RHONDDA CYNON TAF COUNTY BOROUGH COUNCIL

Flood and Water Management Act 2010

Section 19 Flood Investigation Report

Storm Dennis –

Flood Investigation Area RCT06 (Mountain Ash)

October 2022

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This report should be read in its entirety

This report has been prepared in accordance with the requirements of section 19 Flood and Water Management Act 2010. The Council assumes no responsibility or liability from any person in connection with its contents or findings.

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EXECUTIVE SUMMARY

This report has been produced through the duties placed upon Rhondda Cynon Taf County Borough Council under Section 19 of the Flood and Water Management Act 2010. The Act states, “On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

a) which risk management authorities have relevant flood risk management functions and
b) Whether each of those risk management authorities has exercised, or is proposing to exercise those functions in response to the flood”.

This Section 19 investigation provides a factual report of the storm event that occurred on the 15th and 16th of February 2020 within the Rhondda Cynon Taf County Borough Council area, focusing the investigation on the flooding that occurred within the impacted areas of Mountain Ash in the Cynon valley (Flood Investigation Area RCT06, Figure 1).

This report was undertaken to identify the mechanism of flooding, establish which Risk Management Authorities have relevant flood risk management functions under the Flood and Water Management Act 2010 and ascertain if those Risk Management Authorities’ have undertaken or were planning to undertake actions related to those functions to manage the risk of flooding.

The flooding that affected RCT on 15 and 16th of February 2020 was a result of an extreme rainfall event, designated by the Met Office as ‘Storm Dennis’. The impact of the storm event at investigation area RCT06 resulted in internal flooding to approximately 67 properties: including 44 residential and 23 non-residential properties. These impacts were identified through inspections made by RCT’s Flood Risk Management Team during the days following the storm event, as well as information collated by residents, RCT’s Public Health team, RCT’s Highway and Streetcare Depot, Natural Resources Wales and Dŵr Cymru Welsh Water.

It has been established from the evidence gathered within this report that the primary source of flooding at RCT06 on the 15 and 16th of February 2020 was a result of significant overland runoff being generated from the steep hillsides above Mountain Ash East and West, draining to lower ground via a series of ordinary watercourses, many of which became overwhelmed with water and debris and eventually overtopped, impacting several properties on its course of flow.

On review of the condition and hydraulic performance of the culverted infrastructure identified as sources of flooding to properties, two culvert inlets provided inadequate standards of protection in both free-flowing and blockage conditions. The remaining four culvert networks identified as sources of flooding were identified as having adequate standards of protection in free-flowing condition. Despite these culvert networks having sufficient capacity to manage the expected flows, the culverted infrastructure was observed to be in poor condition and its capacities significantly reduced due to blockages caused by mobilised debris from Mountain Ash's upper catchments.

The overtopping of the River Cynon at RCT06 was also identified as a primary source of flooding to properties within the lower reaches of Mountain Ash West. The unprecedently high river level within the River Cynon during Storm Dennis are considered to have contributed to the severity of the overtopping, with NRW's Aberdare station, approximately 5 km upstream of RCT06, recording its highest recorded peak during the event (2.125 metres).

Surface water flooding associated to sheeting runoff from the hillsides and overwhelmed highway drainage network was also identified as sources of flooding to properties within RCT06 during Storm Dennis.

RCT as the Lead Local Flood Authority (LLFA) and Land Drainage Authority (LDA) has been determined as the relevant Risk Management Authority responsible for managing the ordinary watercourse and surface water flooding that occurred at RCT06 during Storm Dennis.

In response to the flooding at investigation area RCT06, the LLFA has undertaken 21 actions and have proposed to undertake a further 8. A summary of which include;

- Undertaken clearance works to the culvert inlet structures identified as sources of flooding following the storm event (assisted by the Highway Authority);
- Carried out survey, jetting and cleansing operations to an estimated 3110 metres of ordinary watercourse drainage network length within the investigation area;
- Led on the development of a central Control Room to compliment the Council's Contact Centre and CCTV Centre, to provide a comprehensive and informed response to residents during storm events;
- Carried out several flood alleviation schemes to facilitate the upgrade of several culvert inlets across RCT06 to improve hydraulic capacity, structural condition and to reduce the risk of potential infrastructure damage/blockages; and

- Installed remote telemetry monitoring devices at key culvert structures to enable operators to ensure the drainage systems within RCT06 are operating effectively.

NRW has been determined as the relevant Risk Management Authority with permissive powers to manage the main river flooding that occurred during Storm Dennis. In response to the flooding at investigation area RCT06, NRW have;

- Carried out their own post event investigative analysis work to understand the mechanism of flooding from the River Cynon at Mountain Ash;
- Commissioned a Cynon Flood Modelling Project, the outcomes of which will include an initial assessment of the viability of potential flood risk management options; and
- Developed a series of recommendations and a detailed action plan to address areas of improvement for future storm events, including the performance and expansion of NRW's Flood Warning Service and incident management response.

The event that occurred on 15 and 16th February was extreme, and it is unlikely flooding from a similar event could be prevented entirely. It is concluded that Risk Management Authorities satisfactorily carried out their flood risk management functions in response to the flood event. All relevant RMAs have proposed further measures to improve preparedness and responses to future flood events.

ABBREVIATIONS

CaRR – Communities at Risk Register

DCWW – Welsh Water

FRMP – Flood Risk Management Plan

FWMA – Flood and Water Management Act 2010

LDA – Land Drainage Authority

LFRMS – Local Flood Risk Management Strategy

LLFA – Lead Local Flood Authority

NRW – Natural Resources Wales

Q – Return Period (1 in X chance of an event occurring in any given year)

RCT - Rhondda Cynon Taf CBC

RCT06 – Flood Investigation Area RCT06

RMA – Risk Management Authority

SAB – Sustainable Drainage Approval Body

SFRA – Strategic Flood Risk Assessment

SOC – Strategic Outline Business Case

SuDs – Sustainable Drainage Systems

WGWE – Welsh Government Woodland Estate

TABLES AND FIGURES

1. INTRODUCTION

1.1. PURPOSE OF INVESTIGATION

On the 15 and 16th of February 2020, RCT was impacted by an extreme weather event which was designated by the Met Office as 'Storm Dennis'. Due to the extent and impact of the event, the LLFA opted to undertake a formal investigation.

The storm resulted in widespread residential and commercial flooding within the Rhondda Cynon Taf County Borough Council area. This report will focus on Flood Investigation Area RCT06 (further referred to as RCT06) which covers the town and community of Mountain Ash within the Cynon valley.

The reason behind RCT's investigation is in response to the duties of the local authority in regard to Section 19; of the Flood and Water Management Act 2010, which states:

1. "on becoming Aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

    a) "Which risk management authorities have relevant flood risk management functions and,
    b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in the response to the flood."

2. "When an authority carries out an investigation under subsection (1) it must (a) publish the results of its investigation, and (b) notify any relevant risk management authority"[1]

The purpose of the investigation is to determine which RMAs have relevant flood risk management functions and which functions have been exercised in response to the flood event in question.

Specific details of Storm Dennis, such as rainfall analysis are covered within a separate overview report that covers the wider RCT area. The report is titled 'Storm Dennis February 2020 – Overview Report' and will be referred to as 'FRM – Storm Dennis – Overview Report'[2].

[1] Flood and Water Management Act 2010 – Section 19 - https://www.legislation.gov.uk/ukpga/2010/29/section/19
[2] Flood Investigation Reports | Rhondda Cynon Taf County Borough Council (rctcbc.gov.uk)

1.2. SITE LOCATION

The area investigated within this report covers the town of Mountain Ash, located within the Cynon Valley and the River Cynon catchment in the north-easternmost region of the county borough. The investigation area falls within the electoral wards of Penrhiwceiber and Mountain Ash.

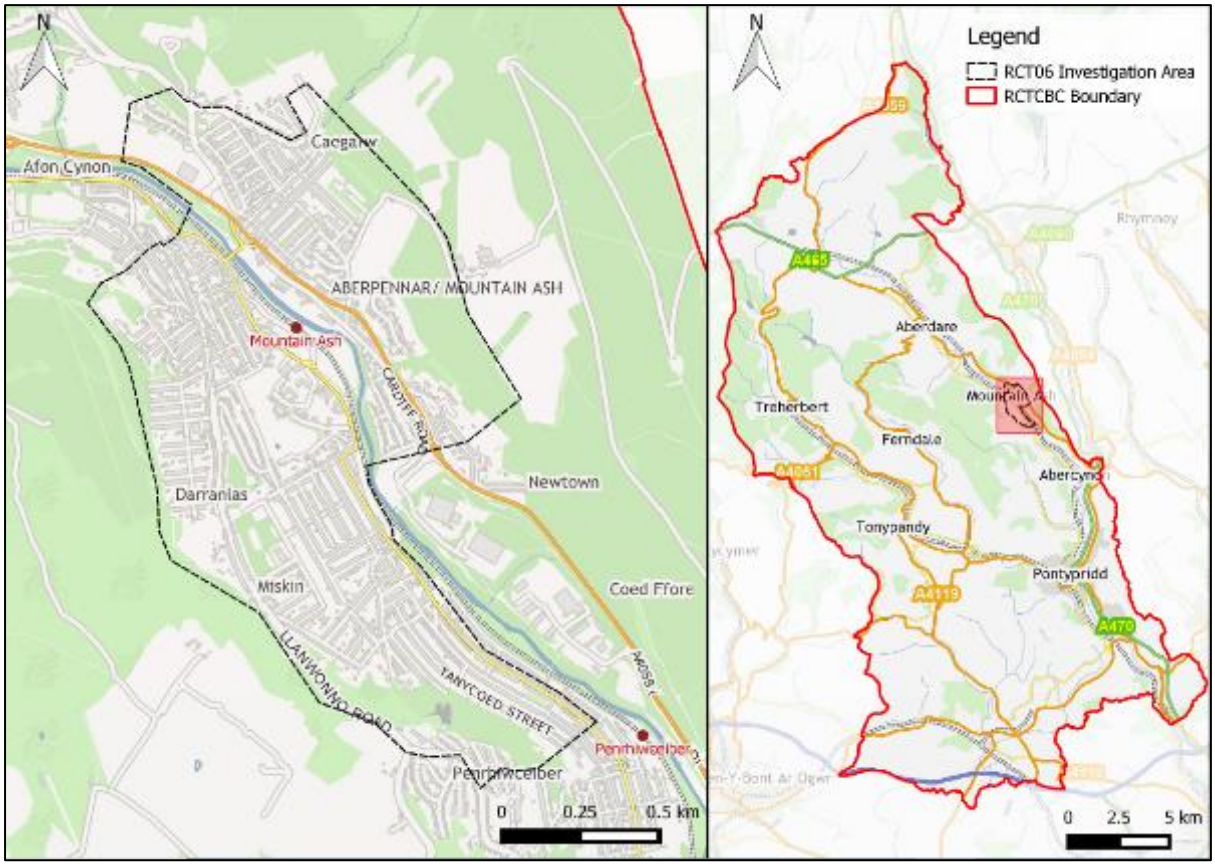

Figure 1: Flood Investigation Area RCT06 Location Plan

The River Cynon, which flows in a southerly direction through the centre of the investigation area, acts as a boundary between the east and west of Mountain Ash. RCT06 is bounded by steep valley hillsides to the north-east and south-west which are drained by multiple named and unnamed ordinary watercourses, including the Nant-y-Ffrwd and the Nant Gelli-Ddu. Many of these watercourses are partially culverted beneath residential areas of Mountain Ash before discharging into the River Cynon.

According to the Welsh Government's CaRR, Mountain Ash is ranked 92nd (out of 2207 communities in Wales) for both surface water and main river flood risk in Wales.

NRW's FRAW map (Figure 2) indicates that the highest risk posed to people and properties within investigation area RCT06 is broadly associated with main river flooding, with a high to low flood risk observed along the length of the River Cynon.

Figure 2 also depicts a high to low risk of surface water and ordinary watercourse flooding sourced by culvert inlets and potential bank breaches across RCT06, including at the Nant y Ffrwd watercourse and towards Trem Y Dyffryn in the north of the investigation area. Isolated areas of surface water flood risk are also identified across Mountain Ash. Flood risk throughout Mountain Ash is further described within RCT's Flood Risk Management Plan (FRMP)[3].

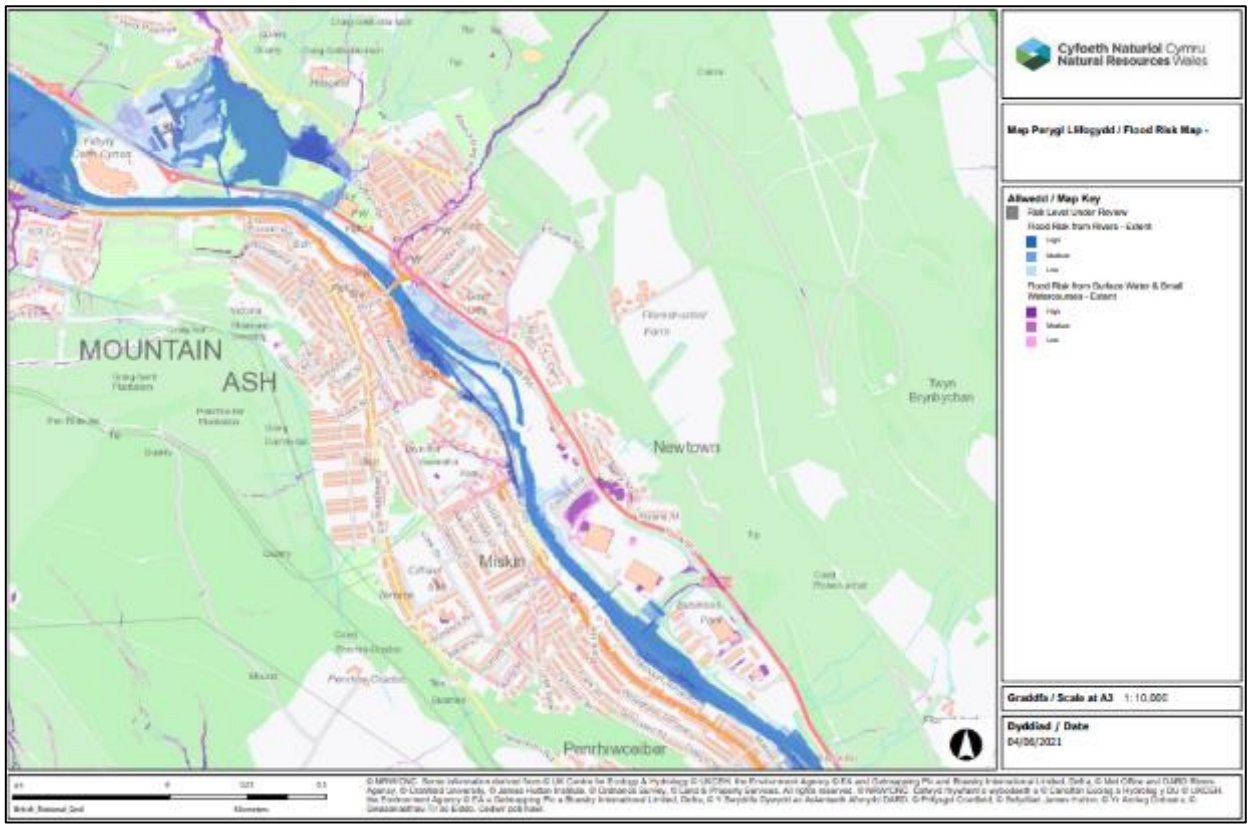

Figure 2: Natural Resources Wales' Flood Risk Assessment Wales (FRAW) map for rivers and ordinary watercourse and surface water flood risk at investigation area RCT06. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

[3] RCT'S Flood Risk Management Plan (rctcbc.gov.uk)

1.3. Drainage System

The surface water drainage systems that serve RCT06 are that of the highway drainage network designed to manage the surface water within the highway and public surface water sewer and combined sewer networks operated by Dŵr Cymru Welsh Water.

1.4. Investigation Evidence

To support the investigation a range of qualitative and quantitative evidence has been gathered from numerous sources, the summary of which is listed within Table 1.

Table 1: Investigative evidence gathered in preparation of the Storm Dennis Section 19 report

Source	Data
Residents	Photos, videos, statements, email correspondence, public engagement survey responses
Responders' statements	Local responders' statements
CCTV Surveys	Internal surveys of the local drainage networks
Met Office Data	Weather Warning information (see FRM – Storm Dennis – Overview Report)
Rain Gauges	RCT and NRW operated gauge information (see FRM – Storm Dennis – Overview Report)
Natural Resources Wales	River Level and Flood Warning data
RCT Flood Risk Management Plan	Site specific information and data for each electoral ward in RCT
Communities at Risk Register	Flood risk ranking and scores for all flood types based on community data in Wales
Flood Investigation Report (Redstart's FIR)	A summary of the source-pathway-receptors, culvert capacity assessment and hydraulic modelling work undertaken by Redstart. The Flood Investigation Report was commissioned by RCT prior to writing the Section 19 report.

Evidence sourced from the 'Flood Investigation Report', commissioned by RCTCBC, will be further referred to as 'Redstart's FIR' throughout this report.

