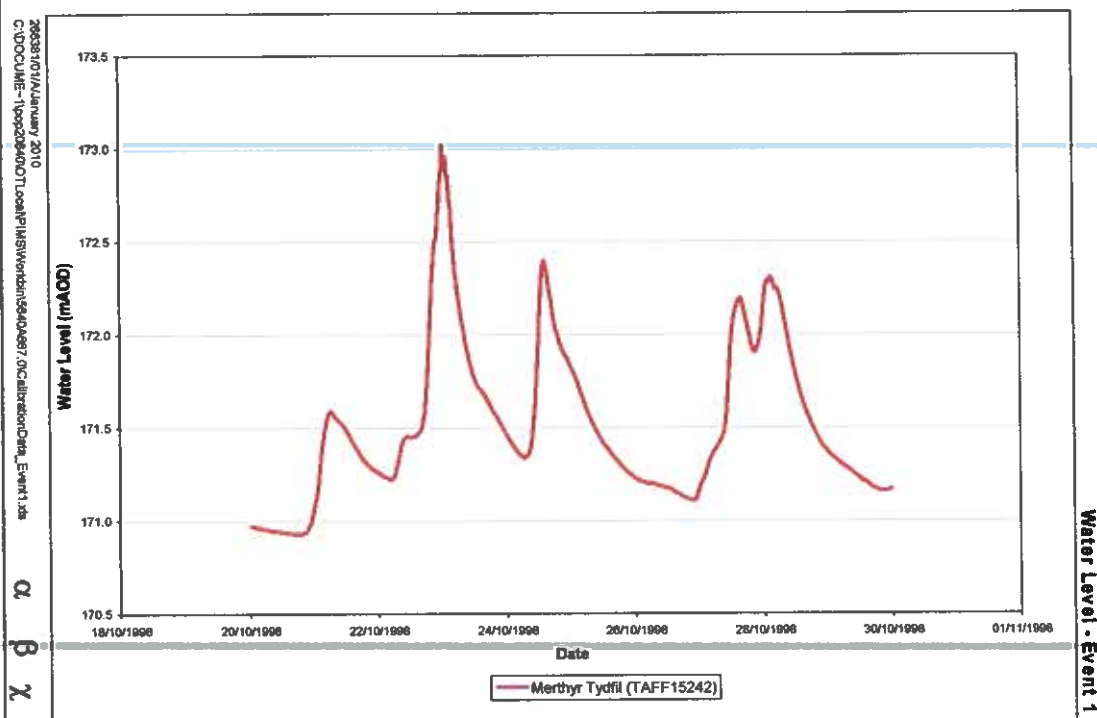
Table 2.9: Summary of Datum at Level Gauges used for Model calibration

| Gauge             | Datum                      | Source                                                    | Comment                                            |
|-------------------|----------------------------|-----------------------------------------------------------|----------------------------------------------------|
| Merthyr Tydfil    | 170.533 mAOD <sup>2)</sup> | EA Wales 21/12/09                                         | ISIS: Q-H control                                  |
| Merthyr Town Weir | 165.83 mAOD                | WISKI data/flood forecasting model report/survey drawings | Weir crest ISIS: 165.83 mAOD                       |
| Fiddlers Elbow    | 79.419 mAOD <sup>2)</sup>  | EA Wales 21/12/09                                         | Water levels at Fiddler's gauge not used           |
| Troedyrhiw        | 132.479 mAOD <sup>3)</sup> | WISKI data/flood forecasting model report                 | No gauging structure, bed level ISIS: 132.44 mAOD  |
| Aberfan FWS       | 121.169 <sup>4)</sup>      | WISKI data                                                | No gauging structure, bed level ISIS: 121.118 mAOD |

Source: EA Wales

Note: <sup>1)</sup> Water level provided by EA Wales from WISKI data provided, datum taken as difference between water level and stage<sup>2)</sup> As per survey November 2007<sup>3)</sup> Survey November 2007: 132.561 mAOD<sup>4)</sup> Survey November 2007: 121.208 mAOD

Figure 2.15: Water Levels Event 1



Source: Environment Agency Wales, WISKI

Figure 2.16: Water Levels Event 2

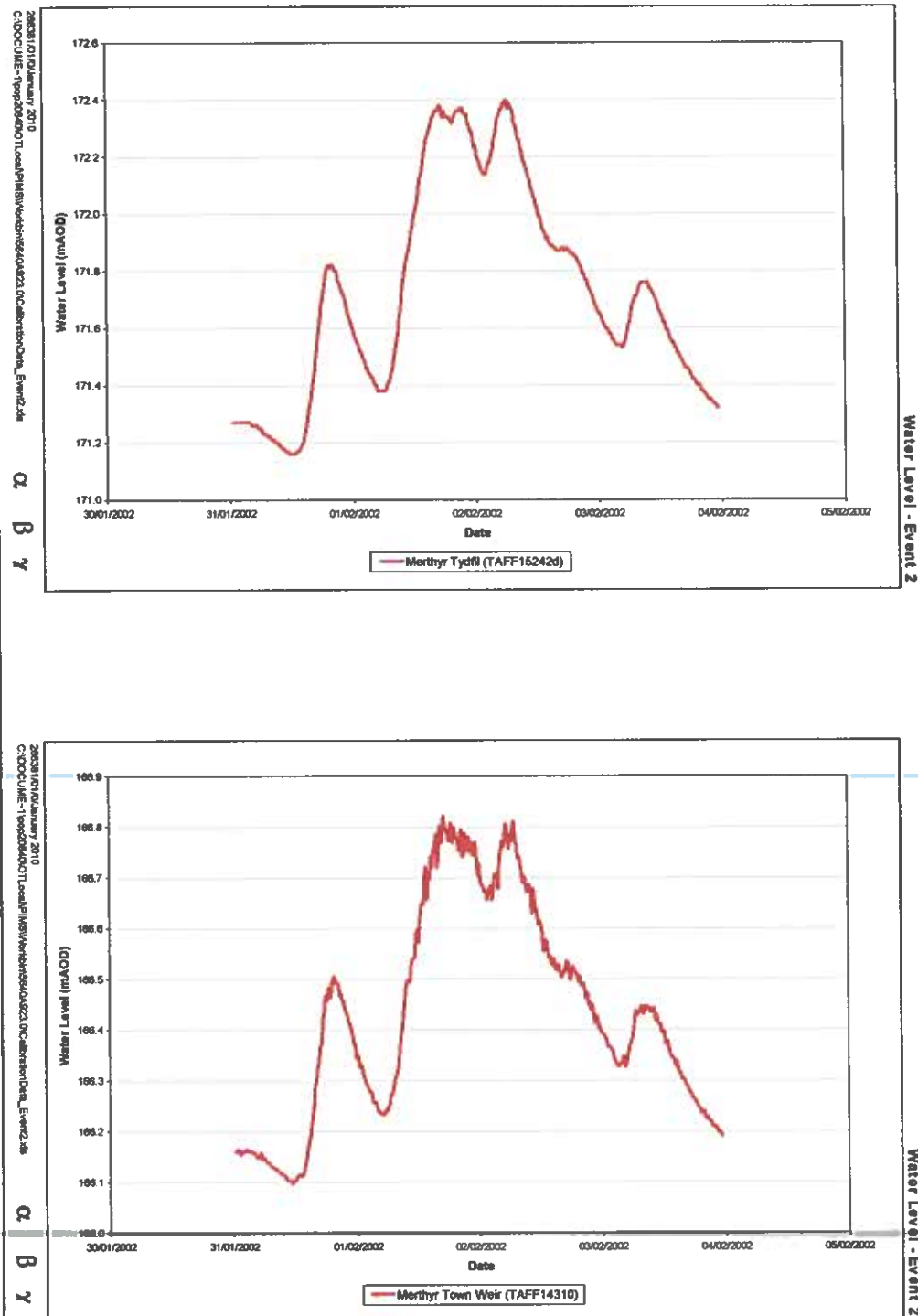
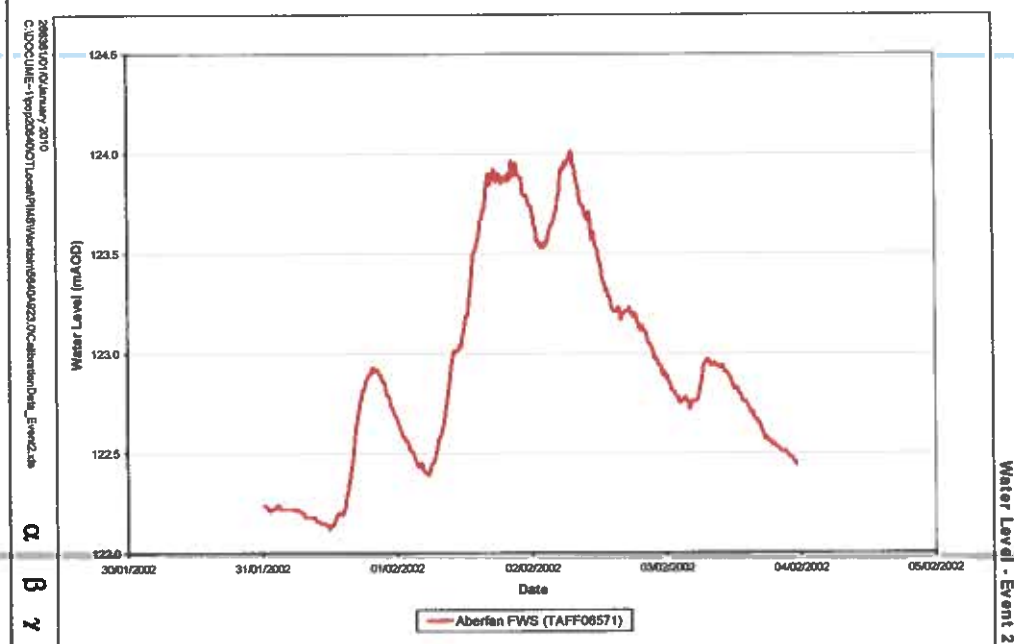
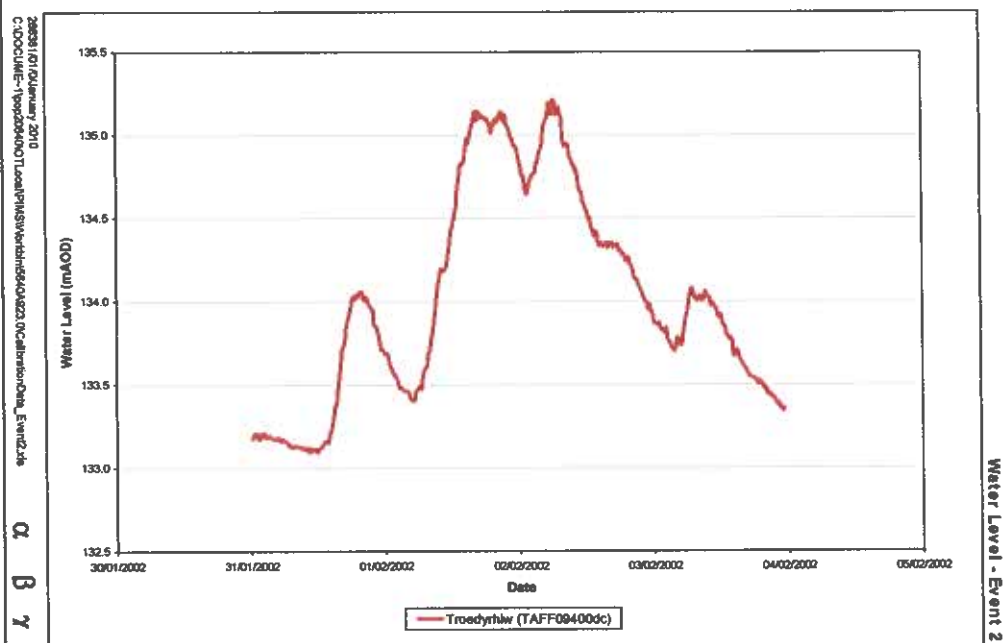


