Merthyr Tydfil County Borough Council

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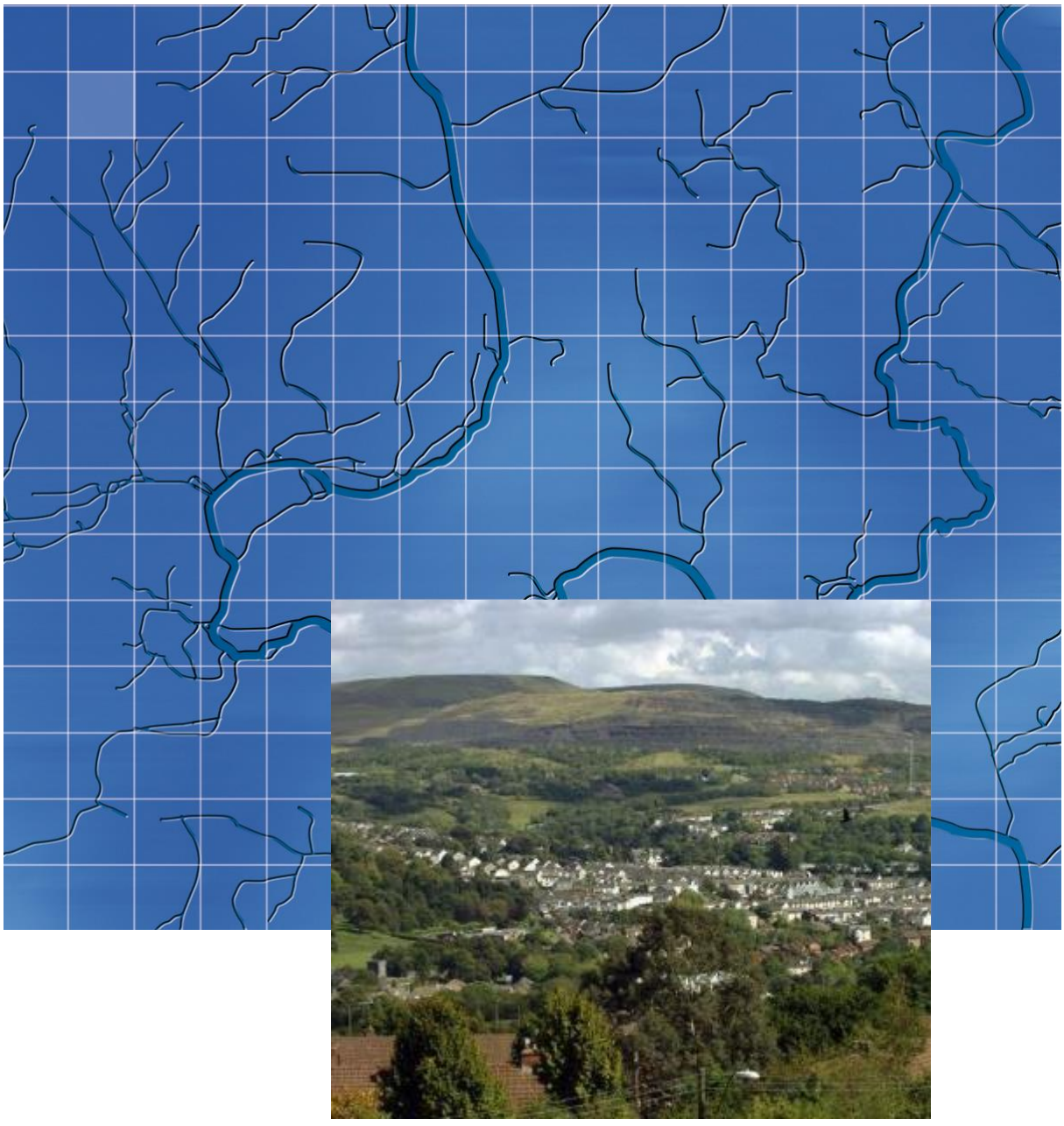
Merthyr Tydfil Strategic Flood Consequence Assessment



Merthyr Tydfil County Borough Council

Merthyr Tydfil SFCA

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1 Introduction

1.1 Background

Wallingford HydroSolutions (WHS) has been commissioned by Merthyr Tydfil County Borough Council (MTCBC) to undertake a Strategic Flood Consequence Assessment (SFCA) to quantify flood risk at three key strategic development sites specified in the Council's Local Development Plan (LDP). The three development sites are the Central Bus Station area, Hoover Strategic Regeneration Area and the Project Riverside site. Exact locations and site areas are detailed in Table 1 below.

The study will identify key flood risk constraints at each of the sites to enable MTCBC to assess their suitability for future development and inform land use policy with regards to flood risk. The three critical sites have been identified by MTCBC as being crucial to the execution of the LDP and the growth of Merthyr Tydfil.

Table 1 – Key Strategic Sites

Site Name	Approximate Area (ha)	Grid Ref (NGR)
Hoover Regeneration Site	46	SO 0541 0449
Central bus Station	1	SO 0479 0617
Project Riverside	10	SO 0739 0006

The SFCA has been produced in accordance with Section 10 of TAN15 which is used to assess flood risk and provides guidance on how to best implement national flood risk policy within the three areas defined and Merthyr Tydfil more widely.

The policies that provide guidance on assessing flood risk in Wales are outlined in Section 2 of this report. Section 3 of this report provides a high-level overview of flood risk within Merthyr Tydfil, with detailed site assessments being presented in Section 4. Site specific analysis has been informed by TAN 15: Development and Flood Risk and recommendations for development zoning within the sites are made.

1.2 Objectives & Scope

The SFCA is required to inform development zoning at three sites identified as critical to reaching the requirements of the LDP. Anticipated population growth in Merthyr Tydfil of 8% by 2031 demands the need for the allocation of suitable sites to increase residential capacity and to support local business development.

The SFCA will be prepared in accordance with Section 10 of TAN15 (as detailed in Section 2 of this report) which states the LDP should include site specific policies and proposals for development and flood risk.

This study will give a complete review of flood risk at each of the sites reviewing all the available data to reach an informed conclusion regarding flood risk. A more general flood risk review within the vicinity of the three Strategic Development Areas (SDA's) has also been undertaken. In the instance of the Hoover Strategic Regeneration Site, bespoke hydraulic modelling of the River Taff has been utilised. The findings of this SFCA will help inform MTCBC on how best to implement national flood risk policy in Merthyr Tydfil.

1.3 Methodology

A methodology for the SFCA was agreed at an inception meeting held on 1st February 2018 between Natural Resources Wales (NRW), WHS and MTCBC. The method involves collating available information regarding existing flood risk at the proposed development sites, reviewing existing data and updates to hydraulic models of the River Taff to quantify flood risk in the study area.

Existing hydraulic models will be used, including the Bus Station model, completed by Capita in 2011, and a WHS model of the River Taff will be extended downstream to ensure the Hoover Site is suitably modelled. Existing outputs of relevant hydraulic models will be used to produce mapping of flood extents and depths across the three sites. In addition to the results of detailed hydraulic modelling, a range of secondary data sources will be reviewed to inform and quantify flood risk including:

- A review of LiDAR data to inform flow paths within the site[1]
- Reports and mapping of historic flood events including fluvial and ground water flooding[2]
- Technical Advice Note 15 (TAN15)[3]
- Planning Policy Wales[4]
- TAN15 Development Advice Maps[5] (DAM).
- NRW fluvial, surface water and reservoir inundation flood maps[6]
- DG5 sewer flooding records from Dwr Cymru Welsh Water (DCWW)
- Site plans[7]
- Flood Defence Data supplied from both NRW[8] and existing FCA's[9]
- Soil scapes[10] and BGS bedrock mapping and borehole data[11] will inform a review of the underlying geology at the sites
- Jubb Consult Ltd FCA for the Merthyr Vale site[12]
- Capita FCA for the Merthyr Bus Station site[13]
- Thomas Mackay Flood Modelling Study for the Dragon Parc site[14]
- NRW Response to the LDP Preferred Strategy[15]

[1] LiDAR data download from: http://lle.gov.wales/Catalogue/Item/LidarCompositeDataset/?lang=en
[2] Provided from MTCBC in GIS format-16/01/2018
[3] Technical Advice Note 15: Development and Flood Risk. Welsh Assembly Government. July 2004.
[4] Planning Policy Wales 9th Edition. Welsh Assembly Government. November 2016.
[5] Lle Map Browser- Development Advice Map available from: http://lle.gov.wales/catalogue/item/DevelopmentAdviceMap2/?lang=en
[6] Natural Resource Wales, Long term flood risk maps: available from https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en
[7] Provided by MTCBC
[8] NRW Flood Defence Mapping Data: https://naturalresources.wales/flooding/managing-flood-risk/flood-risk-map-guidance/flood-defences/?lang=en
[9] Information and previous reports provided by MTCBC (February 2018)
[10] Soilscapes: http://www.landis.org.uk/soilscapes/
[11] Geology of Britain Viewer, British Geological Survey (BGS): https://www.google.co.uk/search?q=bgs+bedrock+map&rlz=1C1CHBF_en-GBGB754GB755&oq=bgs+bedrock+map&aqs=chrome..69i57.2623j0j4&sourceid=chrome&ie=UTF-8
[12] Flood Consequences Assessment. Merthyr Vale. Jubb Consulting Engineers Ltd. January 2018.
[13] Bus Station Flood Consequences Assessment. Capita. 2017.
[14] Flood Modelling Study. Dragon Parc at Abercanaid, Wales. Thomas Mackay. October 2017.
[15] Appendix 1 – Natural Resource Wales LDP Preferred Strategy Representation. October 2017.

2 Policy Guidance on Flood Risk

2.1 Planning Policy Wales

Planning Policy Wales (PPW) (2016) sets out the land use planning policies employed by the Welsh Government and forms a framework for the preparation of Local Development Plans (LDP's). Chapter 13 of the document focuses on constraints to land use planning caused by environmental risks, such as flooding and climate change.

PPW states that a sequential approach to development in flood hazard areas should be adopted, whereby development should be directed away from flood hazard areas, rather than the mitigation of the consequences of flooding in higher flood risk areas. Additionally, climate change will intensify rainfall and increase river flows, and will reduce the service levels provided by existing surface water drainage structure. The Welsh Government advises that planning authorities consult with NRW to ensure that development proposals do not increase flood risk elsewhere, and where possible, reduce flood risk overall. It is recommended that the latest edition of PPW[4] (currently 9th) is referred to when undertaking any future site specific FCA's, to ensure compliance with Welsh Government.

2.2 Technical Advice Note 15

PPW is supplemented by a series of Technical Advice Note's (TAN's). TAN15 focuses on Welsh Government Policy Guidelines regarding development and flood risk. The overarching theme of TAN15 reflects that of PPW, which is to direct new development away from areas that are at high risk of flooding. However, with increasing pressures on development and regeneration, TAN15 sets out requirements to meet should development need to be considered in high flood risk areas. It is possible that development can be permitted in higher flood risk areas should it be demonstrated by a site specific FCA that a development passes the justification test, the principles for which are outlined in Section 6 of TAN15.

TAN15 is informed by the Welsh Government Development Advice Map (DAM), which assigns each area of land a zone that defines its flood risk. The DAM Zone categories and descriptions are provided in Table 2.

Table 2 - Welsh Government DAM Zones

Welsh Government DAM Zone	Description
A	Considered to be at little/no risk of flooding.
B	Areas known to have been flooded in the past, evidenced by sedimentary deposits.
C	Areas that lie within the 0.1% annual probability flood outline, based on the NRW Flood Map.
C1	Areas of the floodplain served by significant defence infrastructure, including flood defences.
C2	Areas of the floodplain without significant flood defence infrastructure.

Section 10 of TAN15 contains guidance on the preparation of Local Development Plans (LDP's) and how they should consider flood risk. Specifically, paragraph 10.5 addresses development in Zone C, where allocations for development should only be made if the development is justified in accordance with Section 6 (justification test), as well as the consequences of flooding being acceptable as per Section 7 and Appendix 1. Additionally, paragraph 10.8 refers to Zone C2 being unsuitable for the allocation of residential development. Any other built development in a Zone C2 area should be justified in accordance with Section 6, 7 and Appendix 1.

TAN15 categorizes development in respect to its vulnerability to flood risk, subsequently providing a basis for flood risk zone compatibility. Some key examples include residential; categorized as highly vulnerable and commercial; classed as less vulnerable. Further examples and details are provided in Section 5 of TAN15.

With regards to flood risk compatibility, TAN15 advises that new residential development (highly vulnerable) is not permitted in Zone C2 (see Table 2), as the risk of flooding in Zone C2 is considered unacceptable for new dwellings. The Local Authority will generally refer to NRW for flood risk advice on planning applications and NRW may object to any applications that do not meet the requirements of Welsh Government Policy.

In addition to fluvial/tidal flooding, TAN15 also requires that due consideration is given to surface water runoff, as the increase in hard standing area on greenfield land will in turn increase the rate of runoff discharging from a new development. It is recommended that Sustainable Drainage Systems (SuDS) are implemented to reduce surface water runoff; with site discharge rates being agreed with the Lead Local Flood Authority (LLFA). Liaison with the relevant Internal Drainage Board (IDB) and Sewerage Undertaker may also be required to ensure there is agreement to a proposed surface water drainage strategy. Further guidance and information is provided in Section 8 of TAN15.

3 Overview of Flood Risk within Study Area

This section seeks to provide an overview of flood risk from all sources within the vicinity of the three SDA's. This section identifies the key flood risk issues for consideration in the detailed site assessments included in Section 4.

3.1 Consultation with Statutory Bodies

Planning Policy Wales (PPW) and associated guidance requires that a Strategic Flood Consequence Assessment be prepared by local planning authorities in consultation with NRW and lead local flood authorities, as well as the local sewerage undertaker and Internal Drainage Boards where relevant.

In order to inform this SFCA, NRW and MTCBC (as the LLFA) were contacted to provide the most up to date information. This was followed up by an inception meeting, along with proactive engagement to agree the structure, methodology and mapping required for the SFCA. In addition, consultation with Dwr Cymru Welsh Water established what sewer flooding data were available to inform the SFCA.

3.2 Catchment Hydrology

The River Taff is split into two watercourses upstream of Merthyr Tydfil, known as the Taff Fawr (western branch) and Taff Fechan (eastern branch). The river rises approximately 17km to the north in the Brecon Beacons National Park, Powys. The catchment area from the gauging station at Merthyr Tydfil (station no: 57015) is approximately 104km^2. The land use throughout the catchment is predominantly rural, with Merthyr Tydfil being the only urban area. For example, only 2.5% of the catchment is recorded as urban at the gauging station according to the National River Flow Archive (NGR of gauging station: SO 043068). The bedrock is largely impermeable, with 73.5% of the bedrock classed as low permeability. The topography is also steep, particularly upstream of Merthyr Tydfil, suggesting a relatively flashy flood response.

3.3 Historical Events

Historical flood events are recorded by NRW and subsequently documented in the form of reports, photographs and mapping. This information is used to update the historical flood map, which shows the maximum extent of all individual recorded flood outlines. It may be the case that localised flood events have occurred but have not been recorded/documented by NRW. MTCBC have also been contacted with regards to obtaining existing information on historical flood events, particularly focusing on flooding at culverts throughout the Hoover Site. The MTCBC data have been provided in GIS format, which contains information on the causes, dates and extents of historical flood events.

The NRW historic flood outlines have been mapped for the area surrounding the three SDA's; central Merthyr (Bus Station), Abercanaid (Hoover Site) and Merthyr Vale areas, and are available as figures A7, A8 and A9 (Appendix A) respectively.

There does not appear to be any flooding recorded and documented by NRW at the Central Bus Station Site. The Bus Station Flood Consequences Assessment[13] (FCA) refers to the Bus Station site as not being affected by flooding during the December 1979 flood event, and that no other historic records were available for that particular study. The MTCBC data shows nearby flooding at Caedraw from a main river event in 1899. Some surface water flooding has also been recorded just south of Pontmorlais during December of 1899.

There are some localised historic flood extents throughout the Hoover site along both the left and right banks of the River Taff as a result of the December 1979 event. These remain close to the river banks and do not extend beyond 20m of the main river. There are no NRW records of flooding along the Nant Graig or Nant Canaid. The MTCBC data records past flooding due to canal overload during

October 2010 at Upper Abercanaid. There are also two areas of flooding within the west of the Hoover Site that were caused by the flooding of ordinary watercourses during 1899.

There do not appear to be any recorded instances of flooding at the Merthyr Vale site, with historic flood extents confined to the Aberfan area. Some additional flood events within the vicinity of the site have been identified which are referred to in the Merthyr Vale FCA completed by Jubb Consulting (2018), which are displayed in Table 3.

Table 3 - Merthyr Vale Historic Flood Data

Historic Flood Event	Flooding at Merthyr Vale Site?
January 1903	Unknown
November 1929	Unknown
December 1960	Unknown
December 1964	Unknown
October 1967	No
December 1979	No
October 1998	No

These records are based on anecdotal data that has been documented in past FCA's for the site. In addition, the Merthyr Vale site has undergone significant change since previous historical flood events. The construction of the new link road, Golwy Yr Afor, acts as a flood defence for the site, which is likely to significantly reduce the risk of flooding at the site during future flood events.

Due to a lack of historic flooding issues at the three SDA's, historic flooding will not be considered in further detail within the site assessments.

3.4 Fluvial Flooding

Fluvial flooding or flooding from rivers is the most dominant flooding mechanism throughout Merthyr Tydfil, with the River Taff and several smaller ordinary watercourses in the area. The smaller watercourses can result in flooding particularly at culverts where blockage risks are high. There are several hydraulic models in the area that provide a higher resolution of flood risk analysis through improved representation of the channel and floodplain compared with generalised JFLOW modelling. These have been used to update the NRW flood map in places; however, certain reaches in the study area are based on generalised, low resolution JFLOW modelling. All NRW flood zone information is based on undefended runs and does not account for any flood defences. The NRW fluvial flood data have been made available in GIS format for use within this SFCA, and has been mapped for the central Merthyr, Abercanaid and Merthyr Vale areas, available in Appendix A as figures A4, A5 and A6 respectively. Details on the existing hydraulic models are displayed in Table 4.

Table 4 - Hydraulic modelling in the Merthyr area

Study Name and Date	Watercourse	Upstream Extent	Downstream Extent	Model Approved by NRW?
WHS Willows Flood Modelling (2017)	River Taff	304745E, 205941N	306055E, 203682N	Yes-For use within the Willows FCA
Capita Bus Station Model (2016)	River Taff and Nant Morlais	Taff – NGR 304333 206789 Nant Morlais – NGR 305210 206730	Taff – NGR 605160 250370 Nant Morlais – NGR 304670 206270	No
Thomas Mackay Dragon Parc Modelling Study (ongoing)	River Taff, Nant Canaid North (NCN) and Nant Canaid West (NCW)	Taff – NGR 304986 205620 NCN – NGR 305166 204623 NCW – NGR 305061 204275	Taff – NGR 306291 203358 NCN – NGR 305232 204255 NCW – NGR 305222 204235	No
JBA Consulting Hydraulic Modelling at Merthyr Vale Colliery Site (2017)	River Taff	TBC	TBC	Yes

The NRW flood map shows the annual probability of river flooding at Merthyr Tydfil using distinct flood zones, which are detailed in Table 5 below.

Table 5 - NRW Flood Zone and Probability of Flooding

NRW Flood Zone	Annual Probability of Flooding (%)
1	<0.1%
2	>0.1%, <1.0%
3	>1.0%

3.4.1 River Taff

The River Taff is the largest watercourse in Merthyr Tydfil. With the exception of the Merthyr Vale site, the NRW flood map for the River Taff is largely based on low resolution JFLOW modelling data, which often produces conservative flood extents in comparison to detailed 1D/2D hydraulic modelling as smaller watercourses and culverts are usually not represented in the model.

The NRW flood map shows large parts of central Merthyr Tydfil to be in Flood Zone 3 of the River Taff, particularly around areas such as Glebeland and Cae-draw, including flooding of the A4054 road network. There are also residential areas at Georgetown that lie in the 0.1% annual probability event (Flood Zone 2). The bus station site is also shown to be affected by the 1% annual probability event (Flood Zone 3), according to the existing NRW Flood Map.

The existing flood map shows that flood extents are relatively confined throughout Abercanaid, with both Flood Zone 2 and 3 remaining close to the river banks. There are localised areas in the north of the site where the floodplain becomes wider along the right bank of the River Taff at the Willows industrial estate.

Throughout the Merthyr Vale and Aberfan area, the extent of Flood Zone 3 is relatively constrained to the river banks, except for several low points to the north, as well as the B4285 at Aberfan. However, the Flood Zone 2 extent is shown to affect large parts of the Merthyr Vale/Project Riverside site.

3.4.2 Other Watercourses

A map of ordinary watercourses has been provided in Appendix A (Figure A13). The ordinary watercourses have been identified from a combination of OS Mapping, aerial imagery and the NRW surface water flood maps.

The key minor watercourses relevant to the development sites are summarised below:

- Nant Morlais (Bus Station site) - Large parts of this watercourse are culverted, however the Flood Zone 2 and Flood Zone 3 extents become broader toward the confluence with the River Taff, affecting the Bus Station site, other existing infrastructure and properties along High Street and at northern parts of Glebeland.
- Nant Canaid (Hoover Site) – The risk associated with the Nant Canaid is currently shown on the flood map as the downstream end of the watercourse has been modelled using JFLOW, indicating that flooding is predicted in south western parts of the Hoover Site. However, large parts of the watercourse are culverted, which is not modelled/represented accurately using JFLOW. Detailed modelling of these structures is currently ongoing as part of the Dragon Parc Modelling Study (Thomas Mackay, 2017). The Dragon Parc FCA also refers to the culvert capacity being insufficient to convey flows from the Nant Canaid to the River Taff, hence creating a flow route through the Hoover site.

- Nant Graig (Hoover site) – Flood risk from small watercourses with catchments less than 3km^2 is not included in the NRW flood map but can often be assessed through use of the pluvial (surface water) flood maps. Therefore, this approach has been adopted for the Nant Graig to estimate flood risk from this watercourse (Figure A11). The 1% AEP event surface water flood map indicates flood extents restricted to the existing channel network. For the 0.1% AEP event, flooding is predicted along the A470 and Graig Road, as well as existing open space in south western areas of the Hoover site.

Due to the fluvial flooding issues identified, it is considered appropriate to include the fluvial flood risk in more detail within the site assessments.

3.5 Flood Defences

There are limited flood defences shown on the NRW flood map throughout the Merthyr Tydfil area, with no formal defences present in the central Merthyr Area or Abercanaid. Formal defences are shown along the left bank of the River Taff downstream of Troedyrhiw to protect the existing High School from flooding. Downstream of the school, formal defences are shown along the right bank of the Taff that prevent flooding at Aberfan Road, as well further downstream at Cottrell Street. Aberfan Road and Cottrell Street therefore lie in an Area Benefitting from Defences (ABD). It is worth noting the informal defences are not shown on the NRW flood map.

The Merthyr Vale FCA refers to the site being defended from events up to and including the 0.1% annual probability fluvial event. The defences are referred to as being constructed at the same time as an adjacent road, adopted by MTCBC. The defences are in the form of a raised road which acts as a flood bund to the Merthyr Vale site. It is located to the west of the Merthyr Vale site boundary.

3.6 Surface Water Flooding

Surface water (pluvial) flooding occurs as a result of direct rainfall accumulating in an area that is unable to drain away. The NRW surface water flood maps use rainfall, topographic and soil data to predict where flooding could occur. These data have been made available for the study in GIS format, and has been mapped for the central Merthyr, Abercanaid and Merthyr Vale areas, available in Appendix A as figures A10, A11 and A12 respectively.

The surface water flood maps show that throughout the central Merthyr area, several road networks are predicted to flood in the 3.3% AEP rainfall event such as High Street, The Walk, Trevethick Street and Gwaelody Garth Road, which qualifies as at "high risk" of pluvial flooding. The 1% AEP rainfall event surface water flood extent largely reflects the 3.3% AEP extent, with street networks such as Vulcan Road and Quarry Row affected at Morgan Town, as well as Aberdare Road and Dyenvor Street to the west. The extreme rainfall event (0.1% AEP) shows that large areas of the road network throughout the central area of Merthyr are flooded, particularly along the A4054 and Twynyrodyn Road. There is also surface water flooding predicted along the road networks surrounding the bus station site, particularly along High Street. The Capita Bus Station FCA also refers to there being a high risk of surface water flooding around the north western site boundary.

Large amounts of surface water flooding are predicted at Pentrebach near Abercanaid, with a large area of the village flooded during the 3.3% AEP event, as well as Duffryn Road that borders Greenfield Special School. Notably within Abercanaid, Stanfield Close is also shown to be affected during this event. Throughout the upper Abercanaid area, surface water flooding affects large parts of the Hoover site (north west), with water ponding in the 3.3% AEP event due to a topographic depression where the existing factory sits. Some flooding is also predicted along the A4054 in this area during the 3.3% AEP event.

Surface water flooding is not shown to significantly affect the Merthyr Vale site, with only a minor flow route shown in the 0.1% AEP extreme rainfall event. There appears to be a low point where surface water accumulates to the east of Cottrell street, however this is shown in the fluvial flood map which suggests that the flooding source is the main River Taff. There do not appear to be any significant surface water flooding issues throughout the Merthyr Vale area.

The present surface water flood maps do not take into consideration the effects of climate change on flooding. It is expected that climate change will cause increased rainfall intensity in the future which in turn will lead to exacerbate surface water flooding. This is further discussed in Section 3.10.

Due to some surface water risk to the three SDA's being identified, surface water flooding will be considered during the detailed site assessments.

3.7 Sewer Flooding

Sewer flooding occurs because of an existing drainage system having insufficient capacity to drain rainfall, consequently causing the release of water at manholes. Sewer flooding can also occur should there be a fault/failure at an existing drainage system.

The responsible authority for sewer flooding at the study area is Welsh Water, the Sewerage Undertaker. Welsh Water was contacted to gather available data on sewer flooding, focusing on the three SDA's and the surrounding land. Welsh Water has confirmed that there are no records of sewer flooding or capacity issues within the vicinity of the Bus Station and Hoover sites. Welsh Water referred to some historic records of sewer flooding at Belle Vue terrace, located just to the east of the Merthyr Vale site, with external flooding recorded at one property on 9th May and 1st June 2001. However, there have been no records of any sewer flooding issues since these dates. It is advised that Welsh Water is contacted as part of any future site-specific assessments to determine system capacity and drainage connection locations.

Due to a lack of sewer flooding issues, sewer flooding will not be considered in further detail within Section 4.

3.8 Reservoir Flooding

There are several reservoirs in the Taff catchment upstream of Merthyr Tydfil in the Brecon Beacons, such as Cantref Reservoir (Taff Fawr), Llwyn on Reservoir (Taff Fawr), Pontsticill Reservoir (Taff Fechan) and Upper and Lower Neuadd Reservoirs (Taff Fechan).

The reservoir flood maps are held by NRW and are included in the "Long Term Flood Risk" online map available on the NRW website. However, it is noted that reservoir flooding is a rare event with a very low probability of occurrence. Current reservoir regulation, which has been further enhanced by the Flood and Water Management Act (2010), ensures that all reservoirs are properly maintained and monitored in order to detect and repair any problem.

The reservoir flood extent is shown to affect all three sites. At the Bus Station site, Flood depths are greater than 2m and velocities are over 2m/s. Further south, areas such as Upper Abercanaid and Abercanaid and within the Hoover site and large parts of the A4054 road network are shown to be inundated during a reservoir flood event. Depths are largely greater than 2m and affect existing development on both sides of the River Taff, including industrial and residential areas. Flood velocities are higher throughout Upper Abercanaid at greater than 2m/s, however are shown to reduce at Abercanaid, with velocities ranging from 0.5m/s to 2m/s, dropping to 0.0m/s-0.5m/s further west. Flooding is also predicted at the Merthyr Vale site by a minimum of 0.3m, with the flood extent becoming constrained downstream at Bryngoleu. Flood water velocities are mostly below 2m/s across parts of the Merthyr Vale site and at Aberfan, shown to be in the region of 0.5m/s to 2m/s on the

NRW flood map. As the probability of reservoir flooding is considered extremely low, it will not be discussed in further detail within Section 4.

3.9 Other Sources

Groundwater flooding occurs as a result of high water tables in the soil, and typically occurs in low-lying areas with permeable soils and bedrock. Groundwater flooding has also been reviewed using available data to gauge the susceptibility of the study area to groundwater flooding. This process has involved reviewing the permeability of soils using Soilscapes online mapping, as well as the permeability of the bedrock using British Geological Survey (BGS) online mapping.