1.5. PUBLIC ENGAGEMENT

Following the initial flooding event that occurred on the 15 and 16th of February during Storm Dennis, flood risk officers from RCT's Flood Risk Management department were deployed to areas across the borough to investigate reports of internal flooding by residents. Residents engaged with the Flood Risk Management team to help determine the initial impacts caused by the flooding event and to investigate the potential source(s) and pathway(s) of flood water. Due to the volume of calls received by RCT's Out of Hours department, visits were prioritised to those areas experiencing significant internal flooding to residential properties.

To support the flood investigations, a public engagement exercise was undertaken between the 4th and 25th of January 2021 by Redstart, on behalf of RCT. The aim of this exercise was to engage with local residents who were affected by the flood event to capture details on how they were impacted, the source and movement of flood water within the area, how receptors were impacted as well as drawing on local knowledge to query how local conditions could have exacerbated the event. This data is useful to help the LLFA better understand and validate our assessment of the flood event to support the investigation under Section 19 of the FWMA.

2. INTRODUCTION

2.1. PREVIOUS FLOOD INCIDENTS

Previous incidences of flooding to properties within the wider investigation area have occurred over the past twenty years, often in relation to the network of ordinary watercourses and culverted infrastructure which convey a substantial volume of water through the town of Mountain Ash. Despite this, no storm event has resulted in flooding so extreme as the flooding that occurred during Storm Dennis.

Information relating to historical flood incidences prior to Storm Dennis is limited however, in recent years the frequency and impact of property flooding has increased with the most notable flood events being Storm Bronagh on 20-21st September 2018 and Storm Callum on 12-13th October 2018.

According to RCT's Flood Risk Management team, localised incidences of surface water flooding across RCT06 has been observed during extreme storm events, often resulting in external flooding however, during Storm Callum in 2018, severe flooding to properties occurred at Cardiff Road and Trem-y-Dyffryn.

2.2. FLOOD INCIDENT

The flooding that occurred on the 15th and 16th February 2020 was a result of an extreme rainfall event, designated by the Met Office as 'Storm Dennis' which affected the majority of RCT and caused widespread flooding to communities.

Specific details of Storm Dennis, such as rainfall and river level analysis are covered within a separate overview report that covers the wider RCT area, referenced 'FRM – Storm Dennis – Overview Report'[2].

The post event inspections undertaken on the days following the storm event by RCT's Flood Risk Management Team and RCT's Public Health, Protection and Community team identified 44 residential properties and 23 commercial properties as internally flooded.

A summary of the source(s) and pathway(s) of flooding within the Mountain Ash investigation area during Storm Dennis have been outlined in Table 2 and further described throughout this section. For the purpose of this investigation, the flood incident at investigation area RCT06 will be described in two parts: the incident at 'Mountain Ash East' catchment area, and the incident at 'Mountain Ash West/Penrhiwceiber' catchment area. Both catchment areas have been split into further sub-catchments which are illustrated below Table 2, within Figure 3.

Table 2: Summary of the source(s), pathway(s) and receptor(s) affected during Storm Dennis within investigation area RCT06

Source	Pathway	Receptor
Mountain Ash East – Sub-Catchment 1		
Intense rainfall running off steep hillsides to the north-east of RCT06 and draining to lower ground via an unnamed watercourse. The debris screen of the watercourse's culvert inlet north of Aberffrwd Road became blocked during the storm event.	Surcharging flows from the culvert inlet north of Aber-Ffrwd Road conveyed downhill in a southerly direction towards and along Dyffryn Road. Pluvial flows accumulated at the Dyffryn Road / Trem-Y-Dyffryn highway junction and conveyed along the residential street for approximately 25 metres.	At least 5 residential properties on Trem-Y-Dyffryn experienced internal flooding during the storm event.

Mountain Ash East – Sub-Catchment 2		
Intense rainfall running off steep hillsides to the north-east of RCT06 and draining to lower ground via the Nant y Ffrwd ordinary watercourse. A culvert inlet at Campbell Terrace surcharged during the storm event.	Surcharging flows from the culvert inlet at Campbell Terrace conveyed towards Jeffrey Street, New Road (A4059) and Ffrwd Crescent (B4275), accumulating at localised low points and entering properties from both the front and rear. Pluvial flows continued to convey from Ffrwd Crescent along Cardiff Road towards the commercial properties located adjacent to the River Cynon.	Internal flooding to 5 residential properties at Campbell Terrace, Allen Street, Ffrwd Crescent and Cardiff Road. 9 non-residential properties were confirmed as internally flooded across Allen Street, Ffrwd Crescent and Cardiff Road.
Collapsed culvert network on the A4059 (New Road)	Surcharging flows discharged from a collapse in the culvert network, contributing additional overland flows along the A4059 (New Road) and Cardiff Road.	Contributed to the internal flooding of 2 residential and 7 commercial properties along Allen Street, Ffrwd Crescent and Cardiff Road.
Intense rainfall running off the hillsides to the north-east of RCT06 draining to lower ground along the steep streets within the sub-catchment. conveying in accordance with local topography and accumulating on Jeffrey Street, New Road (A4059) and Cardiff Road.	Surface water runoff from the eastern hillsides above RCT06 was channelled via the highway network (Aber-ffrwd Road, Allen Street, Phillip Street) towards the lower reaches of Mountain Ash East and accumulating on Jeffrey Street, New Road (A4059) and Cardiff Road.	Primary source of internal flooding to 1 commercial property at Jeffrey Street and contributed to the internal flooding of 5 residential and 9 commercial properties along Allen Street, Ffrwd Crescent and Cardiff Road.
Mountain Ash East – Sub-Catchment 3		
Overland flow originating from the steep hillside to the rear of Clas-Y-Dderwen.	Surface water runoff flowed overland down the hillside to the rear of Clas-Y-Dderwen and entered the rear gardens of several properties.	Internal flooding to 2 residential properties at Clas-Y-Dderwen.
Mountain Ash East – Sub-Catchment 4		
Intense rainfall and subsequent localised surface water accumulation	Surface water accumulated on Cardiff Road and at Usk Villas, conveying towards the	At least 9 residential properties across Cardiff Road and Usk Villas were internally flooded.

exceeded the capacity of the local surface water and combined sewer drainage network.	front of several properties which are situated lower than the road.	
Mountain Ash West / Penrhiwceiber – Sub-Catchment 1		
Intense rainfall running off steep hillsides to the west of RCT06 and draining to lower ground via several unnamed watercourses. A culvert inlet situated adjacent to Victor Street surcharged during the storm event.	Surcharging flows originating from the culvert inlet conveyed along Victor Street towards Beadon Street. Beyond Beadon Street, surface water conveyed into the rear gardens of properties on Quarry Road.	Internal flooding to 2 residential properties at Beadon Street and 4 residential properties along Quarry Road.
An unnamed ordinary watercourse to the rear of Beechwood Bungalows overtopped during the storm event.	Surcharging flows originating from the unnamed ordinary watercourse conveyed from the rear of Beechwood Bungalows towards Pamela Street and onwards towards Beadon Street.	Contributed to the internal flooding of 2 residential properties at Beadon Street and 4 residential properties along Quarry Road.
The main River Cynon overtopped its western embankment adjacent to the B4275 (Oxford Road).	The River Cynon overtopped its banks onto the railway line and Riverside Park within Mountain Ash town centre before conveying onto Henry Street. From Henry Street, fluvial flows conveyed towards the rear of non-residential properties on Oxford Street.	Contributed to the internal flooding of 5 non-residential properties along the B4275 (Oxford Road).
Intense rainfall and subsequent localised surface water accumulation.	Surface water accumulated along the B4275 (Commercial Street, Oxford Street, Miskin Road) at localised low points and as a result of overwhelmed highway drainage infrastructure.	Contributed to the internal flooding of 10 non-residential properties along the B4275 road.
Mountain Ash West / Penrhiwceiber – Sub-Catchment 2		
Intense rainfall running off steep hillsides to the west of	Flows originating within the hillside above Kingcraft	1 residential property adjacent to the culvert inlet was

RCT06 and draining to lower ground via several unnamed watercourses. A culvert inlet situated adjacent to Kingcraft Street surcharged during the storm event.	Street conveyed into the rear garden of an adjacent property.	confirmed as internally flooded.
A culvert inlet to the west of Bryn Ifor surcharged during the storm event.	Surcharging flows from the culvert inlet west of Bryn Ifor conveyed downhill in an easterly direction and immediately into the rear gardens of properties on the street.	Internal flooding to 6 residential properties situated downstream of the culvert inlet at Bryn Ifor.
The main River Cynon overtopped its western embankment adjacent to the B4275 (Oxford Road) within sub-catchment 2.	The River Cynon overtopped its banks at Mountain Ash town centre within sub-catchment 2. Fluvial flows reportedly conveyed south along the railway line and onto the B4275 (Miskin Road).	Internal flooding to 3 residential and 3 non-residential properties along the B4275 (Miskin Road) and and Bailey Street.
Mountain Ash West / Penrhiwceiber – Sub-Catchment 3		
Intense rainfall generating overland flows to convey along the steep hillsides west of RCT06 towards the rear of properties along Arthur Street.	Surface water flowing overland from the hillsides to the west of Mountain Ash West conveyed onto Llanwonno Road. From Llanwonno Road, flows continued to convey in accordance with local topography towards the rear of residential properties on Arthur Street.	3 residential properties on Arthur Street were confirmed as internally flooded.
Mountain Ash West / Penrhiwceiber – Sub-Catchment 4		
An ordinary watercourse situated adjacent to Irene Street overtopped during the storm event.	Surcharging flows originating from an ordinary watercourse adjacent to Irene Street conveyed immediately downhill and into the rear	Internal flooding to 1 residential property at Hill Side.

	garden of properties on Hill Side.	
Mountain Ash West / Penrhiwceiber – Sub-Catchment 5		
Residents at Penrhiwceiber Road reported water ingress through a retaining wall in the rear garden of a property, indicating a potential groundwater source contributed to the flooding.	The exact flow path is unknown; however, the conveyance is attributed to throughflow within the subsurface.	Groundwater contributed to the internal flooding of at least 1 residential property.
Intense rainfall and subsequent localised surface water accumulation.	Surface water accumulated along the B4275 (Penrhiwceiber Road) at localised low points and as a result of overwhelmed highway drainage infrastructure.	Surface water contributed to the internal flooding of 2 residential properties on Penrhiwceiber Road.

On review of Table 2, the principal source of flooding at investigation area RCT06 originated from intense rainfall running off the steep hillsides to the northeast and southwest of Mountain Ash draining to lower ground. This runoff was routed towards the investigation area via several ordinary watercourses, many of which became overwhelmed during Storm Dennis and caused flooding associated to blocked culvert inlets and sheeting runoff directly from the hillsides. Approximately 33 properties were impacted by ordinary watercourse flooding within RCT06.

Localised surface water flooding was identified as a contributing source of flooding to approximately 27 properties within the investigation area as a result of intense rainfall and overwhelmed surface water drainage infrastructure. The overtopping of the main River Cynon was also identified as a source of flooding to 11 properties within the ‘Mountain Ash West/Penrhiwceiber’ catchment area.

Figure 3 depicts the topographic watershed for the Cynon River valley (bold pink line) based on LIDAR, with rainfall falling west and east of the watersheds draining to the Cynon River catchment. The watersheds surrounding RCT06 has been divided into two primary catchment areas: 'Mountain Ash East' catchment (blue hatched area, Figure 3) and 'Mountain Ash West/Penrhiwceiber' catchment (red hatched area, Figure 3). Both catchment areas can be sub-divided into further sub-catchments to illustrate the area of land that would expect to drain towards the investigation area (numbered hatched areas). The flood incident at RCT06 will be further described in two parts: the incident at Mountain Ash East' and 'Mountain Ash West/Penrhiwceiber' catchments.

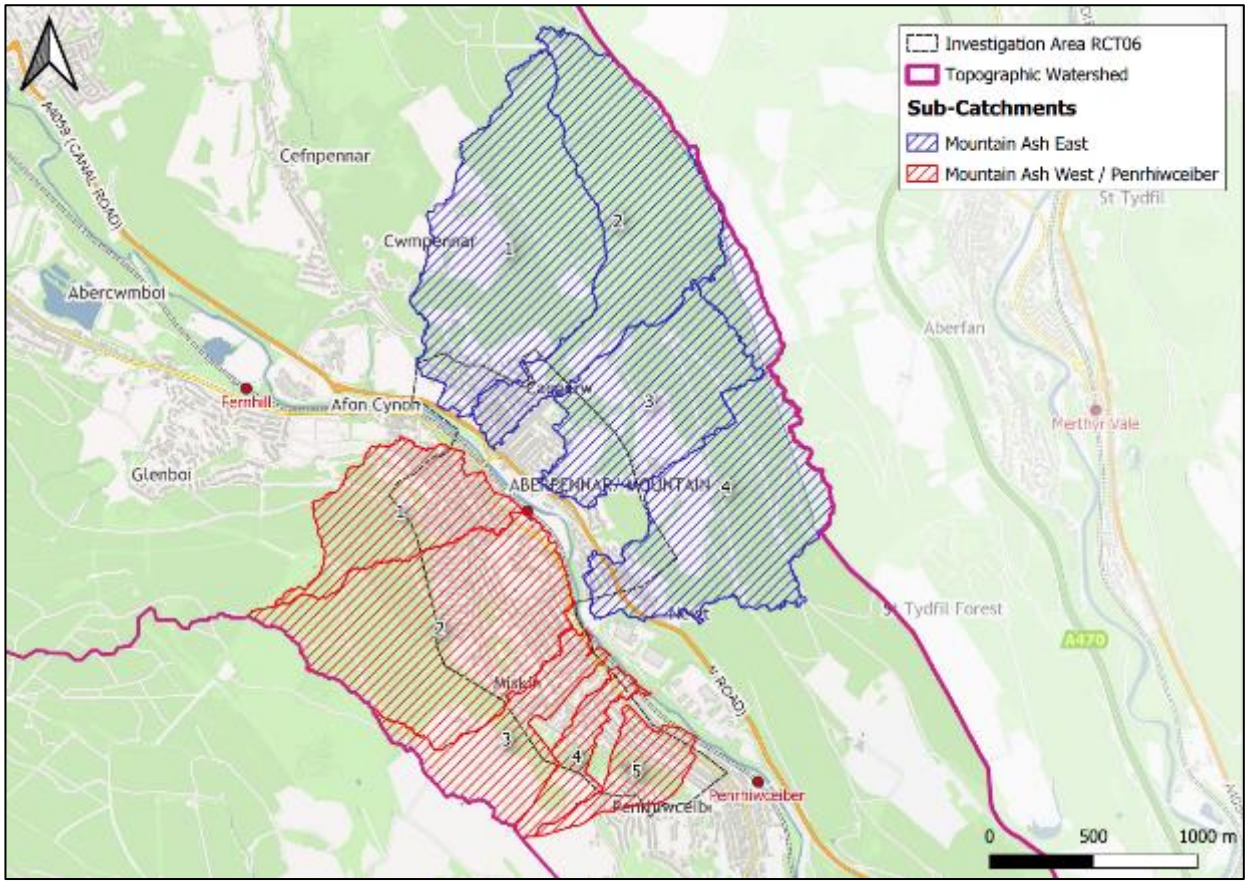

Figure 3: Rainfall Topographic Watersheds, primary catchments and sub-catchment areas surrounding investigation area RCT06

2.2.1. MOUNTAIN ASH EAST CATCHMENT

This catchment area covers the eastern area of Mountain Ash which is drained by a network of named and unnamed ordinary watercourses which discharge into the River Cynon below the A4059 (New Road). The primary watercourse within this sub-catchment is the Nant y Ffrwd.

Figure 4 and 5 depicts the observed pathways of flooding within the 'Mountain Ash East' catchment area, within sub-catchments 1 and 2 (Figure 4) and sub-catchment 3 and 4 (Figure 5), during Storm Dennis. The infrastructure known to have surcharged and contributed to the flooding are also illustrated within both Figures.