Figure 2.16: Water Levels Event 2



Source: Environment Agency Wales, WASKI

Figure 2.17: Water Levels Event 3

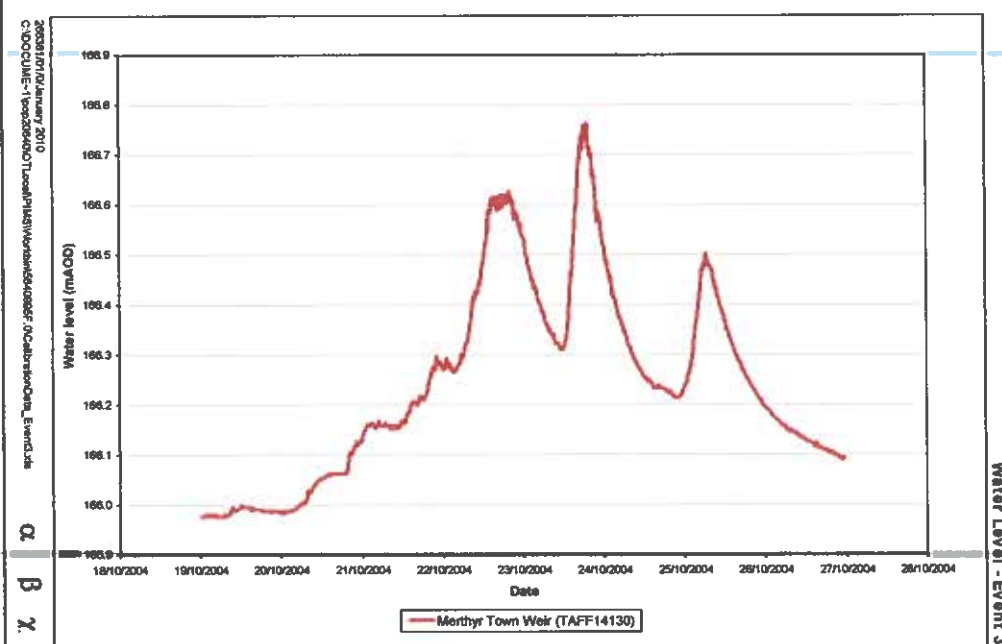
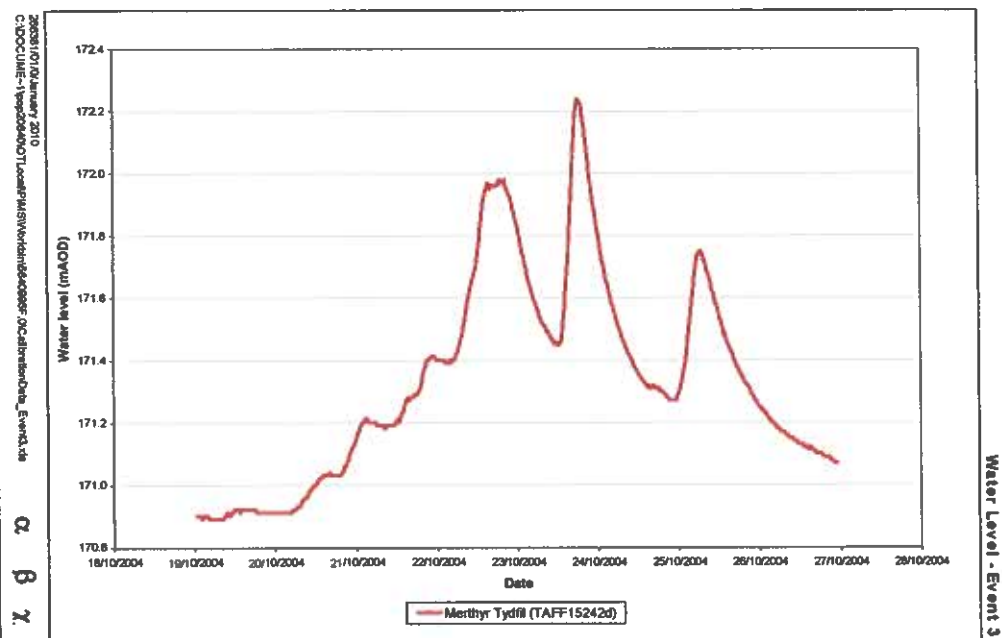
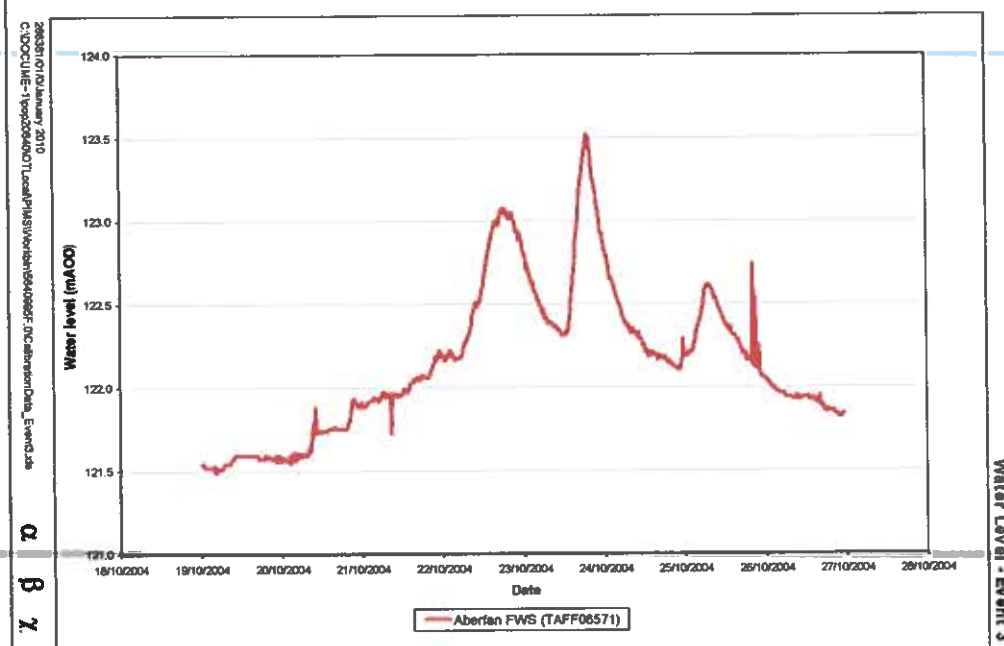
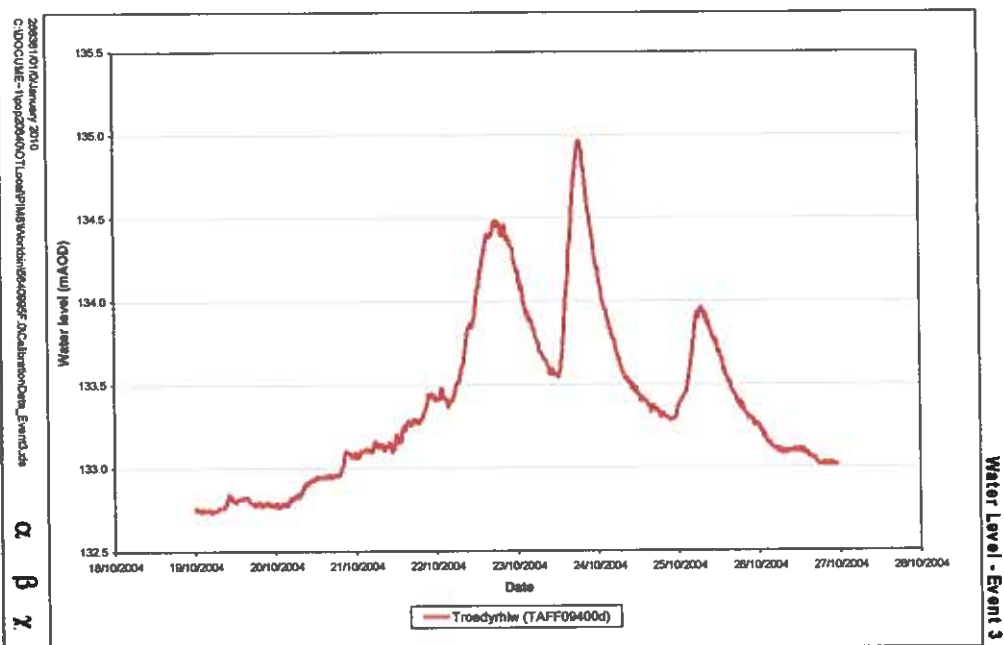


