Section 19 Flood Investigation

23rd December 2020 Flood Event

Dinas Powys, Vale of Glamorgan

Final Report

November 2021

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Revision History

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Contract

This report describes work commissioned by Michael Clogg on behalf of Vale of Glamorgan Council, by an email dated 10 May 2021. Toby Jones and Faye Tomalin of JBA Consulting carried out this work.

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Purpose

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Executive summary

This report has been produced in-line with the duties placed upon The Vale of Glamorgan Council (VoGC) 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 (LLFA) 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 which occurred on 23rd December 2020 and the flooding that happened in the community of Dinas Powys as a result. The investigation focuses on the residential areas surrounding Cardiff Road (A4055) in central Dinas Powys and reviews evidence provided by responders and residents regarding the flood event. It has also been informed by a Section 19 data analysis for Dinas Powys produced by JBA Consulting in March 2021.

The Section 19 data analysis report identifies that due to a series of storm events which occurred throughout the month of December 2020, the soils across the catchment were highly saturated prior to the rainfall on 23rd December.

The nearby Cog Moors rainfall gauge recorded an initial short and intense period of rainfall between 09:00 and 10:00. However, the main period of rainfall started at 12:45 and continued until 18:00, with 47.8mm of rainfall falling over this 5.25hr period, giving an average intensity of 9.1mm/hr. The maximum hourly intensity over the period was 14.4mm/hr between 14:00 and 15:00. The rainfall intensity was >10mm/hr between 13:15 and 15:30 and between 15:45 and 17:00. The storm is reported to have been equivalent to a 1 in 20 year rainfall event which generated a fluvial return period of 10 to 20 years.

Following the flood event, VoGC issued flood incident forms to approximately 684 properties throughout the Dinas Powys area, as well as conducting face to face interviews with residents by means of a door knocking exercise. From the 208 flood incident forms returned to VoGC (a return rate of 30%) these identified that 98 properties flooded internally and that 22 outbuildings and 74 gardens flooded across Dinas Powys.

The source of the flooding originated from the heavy storm event which caused fluvial and surface water flooding. The River Cadoxton and the East Brook overtopped their banks at multiple locations across Dinas Powys, including at Greenfield Avenue, St Cadoc's Avenue and Sunnycroft Lane. Surface water and sewerage systems were overwhelmed and surcharged causing property flooding at Cae'r Odyn and Brookside residential areas, exacerbating fluvial flooding where surface water drainage was unable to drain at St Cadoc's Avenue, Elm Grove Place and Greenfield Avenue residential areas. Other causal factors include backing up of surface water drainage preventing effective drainage and the condition of some highways and DCWW surface water drainage systems.

This report recommends that NRW assess the viability of options to manage the flood risk across Dinas Powys; for DCWW to assess the viability of offline storage for the Cae'r Odyn surface water system; and for the investigation of the condition and cleansing of highways and DCWW surface water and foul drainage systems. It is also recommended that VoGC consider removing a disused footbridge on the East Brook and NRW review their maintenance schedule of the watercourse.

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Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordinance Datum
DCWW	Dŵr Cymru Welsh Water
FWMA	Flood and Water Management Act 2010
JBA	Jeremy Benn Associates Ltd
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LTA	Long Term Average
NRV	Non-return valve
NRW	Natural Resources Wales
RMA	Risk Management Authority
SoP	Standard of Protection
S19	Section 19
TBR	Tipping bucket rain gauge
VoGC	Vale of Glamorgan Council

Definitions

Annual Exceedance Probability: The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

Non-return valve: a valve installed on drains that allows fluid to flow through it in only one direction. It is commonly used to prevent surcharge coming up through drainage systems into properties.

Risk: In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.

Surface water flooding: Flooding as a result of surface water runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse or cannot enter it because the network is full to capacity, thus causing pluvial flooding.

Fluvial flooding: Flooding as a result of the water level in a river, lake or stream rising and overflowing onto the surrounding banks, shores and neighbouring land.

1 Introduction

1.1 Background to investigation

As a Lead Local Flood Authority (LLFA) The Vale of Glamorgan Council (VoGC) has a duty to prepare and publish the results of investigations into significant flood incidents, as detailed within Section 19 (S19) of the Flood and Water Management Act 2010 (FWMA). The Act states, "On becoming aware of a flood in its area, a lead local flood authority (LLFA) 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 report has been prepared for the purpose of meeting the LLFA S19 requirements by providing a detailed, factual account of the flooding that occurred in December 2020 in the vicinity of Dinas Powys, Vale of Glamorgan, South Wales. During this event, it was reported that 98 properties flooded internally and that 22 outbuildings and 74 gardens flooded across Dinas Powys. This report will focus on investigating the causes of the internal flooding of properties as a result of the storm event (Figure 1-1) in residential areas in central Dinas Powys surrounding Cardiff Road (A4055) in the Cadoxton Catchment.

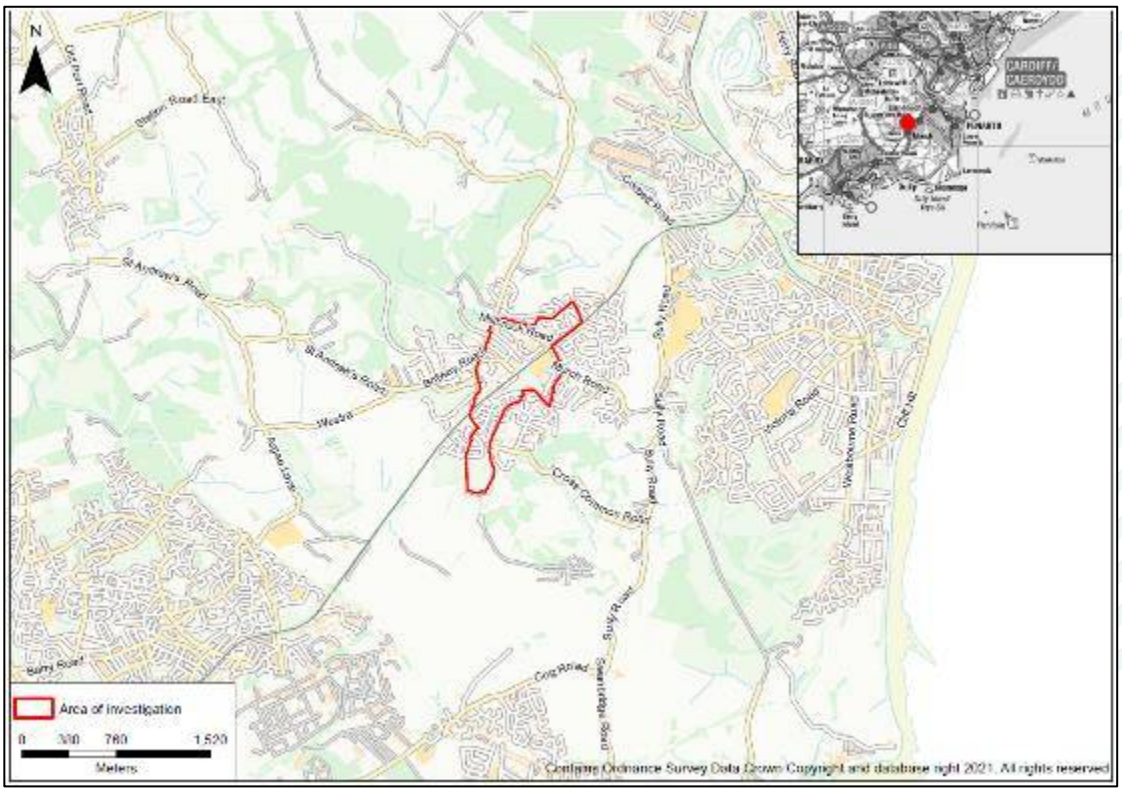


Figure 1-1 Site location

Previous to this report, a flood reconnaissance study, undertaken by JBA Consulting for Natural Resources Wales (NRW), documented widespread flooding

in the area. A Section 19 Data Analysis was also undertaken by JBA Consulting for The Vale of Glamorgan Council, to collect and analyse hydrological data relating to the flood event and document the findings.

To provide an accurate account of the flood event, this S19 Report will:

- Identify events leading up to the flood;
- Investigate the number of properties flooded;
- Investigate which Risk Management Authorities (RMAs) have flood risk management functions in respect of the flooding;
- Investigate whether each RMA has exercised or is proposing to exercise those functions in response to the flood.

1.2 Site location

Dinas Powys is a large village located in the Vale of Glamorgan, South Wales, approximately 9km west of Cardiff (Figure 1-1). The village comprises a large residential population with central commercial areas on Station Road and Cardiff Road. Key infrastructure includes the Dinas Powys railway station, giving access to Barry and Cardiff, and Cardiff Road (A4055), which intersects the village and connects it to Barry (south) and Cardiff (north). The population in the 2011 census was 7,490 with a 2019 population estimate of 7,726.

Located in the Cadoxton River catchment, Dinas Powys is situated at the confluence of the East Brook joining the Cadoxton River. The area of investigation is characterised by 5 distinct areas, defined by source of flooding, flow paths, topography and locality, and are shown in Figure 1-2 (also provided in Appendix A). The 5 areas of investigation are hereby referred to as:

1.2.1 Brookside

Located in the north of Dinas Powys, this residential area is comprised of Brookside, a cul-de-sac to the south of Cardiff Road, and the adjoining portion of Cardiff Road. The area extends from Murch Road to the west, to Chapel Row, to the east.

1.2.2 Greenfield Avenue

Greenfield Avenue runs in a north-westerly direction linking Cardiff Road in the south to Mill Road in the north. This investigation area also consists of Millbrook Road, Elm Grove Road and Cardiff Road, along with Elm Grove Place and St Gwynno's Close to the south of the railway embankment.

1.2.3 Vale Court

This investigation area comprises the residential area around the East Brook, including Sunnycroft Lane, Fairoaks, Vale Court and Murchfield Community Centre.

1.2.4 St Cadoc's Avenue

Located in the South of Dinas Powys, this residential area is comprised of a main avenue and several adjoining cul-de-sacs. St Cadoc's Avenue runs in a north-

westerly direction from Cardiff Road and ends at the cul-de-sac of St Teilo Close in the north.

1.2.5 **Cae'r Odyn**

This investigation area is located on the Southra Park Estate, on the west of Cardiff Road, at the southern extent of Dinas Powys. This area also includes Parc Bryn-y-Don at the southern tip of Dinas Powys.

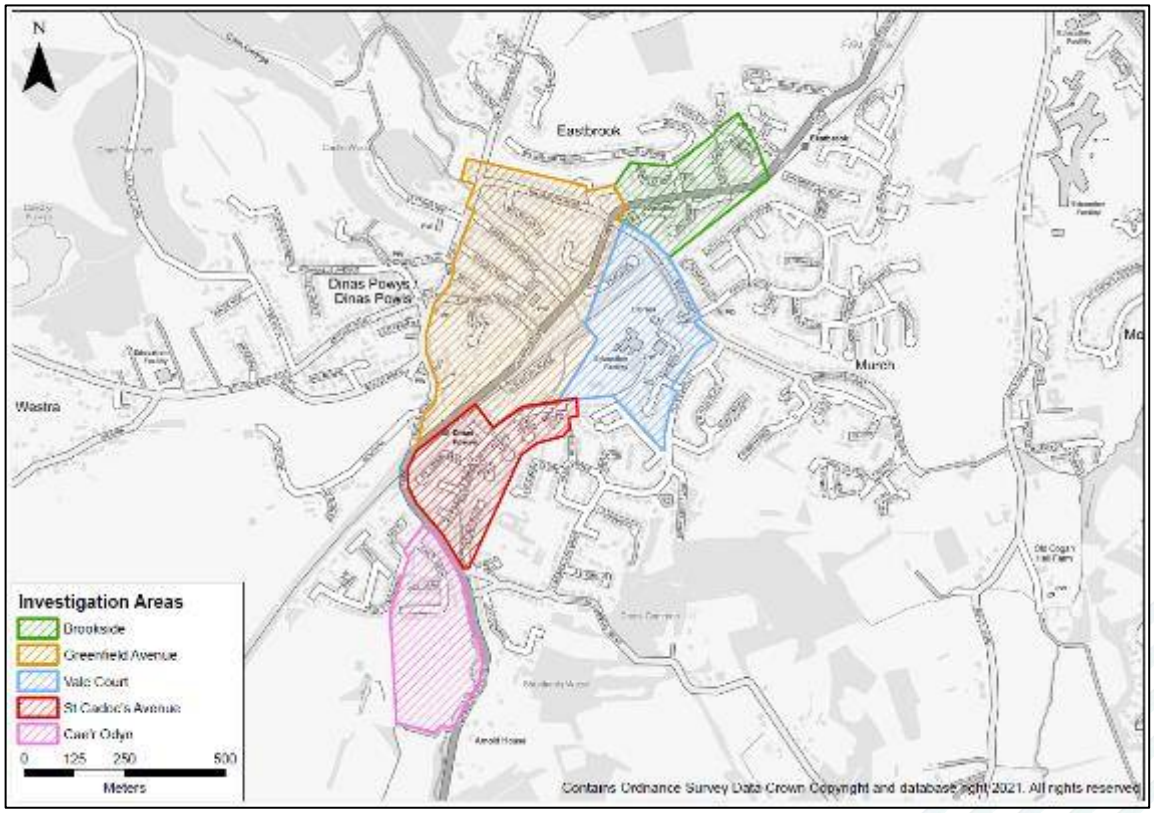


Figure 1-2 Residential areas within area of investigation

Figure 1-3 shows the topography of Dinas Powys using Opensource LiDAR data. Ground levels are shown to be lowest at Cae'r Odyn at approximately 8.7m above ordinance datum (AOD). St Cadoc's Avenue is relatively low lying at 10.4mAOD whilst Brookside and Greenfield Avenue and Millbrook Road are higher at approximately 15mAOD.

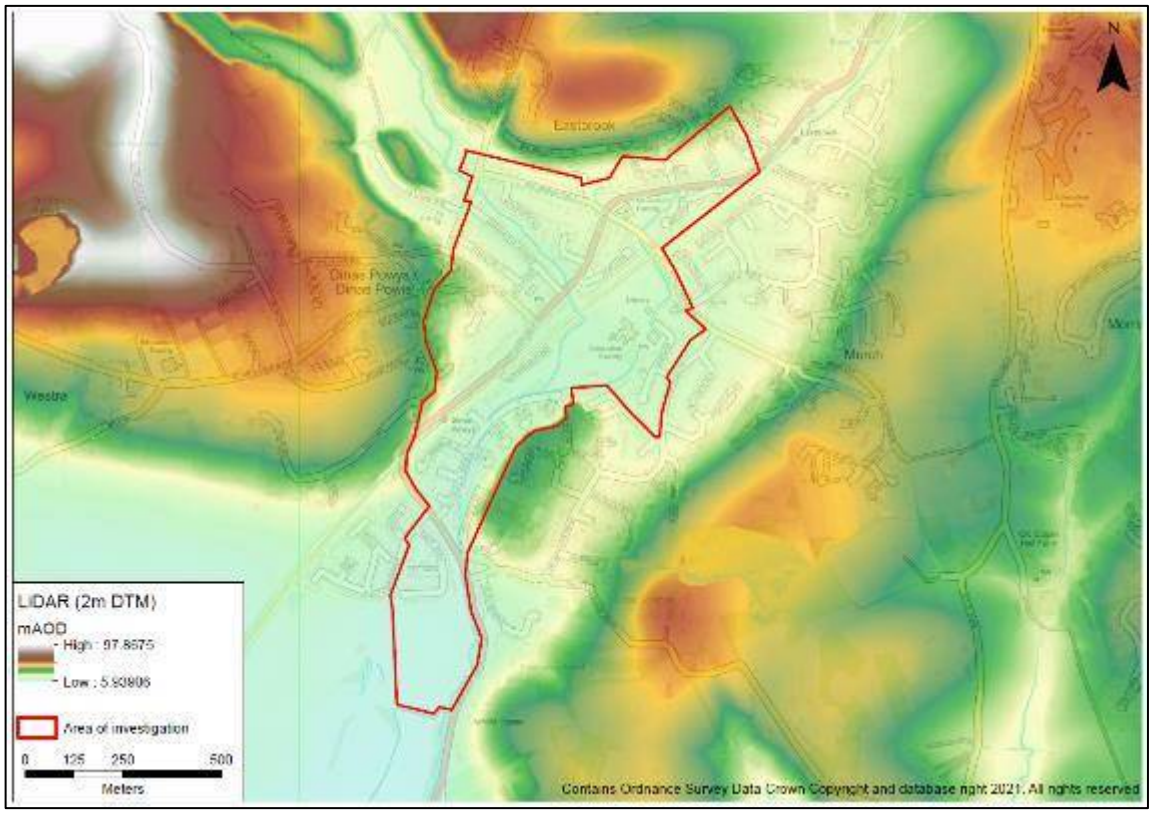


Figure 1-3 LiDAR

2 Roles and responsibilities

2.1 Duties under 'Flood and Water Management Act (2010): Section 19 - Local Authorities: Investigations'

Under Section 19 of the Flood and Water Management Act 2010, the Lead Local Flood Authority, VoGC, has a duty to investigate and publish reports on flood events that occur within its area to the extent that it considers it necessary or appropriate.

(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 response to the flood.

(2) Where 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 authorities.

2.2 Risk Management Authorities

2.2.1 Lead Local Flood Authority

The Vale of Glamorgan Council has been established as the Lead Local Flood Risk Authority (LLFA) for its administrative area under the Flood and Water Management Act 2010. It is responsible for managing the risk of flooding from ordinary watercourses, surface water runoff and groundwater.

Additionally, the LLFA takes on the role of the Sustainable Drainage Systems (SuDS) Approval Body in which they are responsible for approving proposed SuDS systems on new developments and adopting and maintaining constructed systems.

As the LLFA, VoGC has statutory duties:

1 to prepare local flood risk management strategies;

2 to comply with the National Strategy for Flood and Coastal Erosion Risk Management;

3 to co-operate with other authorities, including sharing data;

4 to investigate all flooding within its area, insofar as a LLFA consider it necessary or appropriate;

5 to maintain a register of structures and features likely to affect flood risk;

6 to contribute to sustainable development; and

7 through consenting powers on ordinary watercourses.

2.2.2 Natural Resources Wales

NRW has statutory duties and permissive powers including:

1. Operational powers to manage the risk of flooding from main rivers and the sea, and coastal erosion.

2. General supervision over all matters related to flood and coastal erosion risk management in Wales.

Natural Resources Wales's powers to manage flood risk include the management and maintenance of Main Rivers the construction of new flood risk management assets and maintaining existing flood assets. NRW assesses developers' flood assessments (and supporting documentation) to decide whether developers have met the requirements of *Planning Policy Wales and Technical advice note 15: development and flood risk* (TAN15, 2021) in relation to the risks of flooding from main rivers, the sea and reservoirs.

NRW is a statutory consultee in Local Authorities' planning processes and provides support to Welsh Ministers in their preparation of the National Flood and Coastal Erosion Management (FCERM) Strategy.

Natural Resources Wales provides a direct flood warning service, primarily for areas at risk of fluvial and coastal flooding.

Within the Dinas Powys area of investigation, NRW has confirmed that they undertake maintenance works on both the East Brook and Cadoxton watercourses as part of a twice-yearly intervention involving the manual/mechanical removal of vegetation and the once yearly spraying of vegetation with herbicide.

The work covers the East Brook Channel from the eastern end of Brookside to its confluence with the Cadoxton at St Cadoc's Avenue local to St Teilo Close, and the Cadoxton from Pen-y-Turnpike Road down to the footbridge connecting the A4055 Cardiff Road to Parc Bryn-y-Don.

In 2020 contractors undertook the first of the visits to manage vegetation in July along the Cadoxton River, which was followed up by second visit at the end of October with vegetation removal along both the East Brook and Cadoxton River.

A herbicide spraying operation was undertaken along the East Brook at the end of July 2020.

In addition to the above planned work in 2020, they also undertook ad hoc visits to attend in response to safety concerns and general maintenance including the mowing of banks on the following dates:

- 10th -13th March
- 8th - 9th June
- 13th - 16th July
- 27th - 28th July
- 3rd - 4th August

2.2.3 Highways Authority

The Vale of Glamorgan Council undertake the role of the Highways Authority, being responsible for the maintenance of all adopted highways in the Vale and the associated infrastructure. This includes ensuring the highway has a drainage system that controls the surface water that enters onto the highway, providing and managing highway drainage and roadside ditches to ensure they are clear of obstructions. The above duties and responsibilities of the Highways Authority are

not applicable to Trunk Roads, which are the responsibility of the Welsh Government.

Across the Vale of Glamorgan, the Highways Authority undertake a cyclical maintenance regime, with cleansing of gullies carried out on a 15-18 month average rotation.

2.2.4 Dŵr Cymru Welsh Water

As a Water Utility Company, the role of Dŵr Cymru Welsh Water as a risk management authority is to manage the risk of flooding to water supply and sewerage facilities and flood risk arising from their infrastructure. The main responsibilities of the Water Utility Company are to:

- Ensure their systems have the appropriate level of resilience to flooding, and maintain essential services during emergencies;
- maintain and manage their water supply and sewerage systems to manage the impact and reduce the risk of flooding and pollution to the environment;
- advise LLFAs on how their assets affect local flood risk and work with RMAs to coordinate management of flood risk management assets; and
- work with developers, landowners and LLFAs to understand and manage risks

2.3 Other Authorities

2.3.1 Network Rail

Network Rail has an operational responsibility as a riparian owner and is required to undertake regular maintenance of all assets that pose a risk to flooding.

2.3.2 Landowners and riparian owners

Riparian Landowners are legally responsible under common law for the maintenance of the land from the edge of the watercourse to the middle of the riverbed. The landowner is responsible for removal of obstructions caused within the boundaries of their land affecting the watercourse. This includes the maintenance of the bed, banks and any boundary features e.g. through routine clearance of debris and/or blockages.

2.3.3 Residents

Residents and property owners are responsible for the protection of their own properties against flooding. Residents have the right to defend their property provided they do not increase the risk of flooding to other properties.

2.4 Permissive Powers

Risk Management Authorities have direct permissive powers under the Flood and Water Management Act 2010, as well as the Land Drainage Act 1991. For NRW and the LLFA, this includes:

- Powers to request information.
- The ability to raise levies for local flood risk management works (NRW only).

- Powers to designate certain structures or features that affect flood or coastal erosion risk.
- The expansion of powers to undertake works to include broader risk management actions.
- The ability to cause flooding or coastal erosion under certain conditions.

3 Stakeholder engagement

3.1 VoG Data Collection

Following the flooding in December 2020, VoGC issued flood incident forms to approximately 684 properties throughout the Dinas Powys area as well as conducting face to face interviews with residents by means of a door knocking exercise. Responses were received from 208 property owners/residents regarding the impact of flooding. In addition, the National Flood Forum undertook online engagement sessions with a number of Risk Management Authorities and residents from across Dinas Powys. From this engagement, information was collated regarding:

- Date of flooding;
- extent of flooding to private land and properties;
- depth of flooding on private land and in properties;
- perceived source/cause of flooding; and
- impacts and estimated cost of damages.

In addition, photographs and videos of the flooding were provided by residents, which were used in investigations for this report.

3.2 NRW Flood Reconnaissance

Following the 23rd December flood event, NRW conducted flood reconnaissance work in January 2021. NRW instructed JBA Consulting and Storm Geomatics Ltd to undertake survey work of the investigation area to gather level data, photographs and resident accounts from across the flood extent to determine the scale of flooding. The results of this reconnaissance work were presented to NRW in a report dated February 2021. This S19 report draws on some of the information gathered from the NRW flood reconnaissance.