The central Merthyr Tydfil area is dominated by "slowly permeable seasonally wet acid loamy and clayey soils", with "freely draining floodplain soils" located within the immediate vicinity of the main River Taff. BGS data show the central area of Merthyr to be underlain by sedimentary Siltstone and Mudstone, which indicates moderate permeability. These data suggest that the risk of groundwater flooding is low to moderate, as both the soils and underlying geology are shown to be permeable to an extent.

Further downstream at Abercanaid and the Hoover site, the soils are mostly freely draining with localised areas of slowly draining acid soils. The bedrock is made up of sedimentary mudstone and siltstone, similar to that underlying the central area of Merthyr Tydfil, which is considered moderately permeable. However, there are several low points throughout the site that would be at higher risk, particularly those areas shown to collect water on the surface water flood maps (figure A11 in Appendix A).

The Merthyr Vale and Aberfan area is mostly covered with freely draining soils, with a localised area to the east containing a wet, peaty topsoil. The geology in this area according to BGS data indicates moderate permeability, as the area is underlain by Rhondda Sandstone, mudstone and siltstone. The existing FCA refers to the topography of the site increasing its susceptibility to groundwater flooding as it is lower than surrounding land, however this could be mitigated against by finished floor levels which are generally raised above ground level. Therefore, in light of this information, the risk of groundwater flooding is considered moderate. Should a detailed groundwater flood risk assessment be required, it is recommended that this is undertaken as part of a site specific FCA. However, given an initial high-level review of available data in the area, it is unlikely that groundwater flooding will be the dominant flooding mechanism at any of the three SDA's.

Due to MTCBC records of historic canal flooding at the site, the Canals and Rivers Trust have been contacted in order to confirm the nature of any flood risk issues at the site. However, no further data are available for the study area. It has been advised by MTCBC that records of canal flooding are contained within the historic flooding dataset see Section 3.3.

Considering the risk outlined within this section, there are not considered to be any significant groundwater or canal flooding issues that require further discussion in Section 4.

3.10 Climate Change

The impacts of climate change are likely to increase constraints on development within flood risk areas. This is due to a predicted increase in storm/rainfall intensity, subsequently increasing peak river flows. As of 1st December 2016, Welsh Government updated climate change allowances to reflect research into the effect of climate change on peak river flows and sea levels. Following this, updated guidance was released in December 2017[16] by Welsh Government. Wales has been split into a total of 3 river basin districts; Western Wales, Severn and Dee. Merthyr Tydfil falls into the Severn river basin district, with areas west of Rhondda Cynon Taff assigned the Western Wales district.

A range of percentage increases in river peak flow estimates are provided; lower end (10th percentile), central estimate (50th percentile) and upper end estimate (90th percentile). The guidance note recommends that the central estimate is used for site specific FCA's, with the upper end allowance required for mitigation design, depending on the scale and nature of the proposed development. It is standard practice for commercial and residential development to use the allowance that represents 100 years of climate change relative to present day (known as the total change anticipated for the 2080's). Please see the Welsh Government climate change guidance for further information.

[16] Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales. Welsh Government. December 2017.

4 Site Assessments

4.1 Hoover Strategic Regeneration Area

4.1.1 Site Background & Historical Use

The Hoover Site is located in south Merthyr Tydfil and extends from Rhydycar in the North, through Upper Abercanaid, to Abercanaid in the south (305715E, 204204N). The site boundary covers land on both the left and right bank of the River Taff, including land adjacent to Merthyr Road. The proposed site is approximately 46ha and is located on largely previously developed land. The land is largely utilized for industrial purposes and includes the old Hoover factory at Upper Abercanaid. Much of the developed land is understood to be previously owned in part by Hoover. There is a smaller proportion of land that is currently open space south of the Nant Graig. The site boundary and location are displayed in Figure 1.

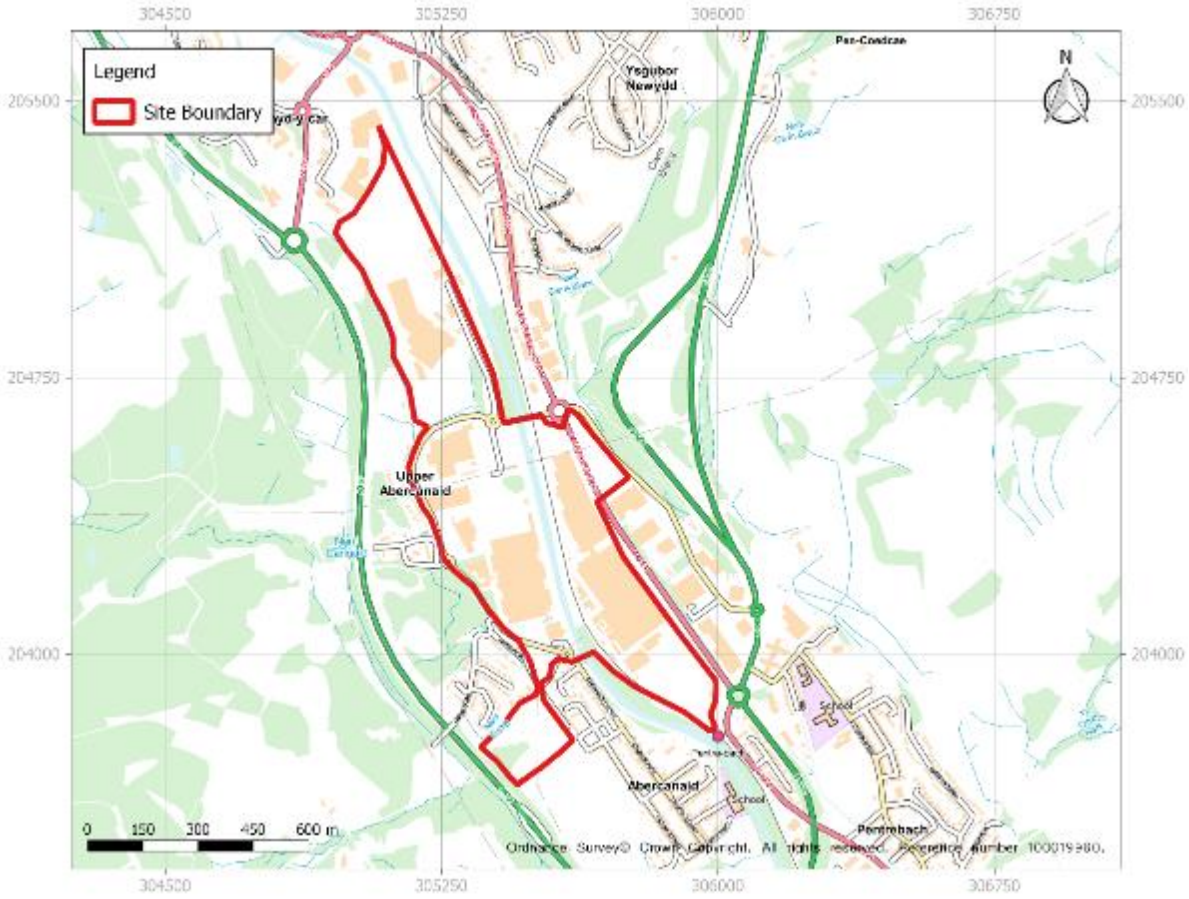


Figure 1 - Hoover Site Boundary and Location

4.1.2 Proposed Development

Indicative development allocations have been provided by MTCBC to inform this SFCA. However, a key outcome of this SFCA is to refine these zones based on the existing TAN15 Dam Zone mapping. Therefore, the allocation of development or development type is likely to change following the submission of this SFCA. The 46ha development is proposed to be of mixed residential/commercial use, including the Dragon Parc residential area. The residential development is mostly concentrated in the south west, with commercial development to the north-west at Upper Abercanaid. To the east, on the left bank of the River Taff, there is a 13ha area of mixed residential and commercial development with open space. The land use designations are shown in Figure 2.

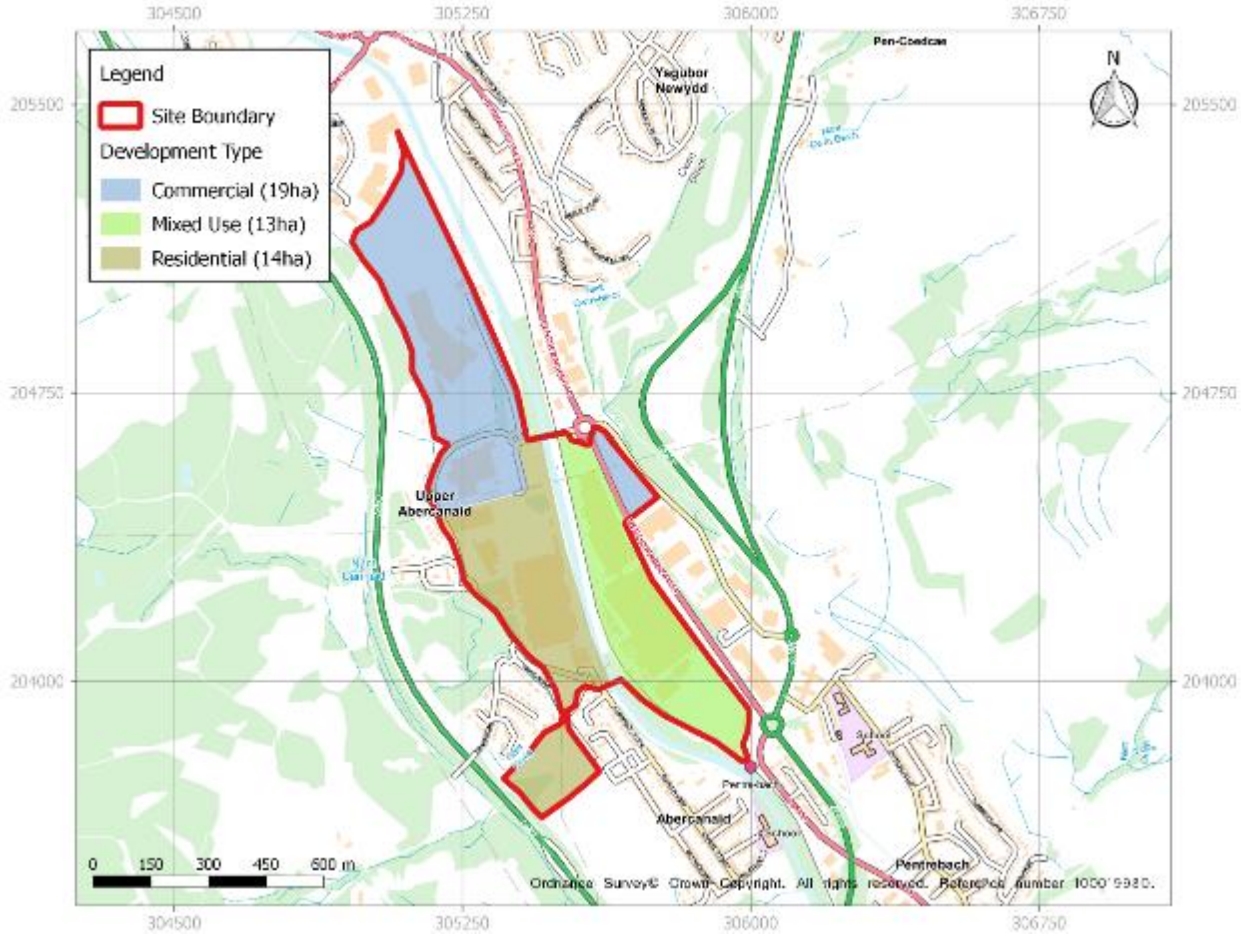


Figure 2 - Hoover site development proposals

4.1.3 Topography

The site generally slopes to the south following the fall of the River Taff in a downstream direction. Due to the size of the site, ground levels vary widely and are generally between 150m AOD-175m AOD. Some areas that are adjacent to the Taff gradually slope eastwards/westwards towards the watercourse. The areas of the site to both the east and west of the River Taff slope southward at an approximate gradient of 1 in 100. The site topography is displayed in Figure 3.

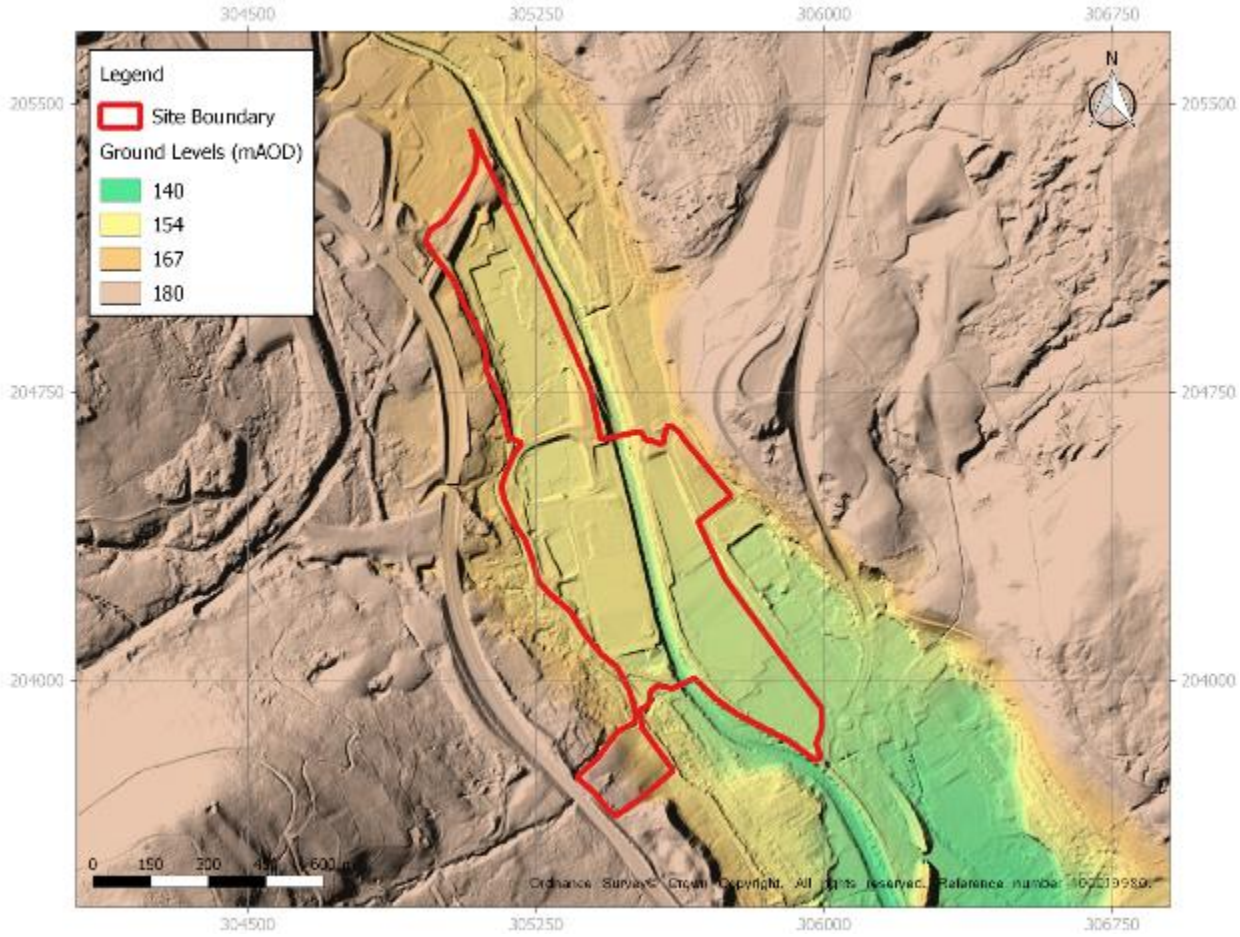


Figure 3 - Hoover site topography

4.1.4 NRW Extreme Flood Outline

The extreme flood is defined as a flood event with an annual probability of occurrence of 0.1%. This is represented by Flood Zone 2 on the NRW flood map. The NRW flood map for the south Merthyr area, including the Hoover site, is available as Figure A5 (Appendix A). The NRW flood map has been overlaid with the site boundary in Figure 4. This shows that approximately 33% of the total site area lies in NRW Flood Zone 2. However, no part of the site that lies to the east of the River Taff is predicted to flood in the 0.1% annual probability flood event. Table 6 below shows the proportion of each development type affected by the NRW extreme flood outline.

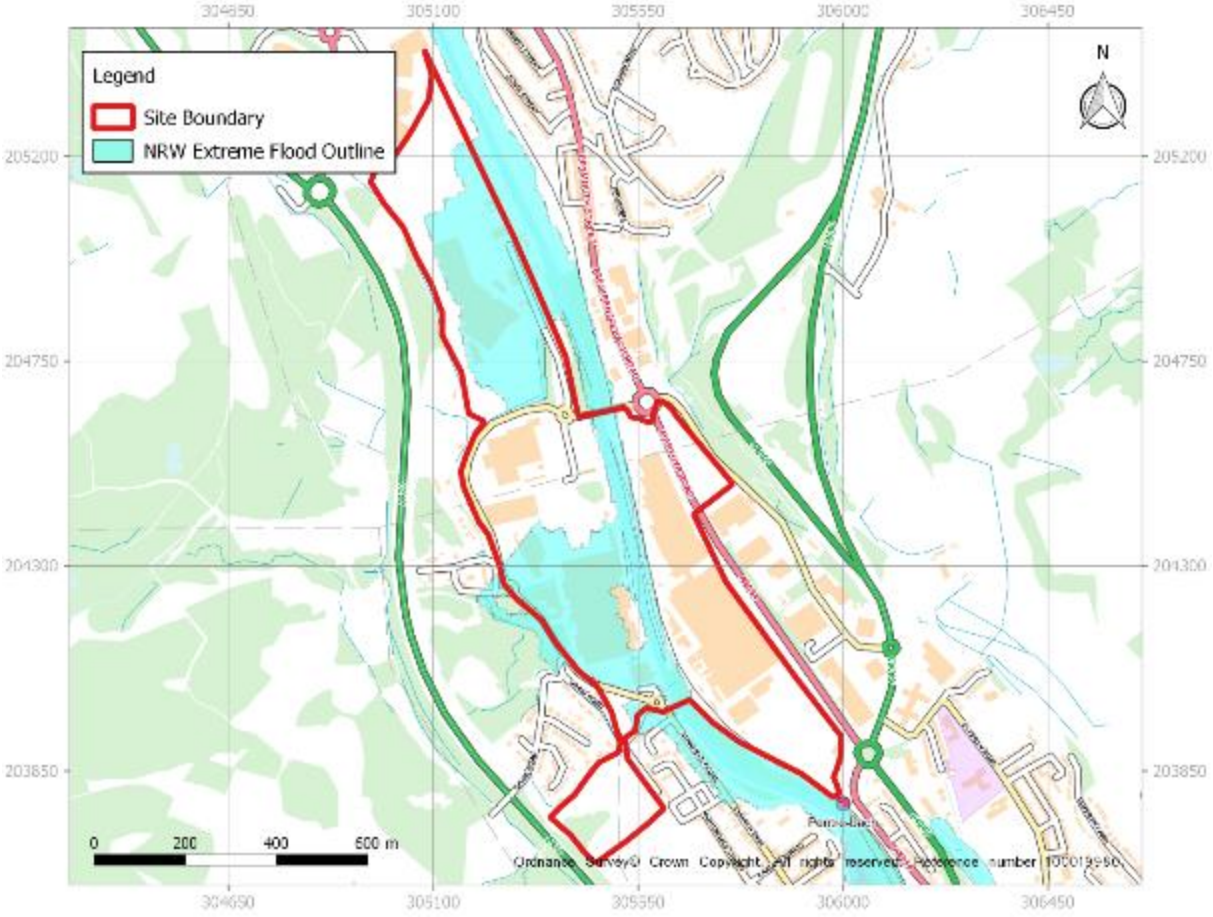


Figure 4 - NRW Extreme Flood Outline: Hoover Site

Table 6 - Proportion of initial indicative development allocations (subject to change following this assessment) covered by NRW extreme flood outline

Development Type	Proportion affected by NRW extreme flood outline (%)
Residential	51%
Commercial	43%
Mixed Use	0%

4.1.5 TAN15 Development Advice Map

The DAM is available in Appendix A (Figure A2). The DAM map has been overlaid with the site boundary in Figure 5. For a description of the DAM Zone designation, please see Table 2. In summary, the site is a mixture of Flood Zone A, B and C2. Zone A encompasses the far south west of the site boundary and small sections to the far west. Zone C2 reflects the NRW extreme flood outline, with Zone B covering the remainder of the site including the area to the east of the River Taff. Part of the site lies within Flood Zone C2, this flood zone covers the western area of the site and the land at Upper Abercanaid. The south western area of zone C2 is associated with flood risk from the Nant Canaid rather than the River Taff.

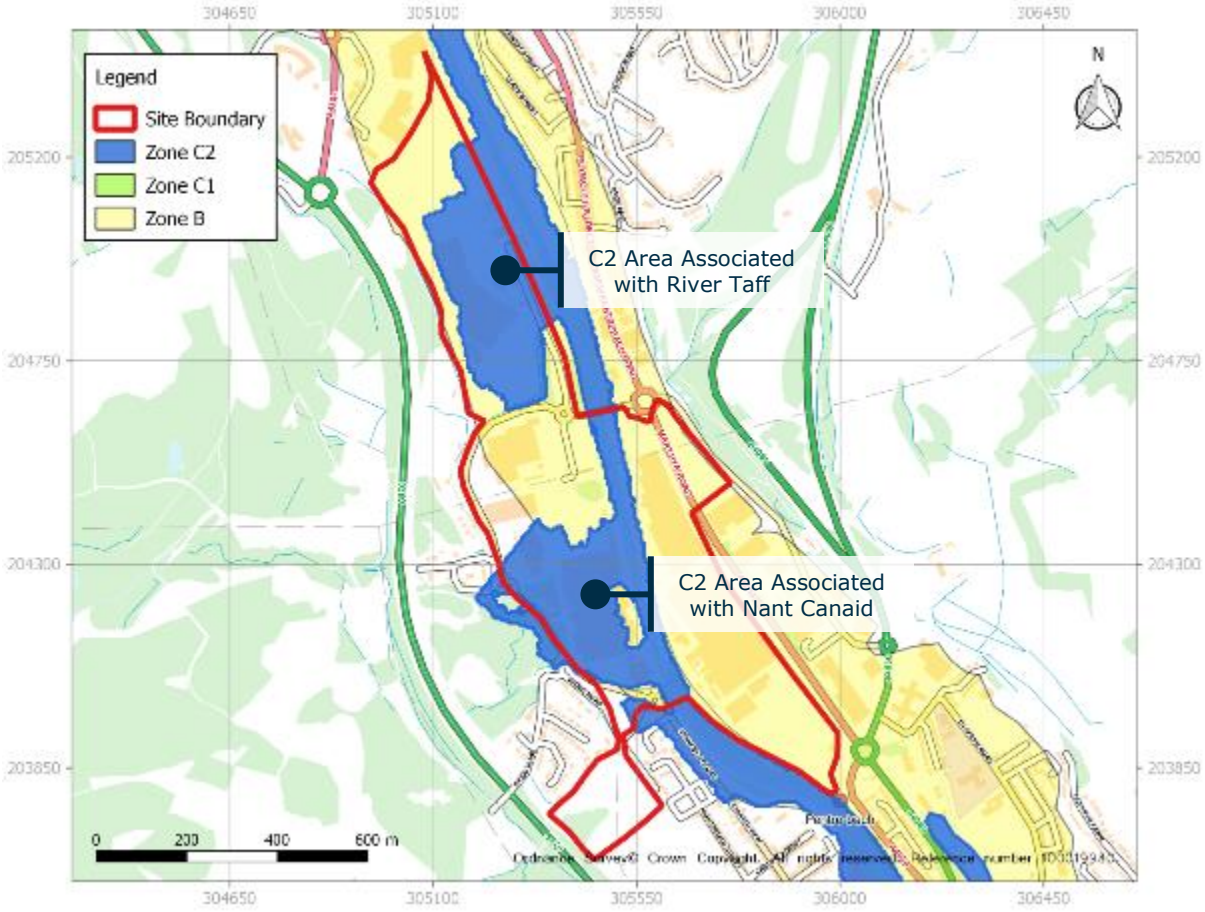


Figure 5 - TAN15 DAM Map for Hoover Site

4.1.6 Hydraulic Modelling

An existing hydraulic model of the River Taff was developed by WHS during 2017, in the form of a 1D/2D linked model utilizing Flood Modeller/TuFLOW software. It should be highlighted that this model only includes analysis of flooding from the River Taff, which represents part of the flood risk to the Hoover site, with the Nant Canaid being a risk to the south west (as highlighted in Figure 5). The River Taff model was accepted by NRW for the purpose of informing the Willows FCA. For this SFCA, the model has been extended downstream by a distance of 355m to encompass the whole of the Hoover site. The updated model active area is shown in Figure 6.

Hydraulic modelling of the Nant Canaid is currently ongoing, with mitigation options being discussed with NRW as part of the Dragon Parc FCA.

It is also worth noting that currently, no model data exist for the Nant Graig, the small watercourse to the south west of the site. Therefore, the flood extents and levels are unknown, which could potentially affect development at south western areas of the site (labelled in Figure 6).

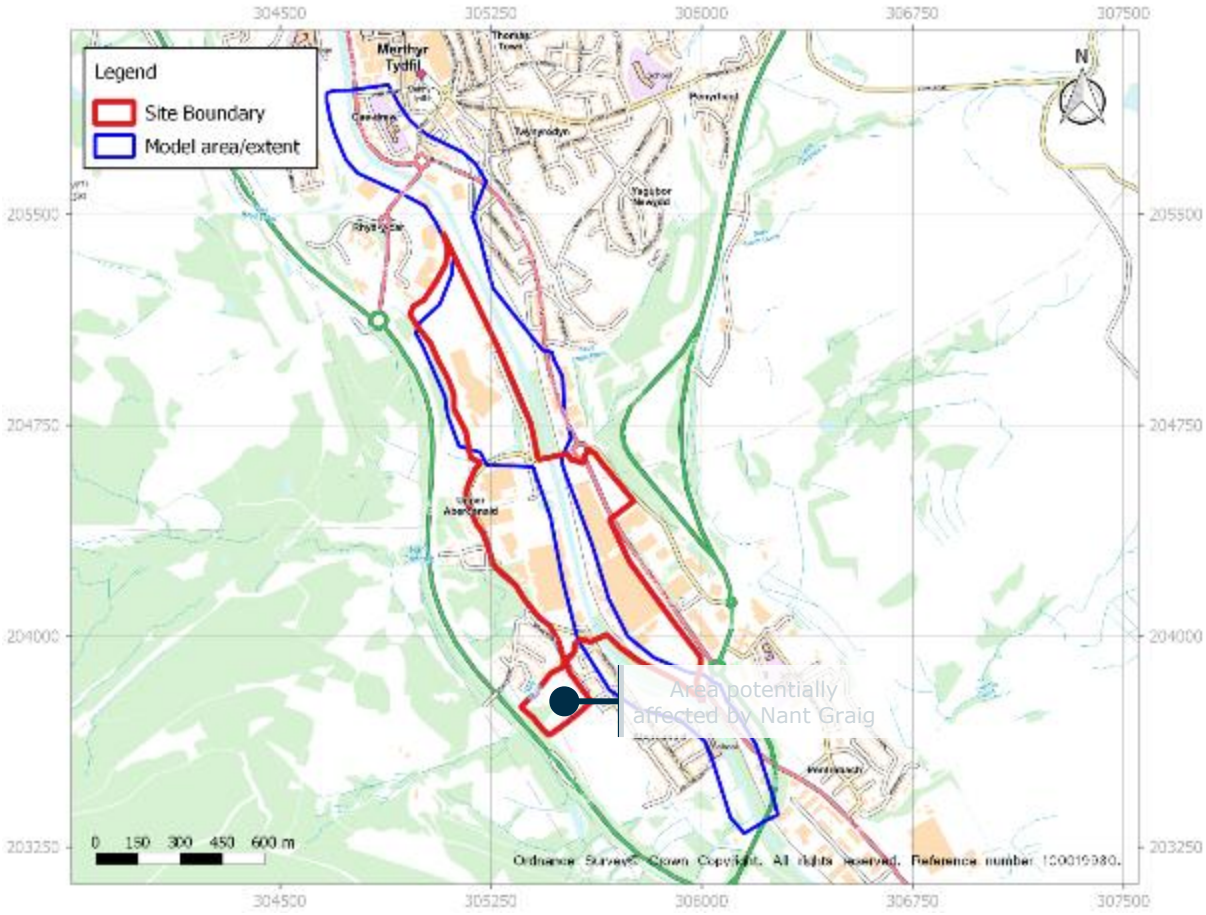


Figure 6 - Hydraulic model extent

The previous model of the River Taff developed by WHS in 2017 was updated for use within this study. It is recommended that the original technical report[17] is read to understand the development of the baseline model. Details of the model changes are provided as Appendix B.