Figure 4: Observed flow paths and surcharged assets within 'Mountain Ash East - Sub-Catchments 1 & 2' during Storm Dennis (15-16th February 2020)

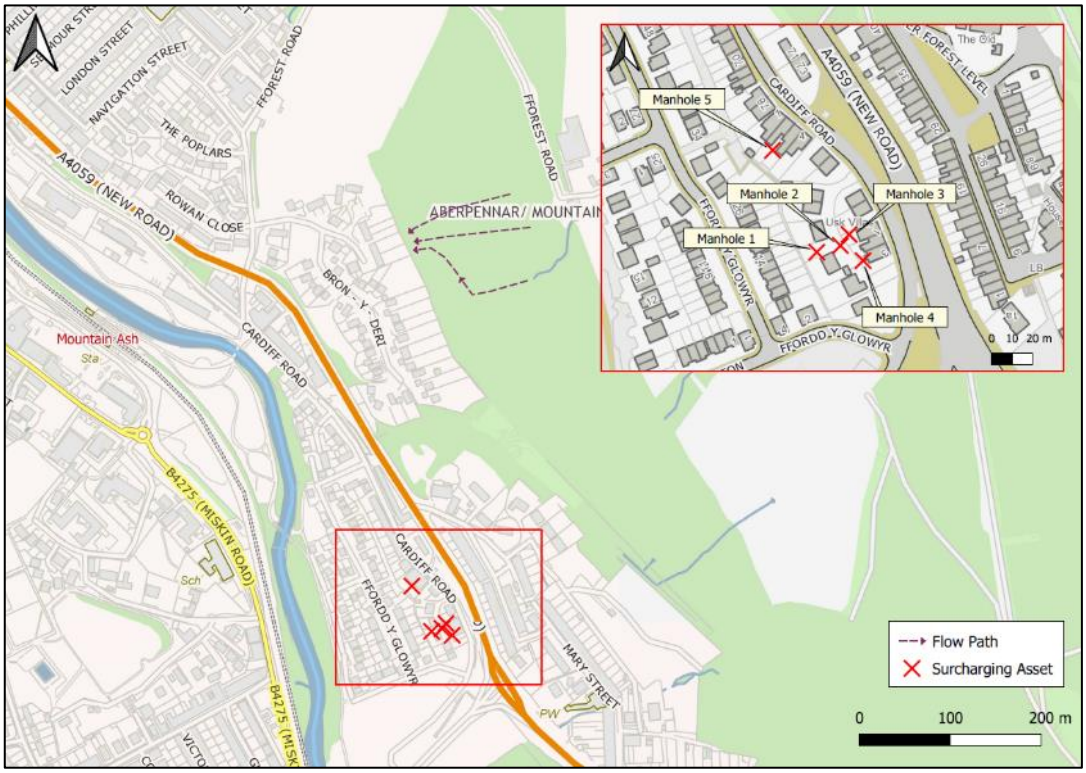

Figure 5: Observed flow paths and surcharged assets within 'Mountain Ash East - Sub-Catchments 3 & 4' during Storm Dennis (15-16th February 2020)

Several calls were received from residents and business owners at Ffrwd Crescent and Cardiff Road on the 16th of February 2020 to report water ingress into multiple properties. Upon a site inspection undertaken by RCT's Flood Risk Management team on the 18th of February 2020, a culvert inlet at Campbell Terrace (labelled 'Culvert Inlet 1', Figure 4), associated to the Nant y Ffrwd ordinary watercourse, was found to have been overcome with debris and was badly damaged. Figure 6 illustrates the poor condition of 'Culvert Inlet 1' captured during post event inspections following Storm Dennis.

Figure 6: Evidence of damage to 'Culvert Inlet 1' at Campbell Terrace identified during post storm investigations (captured by RCT's Flood Risk Management team on 18th February 2020)

Evidence of mobilised and deposited silt, mud and stone along the highway network indicates the flow path originating from 'Culvert Inlet 1' during the storm event. Exceedance flows were observed to convey along Campbell Terrace towards Dyffryn Road. Water overtopped the kerb line at Dyffryn Road and conveyed towards the A4059 (New Road) and the B4275 (Ffrwd Crescent), travelling in a south easterly direction towards Cardiff Road, impacting several properties on its flow path. 9 non-residential and 5 residential properties at Campbell Terrace, Ffrwd Crescent, Allen Street and Cardiff Road were recorded as internally flooded as a result of 'Culvert Inlet 1' surcharging.

Post event inspections also identified a section of the footpath adjacent to the A4059 (New Road) to have suffered from subterranean hydraulic pressure, i.e., the footpath appears to indicate that water from the culvert network, downstream of 'Culvert Inlet 1', erupted through the ground and contributed to the flooding along the highway. The section of damaged culvert is labelled 'Culvert Section 1' in Figure 2.

The damaged footpath was observed as discharging water during the storm event and in the days following. Figure 7 depicts 'Culvert Section 1' discharging flood water and contributing additional surface water flows along the A4059 highway network on 16th February 2020, further exacerbating the flooding of properties associated to 'Culvert Inlet 1'.

Figure 7: Evidence of flood water discharging from a damaged section of footpath adjacent to the A4059 (New Road) and conveying onto the highway during Storm Dennis (captured by RCT officers on 16th February 2020)

Significant surface water flows travelling down steep streets, including Allen Street and Phillip Street, and pooling within the lower reaches of Mountain Ash East was also identified as a primary source of flooding to 2 commercial properties and 1 residential property on the aforementioned streets. Residents also reported surface water overtopping the highway kerb along the A4059 (New Road) as a result of moving cars displacing the standing surface water, which exacerbated the conveyance of surface water within the lower reaches.

To the north-west of 'Culvert Inlet 1', a second culvert inlet (labelled 'Culvert Inlet 2', Figure 4) was reported as surcharging and causing flooding to properties at Trem y Dyffryn during Storm Dennis. 'Culvert Inlet 2' is located to the rear of a property at Aber-Ffrwd Road.

It was evident, based upon an inspection of the area post event, that 'Culvert Inlet 2' had overtopped and conveyed flood water south along Dyffryn Road before reaching a low point at the junction to Trem y Dyffryn. Figure 8, captured post event, also identifies a section of the tarmac driveway below 'Culvert Inlet 2' to have suffered from surface water scour as a result of surcharging overland flows.

Highway drainage gullies along Dyffryn Road also appeared to be blocked and unable to drain the surface water, indicating that material mobilised by the surcharging of 'Culvert Inlet 2' impacted the capacity of the highway drainage infrastructure to manage the flows.

Four residential properties at Trem y Dyffryn, situated near the junction to Dyffryn Road, were confirmed as internally flooded as a result of 'Culvert Inlet 2' surcharging.

Figure 8: Evidence of surface water scour on the driveway of a residential property at Aber-ffrwd Road (Captured by RCT's Flood Risk Management team during post storm investigations)

Within 'Mountain Ash East – Sub-catchment 3', water ingress to properties at Clas-y-Dderwen was reported during the storm event. According to residents, water was flowing overland down the hillside to the rear of the impacted properties and subsequently flooding several rear gardens. Indicative flow paths are illustrated in Figure 5.

Based upon an inspection of the area of hillside to the rear of Clas-y-Dderwen, an unnamed ordinary watercourse channel was identified. The watercourse (illustrated in Figure 9) showed evidence of overtopping and the surrounding hillside was heavily saturated with areas of standing surface water still present during post event inspections.

Figure 9: Evidence of an ordinary watercourse present along the hillside to the rear of Clas-y-Dderwen. (Captured by RCT's Flood Risk Management team during post storm investigations)

Two residential properties were confirmed as internally flooded as a result of the surface water and ordinary watercourse flows conveying down the hillside, with flood depths of up to 200 millimetres reported internally.

Further south within 'Mountain Ash East – Sub-catchment 4', flooding to several residential properties at Cardiff Road and Usk Villas was reported by residents during Storm Dennis. Based upon accounts provided by residents, as well as reports from investigating officers, several surface water and combined sewer manholes were reported as surcharging foul and surface water flows during the storm event after becoming overwhelmed by intense rainfall. The surcharged infrastructure is illustrated in Figure 5.

Nine residential properties at Cardiff Road and Usk Villas were confirmed as internally flooded as a result of surface and foul water accumulation within localised low points. One resident reported flooding of over 2 metres within the ground floor of their property as flood water conveyed towards localised low points. Figure 10 depicts the accumulation of flood water and associated flooding to a property at Cardiff Road.

Figure 10: Flooding to a residential property at Cardiff Road during Storm Dennis (image provided by resident)

2.2.2. MOUNTAIN ASH WEST / PENRHIWCEIBER

This catchment area covers the western area of Mountain Ash and Penrhiwceiber which are drained by a network of unnamed ordinary watercourses which discharge into the River Cynon below the B4275 road and railway track.

Figures 11 and 12 depict the observed pathways of flooding within the 'Mountain Ash West/Penrhiwceiber' catchment area, within sub-catchments 1 and 2 (Figure 11) and sub-catchments 3 and 4 (Figure 12), during Storm Dennis. The infrastructure known to have surcharged and contributed to the flooding are also illustrated within both Figures.

Figure 11: Observed flow paths and surcharged assets within 'Mountain Ash West/Penrhiwceiber - Sub-Catchments 1 & 2' during Storm Dennis (15-16th February 2020)

Figure 12: Observed flow paths within 'Mountain Ash West/Penrhiwceiber - Sub-Catchments 3 & 4' during Storm Dennis (15-16th February 2020)

Several calls were received by residents within 'Mountain Ash West/Penrhiwceiber – Sub-catchment 1', referencing flooding as a result of surcharged ordinary watercourses and culverted infrastructure during Storm Dennis.

A culvert inlet at the top of Victor Street (labelled 'Culvert Inlet 3' in Figure 11), in the uppermost residential area of Mountain Ash West, was identified during post event inspections to have surcharged during the storm event. This surcharging was attributed to a blockage at the culvert inlet as a result of mobilised debris that resulted in an obstruction of flow into the network. Exceedance flows from 'Culvert Inlet 3' flowed down Victor Street and accumulated in the lower section of Beadon Street, impacting two residential properties on Beadon Street from the front and four residential properties at Quarry Road from the rear. Internal flood depths of up to 1 metre were reported within the properties at Quarry Road.

To the south of 'Culvert Inlet 3', it was identified that a watercourse channel situated to the rear of Beechwood Bungalows overtopped during the storm event, causing water to convey overland towards Pamela Street. Upon further inspection, a buried culvert inlet adjacent to Beechwood Bungalows (labelled 'Culvert Inlet 4' in Figure 11) was identified. Both the identified inlet and channel act as an overflow channel to 'Culvert Inlet 3'.

It is considered that the surcharging flows from 'Culvert Inlet 3' overtopped the inlet structure and flowed overland towards 'Culvert Inlet 4'. Water was unable to convey into 'Culvert Inlet 4' due to its poor condition and as a result, surcharging flows conveyed along Pamela Street towards Beadon Street, contributing to the flows from 'Culvert Inlet 3'. Evidence of water pooling on top of the buried culvert inlet is illustrated in Figure 13.

Figure 13: Ordinary watercourse channel upstream of 'Culvert Inlet 4' and evidence of ponding water on top of buried 'Culvert Inlet 4' during post event inspections (captured by RCT's Flood Risk Management team)

Emergency works were carried out by RCT Council within the private land parcel, to reinstate the buried culvert inlet ('Culvert Inlet 4') and excavate the collapsed culvert network to re-establish flows into 'Culvert Inlet 4' and reduce the risk of overland flooding.

A third culvert inlet situated at the top of Kingcraft Street within 'Mountain Ash West/Penrhiwceiber – sub-catchment 2' (labelled 'Culvert Inlet 5' in Figure 11) was also reported by residents as surcharging during Storm Dennis. During post event inspections, material and debris were identified to have caused an obstruction of flow at 'Culvert Inlet 5', resulting in its surcharge. One residential property immediately adjacent to 'Culvert Inlet 5' reported internal flooding, with exceedance flows eroding the adjacent hillside and conveying into the property from the rear.

Approximately 500 metres south-east of 'Culvert Inlet 5', a fourth culvert inlet to the west of properties at Bryn Ifor (labelled 'Culvert Inlet 6' in Figure 11) was also identified as surcharging during the early hours of Sunday 16th February 2020 as a result of debris causing an obstruction of flow. Exceedance flows from 'Culvert Inlet 6' conveyed through the rear boundary walls of several residential properties at Bryn Ifor and onwards to impact the highway, resulting in the internal flooding of 6 properties which reported internal flood depths of up to 100 millimetres.

Emergency works were carried out by a Council appointed contractor following Storm Dennis to remove the debris from the privately owned 'Culvert Inlet 6' and the upstream section of watercourse (Figure 14). During Storm Jorje on the 29th of February 2020, properties at Bryn Ifor were impacted a second time following heavy rainfall.

Figure 14: 'Culvert Inlet 6' at Bryn Ifor during emergency clearance works following Storm Dennis (captured by RCT's Flood Risk Management team on 28th February 2020)

Further south within sub-catchments 3 and 4 of Mountain Ash West/Penrhiwceiber, residents at Arthur Street and Hill Side reported property flooding as a result of surface water ingress to the rear of the impacted properties. Indicative flow paths at Arthur Street and Hill Side during Storm Dennis are illustrated in Figure 12.

Upon an inspection of the hillside above Arthur Street, no culverted infrastructure was identified. It is considered that surface water travelled overland down the hillside above Arthur Street and was intercepted by the highway, resulting in the conveyance of water down Llanwonno Road and onwards towards the rear of properties at Arthur Street. Three residential properties at Arthur Street were confirmed as internally flooded during post event inspections.

Flooding at Hill Side was reported by residents to have originated from the overtopping of an unnamed ordinary watercourse channel to the rear of the impacted properties. A single residential property on Hill Side was confirmed by RCT's investigating officers as internally flooded and a neighbouring property was impacted externally from the rear.

Towards the lower extent of the investigation area within 'Mountain Ash West/Penrhiwceiber - sub-catchment 5', a single property on Penrhiwceiber Road reported internal flooding as a result of water passing through a retaining wall in the property's rear garden. Due to the steep natural slope of the land to the rear of the property, it was deduced by RCT's investigating officers that the water percolating through the rear retaining wall originated as a groundwater source, rather than surface water from the adjacent street. A further one residential property along Penrhiwceiber Road also reported internal flooding during Storm Dennis. Based on an inspection of the area it is considered that surface water accumulated along the highway and was unable to drain away via the surface water drainage infrastructure, resulting in the ingress of water towards the front of the property.

Within the lower reaches of the 'Mountain Ash West/Penrhiwceiber' catchment, flooding from the River Cynon was reported by residents and business owners. Residents' accounts provided as part of the public engagement exercise report that the River Cynon overtopped its western embankment at several locations, resulting in the submersion of adjacent highways, railway lines and open spaces. At least 8 non-residential and 3 residential properties along the B4275 (Oxford Street/Miskin Road) and Bailey Street were impacted internally by the overtopping of the River Cynon during Storm Dennis.

Within Mountain Ash town centre, main river flood water conveyed across the railway line and Railway Park, onto Henry Street and into several car parks to the rear of

Oxford Street. Wrack marks identified to the west of Henry Street carpark (Figure 15) indicate that the overtopping of the River Cynon conveyed approximately 75 metres inland before subsiding.

Main river flood water conveyed into the rear of at least 5 non-residential properties on Oxford Street, causing internal flooding to the basement and ground floors of properties. External flood depths of approximately 1 metre were witnessed during the storm event.

Figure 15: Wrack Marks identifying the extent of main river flooding within Mountain Ash town centre (captured by RCT's Flood Risk Management department on 16th February 2020)

Fluvial flood water conveyed south along Henry Street towards Miskin Road, resulting in significant highway flooding along the B4275, as shown in Figure 16.

Figure 16: Evidence of extensive flooding across Mountain Ash town centre, including at Henry Street carpark (left) and Miskin Road roundabout (right) during Storm Dennis

The River Cynon continued to overtop onto the adjacent railway line and conveyed south, resulting in internal flooding to a further 3 non-residential and 3 residential properties at Miskin Road and Bailey Street. Figure 17 depicts the conveyance of fluvial flows onto Miskin Road from the railway line.

Figure 17: Evidence of fluvial flows conveying onto Miskin Road from the adjacent railway line. (Images provided by a resident)

Residents within the lower reaches of Mountain Ash West/Penrhiwceiber, along the B4275 (Commercial Street/Oxford Street), also reported surcharging and overwhelmed highway surface water drainage as a result of intense rainfall. Surface water accumulation along the highway is considered to be the primary cause of flooding to 5 commercial properties within Mountain Ash town centre, in addition to exacerbating the main river flooding of properties within the lower reaches.

2.3. RAINFALL ANALYSIS

See RCT's 'Overview Report' of Storm Dennis, reference 'FRM – Storm Dennis – Overview Report'[2], for a detailed analysis of the rainfall and ordinary watercourse response.

3. Possible Causes

3.1. Culvert Conditions

There are several ordinary watercourses which drain the hillsides to the east and west of the investigation area and discharge into the River Cynon. Many of these watercourses are culverted beneath RCT06's urban settlements.

Several culvert inlets were inspected by RCT's Flood Risk Management team and Highway and Streetcare Depot following the flood event to assess their condition and help determine whether they served as a contributing factor to the flooding at RCT06. CCTV survey inspections of the culvert network were undertaken to ascertain both the operational condition of the network, and its structural integrity along sections of the network.

It should be noted that all surveys reported in this section were undertaken post flood event. It's not possible to day what debris identified in the survey was mobilised and deposited as a result of the storm event and what had been deposited by previous events. As such, the following should be considered to be reflective of the asset condition at the end of the storm event and may not be necessarily reflective of the condition of the assets prior to the onset of the storm event.

For the purpose of this investigation, the culvert conditions within investigation area RCT06 will be described in two parts: the 'Mountain Ash East' catchment and the 'Mountain Ash West/Penrhiwceiber' catchment.

3.1.1. Mountain Ash East Catchment

Figure 18 outlines the two culvert networks surveyed within the 'Mountain Ash East' catchment and highlights the culvert inlets and manhole known to have surcharged during the storm event.