4 Catchment characteristics

4.1 Catchment overview

The topographic characteristics of the Cadoxton catchment are varied. Upstream of the moors and through the urban area of Dinas Powys the catchment topography is relatively steep. However, the moors and the area downstream of Sully Moors Road to the docks is low-lying and flat. High land at the southern edge of the catchment acts as a natural watershed for the Cadoxton catchment to the north and for the Sully Coastal catchment to the south.

The catchment is predominantly underlain by Triassic Rocks comprised of mudstone, siltstone, and sandstone. There are smaller areas of Carboniferous Dinantian Rocks (limestone with subordinate sandstone and argillaceous rocks), and Jurassic Lias Group (mudstone, siltstone, limestone, and sandstone). Superficial deposits of alluvium (clay, silt, and sand) are found along, and in the areas adjacent to, the nearby watercourse. Soils are predominantly loamy and clayey with impeded drainage, with freely draining soils in smaller areas to the north and south of the catchment.

The lower catchment downstream of Sully Moors Road is highly urbanised. Upstream of this the catchment has mixed land use of some rural areas and the urbanised areas of Dinas Powys and Wenvoe that account for a relatively large proportion of the catchment area.

4.2 River network

The River Cadoxton is a Main River that flows through Dinas Powys north to south (Figure 4-1). It enters Dinas Powys from the north-west where it runs parallel to Greenfield Avenue. It then tracks south alongside St Cadoc's Avenue before crossing under Cardiff Road by Cae'r Odyn and follows the highway south toward Barry. The river then travels south-west before discharging into the Bristol Channel at Barry Docks. Throughout Dinas Powys there are a number of railway and highway crossing which results in the River Cadoxton being culverted for short sections.

The East Brook flows into Dinas Powys from the north-east, passing Brookside and Murchfield Community Centre before it's confluence with the Cadoxton River at the eastern end of St Cadoc's Avenue.

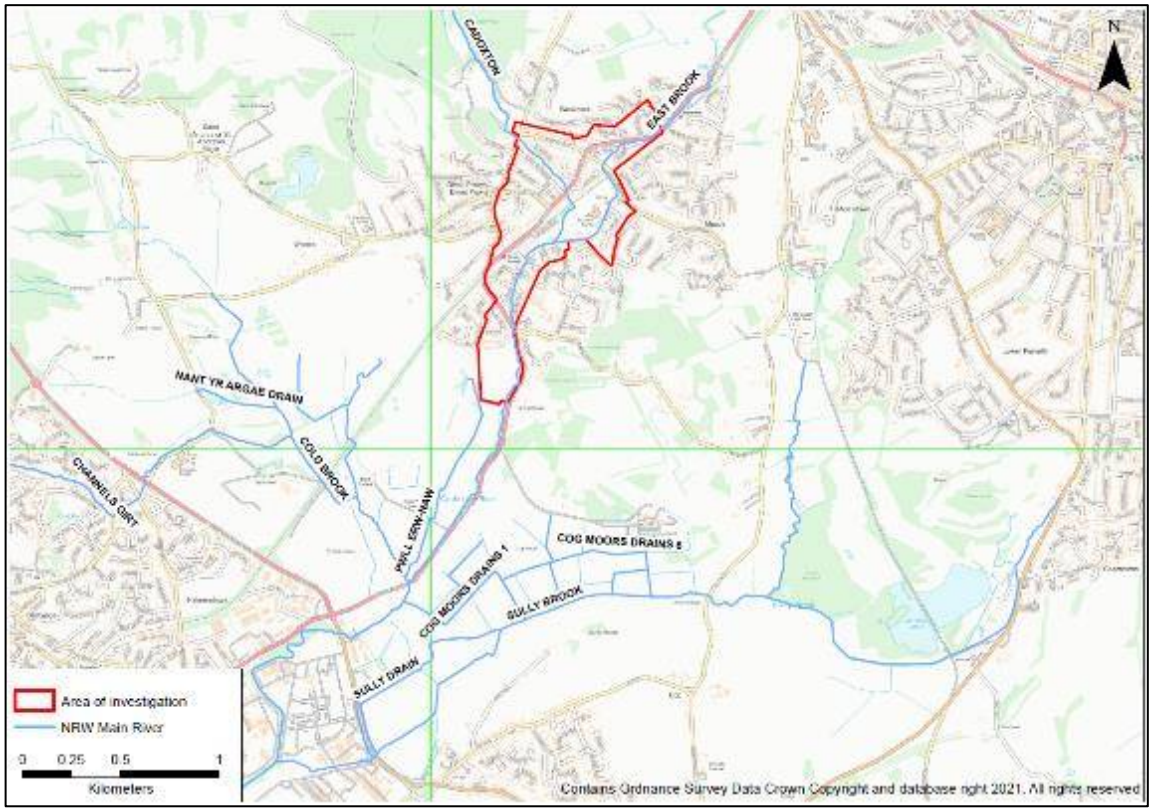


Figure 4-1 Dinas Powys river network

4.3 Drainage systems

It should be noted that responsibility for different sections of drainage systems lies with individual RMA's, and that RMA's have different system capacity targets for their drainage networks. DCWW aim to maintain a 1 in 30 year (0.33% AEP) capacity, while the Highways Authority aims to maintain a 1 in 5 year (20% AEP) capacity. It should be noted that any DCWW surface water system is designed to take roof and yard drainage only, unless specifically designed to receive flows from the highway network. In places the DCWW sewerage system is a combined system, carrying both foul and surface water. The highway network is designed to take flows from the highway only. Across the Vale of Glamorgan, the highway network is cleansed on a 15 to 18 month average rotation. Most systems are not designed with the intention of receiving sheeting overland flows from greenfield areas or floodwater from fluvial systems.

4.3.1 Brookside

A DCWW foul sewer serves the residential properties on the south-eastern spur of Brookside. This foul sewer flows in a northerly direction to the public combined sewer located in Cardiff Road. No public foul sewer is shown on the DCWW asset maps as serving the residential properties on the eastern spur of Brookside, however it is assumed that these properties would drain to the public network.

The public combined sewer flows in an east to west direction along Cardiff Road, and receives flows from the wider Dinas Powys area. (Figure 4-2 and Appendix B).

There is no public surface water sewer serving Brookside or Cardiff Road. It is known that a number of properties within Brookside dispose of surface water via soakaway or direct discharge of surface water into the East Brook.

The highway drainage system at this location discharges directly into the East Brook.

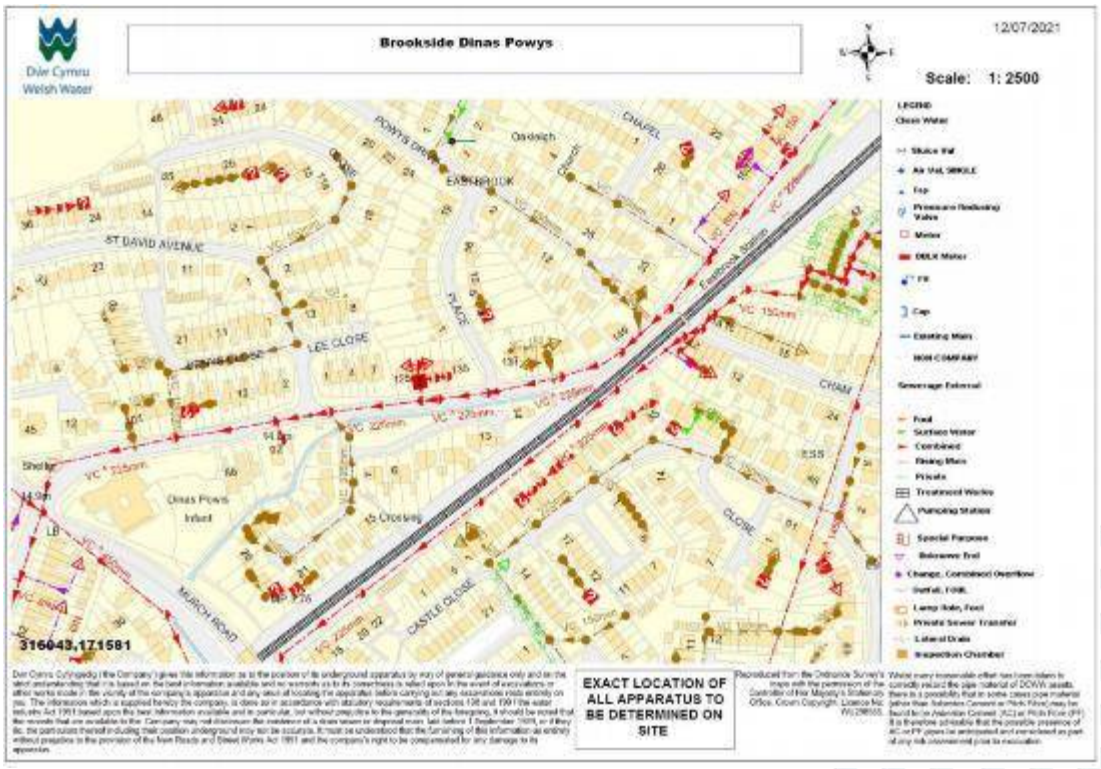


Figure 4-2 Brookside DCWW Asset Map

4.3.2 **Greenfield Avenue**

Greenfield Avenue is served by a public combined sewer flowing in a south-westerly direction towards Cardiff Road, as shown in Figure 4-3 (Appendix B). This system receives flows from Lettons Way to the north, and a number of properties on Greenfield Avenue. As there is no public surface water sewer in this location, it is assumed that surface water from properties is also received by the public combined sewer.

A public combined system also serves the properties in Millbrook Road (Figure 4-4), with the combined sewer flowing in a south-westerly direction towards Cardiff Road. The public combined sewer in Cardiff Road receives a number of connections from the wider Dinas Powys area and flows in a westerly direction towards Elm Grove Place, where it receives flows from the combined system serving Cardiff Road flowing in an easterly direction. At this junction of the combined systems, the network flows in a southerly direction beneath the railway

bridge at Elm Grove Place, where it joins another combined system flowing in a westerly direction.

Elm Grove Place (Figure 4-5) is also served by a public combined sewer. It is assumed that the public combined sewer also receives surface water from the residential properties at this location. The public combined sewer is located to the rear of the properties, prior to flowing in an easterly direction towards 1 Elm Grove Place. Combined flows are then pumped in a westerly direction within the highway, prior to connecting into the combined sewer south of the railway embankment and to the rear of properties in St Gwynno's Close.

The properties in Gwynno's Close are served by a public foul sewer. The public foul sewer flows in an easterly direction to the combined sewer located at the entrance to Elm Grove Place. There are two private surface water sewers serving St Gwynno's Close which outfall into the River Cadoxton immediately upstream and downstream of the access bridge to the close.

Within Greenfield Avenue and Millbrook Road, the highway network is drained via highway gullies. The gullies discharge into the River Cadoxton.

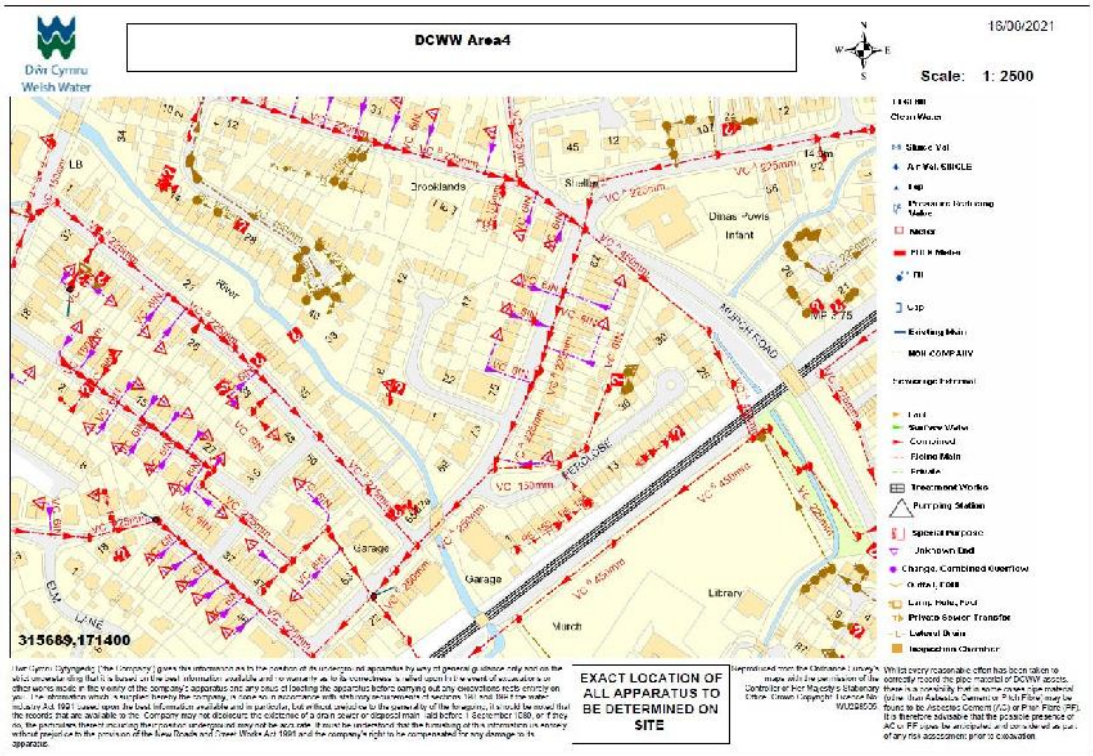


Figure 4-3 Greenfield Avenue DCWW Asset Map

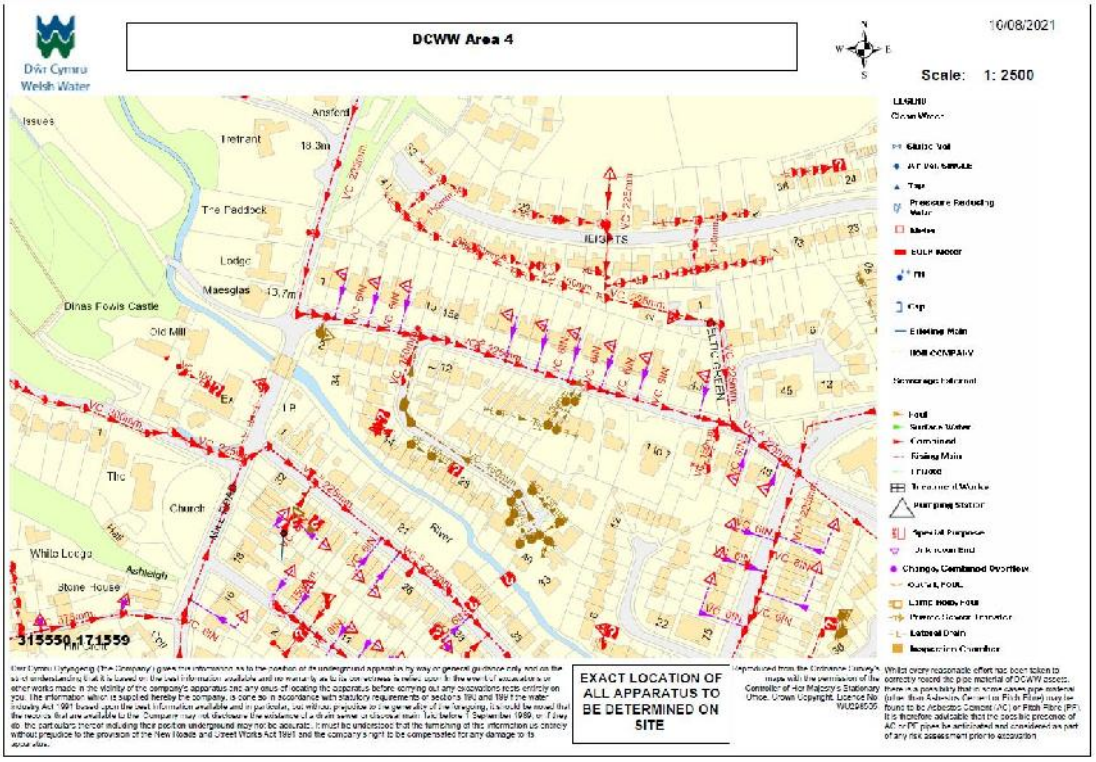


Figure 4-4 Mill Road and Millbrook Road DCWW Asset Map

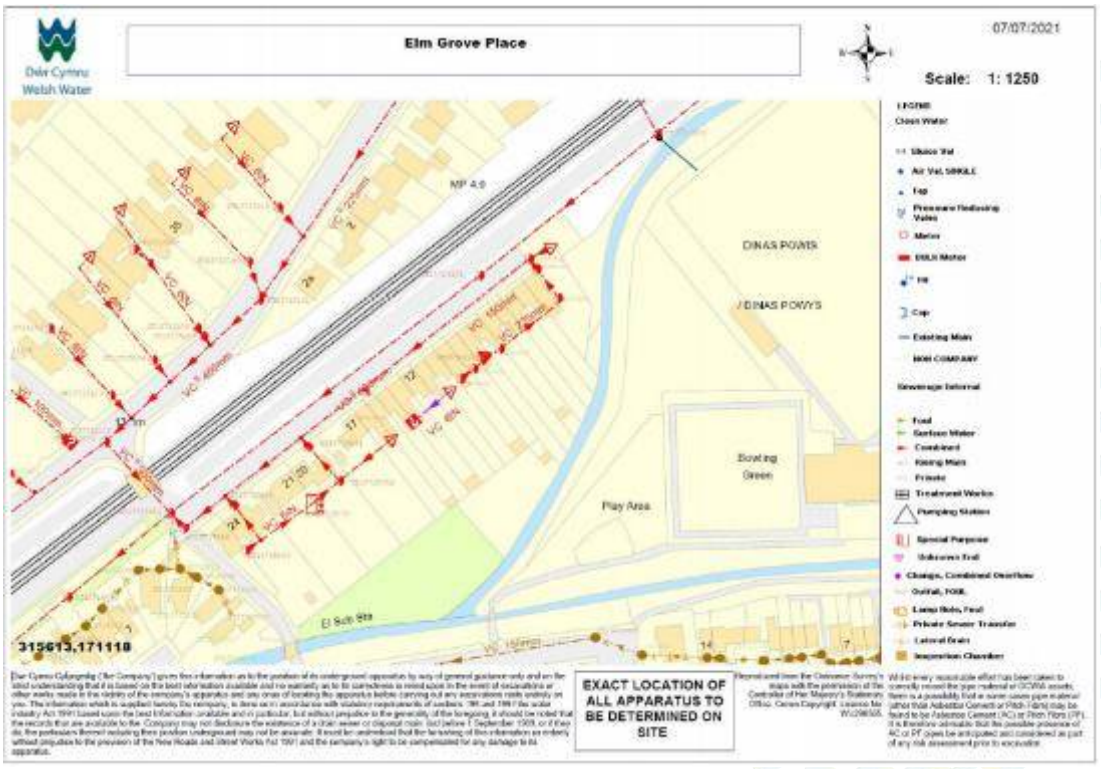


Figure 4-5 Elm Grove Place DCWW Asset Map

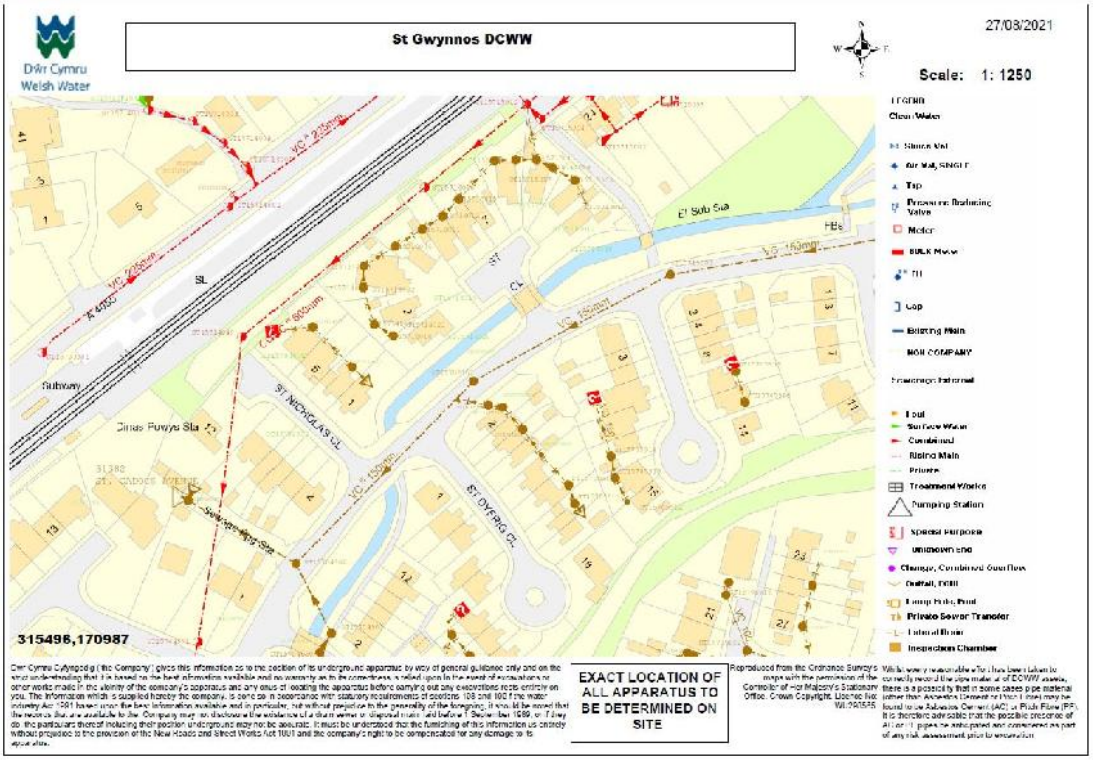


Figure 4-6 St Gwynno's Close DCWW Asset Map

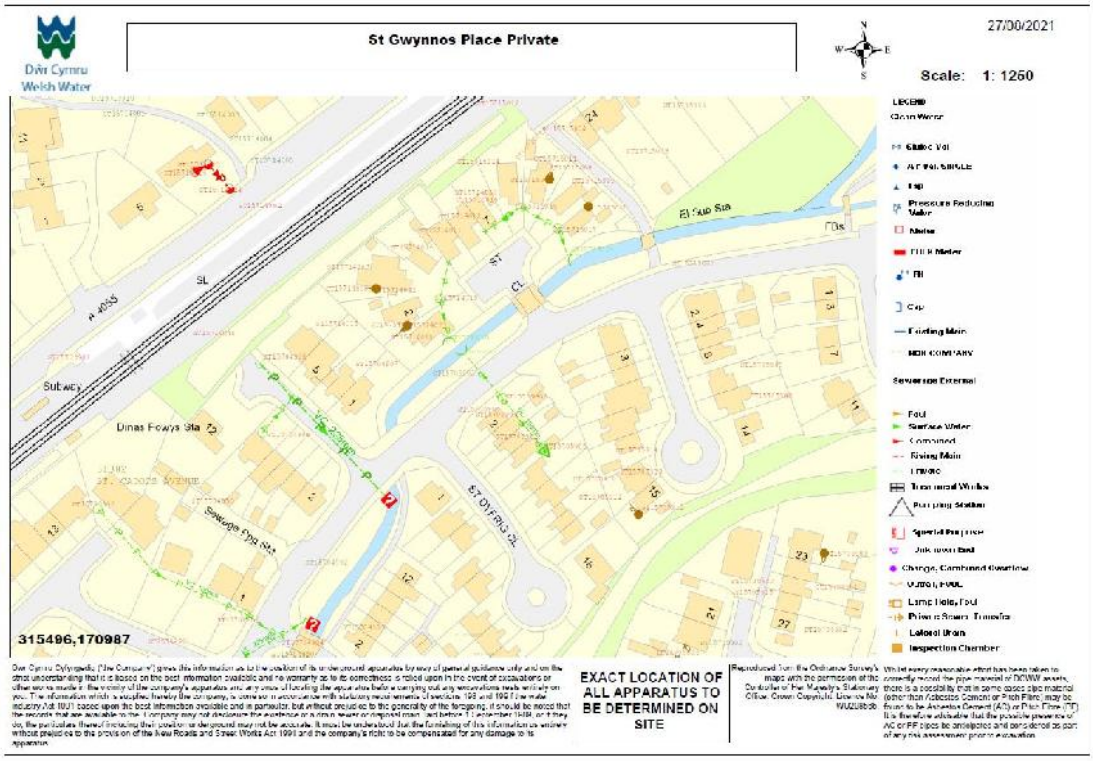


Figure 4-7 St Gwynno's Close - Private Sewer Record

4.3.3 **Vale Court**

Vale Court and Fairoaks are served by a public foul sewer (Figure 4-6 and 4-7, and Appendix B), which also receives flows from the wider Murch area of Dinas Powys.