[17] The Willows: Hydraulic Modelling Report. Wallingford HydroSolutions Ltd. May 2017.

1% AEP Event Plus Climate Change

The impacts of climate change have been assessed quantitatively using the hydraulic model. The model has been run for the 1% AEP event plus a 25% increase in flows due to climate change, which is the central estimate for the Severn River Basin District. The modelled flood depths throughout the Hoover site are displayed in Figure 7. Large parts of the site are shown to not be affected by the River Taff, with some minor flooding through northern areas of the site.

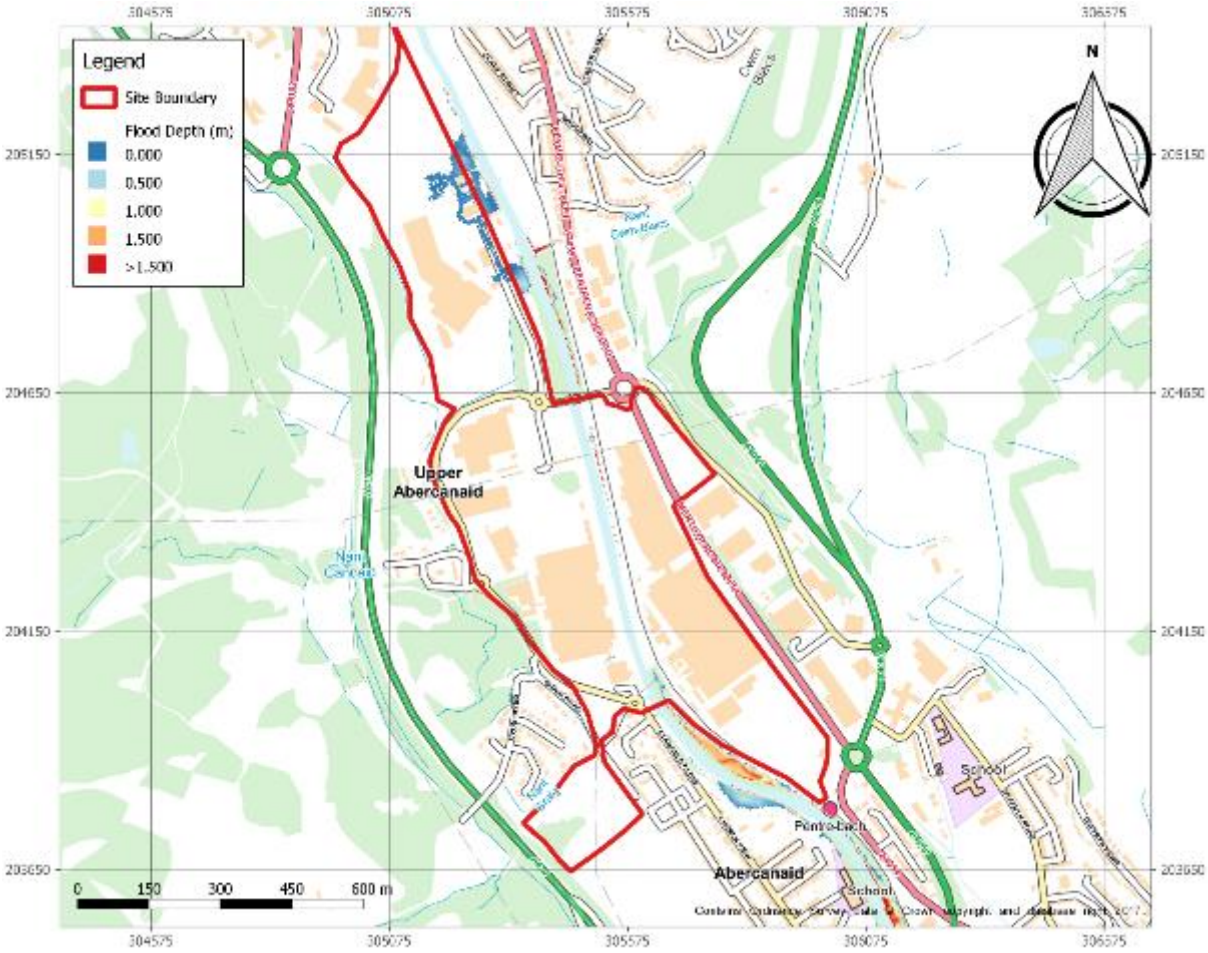


Figure 7 - 1% AEP +25%CC flood depths: Hoover Site

0.1% AEP Extreme Event

The extreme fluvial event for the River Taff catchment has also been modelled, which shows more flooding occurring in northern parts of the site. Although some flooding of development is permitted to occur during the 0.1% AEP event, the consequences should be acceptable in line with Table A1.15 of TAN15, which sets out indicative guidance on allowable depths, velocities, speed of onset and rate of rise for this event. The flood depths and extents are shown in Figure 8. Velocities are low across the flood extent at 0.0-0.3m/s. The general flood depths range from 0.25m-1.00m A maximum flood depth of 2.1m has been identified at a localised low point (highlighted by the red area), with a localised velocity of 2.6m/s just to the north of this. The extreme flood outline can be compared with DAM zone C2, and shows a slight but not significant reduction in flooding from the Taff throughout the north of the Hoover site. It is advised that hydraulic model outputs are compared to Table A1.15 of TAN15 as part of a future site specific FCA, when final development layouts are proposed.

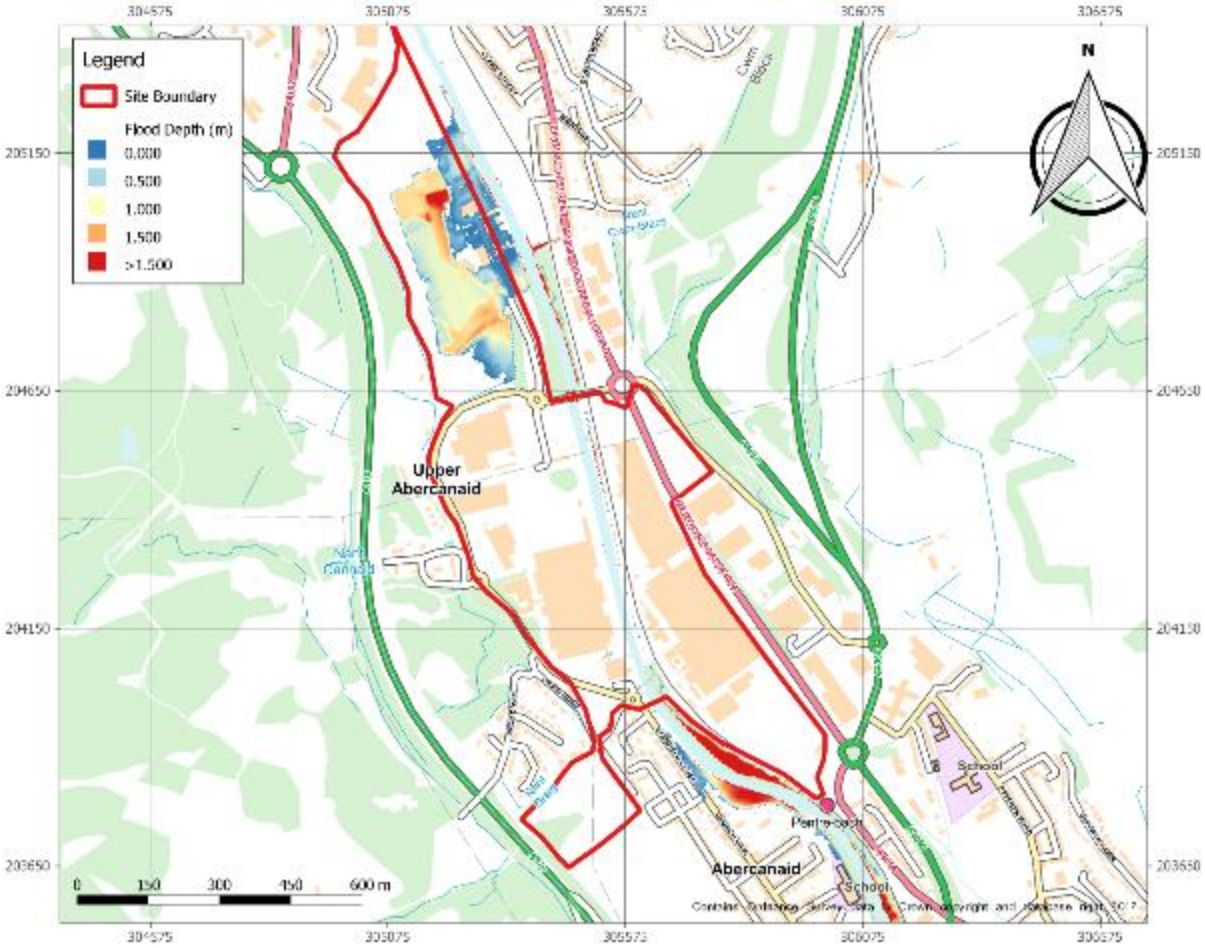


Figure 8 - 0.1% AEP flood depths: Hoover Site

4.1.7 Third Party Impacts

As shown by the hydraulic modelling of the River Taff, some flooding from the River Taff is predicted within the Hoover site, mostly at north western parts of the site during the 0.1% AEP extreme fluvial event. The existing TAN15 DAM map also shows flooding to the south west due to the Nant Canaid.

Mitigation may be required in areas at risk e.g. flood defences or ground raising which can result in impacts on flood risk to 3rd party property or land. In addition, the proposed development alone can displace floodwaters due to increasing the floodplain roughness. Therefore, as part of future site specific FCA's, it is advised that detailed hydraulic modelling is used to assess the impact of any proposed development and associated mitigation on flood risk. The developer should ensure that flood risk is not increased elsewhere by managing flood waters on site. This can include a sequential approach by steering development towards areas at lower risk or the provision of compensatory storage.

4.1.8 Surface Water Flooding

Notably throughout the Hoover Site, surface water flooding affects western areas, with the water shown to pond in low points such as around the existing factory at Abercanaid in the 3.3% AEP event. In the larger magnitude events, there appears to be surface water flooding collecting in both western and northern parts of the site, with flow routes that convey water south toward Graig Road. The 3.3% AEP, 1% AEP and 0.1% AEP event surface water flood extents have been provided as Figure 9.

The surface water risk seems predominantly a result of existing topographic depressions rather than overland flow routes through the site, as labelled in Figure 9. Therefore, this risk should be mitigated against through development as the topography will be altered from its existing state, ensuring that depressions are not created where surface water can pond.

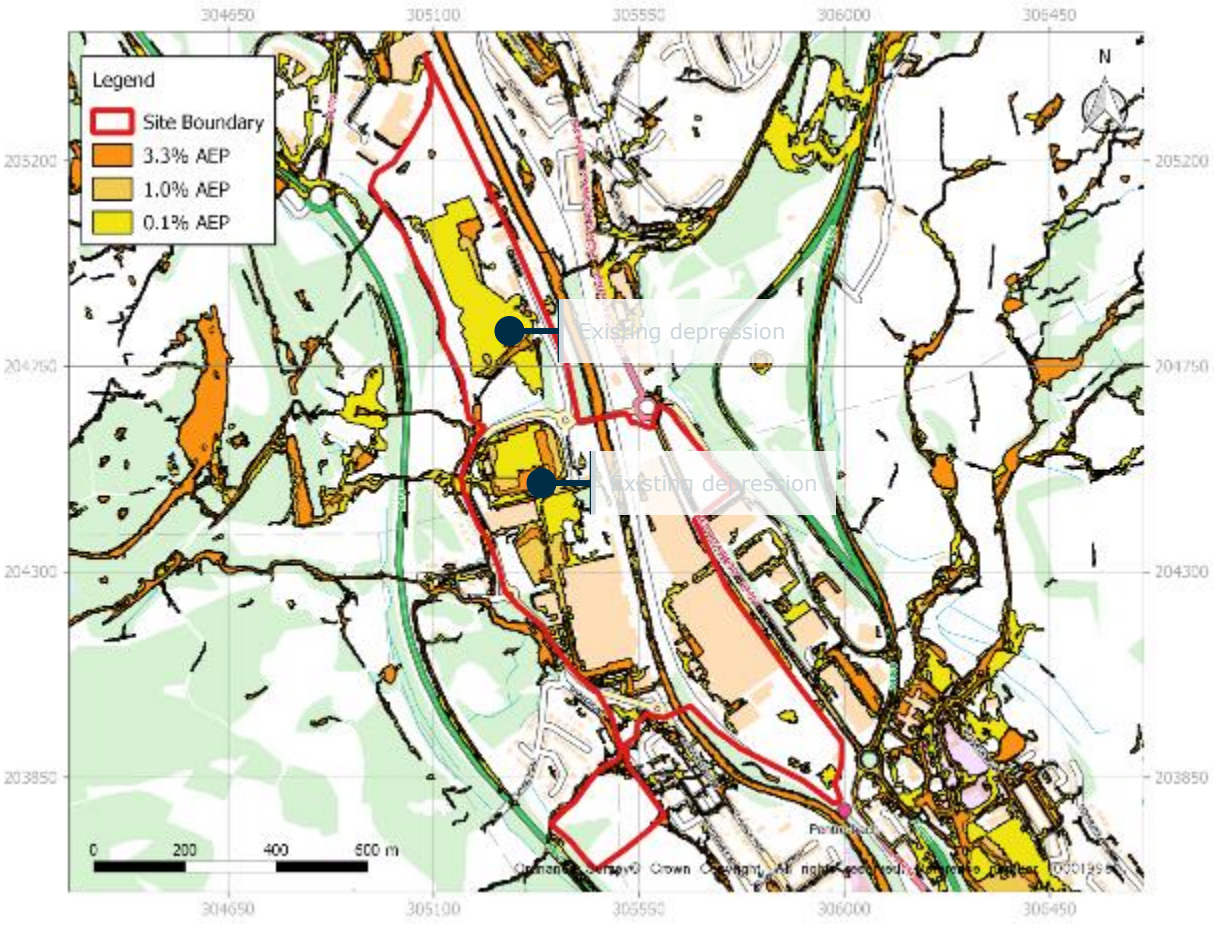


Figure 9 - Surface Water Flood Map

4.1.9 Access & Egress

Flood risk to access/egress routes should be reviewed in light of guidance outlined in TAN15. This is to ensure that residents/customers are able to safely evacuate during times of flood, and to allow emergency surface to access when necessary. For the mixed development area to the east of the River Taff (see Figure 2), access will be via the A4054/Merthyr Road via new road junctions to the north. This route remains flood free up to and including the 0.1% AEP extreme fluvial event. Figure 10 shows the proposed access routes.

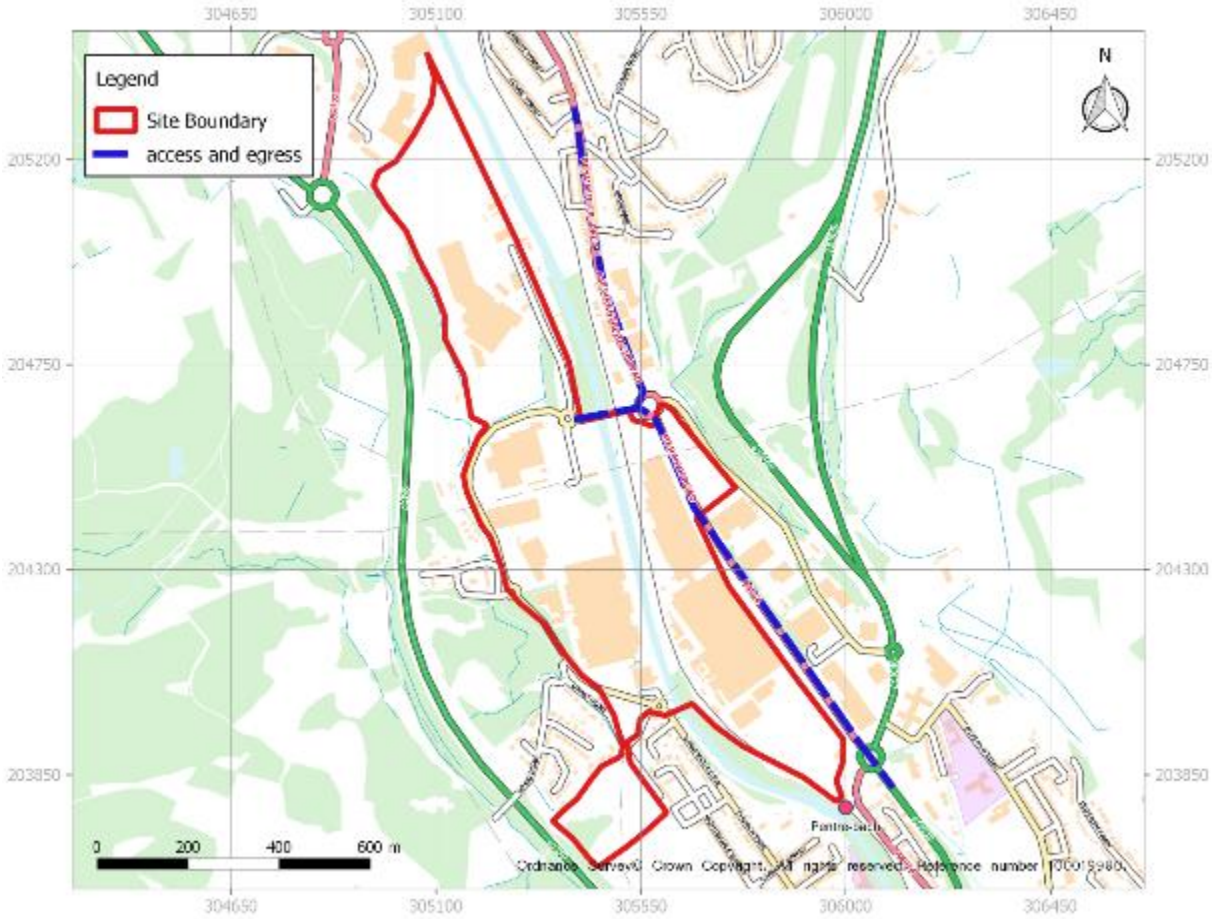


Figure 10 Hoover Site access and egress route

The west of the site is proposed to be accessed via the existing Brandy Bridge over the River Taff that currently serves Abercanaid, using the existing roundabout. This would be the only route to and from the site as it currently stands. Viability of the Brandy Bridge as a suitable access and egress route should therefore be confirmed during a site specific FCA. A new spine road could be provided in addition to the upgrading of existing local roads where required. This route is predicted to be flood free up to and including the 0.1% AEP extreme fluvial event according to the WHS model of the River Taff. This access route is preferred over the minor road to the west as this could be subject to flooding from the Nant Canaid and Nant Graig. It should be noted that the masterplan for the site is currently underway with site plans/layouts subject to change. Therefore, it is recommended that the access/egress routes are finalised with the developer as part of a site specific FCA.

4.1.10 Site Suitability

Based on existing NRW and TAN15 DAM mapping, approximately 51% of the current indicative proposed residential development area (highly vulnerable) is located in DAM Zone C2, which is not permitted by TAN15. However, the flood map in this area is based on coarse resolution JFLOW data, which has been known to overestimate flood extents.

The WHS hydraulic model of the River Taff has confirmed that the flood risk within the Hoover site is confined to the north of the site. Therefore, as this area of the site is located in Zone C2, it is recommended for use as commercial development (less vulnerable development). However, it must be demonstrated that any proposed development will pass the justification test as set out in TAN15, including the acceptability of flood consequences outlined in Table A1.15. A review of the model data currently available indicates that this may be possible, as velocities are largely less than 0.3m/s. Depths are relatively variable (Figure 8) and are lowest to the east and south, below 0.6m. Where depths are above this, ground raising could be considered, providing that there are no third-party impacts on flood risk.

It may be possible to manage flood risk from the River Taff by building up ground or access road levels to reduce the risk of flooding to the northern area of the site. This may then enable development of this area for housing, subject to an amendment of the DAM map and an assessment of third party impacts.

As discussed, the WHS model shows the risk emanating from the River Taff only, and does not include flood risk from the ordinary watercourses to the west i.e. the Nant Canaid and Nant Graig. Hydraulic modelling of the Nant Canaid is currently ongoing as part of the Dragon Parc Modelling Study (Thomas Mackay, 2017), with requirements for the modelling agreed with NRW. Therefore, any development at south western parts of the site should consider this risk, using the detailed hydraulic model to confirm the flood risk from the Nant Canaid. Preliminary results show relatively insignificant refinements in the flood extent; however, mitigation modelling is still ongoing.

In terms of the Nant Graig, no model data currently exist so the flood risk from this watercourse is unknown. Therefore, any development in the boxed area to the south west of the site (labelled in Figure 6) will need to consider the risk from this watercourse.

Parts of the south west of the site are shown to be at risk (DAM Zone C2) from the Nant Canaid. This should be confirmed using the detailed hydraulic model of the Nant Canaid (currently ongoing) to verify flood extents. Therefore, considering the existing data, this area would be more suitable for less vulnerable, commercial development, providing that the justification test is passed. There may be scope for residential development in the south west of the site should detailed mitigation modelling show a reduction in DAM Zone C2 (or change to C1 if flood defences are used) as part of a future site specific FCA.

Based on the current data, the residential area west of the River Taff is considered unsuitable for allocation. The masterplan should seek opportunities to locate highly vulnerable development in areas of lower flood risk e.g. areas in Zone A, B or C1. Following a review of the existing flood risk data available at present, there is potential for the highly vulnerable development to be strategically located in eastern parts of the site (currently proposed as mixed use), as the area is shown to be in a mixture of DAM Zones A and B. For a site specific FCA, further work will be required, see section 4.1.11.

4.1.11 Site Specific FCA Recommendations

Should MTCBC wish to consider this site further as a potential allocation for the Deposit Plan, the following should be addressed as part of a site specific FCA:

- If less vulnerable development (commercial and retail) is proposed in DAM Zone C2, ensure that the justification test is passed. This should include an analysis of third party impacts and acceptability of flood consequences in line with Table A1.15 of TAN15.
- It is recommended that the River Taff model is further developed for development in areas at risk in north of the Hoover site to assess the viability of sustainable options to reduce flood risk in this area and assess third party impacts.
- For development in the south west of the Hoover site, a site specific FCA should include detailed modelling of the Nant Canaid to verify flood extents. If highly vulnerable residential development is proposed, a flood map challenge will be required.
- Further assessment of the Nant Graig will be required for development in the south west of the site, as no model data currently exist for this watercourse.
- Although most of the site is brownfield development, there may be opportunity to reduce surface water run-off rates. A site specific FCA should also recommend SuDS techniques where appropriate to address the management of surface water runoff, in line with TAN15.
- Where possible, a site-specific study should consider the potential for natural flood management techniques that provide amenity and environmental benefits. This could include an investigation into culvert removal or the creation of wetland storage features.

4.2 Bus Station

4.2.1 Site Background and Historical Use

The existing bus station site is located in central Merthyr Tydfil off Castle Street and with land adjoining the A4054 (NGR 304822 206172). The majority of the site is developed, as either paved area or as station buildings, however a portion to the western perimeter is currently grassland. The site boundary, as provided by MTCBC, is shown in Figure 11. The existing land area is the site of Merthyr Bus Station with large areas of the site currently paved.

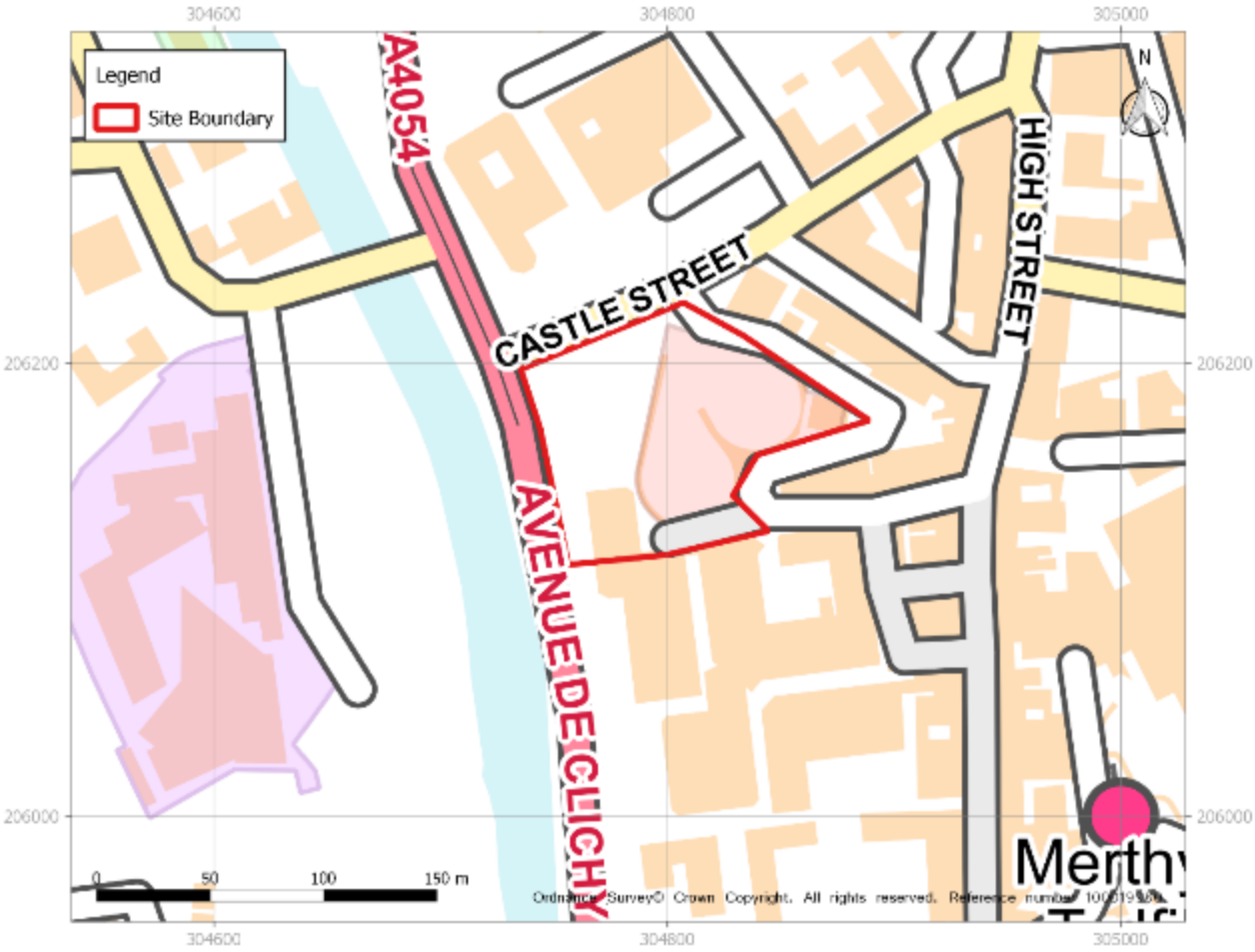


Figure 11 Bus Station site location

4.2.2 Proposed Development

The Bus Station site is intended for use as a retail area, which falls under the "less vulnerable category" in accordance with TAN15. This development type is permitted in Zone C2, where the development meets the requirements of the justification test, outlined in Section 6 of TAN15.

4.2.3 Topography

There is a moderate slope on the site, with a fall toward the River Taff (shown in Figure 12). The lowest elevations are observed along the south and western boundary at approximately 167m AOD, with the highest elevations observed along Wheatsheaf Lane at 172m AOD, suggesting that surface water will drain from the site towards the A4054. The A4054 is assumed to have been raised by a small amount above the natural ground levels, and therefore provides a small embankment to the east of the River Taff; this is however shown not to offer significant protection against more extreme fluvial events (fluvial flood events above the 1% AEP event).