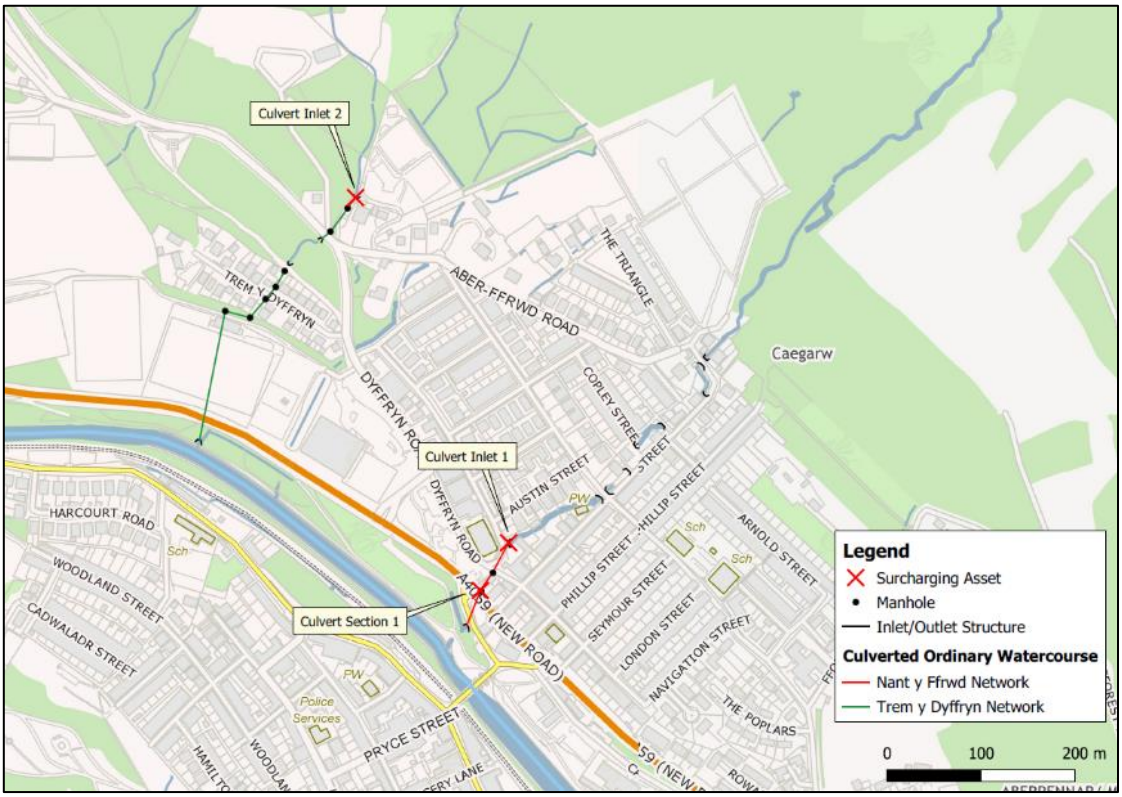

Figure 18: Surveyed culverted ordinary watercourse networks and the infrastructure identified as surcharging within the 'Mountain Ash East' catchment.

The Nant-y-Ffrwd is culverted beneath the A4059 (New Road) and the B4275 (Ffrwd Crescent) at 'Culvert Inlet 1' before discharging into the River Cynon approximately 120 metres downstream.

Both 'Culvert Inlet 1' and 'Culvert Section 1', associated to the 'Nant y Ffrwd' culvert network, were identified as contributing sources of flooding to several residential and commercial properties within the lower reaches of Mountain Ash East. Both the inlet structure and culvert network are identified as the responsibility of the Council.

Upon an inspection of 'Culvert Inlet 1' post storm event, the structure was identified as structurally damaged with significant scour material deposited at the inlet structure, indicating that the inlet had surcharged due to blockage during the storm event (see Figure 6).

A CCTV survey of the 'Nant y Ffrwd' culvert network following Stom Dennis identified significant obstructions present within the network downstream of 'Culvert Inlet 1' as a result of settled debris, reducing the culvert's cross sectional area by up to 95% (Figure 19).

Figure 19: Settled debris deposits identified within the 'Nant y Ffrwd Culvert Network' downstream of ‘Manhole 1’ during CCTV survey, jetting and cleansing operations on 26th February 2020

The volume of settled deposits led to operators abandoning the CCTV survey operations. As a result, approximately 150 tonnes of debris was removed from the network during jetting and cleansing operations, allowing a second CCTV survey to be undertaken which revealed s ome sections of scour and missing stonework within the culvert network. Following emergency works to repair the sections of scour, the network was concluded to be in acceptable structural condition.

The obstruction to the debris screen at ‘Culvert Inlet 1’ caused by the mobilisation of debris within the Nant y Ffrwd watercourse is considered the primary cause of surcharge at ‘Culvert Inlet 1’ during Storm Dennis. The subsequent poor operational condition of the downstream culvert network caused by the mobilisation of debris is considered the primary cause of surcharge from ‘Culvert Section 1’ (Figure 7).

‘Culvert Inlet 2’ is identified as a privately owned structure and was identified as the primary source of flooding to 5 residential properties at Trem y Dyffryn. First responders described the inlet as blocked with debris, inferring that the inlet became obstructed during the storm event. Figure 20 depicts the condition of the inlet prior to Storm Dennis, free from debris and in acceptable condition however, the inlet is identified as an aged asset.

Figure 20: 'Culvert Inlet 2' captured prior to Storm Dennis (captured by RCT's Flood Risk Management team on 13th February 2020)

The ‘Trem y Dyffryn’ culvert network was also surveyed post event by a Council appointed contractor. The survey identified a high volume of settled debris, reducing the networks cross-sectional area by up to 60%, resulting in the survey being abandoned at several locations. This debris is considered to have reduced the culvert’s hydraulic capacity to manage the flow of water entering the network, in addition to causing an obstruction of flow to the inlet structure, both contributing to the surcharging of ‘Culvert Inlet 2’.

The debris identified within the ‘Trem y Dyffryn’ culvert network was also identified to have caused an ordinary watercourse manhole, downstream of ‘Culvert Inlet 2’ to surcharge. The manhole is situated on the driveway of a residential property and surcharging overland flows from the manhole resulted in surface scour to the tarmac driveway, as depicted in Figure 8.

Debris mobilised from the hillside and conveyed towards the ‘Trem y Dyffryn’ culvert network is considered the primary cause of surcharge at ‘Culvert Inlet 2’ and the downstream manhole during Storm Dennis.

3.1.2. MOUNTAIN ASH WEST CATCHMENT

Figure 21 outlines the three culvert networks surveyed within the 'Mountain Ash West' catchment and highlights the culvert inlets known to have surcharged during the storm event.

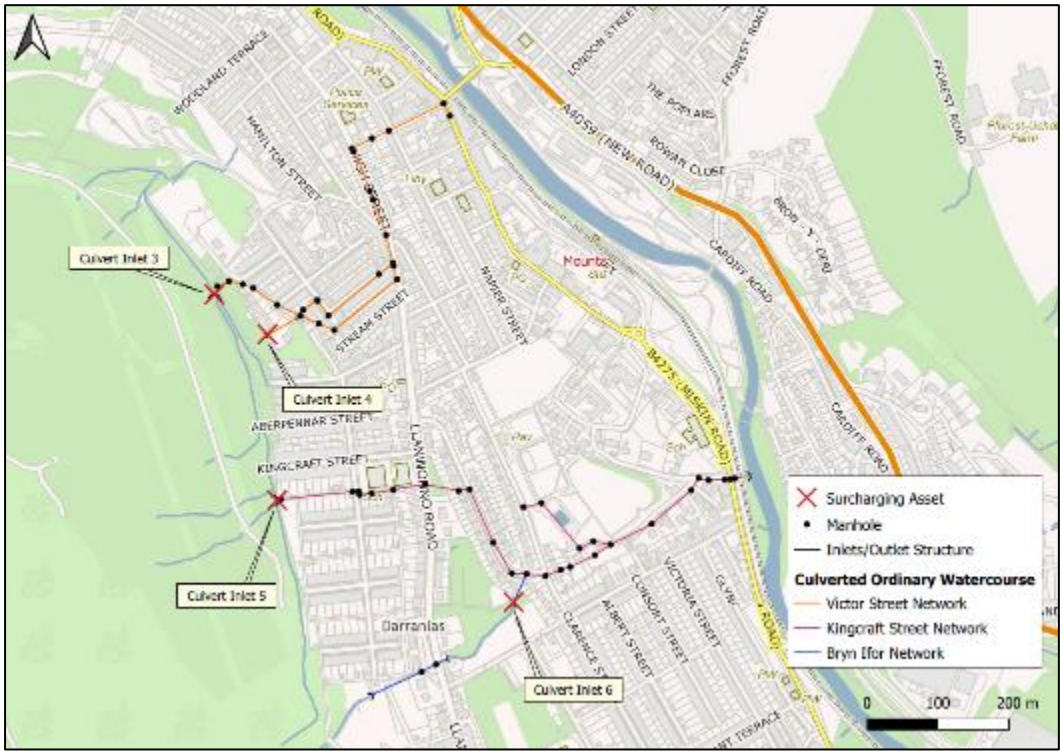

Figure 21: Surveyed culverted ordinary watercourse networks and the infrastructure identified as surcharging within the 'Mountain Ash West' catchment.

'Culvert Inlets 3, 4 and 5' take inflow from the western hillsides of RCT06 via several unnamed ordinary watercourse and surface water runoff which is culverted beneath Mountain Ash West's settlements and discharged into the River Cynon.

Based on an assessment of the drainage arrangements to the west of RCT06, 'Culvert Inlet 3' acts as an overflow system from 'Culvert Inlet 5', and 'Culvert Inlet 4' acts as an overflow system from 'Culvert Inlet 3'. It is considered that the surcharging at 'Culvert Inlet 5' exacerbated the surcharging of 'Culvert Inlet 3 and 4' during the storm event.

Both 'Culvert Inlet 3 and 5' were witnessed by emergency responders to be obstructed with debris mobilised from the hillsides which resulted in surcharging at both inlet structures in addition to the backing up of flow within the ordinary watercourses, resulting in overtopping. 'Culvert Inlet 3' is comprised of a circular 400mm cast iron pipe and 'Culvert Inlet 5' comprises a 300mm concrete pipe, both with headwall

structures and formal debris screens (illustrated in Figure 22). Both culvert inlets are also identified as the responsibility of NRW on behalf of the Welsh Government as land manager of the Welsh Government Woodland Estate.

Figure 22: 'Culvert Inlet 3' (left) and 'Culvert Inlet 5' (right) structures captured post Storm Dennis

Both culvert networks associated to 'Culvert Inlet 3, 4 and 5' were surveyed in June 2020 following Storm Dennis. The results of which identified no defects within the upper section of the 'Kingcraft Street Culvert Network', which suggests that the culvert conditions had minimal influence on the surcharging of 'Culvert Inlet 5'. A CCTV survey of the 'Victor Street Culvert Network' identified some sections of the culvert network to be in poor condition, both structurally and operationally however, the primary cause of surcharge at 'Culvert Inlet 3' has been attributed to the blockages at the inlet screen which reduced the inlet's capacity to manage the inflow of water, resulting in overtopping.

Upon the overtopping of 'Culvert Inlet 3', a former watercourse channel is activated which is considered to have overtopped to the rear of Beechwood Bungalows during the storm event, resulting in the conveyance of water overland towards Pamela Street. Upon further investigation, a buried culvert inlet was identified ('Culvert Inlet 4') which was unable to convey the ordinary watercourse flows from the hillside and into the culvert network.

Emergency works were undertaken by RCT Council to excavate the buried culvert inlet which was identified as a small 150mm pipe and identified as a privately owned structure. 'Culvert Inlet 4' and the downstream network were assessed as being in poor condition with several sections of collapsed pipework (Figure 23). The condition of 'Culvert Inlet 4' and the downstream culvert network is considered to have contributed to the surcharging at this location, however the primary cause of flooding

has been attributed to the volume of water entering the system from the hillside which overwhelmed the watercourse channel to the rear of Beechwood Bungalows and resulted in water flowing overland towards the lower reaches of Mountain Ash West.

Figure 23: Collapsed culvert pipework downstream of 'Culvert Inlet 4' which was identified as buried during emergency repair works (captured by RCT officers post Storm Dennis)

'Culvert Inlet 6' was also identified by first responders as significantly blocked with debris during the storm event. Images captured post event show evidence of flattenned grass and debris deposited around the headwall structure, indicative of the exceedance flows originating from 'Culvert Inlet 6' (Figure 24). Significant works were undertaken by the Council's Highway and Streetcare Depot to remove the debris from the inlet structure and surrounding area on two occasions post Storm Dennis.

The 'Bryn Ifor Culvert Network' was assessed as being in acceptable condition downstream of 'Culvert Inlet 6', with little settled debris present. The culvert network upstream of 'Culvert Inlet 6' which conveys beneath Llanwonno Road, was observed to be in poor operational condition, with settled debris restricting CCTV operations, indicative of the mobilisation of debris from the upper catchment.

Figure 24: Evidence of flattened grass and deposits of debris at 'Culvert Inlet 6' post event (captured by RCT officers)

3.2. ORDINARY WATERCOURSE CONDITIONS

Several sections of natural ditches and open watercourses which drain the steep catchments above RCT06 are identified to flow through the investigation area and discharge into the River Cynon, which flows through the centre of Mountain Ash, as illustrated in Figure 25. The most notable ordinary watercourse is the Nant y Ffrwd.

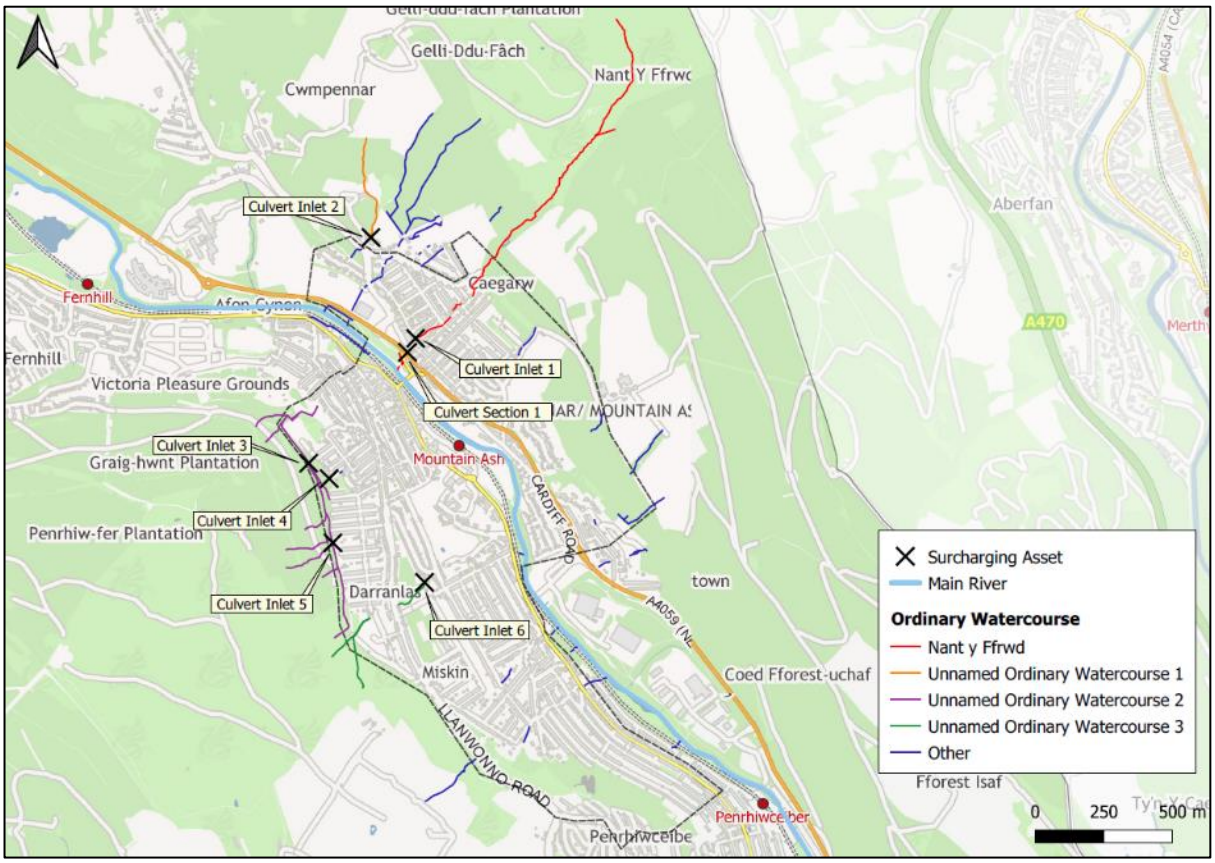

Figure 25: Map of Ordinary Watercourses which feed into investigation area RCT06

Following the storm event, RCT Flood Risk Management officers carried out a site walk-over assessment, where possible, of the ordinary watercourses upstream of the culverted infrastructure identified as sources of flooding (highlighted in Figure 25) to assess the condition of the watercourses for any signs of overtopping, evidence of scour and any land movement of the hillsides.

Information pertaining to the condition of the sections of ordinary watercourse were also assessed during CCTV operations undertaken following the storm event.

3.2.1. NANT Y FFRWD ORDINARY WATERCOURSE

The Nant y Ffrwd has the largest watershed of all ordinary watercourses within RCT06 and conveys from its source within the upper eastern valley hillside towards the River Cynon through residential areas of Mountain Ash East.

Following the surcharging of 'Culvert Inlet 1' and 'Culvert Section 1' (Figures 6 and 7) caused by debris blockages during Storm Dennis, the Nant y Ffrwd ordinary watercourse was inspected by Flood Risk Management officers for signs of debris mobilisation. The watercourse was inspected at three areas, depicted in Figure 26.