DCWW asset maps indicate that there is no public surface water system within this investigation area. There is a public surface water sewer serving Castle Drive which outfalls into the East Brook just south of the Murch Road railway bridge, however this falls outside of the area of investigation. Along the East Brook there are a number of surface water outfalls that may be linked to surface water drainage on the adjacent streets.

The highway network at this location discharges to the East Brook.

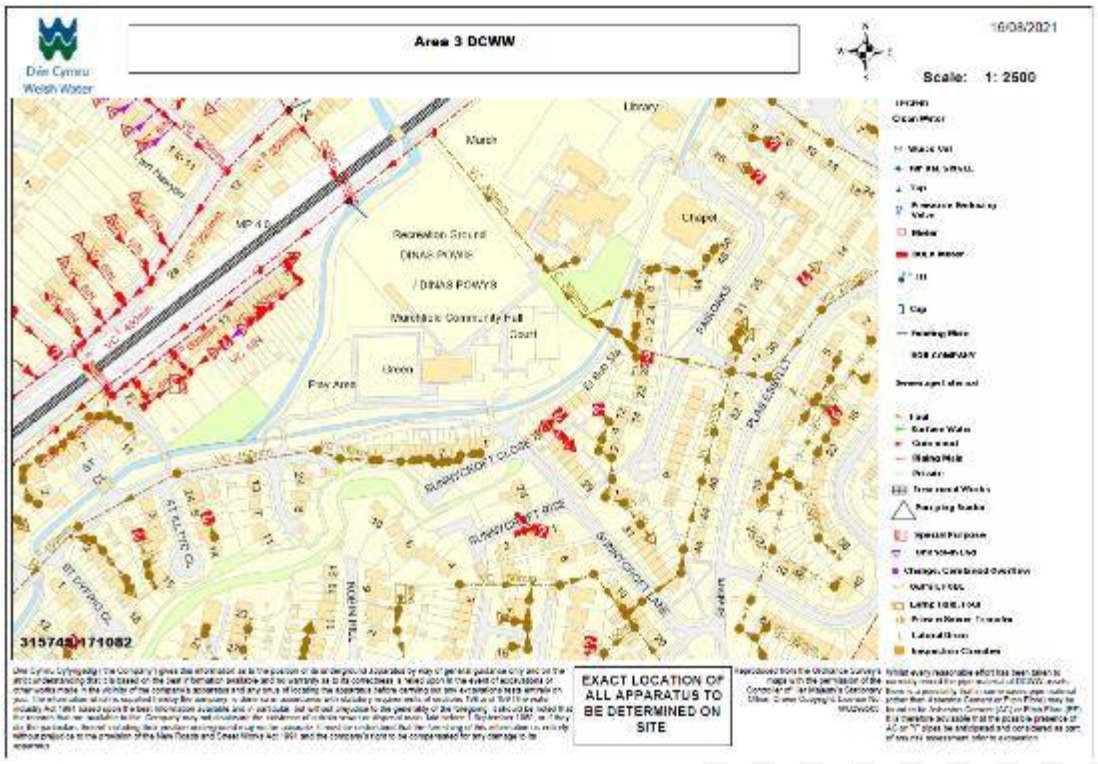


Figure 4-8 DCWW Asset Map – Fairoaks and Murchfield Community Centre

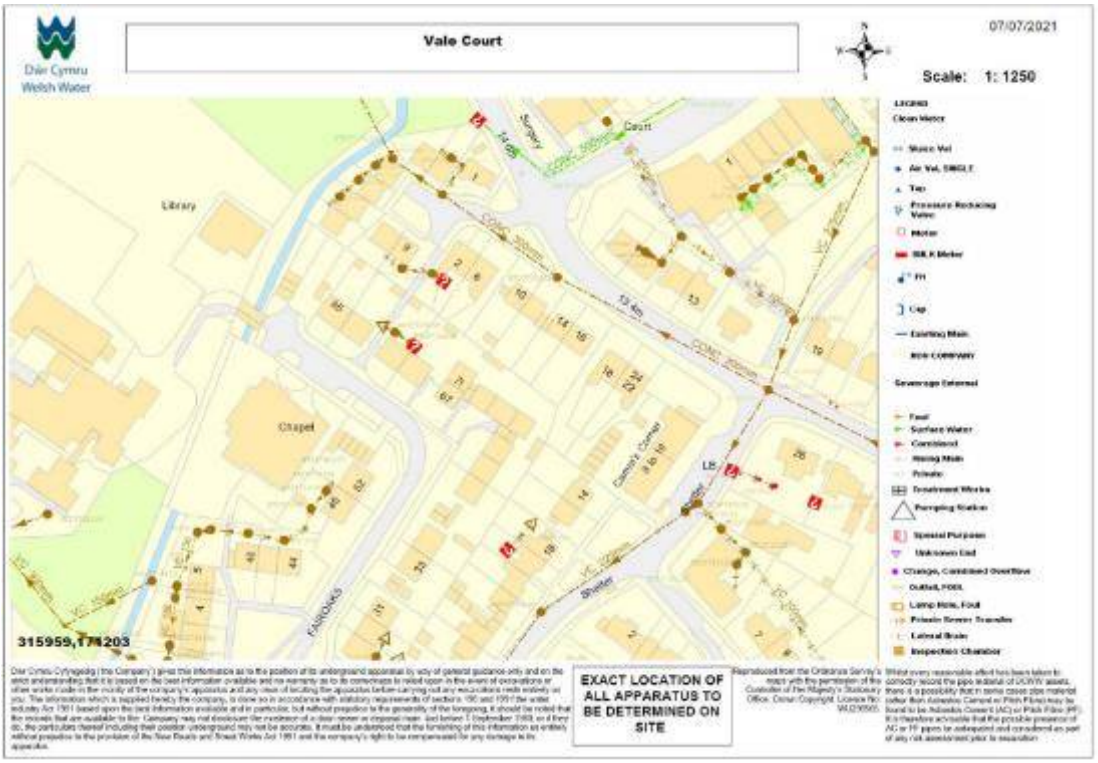


Figure 4-9 Vale Court DCWW Asset Map

4.3.4 **St Cadoc's Avenue**

The public combined sewer flows from the rear of St Gwynno's Close to the northern extent of St Nicholas Close. From there it flows in a southerly direction towards the junction of St Cadoc's Avenue and Cardiff Road. St Cadoc's Avenue from St Teilo Close to St Lythan's Close and St Paul's Close is served by a public foul sewer. St Winifred's Close is served by a public foul system which connects to the combined sewer in St Cadoc's Avenue. There are a number of private sewerage systems in the area.

DCWW asset maps (Figure 4-8 and Appendix B) indicate that there is a limited public surface water system in this investigation area. A private surface water sewer serves a number of properties in St Ambrose Close and outfalls into the Cadoxton upstream of the St Lythan's Close highway bridge. A small number of properties at the southern end of St Cadoc's Avenue are also served by a private surface water system which outfalls into the Cadoxton at this location.

The investigation area is served by a highway network which has various outfalls into the River Cadoxton.

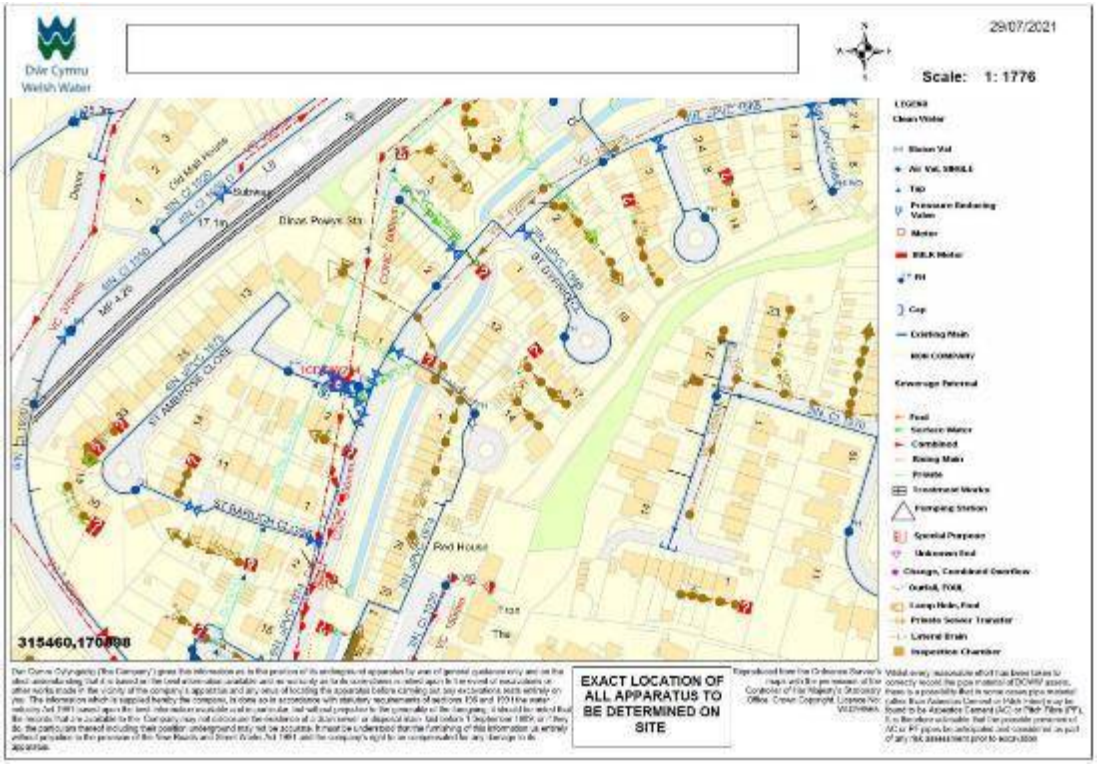


Figure 4-10 St Cadoc's Avenue DCWW Asset Map

4.3.5 **Cae'r Odyn**

The Cae'r Odyn investigation area is served by a public foul and surface water system (Figure 4-9).

The public foul system serves all properties on Cae'r Odyn and Cae Garw, flowing predominantly in an easterly direction to a public combined system to the rear of properties on Cae'r Odyn, bordering Cardiff Road. There is a known Non-Return Valve within the manhole at the rear of 15 Cae'r Odyn. The combined system flows in a southerly direction through parc Bryn-y-Don and towards Barry.

The public surface water sewer serving Cae'r Odyn and Cae Garw predominantly flows in an easterly direction to its outfall into the River Cadoxton, just upstream of the pedestrian footbridge from Cardiff Road into Parc Bryn-y-Don. This outfall is at a low level into the River Cadoxton.

The properties on Cae'r Odyn that back onto Cae Garw are served by private surface water gullies at the rear, which are assumed to drain to the public surface water network at the front of these properties.

Historically, there have been issues of sewer flooding at Cae'r Odyn, from the earliest records of external flooding in 1998 to 2008. DCWW delivered a capital scheme in 2008-2009 to resolve the known flood issue on their system, which consisted of a new combined sewer overflow and associated pipework. DCWW have advised that there have been no confirmed incidences of flooding on the network since the capital works have been completed.

Highway drainage within this investigation area drains into the public sewer network.

Figure 4-11 Cae'r Odyn DCWW Asset Map

5 Information gathering

5.1 Flood risk

5.1.1 Long-term flood risk information

5.1.1.1 Rivers

The Natural Resources Wales (NRW) long-term flood risk map from Rivers shows a large amount of the area of investigation is at risk of flooding from Main Rivers. The majority of St Cadoc's Avenue, Murchfield Playground, and Elm Grove Place have a high risk of flooding of greater than 1 in 30 (3.3%) probability in any year (Figure 5-1). Properties neighbouring the Cadoxton River at the southern extent of Greenfield Avenue, along Cardiff Road and at Vale Court are also at high risk of fluvial flooding.

Properties at Cae'r Odyn, bordering Cardiff Road, and Fairoaks and Sunnycroft Lane are at medium risk and have a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3%) in any year. Similarly, there is medium risk to the southern half of Greenfield Avenue and Cardiff Road in this area.

Cardiff Road and Brookside have low risk of fluvial flooding, as is the case for the majority of Cae'r Odyn and the northern extent of Greenfield Avenue and Millbrook Road. A low risk of fluvial flooding is defined as a 1 in 100 to 1 in 1000 (1% to 0.1%) chance of flooding in any given year.

NRW's Flood Risk Assessment Wales map identifies the Cae'r Odyn estate as an area benefitting from fluvial flood defences (Figure 5-1). The area is defended by an embankment which offers a 1 in 25 annual probability standard of protection (SoP) and on last inspection was considered to be in 'Fair' condition. It should be noted that any protection offered by this asset is not accounted for in NRW's newly published Flood Map for Planning (September 2021) as this only considers assets offering a SoP of 1 in 100 annual probability or greater.

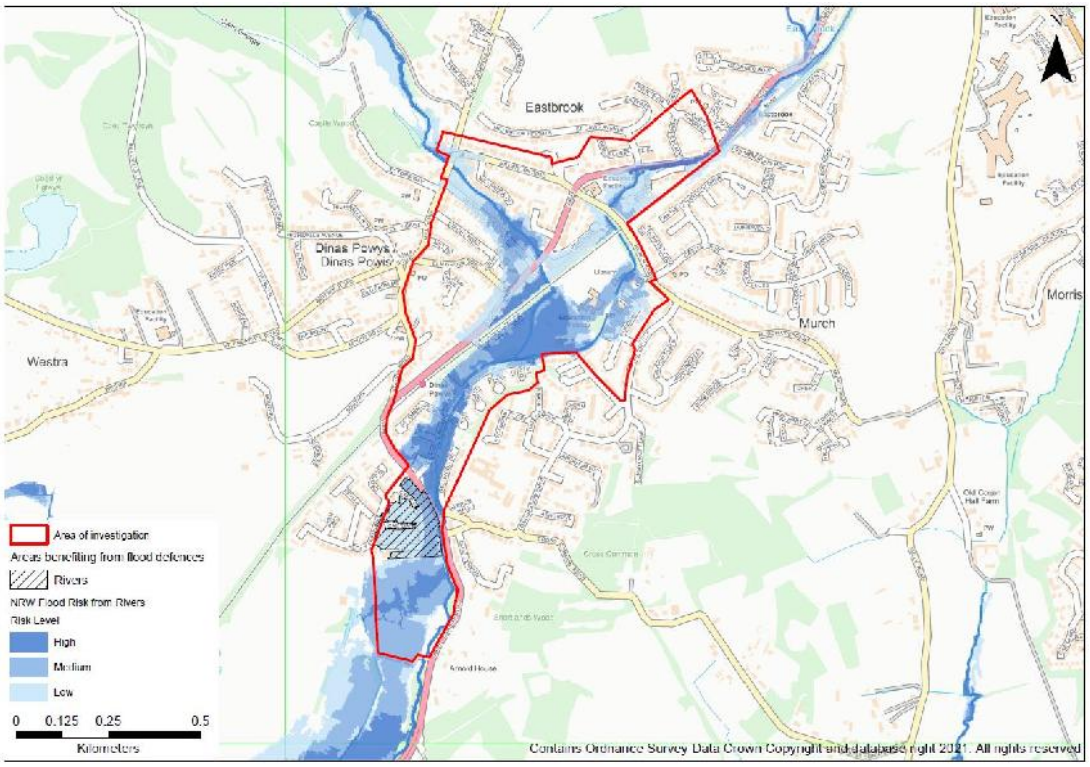


Figure 5-1 Risk of flooding from rivers and the sea

5.1.1.2 Tidal

The Natural Resources Wales (NRW) long-term flood risk map for flooding from the sea indicates that the entirety of the investigation area has a very low risk of flooding from the sea.

5.1.1.3 Surface water

The NRW Flood Map for Surface Water and Small Watercourses shows the area of investigation has a mixed risk of flooding from surface water. Mill Road at the junctions with Millbrook Road and Greenfield Avenue is at high risk of surface water flooding, defined as a chance of flooding of greater than 1 in 30 (3.3%) in any year as a result of rainfall (Figure 5-2). The majority of Millbrook Road is also shown to be at high risk of surface water flooding. Additionally, Vale Court, the residential boundary between Cae'r Odyn and Cae Garw, the rear of residential and commercial properties along Cardiff Road, north of the railway embankment, are at high risk of surface water flooding.

There are a number of areas at low risk of surface water flooding, defined as a chance of flooding between 1 in 1000 (0.1%) and 1 in 100 (1%) in any year. Many of these areas of low risk also have a small, localised area of medium risk within them. A medium risk of surface water flooding is defined as between 1 in 100 (1%) and 1 in 30 (3.3%) chance of flooding each year. Areas at low to medium risk of surface water flooding include the majority of the highway on

Greenfield Avenue, Fairoaks and Sunnycroft Lane and the southern end of Elm Grove Place.

DCWW have previously undertaken capital works in Cae'r Odyn to mitigate the risk of flooding from the main trunk sewer in Cardiff Road. These works consisted of a new combined sewer overflow and associated pipework, including the use of oversized pipes for storage of surface water during rainfall events.

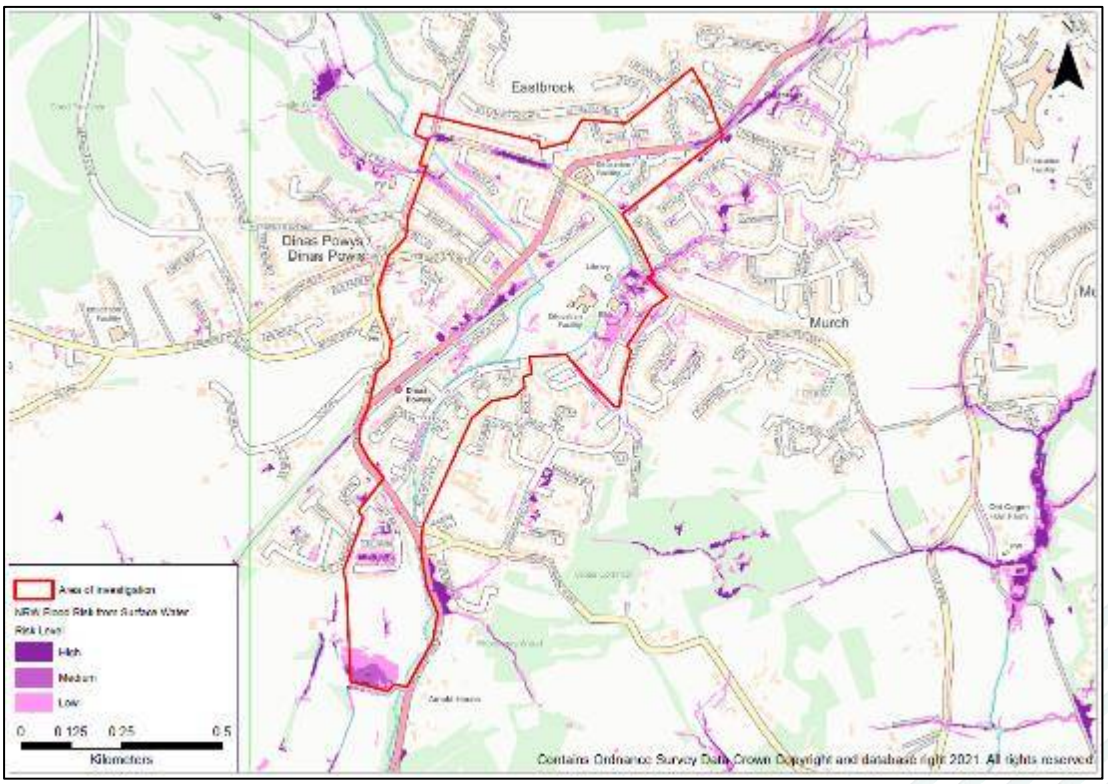


Figure 5-2 Risk of flooding from surface water

5.1.1.4 Groundwater

Groundwater levels are taken from a number of boreholes in the region of Dinas Powys (Figure 5-3). Groundwater is notably high at the north end of Greenfield Avenue at 1.83m below ground level and 8.00m below ground level in the area of Cae'r Odyn and St Cadoc's Avenue. By Cardiff Road in the East Brook area groundwater depths are 8.53m.

As groundwater levels rise in response to precipitation, groundwater can contribute to an increased level of surface water overland flow and a faster flow of water to river channels. However, flooding as a direct result of groundwater rising was not reported and the rapid onset and short duration of the flood event does not characterise groundwater flooding. Although groundwater is not considered to be a direct source of flooding for this event it is acknowledged that a substantial amount of rain fell over a short period of time and on an already saturated catchment, which is likely to have led to surcharging of sewers, combined with high water levels in the river.

Anecdotal reports from residents suggest that groundwater pumping operations at Wenvoe Quarry, upstream of Dinas Powys, leads to additional flows within the watercourse, increasing the likelihood of flooding. However, NRW have previously investigated, and continue to manage the discharge permit for flows into the Bullcroft Brook from the quarry site. The investigation concluded that the maximum permitted discharge rate from the quarry equates to 0.5% of the peak flow throw Dinas Powys during the 1% AEP event. As a result, it is considered that discharge of groundwater into the watercourse system has no significant effect on flood risk in Dinas Powys.

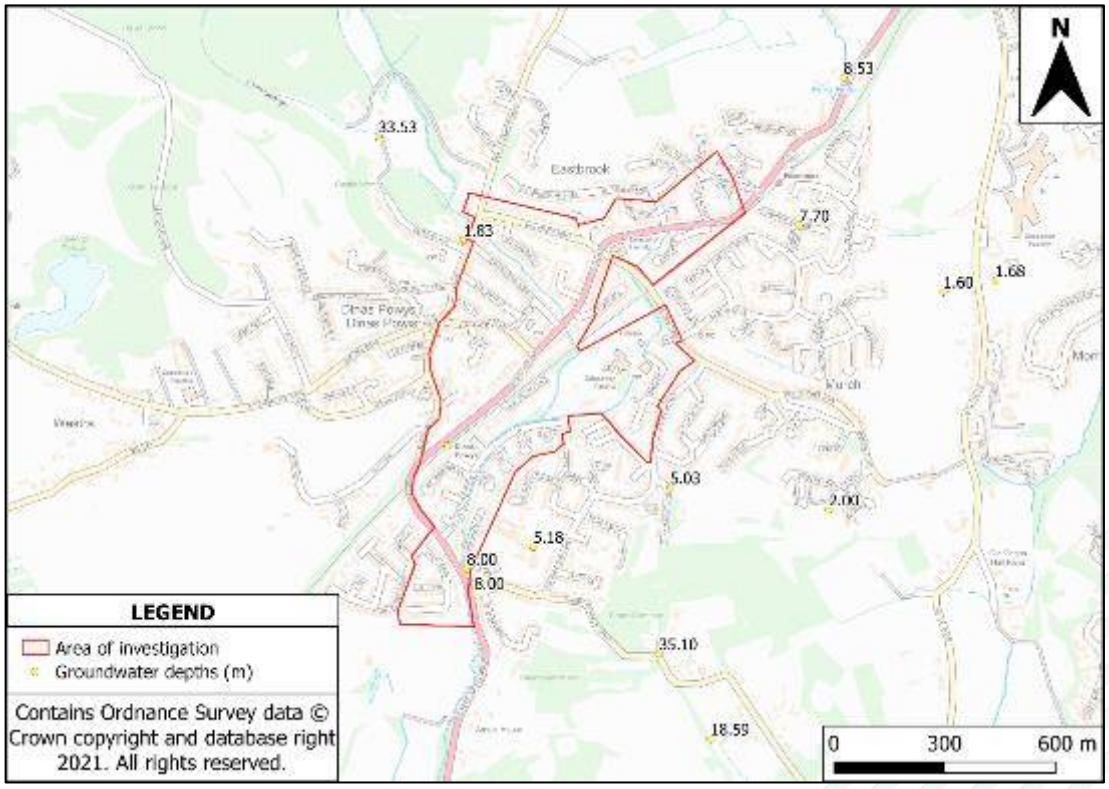


Figure 5-3 Groundwater borehole locations and depths (m)

5.1.2 **Flood history**

There is a lengthy flood history for Dinas Powys with properties on St Cadoc's Avenue, Greenfield Avenue, Elm Grove Place and Cardiff Road at Eastbrook having been affected. Internal property flooding was reported in 1903. 1913, 1948, 1986, 1998, 1999 and 2008. External flooding was also reported in 1965, 1968, 1976, 1995, 2007, 2012, 2013 and most recently in February 2020.