Figure 2.17: Water Levels Event 3



Source: Environment Agency Wales, WISKI

Figure 2.18: Water Levels Event 4

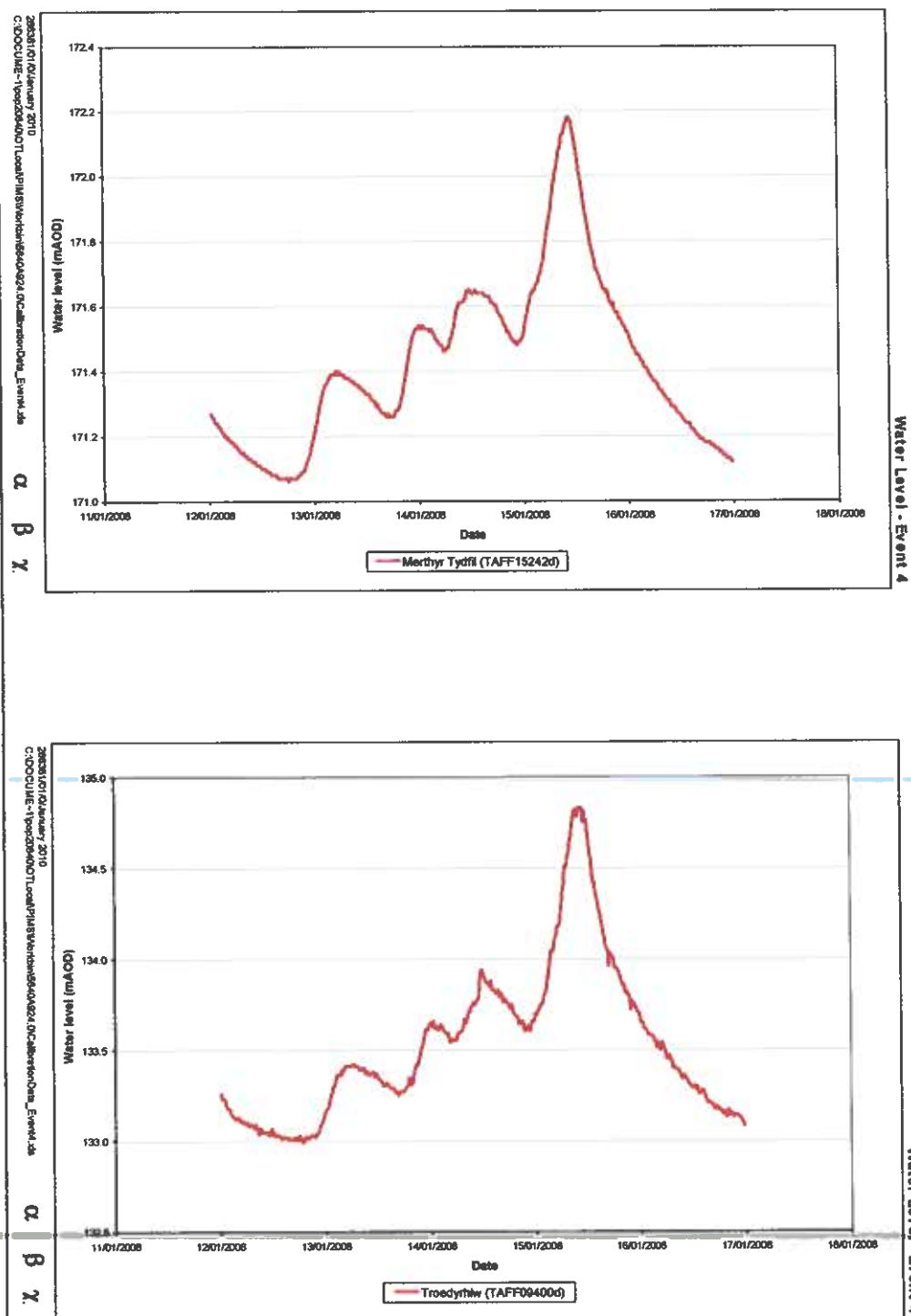
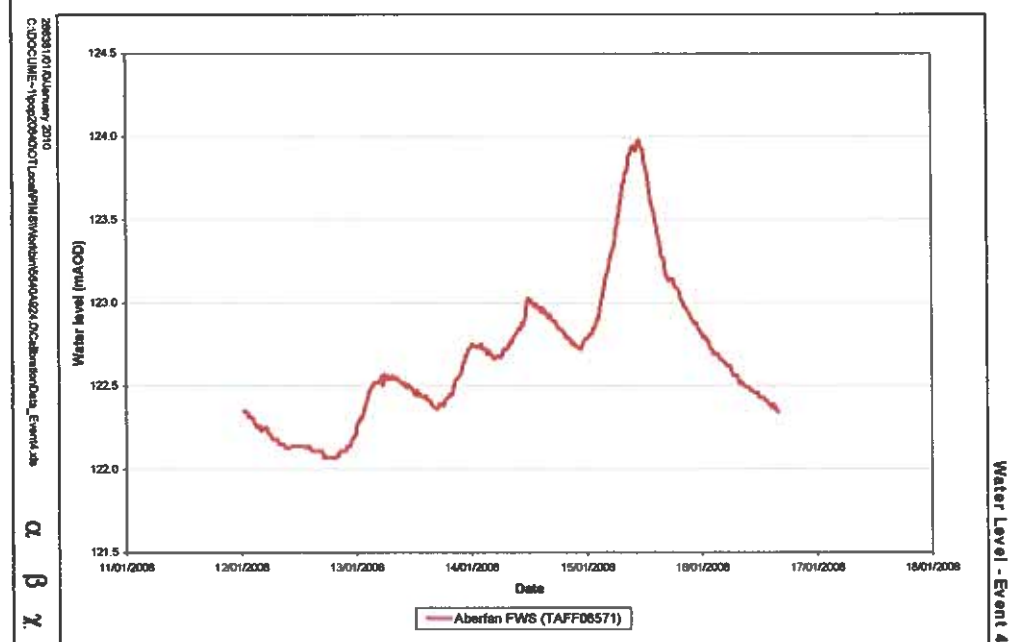


Figure 2.18: Water Levels Event 4



Source: Environment Agency Wales, WISKI

Figure 2.19: Water Levels Event 5

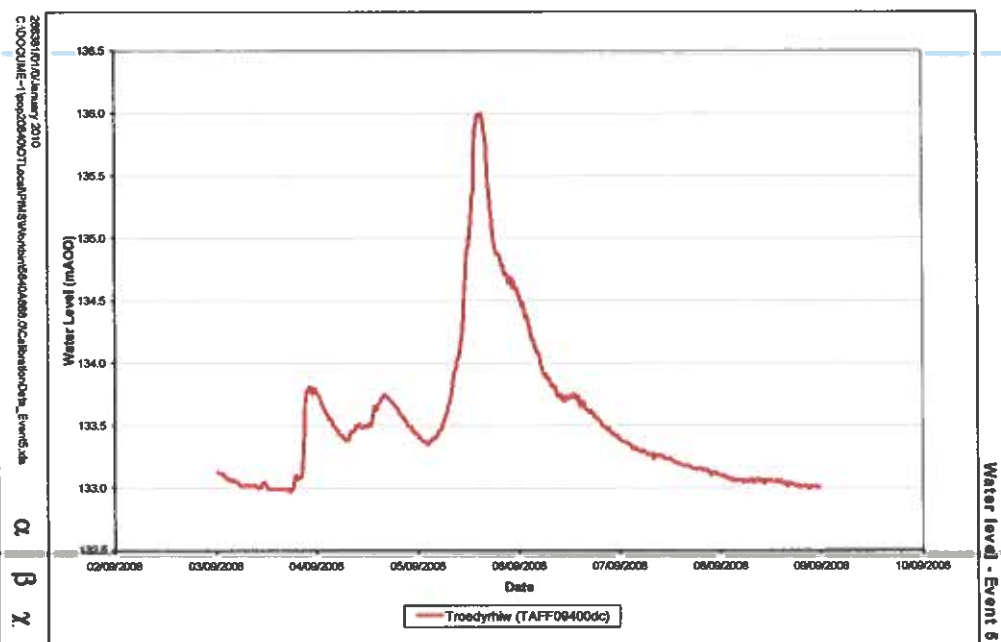
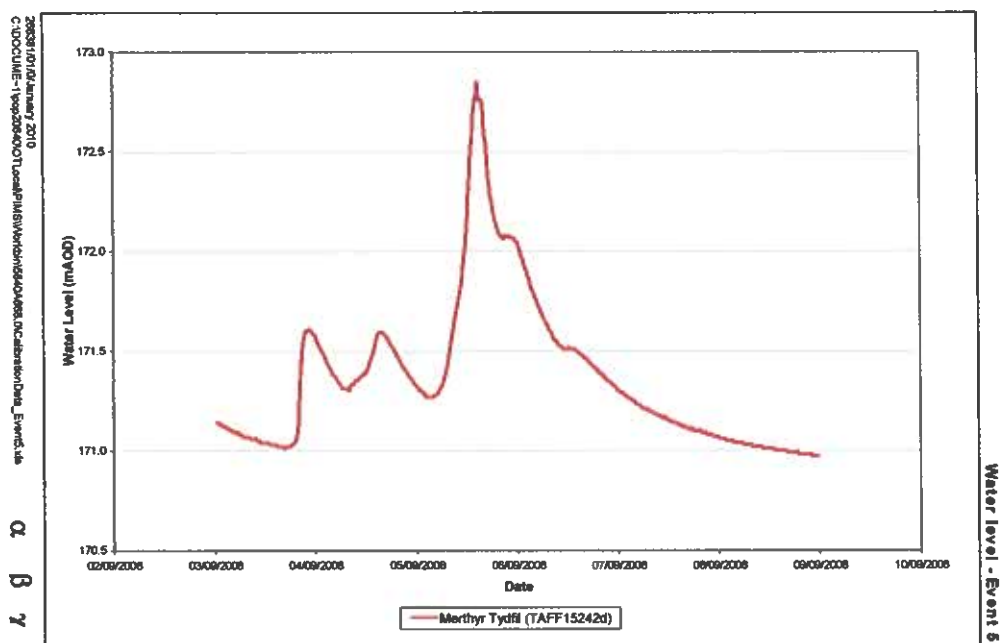
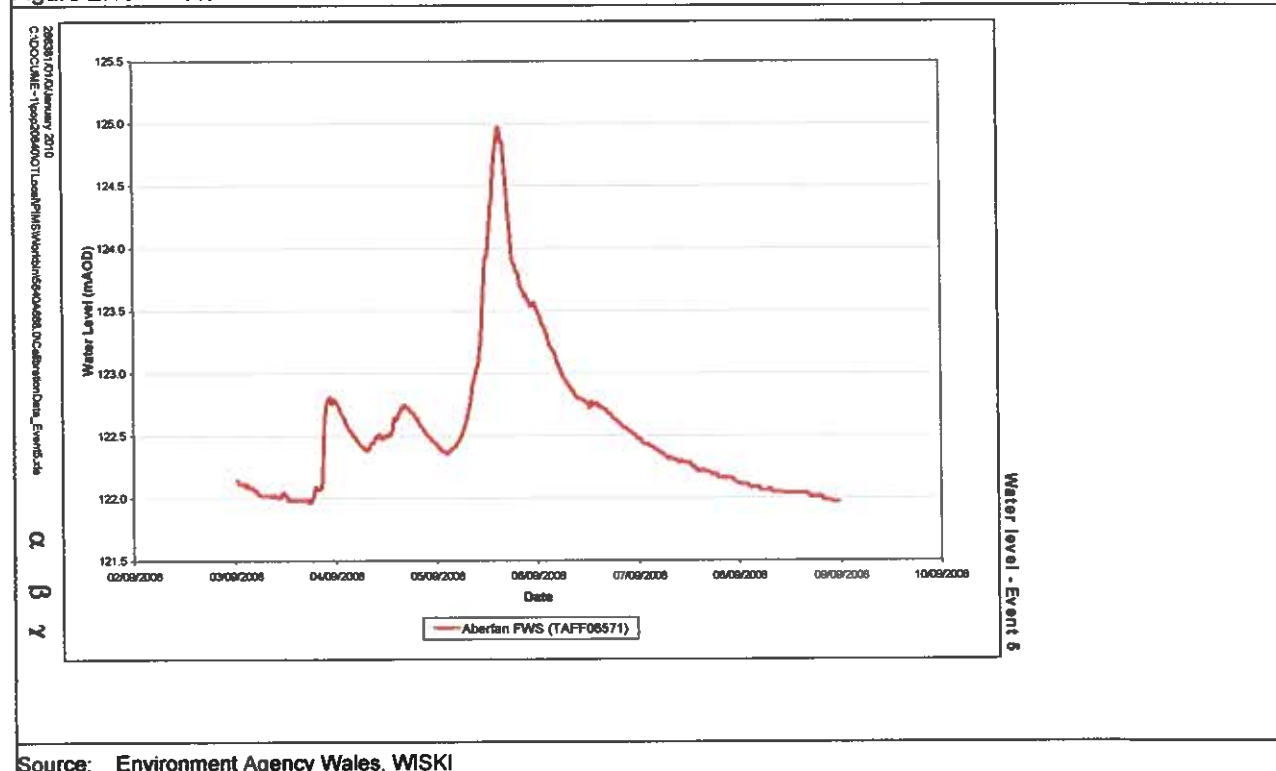


Figure 2.19: Water Levels Event 5



## 2.2.5 Information on De-shoaling

In the area upstream of Crescent Street in Merthyr Vale shoaling occurs in an area upstream and downstream of the footbridge (see Figure 2.20).