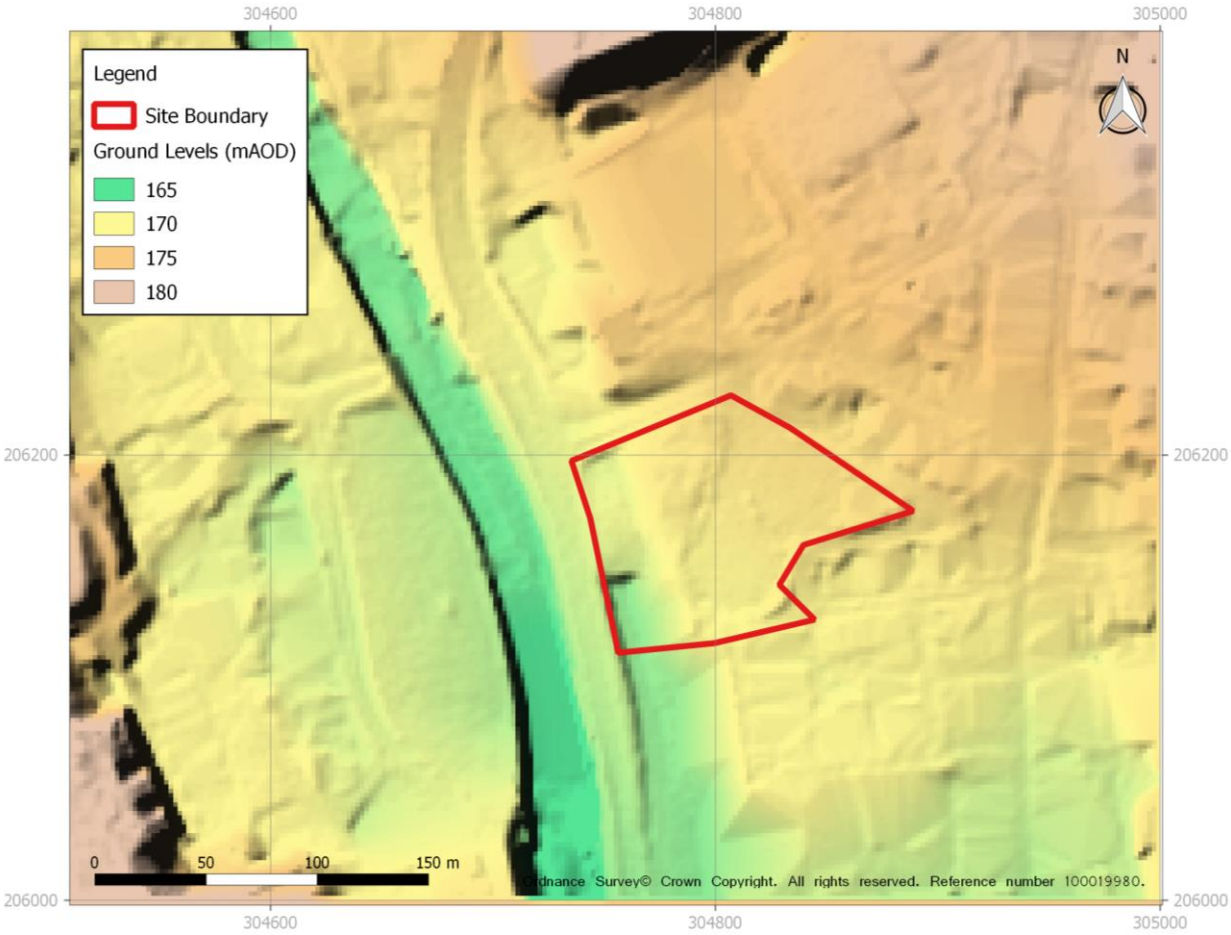


Figure 12 Site topography

4.2.4 NRW Extreme Flood Outline

NRW flood maps show that the site lies wholly in Flood Zone 2, which represents the flood extent associated with the extreme fluvial event (0.1% AEP event). However, it should be noted that the flood map in this area is based on generalised JFLOW modelling, which often provides conservative flood extents. According to the NRW response[15] to the MTCBC Preferred Strategy, the main risk to the Bus Station site is due to flooding from the Nant Morlais, a tributary of the River Taff. The extreme flood outline is available in Figure 13.

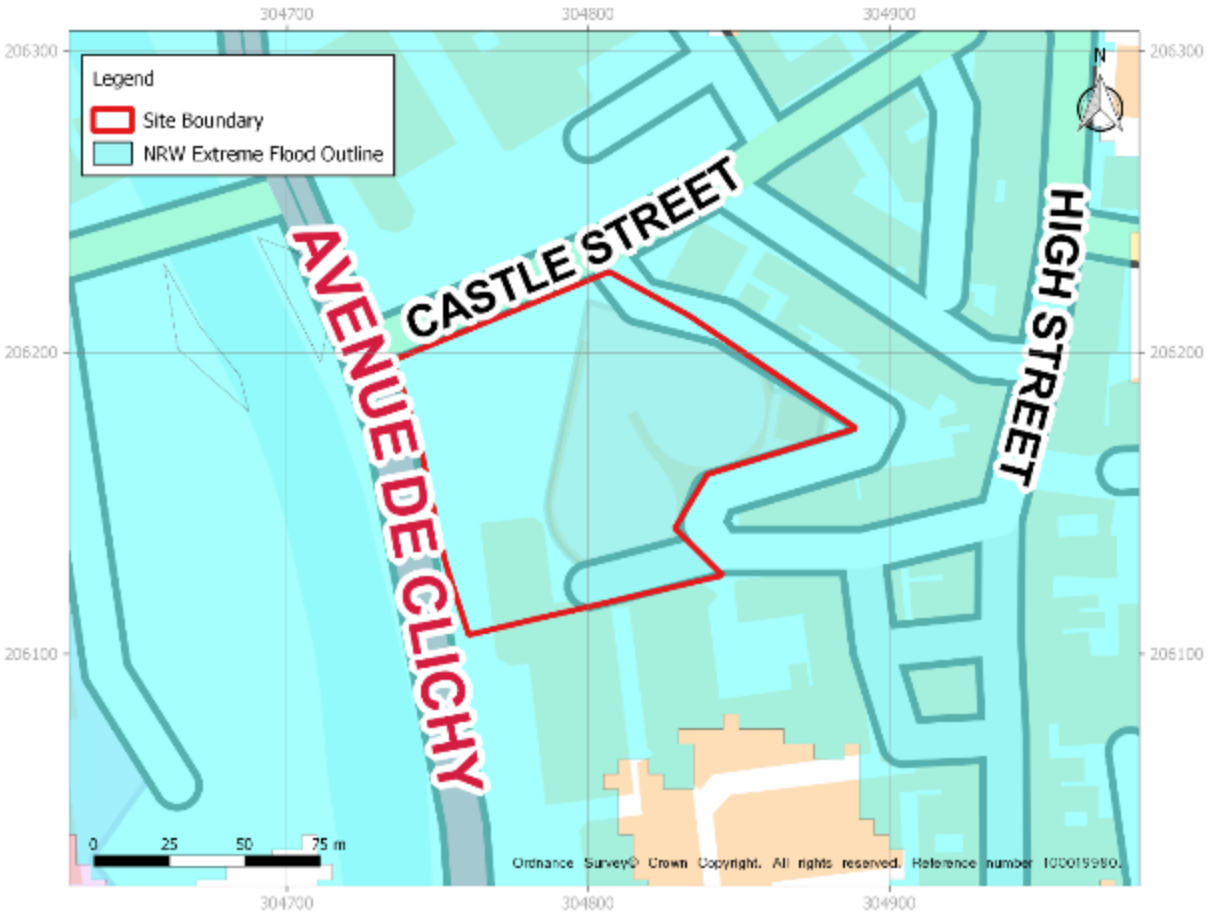


Figure 13 - NRW Extreme Flood Outline

4.2.5 TAN15 Development Advice Map

The TAN15 development advice maps show the site to be entirely within Zone C2, reflecting the fact that it is not protected by any significant flood defence infrastructure. The NRW response to the LDP Preferred Strategy[15] indicates that the risk to the site is predominantly from the Nant Morlais. Less vulnerable development is permitted in DAM Zone C2 providing that the justification test is passed. The DAM map is shown in Figure 14.

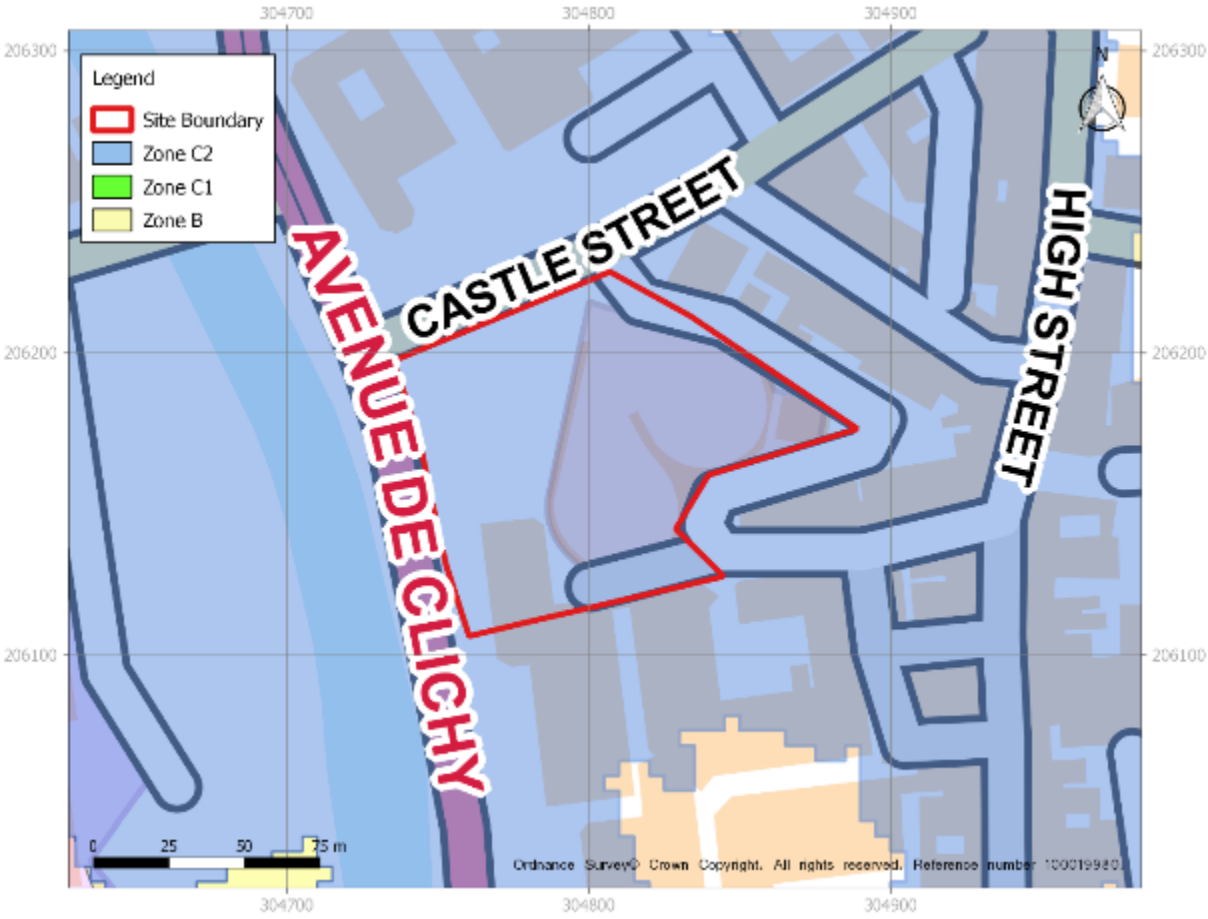


Figure 14 - Welsh Government DAM Map

4.2.6 Hydraulic Modelling

A hydraulic model for the River Taff and Nant Morlais was developed by Capita in 2011, in the form of a 1D/2D linked ESTRY TuFLOW model. This was obtained and used to assess the risk to the Bus Station site in more detail.

From model data provided by NRW (Merthyr Bus Station model, 2011), flood depths and extents can be assessed for the site for the 1% AEP and 0.1% AEP fluvial events. It has been assumed that the far south western corner of site that sits within a topographic depression can be excluded from this assessment, as it is recommended that this minor area is not developed.

During the inception meeting, NRW expressed concern that the hydrology for the Bus Station model was not accurate. Therefore, an updated hydrological analysis of the River Taff and Nant Morlais catchment has been carried out for this version of the SFCA, using the latest FEH techniques. The updated flow estimation was approved by NRW in June 2018. The technical methodology applied to derive the model inflows is provided in the Bus Station Hydrology report, available as Appendix C. A comparison of the existing DAM Zone C2 and the modelled 0.1% AEP extent is available as Appendix D.

1% AEP event

The extent for the 1% AEP event encroaches into the Bus Station site from the north east, covering the majority of the site with the exception of the eastern part of the site. This appears to be a result of a culvert surcharging to the north east along the Nant Morlais, which is labelled in Figure 15. Flood depths however are shallow at 0.01 – 0.10m. Velocities are in the region of 0.05 to 0.40m/s, with the exception of a localised flow path of high velocity flow from the north eastern to central parts of the site, where velocities reach 1.6m/s. The flood extent and depths are displayed in Figure 15.

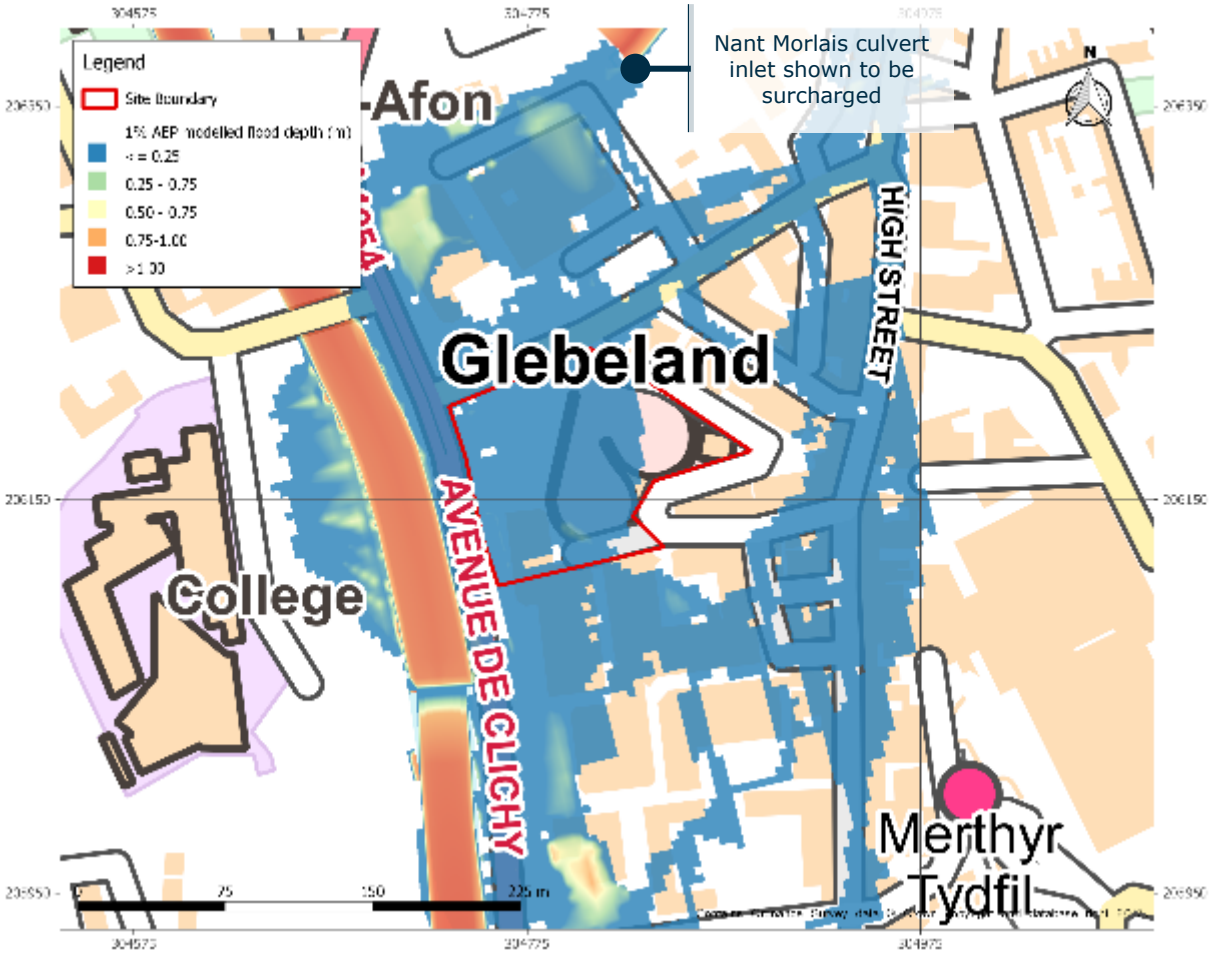


Figure 15 1% AEP fluvial flood depths

1% AEP plus 25% Climate Change Event

A 1% AEP fluvial event plus an allowance for 25% climate change (central estimate – Severn river basin district) was run, with the flood extent and depth displayed in Figure 16. A localised high velocity route from the north eastern to central parts of the site shows velocities of up to 2.0m/s.; however they are more generally between 0.1-0.6m/s. Flood depths are largely shallow, at 0.00-0.15m, increasing to 0.30m at localised spots in the north west and south.

A review of the model outputs shows that the mechanism of flooding is from the Nant Morlais, with flows progressing from a north easterly direction toward the site. This appears to be a result of a culvert surcharging to the north east along the Nant Morlais, which is labelled in Figure 16.

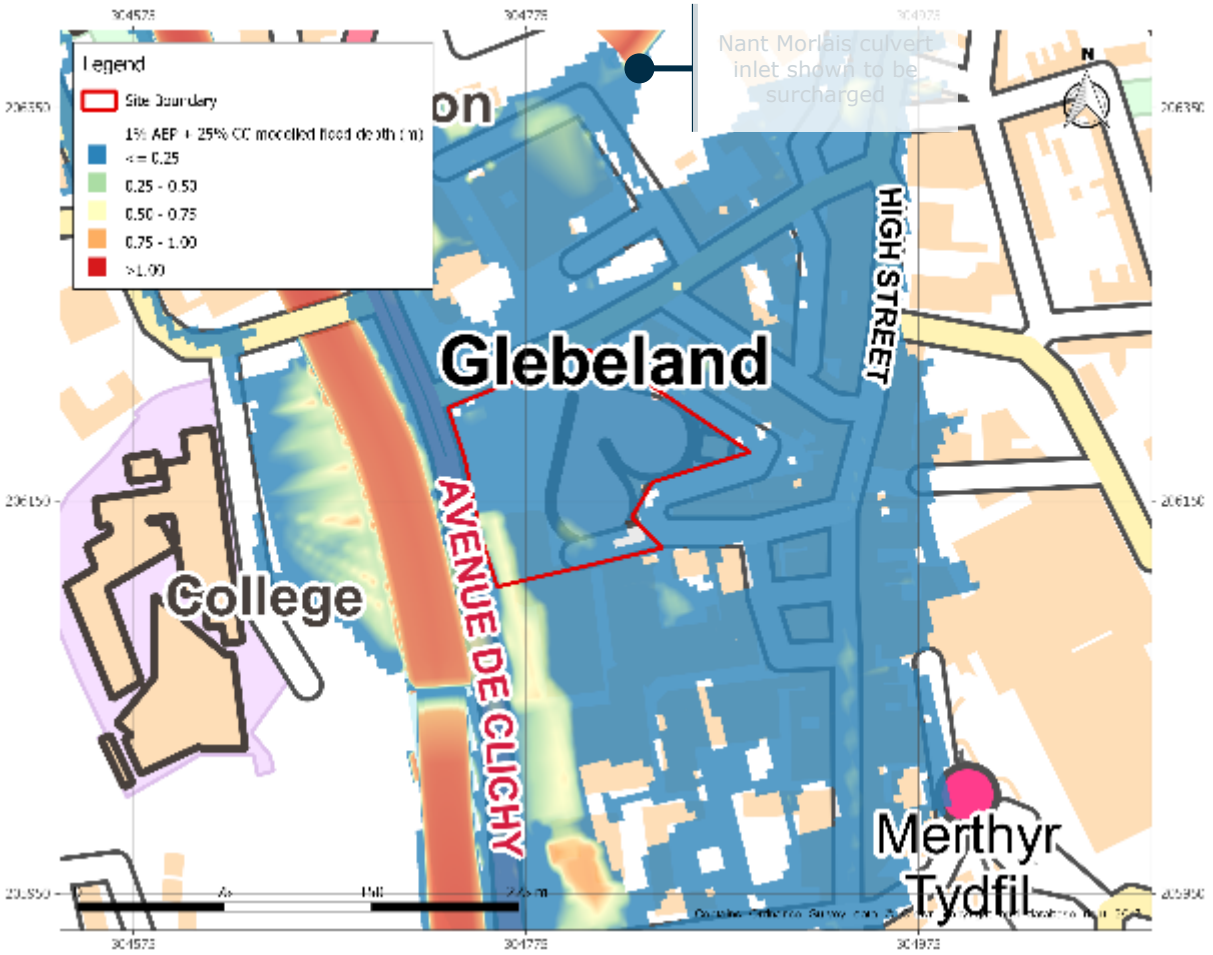


Figure 16 1% AEP plus climate change fluvial flood depths

0.1% AEP event

The 0.1% AEP event aligns more closely with the NRW flood mapping for the area, with the majority of the site shown to be affected. Across the site flood depths are generally shallow, ranging from 0.00-0.20m. A small route of high velocity flow is shown in the model outputs that extends from the north east of the site to central parts of the site, where the velocity is largely above 1.5m/s. Here however, the depths are shallower at around 0.15m. Excluding this flow route, flow velocities are in the region of 0.1m/s – 1m/s, with the velocity reducing at southern part of the site and the estern perimeter. The flood extent and depths are displayed in Figure 17.

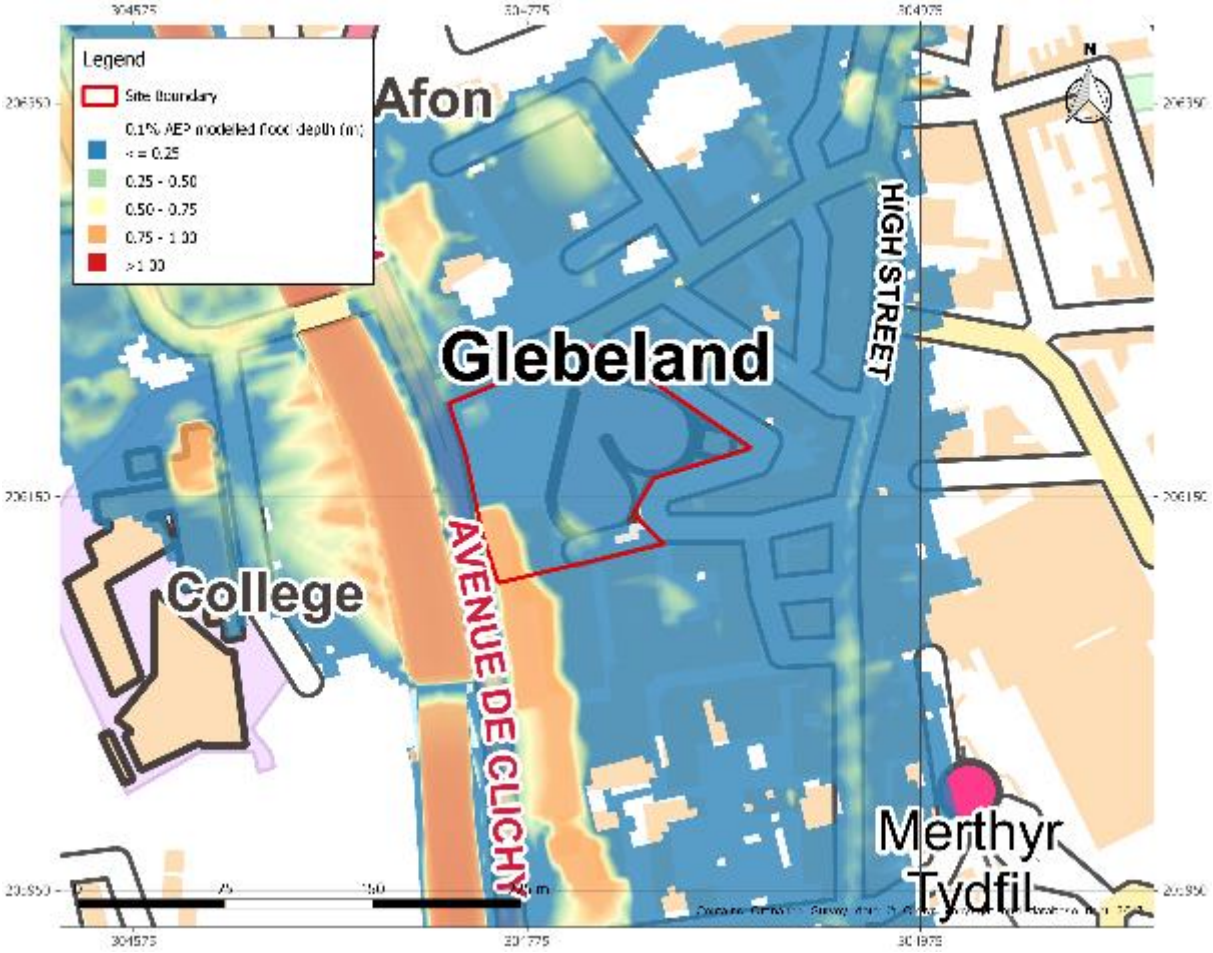


Figure 17 0.1% AEP fluvial flood depths

4.2.7 Third Party Impacts

Mitigation may be required in areas at risk, for example flood defences or ground raising, which can result in impacts on flood risk to 3rd party property or land. In addition, the proposed development alone can displace floodwaters due to increasing the floodplain roughness. Therefore, as part of future site specific FCA's, it is advised that detailed hydraulic modelling is used to assess the impact of any proposed development and associated mitigation on flood risk. The developer should ensure that there is no 3rd party detriment by managing flood waters on site.

4.2.8 Surface Water Flooding

Surface water flooding is predicted to affect the site (further mapping given in Appendix A as figure A10), with ponding in the existing topographical depressions created by the bus station yard. Approximately 10% of the site is affected by the 1 in 30yr pluvial event, whilst 30% is affected by the 1% AEP event. This is particularly evident within the paved areas, currently constituting the bus yard, where water is shown to drain from Castle Street and pond within this area. This likely reflects that the areas around the yard have been raised, thus effectively damming the water within in this area. It is considered that this pattern of surface water ponding will not be replicated upon any redevelopment, where the site topography will be altered from its existing state. A more detailed surface water flood map is displayed in Figure 18.

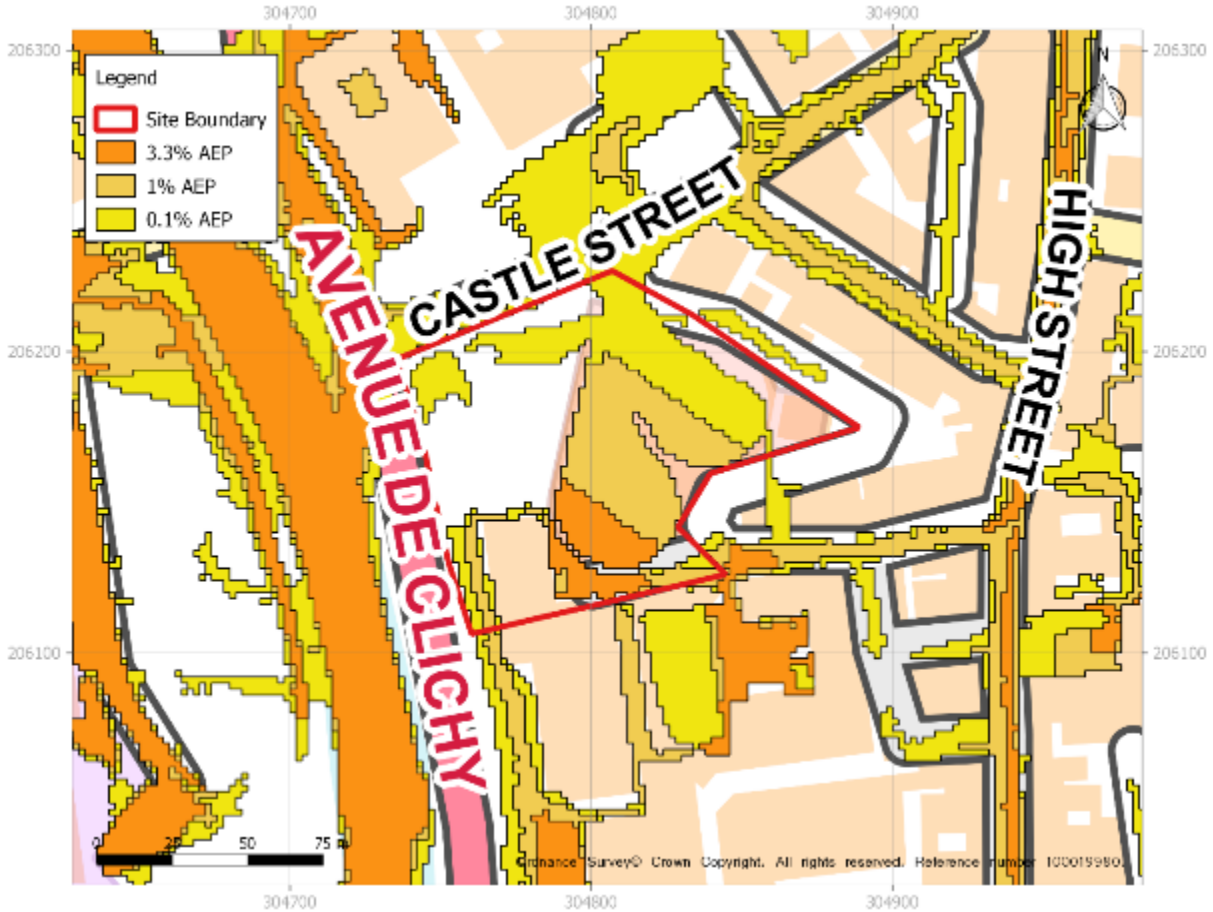


Figure 18 - Surface water flood map

4.2.9 Access & Egress

All access roads are predicted to be affected by the 0.1% AEP fluvial flood extent. It is recommended that a route be taken from the site, eastward bound along Castle Street, turning south east toward High Street, followed by travelling south along Upper/Lower Thomas Street. From this point, a route east from Merthyr Tydfil centre can be taken, away from the farthest reaches of flooding from the River Taff and Nant Morlais. This route has been chosen as it represents the shortest pathway from flooded regions, in addition to crossing areas with lower hazard values, generally less than 0.75 (caution, low hazard), with some localised patches along High Street rising above 1.25 (danger for most) in the extreme event.