In addition, Table 5-1 details the known flood history of the area of investigation based on records held by VoGC.

Table 5-1 Flood history

Date	Source of flooding	Description of impacts
October 1998	Surface water and fluvial flooding	Significant rainfall leading to flooding
October 2000	Surface water and fluvial flooding	Significant rainfall leading to flooding
July 2008	Surface water and fluvial flooding	Internal record of 6 properties flooding internally
December 2012	Surface water and fluvial flooding	Significant rainfall leading to flooding
February 2020	Surface water flooding and fluvial flooding (Storm Dennis)	Significant rainfall leading to flooding
December 2020	Surface water flooding and fluvial flooding	Significant rainfall leading to flooding

6 Hydrological analysis of the December 2020 event

6.1 Conditions at the time

The overall rainfall for January to December 2020 was above average across most of the UK, particularly across western regions. December featured a series of cyclonic systems, with successive spells of unsettled weather generating rainfall over saturated ground. Overall, December rainfall was substantially above average with 139% of the long-term average (LTA) for the UK and in a broad portion of Wales rainfall exceeded 150% of the LTA.

Soil moisture deficits (SMD) were near-zero across the whole of the UK, the wettest soils for late December at a national scale since 2012, meaning there was little capacity for the ground to retain additional water. Mean river flows over January to December 2020 were exceptionally high in Wales. As a result of these conditions surface water flooding causing significant disruption was a recurrent characteristic of the month.

6.2 Overview of Event

The flood event on 23rd December 2020 occurred in response to a short and intense storm event. A short sharp period of intense rainfall was observed between 09:00 and 10:00 at Cog Moors Sewage Treatment Works (STW) TBR rain gauge (the closest rain gauge to the site), recording 8.2mm in 1 hour. After a period of no rainfall for 1.5 hours and 1mm between 11.30 and 12.00 a longer period of persistent heavy rainfall between 12:45 and 18:00 occurred. During this 5.25hr period 47.8mm of rain fell with an average intensity of 9.1mm/hr. The maximum rainfall intensity occurred between 14:00 and 15:00 equalling >10mm/hr. Figure 6-1 below shows the rainfall hyetograph of the flood event at the Cog Moors STW TBR, as detailed in the Section 19 Data Analysis report undertaken by JBA Consulting (Appendix C).

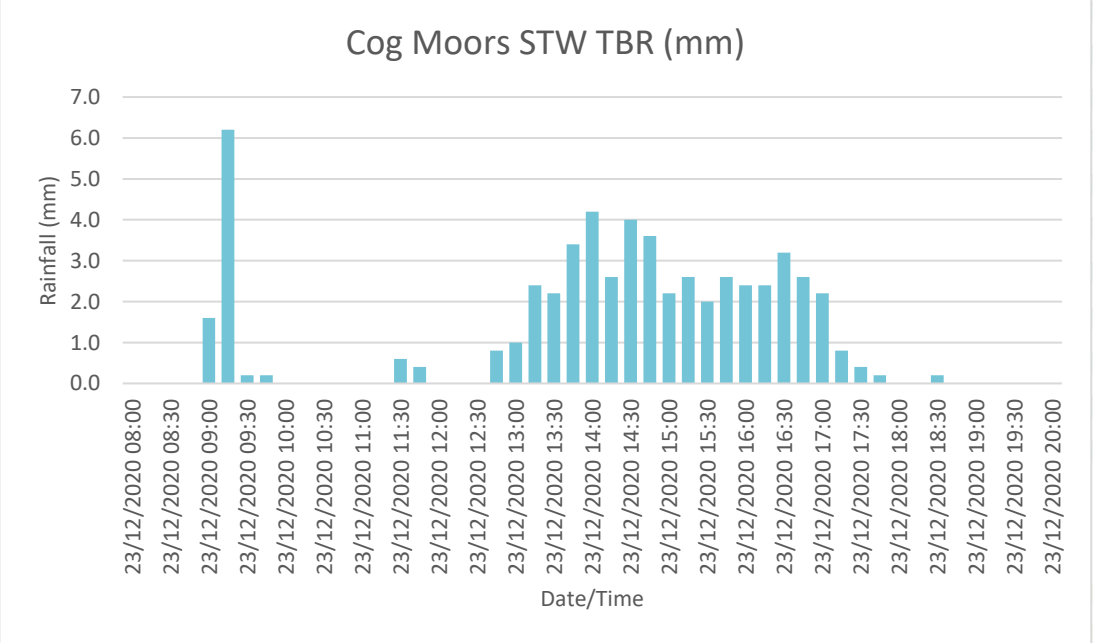


Figure 6-1 Rainfall hyetograph of December 2020 flood event

As described above, prior to the flood there had been a succession of storm events, which had left behind a highly saturated catchment. As a result of this there would have been little capacity for storage within the catchment.

The outcome of this high volume of rainfall falling on a saturated catchment was rapid flows of surface water run-off across non-permeable urban surfaces and slopes. These flows pooled at lower elevations or ran into the Cadoxton River where levels elevated quickly in response. This also caused problems for the surface water sewer network, which was unable to cope with a large volume of water over this short timeframe. The storm is reported to have been equivalent to a 1 in 20 (5%) annual probability rainfall event which generated a fluvial return period of 1 in 10 to 1 in 20 (10% - 5%) annual probability.

The days following the event were comparatively dry in the area with short periods of light rainfall on the 24th and 26th December and no impacts resulting from the additional rainfall were reported.

6.3 Timeline of Event

A timeline of the incident response is given Table 6-1.

Table 6-1 Timeline of incident response

Date & time	Activity/event	Agency
23/12/2020 13:30	NRW issues Flood Alert	NRW
23/12/2020 13:45	Receive alarm from St Richard Gwyn Gauging Station on the Coldbrook.	VoGC
23/12/2020 13:47	Call reporting external flooding at Powys Place.	DCWW
23/12/2020 14:10	Reports of the East Brook overtopping near Fairoaks, along with private drainage concern.	VoGC
23/12/2020 14:15	Police call to VoGC contact centre regarding flooding to the highway of Cardiff Road	VoGC
23/12/2020 14:19	Reports of flooding to the rear of property in Cardiff Road – source of flooding unknown	VoGC
23/12/2020 14:26	Reports of surface water flooding to Millbrook Road	VoGC
23/12/2020 14:43	NRW issues Flood Warning	NRW
23/12/2020 14:47	Customer at Plas Essyllt reported external flooding to the rear that was getting close to going internal flooding.	DCWW
23/12/2020 15:05	Further reports of flooding to Cardiff Road, nr Brookside	VoGC
23/12/2020 15:23	Customer reported external flooding at Cae'r Odyn. Engineer attended site later that day and confirmed four properties were internally flooded by floodwater from the rear of the properties next to Cadoxton River.	DCWW
23/12/2020 15:31	Reports of highway flooding to Cardiff Road, near Elm Grove Road	VoGC

23/12/2020 15:35	South Wales Police reported flooding of Cardiff Road, near Brookside	VoGC
23/12/2020 15:50	Email received by FCERM Inbox regarding flooding at Millbrook Road, Dinas Powys.	VoGC
23/12/2020 15:55	Report of flooding at St Lythans Close	VoGC
23/12/2020 16:07	Reports of internal flooding at Elm Grove Place	VoGC
23/12/2020 16:36	Reports of internal flooding at St Paul's Close	VoGC
23/12/2020 16:45	Reports of internal flooding at Edith Road and Greenfield Avenue	VoGC
23/12/2020 ~17:00	Staff attend Plas Essyllt where brook was overtopping and flooding properties on Sunny Croft Lane. Staff confirmed that flooding had occurred due to the East Brook overtopping and overflowing, resulting in ingress into DCWW sewer network which overloaded the system.	DCWW
23/12/2020	Several reports of Flooding during the evening. Emergency room opened.	VoGC

7 Source-pathway-receptor analysis

7.1 Source

7.1.1 River

There are two watercourses, designated as Main Rivers, which flow through the area of investigation. The River Cadoxton flows through Dinas Powys in a southerly direction, entering from the north-west where it runs parallel to Greenfield Avenue. It then tracks south alongside St Cadoc's Avenue before crossing under Cardiff Road by Cae'r Odyn and follows the highway south toward Barry. The river then travels south-west before discharging into the Bristol Channel at Barry Docks.

The East Brook flows into Dinas Powys from the north-east, passing Brookside and Murchfield Community Centre before it's confluence with the Cadoxton River at the eastern end of St Cadoc's Avenue. The watercourses are not tidally influenced as they flow through Dinas Powys and the Section 19 data analysis for Dinas Powys produced by JBA Consulting in March 2021 identified that is no tidal influence seen at the Sully Moors Road gauge. Additionally, the timing of the peak water level at the Sully Moors Road gauge during the December 2020 event occurred at a trough in the tidal curve at Barry Port, indicating that the tide did not adversely impact levels at the gauge location.

NRW's Flood Risk Assessment Wales map identifies the Cae'r Odyn estate as an area benefitting from fluvial flood defences (Figure 5-1). The area is defended by an embankment which offers a 1 in 25 annual probability standard of protection (SoP) and on last inspection was considered to be in 'Fair' condition. It should be noted that any protection offered by this asset is not accounted for in NRW's newly published Flood Map for Planning (September 2021) as this only considers assets offering a SoP of 1 in 100 annual probability or greater.

7.1.2 Extreme rainfall

The primary source of the floodwater is the extreme rainfall experienced across South Wales on 23rd December 2020 and in particular around Dinas Powys which generates river and local surface water flows.

This investigation presents Cog Moors STW TBR gauge data due to it being the closest gauge to the site being investigated. Rainfall totals at other local rain gauges were also assessed for the 23rd December 2020 event (Table 7-1) that provide context for the storm event across South Wales. Note: Rain fell at slightly different times at the gauges, hence the period and duration vary for each.

The findings indicate that the Cog Moors STW TBR gauge recorded substantially larger rainfall totals than at the other gauges within the vicinity of the storm event (see Figure 7-1 and Table 7-1). NRW have indicated confidence in the Cog Moors STW TBR gauge due to the data being consistent between the primary and secondary gauges that operate independently and after quality checks undertaken on 31st December following the event. Rainfall radar data did not indicate a localised storm around Cog Moors STW TBR, so it is unclear why local rainfall totals differ so substantially from other rain gauges.

The Dinas Powys S19 Data Analysis Report provided an analysis to estimate the flood frequency. The inference of flood rarity from rainfall data is seldom accurate, as treating rainfall rarity as a measure of flood rarity neglects the complex scenarios leading to flood formation. Therefore, a flood frequency specific to the site investigated in this S19 report is not inferred. However, the rainfall frequency estimation suggested Cog Moors STW TBR indicates a frequency of about 5% AEP (20yr return period) and the other rain gauges suggest a frequency of about 70%-20% AEP (1.5yr-5.0yr return period) across the wider area.

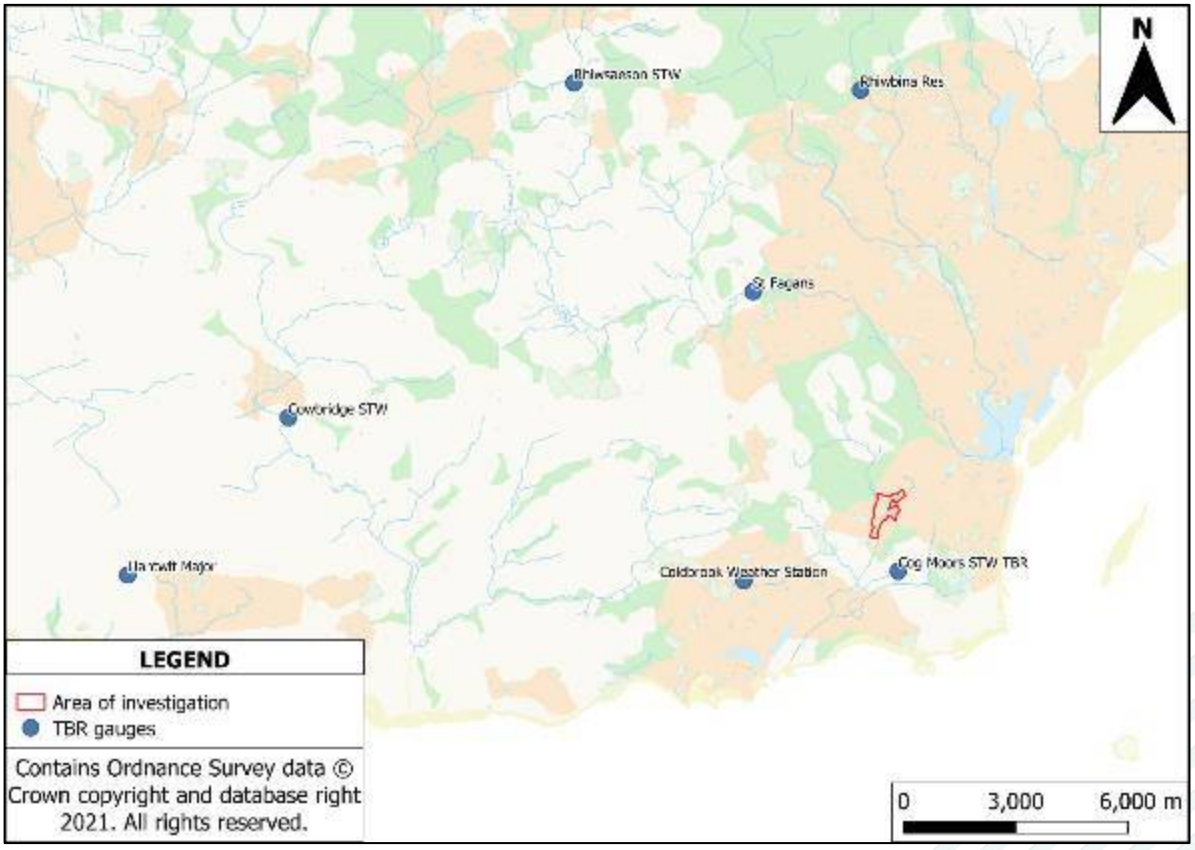


Figure 7-1 Rainfall gauge locations

Table 7-1 Rainfall gauge data

Rain gauge	Distance from Dinas Powys (km)	Rainfall (mm) on 23/12/2020	Coordinates (XY)
Cog Moor STW TBR	1.52	47.8 in 5.25 hrs	315986,169586
		57.2 in 9.75 hrs	
Cold Brook Weather Station	3.86	29.0 in 5.25 hrs	311853,169334
		37 in 9.75 hrs	
St Fagans TBR	6.95	30.8 in 5.25 hrs	312103,177055
		43.6 in 9.75 hrs	
	11.43	27.6 in 6.00 hrs	314976,182442

Rhiwbina Reservoir TBR		44.4 in 9.75 hrs	
Rhiwsaeson STW TBR	14.17	28.2 in 7.00 hrs	307308,182629
		37.4 in 10.00 hrs	
Cowbridge TBR	15.96	28.8 in 6.75 hrs	299675,173689
		35.2 in 9.25 hrs	
Llantwit Major TBR	20.04	32.6 in 8.50 hrs	295375,169481

7.1.1 Groundwater

There are no groundwater level measurements available within the vicinity of the site. As groundwater levels rise in response to precipitation, groundwater could contribute to an increased level of surface water overland flow and a faster flow of water to river channels. However, flooding as a direct result of groundwater rising was not reported and the rapid onset and short duration of the flood event does not characterise groundwater flooding. Therefore, groundwater is not considered to be a direct source of flooding for this flood event.

7.2 Pathway

7.2.1 Brookside

7.2.1.1 Fluvial

The main fluvial flow pathway is from the East Brook overtopping its banks around the Brookside junction, flowing onto the highway and flooding an estimated 300m length of Cardiff Road (Figure 7-2).

There is no evidence of the East Brook overtopping its banks upstream of the Brookside and Cardiff Road junction.

7.2.1.2 Surface water and highway drainage

A significant pathway for flooding in this area is understood to have been via surface water flows. Some surface water pooled directly from the high levels of rainfall on the day, combined with the highway network being hydraulically locked as a result of the elevated water levels in the East Brook.

Surface water flooded Cardiff Road to significant depths, however traffic was still able to pass through, though slowly. Passing traffic is also known to have created bow waves, exacerbating the extent of flood impacts in the area, with the flood extent encroaching into Dinas Powys community school playground/carpark and the electricity substation located on Cardiff Road.

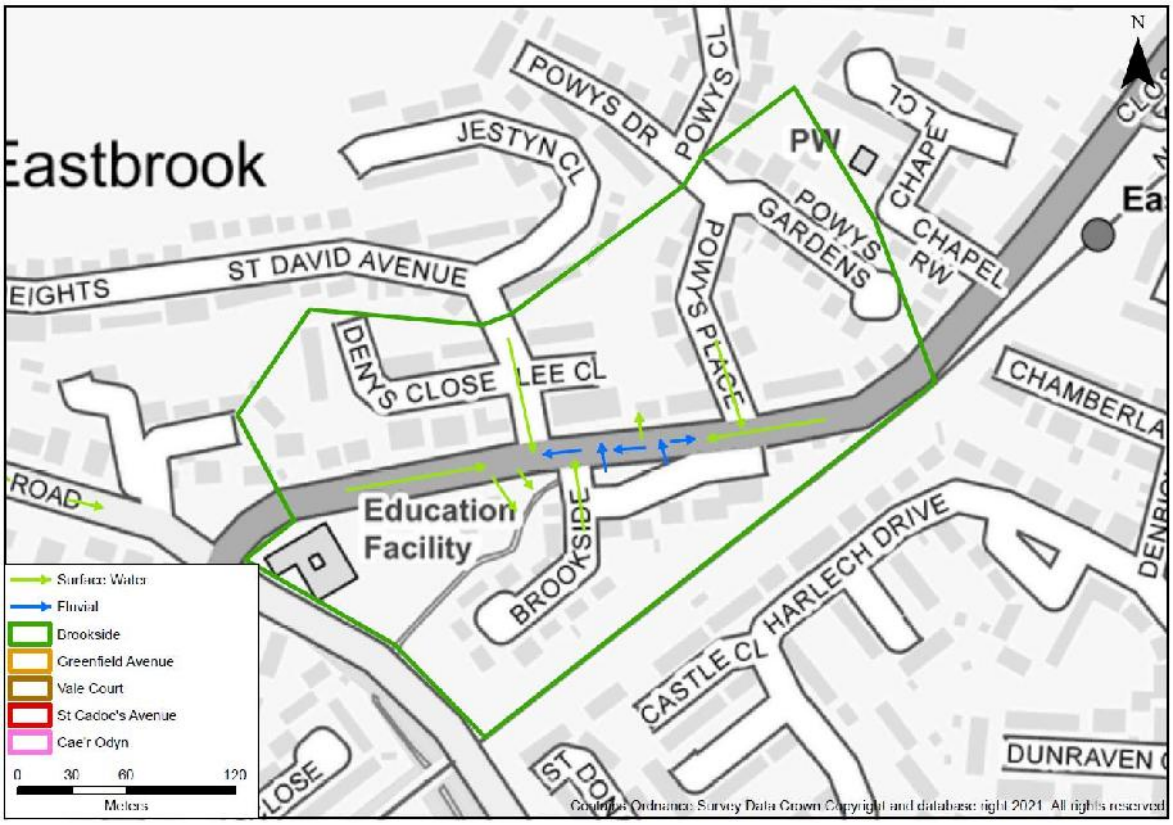


Figure 7-2 Brookside flow paths

7.2.2 **Greenfield Avenue**

7.2.2.1 Fluvial

The Cadoxton River over-topped its banks in serval locations across this investigation area, flooding parts of the junction of Mill Road with Millbrook Road, Greenfield Avenue, and Cardiff Road. Some surface water flooding was reported in this area, contributing to flooding, with the manhole at the junction of Mill Road and Pen-y-Turnpike road reported to have surcharged shortly before the river overtopped. Some surface water flows were reported from Pen-y-Turnpike Road towards Mill Road, however, there have been no reports of surface water flooding of Mill Road, to the south of its junction with Greenfield Avenue.

At the northern extent of this investigation areas, the Cadoxton River overtopped on Mill Road above and below the road bridge before flowing down Millbrook Road and into the rear gardens of Millbrook Close, on the left-hand bank of the river (7-4).

The main flow path onto Greenfield Avenue was from fluvial flows into the rear of several properties located on the right-hand bank of the river and through the public open space (known locally as The Scout Field) located between these properties (Figure 7-3). Due to the road being in camber, fluvial flows were shed to either side of the highway, flooding properties on both sides of Greenfield Avenue. To the southern extent of Greenfield Avenue, some properties reported floodwaters entering the garden at the rear from the channel, and gardens or the property itself, from the highway.

From Greenfield Avenue, fluvial waters flowed along the informal lane between Saint Mary's Catholic Church and residential properties on Cardiff Road. Floodwater then flowed in a southerly direction, through the residential properties on Cardiff Road and towards the railway embankment to the south.

Floodwater was reported to be within the channel immediately upstream of the Cardiff Road bridge, prior to water overtopping the channel downstream of the bridge, flooding the substation on the right-bank of the channel and flowing into the rear carpark of the commercial properties on the southern side of Cardiff Road. The car park is located at a substantially lower level than the commercial properties. The railway embankment at the southern boundary of the car park prevented water flowing in a southerly direction from this location.

The primary fluvial flow path on Elm Grove Place was direct ingress from the River Cadoxton to the rear of the properties, and to the east of 1 Elm Grove Place (Figure 7-3). Water then proceeded to flow across the gardens and open spaces, along with the highway of Elm Grove Place, before flooding the properties from the rear.

Flows from Elm Grove Place also flowed in a westerly direction towards St Gwynno's Close, with 2 properties reported to have flooded externally as a result. Flows flooded the rear gardens of properties prior to flowing towards the highway of St Gwynno's Close and back towards the River Cadoxton.