Figure 26: Nant y Ffrwd ordinary watercourse inspection location plan

The upstream sections of the Nant y Ffrwd ordinary watercourse (Area 1, Figure 26) showed evidence of significant embankment scour (Figure 27) and deposition of material consisting of large stonewash (Figure 28), within the upper channel. This material is assumed to have been mobilised from the upper reaches of the Nant y Ffrwd and carried downstream by the high flows during Storm Dennis.

Figure 27: Photo of significant embankment scour and undercutting to the Nant y Ffrwd ordinary watercourse within Area 1, Figure 26 (captured by RCT's Flood Risk Management team on 25/02/2020)

Figure 28: Photo of debris deposition within the Nant y Ffrwd ordinary watercourse within Area 1, Figure 26 (captured by RCT's Flood Risk Management team on 25/02/2020)

Within Area 2, Figure 26, the Nant y Ffrwd ordinary watercourse is partially culverted beneath residential development and the sections of open channel are heavily modified. On review of the open channels in Area 2, further deposition of material was observed along with significant accumulation of material across the debris screens.

Figure 29 depicts the material, which consists of coarse stone and silt, within Area 2. This material is assumed to have been mobilised from Area 1 and the upper reaches of the Nant y Ffrwd catchment and carried downstream by the high flows during Storm Dennis towards 'Culvert Inlet 1'.

Figure 29: A comparison of the Nant y Ffrwd open watercourse channel, adjacent to Allen Street within Area 2, Figure 26, pre (left) and post (right) clearance of debris material (captured by RCT's Flood Risk Management team on 18/02/2020 (left) and 01/03/2020 (right)

Damage to the channel retaining walls were also identified during post event inspections of Area 2, further indicative of the powerful flows conveying downstream during the storm event. Evidence of a damaged section of retaining wall adjacent to Allen Street is depicted in Figure 30.

Figure 30: Evidence of damaged channel retaining wall within Area 2, Figure 26, of the Nant y Ffrwd ordinary watercourse (captured by RCT's Flood Risk Management team during post storm investigations)

Downstream of 'Culvert Inlet 1' and 'Culvert Section 1' (Area 3, Figure 26), at the outfall of the Nant y Ffrwd, significant deposition of debris was observed. Figure 31 illustrates the condition of the outfall pre (Figure 31, left) and post (Figure 31, right) emergency clearance works, which were carried out by the Authority following Storm Dennis. The observed accumulation of debris provides further evidence of the substantial mobilisation of debris carried by the Nant y Ffrwd watercourse during Storm Dennis.

Figure 31: Evidence of debris accumulation at the outfall of the 'Nant y Ffrwd Culvert Network' pre (left) and post (right) emergency clearance works (captured by RCT's Flood Risk Management team on 16th February 2020)

The high sediment loading from the upper Nant y Ffrwd watercourse is considered the primary cause of surcharge at ‘Culvert Inlet 1’ and ‘Culvert Section 1’, by causing an obstruction of flow and subsequently reducing the capacity of the culvert network and inlet structure to manage the flow of water, resulting in overtopping and associated flooding to properties.

3.2.2. UNNAMED ORDINARY WATERCOURSE 1

‘Culvert Inlet 2’ takes inflow from an unnamed ordinary watercourse (labelled ‘unnamed ordinary watercourse 1’, Figure 25) to the rear of Aber-Ffrwd Road.

Figure 32 depicts the condition of the channel immediately upstream of ‘Culvert Inlet 2’ during post event inspections. The open watercourse upstream of ‘Culvert Inlet 2’ was observed as largely undefined with dense vegetation restricting on-site inspections.

Figure 32: ‘Unnamed ordinary watercourse 1’ upstream of 'Culvert Inlet 2' captured by RCT officers post event

Based on the available CCTV survey data and reports provided by first responders to the area during Storm Dennis, significant debris, inclusive of woody debris, stones and silt, was identified at ‘Culvert Inlet 2’ and within the ‘Trem y Dyffryn’ culvert network which is considered to have been mobilised from upstream by the ordinary watercourse flows.

3.2.3. UNNAMED ORDINARY WATERCOURSE 2

'Unnamed ordinary watercourse 2' (Figure 25) comprises of a network of unnamed open watercourses which drain the western hillsides of RCT06 and feed into 'Culvert Inlets 3, 4 and 5'. The unnamed watercourses are situated on the WGWE which is managed by NRW on behalf of the Welsh Government.

The unnamed ordinary watercourse channels which drain the hillsides to the west of Mountain Ash West were observed to have been heavily eroded during post storm event inspections. The observed embankment and channel scouring is indicative of the entrainment and deposition of material within the watercourses during the storm event, which led to the identified obstructions at 'Culvert Inlets 3 and 5'.

Wrack marks of debris deposited by the overtopping of the watercourses was also observed during post event inspections, as depicted in Figure 33, further indicative of the entrainment and deposition of debris during the storm event.

Figure 33: 'Unnamed ordinary watercourse 2' upstream of 'Culvert Inlet 3' captured by RCT officers post event

The available evidence infers those blockages caused by the mobilisation of debris within 'unnamed ordinary watercourse 2' was the primary cause of surcharge at 'Culvert Inlets 3 and 5' and subsequently 'Culvert Inlet 4' which acts as an overflow system to 'Culvert Inlet 3'.

3.2.4. UNNAMED ORDINARY WATERCOURSE 3

The unnamed ordinary watercourse to the rear of Bryn Ifor (labelled 'unnamed ordinary watercourse 3', Figure 25) was identified as heavily eroded with debris deposits observed along the length of the channel (Figure 34). This debris, inclusive of natural erosive material, is considered to have been mobilised within the upper watercourse by the high velocity flows, and conveyed towards 'Culvert Inlet 6', causing a reduction in hydraulic capacity for the culvert network to manage the inflow of water and resulting in surcharge. Furthermore, the deposited material is also considered to have reduced channel capacity during the storm event, exacerbating the flow of water conveying towards 'Culvert Inlet 6'.

Figure 34: Evidence of embankment erosion (left) and deposition of material (right) within 'unnamed ordinary watercourse 3' upstream of 'Culvert Inlet 6' (captured by RCT officers on 29th February 2020)

3.3. Main River

The designated main River Cynon flows in a south easterly direction through the centre of the investigation area. Areas on the western embankment of the River Cynon, within the 'Mountain Ash West/Penrhiwceiber' catchment area, were impacted during Storm Dennis.

3.3.1. Main River Levels and Flood Warnings

Prior to Storm Dennis, on the 9th of February 2020 during Storm Ciara, the river level sensor for the River Cynon at Mountain Ash monitoring station, which is owned and operated by NRW, was impacted by floating debris and subsequently damaged. NRW operatives organised an immediate repair to be completed on the 11th of February; however, high river levels prevented the execution of the repair. Consequently, river level data was not captured at NRW's Mountain Ash station during Storm Dennis.

The closest river level gauge stations in operation along the River Cynon during Storm Dennis are approximately 5 kilometres both upstream and downstream of the investigation area; at Aberdare and Abercynon respectively. Figures 35 and 36 illustrate water levels within the River Cynon at both stations during Storm Dennis and provide an indication of the River Cynon's response to rainfall during the storm event.

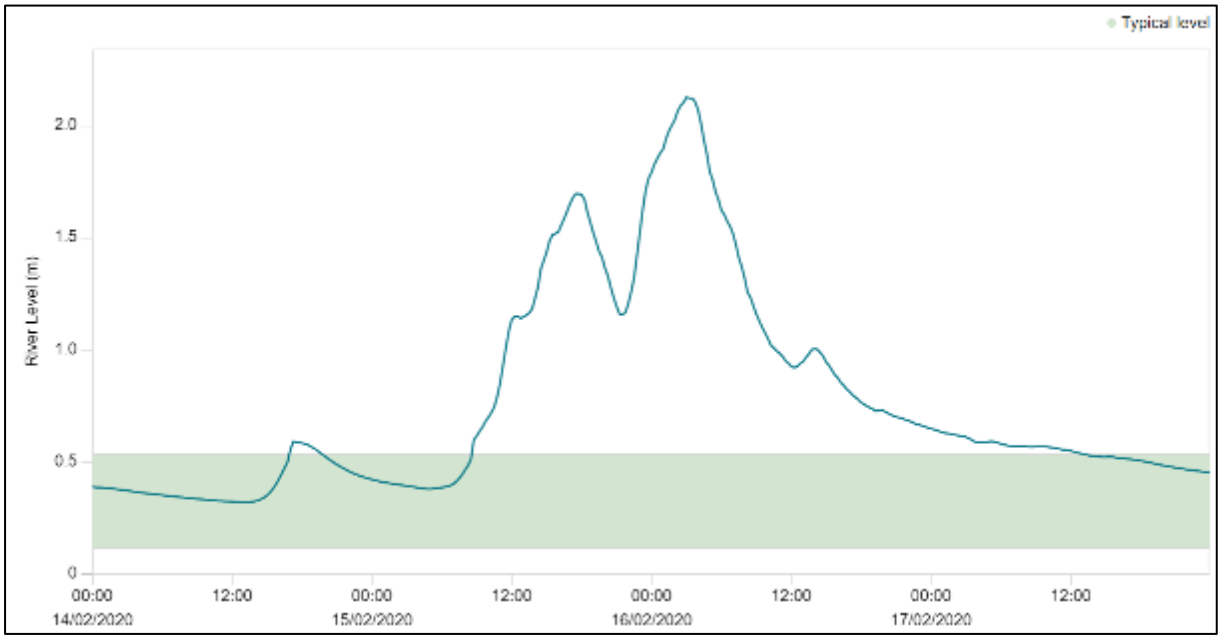

Figure 35: The River Cynon levels at Aberdare station between the 14th and 17th of February 2020 (Natural Resources Wales)

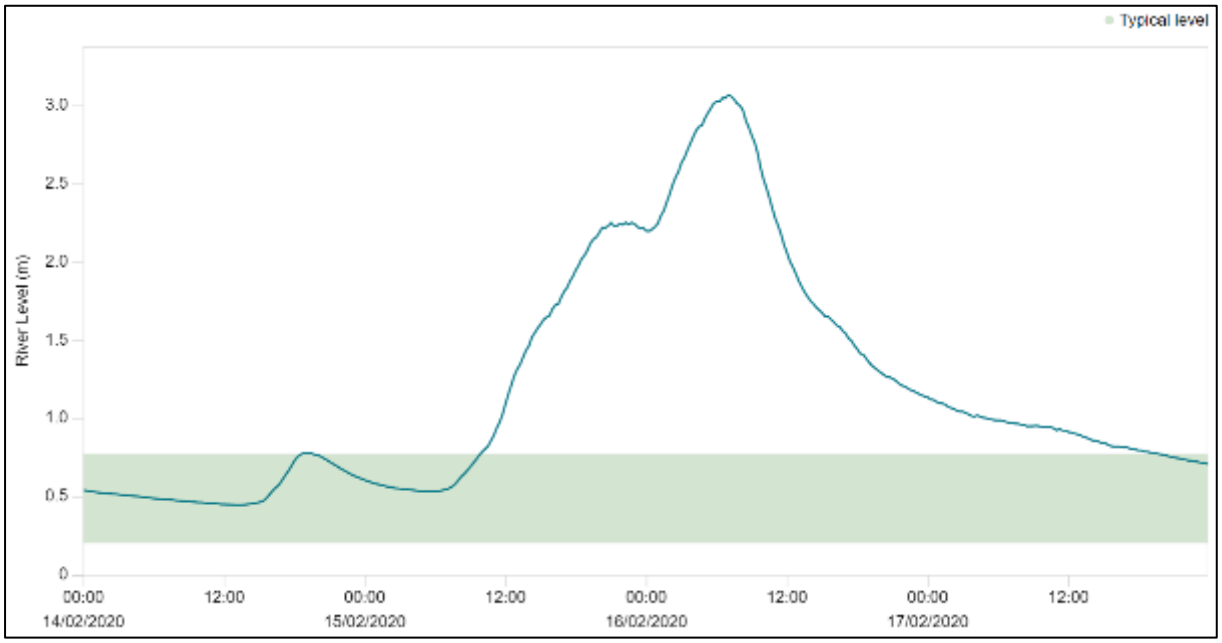

Figure 36: The River Cynon levels at Abercynon station between the 14th and 17th of February 2020 (Natural Resources Wales)

NRW issued a 'Flood Alert' (indicating possible flooding) for the River Cynon at 12:51 on the 15th of February, during that time the River Cynon at Aberdare and Abercynon had reached over a metre in depth. The River Cynon continued to rise during the early hours of Sunday 16th February morning before reaching a peak level of 2.125 metres (03:00 16th February) at Aberdare and 3.067 metres (07:00 16th February) at Abercynon; the highest levels recorded for the River Cynon at both stations.

The green bar displayed on both hydrographs show the typical level of the River Cynon at Aberdare and Abercynon stations, ranging between 0.1 and 0.7 metres. At its peak, the River Cynon was over three times its typical level, stressing the extreme and unprecedented level that RCT's rivers rose to during the storm's peak intensity. As a result of the significant rise in river levels following heavy and persistent rainfall, the River Cynon overtopped its western embankment at RCT06, leading to property flooding.

Investigation area RCT06 falls within NRW's Mountain Ash Flood Warning Area. The Flood Warnings issued by NRW for Mountain Ash, and the associated river levels for the River Cynon captured at NRW's Aberdare and Abercynon stations during Storm Dennis are shown in Table 3.

Table 3: Flood Warnings issued by NRW for the River Cynon at RCT06 during Storm Dennis

Flood Warning Type	Location	Start Time	River Level (m)	
			Aberdare	Abercynon
Flood Alert	River Cynon	12:51 15/02/2020	1.139	1.272
Flood Warning	River Cynon at Mountain Ash	19:45 15/02/2020	1.412	2.159

NRW issued a 'Flood Warning' alert (indicating flooding is expected) for the River Cynon at Mountain Ash at 19:45 on the 15th of February; at which point river levels were above typical levels and continuing to rise at both stations. The 'Flood Warning' alert issued at Mountain Ash was the first flood warning issued by NRW across RCT, closely followed by a 'Flood Warning' alert at Abercynon. Resident accounts and post event investigations indicate that flooding within RCT06 occurred after the issuance of both the 'Flood Alert' and the 'Flood Warning' alert.

NRW have acknowledged within their 'Flood Incidence Response Review'[4] that the operation of the service "came under significant pressure during February and at times became overwhelmed", resulting in flood warnings being issued late (after the onset of flooding) or not issued at all in other areas of the local authority.

Improvements to their flood forecasting and warning services are being internally investigated by NRW and, where feasible, implemented to deliver the recommendations outlined within their Flood Incident Response Review[4].

3.3.2. Main River Flood Risk

As outlined in Section 2, the overtopping of the River Cynon along the western embankment of RCT06 during Storm Dennis has been identified as the primary cause of flooding to several properties along the B4275 (Oxford Street / Miskin Road) and Bailey Street.

[4] February 2020 Floods in Wales: Flood Incident Management Review (cyfoethnaturiol.cymru)

Figure 37 is an excerpt from NRW's Flood Risk Assessment Wales (FRAW) mapping exercise which depicts the main river flood risk extents for the 'Defended' scenario, i.e., with the presence of flood defence infrastructure. The darker shading identifies areas at higher risk of flooding (more frequent/less extreme rainfall events) and lighter shading showing the lower risk areas (less frequent/more extreme rainfall events).

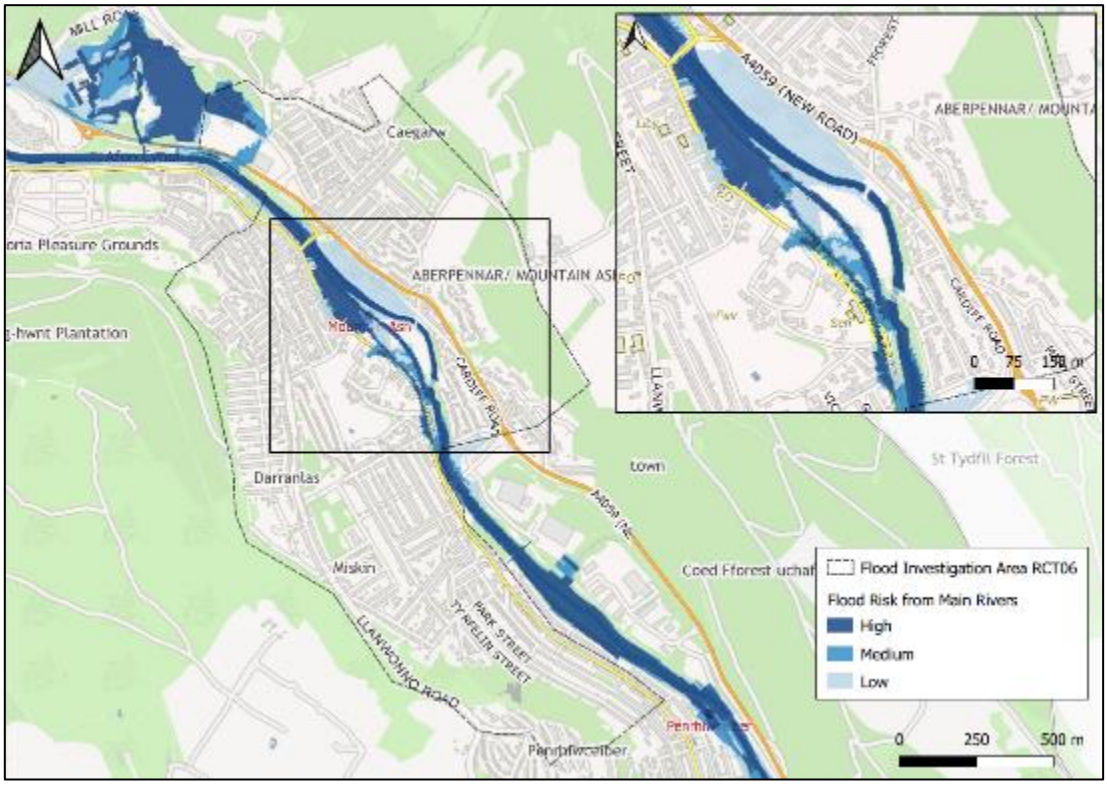

Figure 37: NRW's FRAW map for River sources in RCT06. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

The flooding that occurred within RCT06 during Storm Dennis is largely consistent with the modelled outputs of NRW's FRAW map (Figure 37), with the impacted properties falling within an area of high and medium risk of fluvial flooding. A high risk of flooding means that an area has a chance of flooding of greater than 1 in 30 (3.3%) each year; a medium risk of flooding signifies a yearly chance of flooding between 1 in 100 (1%) and 1 in 30 (3.3%); meanwhile a low risk of flooding means that an area has a chance of flooding between 1 in 1000 (0.1%) and 1 in 100 (1%) each year.