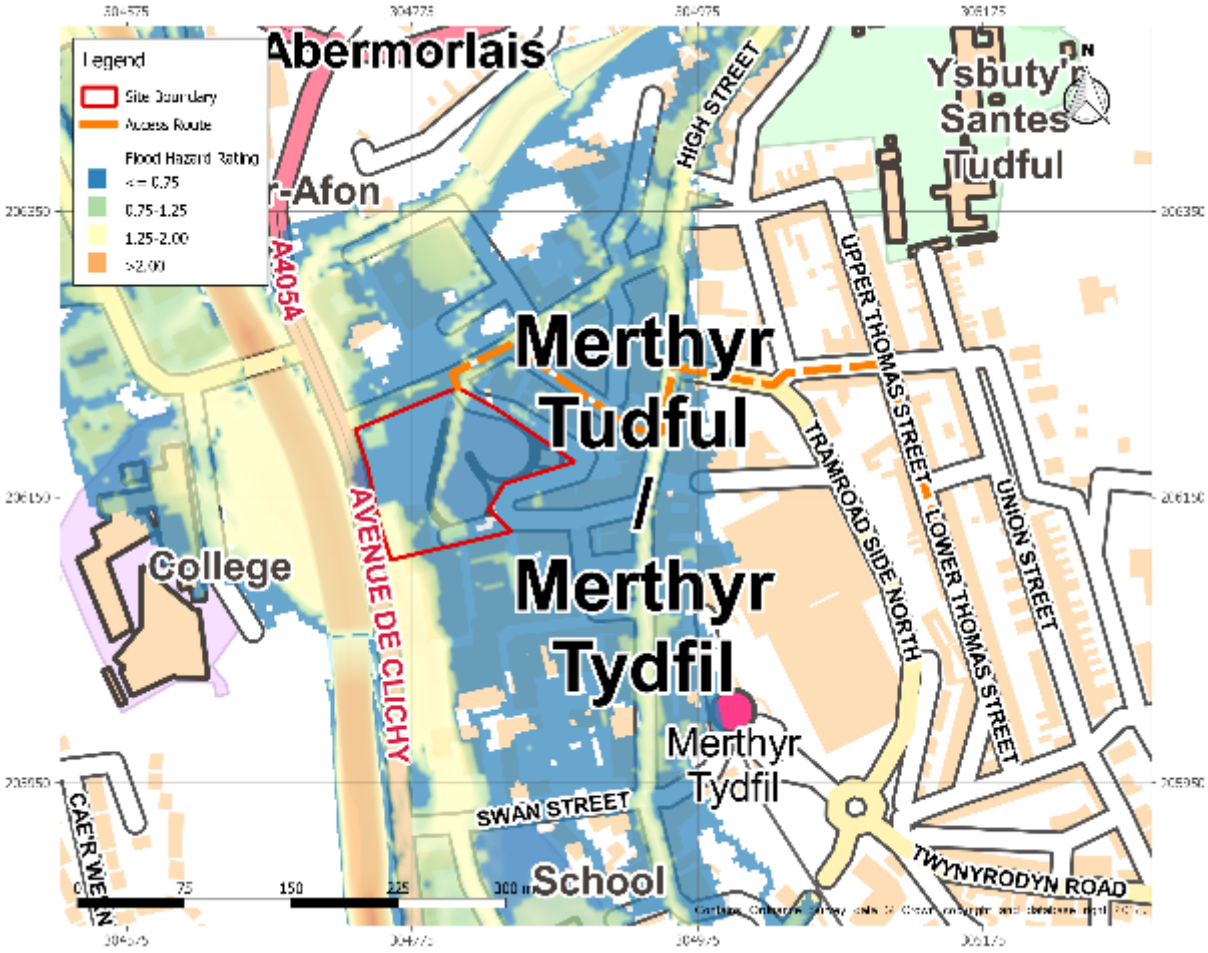


Figure 19 Recommended access/egress routes from the bus station site. Overlaid onto 0.1% AEP hazard rating

4.2.10 Site Suitability

No formal flood defences exist in the area, thus the bus station site is designated Zone C2 status on the Development Advice Maps. Commercial development is classed as less vulnerable and is permitted in Zone C2, providing that the Justification Test is passed. The requirements for the Justification Test are outlined in paragraph 6.2 of TAN15. It should be highlighted that the development will form part of the draft local plan and has been highlighted by MTCBC as a Strategic Development Area. The Bus Station site is also identified in the 2011 adopted Local Development Plan. These will help determine the justification for development within a site specific FCA.

The development should not flood during the 1% AEP event (currently shown to flood according to the existing model with updated hydrology) and should flood to acceptable depths in the 0.1% AEP (depths are less than the indicative value of 0.60m provided in TAN15). However, the current data indicate that velocity values are generally above 0.3m/s, which is the indicative value outlined in table A1.15 of TAN15 for the 0.1% AEP event. This has been confirmed using an updated hydrology assessment requested by NRW and MTCBC, for this version of the SFCA.

Although the site is predicted to flood during the 1% AEP plus 25% climate change scenario according to the Bus Station model, it is noted that, as outlined previously, flood depths for the site are relatively shallow. This suggests that the majority of the site could be lifted above flood levels using minimal ground raising and raised finished floor levels. However, it must be demonstrated that any ground raising will not have a negative impact on flood risk to 3rd party land. It has been assumed that the far south western corner of the site will be omitted from future development plans as it lies in an existing topographic depression.

Based on the existing data available, the site is considered unsuitable for allocation. However, a site specific FCA for the site could demonstrate otherwise. It is recommended that a site specific FCA consider the issues outlined in section 4.2.11.

4.2.11 Recommendations for a Site Specific FCA

Should MTCBC wish to consider this site further as a potential allocation for the Deposit Plan, the following should be addressed as part of a site specific FCA:

- Undertake a detailed review of the hydraulic model of the Nant Morlais to assess scope for further refinements including representation of the culvert inlet near the Bus Station and a storage basin at Pant (SO0642008667).
- Demonstrate that any proposed development will not exacerbate flood risk to 3rd party land using hydraulic modelling.
- Ensure that the site is compliant with Appendix 1 of TAN15, in particular regarding predicted flow velocities and ensuring an appropriate development layout to accommodate any residual flow routes.
- Ensure that the development meets the requirements of the Justification Test.
- Ensure that any increase in paved area uses SuDS techniques to manage surface water, as per TAN15 requirements.

4.3 Merthyr Vale

4.3.1 Site Background and Historical Use

The site covers 15ha of land that lies to the east of the River Taff and to the west of the A4054 between the existing railway line and the new link road, Golwy Yr Afon (NGR: SO 07379 00037). The link road was constructed in 2015 and acts as a flood defence against the river Taff which lies to the west of the road, around 20m to the west of the site boundary. The site is located on to the east of the town of Aberfan which lies approximately 600m to the west of the site. Figure 20 shows the location of the site.

Historically, the site operated as a colliery and was remediated between 1997 and 1999. The site has previously been granted planning permission, however this elapsed in 2016. Following this Merthyr Tydfil County Borough Council alongside NRD implemented a series of flood defence measures to support development of the site. The site has now been granted planning permission (planning ref: P/17/0345) with development expected to progress in due course.

Figure 20 Merthyr Vale Site Location

4.3.2 Proposed Development

The proposed development consists of 153 residential dwellings with a mixture of open market and affordable homes with associated car parking, access and landscaping. The site currently occupies 15ha of greenfield land and the proposed residential dwellings will form part of a wider range of regeneration projects contributing to meeting the housing needs within the Merthyr Tydfil Local Development Plan.

4.3.3 Topography

The proposed site lies to the east of the newly built Golwy Yr Afon link road bounded by the road and the railway line to the west. The site has a maximum width of 180m at its centre and a maximum length of 570m from north to south. The lowest elevations within the site lie to the west where ground levels are around 128m AOD, rising towards the eastern boundary of the site to around 130m AOD. A small embankment runs along the eastern boundary of the site parallel to the train line where maximum elevation reaches around 140m AOD. The overall site has highest elevations towards the north with elevations gently decreasing in a southerly direction. The site topography is displayed in Figure 21.

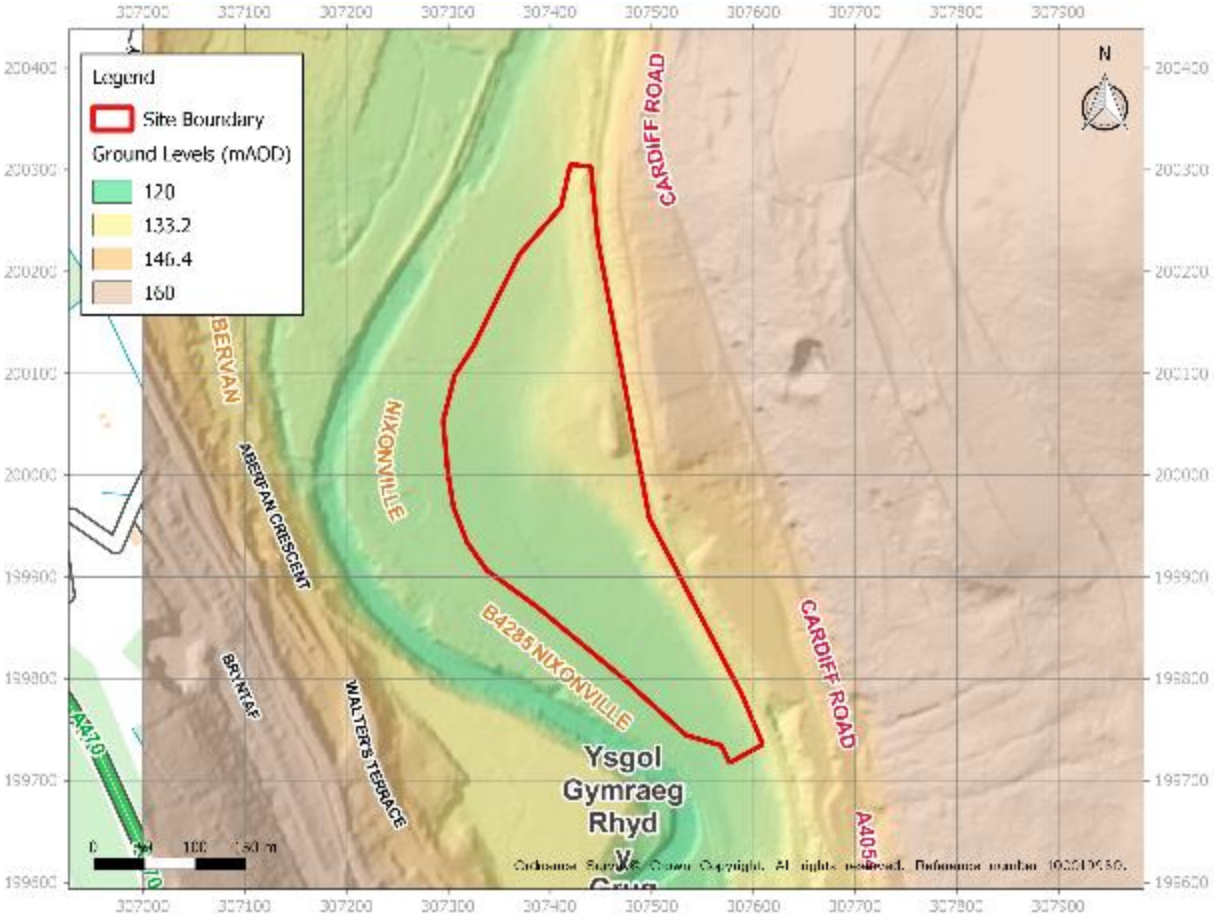


Figure 21- Merthyr Vale Site Topography

The River Taff lies approximately 100m from the western boundary of the site, the river follows the curve of the newly built link road which acts as a flood defence. Two culverted ordinary watercourses

discharge into the River Taff along Nixonville road, which lies approximately 30m to the west of the development site.

4.3.4 NRW Extreme Flood Outline

NRW flood mapping shows that the majority of the site lies within Flood Zone 2, this indicates that the area is at risk from flooding in the 0.1% AEP event. However, the NRW flood map represents flooding as a result of undefended scenarios; additional modelling has shown that with the addition of the new link road the site is not at risk from flooding during such an event. Approximately 71% of the site is covered by Flood Zone 2. This is represented in Figure 22.

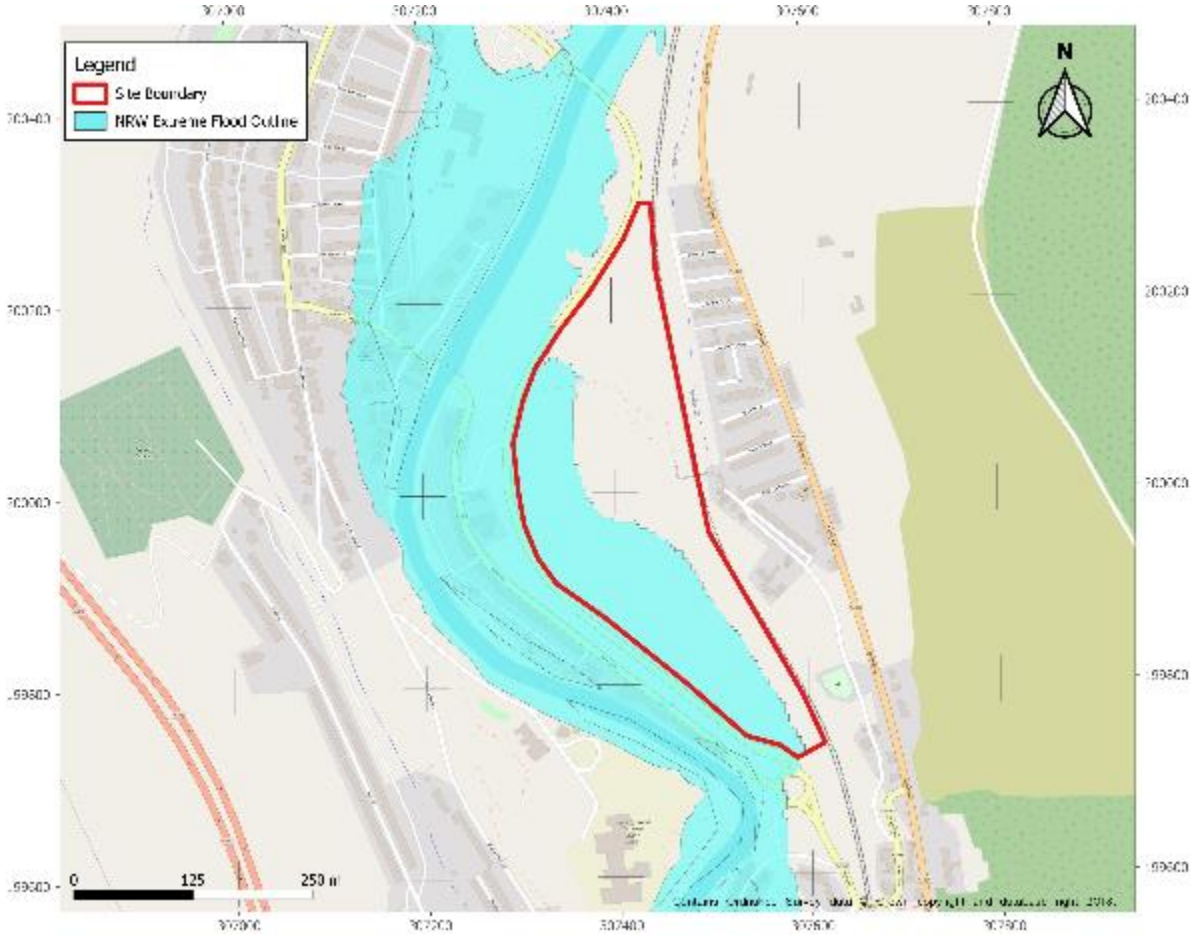


Figure 22 - NRW Extreme Flood Outline

4.3.5 TAN15 Development Advice Map

Historically the site was situated in Zone C2, however, the recent addition of the link road which acts as a flood defence has reduced the risk of flooding on site. The proposed residential development is classed as 'highly vulnerable development' based upon TAN 15 guidelines. The NRW DAM indicates that the site lies within Zone C1, an area of the floodplain which is developed and served by significant infrastructure, including flood defences. TAN 15 states that in Zone C1 "development can take place subject to application of justification test, including acceptability of consequences". A small area is defined as being within Flood Zone B (areas known to have been flooded in the past evidence by sedimentary deposits) and Zone A (considered to be at little or no risk of fluvial or tidal/coastal flooding). Modelling of the River Taff as part of the Merthyr Vale FCA (Jubb Consult, 2018) for a 1% AEP fluvial flood event with 25% climate change allowance predicts that the site is protected with the addition of a 500mm freeboard. The site is also shown to be flood free during the 1000-year event. The DAM is displayed in Figure 23.

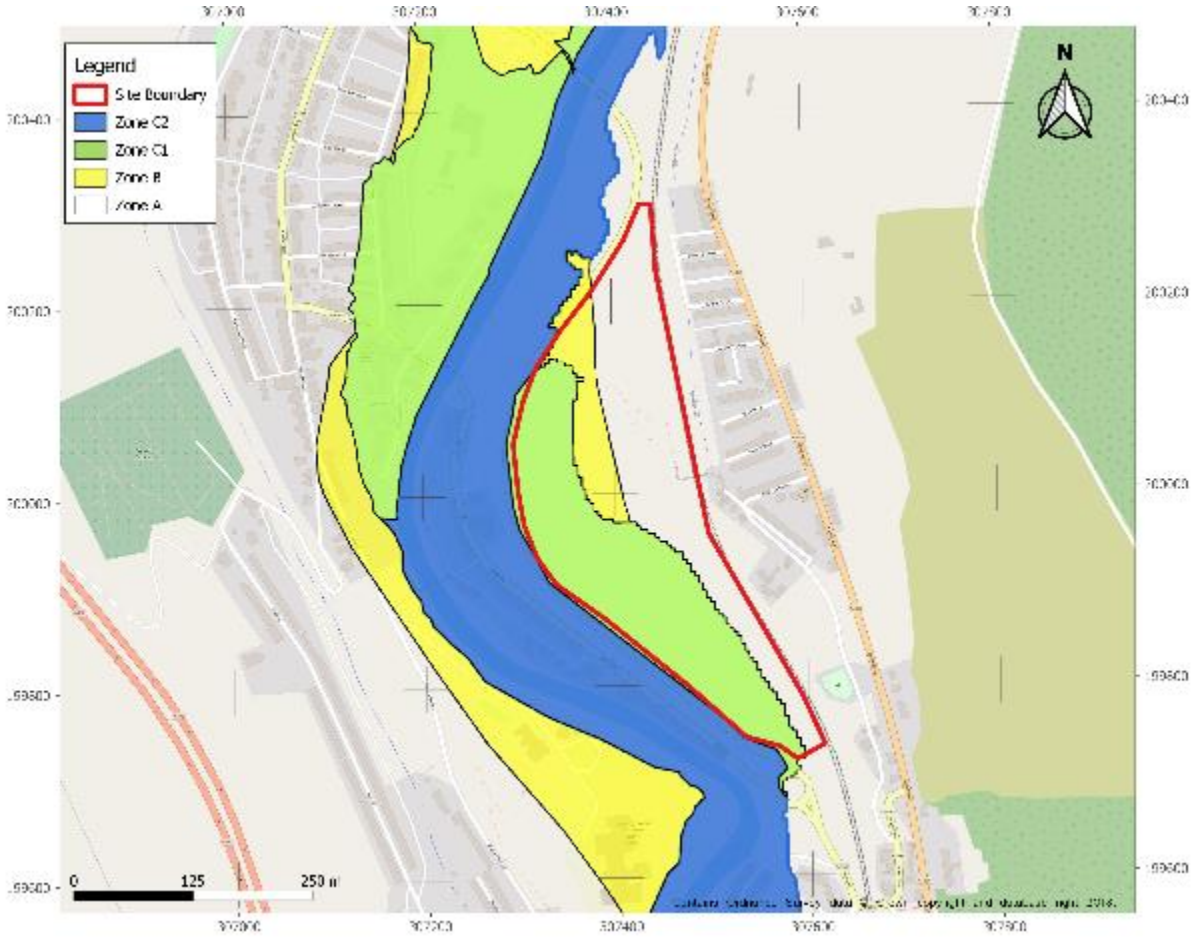


Figure 23 - Merthyr Vale DAM

4.3.6 Hydraulic Modelling

Hydraulic modelling for the site was completed by JBA in 2017 as part of a successful flood map challenge (the model has been accepted by NRW). Following the flood map challenge, the NRW Development Advice Maps were updated accordingly. The site has moved out of Flood Zone C2, due to the inclusion of the new flood defence scheme and highway within the model, and now lies within Flood Zone C1. Flood Zone C1 indicates that the site is suitable for residential development, providing that the justification test can be passed. This has recently been demonstrated, resulting in the site being granted planning permission.

4.3.7 Third Party Impacts

As the site is defended up to and including the extreme fluvial event, there should be no 3rd party impacts from fluvial sources, as the flood event does not reach the site.

4.3.8 Surface Water Flooding

NRW mapping indicates that minor parts of the site are at high risk of surface water flooding in the 3.3% AEP event. The site has several ditches that collect surface water flows and drain from the embankment along the eastern boundary towards the central, flatter area of the site. The surface water flood risk to the overall site is not considered significant. The surface water flood map for the site is shown in Figure 24.

Figure 24 - NRW Surface Water Flood Map

4.3.9 Access and Egress

Access to the site is available via the Golwy Yr Afon link road which was constructed in 2015. This road constrains the eastern boundary of the site. Towards the south of the site there is a roundabout which feeds into the Golwy Yr Afon with a turning already constructed into the site, from here Cardiff Road to the east of the site can be accessed. Cardiff Road is shown to remain flood free in the 0.1% AEP event. It is expected that given the Golwy Yr Afon acts as a flood defence, the road will remain flood free in defended model runs. Access along Cardiff Road remains flood free to the south in the 0.1% AEP event. The proposed access routes are shown in Figure 25.

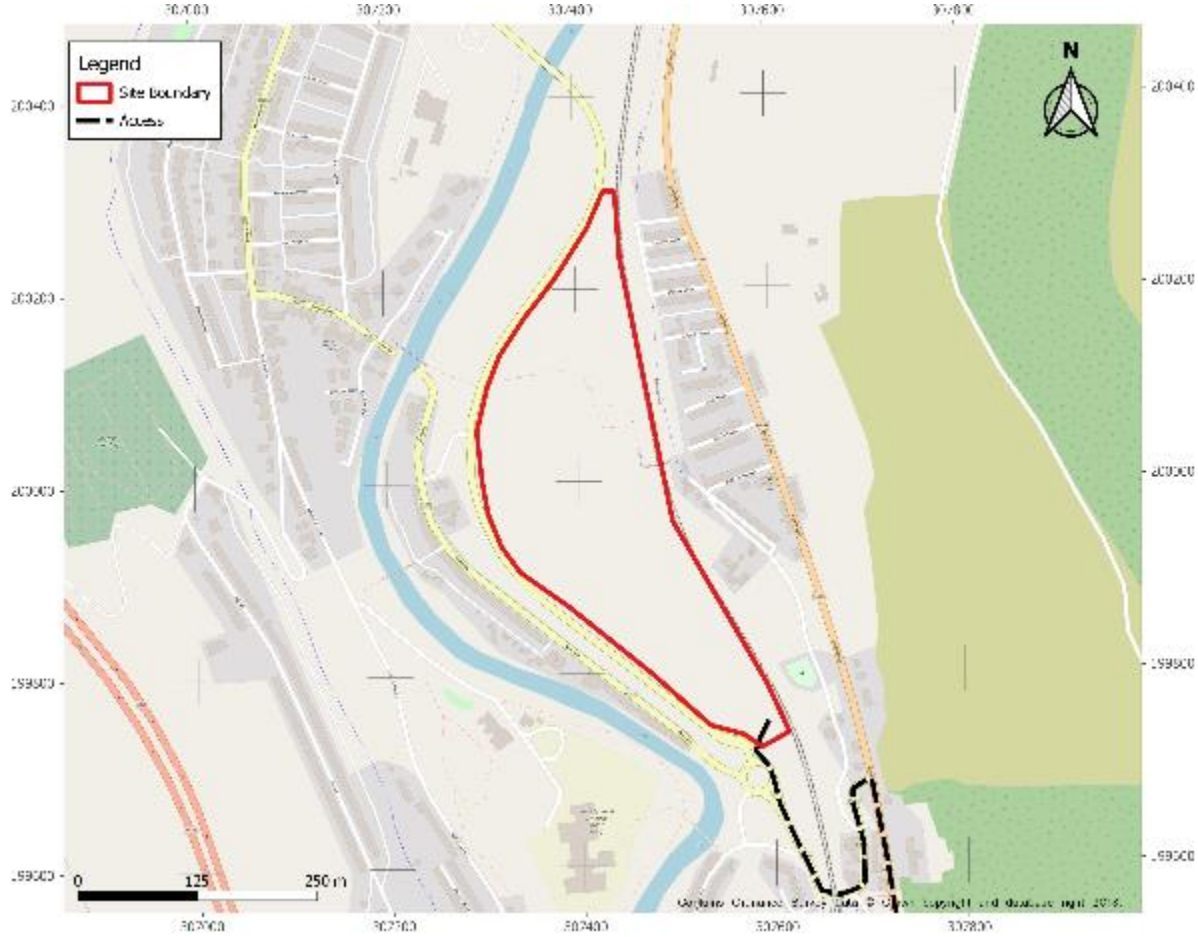


Figure 25 Merthyr Vale proposed access and egress route

4.3.10 Site Suitability

As a remediated former colliery, the site forms a key part of the local authority's regeneration initiative and provides a suitable area for urban housing required in Aberfan and Merthyr Vale. Therefore, despite the site lying within Zone C1, it is considered to meet the requirements of a justification test. A site specific FCA (Jubb Consult, 2018) has demonstrated that the justification test has been passed, this site has received planning consent (planning ref: P/17/0345) with development at the site set to progress.