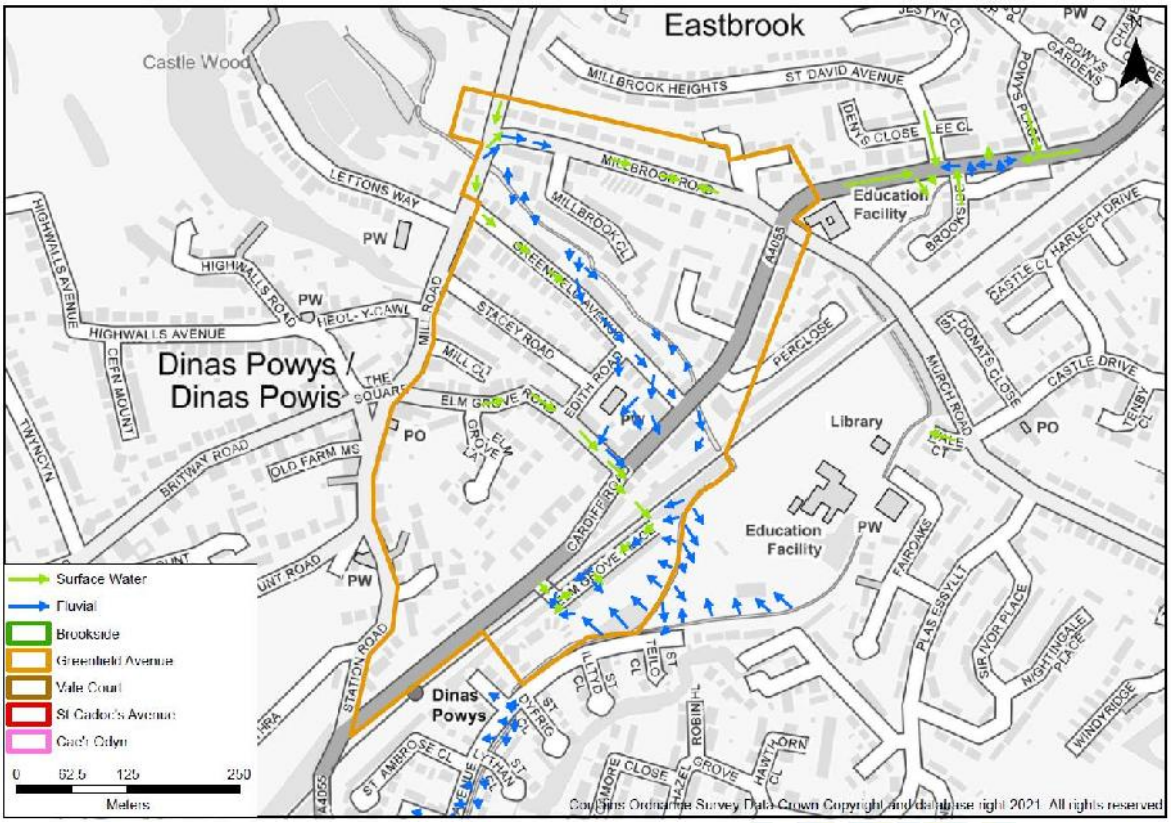


Figure 7-3 Greenfield Avenue investigation area fluvial flow paths

7.2.2.2 Surface water and highway drainage

The main source of flooding in this investigation area was fluvial, however several of the surface water systems in the area were also at capacity, contributing to flooding in the area. Initial signs of flooding within this investigation are reported to be surcharging of the manholes located on the highway network and serving the culverted watercourse at the junction of Mill Road and Millbrook Road, with surface and fluvial water flowing down Greenfield Avenue and Millbrook Road.

In addition, the highway network along Millbrook Road was at capacity, resulting in surface water flooding to the highway. All surface water was retained on the highway, with no property flooding as a result.

There is also anecdotal evidence that the highway network on Elm Grove Road was overwhelmed during the event, with sheeting overland flows observed. Elm Grove Road has a steep gradient, with surface water flowing towards its junction with Cardiff Road. Surface Water combined with the fluvial flows on Cardiff Road, with water then flowing towards the rear of properties 8-10 Cardiff Road, via the garages (no internal flooding observed), which are located at a localised dip in topography. Flows towards the garages were exacerbated at this location as a result of passing traffic creating bow waves onto the driveways of these properties and pushing flows further towards the garages. Water ponded in the rear gardens of these properties, prior to flowing south of the railway line via a Network Rail culvert which conveys flow in an open ditch towards the River Cadoxton, south of the railway embankment, and east of Elm Grove Place. The ditch exceeded capacity and resulted in flows entering Elm Grove Place from the rear of 1 Elm Grove Place and flowing in a westerly direction along the highway of Elm Grove Place, combining with the fluvial flows from the River Cadoxton which had also overtopped at this location (Section 7.2.2.1). In addition, the highway network on Elm Grove Place was hydraulically locked as a result of the high water levels within the River Cadoxton, surcharging and contributing to the surface water flooding at this location.

There are no reports of the DCWW combined network surcharging during the event within the Greenfield Avenue investigation area.

7.2.3 Vale Court

7.2.3.1 Fluvial

Within this investigation area, fluvial flooding was minimal. The East Brook overtopped for a short stretch, north of Sunnycroft Lane, flowing into Murchfield Community Centre from the south. The East Brook also overtopped downstream of the community centre, to its confluence with the River Cadoxton.

7.2.3.2 Surface water, highway drainage and foul sewer

On Vale Court, both the private surface water network and DCWW foul system were overwhelmed. The surface water drainage to the Murchfield Community Centre area appeared to have failed. This led to higher overland flows and reports of blockages to toilets.

7.2.4 St Cadoc's Avenue

7.2.4.1 Fluvial

St Cadoc's Avenue experienced high levels of fluvial flooding from the River Cadoxton which had overtopped its banks alongside St Cadoc's Avenue, downstream of the St Cadoc's Avenue road bridge, downstream of St Dyfrig Close. Water overtopped the right-hand bank of the channel and flowed along the highway into the adjoining cul-de-sacs (Figure 7-4) of St Nicholas Close, St Baruch Close, and St Winifred's Close. Water which overtopped the channel on the left-hand bank entered properties in St Lythans Close, St Pauls Close and St Cadoc's Avenue. At the southern extent of this investigation area, the River Cadoxton overtopped its banks at the rear of properties 2-14 St Cadoc's Avenue (even numbers only). These properties also flooded from the highway as a result of fluvial flows on St Cadoc's Avenue flowing into a south-easterly direction, back towards the river channel. These properties are substantially lower than the rest of the properties in this investigation area. Following flooding of properties at around 6pm, water levels were receding by 8pm.

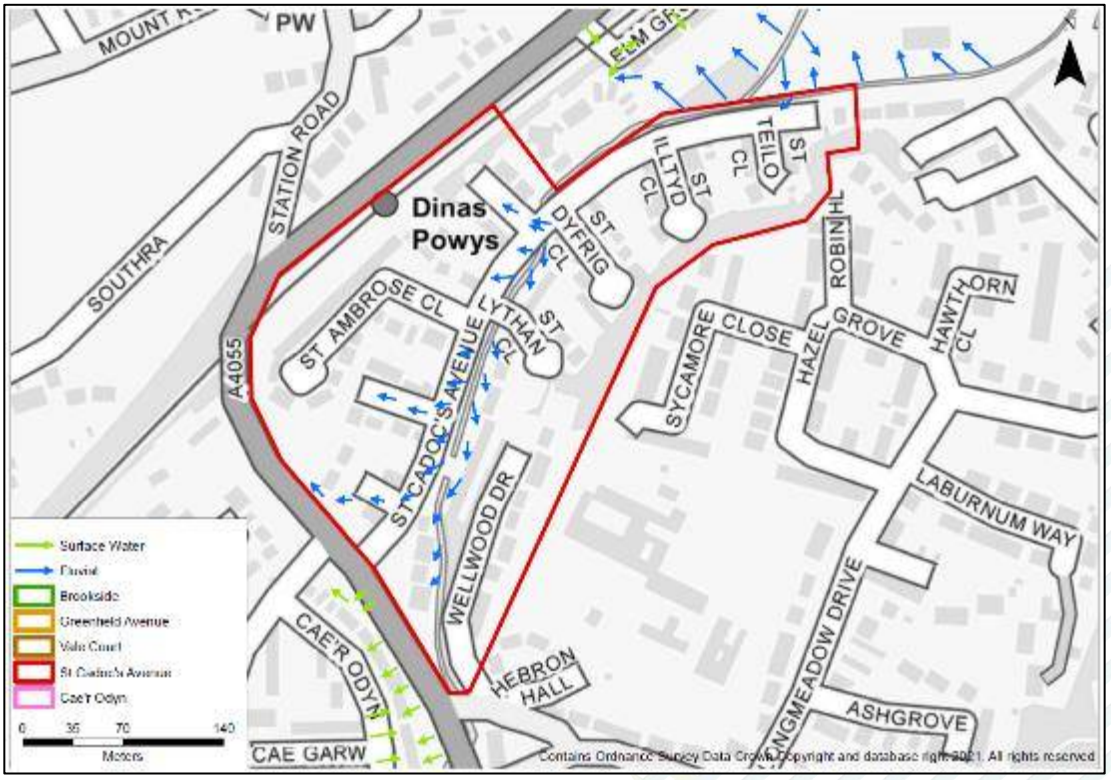


Figure 7-4 St Cadoc's Avenue flow paths

7.2.4.2 Surface water and highway drainage

The main pathway for floodwater was fluvial, however flooding to the highway was exacerbated by the highway drainage network being overwhelmed. The highway network at this location outfalls into the River Cadoxton and was hydraulically locked during the flood event, resulting in surcharging manholes across the investigation area.

7.2.5 Cae'r Odyn

7.2.5.1 Fluvial

The River Cadoxton remained in channel downstream of St Cadoc's Avenue and around the Cross Common Road bridge, prior to overtopping downstream of the Cardiff Road bridge. Fluvial flows entered the rear gardens of two properties on Cae'r Odyn, prior to flooding across Parc Bryn-y-Don with the flood extent on the 23rd December correlating well with the predicted flood extents for the area modelled by NRW. The Cae'r Odyn estate is an area benefitting from fluvial flood defences with a standard of protection of 1 in 25 annual probability.

7.2.5.2 Surface water and highway drainage

Across this investigation area there were multiple sources of surface water flooding.

For properties along Cae'r Odyn, backing onto Cae Garw, surface water ponded in the rear garden where the boundary between the two rows of dwellings is located at a lower level than the property. Surface water gullies at the rear of the properties were also overwhelmed with surface water flowing towards the front of the property. Manholes on the DCWW network at the front of the property were also reported to be surcharging during the event (Figure 7-5). It has also been reported that several other manholes on the DCWW network were surcharging during the event. It is known that the DCWW surface water outfall is located at a very low level within the River Cadoxton, and it is therefore highly likely that this was hydraulically locked during the flood event, resulting in surcharging of the system.

For properties backing onto the Cadoxton River, three main pathways were reported. Firstly, water surcharging from the DCWW public combined system that flows in a southerly direction in the rear gardens. It was report that manholes and the Non-Return Valve (NRV) to the rear of a property were surcharging at the time of the event, with surface water flowing to neighbouring properties as a result of lower ground levels. Secondly, flooding as a result of surface water flowing from the highway towards the front of the properties, which are situated at a significantly lower level than the road.

Additionally, Cae'r Odyn sits adjacent to Cardiff Road, which is slightly elevated to the rear of the gardens. Reports indicate that surface water flowed from the carriageway into the rear gardens of a number of properties. The highway network on Cardiff Road at this location is blocked, and it is likely that passing traffic resulted in bow waves, pushing water into the rear of these properties.

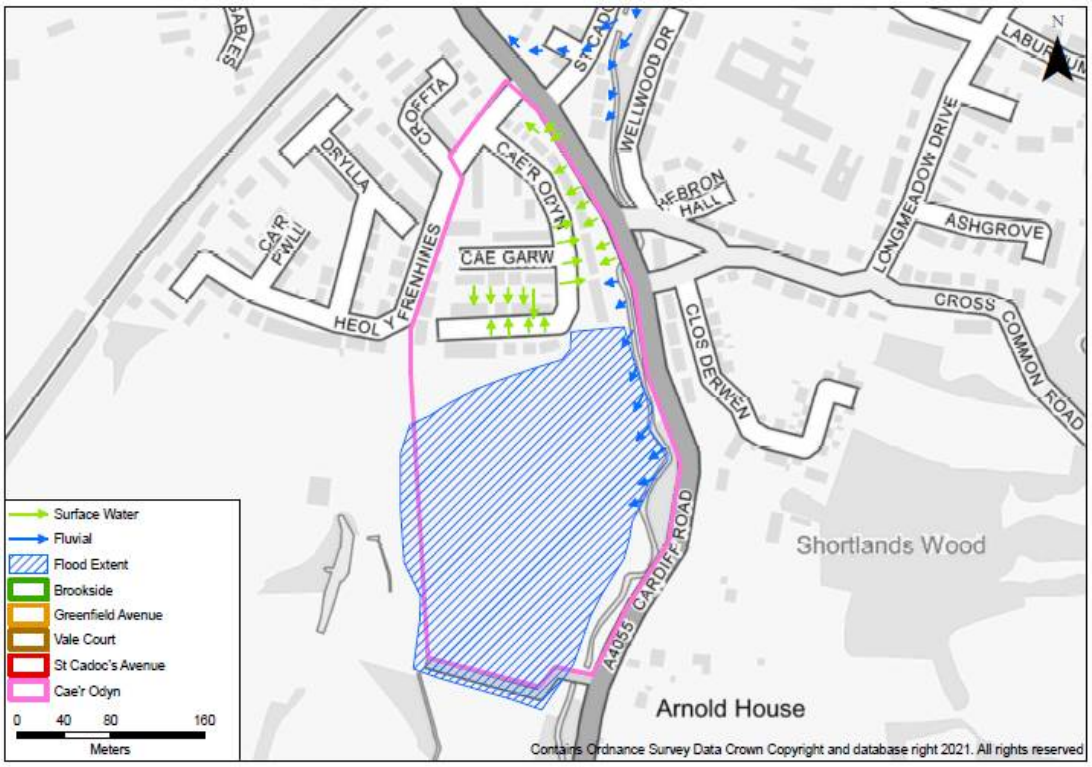


Figure 7-5 Cae'r Odyn flow paths

7.3 Receptors

7.3.1 People

The emotional impact of experiencing flooding and how it can have a harmful impact on mental health is well documented. Multiple reports from residents included concerns about the potential of flooding again and the unrest and anxiety this causes them. Residents also reported loss of personal possessions. The flood event occurred on the 23rd December, with the majority of residents and families celebrating Christmas, which would have increased the mental strain and devastation felt by the community at the time of the event, whilst also experiencing possible detriment to their mental health as a result of the ongoing Covid-19 pandemic.

A number of elderly residents were stranded and had to rely on families and neighbours for help. Residents also reported feeling abandoned, scared and that the measures they could take to protect themselves, such as sandbagging, were ineffective.

7.3.2 Property

The 364 returns from the Flood Incident Forms issued by VoGC identified that 98 properties flooded internally and that 22 outbuildings and 74 gardens flooded across Dinas Powys. As only 30% of the VoGC flood incident forms were returned, the actual number of properties flooded internally could well have been significantly greater than 98.

The depth of floodwater within the properties varies across the areas according to the source, ground levels and local topography. The maximum approximate internal floodwater depth reported were highest in the Greenfield Avenue residential area at 122cm (Table 7-2). Reports of costs of damage to home and possessions from flooding per property varied considerably. Numerous properties reported estimated costs of £500 to £2,000 for properties, 10 residents reported costs exceeding £15,000 and exceptional cases that experienced high level of internal flooding reported estimated costs of £50,000 to £70,000 in damages. Figures 7-6 and 7-7 offer a small representation of the scale of the flooding and the impacts it had.

Table 7-2 Impacts of flooding on residential areas

Investigation Area	Number of properties reported to have flooded internally	Approximate depth of flooding (cm)	Reported estimated cost of damage from flooding (£)
Brookside	1		unknown
Greenfield Avenue	48	122	<1,000-50,000
St Cadoc's Avenue	34	44	2,000-25,000
Vale Court	1	15	2,000-2,500
Cae'r Odyn	14	51	<1,000-70,000

Residents reported that they undertook measures to prevent property flooding including diverting flows and use of sandbags. Only two properties, of those who responded, reported having had temporary property level flood resilience measures installed prior to the storm event.

It was reported that sandbags were available in Barry, but due to the flooded roads Dinas Powys was cut off, so it was not possible for many residents to collect any. Sandbags were limited to 15 per person and many that did have sandbags reported that they were not sufficient to hold back the floodwater.

Figure 7-6 Flooding on Greenfield Avenue, Dinas Powys

Figure 7-7 Internal flooding on St Cadoc's Avenue, Dinas Powys

7.3.3 Infrastructure and services

Evidence collected by the VoGC identified a number of areas of highway and footway which were impacted by the flooding as well as all residential areas investigated reporting flooding of roads. Known highway flood extents have been

recorded and plotted, as shown in Figures 7-8 to 7-12. Notably, a 300m length of Cardiff Road was unpassable at Brookside, and the majority of the length of Elm Grove Place, Greenfield Avenue and St Cadoc's Avenue.

In addition, Murchfield Community Centre experienced extensive flooding, limiting the potential support services the building could have otherwise provide during the storm event. Additionally, during the flooding a power outage occurred on Brookside as a result of floodwater entering the substation at the junction of Brookside and Cardiff Road, limiting the supply of electricity to approximately 10 properties for approximately 2.25 hours.

Flooding across Dinas Powys also affect the DCWW sewerage network within the Vale Court investigation area with reports of some issues on the foul network. These are detailed throughout this report.