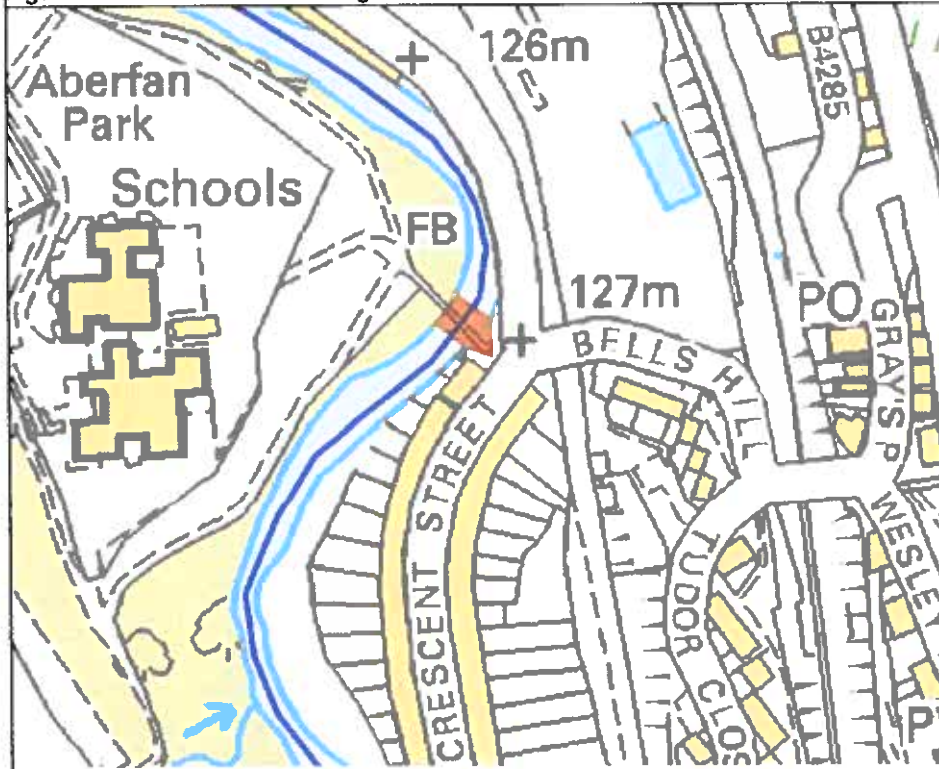
The EA Wales regularly removes the accumulated material upstream of the bridge. Around the school/footbridge, material is removed annually while at the rear of Crescent Street wall material is removed less frequently (5 to 7 years, depending on the build up). Dates of the removal of the shoal around the footbridge have been provided for this study. They are summarised in Table 2.10.

Table 2.10: Dates of De-shoaling

| Date       | Location                                        | Comment                                                                                                                                                                     |
|------------|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 24/4/2006  | Merthyr Vale (footbridge)                       |                                                                                                                                                                             |
| 19/2/2007  | Merthyr Vale (footbridge)                       | Event 4 (Jan 2008) might have been affected by accumulated material as the river bed had not been cleared for a year                                                        |
| 15/10/2008 | Merthyr Vale (footbridge)                       | Event 5 (Sept 2008) might have been affected by accumulated material might have been affected by accumulated material as the river bed had not been cleared for over a year |
| 1/7/2009   | Merthyr Vale (footbridge & rear of Crescent St) |                                                                                                                                                                             |

Source: EA Wales

Figure 2.20: Location of Shoaling



30/09/2009 – Looking downstream from footbridge



30/09/2009 – Looking upstream from footbridge

Source: MM

## 3. Survey

### 3.1 Topographic Survey

Topographic survey of the river and its structures from a number of previous studies was made available for this study. A summary is given in Table 3.1.

Additional survey was provided by The EA Wales in December 2009 to support the 1D-2D model link. It comprises embankment levels which have been built into the 1D-2D model.

Figure 3.1 shows the location of the available survey information.

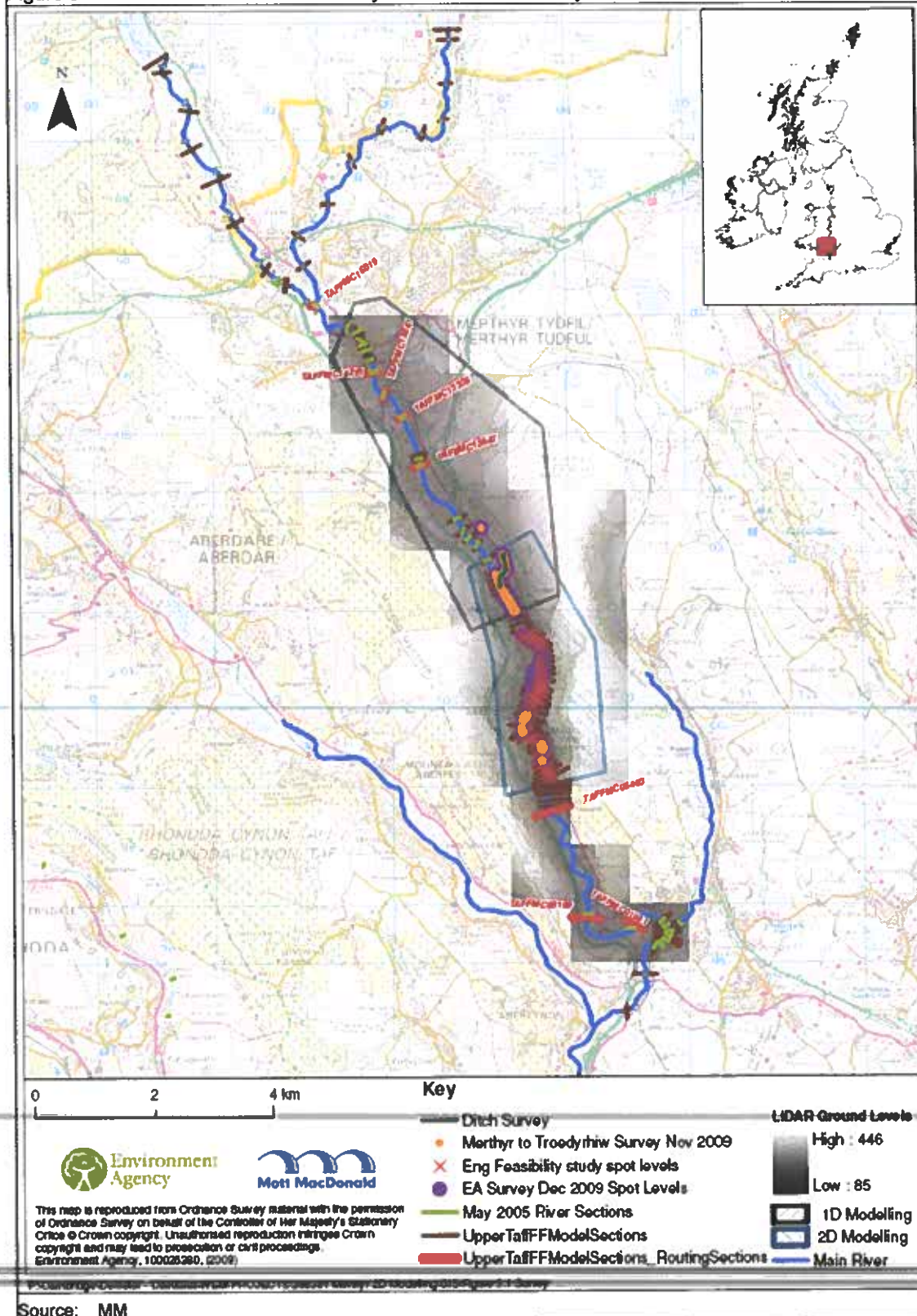
Table 3.1: Summary of Survey provided from Previous Studies

| Original Project                  | Title                                                        | Year                         | Comment                                                                            |
|-----------------------------------|--------------------------------------------------------------|------------------------------|------------------------------------------------------------------------------------|
| MM Merthyr Tydfil to Merthyr Vale | "Various Levels"                                             | December 2009                | Accumulation of a number of previous surveys                                       |
| MM Merthyr Tydfil to Merthyr Vale | Merthyr to Troedyrhiw survey points                          | November 2009                | Survey carried out specifically for this project                                   |
| Engineering Feasibility Project   | Eng Feasibility study spot levels                            | 1999/2000                    | Spot levels taken for 1999/2000 project prior to improvements to flood defences    |
| Engineering Feasibility Project   | Aberfan survey sections                                      | 1999/2000                    | Cross sections taken for 1999/2000 project prior to improvements to flood defences |
| Merthyr Weir Fish Pass            | Merthyr Weir Topographic Survey                              | 2003                         | Survey of Merthyr Weir pre-fish pass installation                                  |
| Merthyr Weir Fish Pass            | As Built General Arrangement Plan and Sections Sheets 1 To 3 | 2009                         | As built drawings for Merthyr fish pass                                            |
| Taff Flood Forecasting            | FFP Infomap Surveys- May 2005 River Sections.                | Not stated (assumed 2003/04) | Cross sections in Excel format                                                     |
| Cinema complex FCA                | Glebeland Merthyr Tydfil Site Survey                         | Not stated (assumed 2004)    |                                                                                    |
| Unknown                           | Slope area assessments                                       | 1999                         | Hand drawn cross sections of the Taff at Fiddlers Elbow gauging station            |

Source: EA Wales

In March 2010 another set of more recently surveyed river cross sections have been provided by the EA Wales. These are located in the Merthyr Vale area. Some of the sections are located where cross sections already exist whereas others complement the existing locations. Their location is shown in Figure 3.2.

Figure 3.1: Location of Additional Survey Provided for this Study



The map illustrates the Taff Valley area, including Abertan Park, Schools, and various streets such as Crescent Street, Tudor Close, and Dismantled Railway. A proposed railway alignment is shown with 12 cross-section points labeled CH 0 to CH 625.0. The Taff River is depicted in blue, and the surrounding urban area is shown in yellow. An inset map in the top right corner shows the location of the study area within Wales.

A horizontal scale bar with three segments. The first segment is labeled '0', the second '0.05', and the third '0.1 km'. Below the bar is a single horizontal line with vertical tick marks at the ends of each segment.



**Environment  
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Mott MacDonald

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 Ordnance Survey, 1000 High Street, Southampton, SO9 4PU

 March 2010 Additional Survey  
 Main River

P:\Cambridge\Demeter - Daedalus\WEM\PROJECTS\26638 - Marlyn 2D Modeling\01C\Figure 3.2 Adjunctal Survey March2010

C:\DOCUME~1\fei25034\LOCALS~1\Temp\daefae7a-976f-4de6-b846-fbc85537fa08\Merthyr\_Tydfil\_FRM\_Main\_Phase-revB.doc

## 3.2 LIDAR

LiDAR<sup>1</sup> data has been downloaded from the Environment Agency Geomatics Group website. The coverage is shown in Figure 3.3.

The filtered LiDAR data has been reviewed in detail before using it for modelling. Gaps have been infilled.