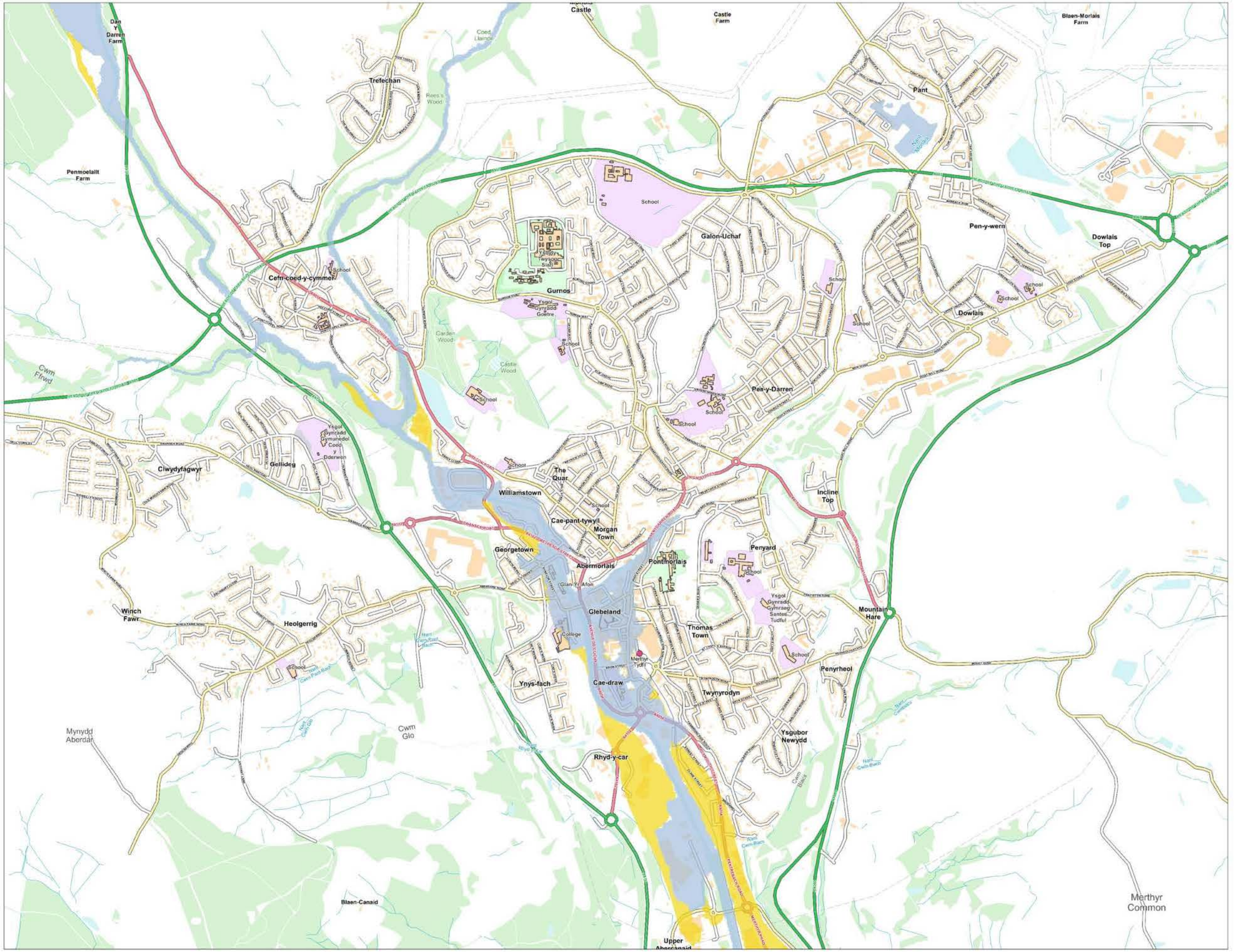
4.4 Emergency Planning

In addition to the access and egress routes defined for the three SDA's, it is imperative that emergency planning, suitable for the development type is established.

Large parts of the SDA's lie within a NRW Flood Warning Area, such that warnings are expected to be issued if flooding is possible. There is also a 5-day flood forecasting system available on the NRW website. Flood warnings are available from NRW by a preferred contact method e.g. by phone or email. It is recommended that landowners/property owners in flood risk areas shown on mapping provided in Appendix A sign up to this service. There also exists a river gauging station at Georgetown in Merthyr Tydfil, to which live river levels are published sub daily. It is essential that any early flood warnings are heeded and that, where required, there is an effective evacuation plan in place for the site.

Appendix A – Flood Maps

Report Figure No.	Description
A1	Development Advice Map: Central Merthyr
A2	Development Advice Map: Abercanaid
A3	Development Advice Map: Merthyr Vale
A4	NRW Flood Map: Central Merthyr
A5	NRW Flood Map: Abercanaid
A6	NRW Flood Map: Merthyr Vale
A7	Historic Flood Map: Central Merthyr
A8	Historic Flood Map: Abercanaid
A9	Historic Flood Map: Merthyr Vale
A10	Surface Water Flood Map: Central Merthyr
A11	Surface Water Flood Map: Abercanaid
A12	Surface Water Flood Map: Merthyr Vale
A13	Ordinary Watercourse Map: Study Area



Legend

TAN15 Development Advice Map Zones

- Zone C1
- Zone C2
- Zone B
- Zone A

N

0 250 500 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
TAN15 Development Advice Map (DAM) for Central Merthyr Tydfil

Figure number:
WHS1580-T02-001-R01

WHS

Heolgerrig
Tudful / Merthyr Tydfil
College
Thomas Town
Hare
School
Penyrheol
Ynys-fach
Cae-draw
Twynyrodyn
Pen-Coedcae
Ysgubor Newydd
Rhyd-y-car
Cwm Golau
Blaen-Canaid
Merthyr Common
Upper Abercanaid
Blaen-Bargoed Cottages
Pentre-bach
Abercanaid
Pentrebach
Mynydd Cilfach-yr-encil
Cefn Pennar
Pen-Rhiw-'Ronen
Mynydd Gethin
Buarth-Weunydd
Ysgol Plant Lau Troed-Y-Rhiw
Troedyrhiw
Troed-y-Rhiw
Upper Cefn Pennar Cottages
Coly Isaf Farm
Penddeugae-Fâch

Legend

TAN15 Development Advice Map Zones

- Zone C1
- Zone C2
- Zone B
- Zone A

N

0 250 500 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
TAN15 Development Advice Map (DAM) for Abercanaid, Merthyr Tydfil

Figure number:
WHS1580-T02-002-R01

WHS

Legend

- Zone C2
- Zone C1
- Zone B
- Zone A

N

0 250 500 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
TAN15 Development Advice Map (DAM) for south Merthyr Tydfil, Merthyr Vale Area

Figure number:
WHS1580-T02-003-R01

WHS

Legend

- NRW Flood Zone 3 (1% AEP)
- NRW Flood Zone 2 (0.1% AEP)
- NRW Flood Zone 1

N

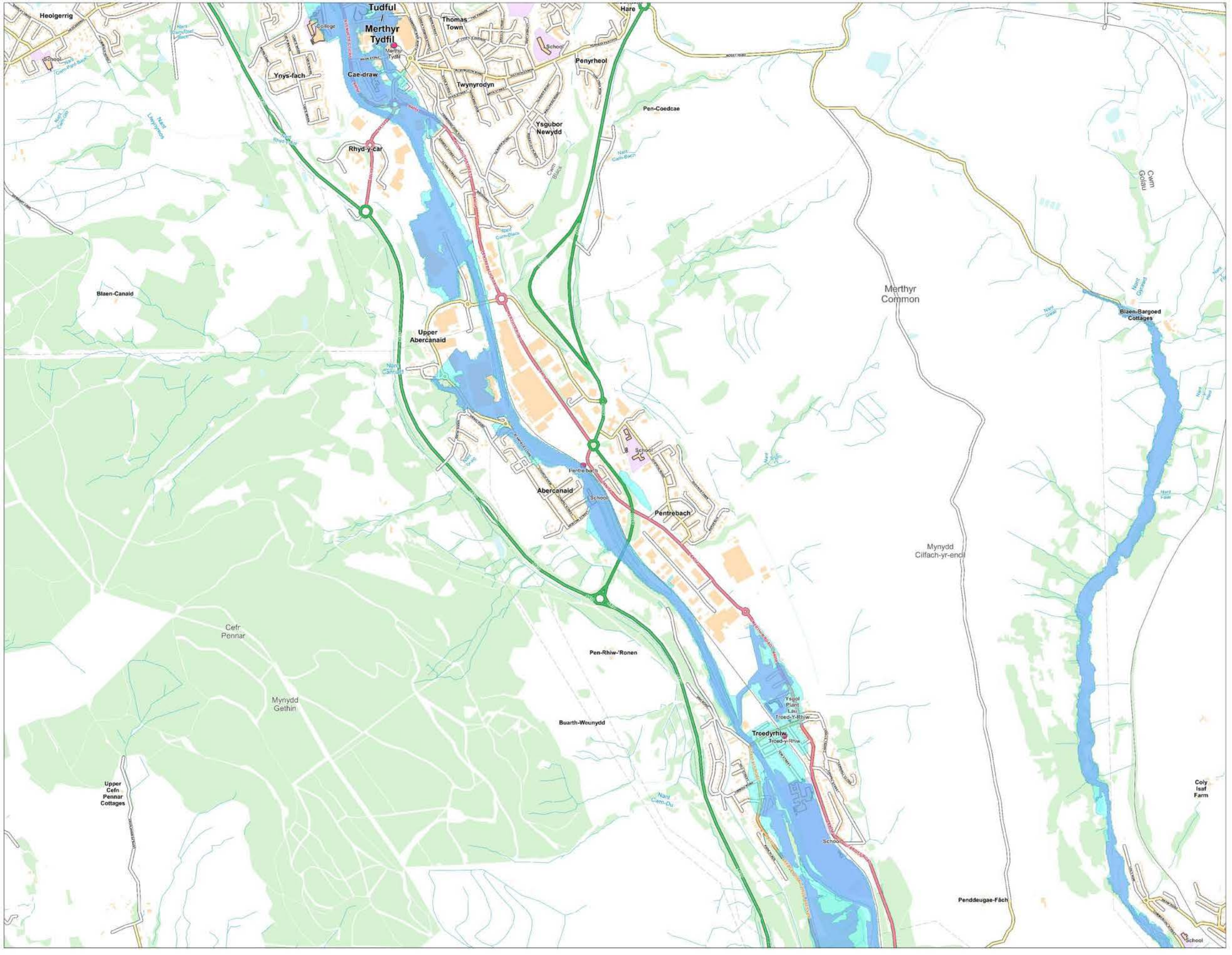
0 250 500 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
NRW flood map for central Merthyr Tydfil

Figure number:
WHS1580-T02-004-R01

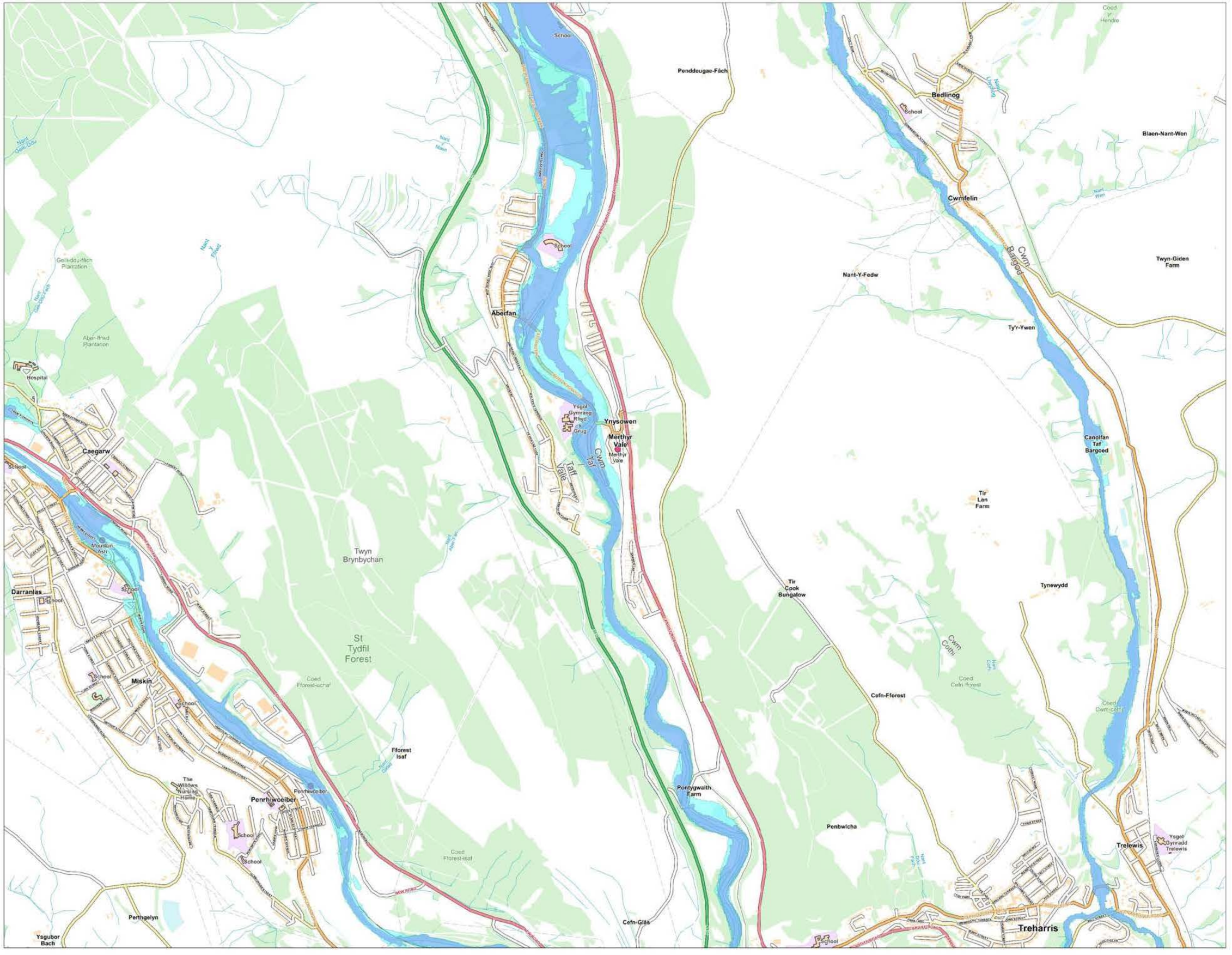
WHS



Project Title:
Merthyr Tydfil SFCA

Figure Title:
NRW Flood Map for Abercanaid, Merthyr Tydfil

Figure number:
WHS1580-T02-005-R01



Legend

- NRW Flood Zone 2 (0.1% AEP)
- NRW Flood Zone 3 (1% AEP)

N

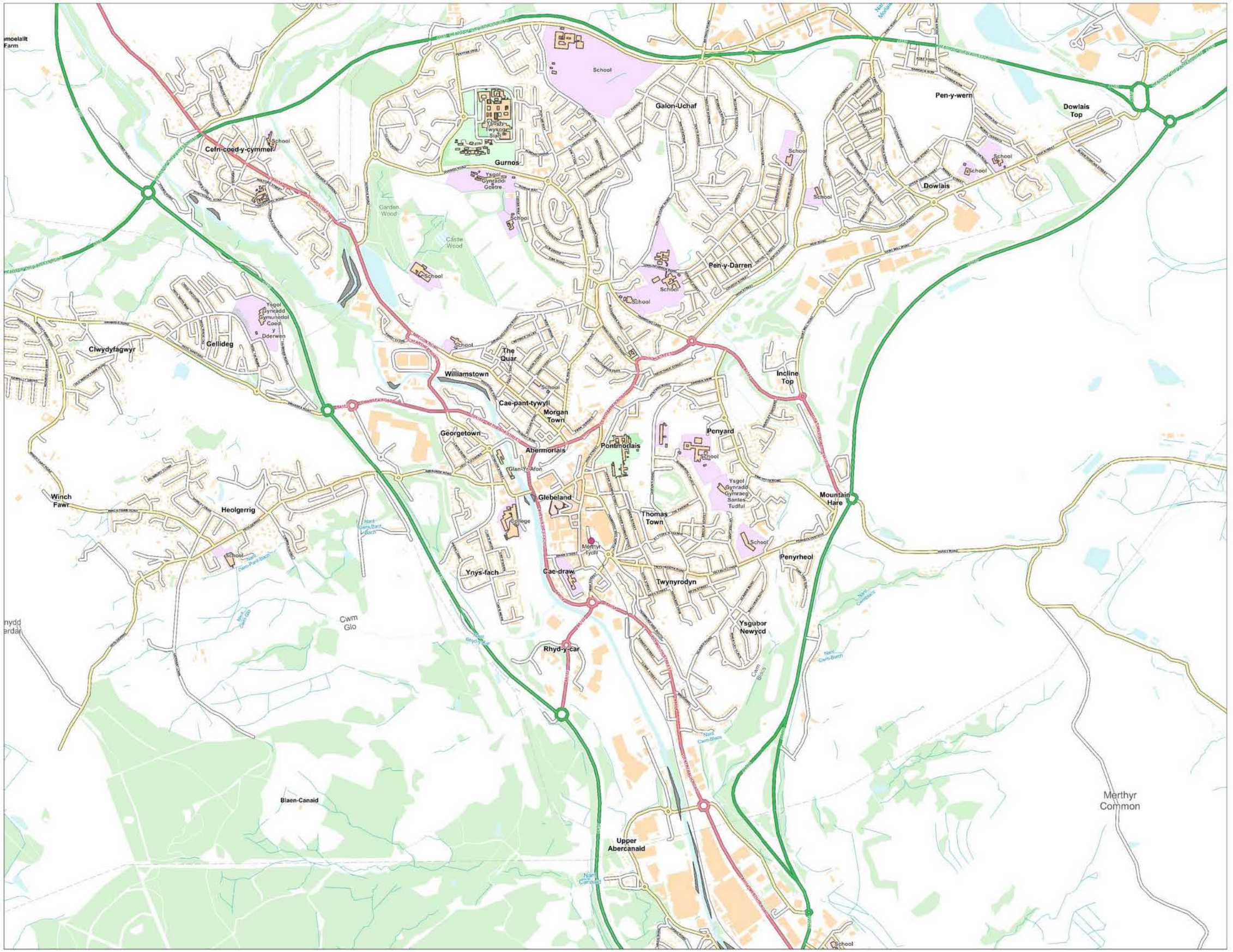
0 250 500 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
NRW Flood Map for South Merthyr Tydfil, Merthyr Vale Area

Figure number:
WHS1580-T02-006-R01

WHS



Legend

NRW - Historic Flood Outlines

Historic Flood Outlines

N

0 250 500 m

Project Title:

Merthyr Tydfil SFCA

Figure Title:

NRW historic flood map for central Merthyr Tydfil

Figure number:

WHS1580-T02-007-R01

Legend

NRW - Historic Flood Outlines

Historic Flood Outlines

N

0 250 500 m

Project Title:

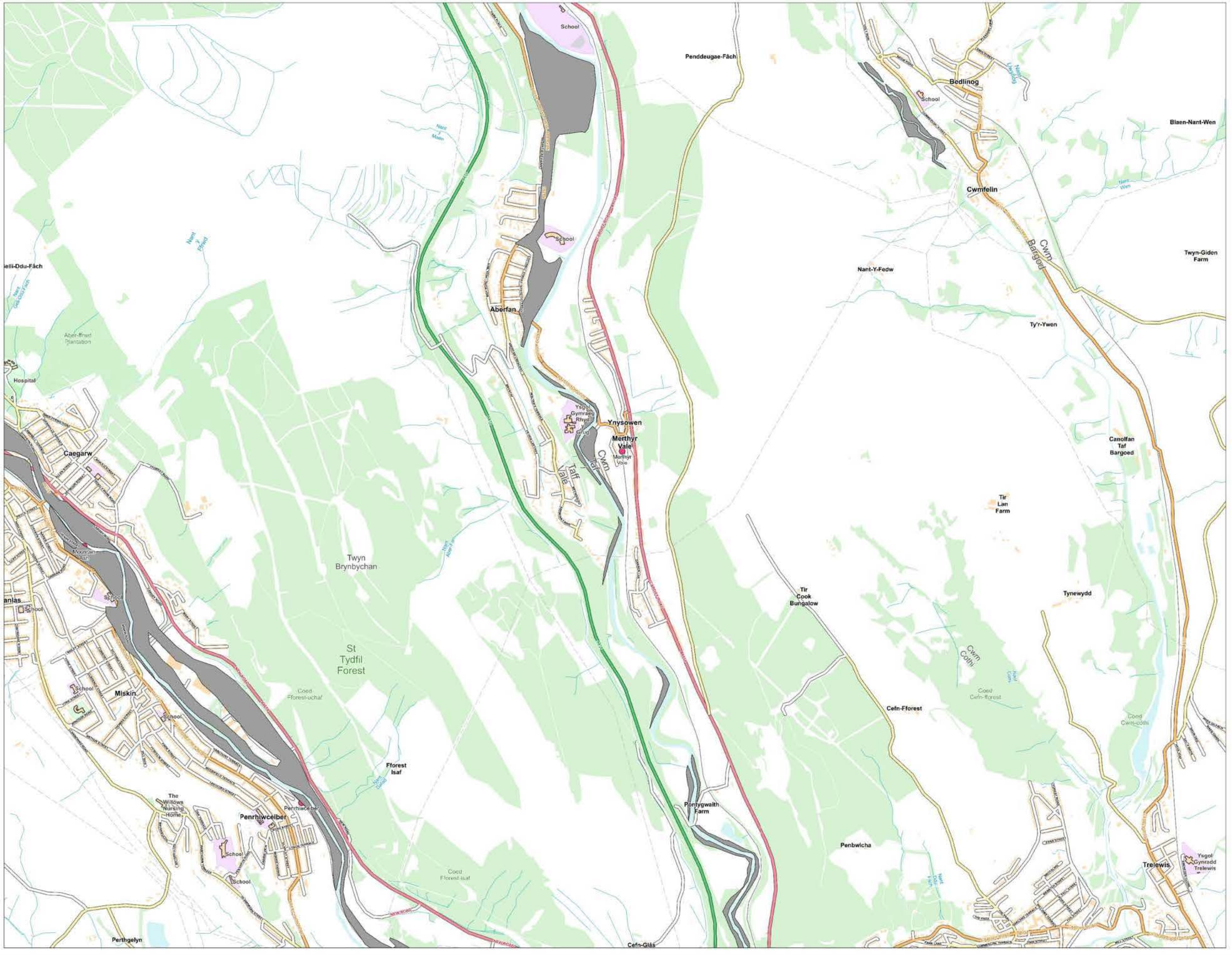
Merthyr Tydfil SFCA

Figure Title:

NRW historic flood map for Abercanaid, Merthyr Tydfil

Figure number:

WHS1580-T02-008-R01



Legend

NRW - Historic Flood Outlines

Historic Flood Outlines

N

0 250 500 m

Project Title:

Merthyr Tydfil SFCA

Figure Title:

NRW historic flood map for south Merthyr Tydfil, Merthyr Vale Area

Figure number:

WHS1580-T02-009-R01

WHS

Legend

- 3.3% Annual Probability
- 1.0% Annual Probability
- 0.1% Annual probability

N

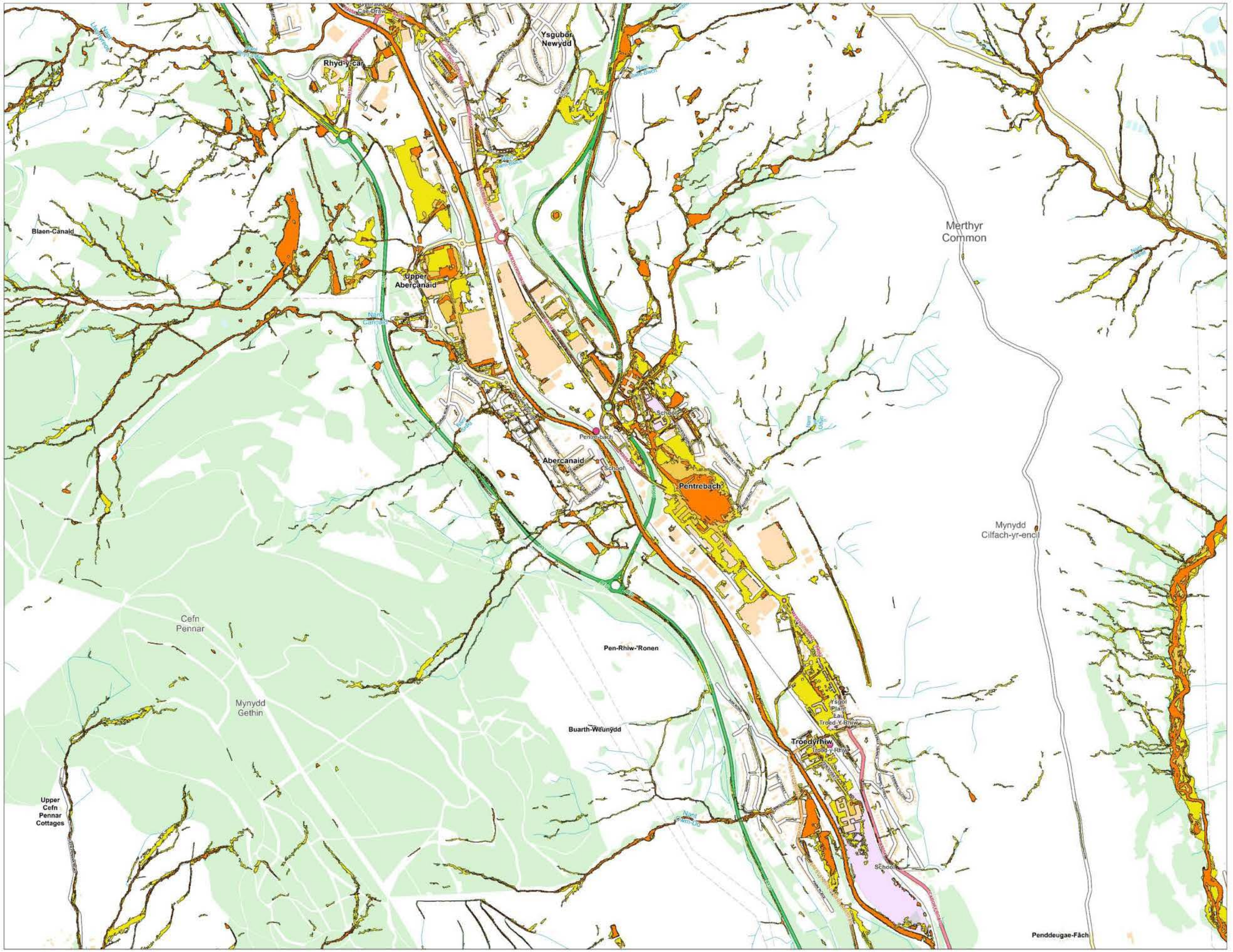
0 225 450 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
NRW surface water flood map for central Merthyr Tydfil