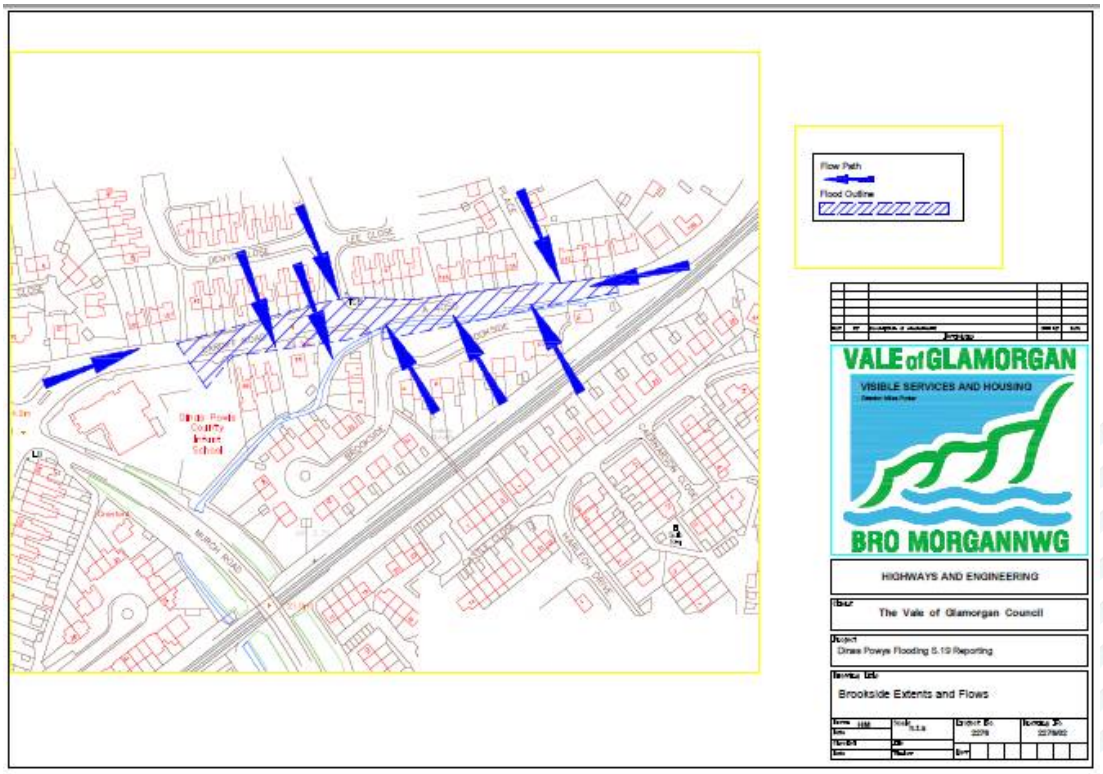


Figure 7-8 Highway Flood Extent - Brookside

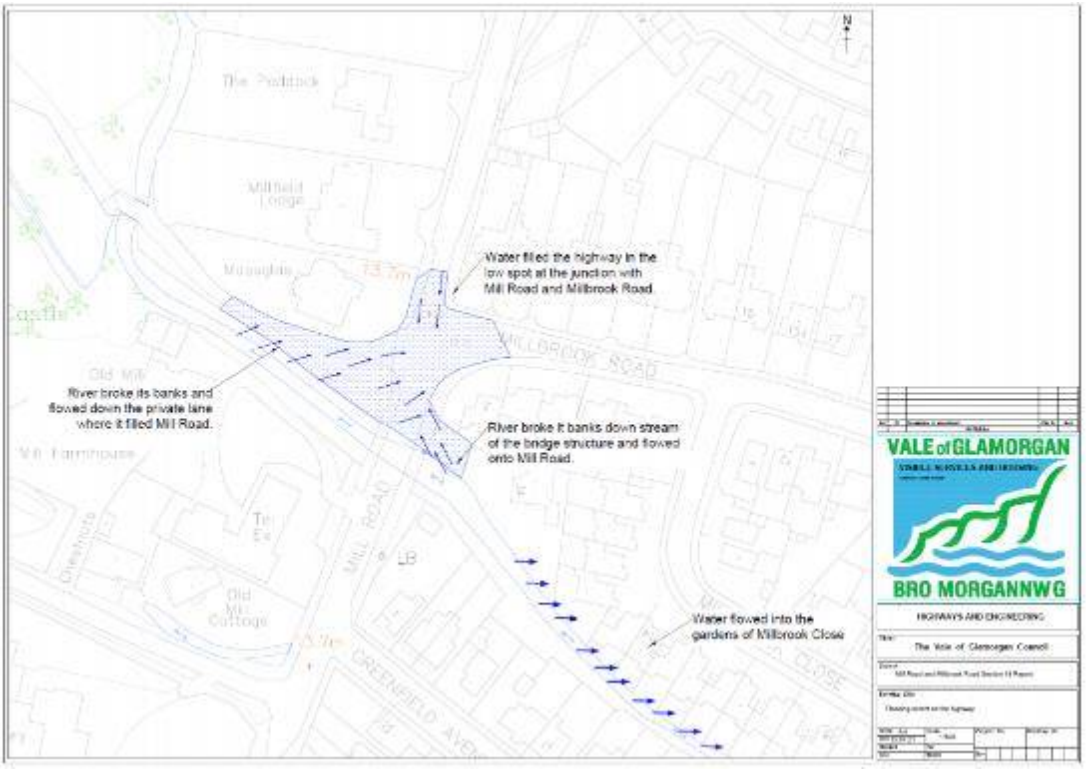


Figure 7-9 Highway Flood Extent - Mill Road

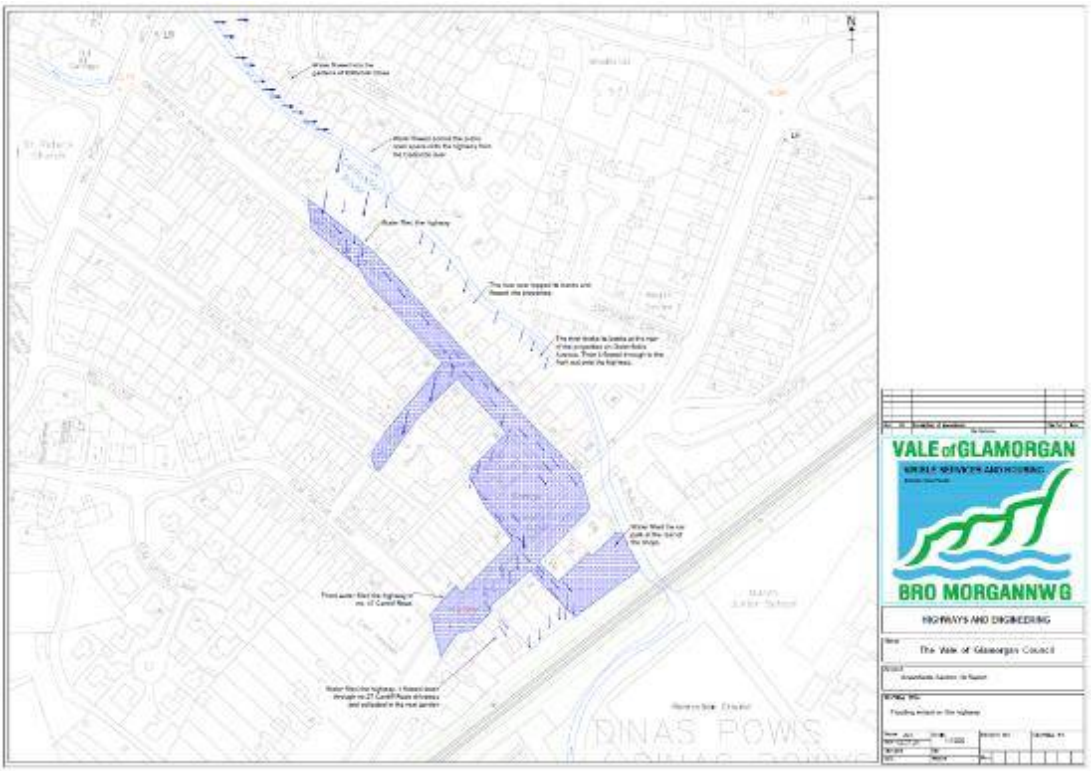


Figure 7-10 Highway Flood Extent - Greenfield Avenue

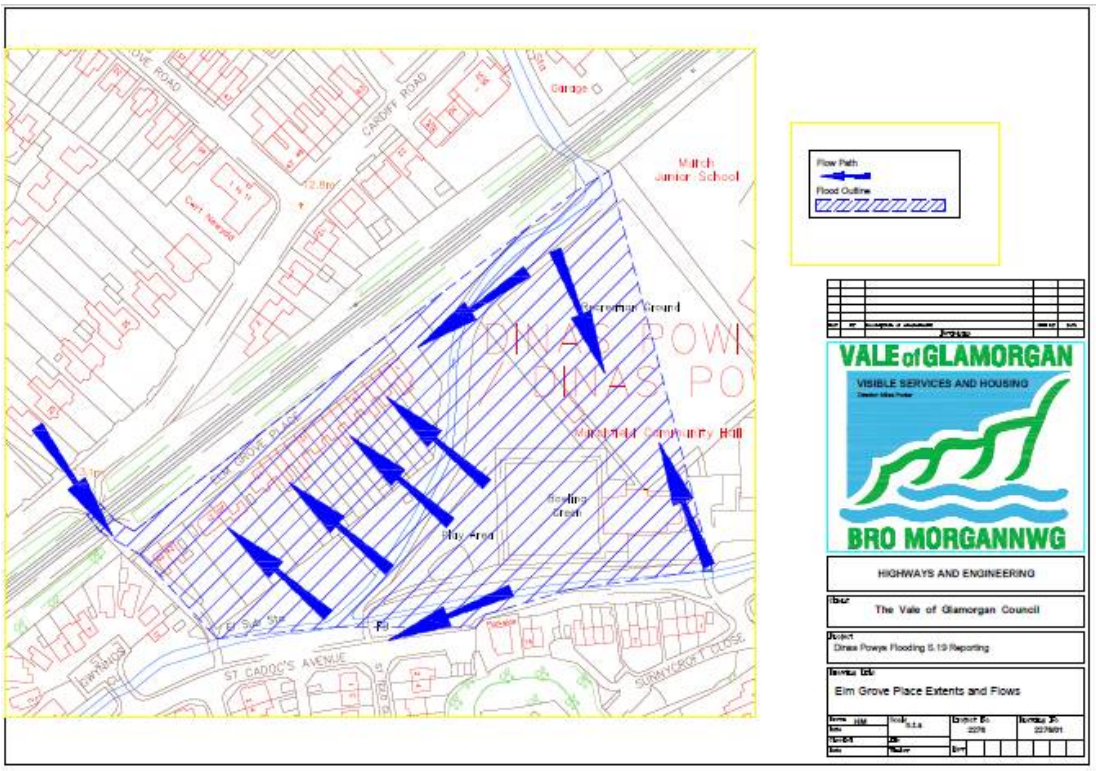


Figure 7-11 Highway Flood Extent -Elm Grove Place

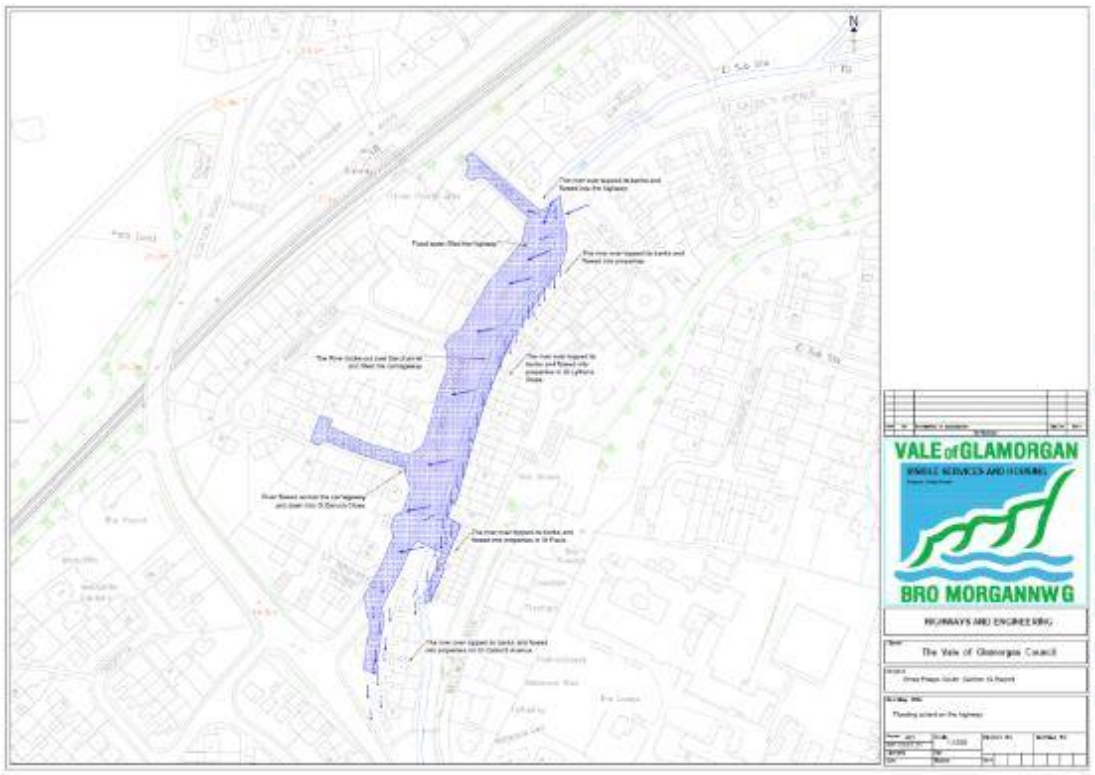


Figure 7-12 Highway Flood Extent - St Cadoc's Avenue

8 Causal factors

Determining the exact cause of flooding is complicated and flooding often results from a combination of factors. Where location specific issues, such as blockages, are identified these will be described in the following section. Whilst it is acknowledged that factors such as channel geometry, vegetation growth and structures can affect water levels both upstream and downstream on a watercourse, it is beyond the scope of the current investigation to determine the relative influence of each factor on the flood event of the 23rd December 2020 across Dinas Powys. NRW, as the lead RMA for Main River flooding have recently undertaken detailed modelling of the catchment incorporating the influence of all relevant structures on the Eastbrook and River Cadoxton to inform the development of the Dinas Powys Flood Risk Management Scheme Outline Business Case. Where flooding is identified that does not match with the best available predictions, usually NRW's Flood Risk Assessment Wales (FRAW) products, this will be highlighted and the appropriate RMA identified to take forward further investigations or assessment as appropriate.

8.1 Brookside

The main causal factor leading to surface water flooding was the inability of highway surface water drainage to drain into the East Brook due to high levels within the channel resulting in hydraulic locking of the highway network. There was insufficient storage capacity within the highway network to take the high rainfall volumes observed during this event. However, the highway network is not designed to provide flood storage during a storm event of this size, or to consider hydraulic locking of the system.

Anecdotal reports from residents also raise concerns that poor channel maintenance at Brookside limited channel capacity of the East Brook. This includes reports of no dredging or vegetation removal from the East Brook and only minimal vegetation clearance to the bank. However, as detailed in Section 2.2.2, NRW have stated that they undertake maintenance to the East Brook as part of a twice-yearly intervention from the eastern end of Brookside to its confluence with the Cadoxton watercourse at St Cadoc's Avenue local to St Teilo Close.

- manual waterway management and blockage risk checks undertaken twice per year, and on the basis of risks identified through inspections, or raised by community members;
- intermittent tree and scrub trimming in autumn/winter;
- bank mowing and vegetation management twice per year, generally at the start and end of summer. This was carried out along the East Brook in October 2020.

At Brookside, NRW has provided information on their latest maintenance works, detailing that they undertook cutting of vegetation on the left bank of the watercourse, upstream of the Brookside junction with Cardiff Road, in 2020 and 2021. In addition, in-channel weed spraying was carried out in July 2020 and removal of the sprayed vegetation and additional vegetation clearance followed in October 2020. The wall retaining the highway upstream of the Brookside junction with Cardiff Road, forming part of the right bank to the channel is not an NRW asset.

Downstream of the junction, NRW cleared the watercourse of debris and vegetation in July 2021 as part of their maintenance regime.

In addition to the planned work in 2020, NRW also undertook ad hoc visits to attend the area of investigation following safety concerns and general maintenance including the mowing of banks on the following dates:

- 10th -13th March
- 8th - 9th June
- 13th - 16th July
- 27th - 28th July
- 3rd - 4th August

NRW focus on conveyance ability of the channel, resulting in vegetation clearance to the right hand bank being undertaken on the basis of risks identified through inspections, or raised by community members.

Given the timing of the event, in winter, vegetation coverage on the right hand bank will have been at its lowest, and as a result the impact of the in-channel vegetation on the right hand bank of the channel is likely to be minimal.

In total within this investigation area, 1 property is reported to have flooded internally, with 1 outbuilding also reported to have flooded. There were 5 reports of garden flooding.

8.2 Greenfield Avenue

The primary cause of flooding along Greenfield Avenue and to the northern extent of Millbrook Road was the River Cadoxton overtopping resulting in fluvial flooding to the highway and properties. Fluvial floodwater tracked south, resulting in additional property and highway flooding to Cardiff Road. The extent of flooding during the flood event correlates well to the predicted flood extents modelled by NRW. These modelled flood extents are based on current channel status, geomorphology and maintenance regimes.

Anecdotal reports from residents also raise concerns that poor channel maintenance to the River Cadoxton from Greenfield Avenue to Elm Grove Place limits channel capacity. This includes reports of no dredging or vegetation removal from the Cadoxton and only minimal vegetation clearance to the bank. As detailed in Section 2.2.2, NRW has confirmed that they undertake maintenance works on River Cadoxton as part of a twice-yearly intervention involving the manual/mechanical removal of vegetation and the once yearly spraying of vegetation with herbicide. The work covers the Cadoxton from Pen-y-Turnpike Road down to the footbridge connecting the A4055 Cardiff Road to Parc Bryn-y-Don. NRW do not have a duty to undertake this maintenance and utilise their permissive powers to carry out this maintenance work to the river channel.

A large stretch of the River Cadoxton within this investigation area is located at the boundaries of a number of properties, such as those in Greenfield Avenue, Millbrook Close and Elm Grove Place. As a result, there are a large number of riparian owners (in the form of homeowners/residents of Dinas Powys) which have a legal responsibility under common law for the maintenance of the land from the edge of the watercourse to the middle of the riverbed, as detailed in Section 2.3.2.

The landowner is responsible for removal of obstructions caused within the boundaries of their land affecting the watercourse, including the maintenance of the bed and banks. It is unknown as to what maintenance regime each riparian owner undertakes along this reach of the River Cadoxton.

Given the timing of the event, in winter, vegetation coverage on the right hand bank will have been at its lowest, and as a result the impact of the in-channel vegetation on the right hand bank of the channel is likely to be minimal.

Surface water systems were also at capacity, resulting in surcharging of manholes and surface water flooding to the northern extent of Greenfield Avenue. The highway network at this location discharges to the River Cadoxton and was therefore hydraulically locked as a result of the elevated water levels within the river channel.

To the southern extent of Millbrook Road, surface water was the primary cause of flooding, with the highway network at capacity and overwhelmed by the extreme rainfall during the event. It is unknown as to the outfall of this system; however, it is assumed that it discharges to the River Cadoxton. As a result, the system would have been hydraulically locked at the time of the event. A CCTV system investigating the condition of the highway drainage network on Millbrook Road was undertaken in August 2021. The investigation identified that the highway network at this location is in very poor condition, with a number of blockages and collapses within the network. A number of these blockages are as a result of utility network pipe crossings within the highway pipes causing debris to build up against the pipe crossing, reducing the cross-sectional area of the network and its ability to convey flow. In addition, pipe crossings may result in weaking of the highway network lines, resulting in collapse. The poor condition of the highway network is a contributing factor to the volume of surface water flooding experienced on Millbrook Road. However, as the highway network is not designed to provide flood storage during a storm event of this size or hydraulic locking of the system, it is likely that the system would have been at capacity and overwhelmed during this rainfall event, regardless of its condition. It is therefore not known as to what extent the poor condition of the system exacerbated flooding in this area without full capacity modelling of the system.

To the rear of the commercial properties on Cardiff Road, the car park flooded as a result of the River Cadoxton overtopping downstream of the Cardiff Road bridge. Flood levels within the car park are likely to have been elevated as a result of the railway embankment at its southern boundary preventing floodwater flowing south. The low ground levels of the car park compared to Cardiff Road also result in a localised depression creating informal, temporary flood storage during this event, with floodwater unable to flow in a northerly or southerly direction.

Flooding of Cardiff Road at its junction with Elm Grove Road is likely to have been exacerbated, if not primarily caused, by surface water runoff from Elm Grove Road. The highway network on Elm Grove Road was overwhelmed during the event, resulting in surface water flows on the highway. The steep gradient of the highway increases velocities of flow resulting in a larger volume of surface water reaching Cardiff Road more quickly. Flooding to the Cardiff Road highway was exacerbated by passing vehicles creating bow waves, pushing floodwater towards

properties. Local ground levels cause floodwater to flow in a southerly direction between properties 8 and 10 Cardiff Road, to the Network Rail culvert within the railway embankment. The Network Rail culvert was likely to be at capacity, with the ditch to the River Cadoxton also at capacity as a result of the elevated levels within the Main River. As a result, floodwater escaped onto Elm Grove Place from the southern face of the railway embankment, primarily flowing in a westerly direction along the highway.

Elm Grove Place also flooded as a result of the highway network being at capacity and hydraulically locked at the time of the event. The highway network is not designed to provide flood storage during a storm event of this size, or to consider hydraulic locking of the system. This area also flooded as a result of the River Cadoxton overtopping its banks to the rear of the properties. Floodwater from all sources flowed in a westerly direction from the highway towards the properties on St Gwynno's Close.

Across this investigation area, it has been reported that 48 properties flooded internally, with a further 9 outbuildings flooded. It was reported that 40 properties flooded externally.

8.3 Vale Court

The primary cause of flooding in this area was surface water as a result of the highway network, and private surface water systems, being at capacity. The highway network and private surface water systems outfall into the East Brook and were therefore hydraulically locked during the event, as a result of the high levels within the channel. This resulted in water backing up into the systems and surcharging, along with a large volume of surface water not able to enter the systems.

There was insufficient storage capacity within the highway network to take the high rainfall volumes observed during this event. However, the highway network is not designed to provide flood storage during a storm event of this size, or to consider hydraulic locking of the system. Given the age and nature of the private surface water network, it is also unlikely that a rainfall event of this size, and/or hydraulic locking of the system was considered during its design. The storage capacity of the highway and private surface water systems, along with hydraulic locking of the outfalls resulted in the widespread surface water flooding across this investigation area.

The secondary cause of flooding in this investigation area is the East Brook overtopping at the footpath culvert at Sunnycroft Lane, resulting in fluvial flooding of Murchfield Community Centre. The pipe culvert under the footpath access bridge acts as a bottleneck for the watercourse, limiting the capacity of the watercourse to channel flows. In addition, the watercourse receives a large volume of surface water from the surrounding urban catchment, which is primarily impermeable, from both the highway network and private surface water systems discharging into the East Brook.

Across the investigation area, it was reported that 1 property flooded internally, with a further 2 outbuildings flooding and 1 property reporting external flooding.

8.4 St Cadoc's Avenue

The main causal factor within the St Cadoc's Avenue investigation was exceedance of the channel capacity of the River Cadoxton. The River Cadoxton overtopped its banks downstream of the St Lythan's Close highway bridge, resulting in widespread flooding on both sides of the river channel.

The river at this location also receives a large volume of surface water from the surrounding highway network and private surface water sewers via a number of outfalls into the river channel. The surrounding catchment feeding the private surface water network is urban, with a large impermeable contributing catchment.

It is also worth noting that there are a number of structures on this stretch of the River Cadoxton, including the A4055 Cardiff Road Bridge, and several highway bridges along St Cadoc's Avenue. Several factors, including orientation of the upstream / downstream face and bridge capacity, along with channel geomorphology such as the concrete, canalised channel at St Cadoc's Avenue, can impact channel conveyance and capacity, contributing to the potential for overtopping. Without further detailed assessment it is not possible to confirm the influence of channel form or structures on the extent of flooding. It is not considered that the current form of the river channel is the primary reason for channel exceedance, however the nature of this channel, and its structures, may contribute to the frequency of overtopping at this location during a storm event of this size.

Reports were also received regarding a number of manholes surcharging during the flood event. All surface water network at this location outfall to the River Cadoxton and were hydraulically locked as a result of the elevated river levels. Surface water networks being at capacity therefore contributed to flooding across the investigation area, however these networks are not designed to provide flood storage during a storm event of this size, to consider hydraulic locking of the system or to receive flows on the highway as a result of fluvial flooding.

It was reported that 34 properties flooded internally. whilst 12 properties experienced external flooding across the investigation area.

8.5 Cae'r Odyn

The primary cause of flooding within the Cae'r Odyn residential area was surface water flooding, likely exacerbated by high river levels at the surface water network outfall potentially combined with some out of bank flooding from the River Cadoxton. The volume and intensity of observed rainfall taken in combination with high water levels in the receiving watercourse is likely to have overwhelmed the DCWW public surface water network and lateral connections. In addition, there are anecdotal reports that local residents lifted manhole covers in the area in a bid to dispose of flood waters into the public sewerage system, this would result in the public network receiving flows it has not been designed to receive (i.e. additional surface water runoff primarily from saturated gardens and/or fluvial flows) leaving the network at or exceeding capacity. Further detailed assessment is required to confirm the potential influence of river levels at the surface water outfall, and interaction of pluvial and fluvial flood risk at this location. The outfall to the system is at a low level (Figure 8-1), with the potential

to result in hydraulic locking of the system when levels within the river channel are elevated.

Reports received suggest that the Fire and Rescue Service attended this area to clear a blocked drain, following which water drained away quickly. This suggests that the highway and/or DCWW surface water network may be blocked or in need of maintenance. Any blockage would result in reduced capacity of the system to store surface water during the rainfall event. DCWW have confirmed that the system within the Cae'r Odyn investigation area was checked on the 29th December 2020, confirming that it was fully operating as designed. DCWW also undertook surveys of the system in January 2021. This survey identified a small volume of silt within the surface water system. As a result, the system was cleansed and silt removed by DCWW It is not known to what extent this blockage and/or build up of silt exacerbated flooding at this location.

Figure 8-1 DCWW Outfall to the River Cadoxton (VOGC)

Reports were also received regarding surface water entering the rear gardens of properties in Cae'r Odyn which border Cardiff Road. A walkover survey of the gullies on Cardiff Road in June 2021 show that they were significantly blocked (Figure 8-2), suggesting poor maintenance of the highway network. Should this blockage have been present at the time of the flood event, surface water would have been unable to enter the highway network resulting in surface water flooding of Cardiff Road. Passing vehicles creating bow waves then resulted in floodwater entering the rear gardens of the properties in Cae'r Odyn.

It was reported that 14 properties flooded internally, whilst a further 5 properties experienced flooding to an outbuilding. 13 properties reported external flooding across the investigation area.

The primary cause of flooding to Parc Bryn-y-Don was the River Cadoxton overtopping its banks.

Figure 8-2 One of two blocked gullies on Cardiff road adjacent to Cae'r Odyn.

9 Conclusion and recommendations

9.1 Conclusions

This report has detailed the investigation into the flooding of Dinas Powys in the Cadoxton Catchment on 23rd December 2020. This investigation has reviewed evidence provided by responders and residents and has been informed by a Section 19 data analysis for Dinas Powys produced by JBA Consulting.

Within the area of investigation, impacts from the storm event were experienced at a number of locations. The evidence gathered in this report demonstrates that the cause of flooding was due to heavy rainfall resulting in a combination of surface water flooding and fluvial flooding from the Cadoxton River and East Brook.

The impact of the flooding was that 98 properties flooded internally and that 22 outbuildings and 74 gardens flooded across Dinas Powys. This caused more than £2,000 of estimated damages to numerous individual properties and up to an estimated £70,000 in extreme cases. Residents affected have experienced lasting anxiety and stress as a result of the flooding. The figures highlighted in this report are based on a return rate of Flood Incident Forms of 30%, and as a result the impact of flooding may be far greater than detailed in this report.

The flooding of the residential areas Cae'r Odyn and Brookside largely occurred due to surface water flooding. This was likely exacerbated by high river levels preventing effective drainage and poorly functioning surface water drains. Alleged poor channel maintenance at Brookside may have also limited channel capacity of the East Brook, contributing to its high levels.

Flooding in St Cadoc's Avenue, Greenfield Avenue and Elm Grove Place residential areas occurred from the River Cadoxton exceeding channel capacity and flowing onto roads and into properties. Surface water drainage being overwhelmed and hydraulically locked exacerbated flooding at all locations and was the primary cause of flooding at Vale Court and Cae'r Odyn.