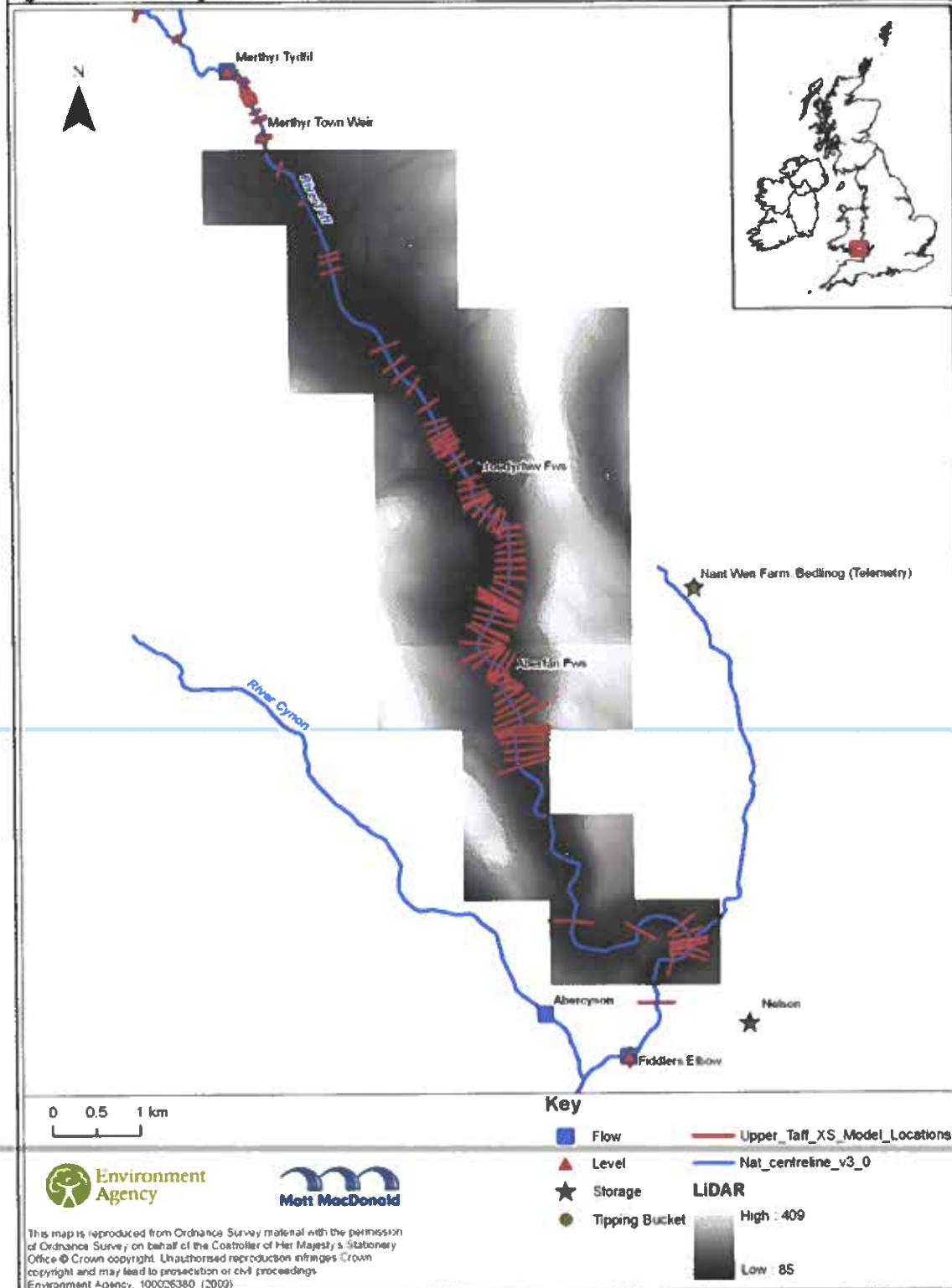
The new school building in Aberfan is a recent development and is therefore not captured by the LiDAR data. Ground levels have been changed as part of the construction work.

Ground level survey was provided by the EA Wales for the areas modified and the LiDAR data has been updated accordingly. We carried out an interpolation between the surveyed ground levels to produce a surface which has been incorporated into the existing LiDAR data.

---

<sup>1</sup> LiDAR = Light Detection And Ranging.

Figure 3.3: Coverage of LiDAR Data



Source: EA, Geomatics Group, MM

## 4. Hydrological Modelling

### 4.1 Method Statement

Two options for the hydrological modelling were presented in the Inception Report. Following a detailed discussion of the presented options with the EA Wales, it was decided that the study should focus on Option 2.

Option 2 suggested the derivation of the flood hydrographs by applying the Revitalised FEH (ReFH) rainfall runoff method, and the statistical method to derive design flow hydrographs of the River Taff and the River Fechan upstream of the two reservoirs, and for the intermediate catchments downstream of the respective reservoirs. The flow hydrographs would then be routed through the reservoirs and further downstream to Merthyr Tydfil to determine the design hydrographs at the upstream end of the new model. Flow from the sub-catchments downstream of Merthyr would also be estimated by applying the ReFH rainfall runoff method.

As mentioned above the flows along the River Taff and River Fechan are attenuated by the operation of the reservoirs, hence it is not possible to use traditional methods to estimate the ReFH model parameters. A flood event analysis, to estimate the ReFH model parameters, using the rainfall and flow data at the gauging stations is not appropriate since flow records are altered by the operation of the reservoirs. Natural flow discharge from the subcatchments is required.

An alternative method has been used to estimate ReFH model parameters. Initially the ReFH model parameters were estimated using catchment descriptors. The natural flow discharges of the ReFH subcatchments were routed through the reservoirs and recorded and simulated flows were compared. The ReFH model parameters were adjusted to match the flows at Merthyr Tydfil and Fiddlers Elbow gauging stations.

There are only two flow records, at Merthyr Tydfil and at Fiddler's Elbow, that allow the application of the statistical method. Design peaks at Fiddler's Elbow for a range of return periods were derived as part of an update to the Flood Risk Mapping Study carried out by WS ATKINS in 2007 which has also been used for the CFMP of the Taff catchment. A single site analysis and a pooling group analysis were carried out, and the results of the single site analysis were brought forward for the determination of design peak flows.

We have carried out a frequency analysis at Merthyr Tydfil, and updated the frequency analysis at Fiddler's Elbow using the latest version of Win-FAP (3.02) and data up to 2008. The results of the single site and the pooling group analysis have been discussed with the EA Wales, and the design peak flows for the pooling group have been taken forward. These peak flows have been compared against the peak flows derived using the rainfall runoff method (ReFH), and subsequently adjustments have been made.

Catchment rainfall has been used for the calibration of the hydrological model. Where flow records exist they have been used to calibrate the hydrological model.

For the purpose of the hydrological model calibration, the latest revision of the FF model has been used without modifications. The model covers an area extending further downstream than required for flood risk mapping. However, in order to make use of the available historic data, in particular at Fiddler's Elbow, it was agreed to keep the model extended to the gauge at Fiddler's Elbow.

We have carried out the following steps which are described in this section:

#### Hydrological calibration – Individual Calibration Events:

1. Derivation of the inflows from sub-catchments upstream Merthyr Tydfil using the ReFH rainfall runoff method for the five calibration events.
2. Routing of flow through a simple routing model to Merthyr Tydfil and comparing computed flows against observed flows.
3. Optimise ReFH parameters of upper sub-catchments.
4. Derivation of the inflows from sub-catchments downstream of Merthyr Tydfil using the ReFH rainfall runoff method for the five calibration events
5. Run 1d model with observed inflow at Merthyr Tydfil and compare computed flows against observed flows at Fiddler's Elbow.
6. Optimise ReFH parameters of downstream sub-catchments.
7. Run 1d model with ReFH flows from routing model and compare computed flows against observed flows at Fiddler's Elbow..

The finalised inflows derived for the sub-catchments for the individual calibration events together with the observed flow at Merthyr Tydfil will be further used for the calibration of the hydrodynamic model (see Chapter 5).

#### Hydrological calibration:

1. Derivation design model parameters for each sub-catchment based on an average of the parameters optimised for the individual calibration events.
2. Routing of flow through the routing model to Merthyr Tydfil and comparing computed flows against observed flows.
3. Routing of flow further downstream to Fiddler's Elbow using the 1d model and comparing computed flows against observed flows.

#### Derivation of design hydrographs:

1. Estimate design peak flows at Merthyr Tydfil and Fiddler's Elbow (most suitable results from statistical methods).
2. Setting up of all ReFH boundaries for design runs.
3. Run routing model to Merthyr Tydfil and compare peak design flow against estimated peak flow at Merthyr Tydfil.
4. Make adjustments if required and finalise design runs for the upper catchments.
5. Run 1D model with design flows from routing model at Merthyr and compare peak design flow against estimated peak flow at Fiddler's Elbow.
6. Make adjustments if required and finalise design runs for the downstream catchments.

It should be noted that the high flows recorded (such as Calibration Event 1 in 1998 and in 1979) are to be treated with caution since they have been estimated by extrapolation.

## **4.2 Data**

The following hydrometric data has been used for calibration of the hydrological model:

- Catchment rainfall for the individual sub-catchments,
- Observed flow at Merthyr Tydfil and Fiddler's Elbow, and

Details are given in Chapter 2.

### 4.3 Software

In order to estimate design flow hydrographs we have followed the procedures from the Flood Estimation Handbook. The following software has been used:

- FEH CD-ROM version 3.0,
- WinFAP FEH version 3.02.

### 4.4 Catchment Schematisation

#### 4.4.1 Main Sub-catchments

The catchment has been split into a number of sub-catchments taking into account the geography of the catchment, the main river course and its confluences with the main tributaries, the location of features such as reservoirs and flood storage schemes, and the location of gauges along the river courses. In addition, information on flow paths and inter-catchment connection provided by the EA Wales have been taken into account for the catchment delineation. The catchment of the Taff to Fiddler's Elbow has been split into 12 sub-catchments as listed in Table 4.1 and shown Figure 4.1 The boundaries have been derived using the FEH-CDROM or, where boundaries were available from previous studies these have been checked and updated where required. Catchment boundaries derived from the FEH-CDROM have been digitised.