3.3.3. Main River Flood Defences

As illustrated in Figure 38 (demarcated by a bold red line), there are approximately 475 metres and 400 metres of formally designated flood defence along the eastern and western banks of the River Cynon at RCT06, respectively. This infrastructure is operated and maintained by NRW.

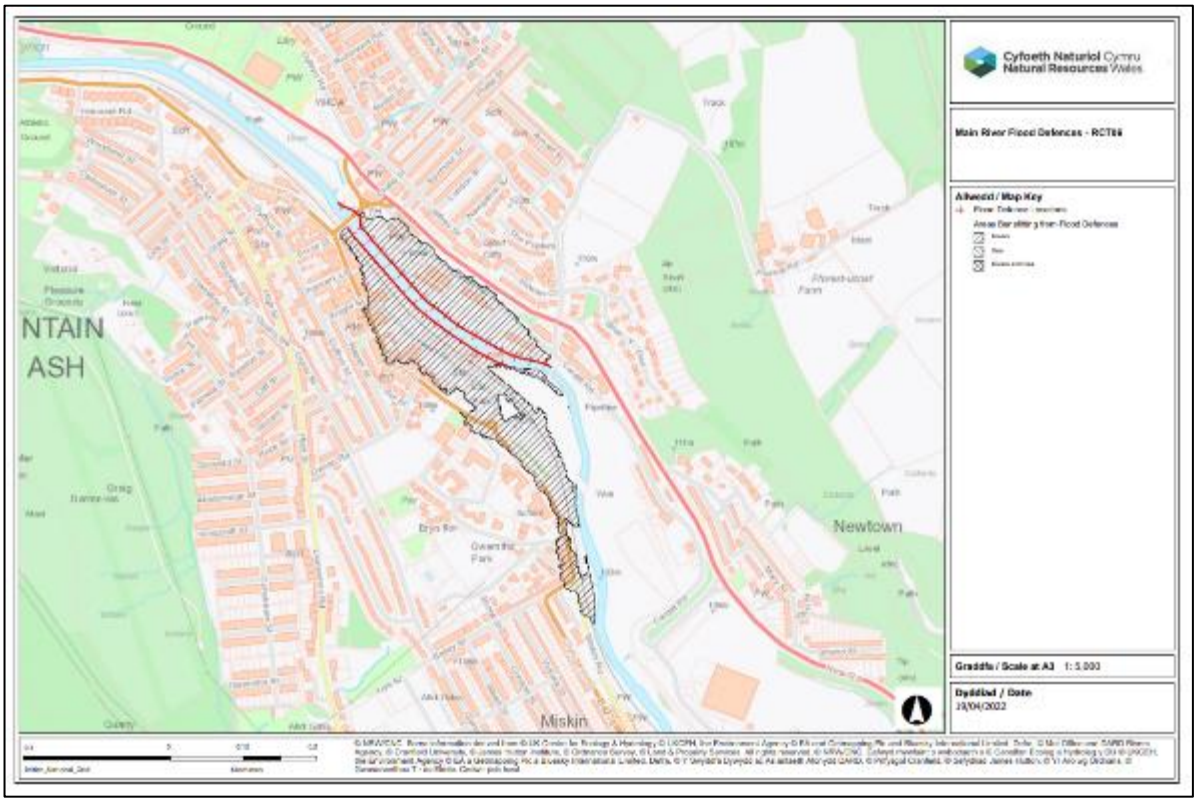

Figure 38: Natural Resources Wales' map for Main River Flood Defences and areas benefiting at RCT06. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved

The current indicative design standard of protection (SOP) for flood defences on a main river is 1 in 100 annual probability (Q100) flood event plus, for new defences, an allowance for climate change. This is stated within the Welsh Government's National Strategy for Flood and Coastal Erosion Risk Management which encourages main river flood alleviation schemes to provide a SOP up to Q100[5].

Based on the available information provided within Figures 37 and 38, the impacted properties along the B4275 (Oxford Street/Miskin Road) and Bailey Street fall within areas which benefit from flood defence infrastructure (black hatched area, Figure 38) however, based on the high and medium flood risk (fluvial) extents present along those

[5] National Strategy for Flood and Coastal Erosion Risk Management in Wales (English) (gov.wales)

streets, the impacted properties within RCT06 are not considered to be protected up to Q100 SOP. There still appears to be a high risk of fluvial flooding present along the impacted streets which may be associated with flood water conveyance along the railway line, as occurred during Storm Dennis.

It should be stressed however, Storm Dennis was estimated as being in excess of a 1 in 200 annual probability (Q200) flood event, therefore the unprecedented rise in river levels within the River Cynon during the storm event resulted in the overtopping of assets up to Q100 SOP.

3.4. HIGHWAY DRAINAGE CONDITIONS

Surface water runoff along the highway was reported by residents at various locations across the investigation area during Storm Dennis, however, there is no evidence to suggest that the condition of the highway drainage within RCT06 significantly contributed to the flooding of properties. The highway drainage infrastructure was overwhelmed by intense rainfall and subsequent surface water flows, in addition to ordinary watercourse flooding associated to culvert infrastructure surcharging and the overtopping of the River Cynon, which led to the accumulation of standing water entering properties within the lower reaches of the investigation area.

To the southwest of the investigation area at Cardiff Road and Usk Villas, the highway drainage infrastructure became overwhelmed during the storm event as a result of intense rainfall which caused two highway surface water drainage manholes to surcharge, labelled 'Manhole 1 and 2' in Figure 39. Both structures contributed to the internal flooding to three residential properties at Cardiff Road.

The impacted properties at Cardiff Road are situated lower than the highway, contributing to the accumulation of surface water at the low points and the conveyance of flood water into residential properties.

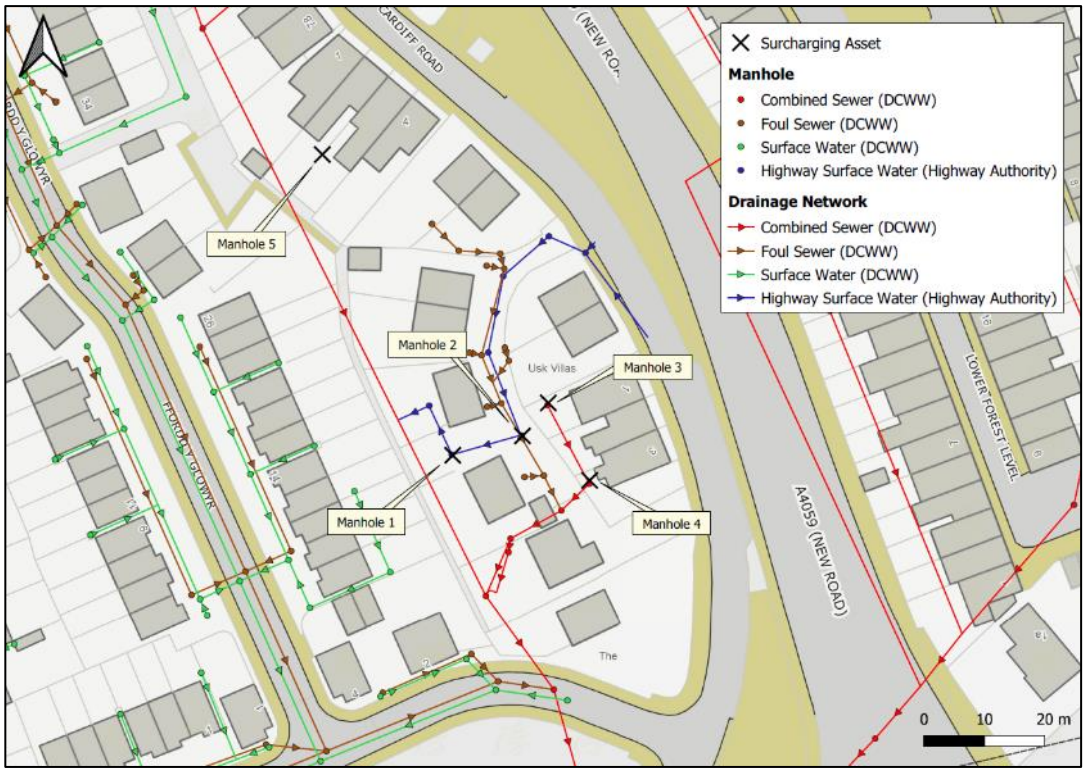

Figure 39: Map of the highway drainage network and DCWW operated sewer networks at Cardiff Road, Mountain Ash East. The surcharged assets during Storm Dennis are highlighted and labelled.

As depicted in Figure 39, the highway surface water drainage network connects into the combined sewer network, owned and operated by DCWW, which runs to the rear of the impacted properties and parallel to Cardiff Road.

CCTV inspections of the highway surface water drainage network at Cardiff Road, undertaken post storm event, identified no structural or operational defects. The network was assessed as free-flowing and in acceptable condition, inferring that the drainage network became hydraulically overwhelmed during the storm event.

The condition of the combined sewer network, which falls under the responsibility of DCWW, was not assessed post Storm Dennis, however based on CCTV surveys undertaken by RCT, the combined sewer network at the point of connection with the highway surface water drainage network, appeared to be silted, with 10-25% of the network's cross-sectional area lost due to settled debris and silt.

Based on the available evidence it is considered that the high flows within the combined sewer network, flowing parallel to Cardiff Road, contributed to the surcharging of 'Manhole 1 and 2' due to a backing up of flow as a result of intense rainfall.

Two separate sources of flooding were also identified by residents and inspecting officers to have impacted properties in the Cardiff Road and Usk Villas area: a private combined sewer manhole (Manhole 5, Figure 39) and two DCWW owned and operated combined sewer manholes (Manhole 3 and 4, Figure 39). Both sources of flooding have been further described in Section 3.7.

Overland flows from areas of hillside, runoff originating from surcharged culvert infrastructure, and the overtopping of the River Cynon to the rear of the B4275 (Oxford Street/Miskin Road), also resulted in the deposition of mud, silt and debris across several streets which is assumed to have entered the highway drainage network via gullies. In these instances, it is likely that highway drainage assets will have had a limited capacity to intercept flows within the investigation area, further exacerbating the surface water flooding. Figure 40 depicts the high sediment loading deposited onto Campbell Terrace (right) and Ffrwd Crescent (left) by the surcharging Nant y Ffrwd ordinary watercourse flows within Mountain Ash East.

Figure 40: Evidence of debris deposited onto Ffrwd Crescent (left) and Campbell Terrace (right) as a result of 'Culvert Inlet 1' associated to the Nant y Ffrwd watercourse surcharging during Storm Dennis (captured by RCT officers during the storm event)

Highway drainage is not designed to manage overland flows from private areas, parks or open space, nor is it designed to accommodate fluvial flows that may arise during storm events. In this instance, the capacity of the highway drainage in RCT06 was exceeded as a result of main river, ordinary watercourse and surface water flows entering the network at various locations. The maintenance condition of the highway drainage infrastructure is not considered to have significantly impacted the flooding experienced during Storm Dennis.

3.5. SURFACE WATER

Overland flows from areas of hillside and the localised accumulation of surface water as a result of overwhelmed drainage infrastructure has been determined as the primary cause of flooding to 17 properties within the investigation area, including at Clas-y-Dderwen, Cardiff Road, Arthur Street and Hillside.

Surface water runoff as a result of ordinary watercourse flooding associated to blocked and overwhelmed culvert inlets has also been determined as a contributing source of flooding to several properties across the investigation area, and in addition to this, is also considered to have contributed to and exacerbated the main river flooding observed across the Mountain Ash West embankment.

On review of NRW's national surface water and ordinary watercourse flood map (Figure 41), the extent of flooding from pluvial sources is minimal, with only small, localised areas of high to low flood risk observed along the lower streets within RCT06, where water naturally accumulates. Despite the FRAW map indicating little surface water and ordinary watercourse flood risk across RCT06, surface water conveyance was observed along several highway networks and as overland flow originating from areas of hillside which is confirmed to have impacted several properties.

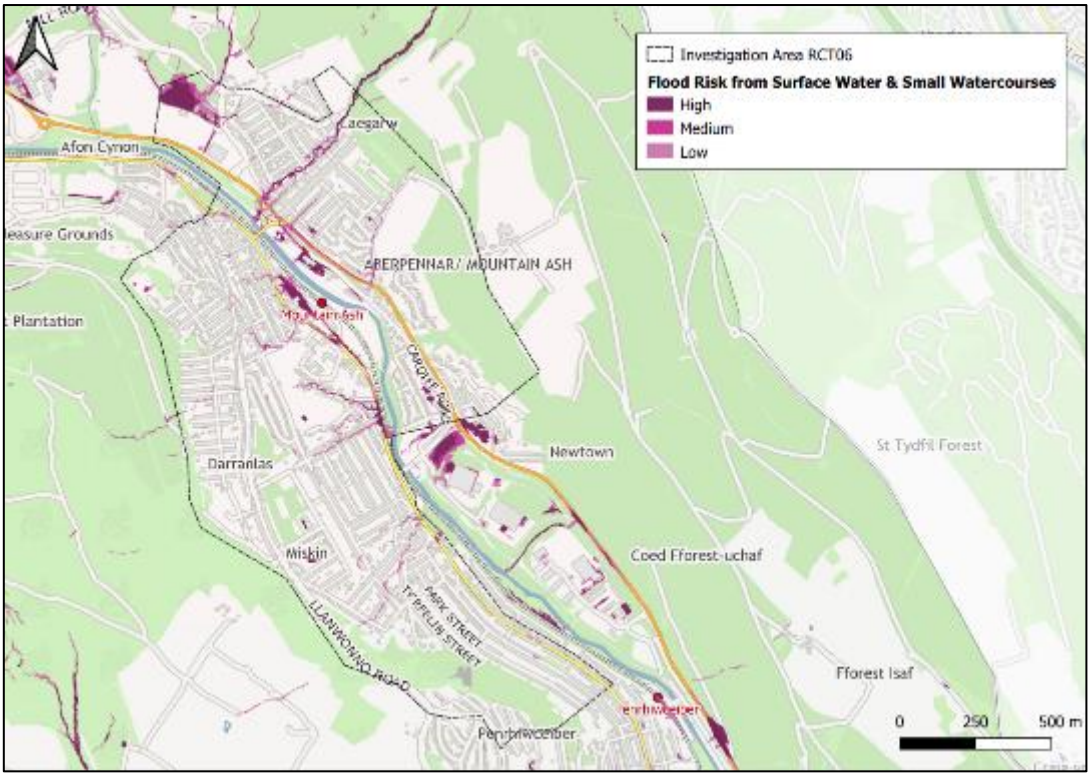

Figure 41: NRW's FRAW map for surface water sources in RCT06. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

To the southwest of the Mountain Ash East catchment, overland flows originating from land to the rear of Clas-y-Dderwen were observed during the storm event. Upon an inspection of the hillside by RCT's Flood Risk Management team identified a small ordinary watercourse channel (Figure 42). The land surrounding the channel was saturated and showed evidence of overtopping.

Figure 42: Photo of ordinary watercourse channel identified on land to the rear of Clas-y-Dderwen which is considered to have overtopped during Storm Dennis (captured by RCT's Flood Risk Management team on 12/03/3030)

During the storm event, it is considered that intense rainfall led to significant overland flows to travel down the catchment, causing the ordinary watercourse channel to overtop and convey towards the rear of Clas-y-Dderwen, resulting in internal flooding to two residential properties.

The minimal surface water and ordinary watercourse flood risk present at RCT06 (depicted in Figure 41), particularly within the Mountain Ash West catchment, further supports the conclusion that obstructions to several culverted watercourse infrastructure caused by mobilised debris was the primary cause of flooding to most properties within the investigation area.

Despite this, ordinary watercourse and surface water flooding were identified as the primary sources of flooding at RCT06 and therefore it would appear that the flood risk presented by both flood sources is underrepresented by the FRAW mapping (Figure 41).

3.6. GROUNDWATER FLOODING

A single property on Penrhiwceiber Road, within the Mountain Ash West catchment, reported internal flooding as a result of water passing through a retaining wall within the property's rear garden. Based on an inspection of the steep slope the rear of the impacted property, undertaken by RCT's Flood Risk Management officers post event, and given the prolonged period of rainfall during February 2020, it is considered likely that the groundwater table was high during Storm Dennis, indicating that the water percolating through the rear retaining wall was groundwater, rather than surface water from the adjacent street.