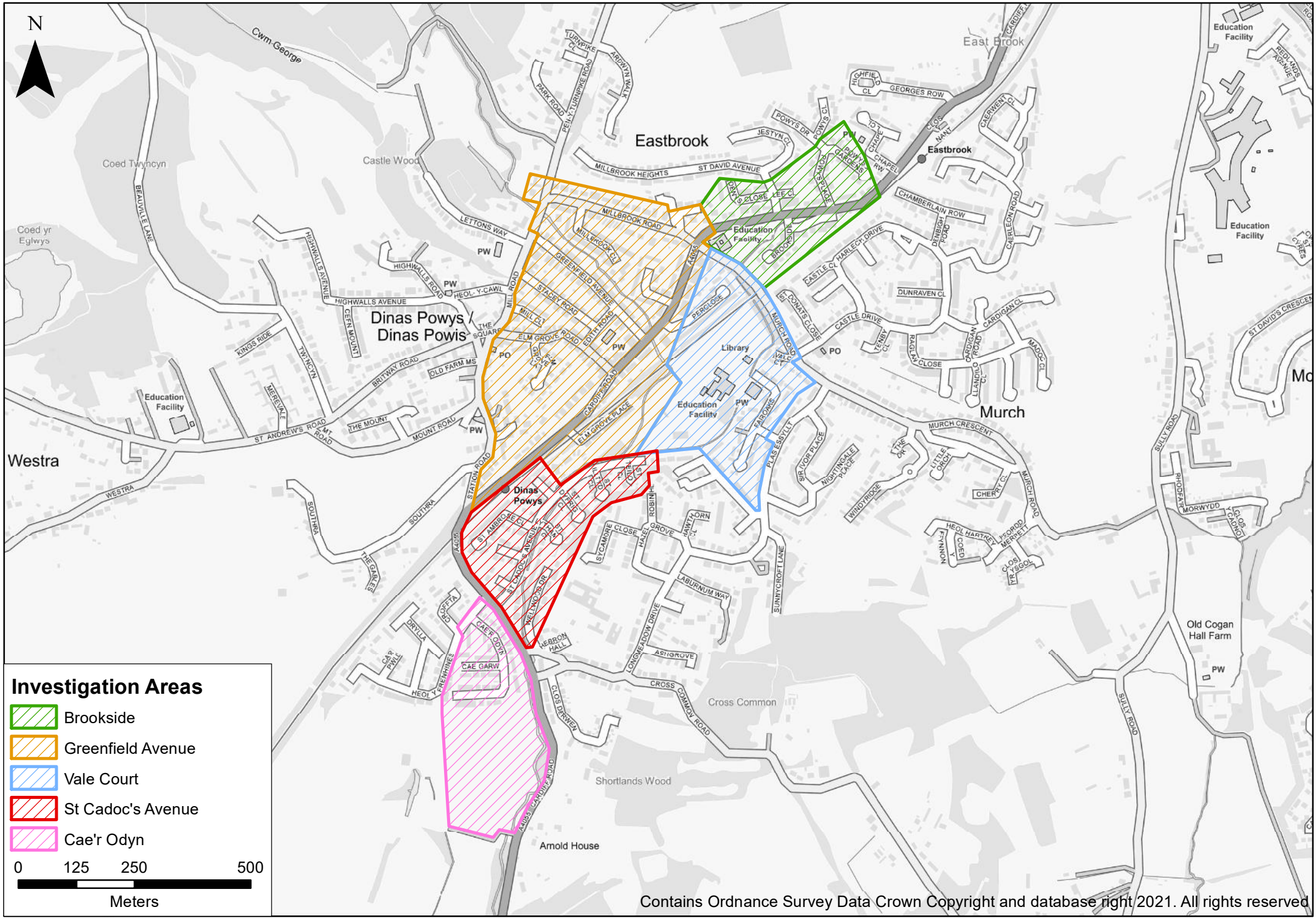
The below actions are recommended in response to these findings.

9.2 Recommendations

Risk Management Authority/Stakeholder	Recommended actions
NRW	Consider the viability of options to reduce the flood risk from main rivers in Dinas Powys, including property flood resilience measures.
NRW	Review the maintenance schedule for the East Brook and River Cadoxton.
VoGC	Consider the viability of Property Flood Resilience measures for at risk properties across Dinas Powys, working in collaboration with NRW.
DCWW	Confirm the condition of surface water and foul drainage systems on Cae'r Odyn.

DCWW / LLFA	Consider catchment options further to reduce surface water flood risk for the Cae'r Odyn community.
Highways Authority (VoGC)	Investigate condition of highway surface water drainage systems on Cardiff Road and review frequency of asset maintenance. Cleanse gullies on Cardiff Road adjacent to Cae'r Odyn.
Highways Authority (VoGC)	Remediate the condition of the highway network in Millbrook Road
Highways Authority (VoGC)	Investigate the condition of the highway drainage system in the wider East Brook area via CCTV survey and cleanse as required.
Highways Authority (VoGC)	Investigate the condition of the highway drainage system around Elm Grove Place, Cardiff Road and Elm Grove Road via CCTV survey and cleanse as required.
Highways Authority (VoGC)	Consider what access and egress provisions are available for Elm Grove Place
VoGC	Confirm capacity / form, ownership and maintenance of the culvert beneath the railway embankment at Elm Grove Place, and receiving ditch / channel
VoGC	Consider removal of disused footbridge on East Brook
VoGC	Investigate the condition of the private surface water systems connecting into the Eastbrook via CCTV survey and cleanse as required.

APPENDIX A – Site Investigation Areas


N
Investigation Areas
Brookside
Greenfield Avenue
Vale Court
St Cadoc's Avenue
Cae'r Odyn
0 125 250 500
Meters
Dinas Powys / Dinas Powis
Eastbrook
Murch
Westra
Cross Common
Shortlands Wood
Arnold House
Old Cogan Hall Farm
Coed Twyncyn
Castle Wood
Coed yr Eglwys
Cwm George
East Brook
Education Facility
Library
PW
PO
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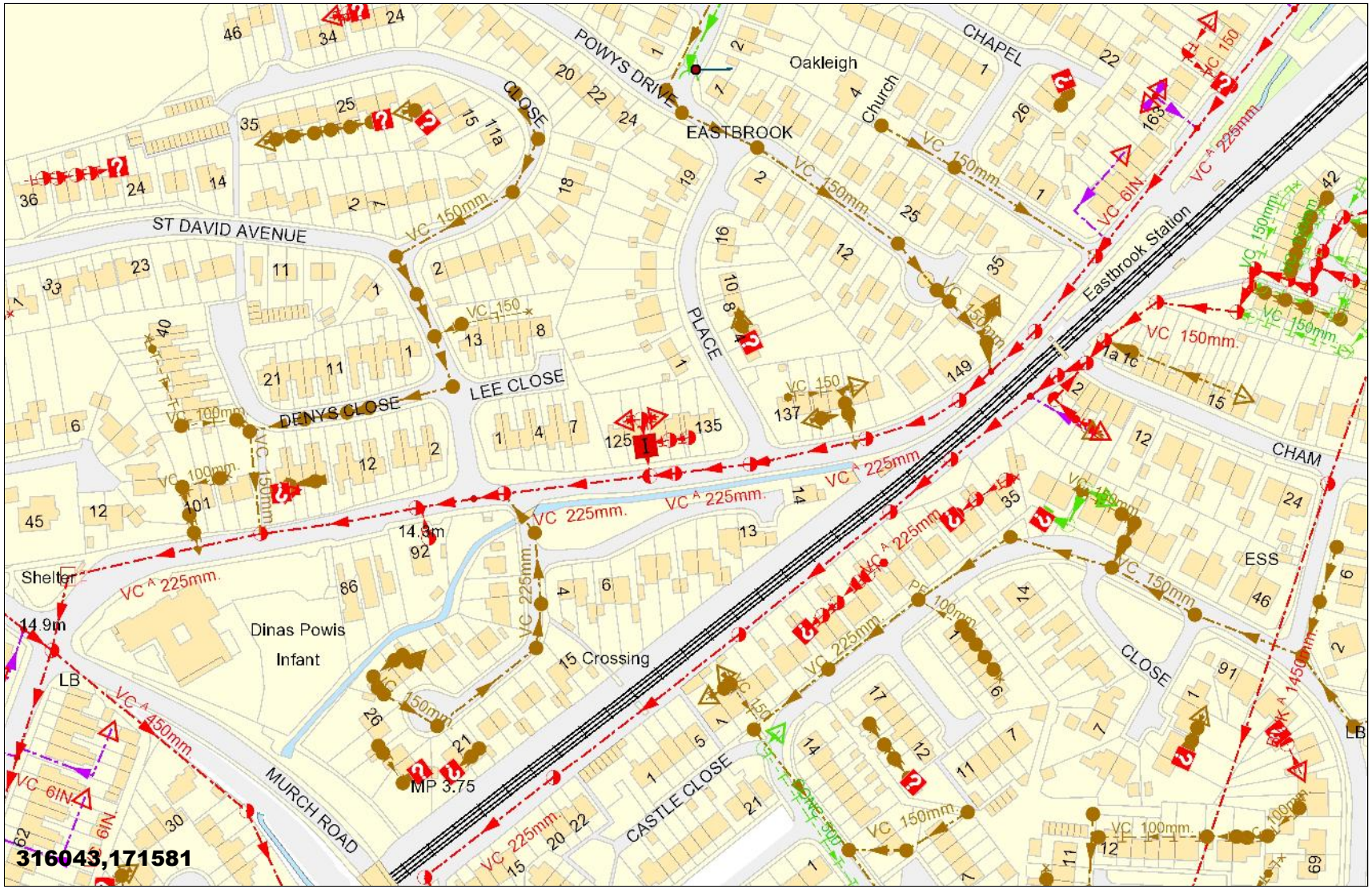
APPENDIX B – DCWW Asset Maps

Dŵr Cymru
Welsh Water

Brookside Dinas Powys

12/07/2021

Scale: 1: 2500



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

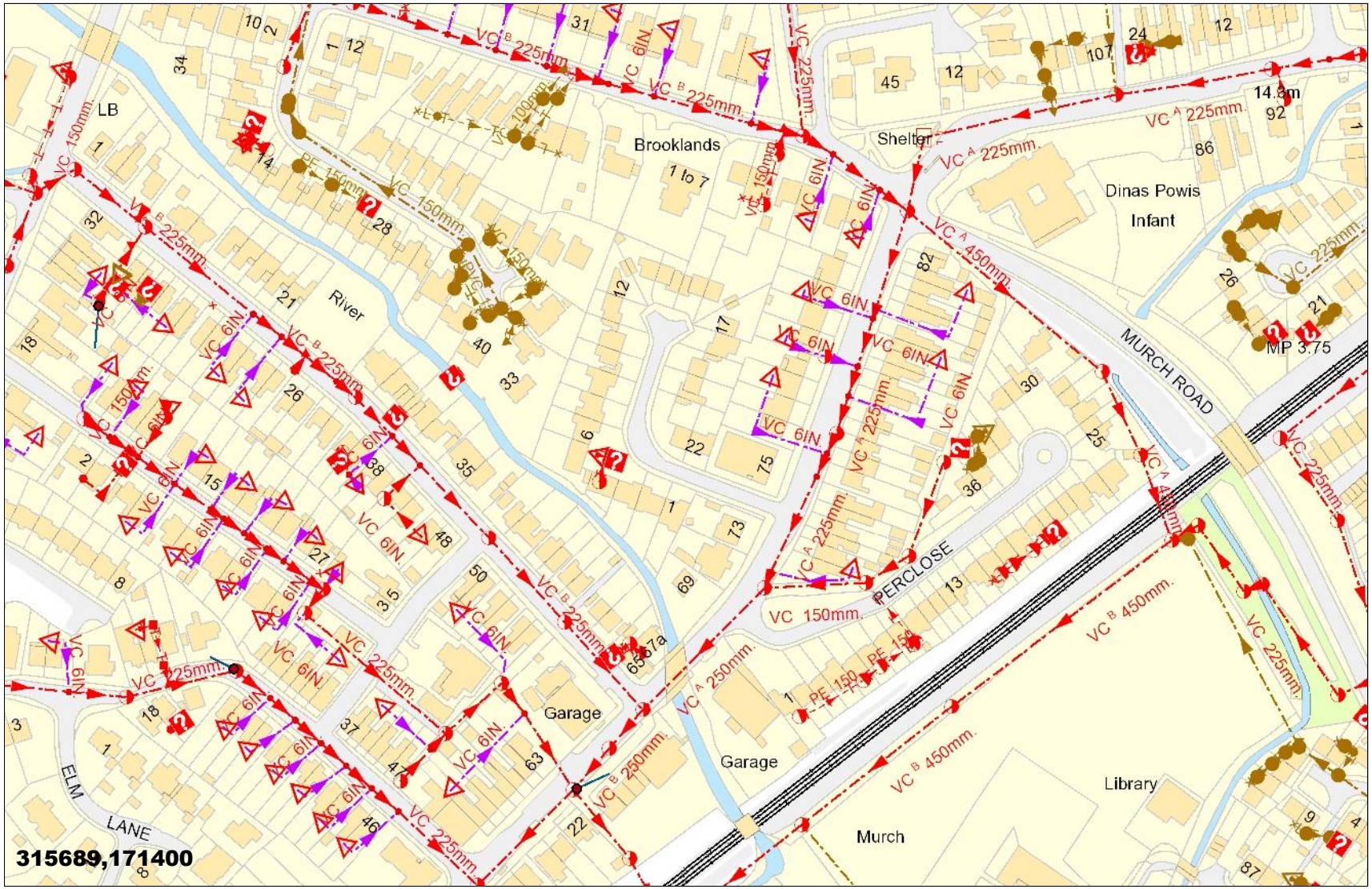
Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be Asbestos Cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Dŵr Cymru
Welsh Water

DCWW Area4

16/08/2021

Scale: 1: 2500



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

Dwr Cymru Cyfyngedig ('the Company') gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon In the event of excavations or other works made in the vicinity of the company's apparatus and any onus of locating the apparatus before carrying out any excavations rests entirely on you. The information which is supplied hereby the company, is done so in accordance with statutory requirements of sections 198 and 199 f the water industry Act 1991 based upon the best Information available and in particular, but without prejudice to the generality of the foregoing, it should be noted that the records that are available to the Company may not disclosure the existence of a drain sewer or disposal main laid before 1 September 1989, or if they do, the particulars thereof including their position underground may not be accurate. It must be understood that the furnishing of this information us entirely without prejudice to the provision of the New Roads and Street Works Act 1991 and the company's right to be compensated for any damage to its apparatus.

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

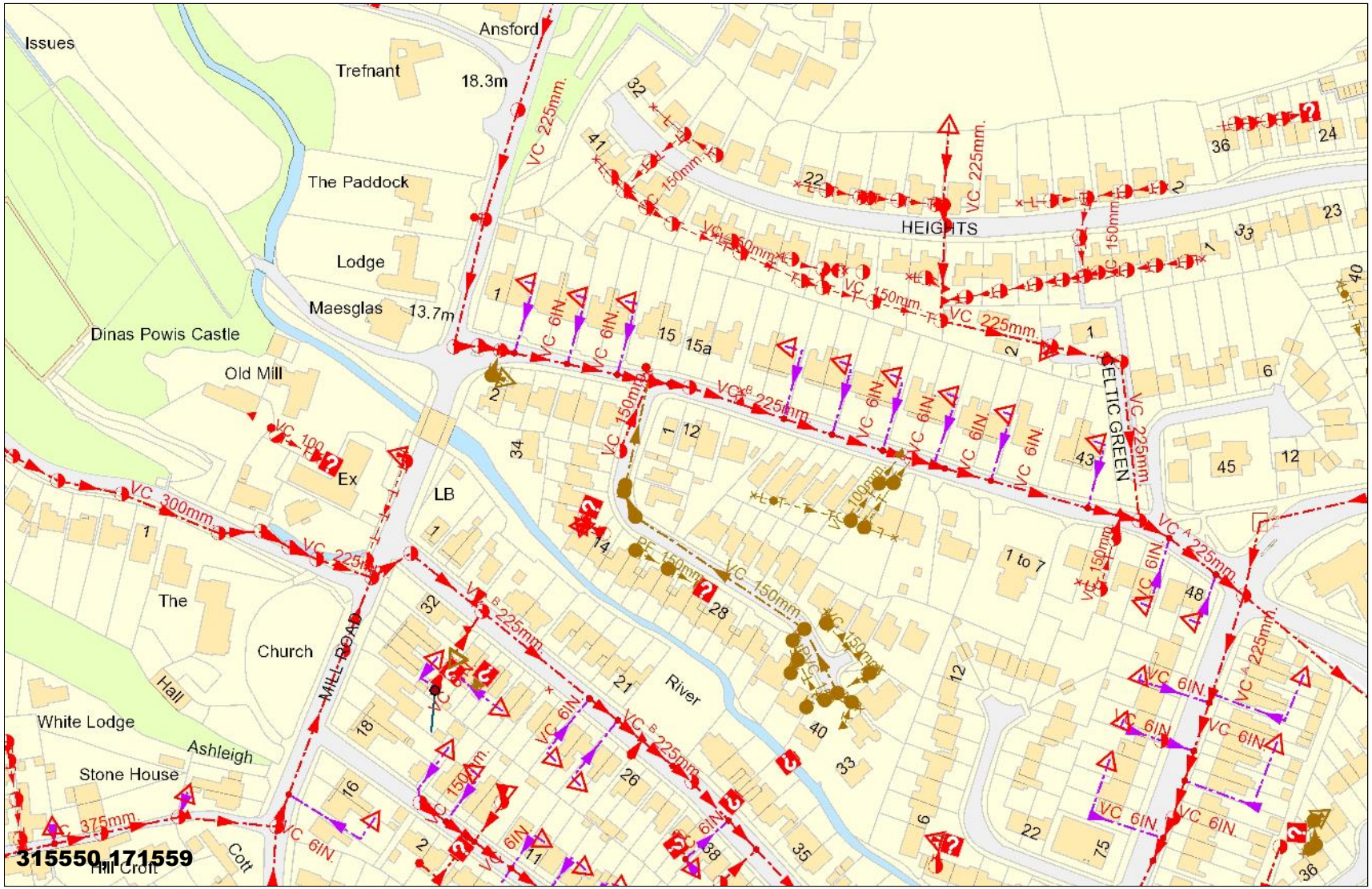
Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be Asbestos Cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Dŵr Cymru
Welsh Water

DCWW Area 4

16/08/2021

Scale: 1: 2500



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
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- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

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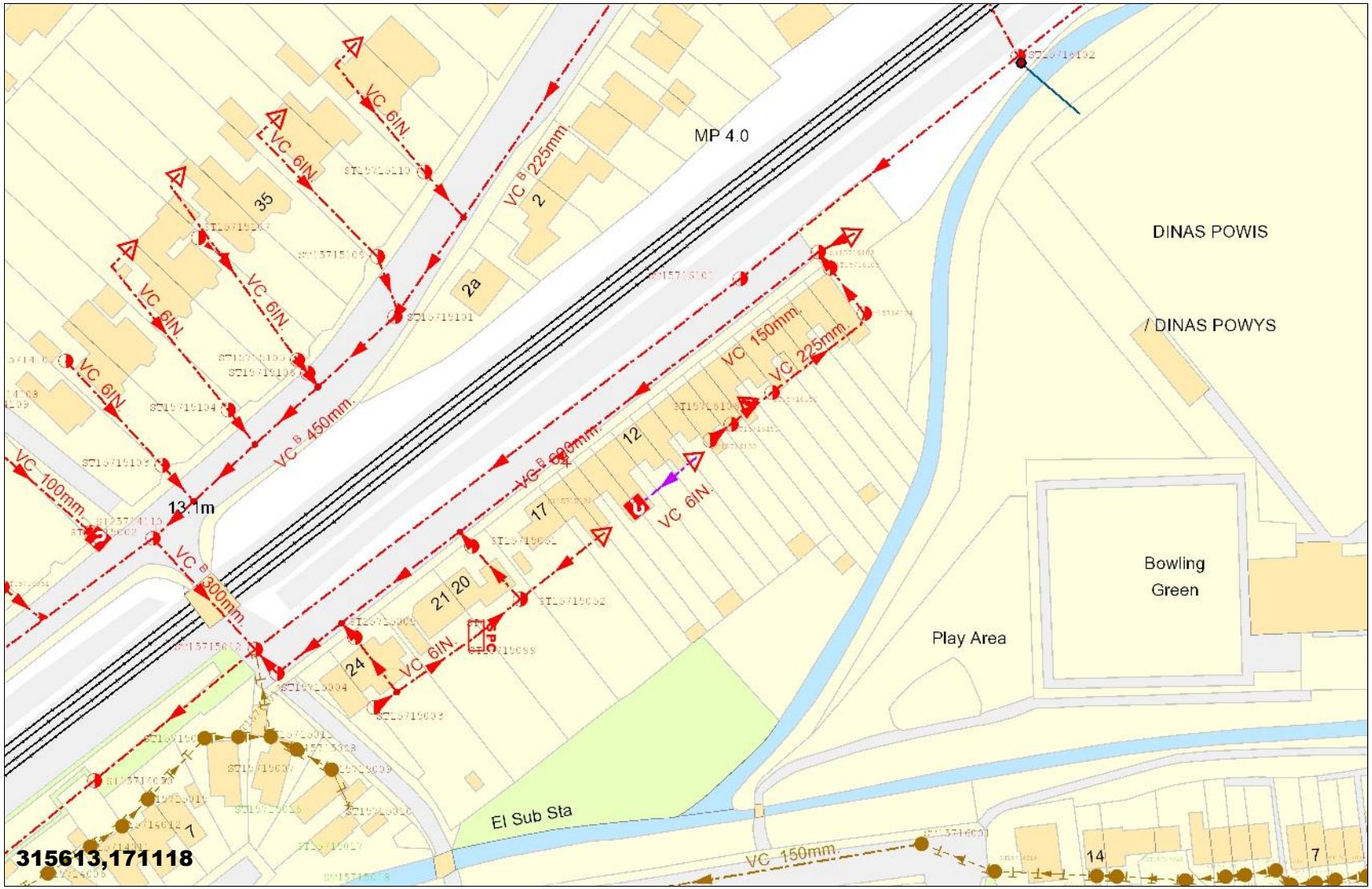
Dŵr Cymru
Welsh Water

Elm Grove Place

07/07/2021

Scale: 1: 1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
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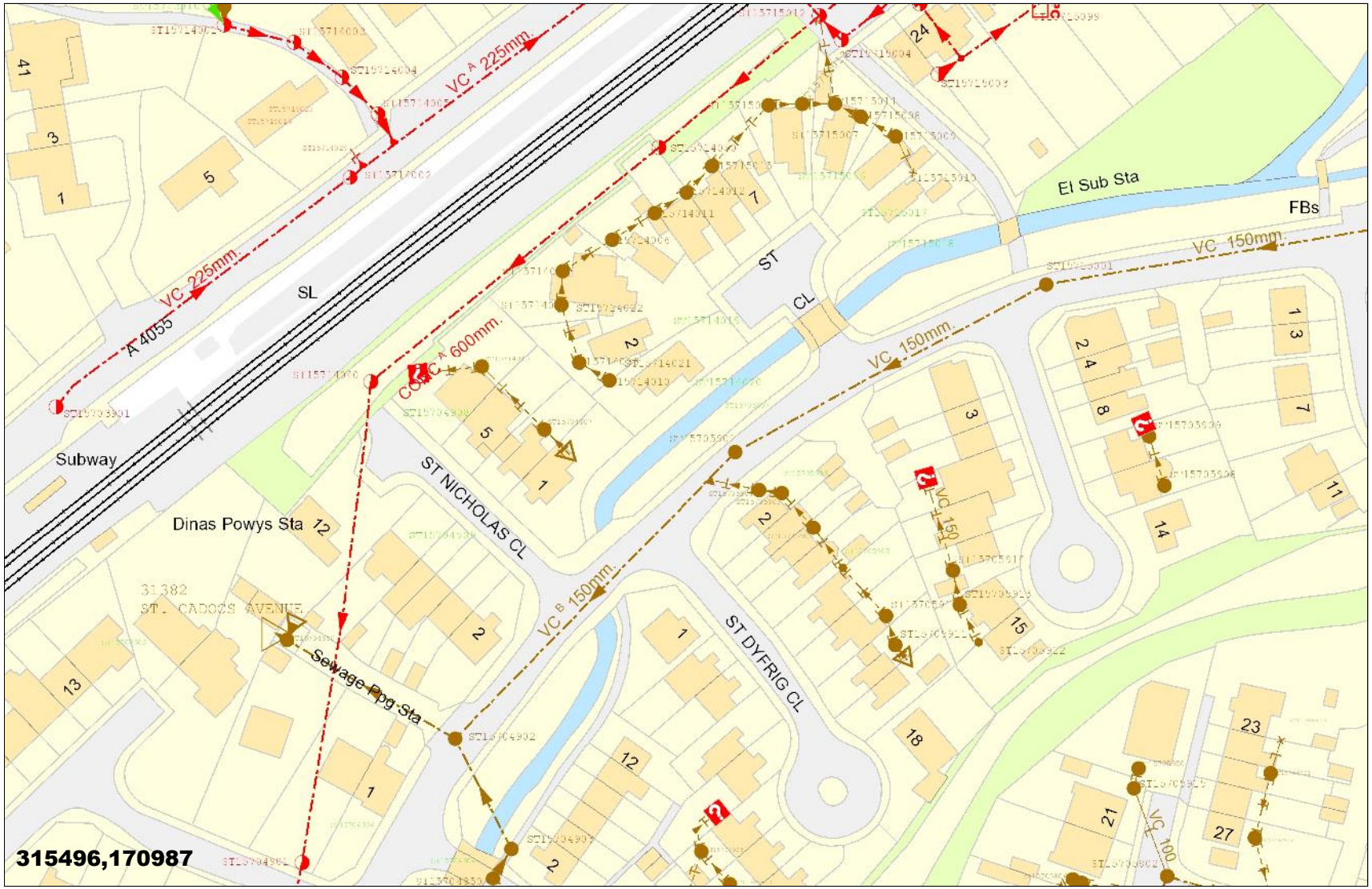
Dŵr Cymru
Welsh Water