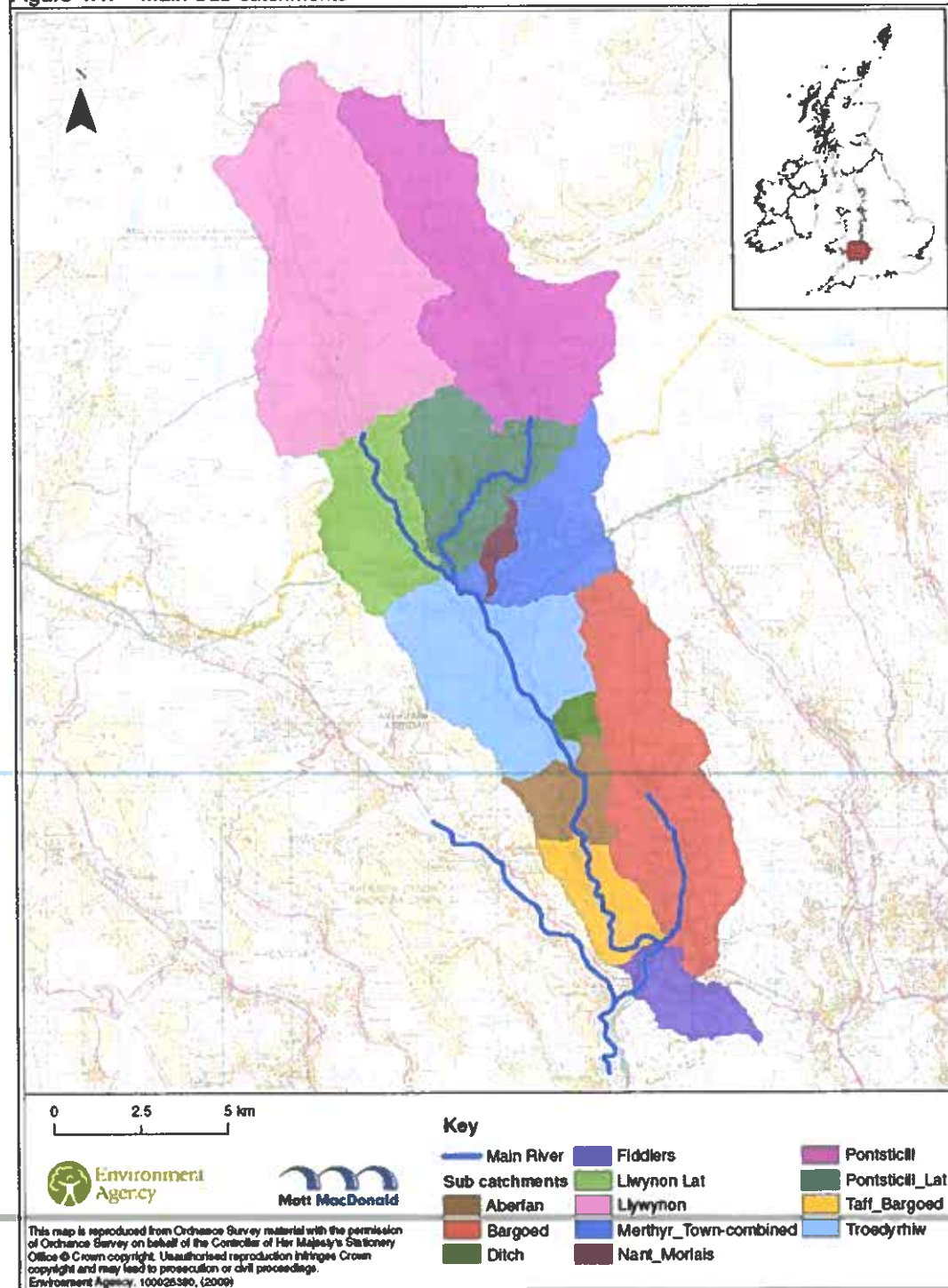
The area of the LlwynonLat sub-catchment was reduced in accordance with the sub-catchment outline provided with the Engineering Feasibility Study by WS ATKINS (2000) which identified that the area drains via an underground stream to an adjacent river catchment.

Table 4.1: Summary of Main Sub-catchments

| Catchment             | River        | Area (km <sup>2</sup> ) | Comment 1                 | Comment 2      |
|-----------------------|--------------|-------------------------|---------------------------|----------------|
| Pontsticill           | Taff Fechan  | 33.3                    | Includes three reservoirs | Head-catchment |
| Pontsticill_Lat       | Taff Fechan  | 15.2                    |                           | Intermediate   |
| Llwynon               | Taff         | 43.8                    | Includes three reservoirs | Head-catchment |
| Nant_Morlais          | Taff         | 1.5                     |                           | Head-catchment |
| Merthyr_Town-combined | Nant Morlais | 12.0                    | Includes flood storage    | Head-catchment |
| Troedyrhiw            | Taff         | 22.1                    |                           | Intermediate   |
| Aberfan               | Taff         | 5.9                     |                           | Intermediate   |
| Bargoed               | Bargoed      | 28.9                    |                           | Head-catchment |
| Taff_Bargoed          | Taff         | 6.9                     |                           | Intermediate   |
| Fiddlers              | Taff         | 6.0                     |                           | Intermediate   |
| Llwynon Lat           | Taff         | 13.3                    |                           | Intermediate   |
| Ditch                 | Taff         | 1.5                     |                           | Head-catchment |

Source: MM

Figure 4.1: Main Sub-catchments



Source: MM

#### 4.4.2 Other Sub-catchments

The sub-catchments described above have been delineated in order to estimate the inflow into the river from various parts of the catchment. These catchments have generally been determined taking the main features and catchment characteristics into account in order to ensure an appropriate distribution of inflows into the model.

In some areas, however, more details have been required when modelling the river levels and the floodplain flow. In the Troedyrhiw area, flow from an area upstream of the *Ditch* catchment enters the catchment via a culvert. As this is an area known to have been flooded in the past, the hydraulic model will take some of the details such as the floodplain characteristics and the dimension of the culvert into account to model the inter-catchment flow. The two catchments delineated to represent the inter-catchment flow are shown in Figure 4.4.

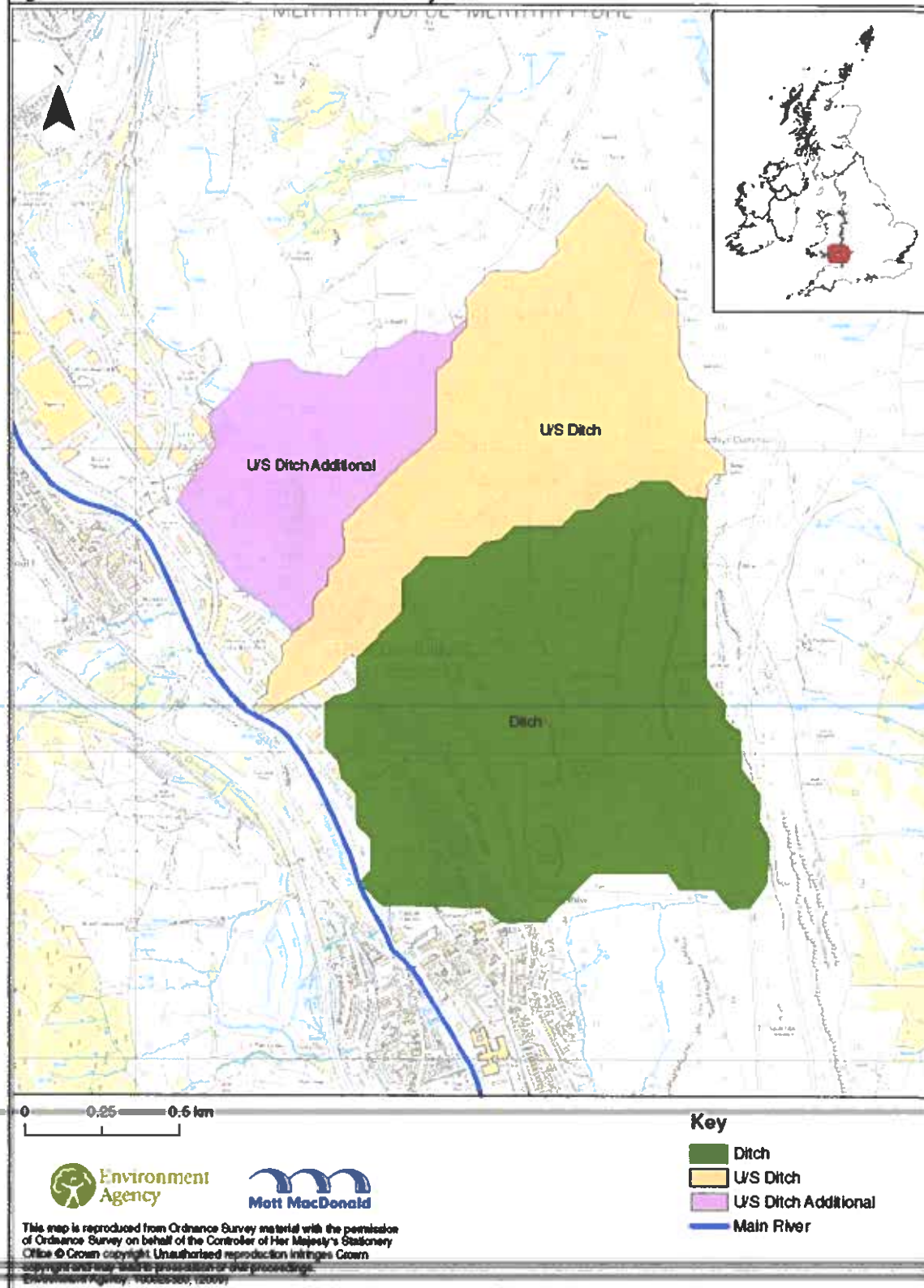
Consequent to the incorporation of the two catchments, the area of the *Troedyrhiw* catchment has been reduced accordingly.

Table 4.2: Summary of Additional Sub-catchments

| Catchment           | River | Area (km <sup>2</sup> ) |
|---------------------|-------|-------------------------|
| US Ditch            | Ditch | 0.92                    |
| US Ditch Additional | Ditch | 0.52                    |

Source: MM

Figure 4.2: Additional Sub-catchment at Troedyrhiw



Source: MM

266381/EVT/HYD/M/B 16 September 2010

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## 4.5 Determination of Initial ReFH Model Parameters

The ReFH rainfall – runoff method using catchment descriptors has been applied to derive inflows into the hydrodynamic model. This approach has been accepted because none of the sub-catchments is gauged, and the existing flow gauges are located downstream of a number of reservoirs along the two main tributaries, The Taff and the Taff Fechan. Catchment parameters derived using observed flow and rainfall data at Merthyr Tydfil and Fiddler's Elbow gauge respectively, cannot be easily transferred to other sub-catchments further upstream due to the impact of the reservoirs on flows at the gauges.

The catchment descriptors for all catchments have been derived from the FEH-CD-ROM version 3.0. These have been used unmodified for all head-catchments for the initial hydrological model calibration. Catchment descriptors for the intermediate catchments using an area weighting have been calculated as recommended in FEH. The catchment descriptors as derived from the FEH-CD-ROM are shown in Appendix B.

## 4.6 Routing Models

In order to route the flow from the various sub-catchments to the locations where flows are recorded the latest version of the Upper Taff FF Model has been used unmodified with the exception of some inflow boundaries representing the catchment schematisation described in Section 4.4.1. The ISIS model schematics are shown in Figure C.1 and Figure C.2.

## 4.7 Calibration

The 12 sub-catchments have been set-up as ReFH boundaries in ISIS. The catchment descriptors derived from the FEH-CD-ROM have been imported, together with the catchment rainfall for each calibration event.

The flows have then been routed to the location of the flow gauges at Merthyr Tydfil and Fiddler's Elbow where the modelled and the observed flows have been compared.