Figure number:
WHS1580-T02-010-R01

WHS



Legend

- 3.3% Annual Probability
- 1.0% Annual Probability
- 0.1% Annual probability

N

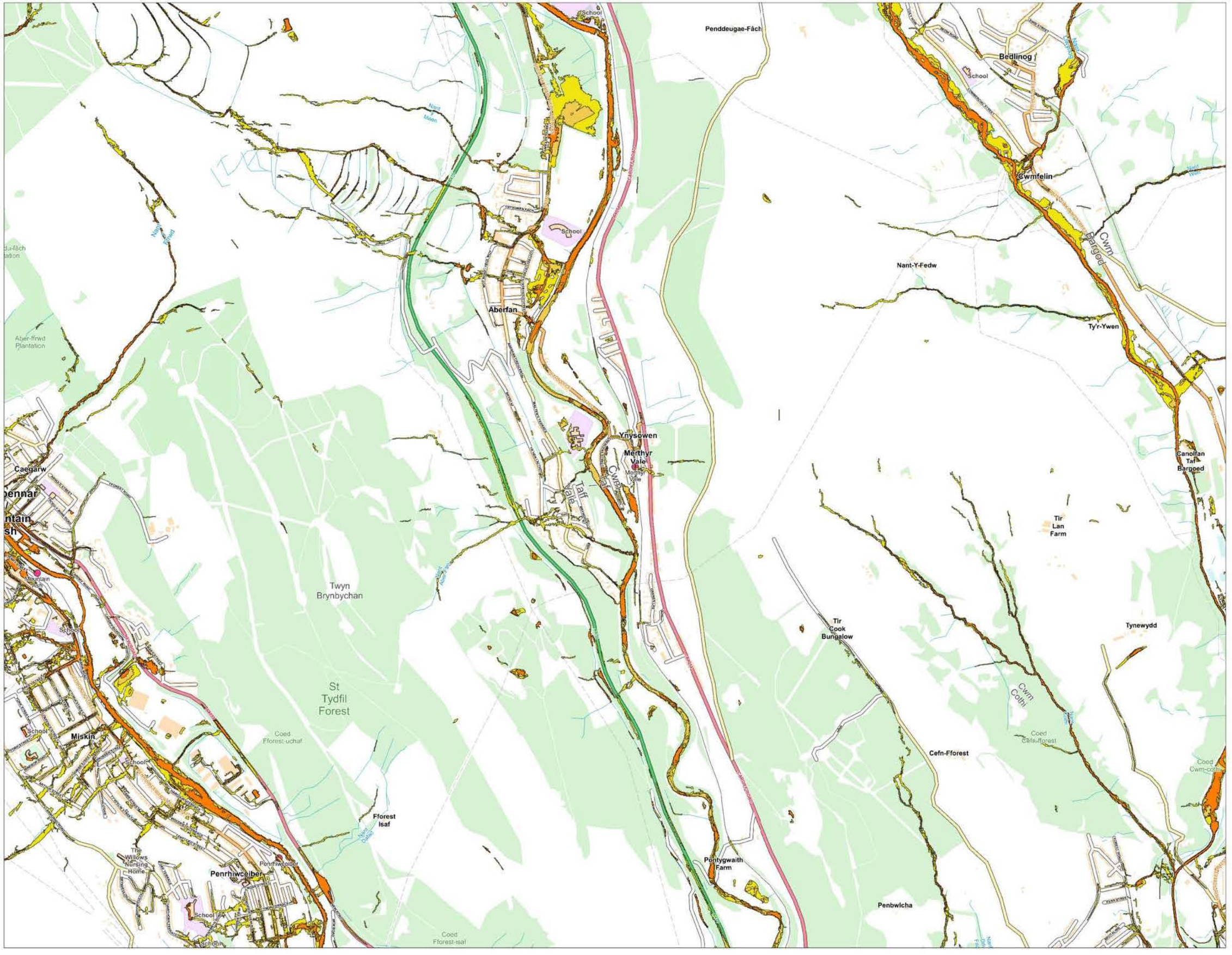
0 225 450 m

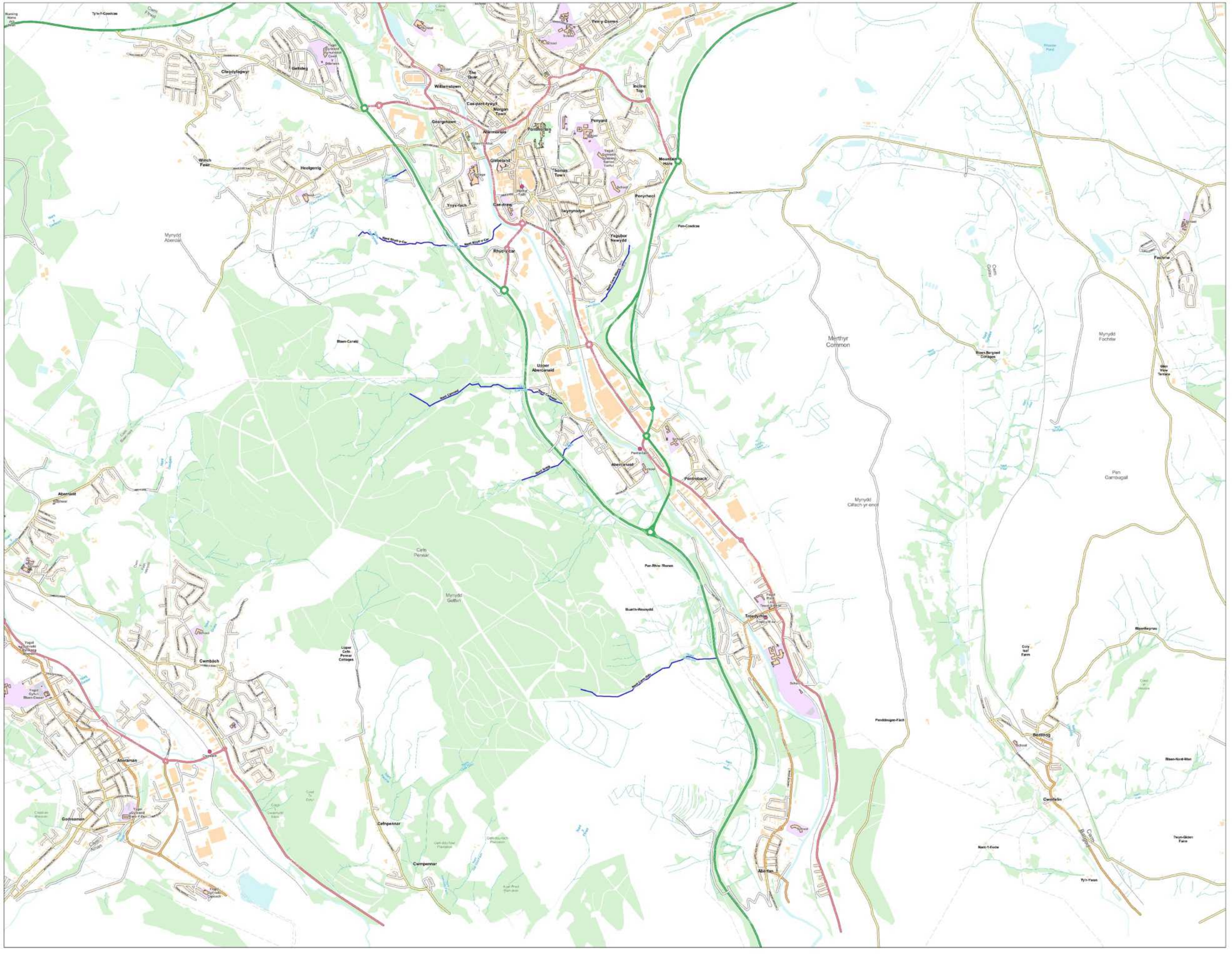
Project Title:
Merthyr Tydfil SFCA

Figure Title:
NRW surface water flood map for Abercanaid, Merthyr Tydfil

Figure number:
WHS1580-T02-011-R01

WHS


Legend
3.3% Annual Probability
1.0% Annual Probability
0.1% Annual probability
Penddeugae-Fâch
Bedlinog
Cwmfelin
Nant-Y-Fedw
Ty'r-Ywen
Canolfan Taf Bargoed
Aberfan
Ynysowen
Merthyr Vale
Caegarw
Twyn Brynbychan
St Tydfil Forest
Tir Lan Farm
Tir Cook Bungalow
Tynewydd
Cefn-Fforest
Miskin
Penrhiwceiber
Fforest Isaf
Pontygwaith Farm
Penbwlcha
Project Title:
Merthyr Tydfil SFCA
Figure Title:
NRW surface water flood map for south Merthyr Tydfil, Merthyr Vale Area
Figure number:
WHS1580-T02-012-R01



Legend

- Ordinary Watercourses

N

0 250 500 750 m

Project Title:
Merthyr Tydfil SFCA

Figure Title:
Map of ordinary watercourses in the study area

Figure number:
WHS1580-T02-013-R01

WHS

Appendix B – River Taff Model Changes

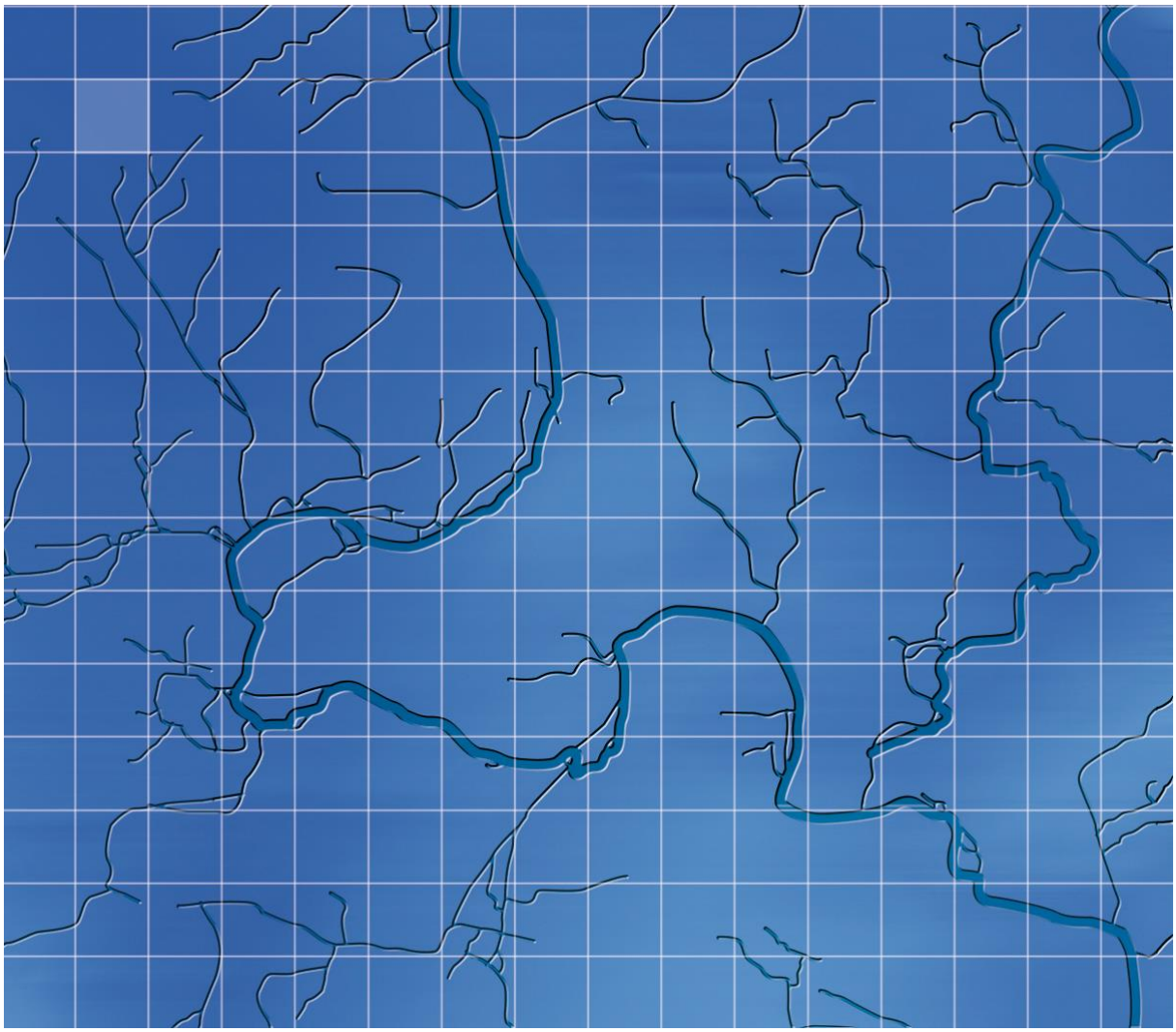
Change	Shapefile(s)/Node(s)	Domain	Comments
3 river sections added to extend model 355m downstream	TAFF11285, TAFF11048	1D	Cross section data and chainages maintained from 2010 Merthyr Tydfil to Merthyr Vale Depth and Velocity Study.
Nodes shapefile updated to reflect 2 additional 1D nodes	1d_nwk_FM_Nodes_P_003.shp	2D	Node names from above study maintained
1D/2D links extended downstream	2d_bc_hxl_WILL_L_003.shp	2D	Digitised based on LiDAR data, ensuring that widths match 1D activated widths
Downstream boundary updated to reflect updated model extent	2d_bc_dsbdy_L_003.shp	2D	Slope derived from LiDAR data
Materials layers extended downstream	2d_mat_roads_R_002.shp, 2d_mat_buildings_R_002.shp	2D	Used to define roughness, values used from existing model.
Stubby buildings layer extended downstream	2d_zsh_stubby_buildings_R_002.shp	2D	View original model report for explanation on stubby buildings
1d channel inactive area extended	2d_code_TAFF_R_003.shp	2D	Snapped to 1D/2D links
Model active area extended	2d_code_Active_Area_R_003.shp	2D	

Appendix C – Bus Station Hydrology Report

Merthyr Tydfil County Borough Council

June 2018

Flood Peak Flow Estimate for River Taff and Nant Morlais at Merthyr Tydfil Bus Station site



Merthyr Tydfil County Borough council

Flood Peak Flow Estimate for River Taff and Nant Morlais at Merthyr Tydfil Bus Station site

Document issue details

WHS 1598

Version	Issue date	Issue status	Prepared By	Approved By
1	25/5/18	Draft	Joel Leyshon Jones *Consultant*	Daniel Hamilton *Consultant*
1.1	29/6/18	Final	Joel Leyshon Jones *Consultant*	Daniel Hamilton *Consultant*

For and on behalf of Wallingford HydroSolutions Ltd.

The WHS Quality & Environmental Management system is certified as meeting the requirements of ISO 9001:2008 and ISO 14001:2004 providing environmental consultancy (including monitoring and surveying), the development of hydrological software and associated training.

Registered Office Maclean Building, Benson Lane, Wallingford OX10 8BB
www.hydrosolutions.co.uk

1 Requirements

Wallingford HydroSolutions Ltd have been commissioned by Merthyr Tydfil County Borough Council to derive new peak flow estimates for the River Taff and Nant Morlais. This is to provide updated model inflows to the existing Bus Station hydraulic model developed by Capita, in turn improving flood mapping in central Merthyr Tydfil.

The client requires peak flow estimates and hydrographs for a range of flood events, including the 100 year, 100 year plus 25% climate change[1] and 1000-year events. The hydrology is derived at three separate inflow locations, including two direct inflows, and one lateral inflow as detailed in Figure 1 below.

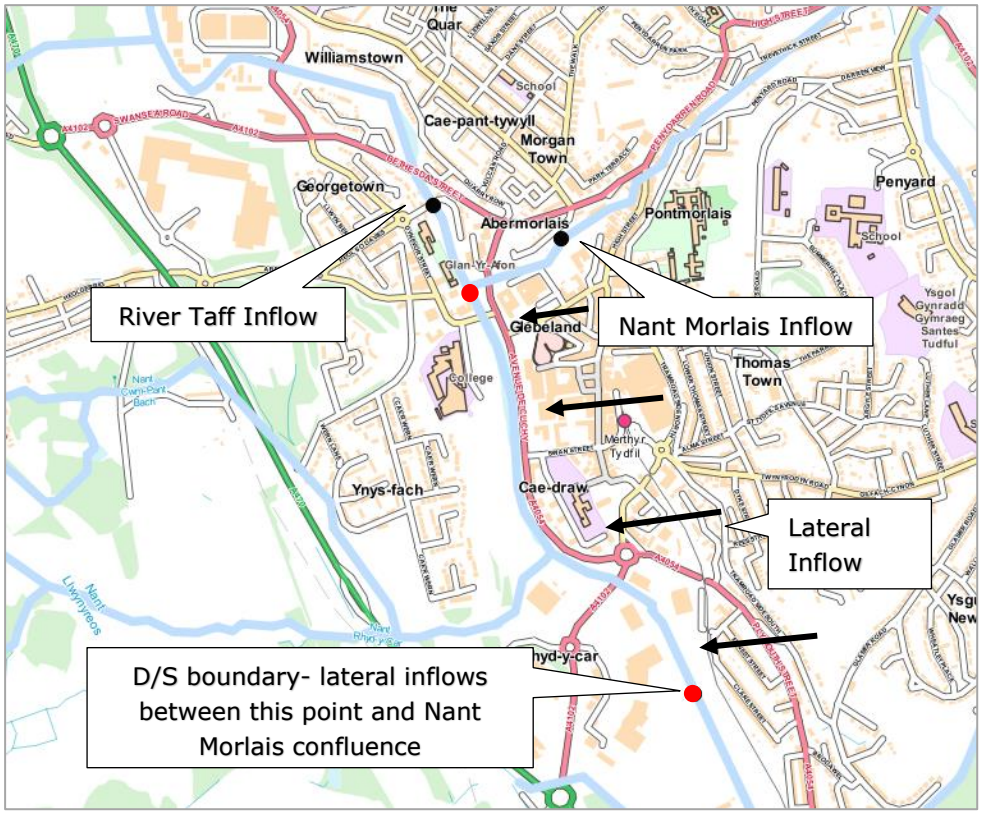


Figure 1 Location of Direct Inflows (black dots represent direct inflow) and Lateral Inflow (red dots show length of watercourse represented by lateral inflow) *Contains OS data © Crown Copyright (2018)*

2 The Catchment

The relevant catchment boundaries are presented in Figure 2. The FEH Web Service[2] was used to derive the catchment descriptors for each input location. Table 1 presents the relevant catchment descriptors. The lateral catchment descriptors have been calculated using a weighted averaging approach.

[1] Welsh Government (2016) *Flood Consequence Assessments: Climate change allowances*, Published 23/08/2016
[2] https://fehweb.ceh.ac.uk/GB/map

The catchment descriptors were first derived for a point marking the downstream boundary of the model at 305150, 205350. This generated a catchment of 129.97 km^2. A catchment was then derived downstream of the River Taff-Nant Morlais confluence at 304650, 209250, which is immediately downstream of where the two direct inflows were estimated. This generated a catchment of 125.63 km^2.

The catchment descriptors for the larger basin at the downstream boundary of the hydraulic model are a weighted sum of the catchment descriptors for the upstream catchment and the intervening area represented by the lateral inflow. The catchment descriptors for the intervening catchment can therefore be calculated based on this assumption. For SAAR, BFIHOST and PROPWET the catchment descriptors for the lateral inflow are the remaining values required to match the catchment descriptors for the larger basin. In addition URBEXT and FPEXT are required for the statistical method, these were calculated in a similar way, with some additional conversions required. FARL was set to 1 as there is no storage in the incremental catchment.

Ultimately the Taff catchment has a low URBEXT2000 and is classed as 'essentially rural' according to FEH guidance, however the Nant Morlais and lateral catchment have relatively high values and are so classed as 'heavily urbanised'.

Table 1 Relevant catchment descriptors from the FEH Web Service

Catchment Descriptor	River Taff	Nant Morlais	Lateral Catchment
Area (km^2)	114.13	11.34	4.34
SAAR (standard average annual rainfall 1961 - 1990mm)	1849	1512	1578
BFIHOST (baseflow index derived from HOST soils data)	0.36	0.36	0.33
FARL (index of flood attenuation due to reservoirs and lakes)	0.85	0.95	1
FPEXT (extent of flood plain)	0.03	0.04	0.06
PROPWET	0.55	0.54	0.55
URBEXT2000	0.02	0.17	0.18

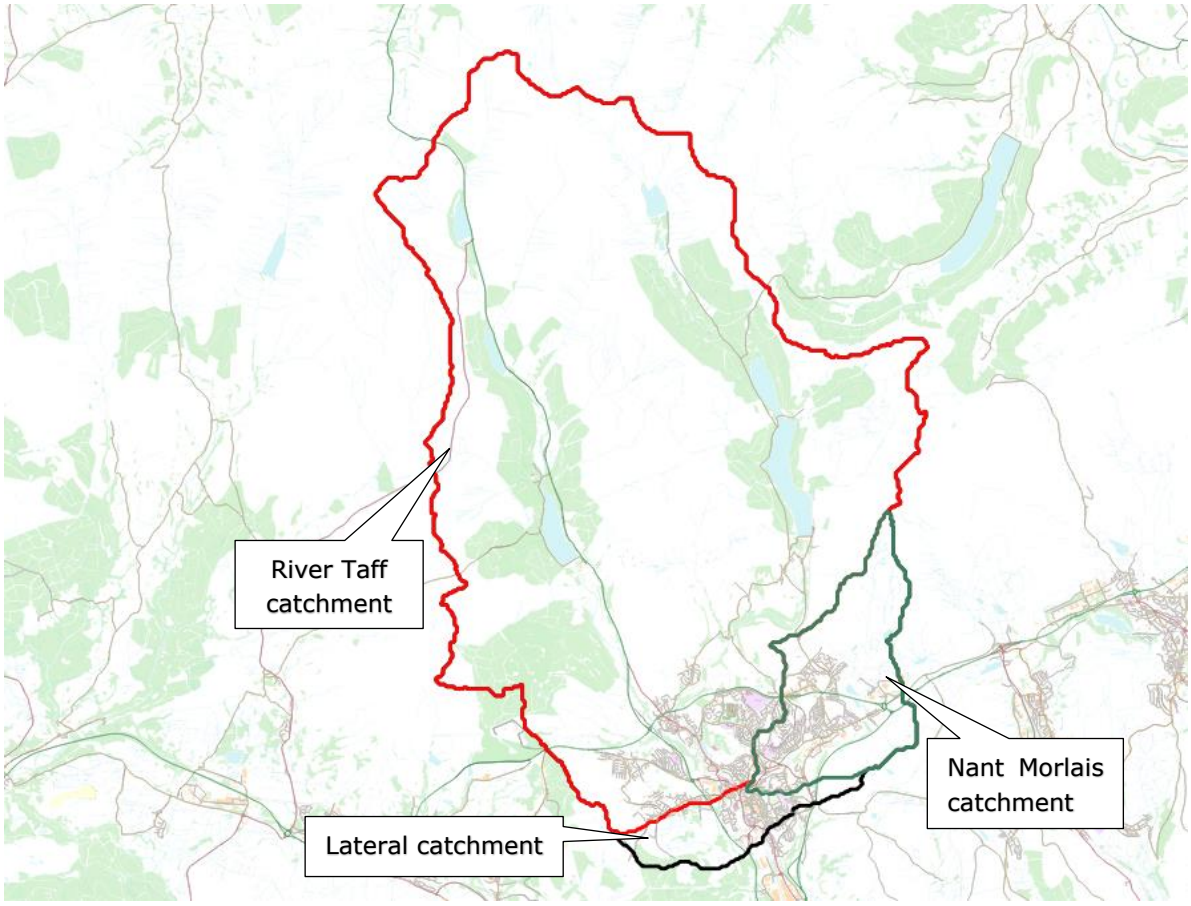


Figure 2 **– Catchment boundaries as defined by the FEH webservice.** *Contains OS data © Crown Copyright (2018)*

3 Outline of methodology

The flood estimates have been developed using the latest Flood Estimation Handbook statistical and rainfall runoff methods as outlined in Section 1.

The WINFAPv4 software[3] is used to apply the statistical methodology using the NRFA Peak Flow Dataset v6.0. This method requires the estimation of a normalised flood frequency curve, termed the flood growth curve and the estimation of the normalising variable; the median annual flood, QMED. The rainfall-runoff methods are those first published by Kjeldsen[4], which were subsequently updated in 2015 and implemented within the ReFH2 software[5]. Both methods supersede older methods as the national design standard for estimating flood frequency.

3.1 Local Gauging Stations

There are three gauging stations upstream of the points of interest. The gauging stations are the Taff at Merthyr Tydfil (57015), Taff at Llwynon Reservoir (57002) and the Taf Fechan at Taf Fechan

[3] http://www.hydrosolutions.co.uk/products.asp?categoryID=10838
[4] Kjeldsen, T. R. 2007. The revitalised FSR/FEJ rainfall-runoff method. Supplementary Report No.1. CEH.
[5] http://www.hydrosolutions.co.uk/products.asp?categoryID=4671

Reservoir (57001). The locations of these are presented within Figure 3. Two of the stations Taff at Llwynon Reservoir (57002) and the Taf Fechan at Taf Fechan Reservoir (57001) were not considered suitable for pooling. From the NRFA website, the Taff at Llwynon Reservoir is referenced as only measuring from a low flow reservoir flume, therefore not recording the high flows, of practical use in this analysis. The Taff Fechan at Taff Fechan Reservoir was described as being substantially affected by exports for a private water supply, in addition to be affected by the artificial flow regime from the reservoir. The Taff at Merthyr Tydfil (57015), was however flagged as suitable for QMED and pooling, it has therefore been used in deriving the peak flow estimates.

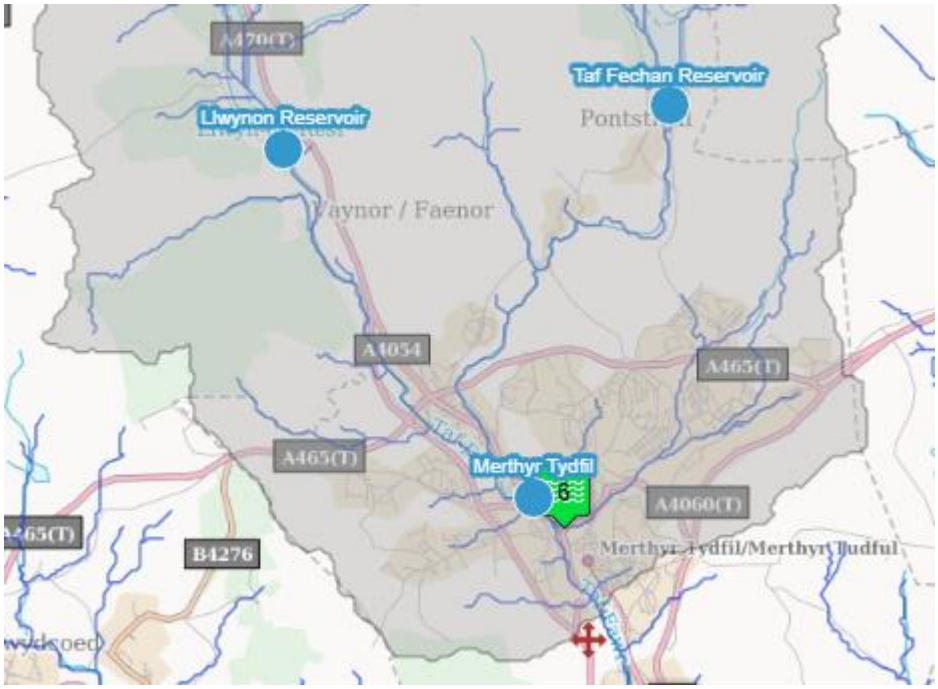


Figure 3 Location of gauging stations within the Taff catchment

3.2 Derivation of the Median Annual Flood

Estimates of QMED from observed data ($QMED_{obs}$) at donor stations can be used to adjust the estimate of $QMED_{cds}$ at the subject site. Possible donor catchments to use for adjustment of QMED were sought on the basis of being geographically close. Whilst the similarity of catchment descriptors; Area, SAAR, FARL and BFIHOST were also considered.

3.2.1 River Taff

The rural QMED for this location was initially estimated from catchment descriptors ($QMED_{cds}$) as 66.921 m^3s^{-1}. A donor group was compiled of initially six catchments by default. These catchments generally underestimate the $QMED_{cds}$ in comparison with the $QMED_{obs}$; the exception to this is the Rhondda Fawr at Tynewydd (57017).

The Taff at Merthyr Tydfil being located just 0.18km upstream naturally represented the catchment descriptors for the target catchment extremely well, and also contained an ample data record (36yrs). Furthermore, since the FARL for the River Taff catchment is 0.85 it is important that the attenuating effect of the upstream reservoirs are captured. As the gauging station's catchment includes the same reservoirs this ensures that their impact is incorporated into the QMED estimate.

Due to the proximity of the station and the length of its gauged record no further donor stations were used. The donor group is shown in Table 4.

Table 2 Donor group used for Lateral Inflow QMED estimation

Gauging Station	Distance (km)	Notes
Target Site		
57015 (Taff @ Merthyr Tydfil)	0.18	Selected
57007 (Taff @ Fiddlers Elbow)	5.23	Rejected
58006 (Mellte @ Pontneddfechan)	7.82	Rejected
57005 (Taff @ Pontypridd)	10.76	Rejected
57004 (Cynon @ Abercynon)	10.77	Rejected
56001 (Usk @ Chainbridge)	12.50	Rejected

The best estimate of the natural QMED following donor transfer is 95.638 m^3s^{-1}. Note that the observed QMED values for each gauged catchment were deurbanised prior to being used for donor transfer.

In order to account for the impact of urbanisation on flood peaks, the estimated value of QMED has been adjusted with an Urban Adjustment Factor (UAF). The Taff upstream of the Nant Morlais confluence is classed as 'essentially rural' based on FEH guidance, the UAF is 1.018, and the best estimate of the urbanised QMED is 97.323 m^3s^{-1}.

3.2.2 Nant Morlais

The rural QMED for this location was initially estimated from catchment descriptors ($QMED_{cds}$) as 10.460 m^3s^{-1}. A donor group was also used for this catchment. This was initially composed of six catchments. No gauging stations were identified in the Nant Morlais catchment.

The Taff at Merthyr Tydfil (57015) was rejected as it holds a significantly lower FARL value than that of the target catchment. The Sirhowy at Wattsville (56011) was removed from the list since it carried a BFIHOST value considerably higher than the target catchment.

As a result, four stations comprised the donor group, including the Taff at Fiddlers Elbow (57007), the Rhymney at Bargoed (57014), the Taff at Pontypridd (57005), and the Cynon at Abercynon (57004). All of these stations had catchment descriptor values which were in a similar range to those of the target catchment. There appeared to be a consensus between these stations regarding the underestimation of $QMED_{obs}$ by $QMED_{cds,}$ apart from the Cynon which showed a slight overestimation. The donor group is shown in Table 3.