St Gwynnos DCWW

27/08/2021

Scale: 1: 1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
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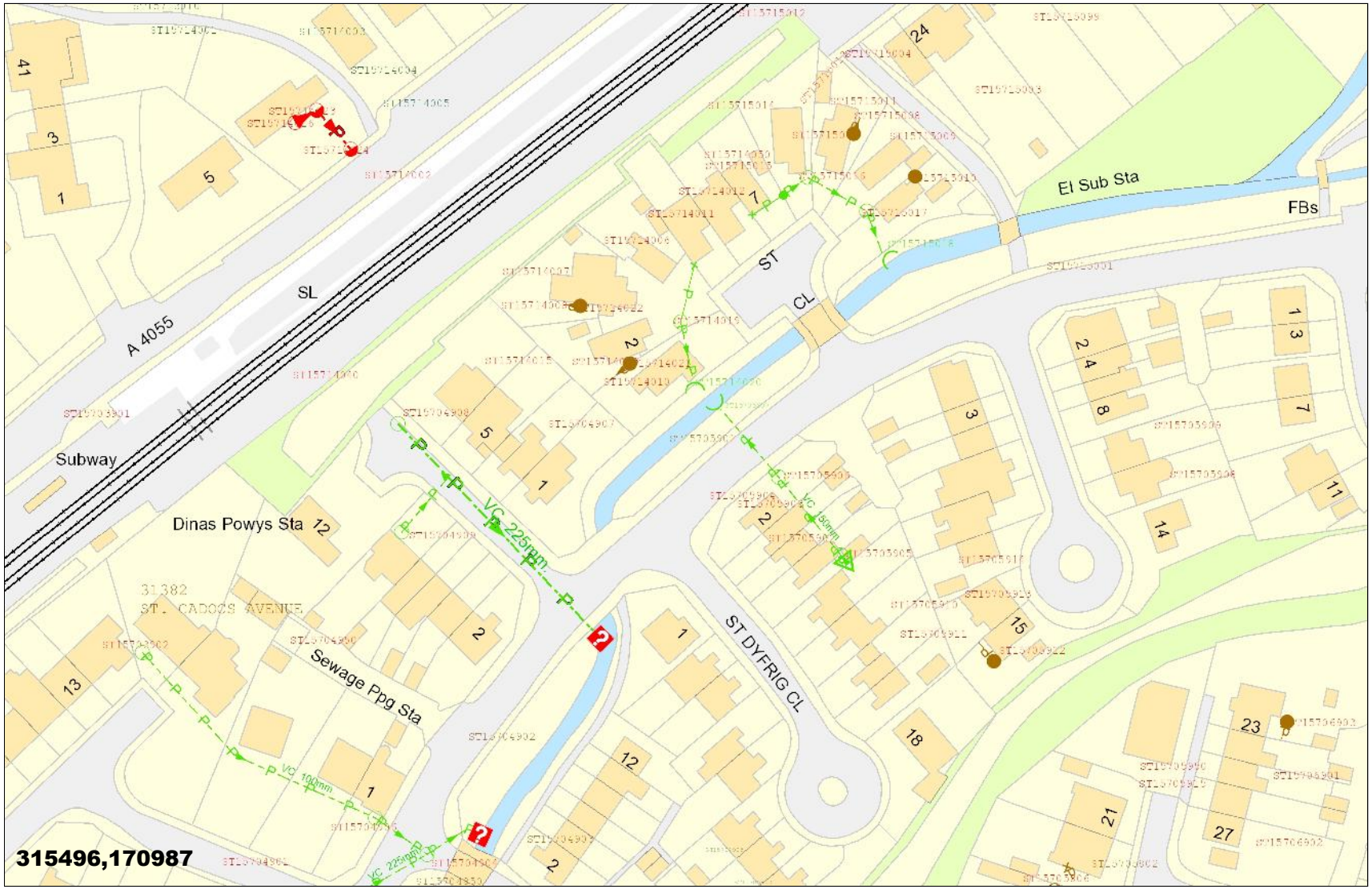
Dŵr Cymru
Welsh Water

St Gwynnos Place Private

27/08/2021

Scale: 1: 1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
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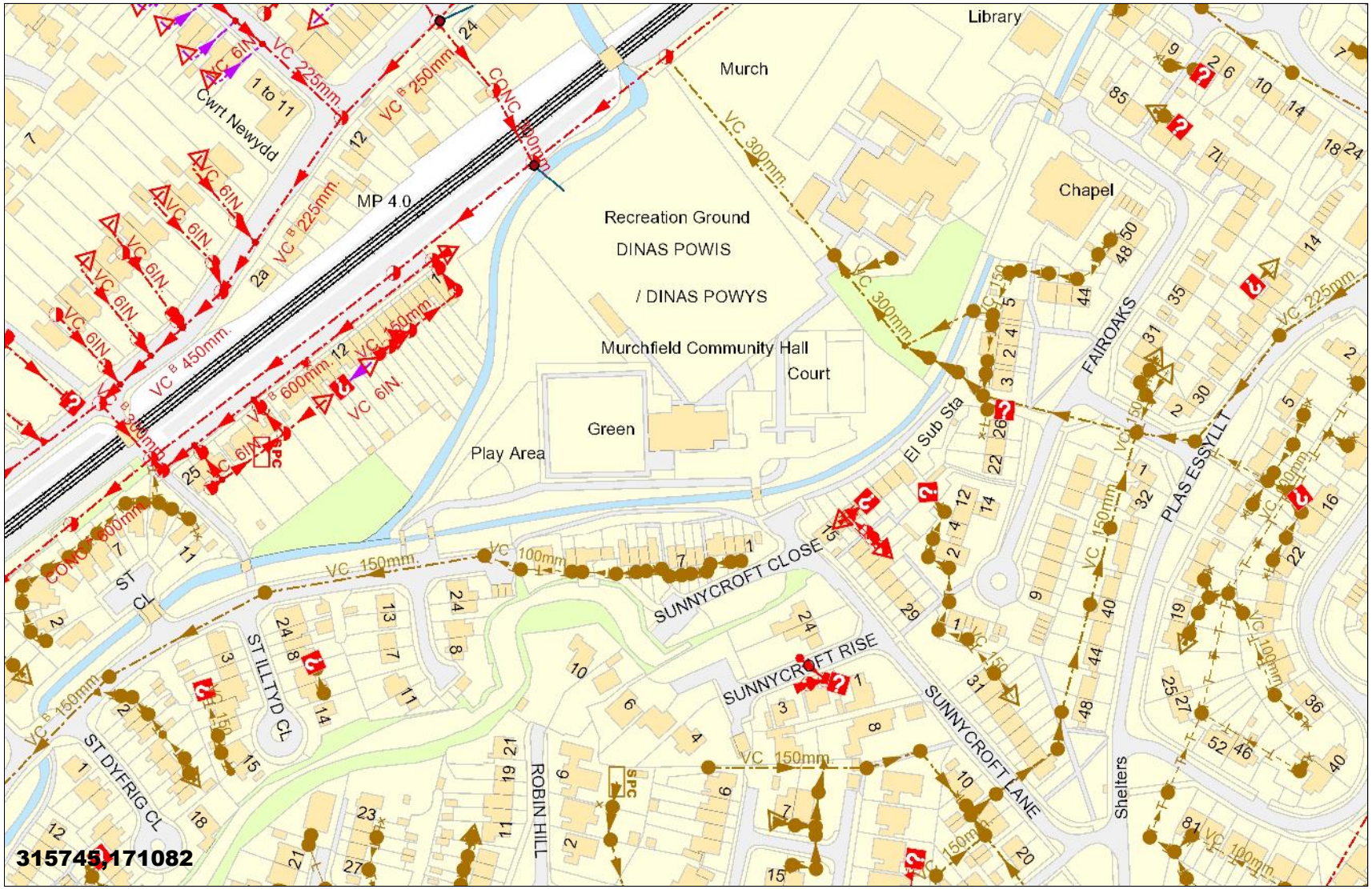
Dŵr Cymru
Welsh Water

Area 3 DCWW

16/08/2021

Scale: 1: 2500



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
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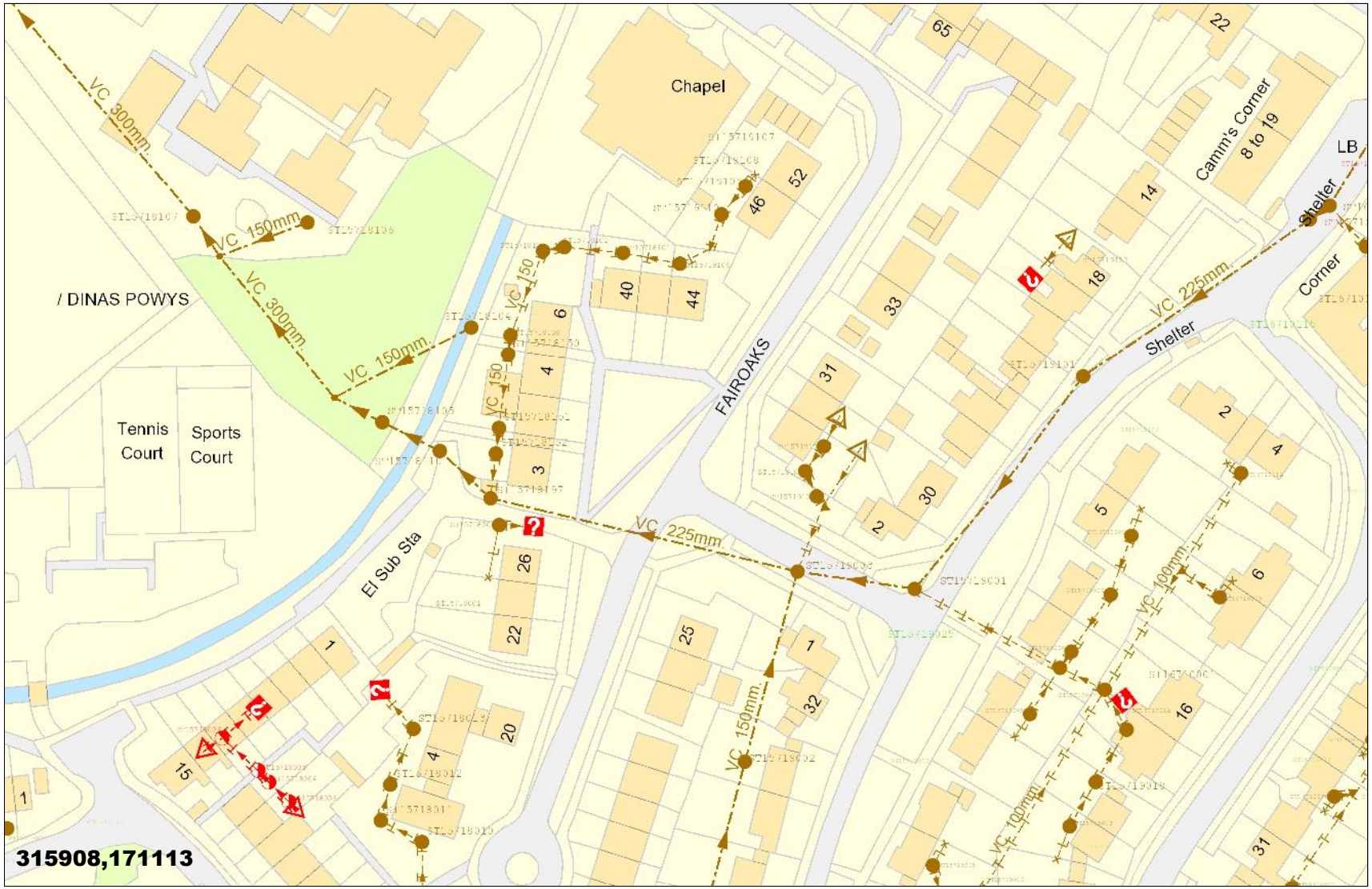
Dŵr Cymru
Welsh Water

Fairoaks

07/07/2021

Scale: 1: 1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
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Dŵr Cymru
Welsh Water

Vale Court

07/07/2021

Scale: 1: 1250

LEGEND

Clean Water

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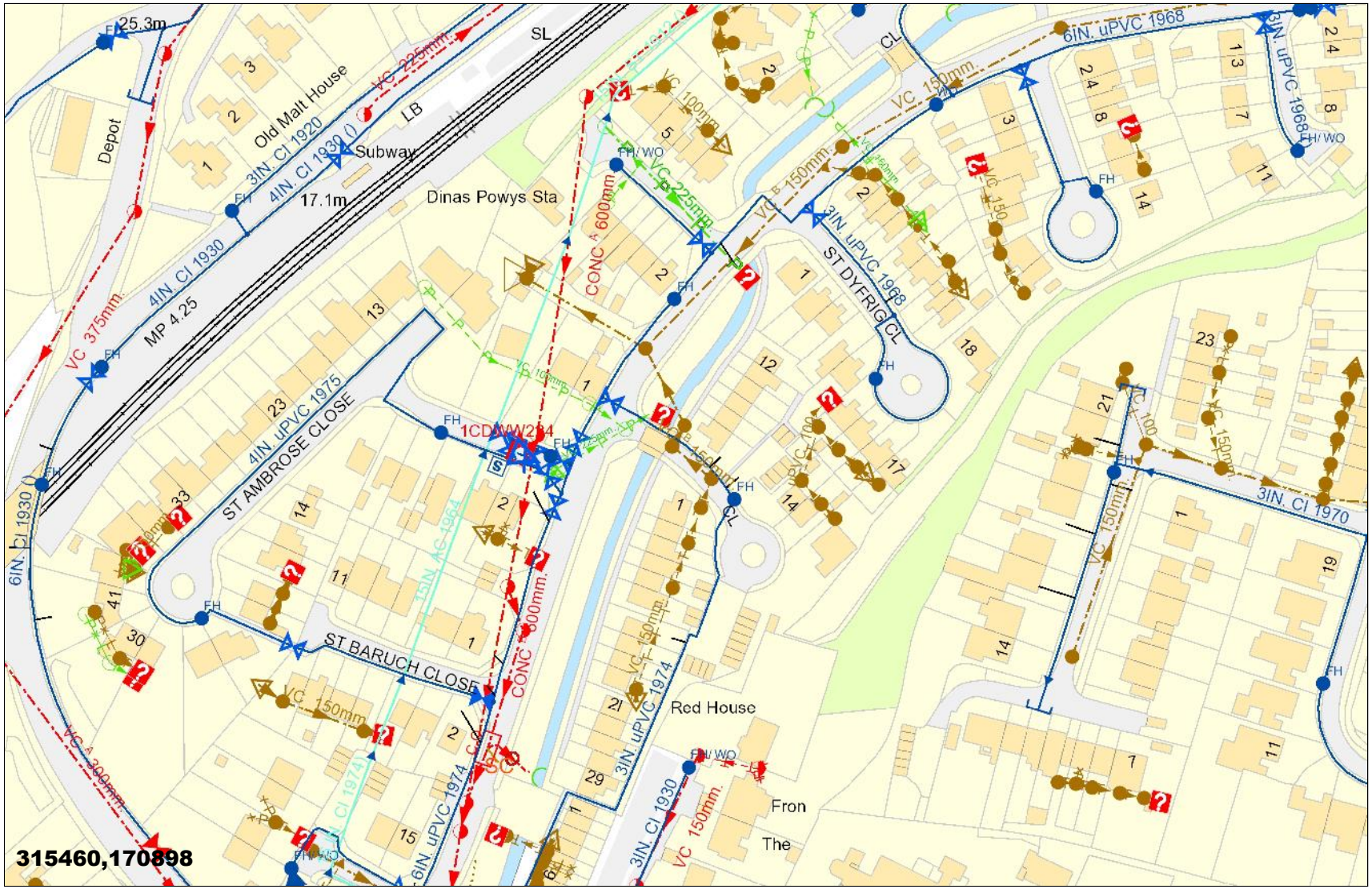
Dŵr Cymru
Welsh Water

29/07/2021

Scale: 1: 1776



LEGEND

Clean Water

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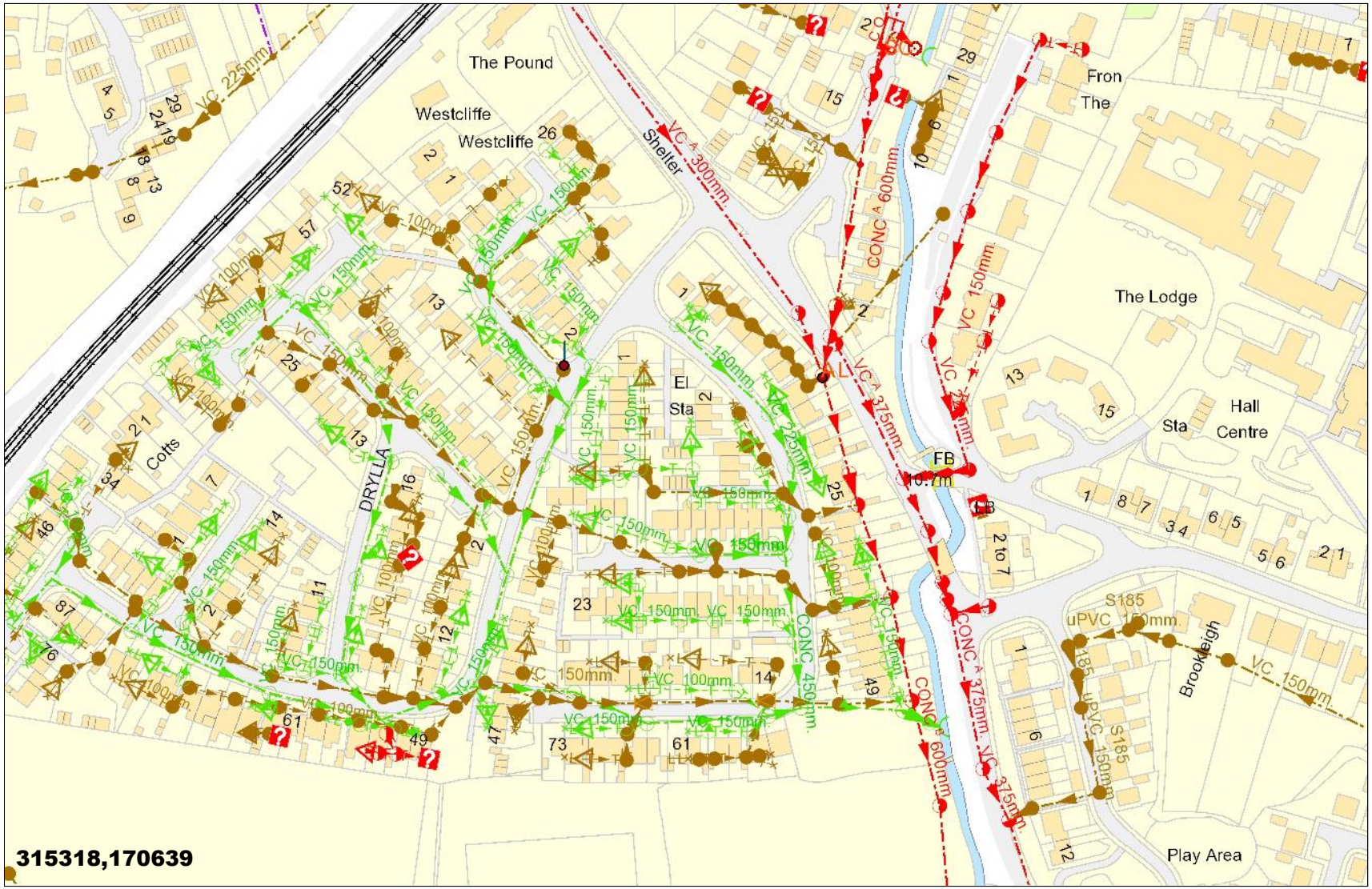
Dŵr Cymru
Welsh Water

Dinas Powys Area 1

16/08/2021

Scale: 1: 2500



LEGEND

Clean Water

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APPENDIX C – S19 Data Analysis Report, JBA Consulting, 2021

Executive summary

In December 2020 flooding occurred in the Cadoxton River catchment, Vale of Glamorgan, South Wales. This was predominantly in the village of Dinas Powys, but also along Sully Moors Road and Cold Brook, a tributary of Cadoxton River. A flood reconnaissance study for the event, undertaken by JBA Consulting for Natural Resources Wales (NRW), documented widespread flooding.

As part of the Vale of Glamorgan Council (VoGC) documenting process for significant flood incidents, JBA Consulting was commissioned to compile an account and analysis of the meteorological and hydrological event data. This analysis was undertaken to support understanding and communication of the flood event and to provide an estimate of the event frequency. Assessment of data for an earlier flood event (February 2020) was also carried out.

The key tasks for the study were:

- Collect and collate hydrometric datasets and any other relevant data / information.
- Review, quality check and analyse all data, extracting and visualising key parameters such as storm duration, time-to-peak, flood peak travel time, and maximum and total values.
- Examine NRW ratings for Dinas Powys and Sully Moors Road level gauges and determine if flow series, in which there is reasonable confidence, can be derived. Comparison of the existing ratings, and results derived from them, with those derived from hydraulic modelling as part of a study commissioned by NRW to review and update the ratings (running in parallel with this study).
- Estimate event frequency from level, flow (where possible) and rainfall data, to provide a probable range in which the events lie.
- Document the findings of the assessment, including discussion and comparison of the hydro-meteorological conditions for the two events, and results of the frequency analysis.

The main findings, conclusions and recommendations from the study were:

- The total rainfall depth and antecedent conditions were similar for both events. However, the December 2020 event led to extensive flooding and internal flooding of many properties in Dinas Powys, whereas it is believed that no internal property flooding occurred during the February 2020 event.
- The main difference between the events is that the duration of the February storm was approximately 2.5 times longer than the December storm. For the December event the maximum hourly rainfall intensity was double that of the February event. The shorter rainfall duration for the December event is likely to have led to surface water sewer drainage issues, with the volume of water received over a short period causing surcharging of the sewers, combined with high water levels in the Cadoxton River. The longer duration over which the rain fell for the February event would have enabled the channel and sewers to better cope with the volume of water.
- In summary, the December 2020 flood event was the result of a short and intense rainfall event, whereas the February 2020 flood event was the response to a prolonged and low intensity series of rainfall events.
- Frequency analysis of level and flow gauge data indicates that the December 2020 flood event has an estimated annual exceedance probability (AEP) of 5%. The February 2020 flood event has an estimated AEP of 20%. There is

substantial uncertainty in these estimates, although confidence is increased by different approaches generating similar frequency estimates.

- A 5% AEP event estimate for the December 2020 flood event might be considered too frequent given the impact of the flooding. However, the best available data has been used; until further data or information becomes available, these will remain the best estimates of the event frequency.
- It is recommended that the frequency estimates are revisited:
  - As the river gauge record length increases.
  - When any further large events occur.
  - When high flow spot gaugings have been collected and used to verify / amend the river gauge rating.

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Doncaster
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Exeter
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Newcastle upon Tyne
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Wallingford
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Registered Office
1 Broughton Park
Old Lane North
Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

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info@jbaconsulting.com
www.jbaconsulting.com
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ISO 14001:2015
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ISO 45001:2018