A review of available geological information indicates that RCT06 is underlain by superficial deposits consisting of Glacial Till and River Deposits, overlying Lower Middle Carboniferous Coal Measures, consisting of mudstone, sandstone and siltstone[6]. Superficial deposits associated with fluvial deposition, such as river gravels and alluvial clays and sands, are found at the base of the main river valleys. According to the Environment Agency, flooding from groundwater is most common in these areas with sand and gravel in the river valleys, again indicating that the investigation area is susceptible to groundwater flooding[7].

[6] Geology of Britain viewer | British Geological Survey (BGS)
[7] Flooding from Groundwater, Environment Agency, September 2011 (publishing.service.gov.uk)

3.7. DCWW Apparatus

Reports of surcharging foul and surface water were received from residents at Cardiff Road to the southwest of RCT06 during Storm Dennis. Upon an inspection of the area, three combined sewer manholes, including one private system, were observed as surcharging during the storm event and causing internal flooding to seven residential properties at Cardiff Road and Usk Villas.

The DCWW owned and operated manholes, labelled ‘Manhole 3 and 4’, are illustrated in Figure 39, and as depicted in the Figure, connect into the primary combined sewer network which runs parallel to Cardiff Road. The surcharging of both ‘Manhole 3 and 4’ has been attributed as the source of flooding to three residential properties at Usk Villas.

DCWW undertook an inspection of their combined sewer system in November 2018 following Storm Callum in October 2018. The inspection identified no restrictions or silt accumulation within the network however, upon a CCTV survey undertaken by the Council following Storm Dennis, settled debris was identified within the combined sewer network. Due to the extreme weather in February 2020, it is reasonable to state that the sewer system became overwhelmed, however it is unlikely that the silt levels would have contributed.

Based on the available evidence, the combined sewer network running parallel to Cardiff Road is considered to have contributed to the surcharging of ‘Manhole 3 and 4’ due to a combination of outfall locking and/or backing up of flow from the primary combined sewer network and into the connecting combined sewer network fronting the properties at Usk Villas which is set at a lower elevation.

The privately owned combined sewer manhole, located to the rear of properties at Cardiff Road, was also identified as a source of flooding to four residential properties. The manhole is depicted in Figure 39 and labelled ‘Manhole 5’ for reference. During the storm event, ‘Manhole 5’ was identified as surcharging as a result of intense rainfall which is considered to have overwhelmed the private drainage infrastructure.

DCWW reported no further issues within RCT06 during Storm Dennis and it is not believed that any DCWW infrastructure was damaged during the storm event. Whilst DCWW have concluded that their assets performed well during Storm Dennis, the majority of drainage infrastructure within the investigation area is comprised of combined sewer networks which are likely to have become overwhelmed during the storm event for the reasons outlined in Section 3.4.

3.8. ACCESS STRUCTURES

No access structures were identified during the asset investigations within the area, as such ‘access structures’ have not been considered within this report.

3.9. System at Capacity

Culvert networks within the investigation area (Figures 18 and 21) were surveyed post event to ascertain the internal condition of the networks, the results of which fed into a review of the hydraulic performance of the network to ascertain its current standard of protection using Causeway Flow modelling. The results of the culvert inlet capacity assessments are summarised in the Table below (refer to Figures 18 and 21 for culvert labels).

Table 4: Summary of the culvert capacity assessment results which indicate the current standard of protection of culvert networks across RCT06 in free flowing and blockage conditions

Culvert Network	Standard of Protection (SOP) – Free Flowing	Standard of Protection (SOP) – Blockage Condition
Culvert Inlet 1	Q800 (0.125% AEP)	Q2 (50% AEP)
Culvert Inlet 2	Q4 (25% AEP)	<Q2 (<50% AEP)
Culvert Inlet 3	Q200 (0.5% AEP)	<Q2 (<50% AEP)
Culvert Inlet 4	<Q2 (<50% AEP)	<Q2 (<50% AEP)
Culvert Inlet 5	Q200 (0.5% AEP)	<Q2 (<50% AEP)
Culvert Inlet 6	Q500 (0.5% AEP)	Q2 (50% AEP)

The results from the culvert capacity assessments and hydraulic modelling undertaken as part of Redstart's FIR, infer that 'Culvert Inlet 1' associated to the 'Nant y Ffrwd' culvert network, 'Culvert Inlet 3' associated to the 'Victor Street' culvert network, 'Culvert Inlet 5' associated to the 'Kingcraft Street' culvert network, and 'Culvert Inlet 6' associated to the 'Bryn Ifor' culvert network, provide adequate standards of protection in free-flowing conditions. The SOP for all four networks is significantly reduced to Q2 and below in 'medium' (67%) blockage conditions[8].

On review of the culvert capacity assessments, it can be concluded that 'Culvert Inlets 1, 3, 5 and 6' surcharged due to mobilised debris causing an obstruction of flow which reduced the inlets' hydraulic capacities to manage the flow of water entering the

[8] Natural Resources Wales Guidance Note (Ref No GN43)

networks, resulting in the surcharging of ‘Culvert Inlet 1’, ‘Manhole 1’, ‘Culvert Inlet 3’, ‘Culvert Inlet 5’ and ‘Culvert Inlet 6’.

It is noteworthy to comment that the catchment areas feeding the ‘Kingcraft and Victor Street’ culvert networks are small but steep. It is considered that both ‘Culvert Inlet 3 and 5’ have reasonable capacity to manage the flow of water entering from the direct catchments however, the presence of land / contour drains associated to the catchment areas feeding ‘Culvert Inlet 3 and 5’ are considered to intercept flows from a larger catchment area and divert them towards the inlets, thereby exacerbating the flow of water entering the networks during storm conditions. Despite this, blockages caused by mobilised debris conveying towards both culvert inlets has been identified as the primary mechanism of surcharge.

‘Culvert Inlet 4’ associated to the ‘Victor Street’ culvert network does not provide adequate standards of protection in accordance with current design standards, as defined by CIRIA C786, in both free-flowing and blockage conditions. It should be noted that ‘Culvert Inlet 4’ is not a dedicated inlet, but an overflow network associated to ‘Culvert Inlet 3’. The overtopping at ‘Culvert Inlet 3’ is considered to have exacerbated the flooding at ‘Culvert Inlet 4’, however, the poor condition of ‘Culvert Inlet 4’ is considered the primary cause of flooding.

‘Culvert Inlet 2’ associated to the ‘Trem y Dyffryn’ culvert network does not provide adequate standards of protection in accordance with current design standards, as defined by CIRIA C786, in both free-flowing and blockage conditions. Despite blockages to the inlet structure being identified as the primary cause of flooding at ‘Culvert Inlet 2’, it is considered likely that the inlet would have become hydraulically overloaded in free-flowing condition during Storm Dennis.

3.10. Summary of Possible Causes

The above sections have identified and described the possible causes of flooding within investigation area RCT06 during Storm Dennis (15-16th February 2020). A summary of the identified source(s) and possible cause(s) of flooding (issue) has been outlined below in Table 5.

Table 5: Summary of source(s) and possible cause(s) of flooding in investigation area RCT06 during Storm Dennis.

Ref No	Asset (Source)	Issue	Asset Owner	Type of Flooding
1	Culvert Inlet 1	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from upstream within the ordinary watercourse. This caused surcharging flows to overtop the inlet and flow south and south-east towards the A4059, Ffrwd Crescent and Cardiff Road.	RCT Highway Authority	Ordinary Watercourse
2	Culvert Section 1	A section of the Nant y Ffrwd culvert network failed during the storm event, resulting in ordinary watercourse flows discharging from beneath a footpath and conveying along the A4059 and B4275. This has been attributed to debris accumulation within the culvert network reducing the cross-sectional area by up to 95%.	RCT Highway Authority	Ordinary Watercourse
3	Culvert Inlet 2	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from upstream within the ordinary watercourse. Surcharging flows conveyed south along Dyffryn Road towards Trem-Y-Dyffryn.	Private Landowner(s)	Ordinary Watercourse

4	Culvert Inlet 3	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from upstream within the ordinary watercourse. Surcharging flows conveyed along Victor Street towards Beadon Street.	Welsh Government (managed by Natural Resources Wales)	Ordinary Watercourse
5	Culvert Inlet 4	The culvert inlet was identified as buried and the culvert network in poor condition which contributed to the overtopping of the upstream ordinary watercourse which resulted in overland flows towards Pamela Street, Beadon Street and the rear of properties on Quarry Road.	Private Landowner(s)	Ordinary Watercourse
6	Culvert Inlet 5	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from upstream within the ordinary watercourse. Surcharging flows conveyed into the rear garden of a nearby property at Kingcraft Street and onwards towards the lower reaches of the town.	Welsh Government (managed by Natural Resources Wales)	Ordinary Watercourse
7	Culvert Inlet 6	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from upstream within the ordinary watercourse. Surcharging flows conveyed towards the rear of properties on Bryn Ifor.	Private Landowner(s)	Ordinary Watercourse
8	Ordinary watercourse to the rear of Hill Side	The watercourse overtopped its embankments following intense rainfall, leading to water conveying down the adjacent hillside and into the rear gardens of properties on Hill Side.	Private Landowner(s)	Ordinary Watercourse

9	Overland flows from the hillside to the rear of Clas-Y-Dderwen	Intense rainfall across the catchment resulted in overland flows conveying down the hillside towards the rear of properties at Clas-Y-Dderwen. A land drainage channel located to the rear of Clas-y-Dderwen was also identified as overtopping and contributing additional overland runoff towards the rear of properties.	Welsh Government (managed by Natural Resources Wales)	Surface Water
10	Overland flows from the hillside to the rear of Arthur Street	Intense rainfall across the catchment resulted in overland flows conveying from the hillside towards Llanwonno Road and onwards to impact the rear of properties at Arthur Street.	Various Landowners	Surface Water
11	Surface water drainage network across RCT06	Intense rainfall across RCT06, combined with the overtopping of the River Cynon, surcharging infrastructure and overland flows, severely overwhelmed highway drainage infrastructure and resulted in the accumulation of surface water on many streets throughout the investigation area.	RCT Highway Authority	Surface Water
12	Combined sewer network at Cardiff Road	The combined sewer network at Cardiff Road became overwhelmed by intense rainfall during the storm event, resulting in surcharging manholes. The combined sewer network is considered to have contributed to the surcharging of connecting surface water drainage systems at Cardiff Road and Usk Villas.	DCWW & Private Landowner	Sewer

13	River Cynon	Unprecedently high river levels within the River Cynon resulted in the main river overtopping its western bank, causing fluvial flows to convey across the railway line and into several streets and adjacent properties.	Natural Resources Wales	Main River
14	Groundwater	A resident who experienced internal flooding at Penrhiwceiber Road reported water ingress through a retaining wall in the property's rear garden, indicating potential groundwater flooding.	Private Landowner(s)	Groundwater

4. Risk Management Authority Actions

A Welsh Risk Management Authority is defined in Section 6 of the Flood and Water Management Act 2010 as NRW; a LLFA, a district council for an area where there is no unitary authority, or a highway authority wholly in Wales; an internal drainage board for an internal drainage district that is wholly or mainly in Wales; a water company that exercises functions in relation to an area in Wales. As the LLFA, RCT has the responsibility to coordinate the management of flood risk and the interaction of Risk Management Authorities across Rhondda Cynon Taf.

An overview of the relevant Risk Management Authority in relation to flood type is provided in Table 6. For further details of the roles and responsibilities of individual Risk Management Authorities in managing flooding, refer to the Welsh Government's National Strategy for Flood and Coastal Erosion Risk Management, Section 4 'Roles & Responsibilities'[5] , and RCT's 'FRM – Storm Dennis - Overview Report'[2].

Table 6: Risk Management Authority with relevant functions to manage the risk for different flood types

Type of Flooding	Relevant Risk Management Authority
Flooding from Main River, reservoirs and the sea (including coastal erosion).	Natural Resources Wales
Flooding from ordinary watercourses, surface water and groundwater	Lead Local Flood Authority
Flooding from water and sewage systems	Water Companies (Dŵr Cymru Welsh Water)
Flooding from the highway	Highway Authority
Flooding from the highway (motorways and major trunk roads)	Welsh Government Trunk Road Agency

Risk Management Authorities have direct flood risk management functions under the Flood and Water Management Act 2010, as well as the Water Resources Act 1991, Land Drainage Act 1991 and the Highways Act 1980. Through analysis of the flooding that impacted RCT06, the flood risk management functions exercised, or proposed to be exercised, by relevant RMAs were recorded pursuant to Section 19 of the Flood and Water Management Act 2010, which states:

"On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

a) Which risk management authorities have relevant flood risk management functions and,

b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in the response to the flood."

Through the investigation process, the source(s) and possible cause(s) of flooding in RCT06 as a result of Storm Dennis has been previously identified and summarised within Table 5. The Risk Management Authorities responsible for managing the flooding have been listed within Table 7 below, along with a series of recommendations presented by the LLFA.

Table 7: Recommendations provided by the LLFA to be considered by the relevant Risk Management Authority identified in response to the source(s) of flooding in RCT06 (as per Table 5)

Ref No	Asset (Source)	Asset Owner	Type of Flooding	Relevant Risk Management Authority	Recommendations	
1	Culvert Inlet 1	RCT Highway Authority	Ordinary Watercourse	Lead Local Flood Authority, Land Drainage Authority & Highway Authority	**R1A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R1B	The LLFA and LDA to investigate the standard of protection and the condition of authorised culvert structures and network as a whole.
					R1C	The LLFA to jet and cleanse the ordinary watercourse culvert network.
					R1D	The LLFA and LDA to review the risk of scour potential within the upstream ordinary watercourse channel.

					R1E	The LLFA and LDA to work with upstream riparian landowners to identify suitable management methods to reduce the risk of scour within the ordinary watercourse.
					R1F	The LLFA to develop an SOC to identify suitable management methods to reduce the risk of ordinary watercourse, surface water and groundwater flooding in Mountain Ash East.
					R1G	The LLFA to install remote telemetry monitoring at several locations along the Nant y Ffrwd to monitor the risk of blockage at Culvert Inlet 1 and upstream.
2	Culvert Section 1	RCT Highway Authority	Ordinary Watercourse	Lead Local Flood Authority, Land Drainage Authority & Highway Authority	**R2A**	The LLFA and LDA to identify asset ownership and responsibility.
					R2B	The LDA and LLFA to investigate the standard of protection and the condition of the culvert network as a whole.
					R2C	Jet and cleanse the ordinary watercourse network.
					R2D	The LLFA to develop an SOC to identify suitable management methods to reduce the risk of ordinary watercourse, surface water and groundwater flooding in Mountain Ash East.
3	Culvert Inlet 2	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and	**R3A**	The LLFA and LDA to identify drainage asset ownership and responsibility.

				Land Drainage Authority	**R3B**	The LLFA and LDA to investigate the standard of protection and the condition of authorised culvert structures and network as a whole.
					R3C	The LLFA to jet and cleanse the ordinary watercourse culvert network.
					R3D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.
					R3E	The LLFA and LDA to engage with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
4	Culvert Inlet 3	Welsh Government (managed by Natural Resources Wales)	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	**R4A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R4B	The LLFA and LDA to investigate the standard of protection and the condition of authorised culvert structures and network as a whole.
					R4C	The LLFA to jet and cleanse the ordinary watercourse culvert network.
					R4D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.