Table 3 Donor group used for Nant Morlais QMED estimation

Gauging Station	Distance (km)	Notes
Target Site		
57007 (Taff @ Fiddlers Elbow)	2.27	Selected
57014 (Rhymney @ Bargoed)	6.20	Selected
57015 (Taff @ Merthyr Tydfil)	6.99	Rejected
57005 (Taff @ Pontypridd)	7.47	Selected
57004 (Cynon @ Abercynon)	8.95	Selected
56011 (Sirhowy @ Wattsville)	10.6	Rejected

The best estimate of the natural QMED following donor transfer is 13.348 m^3s^{-1}. Note that the observed QMED values for each gauged catchment were deurbanised prior to being used for donor transfer.

In order to account for the impact of urbanisation on flood peaks, the estimated value of QMED has been adjusted with an Urban Adjustment Factor (UAF). The Nant Morlais upstream of the Nant Morlais confluence is classed as 'heavily urbanised' based on FEH guidance, the UAF is 1.159, and the best estimate of the urbanised QMED is 15.471 m^3s^{-1}.

3.2.3 Lateral Inflow

To calculate QMED for the lateral inflow, the QMED values for the upstream catchment and downstream catchment are estimated. The upstream value is then subtracted from the downstream value. Using the catchment descriptor equation yields a QMED value of 73.543 m^3s^{-1} for the upstream catchment and 76.735 m^3s^{-1} for the downstream catchment, resulting in a QMED value of 3.192 m^3s^{-1}.

To potentially refine this initial estimate, both the up and downstream catchments were assessed for donor transfer. The donor groups were identical comprising the same six catchments. The reservoirs upstream of Merthyr Tydfill are thought to have a significant impact on flood attenuation which results in both catchments having low FARL values. On this basis a number of stations in the initial donor group were rejected given their relatively high FARL values. Two stations were retained in the donor transfer for both catchments. The two stations were both sited on the Taff, the Taff at Merthyr Tydfil (57015) lying slightly upstream of both catchments, and the Taff at Fiddlers Elbow (57007) downstream. The donor group is shown in Table 4.

Table 4 Donor group used for Lateral Inflow QMED estimation

Gauging Station	Distance (km)	Notes
Target Site		
57015 (Taff @ Merthyr Tydfil)	0.79	Selected
57007 (Taff @ Fiddlers Elbow)	4.63	Selected
58006 (Mellte @ Pontneddfechan)	8.30	Rejected
57005 (Taff @ Pontypridd)	10.31	Rejected
57004 (Cynon @ Abercynon)	10.43	Rejected
57014 (Rhymney @ Bargoed)	12.26	Rejected

The best estimates of the natural QMED following donor transfer are 106.192 m^3s^{-1} and 102.683 m^3s^{-1} for the down and upstream catchments respectively. The donor adjusted QMED value for the lateral inflow is therefore 3.509 m^3s^{-1}.

To account for the impact of urbanisation on flood peaks, the estimated values for QMED have been adjusted with the application of Urban Adjustment Factors (UAF). Both catchments are classed as 'slightly urbanised' based on FEH guidance, the UAF is 1.035 and 1.031 for the down and upstream catchments respectively. The resulting best estimates for the urbanised QMED are 109.932 m^3s^{-1} and 105.837 m^3s^{-1}, resulting in a final urbanised QMED value of 4.095 m^3s^{-1} for the lateral inflow.

For comparison the catchment descriptor QMED value is 6.320 m^3s^{-1} when using the descriptors estimated for the incremental area. This value is not considered as reliable as the QMED value derived from the subtraction method. The weighting method used to derive the descriptors is very sensitive to the up and downstream catchments, and given the small incremental area involved, descriptors can sometimes be unrealistic.

3.3 Derivation of the Growth Curve

Within the FEH methodology flood growth curves for ungauged sites are formed by pooling annual maxima data from similar catchments which are flagged as being suitable for pooling, a threshold of 500 station-years is further required (a sum of record lengths) in this process. The results, and decisions made in the process to arrive at these, are outline in the next section, separated into the respective catchments.

3.3.1 River Taff

An initial pooling group was formed for the development of a flood growth curve, by pooling data from 14 catchments. The Bran at Dosmucheran (4006), was removed as it had a negative L-Skew value, which reflects the fact that the distributions are bounded. This may be valid, being a result of sampling error, however it may also indicate issues with the quality of the data. The records were removed as a precautionary approach which may result in a conservative (high) estimate of the growth factors within the target catchment.

A final pooling group containing 13 stations and 519 station years was derived. Table 5 shows the full list of pooling group members along with the reason for any stations being removed. The distance shown is the distance from each candidate station to the sites in a similarity distance space (the FEH distance measure).

Table 5. Pooling group selection and reasons for retaining or removing from final pooling group.

Station	Distance SDM	AREA	SAAR	FARL	URBEXT 2000	Decision	Reasoning
57015 (Taff @ Merthyr Tydfil)	0.045	111.25	1858	0.85	0.012		
75004 (Cocker @ Southwaite Bridge)	0.306	116.17	1976	0.83	0		
4006 (Bran @ Dosmucheran)	0.478	117.54	2203	0.814	0	**Reject**	**Negative L-skew**
4005 (Meig @ Glenmeanie)	0.516	123.67	2145	0.918	0		
84017 (Black Cart Water @ Milliken Park)	0.546	103.16	1790	0.786	0.017		
8008 (Tromie @ Tromie Bridge)	0.593	131.61	1436	0.898	0		
75009 (Greta @ Low Briery)	0.596	146.99	2025	0.91	0		
76004 (Lowther @ Eamont Bridge)	0.61	156.1	1828	0.901	0.002		
21020 (Yarrow Water @ Gordon Arms)	0.629	153.94	1496	0.82	0		
86002 (Eachaig @ Eckford)	0.63	138.67	2470	0.836	0		
21034 (Yarrow Water @ Craig Douglas)	0.656	116.18	1555	0.767	0		
93001 (Carron @ New Kelso)	0.754	139.21	2616	0.858	0		
69015 (Etherow @ Compstall)	0.758	149.4	1322	0.831	0.033		
69041 (Tame @ Broomstairs)	0.767	115.85	1290	0.887	0.12		

To model the growth curve a three-parameter generalised logistic (GL) distribution was used, which is the FEH recommended distribution for use within UK flood data to model the growth curve.

Figure 4 shows the estimated flood frequency curve for the subject site and Table 6 presents the flood growth curve indexed by return period. It was not necessary to apply the permeable adjustment as no catchments in the pooling group had an SPRHOST less than 20. The growth curve was also adjusted for urbanisation.

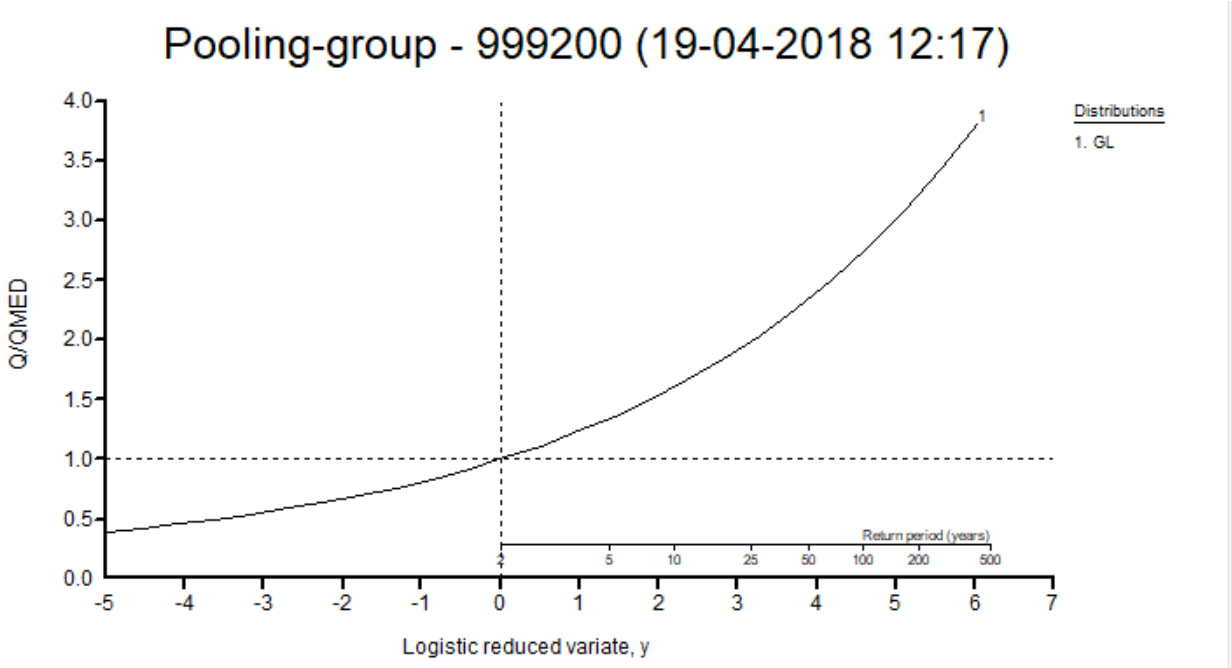


Figure 4 Flood growth curve for River Taff

Table 6. Growth Curve Estimates for the River Taff

Return Period (years)	Growth Curve (GL distribution)
2	1
25	1.99
50	2.34
100	2.74
200	3.22
500	3.98
1000	4.67

The peak flows estimated from the statistical method for the River Taff are is presented in Table 7. These represent the QMED value rescaled by the growth curve for a range of return periods.

Table 7. Peak Flow Estimates for the River Taff

Return Period (years)	Peak Flows (m^3s^{-1})
2	97.32
25	193.77
50	227.44
100	266.86
200	312.99
500	386.86
1000	454.40

3.3.2 Nant Morlais

An initial pooling group was formed for the development of a flood growth curve, by pooling data from 16 catchments. The Camel at Camelford (49006) was rejected as it has a negative L-Skew value, which reflects the fact that the distribution is bounded. This may be valid, being a result of sampling error, however it may also indicate issues with the quality of the data. The record was removed as a precautionary approach which may result in a conservative (high) estimate of the growth factors within the target catchment.

A final pooling group containing 15 stations and 508 station years was derived. Table 8 shows the full list of pooling group members along with the reason for any stations being removed or retained. The distance shown is the distance from each candidate station to the sites in a similarity distance space (the FEH distance measure).

Table 8. Pooling group selection and reasons for retaining or removing from final pooling group.

Station	Distance SDM	AREA	SAAR	FARL	URBEXT 2000	Decision	Reasoning
47022 (Tory Brook @ Newnham Park)	0.305	13.43	1403	0.942	0.014		
25011 (Langdon Beck @ Langdon)	0.459	12.79	1463	1	0.001		
49006 (Camel @ Camelford)	0.46	12.52	1418	1	0.003	**Reject**	**negative L-skew**
206006 (Annalong @ Recorder)	0.482	14.44	1704	0.981	0		
69047 (Roch @ Littleborough)	0.556	14.78	1353	0.89	0.034		
25003 (Trout Beck @ Moor House)	0.563	11.4	1905	1	0		
71003 (Croasdale Beck @ Croasdale Flume)	0.583	10.71	1882	1	0		
28033 (Dove @ Hollinsclough)	0.714	7.92	1346	1	0		
49005 (Bollingey Stream @ Bolingey Cocks Bridge)	0.915	16.08	1044	0.991	0.006		
45816 (Haddeo @ Upton)	0.934	6.81	1210	1	0.005		
27032 (Hebden Beck @ Hebden)	1.013	22.25	1433	0.997	0		
48009 (st Neot @ Craigshill Wood)	1.021	22.97	1511	0.982	0.002		
49003 (de Lank @ de Lank)	1.022	21.61	1628	0.998	0		
54022 (Severn @ Plynlimon Flume)	1.105	8.75	2481	1	0		
48004 (Warleggan @ Trengoffe)	1.141	25.26	1445	0.978	0.003		
25012 (Harwood Beck @ Harwood)	1.146	24.58	1577	1	0		

To model the growth curve a three-parameter generalised logistic (GL) distribution was used, which is the FEH recommended distribution for use within UK flood data to model the growth curve. Figure 5 shows the estimated flood frequency curve for the subject site and Table 9 presents the flood growth curve indexed by return period. It was not necessary to apply the permeable adjustment as no catchments in the pooling group had an SPRHOST less than 20. The growth curve was also adjusted for urbanisation.

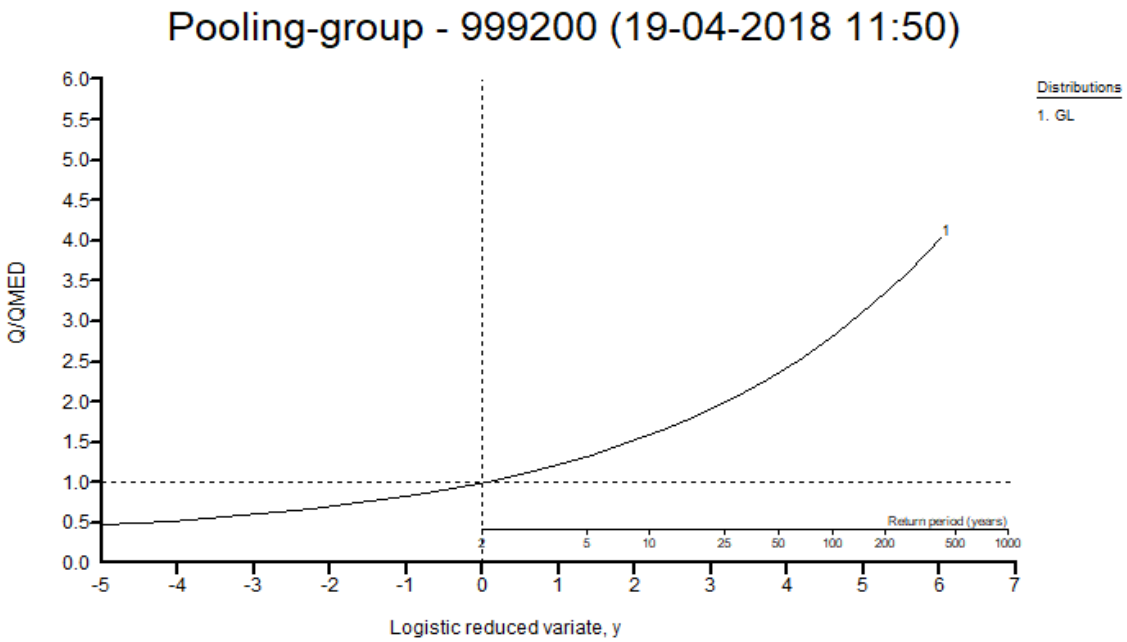


Figure 5 Flood growth curve for Nant Morlais

Table 9. Growth Curve Estimates for the Nant Morlais

Return Period (years)	Growth Curve
2	1
25	1.99
50	2.37
100	2.81
200	3.35
500	4.24
1000	5.08

The peak flows estimated from the statistical method for the Nant Morlais are presented in Table 10. These represent the QMED value rescaled by the growth curve for a range of return periods.

Table 10. Peak Flow Estimates for the Nant Morlais

Return Period (years)	Peak Flow (m^3s^{-1})
2	15.47
25	30.83
50	36.59
100	43.49
200	51.81
500	65.56
1000	78.54

3.3.3 Lateral Inflow

An initial pooling group was formed for the development of a flood growth curve, by pooling data from 16 catchments. The Camel at Camelford (49006) and Rhondda Fawr at Tynrwydd (57017) were rejected as they have negative L-Skew values, which reflect a bounded distribution. This may be valid, being a result of sampling error, however it may also indicate issues with the quality of the data. Both records were therefore removed as a precautionary approach which may result in a conservative (high) estimate of the growth factors within the target catchment. The Hodge Beck at Bransdale Weir (27010) was added to keep the total number of station years in the pooling group above the threshold of 500 years.

This resulted in a final pooling group containing 15 stations and 529 station years. Table 11 shows the full list of pooling group members along with the reason for any stations being removed or retained. The distance shown is the distance from each candidate station to the sites in a similarity distance space (the FEH distance measure).

Table 11. Pooling group selection and reasons for retaining or removing from final pooling group.

Station	Distance SDM	AREA	SAAR	FARL	URBEXT 2000	Decision	Reasoning
45816 (Haddeo @ Upton)	0.974	6.81	1210	1	0.005		
28033 (Dove @ Hollinsclough)	1.069	7.92	1346	1	0		
91802 (Allt Leachdach @ Intake)	1.258	6.54	2554	0.992	0		
71003 (Croasdale Beck @ Croasdale Flume)	1.395	10.71	1882	1	0		
25003 (Trout Beck @ Moor House)	1.413	11.4	1905	1	0		
54022 (Severn @ Plynlimon Flume)	1.422	8.75	2481	1	0		
76011 (Coal Burn @ Coalburn)	1.543	1.63	1096	1	0		
27051 (Crimple @ Burn Bridge)	1.557	8.17	855	1	0.006		
49006 (Camel @ Camelford)	1.586	12.52	1418	1	0.003	**Reject**	**negative L-skew**
25011 (Langdon Beck @ Langdon)	1.608	12.79	1463	1	0.001		
47022 (Tory Brook @ Newnham Park)	1.687	13.43	1403	0.942	0.014		
206006 (Annalong @ Recorder)	1.741	14.44	1704	0.981	0		
69047 (Roch @ Littleborough)	1.888	14.78	1353	0.89	0.034		
49005 (Bollingey Stream @ Bolingey Cocks Bridge)	2.037	16.08	1044	0.991	0.006		
57017 (Rhondda Fawr @ Tynewydd)	2.13	16.64	2458	0.999	0.016	**Reject**	**negative L-skew**
23018 (Ouse Burn @ Woolsington)	2.175	10.14	670	0.977	0.1		
25019 (Leven @ Easby)	2.178	15.09	830	1	0.004		
49003 (de Lank @ de Lank)	2.245	21.61	1628	0.998	0		

To model the growth curve a three-parameter generalised logistic (GL) distribution was used, which is the FEH recommended distribution for use within UK flood data to model the growth curve.

Figure 6 shows the estimated flood frequency curve for the subject site and Table 12 presents the flood growth curve indexed by return period. It was necessary to apply permeable adjustment to the Brompton Beck at Snainton Ings (27073) as it had an SPRHOST less than 20 and non-flood years. The growth curve was also adjusted for urbanisation.

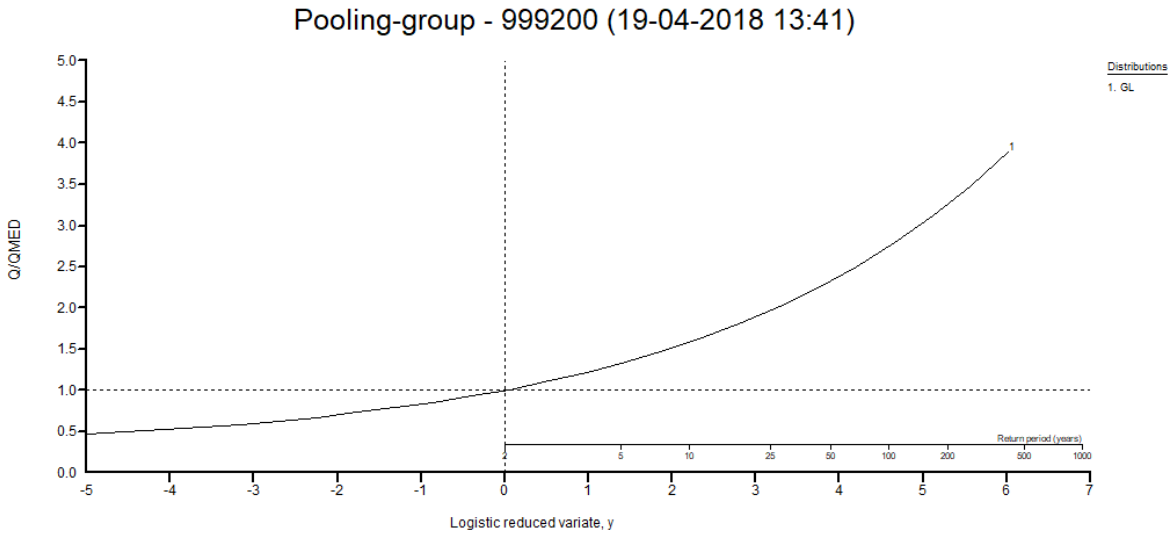


Figure 6. Flood growth curve for lateral inflow catchment

Table 12. Growth Curve Estimates for lateral inflow catchment

Return Period (years)	Growth Curve
2	1
25	2.00
50	2.39
100	2.84
200	3.40
500	4.32
1000	5.19

The peak flows estimated from the statistical method for the lateral inflow are is presented in Table 13. These represent the QMED value rescaled by the growth curve for a range of return periods.

Table 13. Peak Flow Estimates for lateral inflow catchment

Return Period (years)	Peak Flow (m^3s^{-1})
2	4.10
25	8.21
50	9.77
100	11.64
200	13.91
500	17.67
1000	21.24

4 Peak Flows Estimation using the Rainfall- Runoff methodology

The catchments were modelled using the ReFH 2.2 software and the FEH13 rainfall. This uses standard design rainfall events and catchment descriptors to produce hydrographs for the site. Note that the catchment model uses the DPLBAR and DPSBAR, which are reliant on catchment geometry, to generate some of the parameters required. Since these cannot be calculated for an incremental catchment, plot scale equations were used which negate the use of these descriptors to estimate flows. The recommended duration for the River Taff and Nant Morlais, were 8.50 and 4.75 hours respectively. As the purpose of the flow estimates are to drive the hydrology for a hydraulic model with the location just downstream of the confluence of these catchments, the duration attributed to the dominant catchment (River Taff), will be used for all estimation locations.

4.1.1 River Taff

The recommended duration and timestep of 8.5 hours and 0.5 hours were applied. Default parameters for urbanisation were used, however as the catchment is essentially rural the final peak flows are not sensitive to these.

Table 14 Peak Flow Estimates for River Taff as returned by ReFH 2.2 Software

Return Period (years)	Peak Flow estimate (m^3/s)
2	121.30
25	212.70
50	238.65
100	267.00
200	300.55
500	360.88
1000	426.27

4.1.2 Nant Morlais

The recommended duration and timestep was 4.75 hours and 0.25 hours, however since this is a minor catchment relative to the River Taff, the Taff catchment durations and timesteps of 8.5 and 0.5 were applied. Default parameters for urbanisation were used.

Table 15 Peak Flow Estimates for Nant Morlais as returned by ReFH 2.2 Software

Return Period (years)	Peak Flow estimate (m^3/s)
2	12.77
25	22.41
50	25.11
100	28.14
200	31.72
500	38.55
1000	46.25

4.1.3 Lateral Catchment

The duration and timestep were 8 hours and 0.25 hours, however since this is a minor catchment relative to the River Taff, the Taff catchment durations and timesteps of 8.5 and 0.5 were instead applied. Default parameters for urbanisation were used.

Table 16 Peak Flow Estimates for lateral inflow catchment as returned by ReFH 2.2 Software

Return Period (years)	Peak Flow estimate (m^3/s)
2	7.24
25	12.90
50	14.40
100	16.20
200	18.20
500	21.90
1000	25.90

5 Final Hydrology

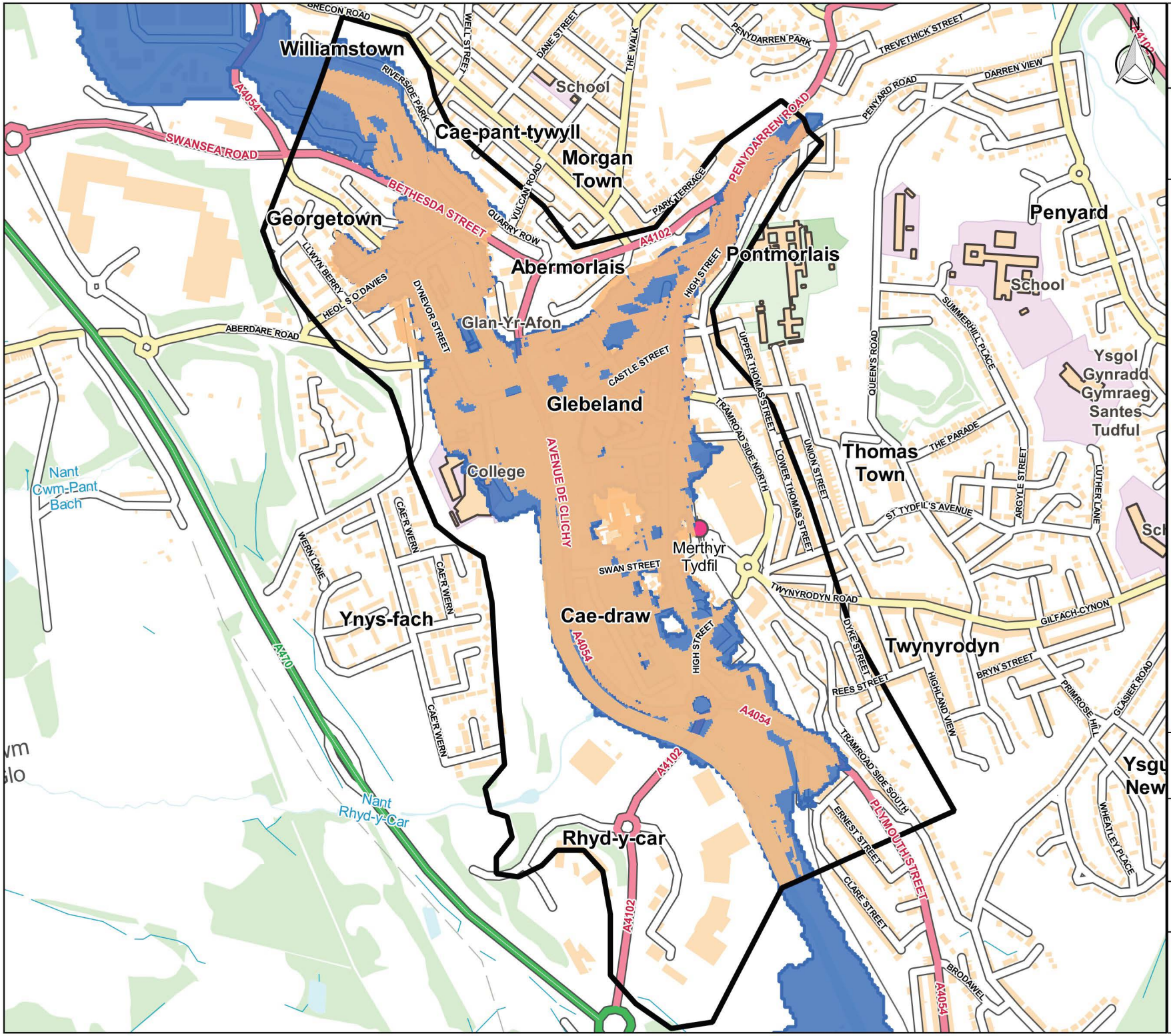
The statistical method generally predicts higher flows, especially for the higher return periods events for the River Taff and Nant Morlais. The rainfall runoff method predicts slightly larger flows than the statistical method when applied to the lateral inflow.

Based on NRW guidance the statistical estimates are used for return period up to and including 1:100. The flow estimates for the return periods above 1:100 are estimated by rescaling the statistical 1:100-year peak flow estimate by the ratio of the ReFH 2.2 peak flow estimate for the target return period to the corresponding ReFH 2.2 peak flow estimate for the 1:100 year return period.

Table 17 Final peak flow estimates

Return Period (years)	River Taff (m^3s^{-1})	Nant Morlais (m^3s^{-1})	Lateral Catchment (m^3s^{-1})
2	97.32	15.47	4.10
25	193.77	30.83	8.21
50	227.44	36.59	9.77
100	266.86	43.49	11.64
500	360.69	59.58	15.74
1000	426.04	71.48	18.61

Appendix D – Existing Dam Zone C2 vs Bus Station Modelled 0.1% AEP Extent



Project :

Merthyr Tydfil SFCA

Client :

Cyngor Bwrdeistref Sirol MERTHYR TUDFUL / MERTHYR TYDFIL County Borough Council

Legend :

- Bus Station 0.1% AEP extent
- Existing DAM Zone C2 Extent
- Bus Station model active area

Scale : 0 100 200 300 m

Title :

Bus station 0.1% AEP Extent vs existing DAM zone C2

Drawing :	Rev :
WHS1598-T01-0001	2

WHS