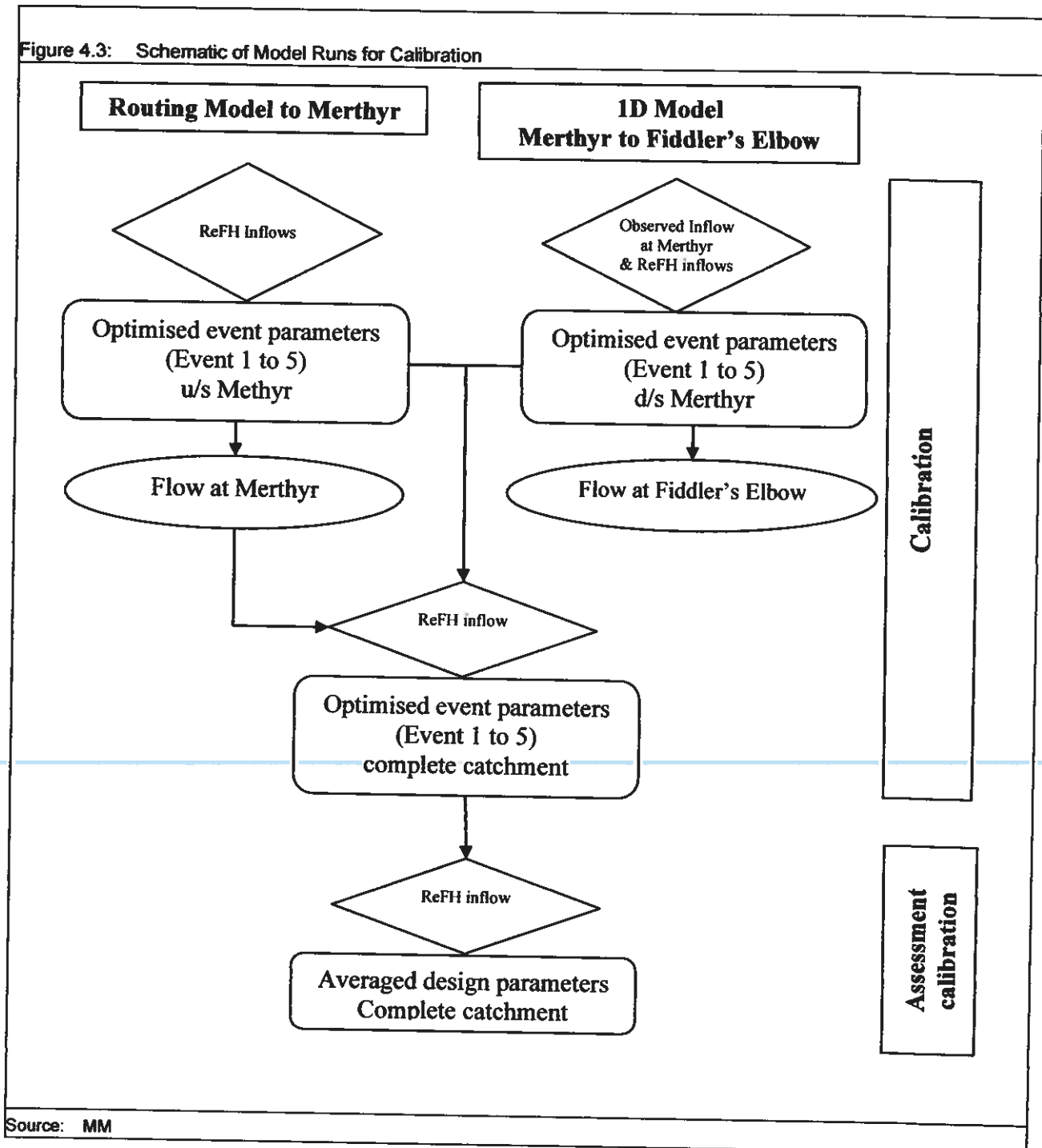
Based on the comparison for each calibration event, changes have been made to the hydrological model including:

- The distribution of inflows from the sub-catchments,
- A revision of the rainfall profiles where there was evidence that the rainfall profiles did not represent the event rainfall,
- The ReFH catchment model parameters such as the time to peak ( $T_p$ ), the maximum storage capacity ( $C_{max}$ ), the baseflow recharge (BR) and the initial storage  $C_{ini}$ .

Based on an average of the parameters derived for each calibration event individually, a single parameter set for the design model has been derived. The calibration events have been run with the design parameter set for verification purposes.

Figure 4.3 shows a schematic of the model runs carried out for calibration and verification.

Figure 4.3: Schematic of Model Runs for Calibration



Source: MM

#### 4.7.1 Upper Sub-catchments

The flow from the four upper sub-catchments has been routed to the gauge at Merthyr where the computed flow has been compared against the observed flow. Based on the comparison, modifications have been made.

Figure 4.4 to Figure 4.8 show the comparison of modelled and observed flows at Merthyr Tydfil for the calibration events. For each event the figures show the progress from the initial run with the unmodified catchment descriptors and rainfall profiles to the finalised calibration for the individual events. Figure 4.4 to Figure 4.8 also show the model runs with the finalised set of design model parameter for each event.

Generally the results indicate that the existing model has some limitations regarding the representation of the reservoirs in particular in situations where the reservoirs have some capacity left at the beginning of an event.

#### 4.7.1.1 Inflow Distribution

Inflows from the four sub-catchments have been kept as set up in the FF model.

#### 4.7.1.2 Rainfall Adjustments

There is no evidence of grossly erroneous rainfall profiles and therefore changes to the event rainfall data have not been made. The calibration is based on the assumption that the derived catchment rainfall profiles generally provide a good representation of the event rainfall across the catchment.

#### 4.7.1.3 ReFH Parameters

Of the four parameters defining the ReFH model, modifications have been made to the maximum storage capacity (Cmax) and to the baseflow recharge BR. The modifications are summarised in Table 4.10

Table 4.3: Adjustments to ReFH Parameters - Upper Catchments

| Sub-catchment  | Event 1 |    | Event 2 |     | Event 3 |     | Event 4 |    | Event 5 |    |
|----------------|---------|----|---------|-----|---------|-----|---------|----|---------|----|
|                | Cmax    | BR | Cmax    | BR  | Cmax    | BR  | Cmax    | BR | Cmax    | BR |
| Pontsticill    | 0.6     | -  | 1.5     | 0.5 | 1.5     | 0.5 | 0.7     | -  | 0.5     | -  |
| PontsticillLat | 0.6     | -  | 1.5     | 0.5 | 1.5     | 0.5 | 0.7     | -  | 0.5     | -  |
| Llwynon        | 0.6     | -  | 1.5     | 0.5 | 1.5     | 0.5 | 0.7     | -  | 0.5     | -  |
| LlwynonLat     | 0.6     | -  | 1.5     | 0.5 | 1.5     | 0.5 | 0.7     | -  | 0.5     | -  |

Source: MM

In order to derive a single set of parameters for the design model runs the parameters derived for the individual calibration events have been averaged. The design parameters are shown in Table 4.4. As there is no evidence that any of the events had either particularly reliable observed data or represents the catchments response to rainfall better than other events, equal weighting has been applied to the five events.

Table 4.4: Adjustment Factors to ReFH Parameters for Design Model Runs – Upper Catchments

| Sub-catchment  | Cmax | TP | BR  | Cini |
|----------------|------|----|-----|------|
| Pontsticill    | 1    | 1  | 0.8 | 1    |
| PontsticillLat | 1    | 1  | 0.8 | 1    |
| Llwynon        | 1    | 1  | 0.8 | 1    |
| LlwynonLat     | 1    | 1  | 0.8 | 1    |

Source: MM

#### **4.7.1.4 Results of Calibration of Individual Events**

Modifications of the ReFH model parameters have been necessary in order replicate the catchments' response to rainfall for the selected calibration events as described above. The modelled and observed peak flows are summarised in Table 4.12.



X

A

100 100

5.3

B

100

100

100

100

100

Figure 4.4: Comparison of Modelled and Observed Flow at Merthyr Tydfil Gauge – Event 1

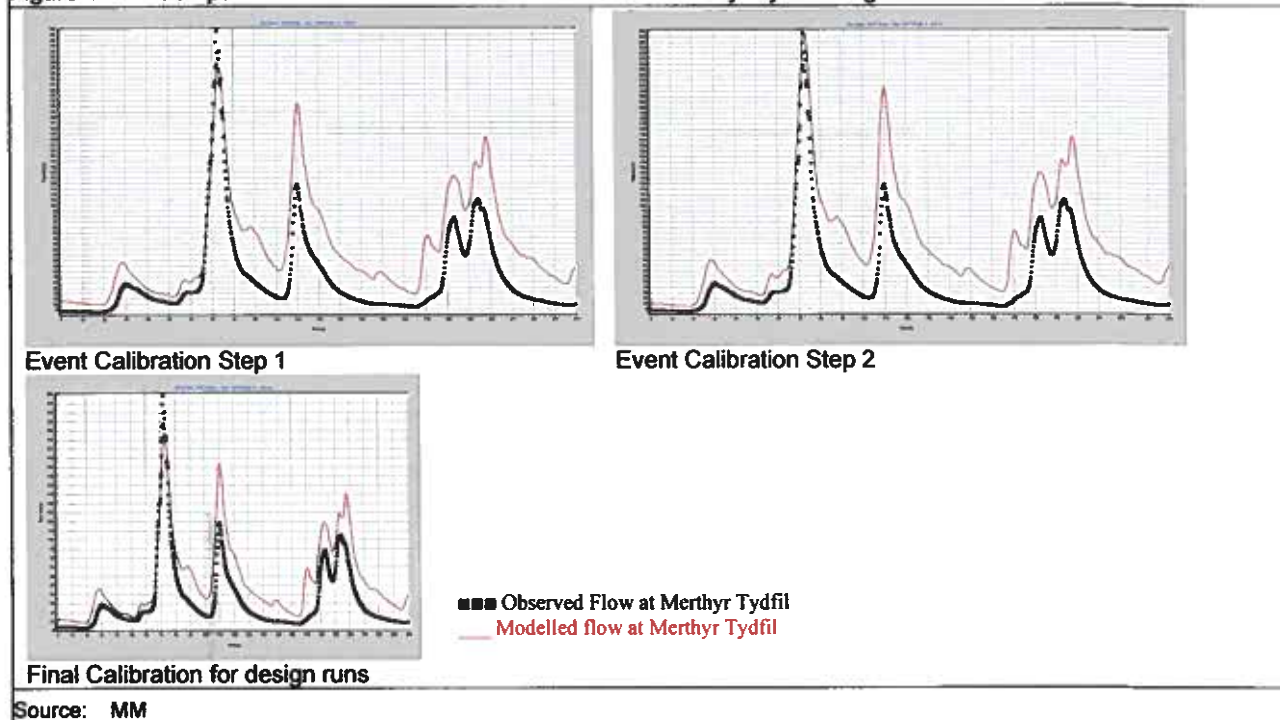


Figure 4.5: Comparison of Modelled and Observed Flow at Merthyr Tydfil Gauge – Event 2