					R4E	The LLFA and LDA to work with NRW to identify suitable management methods to reduce the risk of scour within the ordinary watercourse.
					R4F	The LLFA to install remote telemetry monitoring at Culvert Inlet 3 to monitor the risk of blockage.
5	Culvert Inlet 4	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	**R5A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R5B	The LLFA and LDA to investigate the standard of protection and the condition of authorised culvert structures and network as a whole.
					R5C	The LLFA and LDA to action repairs to the section of damaged culvert network and to re-establish ordinary watercourse flows into the culvert system.
					R5D	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.
6	Culvert Inlet 5	Welsh Government (managed by Natural Resources Wales)	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	**R6A**	The LLFA, LDA and NRW to identify drainage asset ownership and responsibility.
					R6B	The LLFA and LDA to investigate the standard of protection and the condition of authorised

						culvert structures and network as a whole.
					R6C	The LLFA to jet and cleanse the ordinary watercourse culvert network.
					R6D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.
					R6E	The LLFA and LDA to work with NRW to identify suitable management methods to reduce the risk of scour within the ordinary watercourse.
					R6F	The LLFA to install remote telemetry monitoring at Culvert Inlet 5 to monitor the risk of blockage.
7	Culvert Inlet 6	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	**R7A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R7B	The LLFA and LDA to investigate the standard of protection and the condition of authorised culvert structures and network as a whole.
					R7C	The LLFA to jet and cleanse the ordinary watercourse culvert network.
					R7D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.
					R7E	The LLFA and LDA to work with riparian landowners to identify suitable management methods to reduce the

						risk of scour within the ordinary watercourse.
					R7F	The LLFA and LDA to action repairs to the culvert structure and provide improved access for future maintenance.
8	Ordinary watercourse from the hillside to the rear of Hill Side	Private Landowner	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	**R8A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R8B	The LLFA and LDA to inspect and investigate the ordinary watercourse conditions.
					R8C	The LLFA and LDA to engage and work with the riparian landowner to regulate the ordinary watercourse infrastructure to ensure the watercourse is free flowing and unobstructed.
9	Overland flows on the hillside to the rear of Clas-Y-Dderwen	Welsh Government (managed by Natural Resources Wales)	Surface Water	Lead Local Flood Authority and Land Drainage Authority	**R9A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R9B	The LLFA and LDA to inspect and investigate the surface water and ordinary watercourse drainage arrangements on the area of land where the ditch is located.
					R9C	The LLFA and LDA to regulate the land drainage channel to ensure the riparian owner maintain an unobstructed flow.
					R9D	The LLFA and LDA to work with NRW to identify suitable management methods to reduce the risk of ordinary watercourse,

						surface water and groundwater flooding above Clas-y-Dderwen.
10	Overland flows to the rear of Arthur Street	Various Landowners	Surface Water	Lead Local Flood Authority and Land Drainage Authority	**R10A**	The LLFA and LDA to identify drainage asset ownership and responsibility.
					R10B	The LLFA and LDA to inspect and investigate the condition of surface water and ordinary watercourse drainage arrangements on the areas of hillside to the rear of Arthur Street.
11	Surface water drainage network across RCT06	RCT Highway Authority	Surface Water	Highway Authority and Lead Local Flood Authority	**R11A**	The Highways Authority to jet and cleanse the highway drainage network and action repairs accordingly.
					R11B	The LLFA and Highway Authority to evaluate surface water management options to alleviate pluvial flooding at locations across the investigation area.
12	Combined sewer network at Cardiff Road	DCWW and Private Landowner	Sewer	DCWW	**R12A**	DCWW to work evaluate the standard of service and the condition of the sewer network servicing Cardiff Road and Usk Villas.
					R12B	DCWW to work with the LLFA and Highway Authority to identify suitable management methods to reduce the risk of flooding from surface water and sewer sources.
13	River Cynon	Natural Resources Wales	Main River	Natural Resources Wales	**R13A**	NRW to “complete detailed investigative analysis work to understand the mechanisms of flooding in areas known to have flooded from main

						rivers", including the River Cynon at Mountain Ash. Aligns with recommendation 'Action FD2' within NRW's Flood Incident Management Review.
					R13B	NRW to investigate the standard of protection provided by flood defences throughout RCT06 and "consider improvements to NRW flood alleviation schemes and structures on a prioritised basis". Aligns with recommendation 'Action FD3' within NRW's Flood Incident Management Review.
					R13C	NRW to work with landowner(s) to assess and review the risk of flooding from the River Cynon at locations known to have overtopped during the event but are currently 'undefended', to identify the viability of risk management options.
14	Groundwater	Private Landowner	Groundwater	Lead Local Flood Authority and Land Drainage Authority	**R14A**	The LLFA and LDA to exercise their permissive powers under Section 64 of the Land Drainage Act to investigate the source and possible causes of groundwater flooding at Penrhiwceiber Road.

4.1. LEAD LOCAL FLOOD AUTHORITY

In review of Ref 1 - 11 and Ref 14 in Table 7, the LLFA has been determined as the relevant Risk Management Authority in relation to the ordinary watercourse and surface water flooding which occurred at investigation area RCT06 during Storm Dennis.

The LLFA exercised the following functions in response to the flooding at RCT06:

- Officers investigated the initial flooding and have produced this report in line with Section 19 of the Flood and Water Management Act 2010.
- Officers contacted residents affected by flooding to offer support and advice to assist in the recovery following the event.
- A public engagement exercise carried out by Redstart, on behalf of RCT as the LLFA, was undertaken in order to gain further local insight and anecdotal evidence to support the flood investigation.
- The LLFA and LDA have exercised their permissive powers under Section 64 of the Land Drainage Act 1991 to investigate the condition of culvert structures, network conditions, ordinary watercourse conditions and surface water drainage arrangements to determine their impacts on the flooding within the investigation area. **(R1B, R2B, R3B, R4B, R5B, R6B, R7B, R8B, R9B, R10B, R11B, R14A)**
- An estimated 3110 metres of ordinary watercourse culvert network length and 240 metres of surface water drainage network length within RCT06 has been surveyed following the storm event to ascertain both the operational condition of the network, and its structural integrity along sections of the network. **(R1B, R2B, R3B, R4B, R5B, R6B, R7B)**
- An estimated 213 tonnes of material and debris was removed from the culvert networks within investigation area RCT06 during jetting and cleansing operations. **(R1C, R2C, R3C, R4C, R6C, R7C)**
- The LLFA, assisted by the Highway Authority, have undertaken clearance works to the culvert network systems which fall under the responsibility of the Authority **(R1C, R2C)**. In addition to this, the LLFA and Highway Authority have carried out clearance works to the culvert inlet structures which fall under private land ownership (**R3C, R5C, R7C**) in addition to those structure which fall under the responsibility of NRW as land estate managers of the WGWE. **(R4C, R6C)**

- The LLFA commissioned Redstart to investigate the standard of protection of the existing culvert networks in RCT06 to determine their hydraulic capacity following the identification of operational and structural defects within sections of the networks. **(R1B, R2B, R3B, R4B, R5B, R6B, R7B)**
- The LLFA has exercised its powers, under Section 13 of the FWMA, to request information and co-operation from the relevant risk management authorities (NRW and DCWW) in relation to their responsibilities as RMAs in response to Storm Dennis.
- The LLFA has set up a central Control Room, to compliment the Council's Contact Centre and CCTV centre which is based at the Council's offices, to provide a comprehensive and informed response to the residents of RCT as appropriate during storm events.
- The LLFA have initiated an interim Property Flood Resistance project offering expandable flood gates to those properties deemed at high risk of flooding from local sources.
- The LLFA, working in partnership with NRW, have expanded their interim Property Flood Resistance project offering expandable flood gates to those properties deemed at high risk of flooding from the main river, as per NRW's determination.
- The LLFA and LDA have initiated engagement with riparian landowners to ensure the ordinary watercourse infrastructure is free flowing and unobstructed. **(R3E, R4E, R5D, R6E, R7E, R8C, R9C, R9D)**
- In response to Ref 1, the LLFA have completed repair works to improve the structural condition of 'Culvert Inlet 1' following the damages caused by mobilised debris. **(R1C, R1F)**
- In response to the volume of debris which conveyed down the Nant y Ffrwd during the storm event, the LLFA have completed scour protection works to the channel at Granville Terrace and Allen Street to control the mobilisation of debris and minimise erosion within the watercourse. These works involved structural repairs to the channel bed and walls, and the installation of a downstream weir and concrete apron. **(R1D, R1E, R1F, R2D)**
- The LLFA have undertaken a flood alleviation and upper catchment scour scheme to address the issue of debris mobilisation along the Nant y Ffrwd. The scheme involved the installation of a debris catcher and weir in the upper catchment to prevent the conveyance of debris downstream and causing damage/blockages to the culverted network. **(R1D, R1E, R1F, R2D)**

- In response to Ref 4 and 6, the LLFA have led on the completion of a flood alleviation scheme in the Mountain Ash West area to improve the hydraulic capacity and condition of the culverted ordinary watercourse infrastructure associated to 'Culvert Inlet 3 and 5'. The works involved the installation of an overflow network at 'Culvert Inlet 3' and the facilitation of a new headwall and manhole at 'Culvert Inlet 5'. **(R4C, R4E, R6C, R6E)**
- In response to Ref 5, the LLFA undertook emergency repair works to the section of damaged culvert network at 'Culvert Inlet 4', and to re-establish ordinary watercourse flows into the culvert network to reduce the risk of overland flooding. **(R5C)**
- In response to Ref 7, the LLFA have completed upgrade works to 'Culvert Inlet 6' following damages caused by mobilised debris during the storm event. The works also include the facilitation of an overland conveyance route to manage exceedance flows. **(R7C, R7E)**
- The LLFA, in collaboration with the Highway Authority, have completed a flood routing scheme along the lower reaches of Mountain Ash East to improve the capacity of the surface water drainage network and to manage exceedance flows from 'Culvert Inlet 1' by installing overflow structures and interception controls within the highway. **(R1F, R2D, R11B)**
- The LLFA have installed remote telemetry monitoring devices at key culvert structures, including at 'Culvert Inlet 3 and 5' and along the Nant Y Ffrwd ordinary watercourse channel, to enable operators to ensure that drainage systems in Mountain Ash are operating effectively. **(R1G, R4F, R6F)**

The LLFA propose to exercise the following functions in response to the flooding at RCT06:

- Following the surveying of culvert networks in RCT06, the LLFA propose to input and update all relevant asset data.
- The LLFA and LDA intend to clarify drainage asset owners and management responsibilities to make them aware of riparian responsibility. To ensure landowners manage the risk in compliance with the relevant legislation, a team of Flood Enforcement Officers including legal support is to be appointed. **(R1A, R2A, R3A, R4A, R5A, R6A, R7A, R8A, R9A, R10A)**
- The LLFA will develop a Strategic Outline Business Case for the Nant y Ffrwd ordinary watercourse catchment area to better understand the risk of flooding using a whole catchment approach to provide recommendation for suitable

management mechanisms to reduce the wider risk of flooding to people and properties from local sources (Ordinary Watercourse, Surface Water and Groundwater). **(R1F, R2D, R11B)**

- The LLFA and LDA will work with landowners and property owners to manage their personal flood risk through local measures, such as property resilience and resistance measures.

- The LLFA and LDA will continue to engage with riparian landowners and regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed. **(R3E, R4E, R5D, R6E, R7E, R8C, R9C, R9D)**
- The LLFA propose to install a remote telemetry monitoring device at 'Culvert Inlet 1' to monitor the risk of blockage and to enable operator to ensure the drainage system is operating effectively. **(R1G)**
- As part of RCT's comprehensive review of the County Borough's most at risk communities, the LLFA are proposing to undertake a formal Strategic Flood Risk Assessment (SFRA) of the Cynon catchment area to better understand the overall risk from ordinary watercourse and surface water flooding in order to target investment to areas of highest risk. The SFRAs also aim to encourage whole catchment measures, including working with natural processes, to alleviate flood risk in those areas of highest risk. **(R1F, R2D, R3D, R4D, R6D, R7D, R9D)**
- LLFA and LDA propose to undertake Geomorphological assessments of the upper catchments in Mountain Ash West and East to determine the risk of culvert blockages as a result of scour and debris potential. In addition to this the LLFA and LDA will engage with riparian landowners and NRW as land managers of the WGWE to identify suitable management methods to reduce the risk of scour within the ordinary watercourses. **(R1D, R3D, R4D, R6D, R7D)**

4.2. NATURAL RESOURCES WALES

In review of Ref 13 in Table 7, NRW has been identified as the relevant Risk Management Authority in relation to the main river flooding from the River Cynon during Storm Dennis.

NRW have exercised the following functions in response to the flooding at RCT06:

- NRW have carried out post event data collection including an assessment of the properties impacted by main river flooding and a survey of wrack marks, i.e., the marked high-water level.
- NRW removed a large amount of shoal from the River Cynon channel in September 2020.
- NRW have undertaken repairs to the embankment which was damaged during Storm Dennis.
- NRW has introduced improved digital services to provide comprehensive flood risk, river level and rainfall information to households, businesses and communities across Wales. The improved service was launched in September 2020 on the NRW website and will, according to NRW, improve how live flood warning and water level data is shared before and during flood events.
- Utilising post event data and information, NRW have reviewed the Resultant Thresholds for the River Cynon at Mountain Ash Flood Warning Area (FWA). This is critical for assessing the performance, timeliness and accuracy of the warning service after a flood. **(R13B)**.
- Following the flooding events of February 2020, NRW published a review of its incident response to Storm Ciara and Dennis in October 2020[9]. This review contains several recommendations for improvements to their ways of working and services which NRW are in the process of implementing through an internal delivery programme.
- NRW have developed a detailed Implementation Programme to address the areas of improvement work required to deliver the recommendations of the Flood Warning Service Review carried out by NRW in 2018. Several of the recommendations directly link to the recommendations set out by NRW within their Flood Incident Management Review. **(R13C)**
- NRW have commissioned a Cynon Flood Modelling Study which is programmed for completion during Summer 2022. **(R13A)**

[9] Natural Resources Wales / Our response to Storm Ciara and Storm Dennis

NRW also propose to exercise the following functions in response to the flooding at RCT06:

- Following the completion of NRW's Cynon Flood Modelling Project, NRW propose to undertake an initial assessment of the viability of potential flood risk management options. Consideration should be given to areas at high risk of flooding from rivers on a prioritised basis. **(R13A)**
- Following the completion of NRW's Cynon Flood Modelling Study, NRW propose to undertake further threshold work and flood warning area amendments. **(R13A, R13B)**
- NRW to complete river channel shoal removal in 2023, as per their current maintenance schedule. The shoal removal operations at Mountain Ash are currently planned to be carried out every three years to ensure the build-up of material in the channel does not increase the flood risk and the impact of carrying out these operations with heavy machinery on the environment can be mitigated. The River Cynon at Mountain Ash will be inspected regularly and if the build-up of river gravel increases to a level that needs to be removed this work can be brought forward.
- NRW will undertake a review of the modelled outputs and adopt changes to their maintenance program within the investigation area if required. **(R13A)**

4.3. WATER COMPANY

In review of Ref 12 in Table 7, DCWW has been identified as the relevant Risk Management Authority in relation to the sewer flooding at Cardiff Road during Storm Dennis.

DCWW have exercised the following functions in response to the flooding at RCT06;

- DCWW carried out their own investigations in response to incidence of flooding that were reported by residents directly to DCWW.
- DCWW have reviewed CCTV surveys from 2019 and carried out further survey work in November 2021 to ensure their system is fully operating. **(R12A)**
- To monitor the water levels within the combined sewer at Cardiff Road and to understand how their asset reacts in storm conditions, DCWW have installed a cello monitor within the chamber downstream of the impacted properties. This will allow DCWW to monitor flows and trends, as well as triggering alarms of any rising levels, to determine how DCWW manage and response to storm event to minimise flood risk. **(R12B)**

DCWW propose to exercise the following functions in response to the flooding at RCT06;

- DCWW will monitor and carry out remedial works that are identified as required.
- DCWW propose to review the connections into their combined sewer system at Cardiff Road and discuss their findings with the Local Authority with the aim of reducing surface water connections into DCWW's system and to alleviate sewer flooding in the area. **(R12B)**

4.4. HIGHWAY AUTHORITY

During the investigation into the flooding at RCT06 during Storm Dennis, the Highway was identified as flooding as a result of ordinary watercourse and surface water flooding associated to blocked and overwhelmed culverted watercourse infrastructure, overland flows from areas of hillside and as a result of the River Cynon overtopping its banks.

Ref 1, 2 and 11 of Table 7 identifies the Highway Authority as a relevant Risk Management Authority in relation to the surface water flooding that occurred along the highway across RCT06.

RCT as the Highway Authority have exercised the following functions in response to the flooding at RCT06:

- The Highway Authority assisted with the emergency response during the event by supplying equipment and sandbags, some to individual properties and using sandbags to redirect flood water away from properties.
- The Highway Authority exercised their functions under Section 100 of the Highways Act 1980, to arrange for all gullies and open drains in the highway to be inspected and cleansed following the influx of fluvial flood water to ensure the safety of the highway post event. **(R11A)**
- The Highway Authority has undertaken emergency clearance and repair works to the culverted infrastructure identified as sources of flooding. **(R1C, R2C, R3C, R4C, R5C, R6C, R7C)**
- The Highway Authority have assisted the LLFA in completing a flood routing scheme along the lower reaches of Mountain Ash East to improve the capacity of the surface water drainage network and to manage exceedance flows from ‘Culvert Inlet 1’ by installing overflow structures and interception controls within the highway. **(R1F, R2D, R11B)**
- The Highway Authority have increased their resource capacity by establishing a dedicated ‘Pluvial Drainage Team’ to focus entirely on the refurbishment and maintenance of RCT’s existing and enhanced highway drainage infrastructure.

RCT as the Highway Authority propose to undertake the following function in relation to the event at RCT06:

- The Highway Authority to work with the LLFA and DCWW to evaluate surface water management options to alleviate pluvial flooding at locations across the investigation area. **(R11B)**

USEFUL LINKS/CONTACTS

Blue Pages – property Resilience - http://bluepages.org.uk/

Flood Re – Flooded Property Insurance Scheme - https://www.floodre.co.uk/

Natural Resources Wales – Check Flood Warnings - https://naturalresources.wales/flooding/check-flood-warnings/?lang=en

Natural Resources Wales - Long Term Flood Risk - https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en

Rhondda Cynon Taf CBC - Local Flood Risk Management Plan - https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/FloodAlleviation/Floodriskregulations2009.aspx

Rhondda Cynon Taf CBC - Local Flood Risk Management Strategy - https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/FloodAlleviation/LocalFloodRiskManagementStrategy.aspx

Rhondda Cynon Taf CBC – Sustainable Drainage – https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/SustainableDrainage/SustainableDrainage.aspx

Welsh Government - National Strategy for Flood and Coastal Erosion Risk Management - https://gov.wales/sites/default/files/publications/2019-03/national-strategy-for-flood-and-coastal-erosion-risk-management-in-wales.pdf

Welsh Water – How to Contact Us – https://www.welshwater.com/en/Contact-Us.aspx