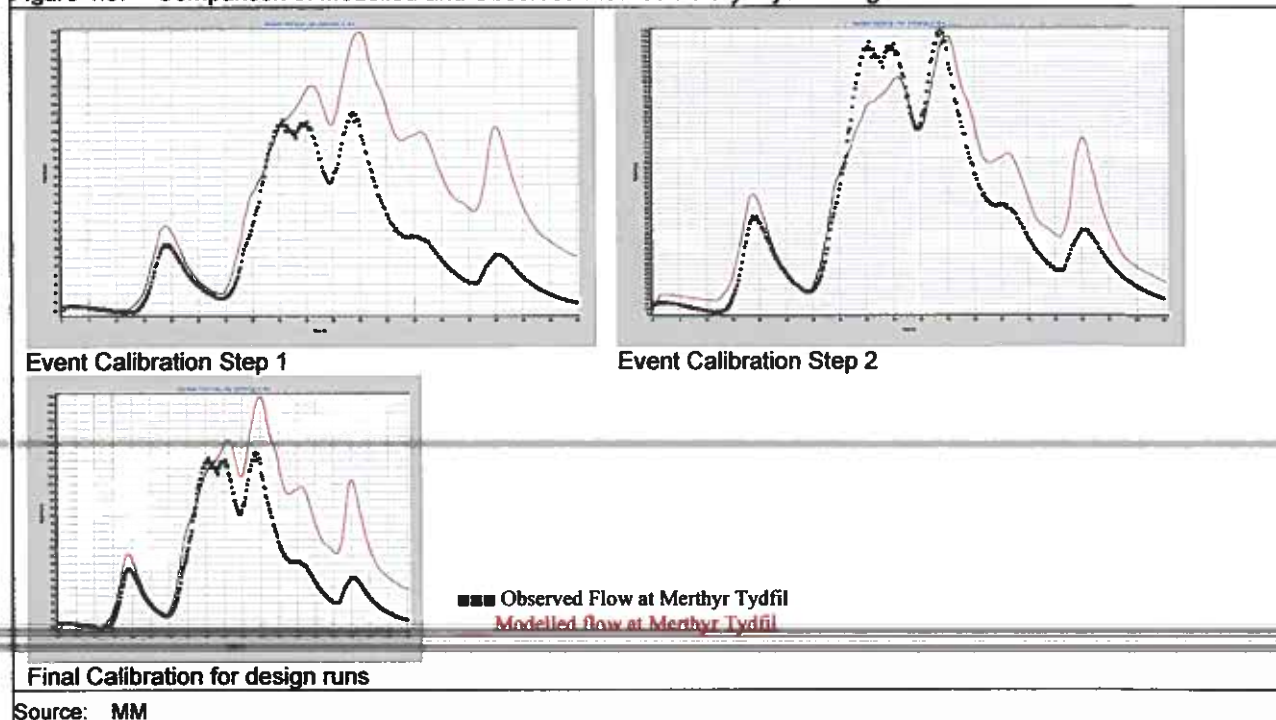
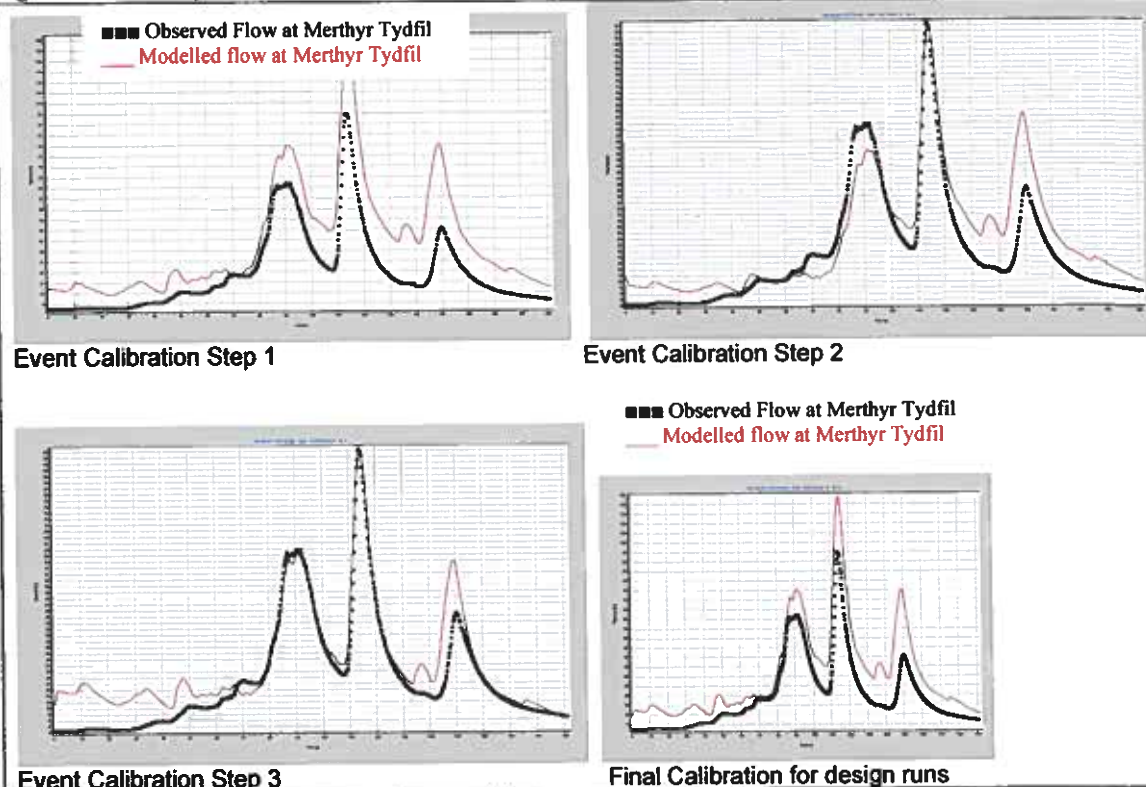
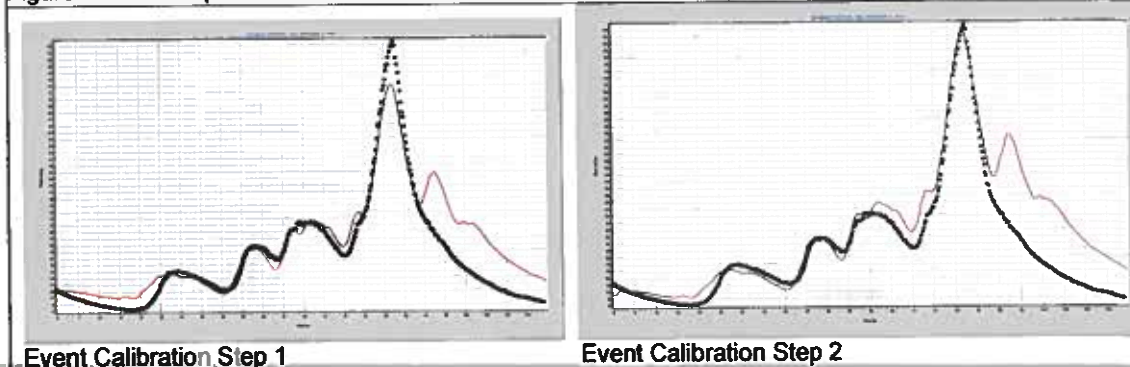


Figure 4.6: Comparison of Modelled and Observed Flow at Merthyr Tydfil Gauge – Event 3



Source: MM

Figure 4.7: Comparison of Modelled and Observed Flow at Merthyr Tydfil Gauge – Event 4



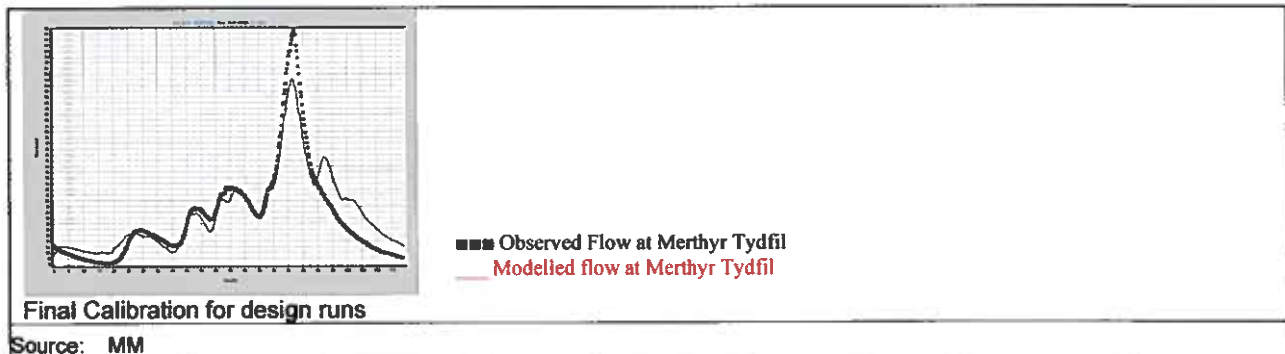
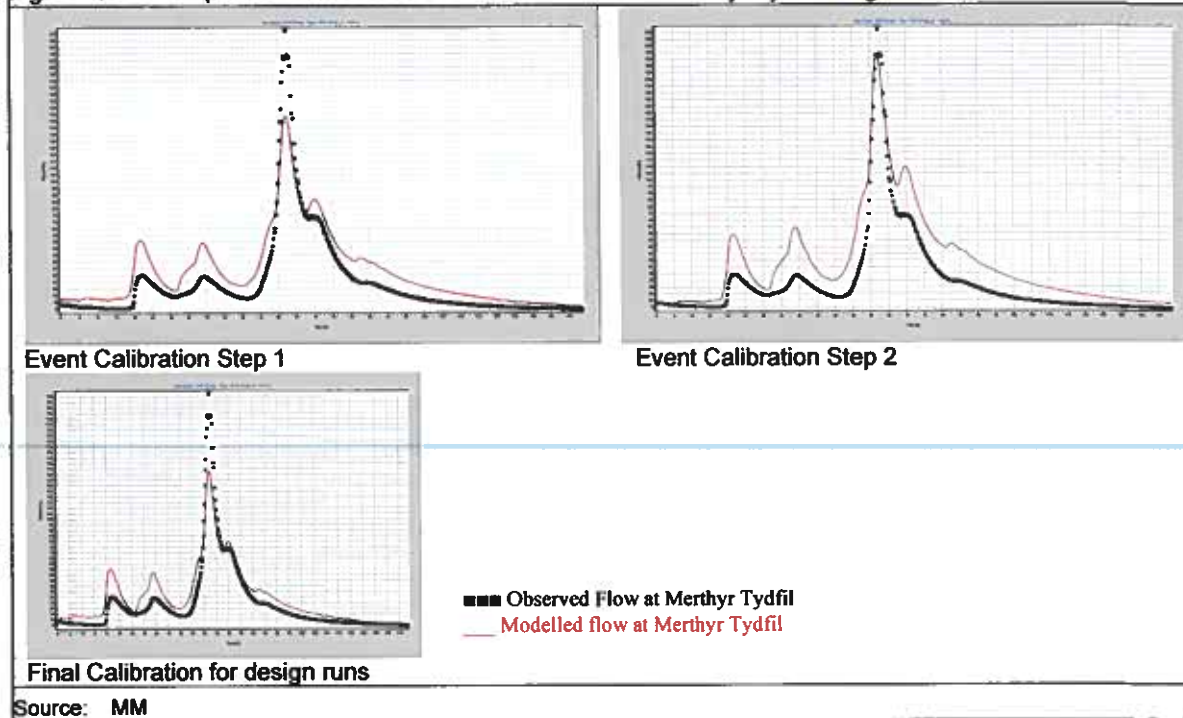


Figure 4.8: Comparison of Modelled and Observed Flow at Merthyr Tydfil Gauge – Event 5



#### 4.7.2 Downstream Sub-catchments

In order to focus on the calibration of the downstream sub-catchments, and to avoid error accumulation from the upper catchments, the 1D model has been run with observed flows at its upstream boundary at the Merthyr Tydfil gauge.

Figure 4.9 to Figure 4.13 show the comparison of modelled and observed flows at Fiddler's Elbow for the calibration events. For each event the figures show the progress from the initial run with the unmodified catchment descriptors ('*Model run with catchment descriptors*') and rainfall profiles to the finalised calibration ('*Event Calibration*').

Generally the results of the initial model calibration show a reasonable good match between observed and modelled flow at Fiddler's Elbow regarding the timing of the hydrograph and the peak flow. The overall flow